Smart Cluster Energy System for the Fish Processing Industry

ISMF Biennial Conference
15th Jan.2019, Cardiff

piSCES

Academic Partners

Waterford Institute *of* Technology

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Implementation Partners

BIM

Port of Milford Haven

piSCES

- Funded by the ERDF (European Regional Development Fund) – Interreg Ireland Wales Cooperation Programme

- Project Partners:
  Academic Partners - Cardiff University, Waterford Institute of Technology
  Implementation Partners - Milford Haven Port Authority & Bord Iascaigh Mhara

piSCES Aims

- To develop a smart cluster energy system
- Reduce costs for energy intensive processes within the fish processing industry
- Predict future energy consumption
- Maximise renewable energy use & off peak tariffs

Presentation Agenda

- **Part 1**

1. Overview (MHPA Buildings & appliances)
2. Simulation model (Designbuilder)
3. Result of simulation model for main appliances
4. Ontology of Fish processing industries
5. Battery model

- **Part 2**

1. Steps to follow
2. Prediction
3. Optimization
4. CUSP demo

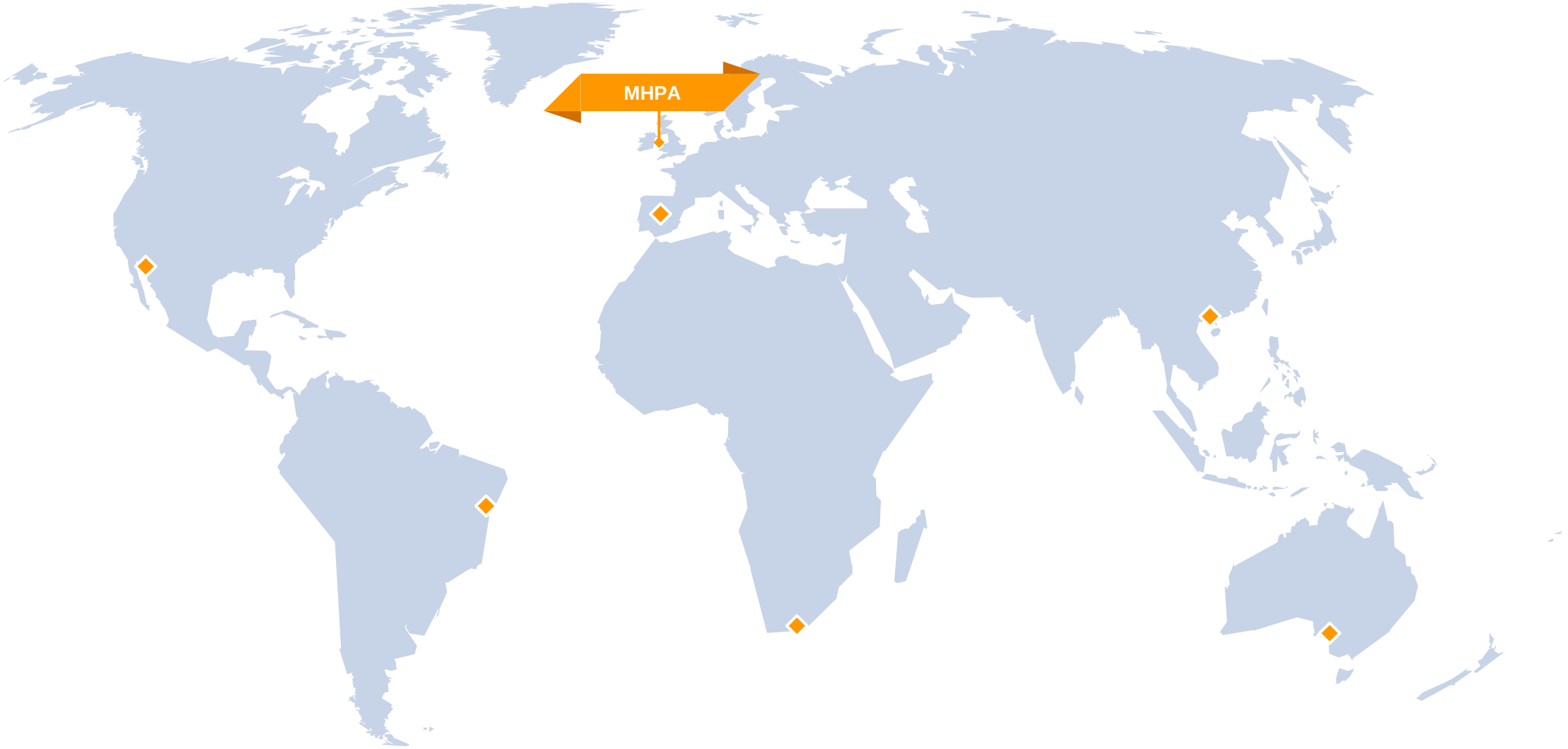
1

Overview

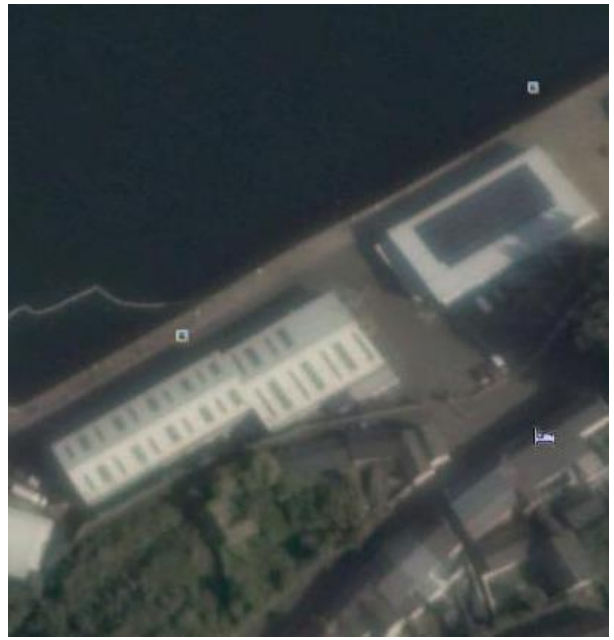
Packaway building in MHPA

“Milford Haven port is a major port in the UK, and is considered the largest energy port in the UK. The port is responsible for the safe movement of vessels on the Milford Haven and deep water site, on the western coast of the UK.

MILFORD HAVEN ON MAP



Site view



Packaway building

Packaway building

Solar panel with 50 Kw capacity

Flake ice

Box washing machine

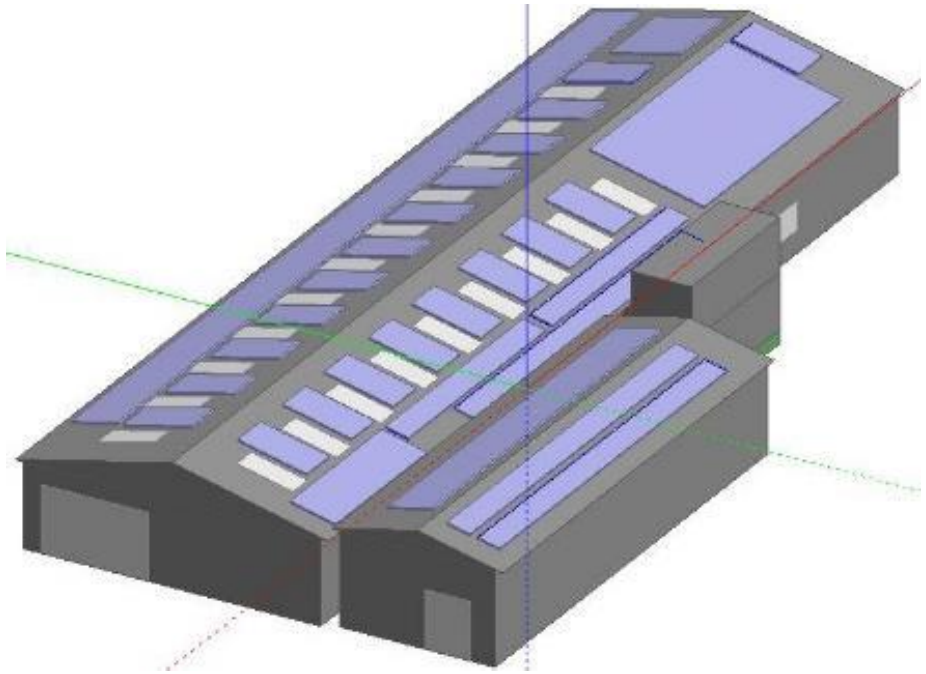
Cold room

Data analysis

Appliance	How it is works
1.Box washing machine	The box washing machine has the power capacity 50 Kw. It works only when the fishers want to clean the boxes after use it for a very short time a day.
2. Lighting system	Lighting system in this building is about 17 double tubes (25 W each). According to staff, fishers do not use it in day time due to daylight. They use it in the night foe a very short period based on the system
3.Flake ice	Flake ice produces small pieces of ice for use in the cold storage to preserve the fish. It consumes about 32 Kw of power.
4.Cold storage	Cold storage is under operation all the time to meet the demand for fishers with the quantity they need. Also, it is considered the most power-consuming device in the building. This is because of the low temperature needed (-5 degrees).

2

Modeling and Simulation



Packaway Building

Solar panel with 50 Kw capacity

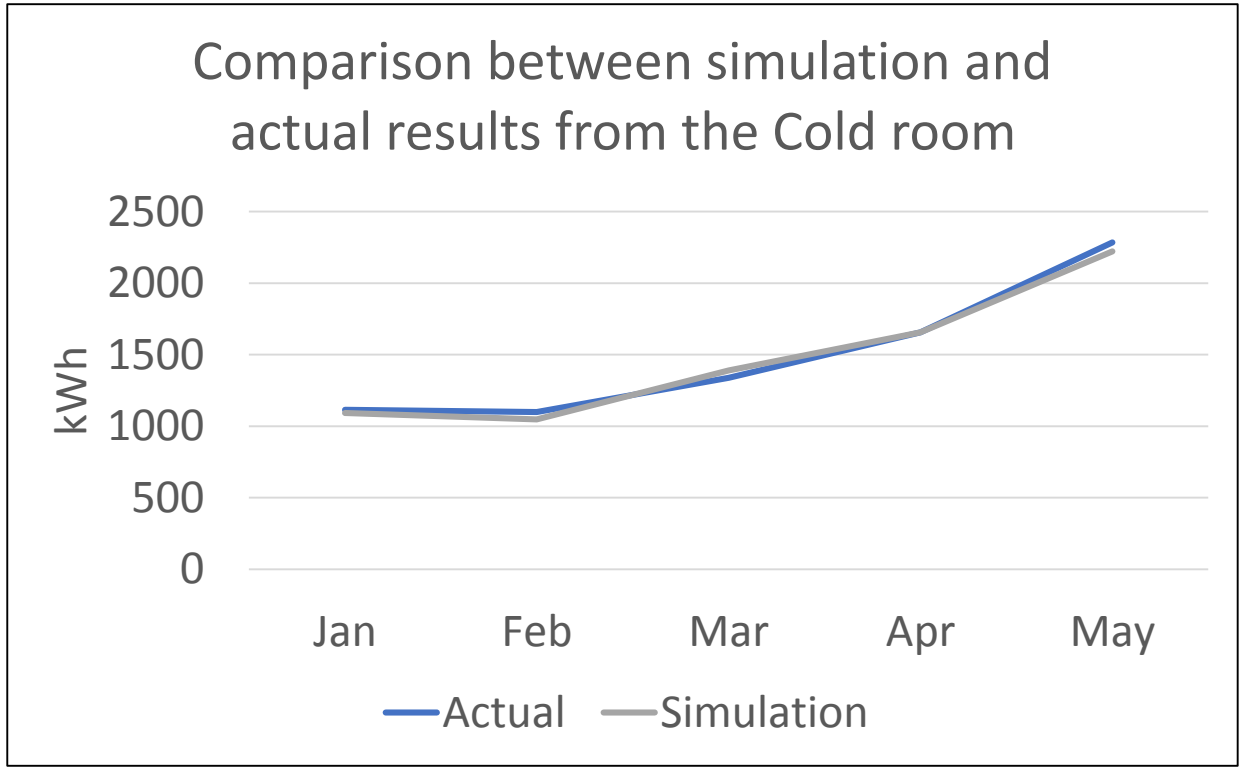
Flake ice machine

Cold room

3

Result Analysis

Month	Actual (kWh)	Simulation (kWh)
Jan	1114.5777	1091.693488
Feb	1097.73807	1046.688088
Mar	1338.39973	1388.604113
Apr	1655.6705	1656.761288
May	2284.6715	2222.454163



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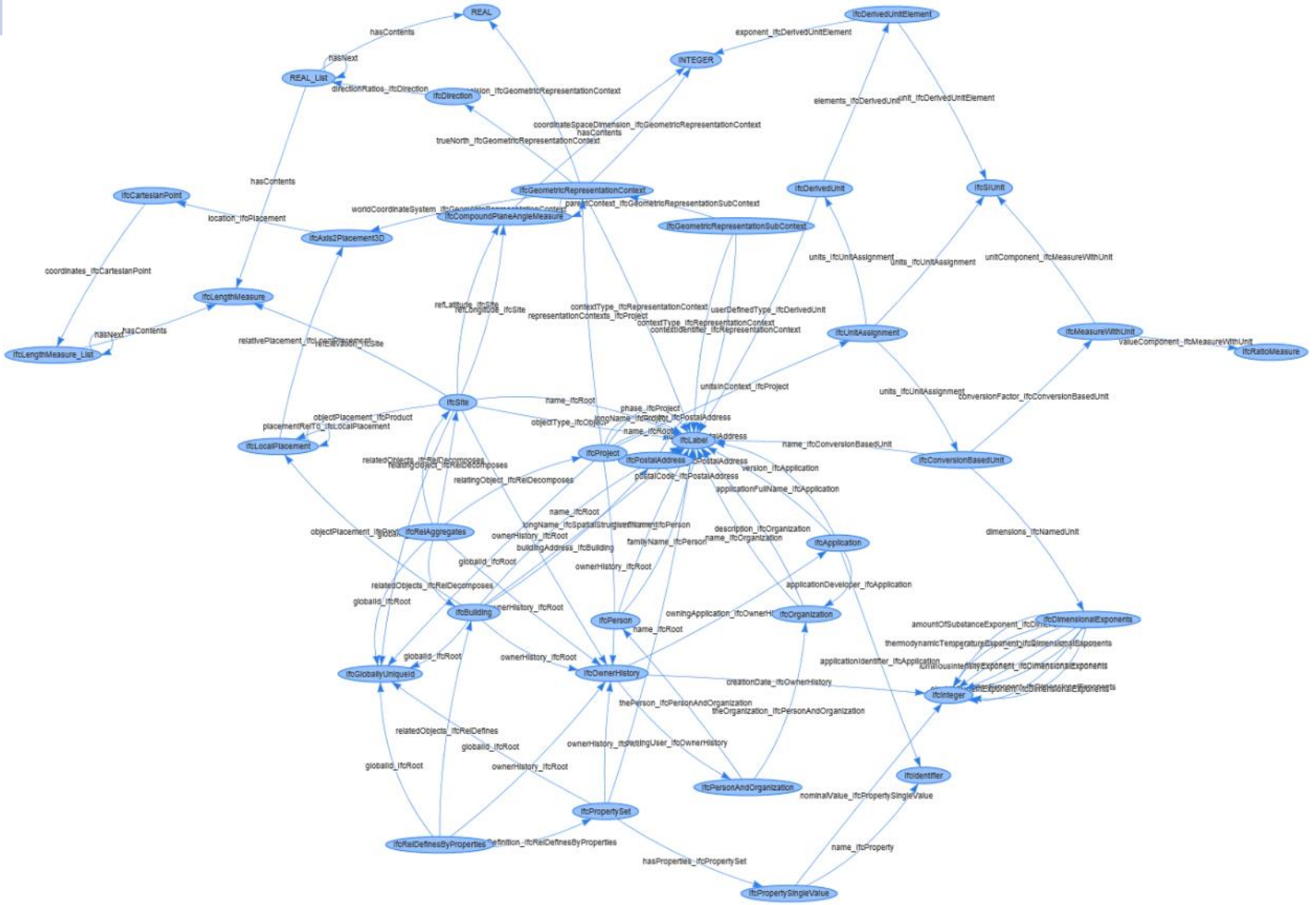
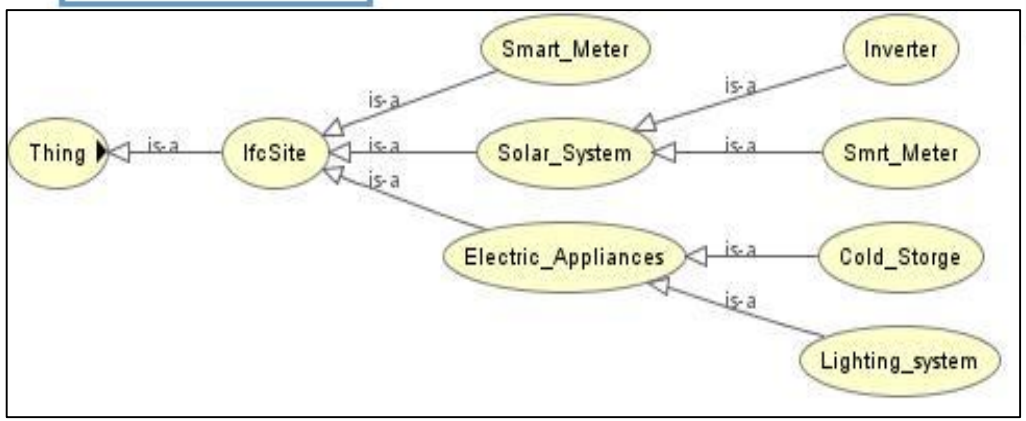
Ontology of fish processing industries

Ontology for knowledge generation



- Query the knowledge repository to inform prediction and simulation.
- Determine impact of variable on the overall set of objectives.
- Understand the relationships between various components.

Semantic map of fish processing industries



Weather
Climate

ExteriorInformation

Rooms
Walls
Windows
spaces

Buildinginformation

Smart meter
Fish quantity
Utlity bills

SourcesInformation

Staff
Customers
Producers
Actvities

FisheriesInformation

Fishery port Ontology

EnergyInformation

ActorInformation

Energy consumption
Energy generation
Carbon emission

Schedules
Preferences

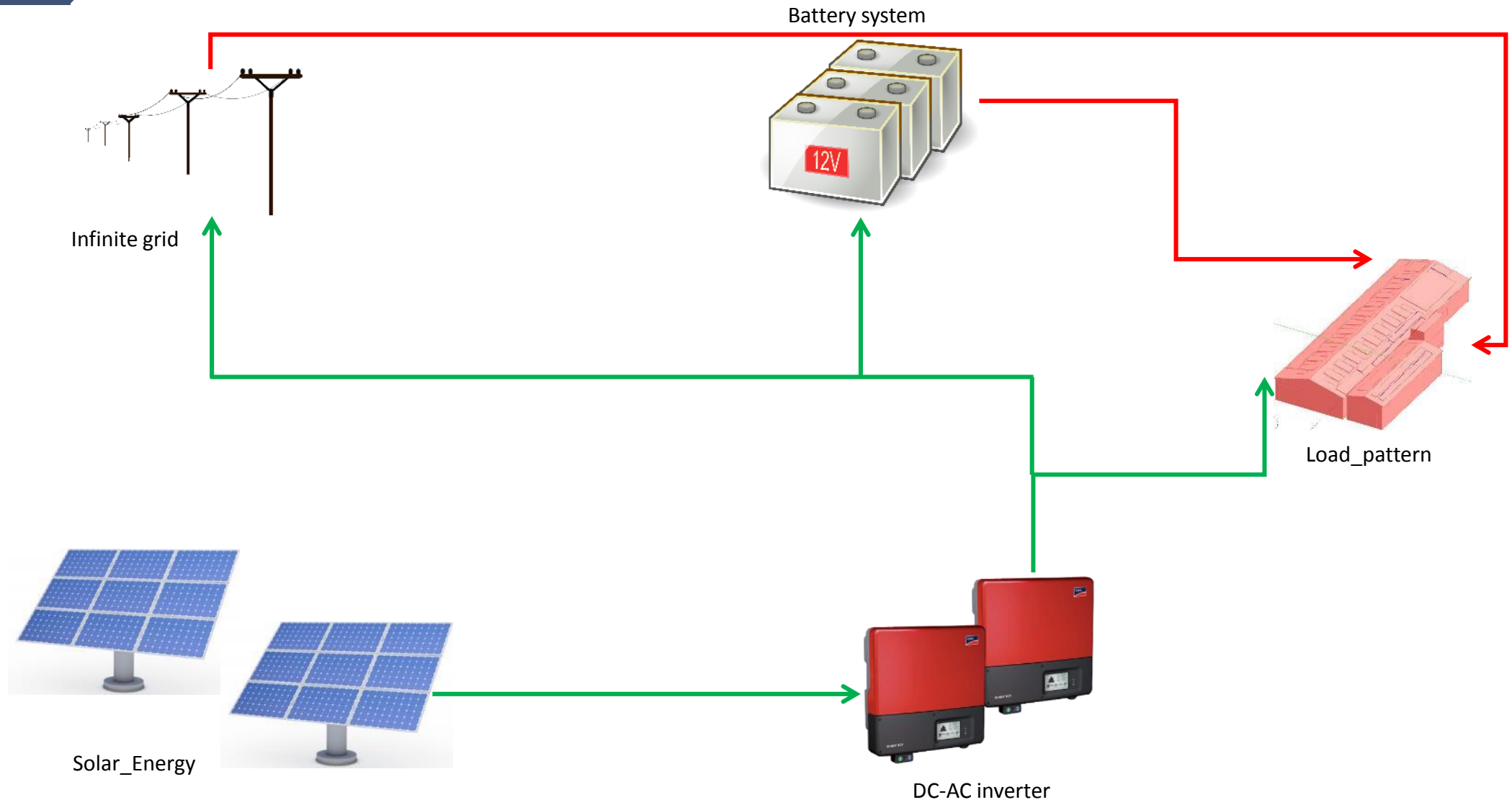
ProcessInformation

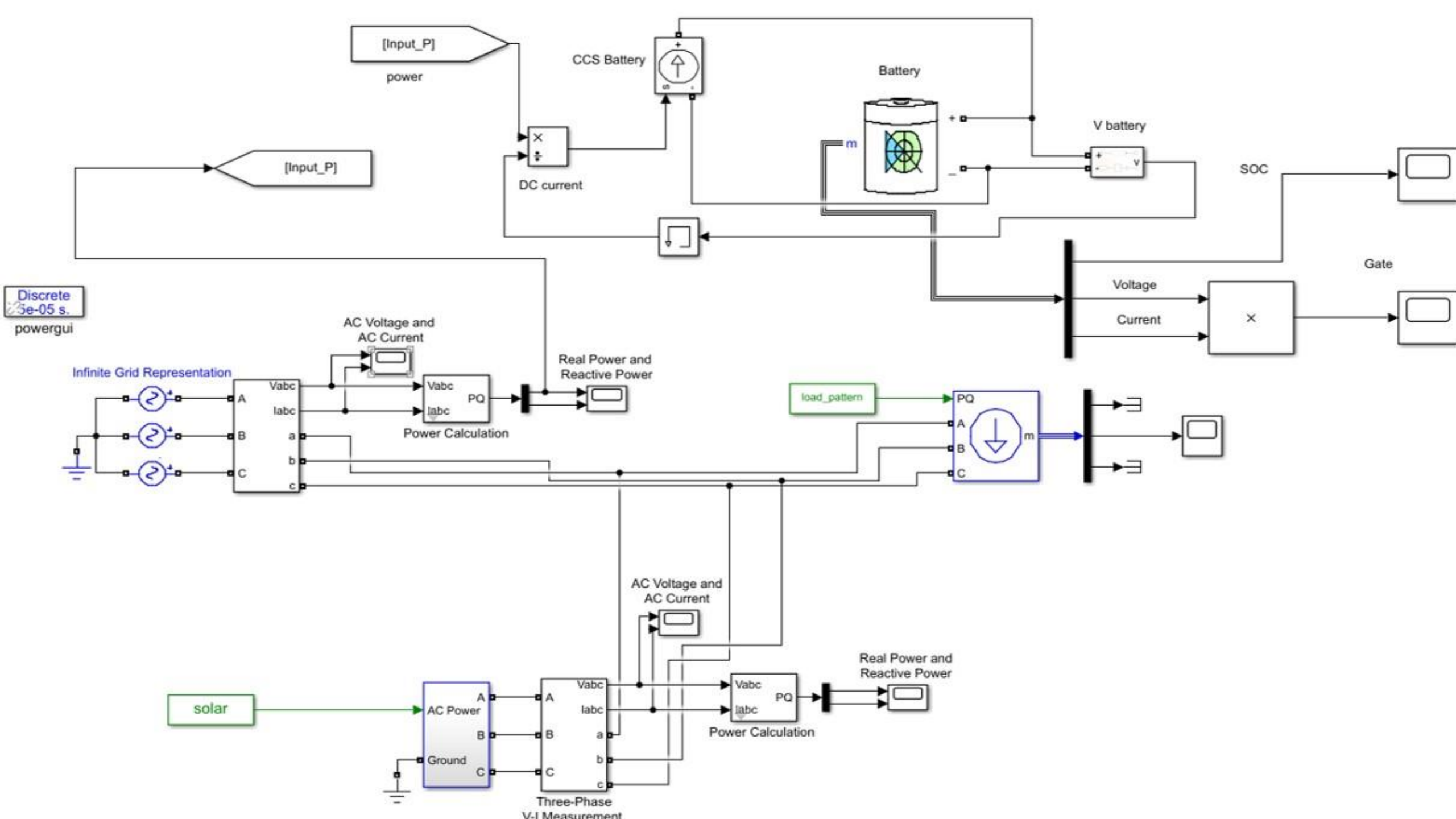
Systems
Processes
Appliances

5

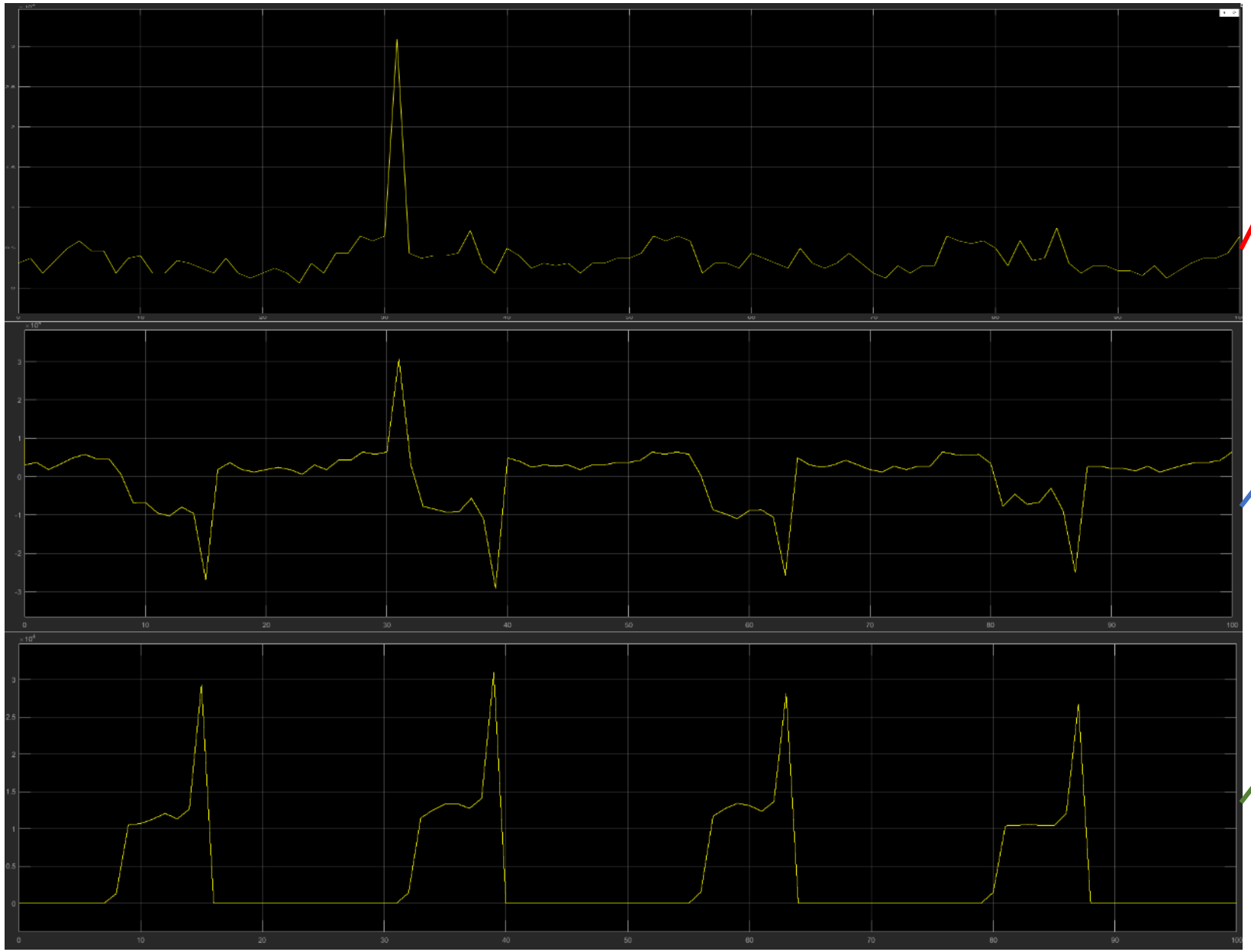
Battery model

Battery model




[Input_P]
power
CCS Battery
Battery
V battery
DC current
[Input_P]
SOC
Discrete
5e-05 s.
powergui
Voltage
Current
Gate
AC Voltage and
AC Current
Infinite Grid Representation
Real Power and
Reactive Power
Vabc
Iabc
PQ
Power Calculation
load_pattern
A
B
C
a
b
c
m
AC Voltage and
AC Current
Real Power and
Reactive Power
solar
AC Power
Ground
Three-Phase
V-I Measurement
Power Calculation

Result of Battery model



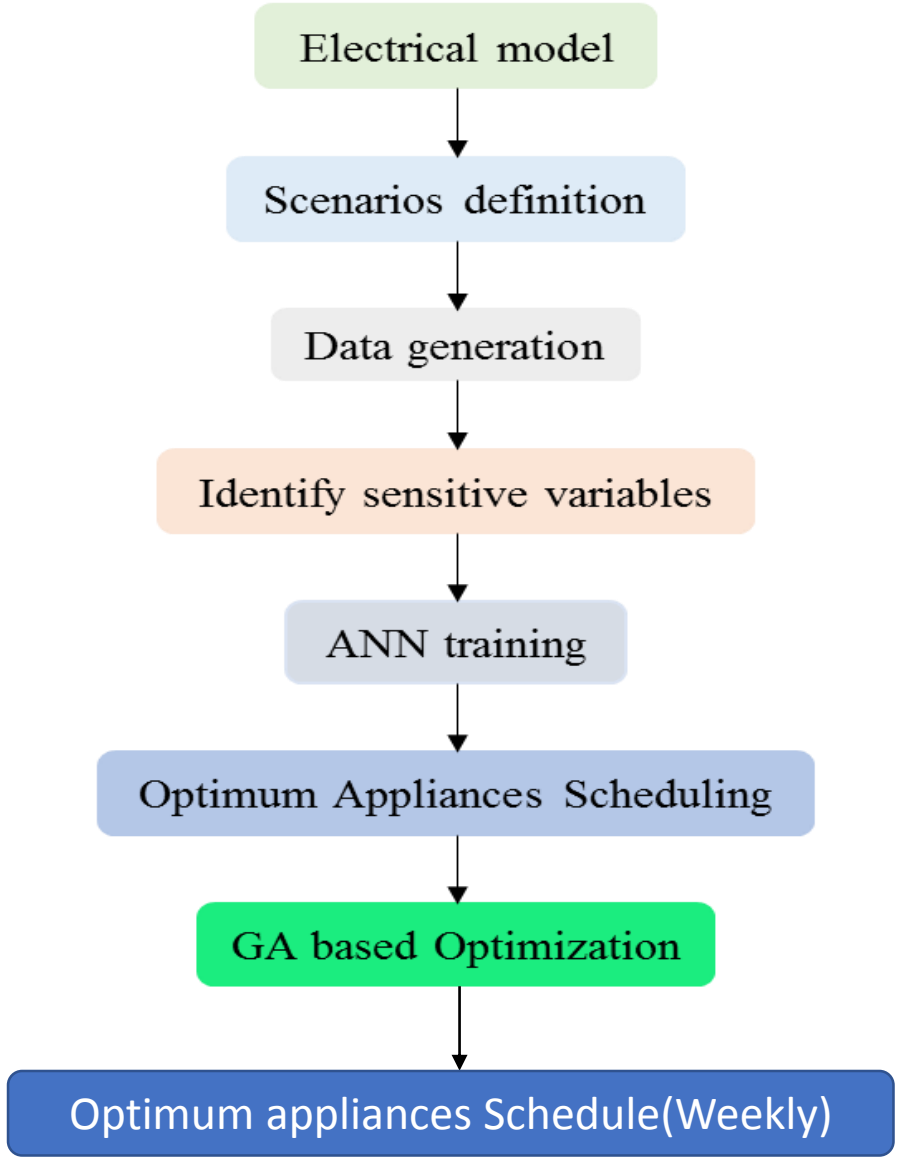
Part 2

1

Steps to follow

1. **Simulation model**
   - Full simulation model for the Packaway building
   - Split models one for appliances and one for flake ice
2. **Prediction**
   - **Create a Artificial Neuronal Network to predict 1 step ahead consumption in Packaway**
   - **Use simulation model to generate historical data and use existing historical data to train the Artificial Neuronal network (accuracy of prediction)**
3. **Optimized schedules for appliances**
   - Start time, End time, weekly schedule
   - schedule implementation and actuation
4. **Integration with CUSP**
   - Integrating the simulation model
   - Integrating the prediction
   - Other functionality required by MHPA

Methodology



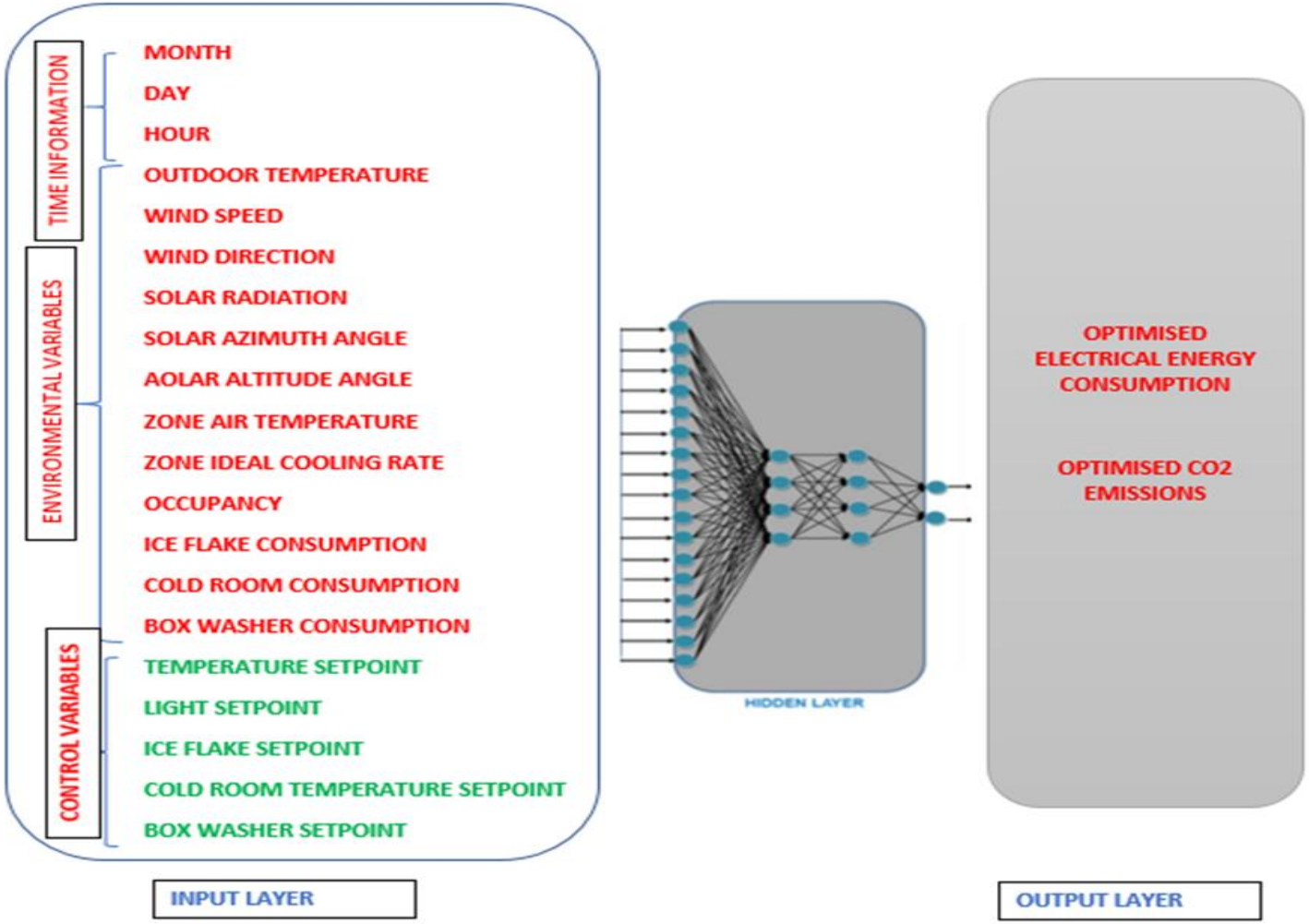
SIMULATED SCENARIO DEFINITION

Scenario Definition	Holistic Solution
Control Variables	- Ice Flake machine setpoint - Cold room setpoint - Box washing machine setpoint - Lighting setpoint
Objectives	- Desired amount of energy consumption • Electrical energy minimization • Ice Flake machine setpoint (off=0, on=1) • Cold room temperature setpoint (-15 deg.) • Box washing machine setpoint (off=0, on=1) • Lighting setpoint (off=0, on=1) • Boat charging
Effective environmental variables	The most effective variables will be determined after sensitivity analysis
Control Rules	To be generated based on optimized setpoints
Actors	Occupancy sensors, Lighting automation system, automation system, facility manager, actuators, temperature sensors, weather stations.
When applicable	The scenario is applicable to optimize energy and CO2 emissions in the PACKWAY building MHPA.

2

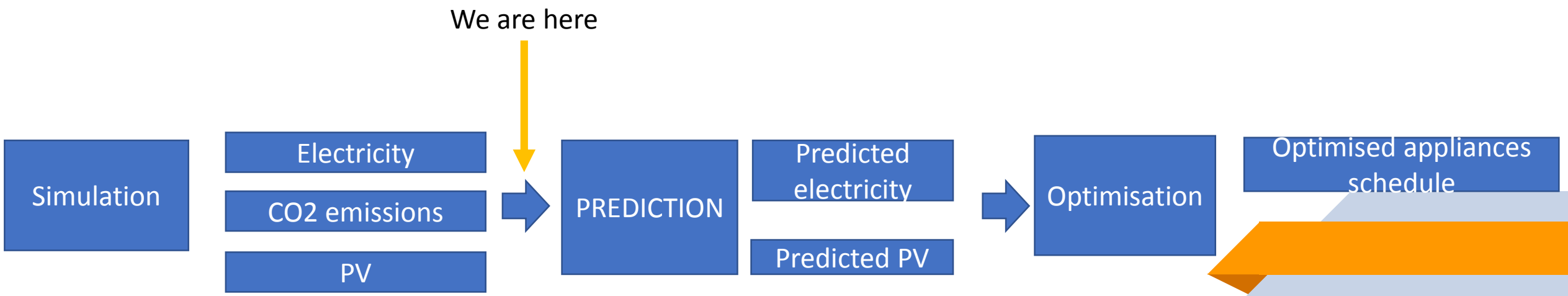
Prediction

STEP 2: THE PREDICTION

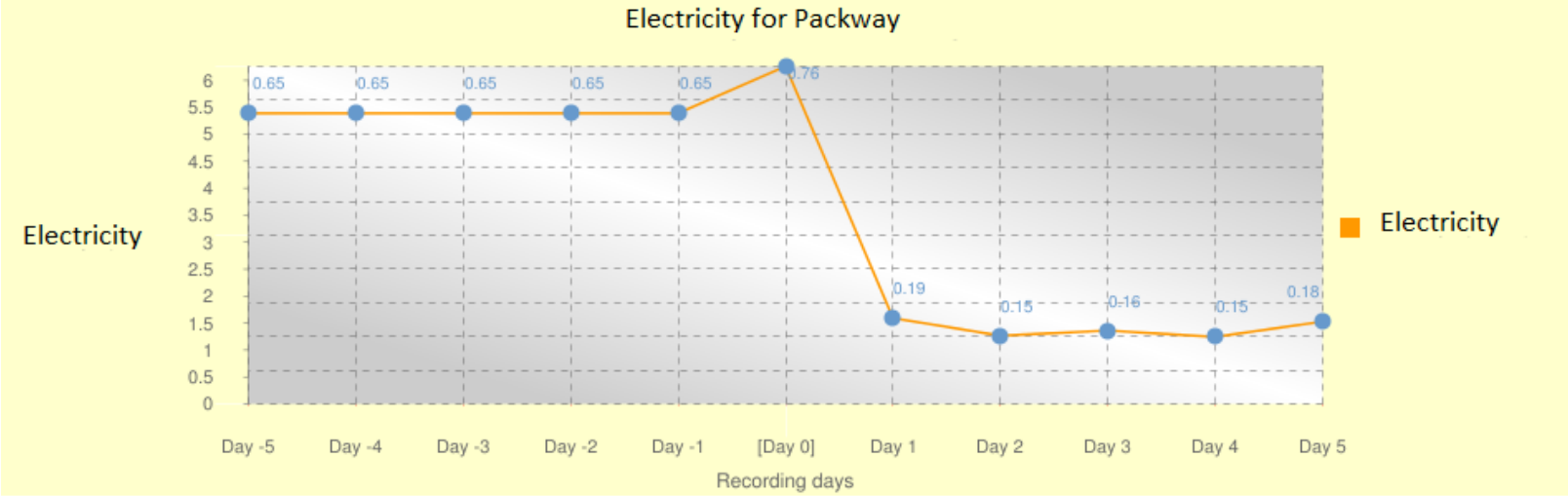


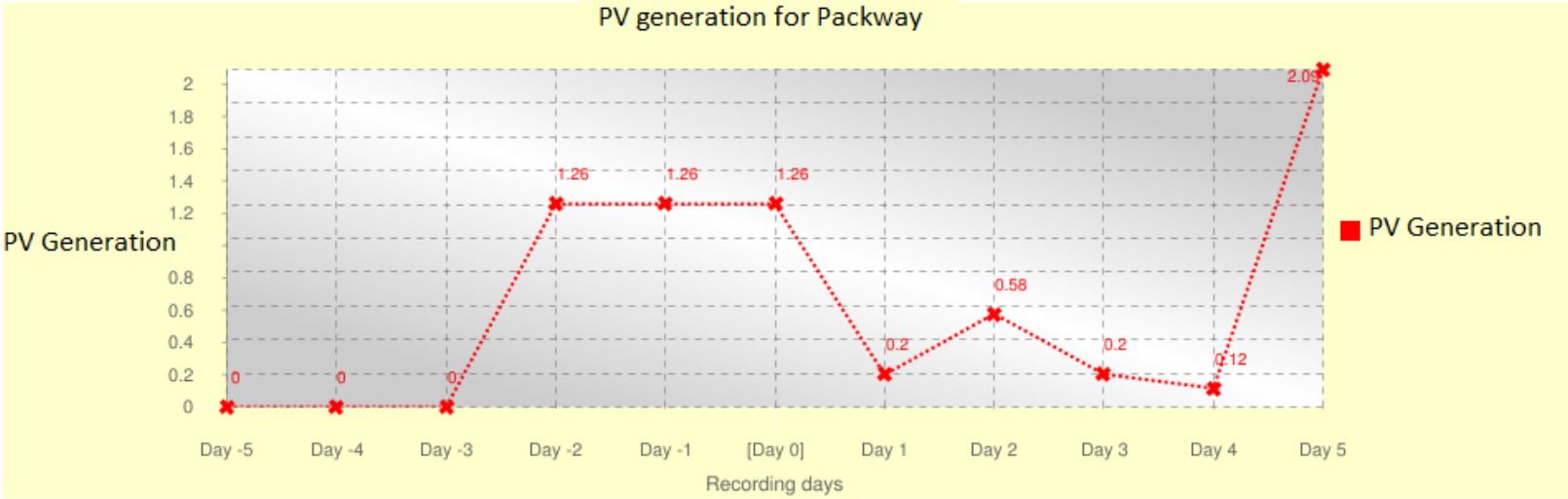
Objectives for prediction

- Predict electricity consumption for PACKWAY
  - 15 minutes in future
  - 1 hour in future
  - 1 day in future
- Subject to quality of data and quantity of data



A prediction example



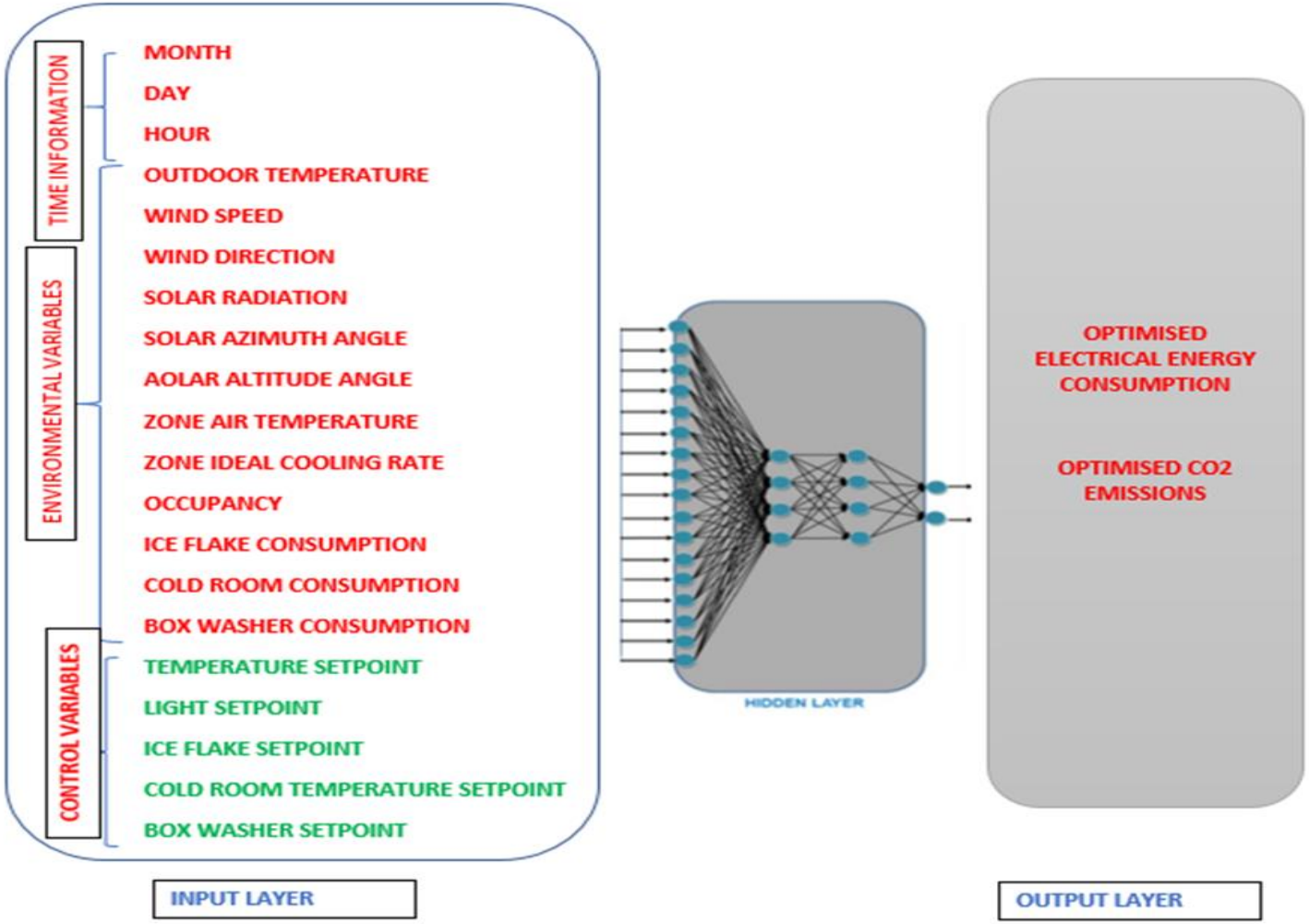


Prediction by **end March 2018**

2nd iteration by end of April 2018

- (1h/day)prediction of Packway consumption
- (1h/day) prediction of Packway PV

STEP 2: THE PREDICTION



3

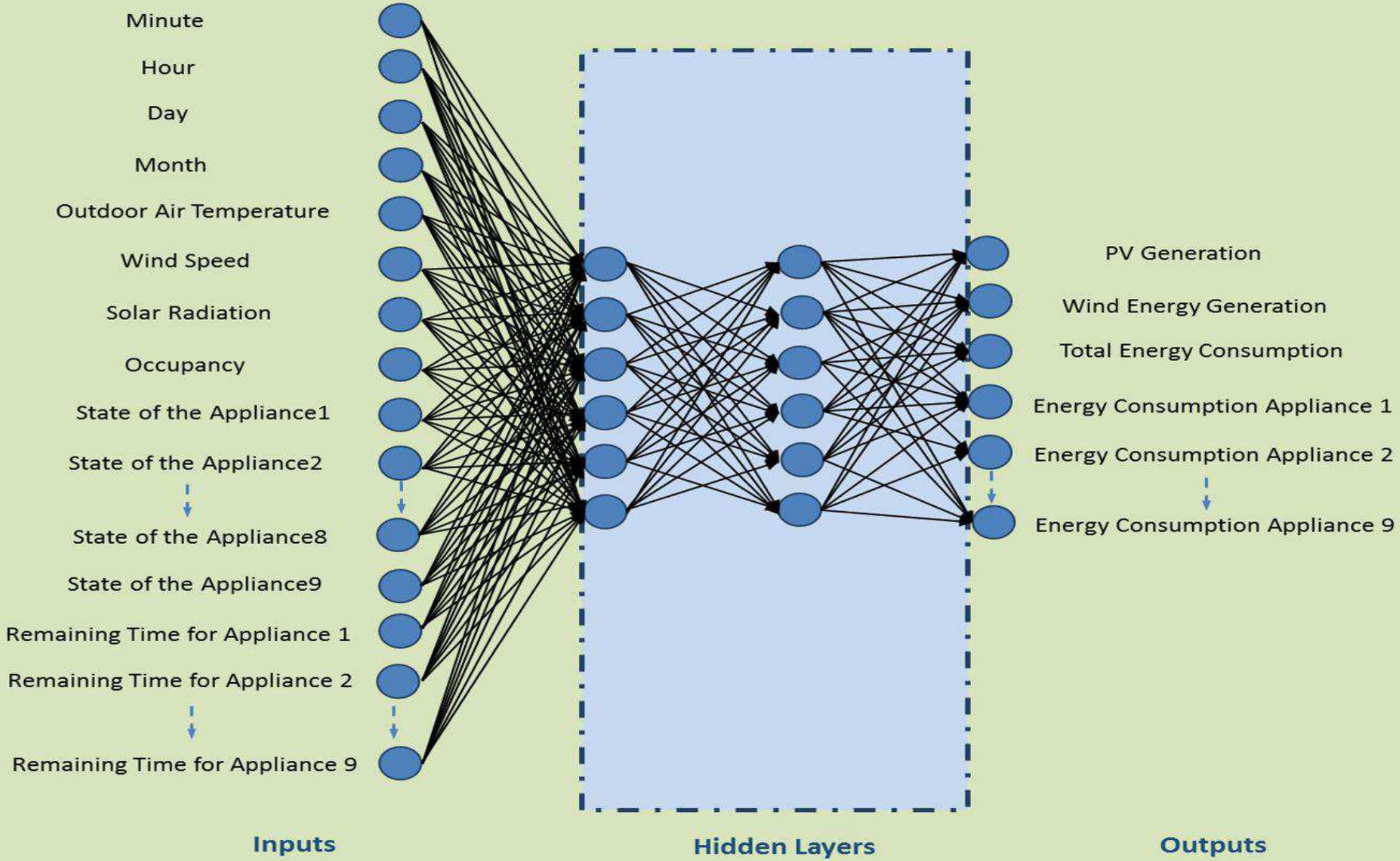
Optimized schedule

Optimized schedule

No	Appliance	Power Rating (kW)	Minimum Running Time (minutes)	Interruption of Appliance	Required Usage Frequency	Required Start Time
1	Box washing machine	50 KWh	30	Not Possible	Once a day	Between (6:00-16:00)
2	Ice Flake machine	30kWh	60	Possible	Twice a day	Between (6:00-16:00)
3	Cold storage room	30kWh	180	Possible	Twice a day	Between (0:00-23:45)
4	Lighting system	25 W/per tube	60	Possible	Twice a day	Between (0:00-23:45)

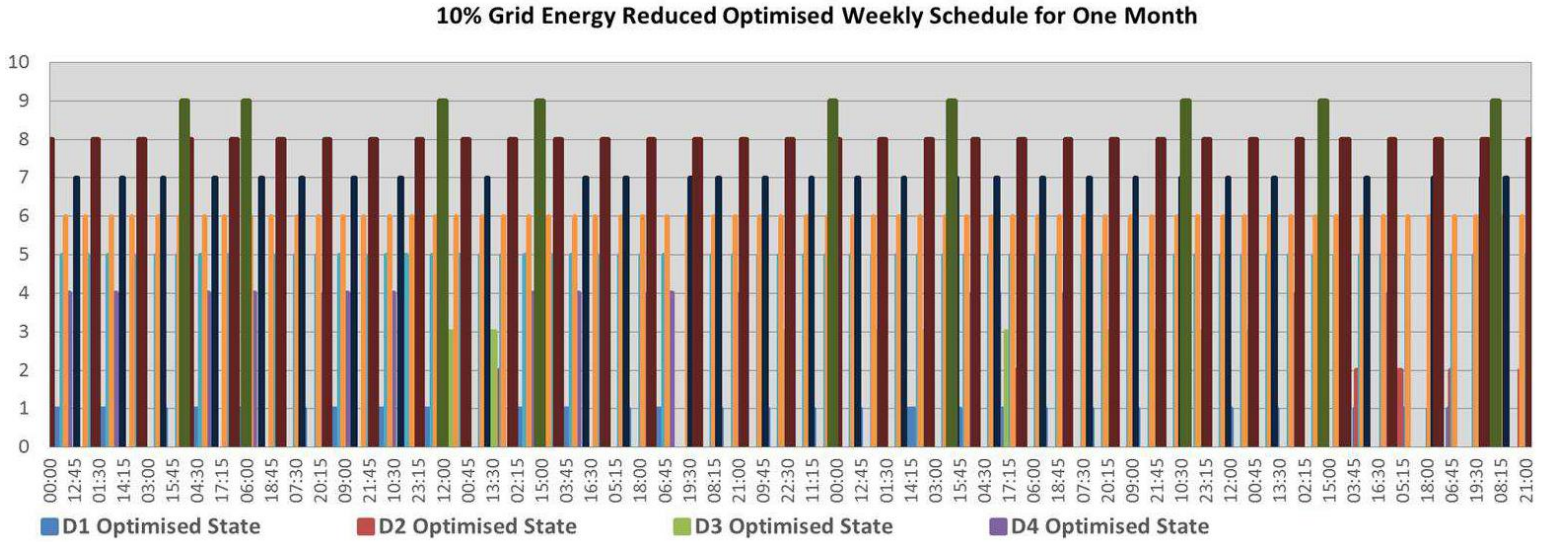
Scheduling workflow

- Then the model is converted to EnergyPlus model to generate the data set by changing the schedule of selected appliances.
- The **data generated with EnergyPlus simulation is then analysed** with a stepwise sensitivity analysis approach to determine most sensitive environmental variables.
- ANN -> Date and time info, wind speed, diffuse solar radiation, occupancy, **appliances on/off state for the selected time frame**, and the remaining duration time for each appliance as inputs.
- Wind power generation, PV electricity generation and total energy consumption and individual energy consumption for each appliance are used as outputs.


Minute
Hour
Day
Month
Outdoor Air Temperature
Wind Speed
Solar Radiation
Occupancy
State of the Appliance1
State of the Appliance2
State of the Appliance8
State of the Appliance9
Remaining Time for Appliance 1
Remaining Time for Appliance 2
Remaining Time for Appliance 9
PV Generation
Wind Energy Generation
Total Energy Consumption
Energy Consumption Appliance 1
Energy Consumption Appliance 2
Energy Consumption Appliance 9
Inputs
Hidden Layers
Outputs

Optimisation results and objectives

- Correlated the PV energy generation with the consumption schedules
- Determining when(at what time) an appliance should start and for how long: **<u>Schedule:[State s, Device d, day D, time T]</u>**
  - Ice flake: start at **09:00 to 10:30**. Day: **Monday**.
  - Box washer start at **10:30 to 11:30**. Day: **Monday**.



Task to follow for optimization

- **Task 1:** Progress with the simulation model for Packway building
- **Task 2:** Develop a holistic optimization scenario for Packway building
- **Task 3:** Calibrate the EnergyPlus simulation models
- **Task 4:** Start generating data based on the modelling
- **Task 5:** Train an ANN based on the generated data
- **Task 6:** Determined optimized setpoints and develop rules