MPC - Modelica System Integration

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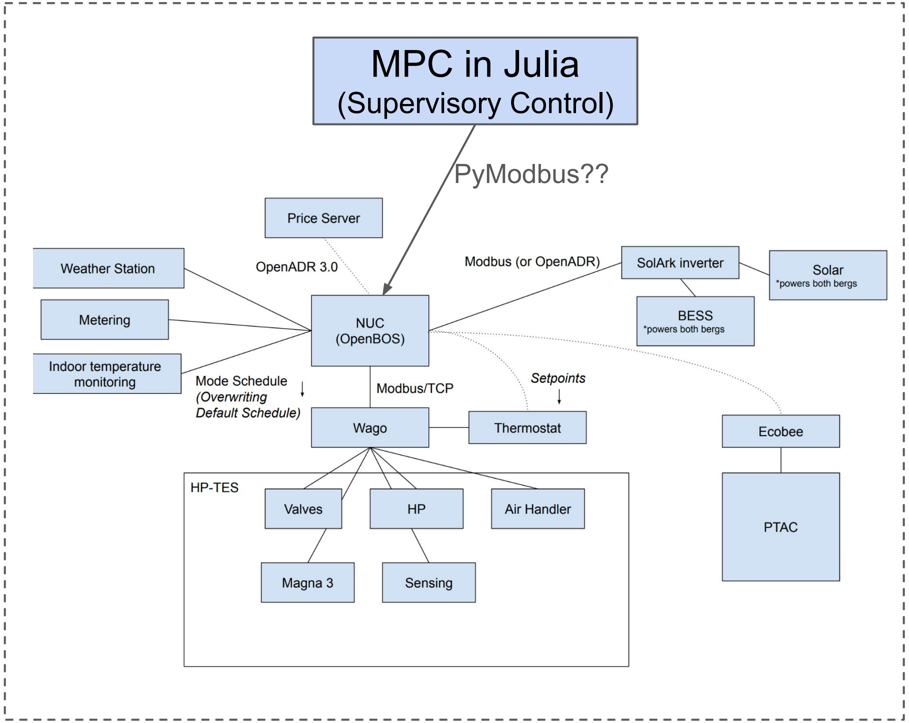
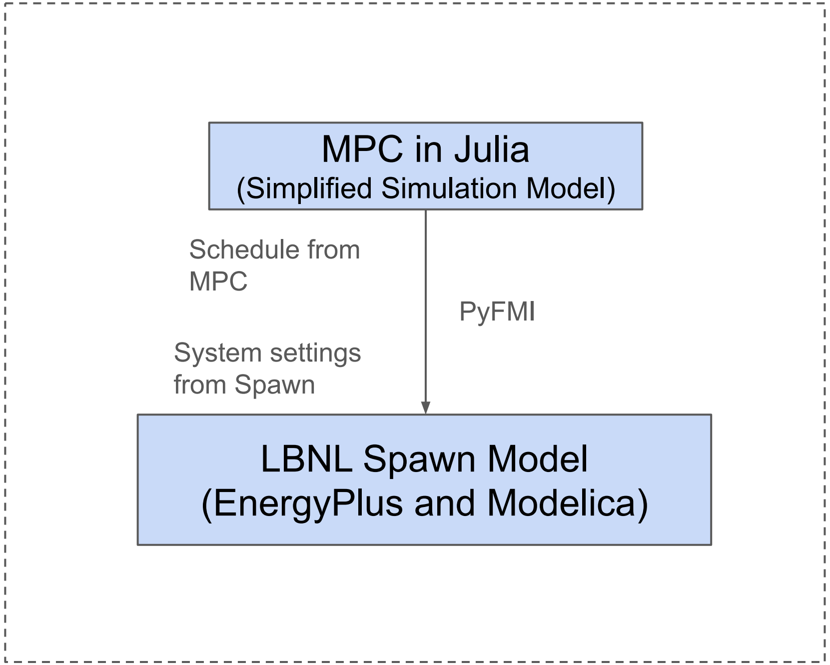
Big Picture

Real-Time (credit: Lazlo)



Real Berg Structure

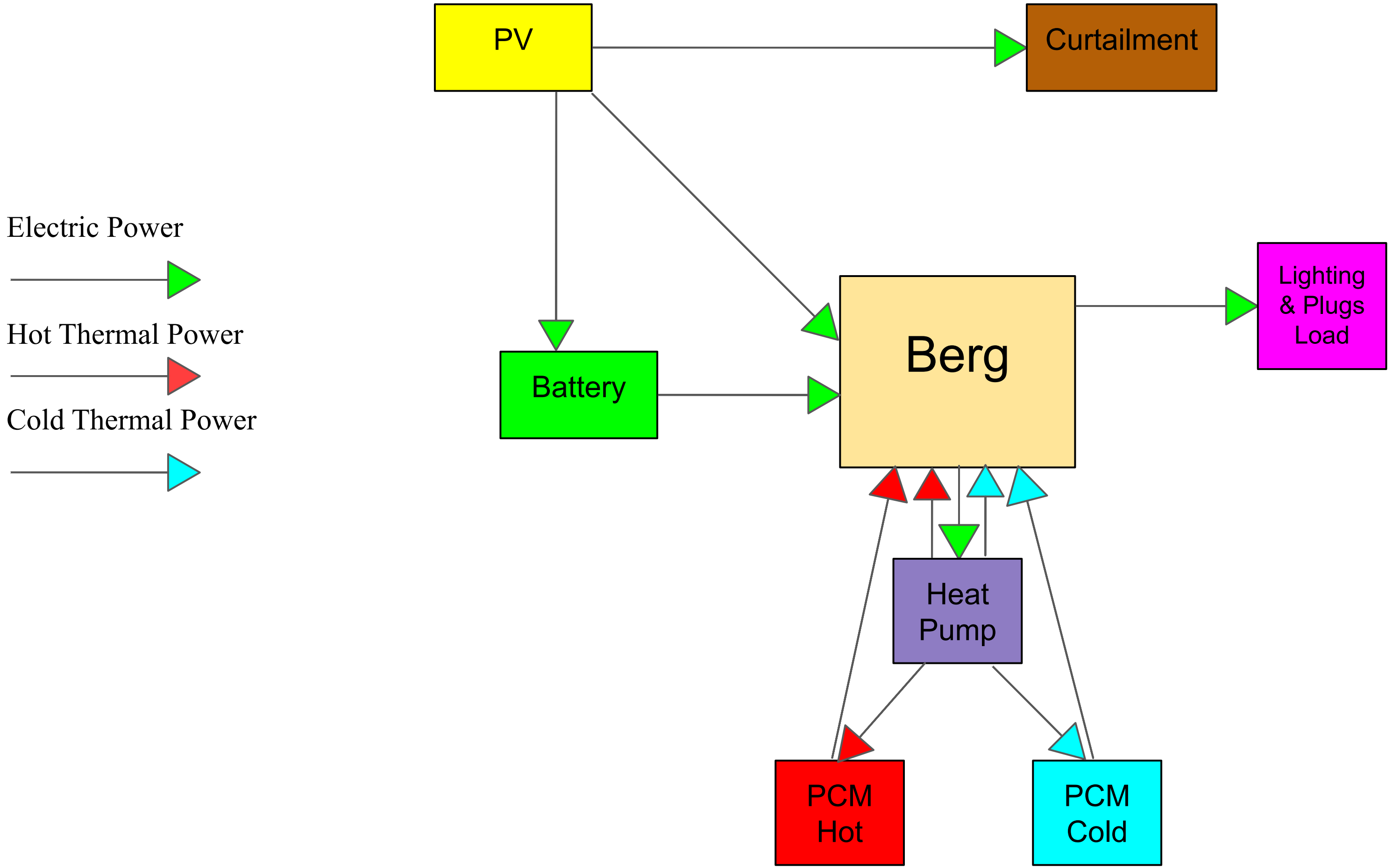
Simulation



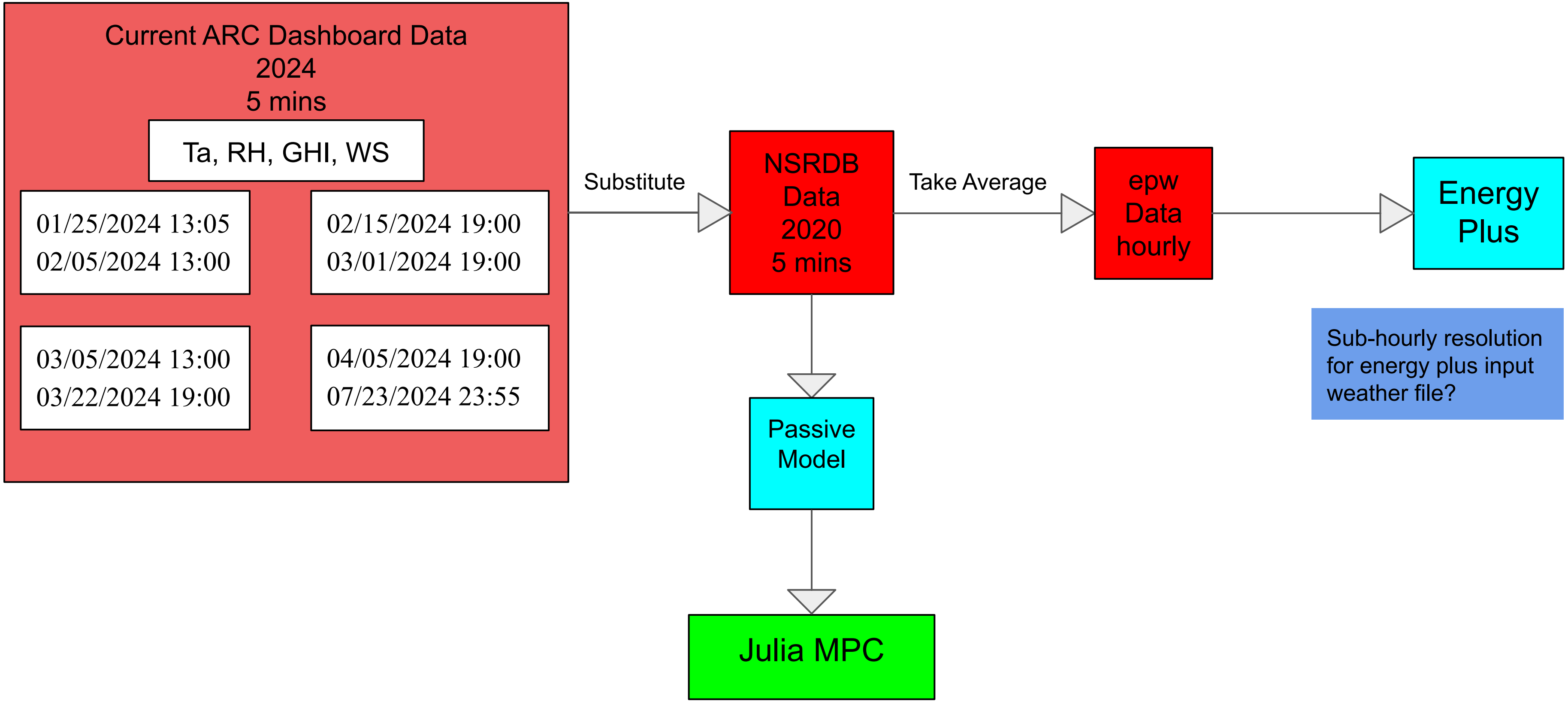
Modeled Berg Envelope in Energy Plus

Modeled HP-TES in Modelica

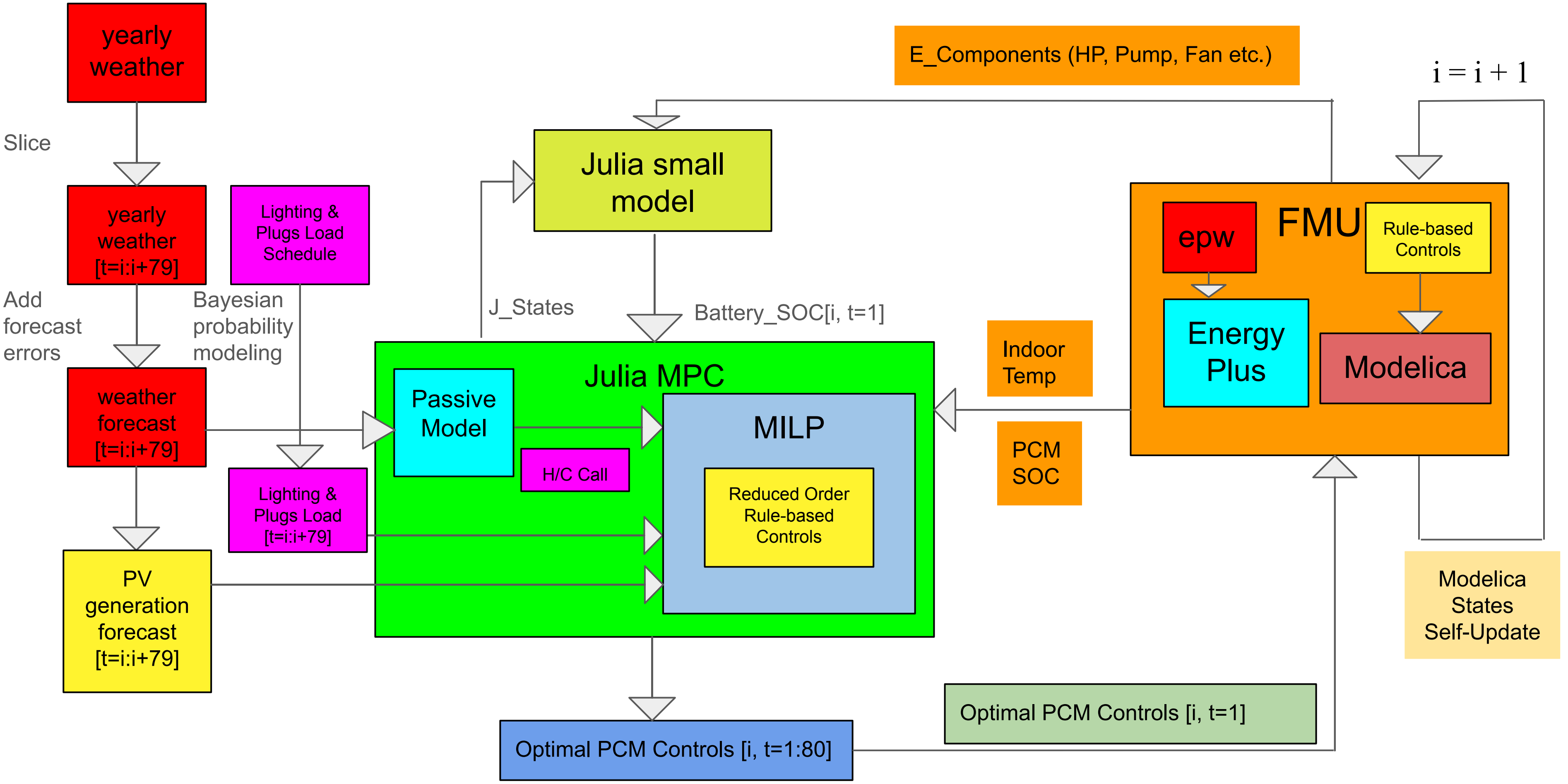
Physical System Layout



Data


Current ARC Dashboard Data
2024
5 mins
Ta, RH, GHI, WS
01/25/2024 13:05
02/05/2024 13:00
02/15/2024 19:00
03/01/2024 19:00
03/05/2024 13:00
03/22/2024 19:00
04/05/2024 19:00
07/23/2024 23:55
Substitute
NSRDB Data 2020 5 mins
Take Average
epw Data hourly
Energy Plus
Passive Model
Julia MPC
Sub-hourly resolution for energy plus input weather file?

Integrated Model Structure



MPC Time Interval

Interval Type	Interval Length	# of Intervals	Length	Aggregated Horizon	Aggregated # of Intervals
1	5 mins	6	0.5 hours	0.5 hours	6
2	30 mins	5	2.5 hours	3 hours	11
3	1 hour	21	21 hours	1 day	32
4	2 hours	48	96 hours	5 days	80

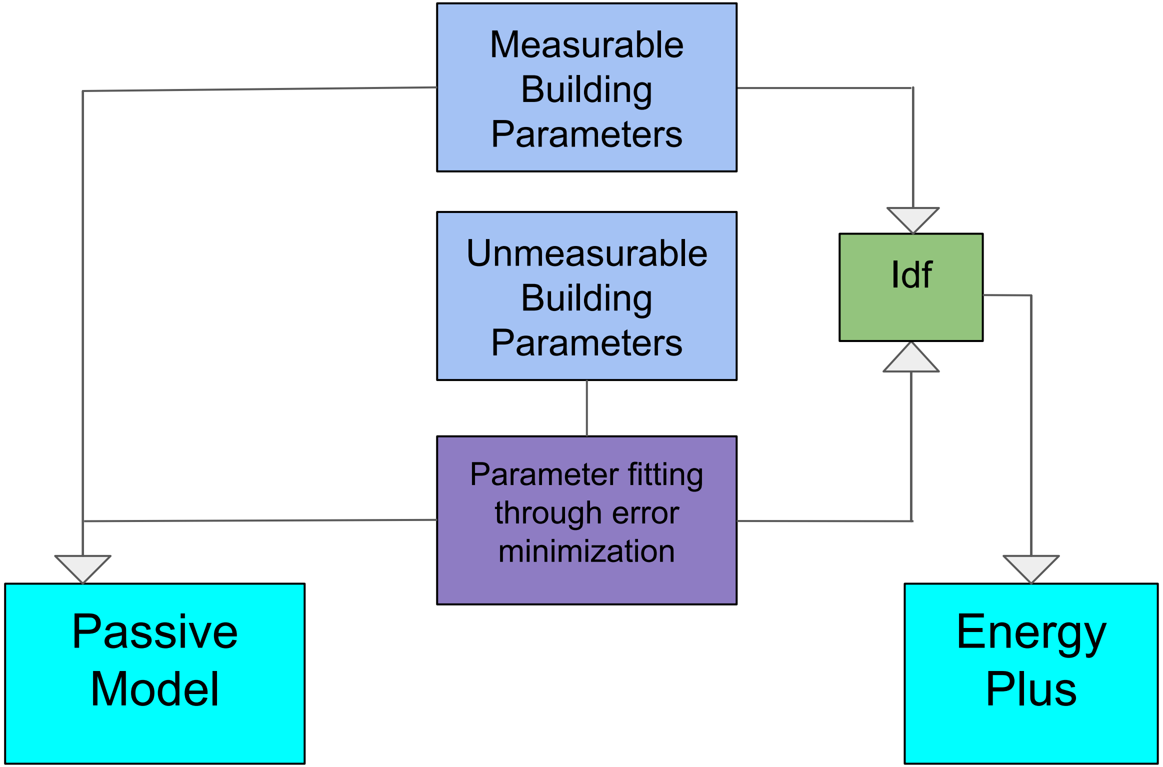
Model Time Definition

MPC Time Step			
	Iteration i = 0	Iteration i = 1	Iteration i = 2
Mode	Start FMU first; Run FMU with default command	Start MPC, optimize, send command to FMU	Run FMU with MPC command; Re-run MPC, optimize,send command to FMU
Current Time	0:00	0:00	0:05
MPC Model t=1	/	0:05	0:10
Solve Time	/	00:00 to 00:05	00:05 to 00:10
Weather Input	/	Weather forecast at 00:00 of horizon starting at 00:05	Weather forecast at 00:05 of horizon starting at 00:10
M_States[t=1]	Initial_M_States used to start the FMU	M_States[t=1, i=1] = M_States output from (i = 0)	M_States[t=1, i=2] = M_States[t=2, i=1] at 00:10, or between 00:05 to 00:10
J_States[t=1]	/	J_States[t=1, i=1] = Initial J_States	J_States[t=1, i=2] = J_States[t=2, i=1] at 00:10, or between 00:05 to 00:10
Current Action	/	Nothing: from 00:00 to 00:05	D[t=1, i=1]: from 00:05 to 00:10
Next Optimal Decision	Nothing: from 00:00 to 00:05	D[t=1, i=1]: from 00:05 to 00:10	D[t=1, i=2]: from 00:10 to 00:15
M_States output	Initial_M_States after doing nothing for 5 minutes	M_States[t=2, i=1] at 00:10, or between 00:05 to 00:10	M_States[t=2, i=2] at 00:15, or between 00:10 to 00:15
J_States output	/	J_States[t=2, i=1] at 00:10, or between 00:05 to 00:10	J_States[t=2, i=2] at 00:15, or between 00:10 to 00:15
time points for FMU	[00:00, 00:05]	[00:05, 00:10]	[00:10, 00:15]
PV_Gen_0	/	PV Generation from 00:00 to 00:05	PV Generation from 00:05 to 00:10
Battery_SOC_0	/	Battery SOC at 00:00	Battery SOC at 00:05 (InStorageBattery_past[1])
Battery_SOC[t=1]	/	Battery SOC at 00:05	Battery SOC at 00:10 (InStorageBattery_past[2])
PV2B[t=1]	/	PV2B[t=1, i=1] = Average POWER from 00:05 to 00:10	PV2B[t=1, i=2] = Average POWER from 00:10 to 00:15
Curtailment_past	/	Curtailment between 00:00 to 00:05 = 0 (J_States[t=1, i=1])	Curtailment between 00:05 to 00:10 (J_States[t=1, i=2])
PV2B_past	/	PV2B between 00:00 to 00:05 = 0 (J_States[t=1, i=1])	PV2B between 00:05 to 00:10 (J_States[t=1, i=2])

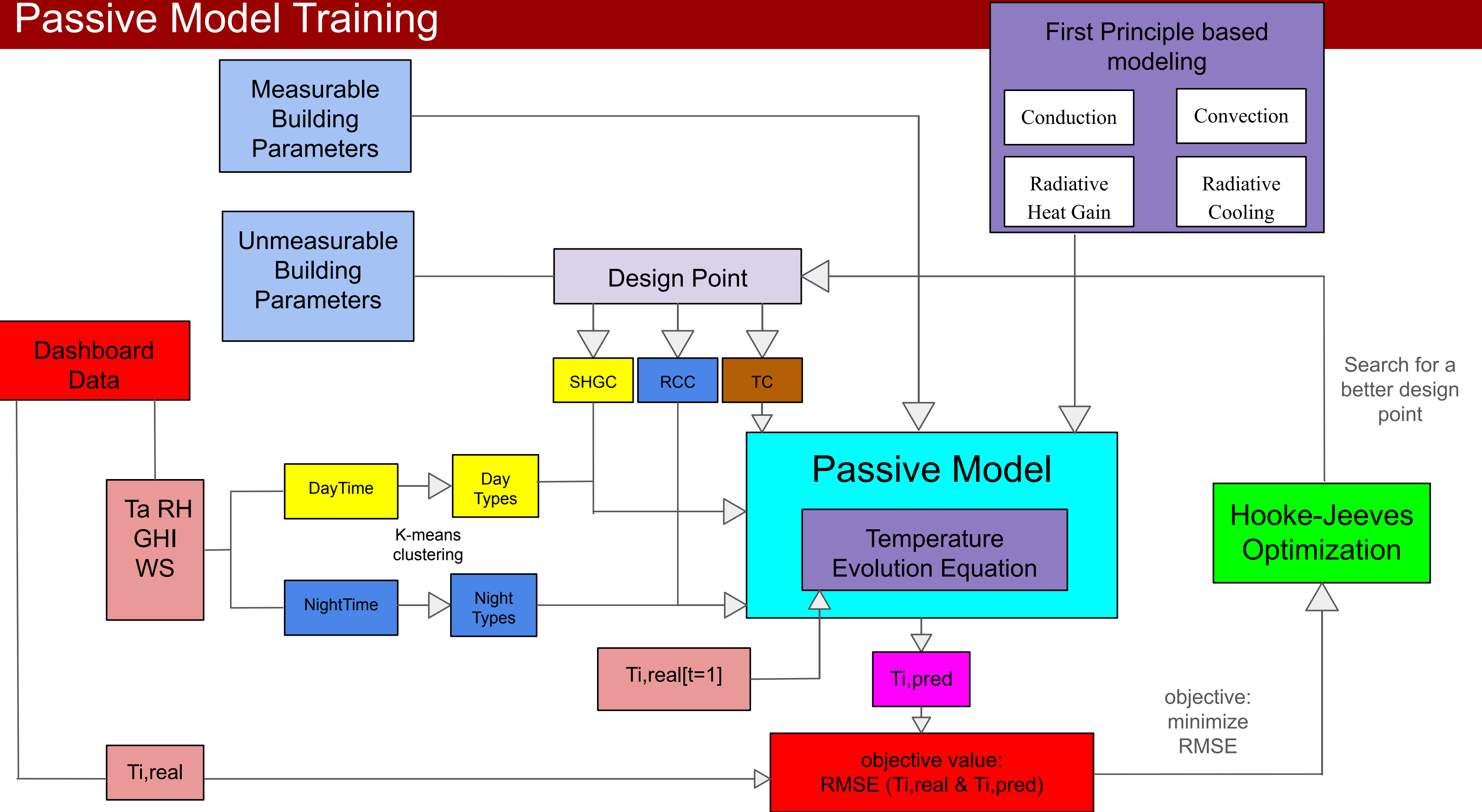
Initial States

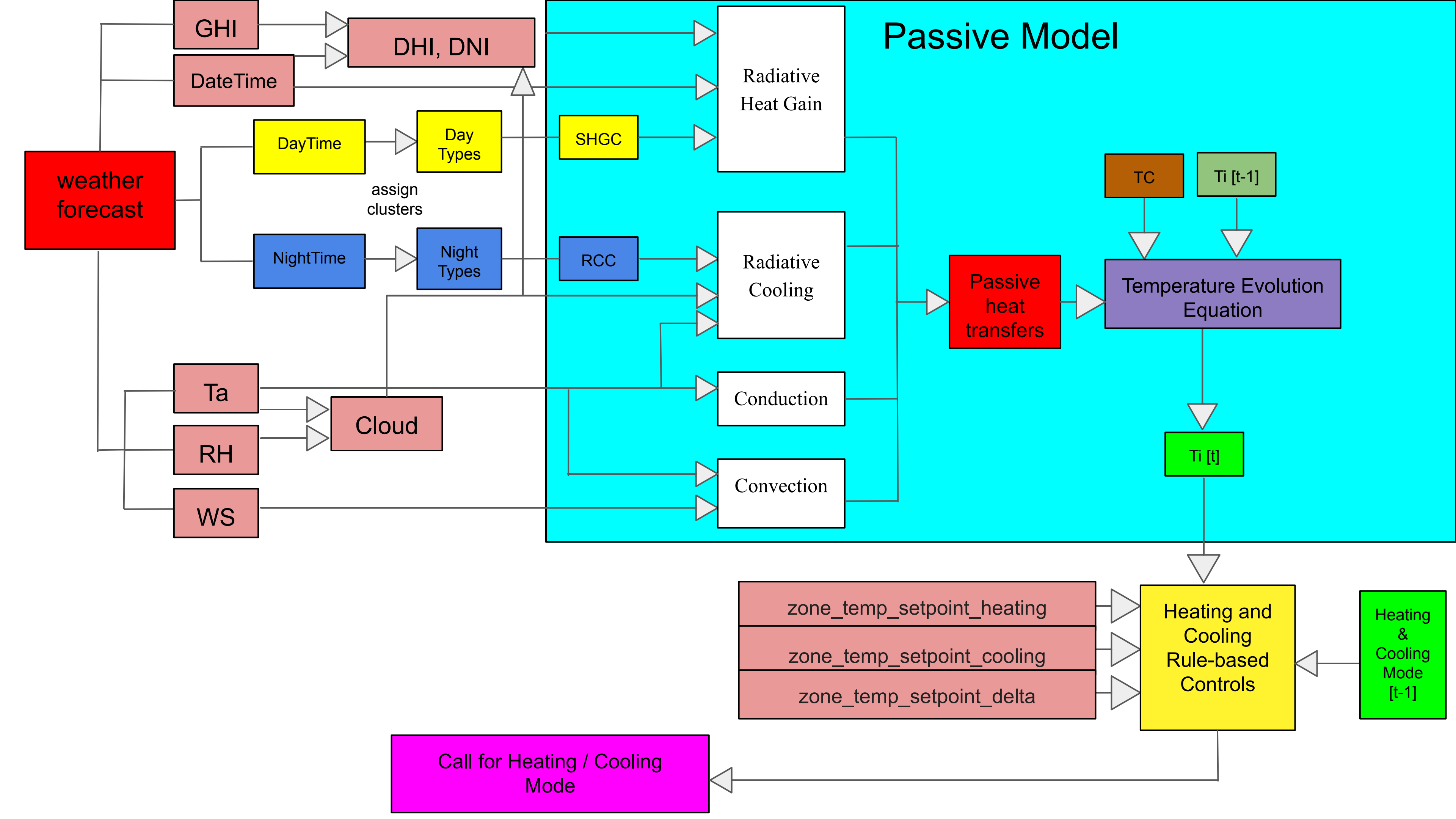
M State Name	Initial Value
PCM Hot Initial Temperature	48 [°C]
PCM Cold Initial Temperature	11 [°C]
Initial Indoor Temperature	22 [°C]
PCM Hot Capacity	11 [kWh]
PCM Cold Capacity	7 [kWh]
Zone Temperature Cooling Setpoint	22 [°C]
Zone Temperature Heating Setpoint	20 [°C]
Zone Temperature Delta Setpoint	0.5 [°C]
PCM Cold Initial SOC	0.5
PCM Hot Initial SOC	0.5
J State Name	**Initial Value**
PV Generation at last timestep	0 [kW]
Actual power consumption at last timestep	0 [kW]
Battery Initial SOC	0.5

Berg Structure Modeling



Passive Model Training





Passive Model
GHI
DateTime
DHI, DNI
weather forecast
DayTime
Day Types
NightTime
Night Types
assign clusters
SHGC
RCC
Radiative Heat Gain
Radiative Cooling
Conduction
Convection
Ta
RH
WS
Cloud
Passive heat transfers
TC
Ti [t-1]
Temperature Evolution Equation
Ti [t]
zone_temp_setpoint_heating
zone_temp_setpoint_cooling
zone_temp_setpoint_delta
Heating and Cooling Rule-based Controls
Heating & Cooling Mode [t-1]
Call for Heating / Cooling Mode

Heating & Cooling Rule-based Controls

	Ti [t] < T_heat - T_delta	T_heat - T_delta <= Ti [t] <= T_heat + T_delta	Ti [t] > T_heat + T_delta
Heating Mode [t-1] = 0	Heating Mode [t] = 1	Heating Mode [t] = 0	Heating Mode [t] = 0
Heating Mode [t-1] = 1	Heating Mode [t] = 1	Heating Mode [t] = 1	Heating Mode [t] = 0

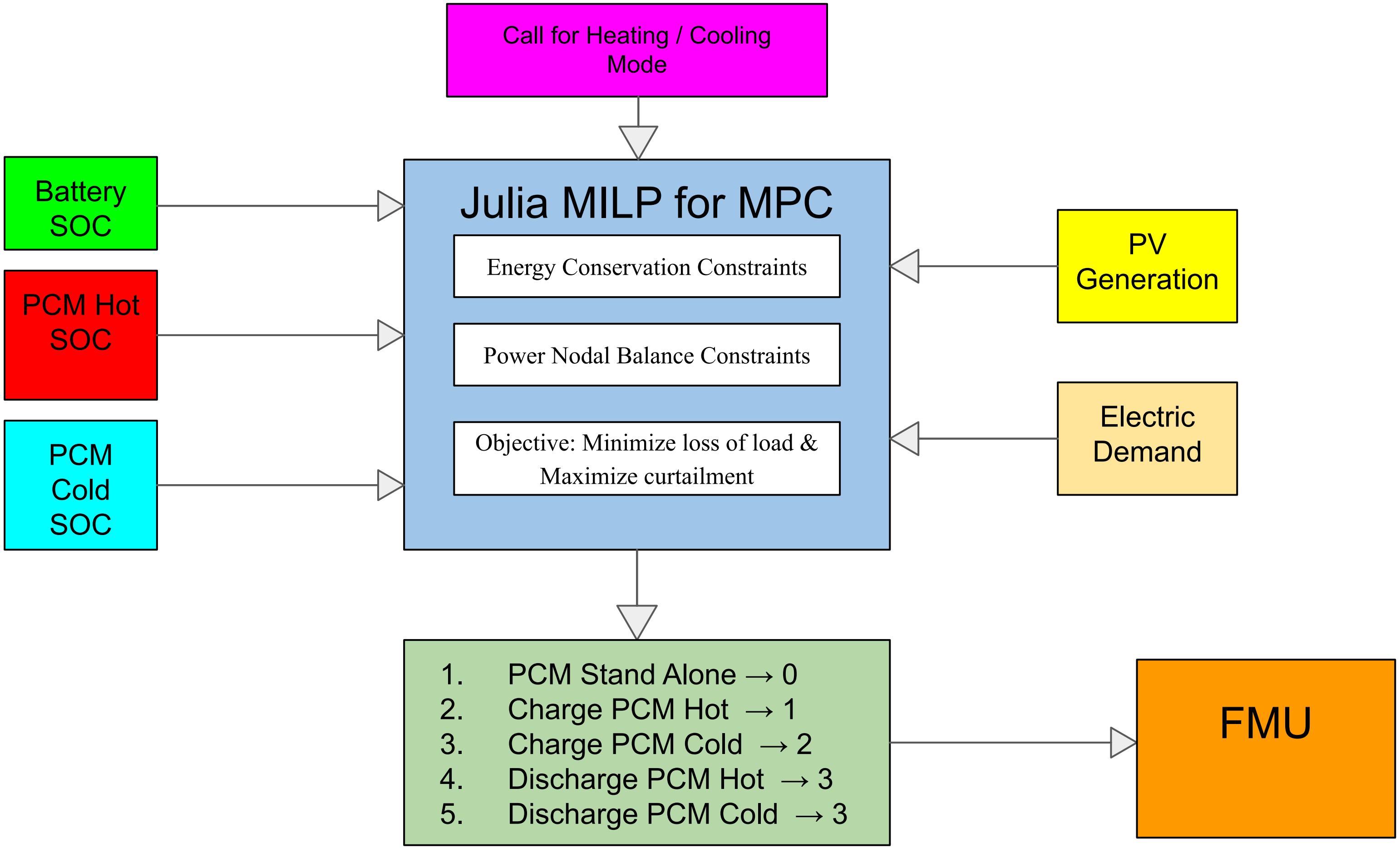
	Ti [t] > T_cool + T_delta	T_cool - T_delta <= Ti [t] <= T_cool + T_delta	T_cool - T_delta < Ti [t]
Cooling Mode [t-1] = 0	Cooling Mode [t] = 1	Cooling Mode [t] = 0	Cooling Mode [t] = 0
Cooling Mode [t-1] = 1	Cooling Mode [t] = 1	Cooling Mode [t] = 1	Cooling Mode [t] = 0

Heating Mode	HP Heating	PCM Hot Discharging
0	0	0
1	0	1
1	1	0
1	1	1

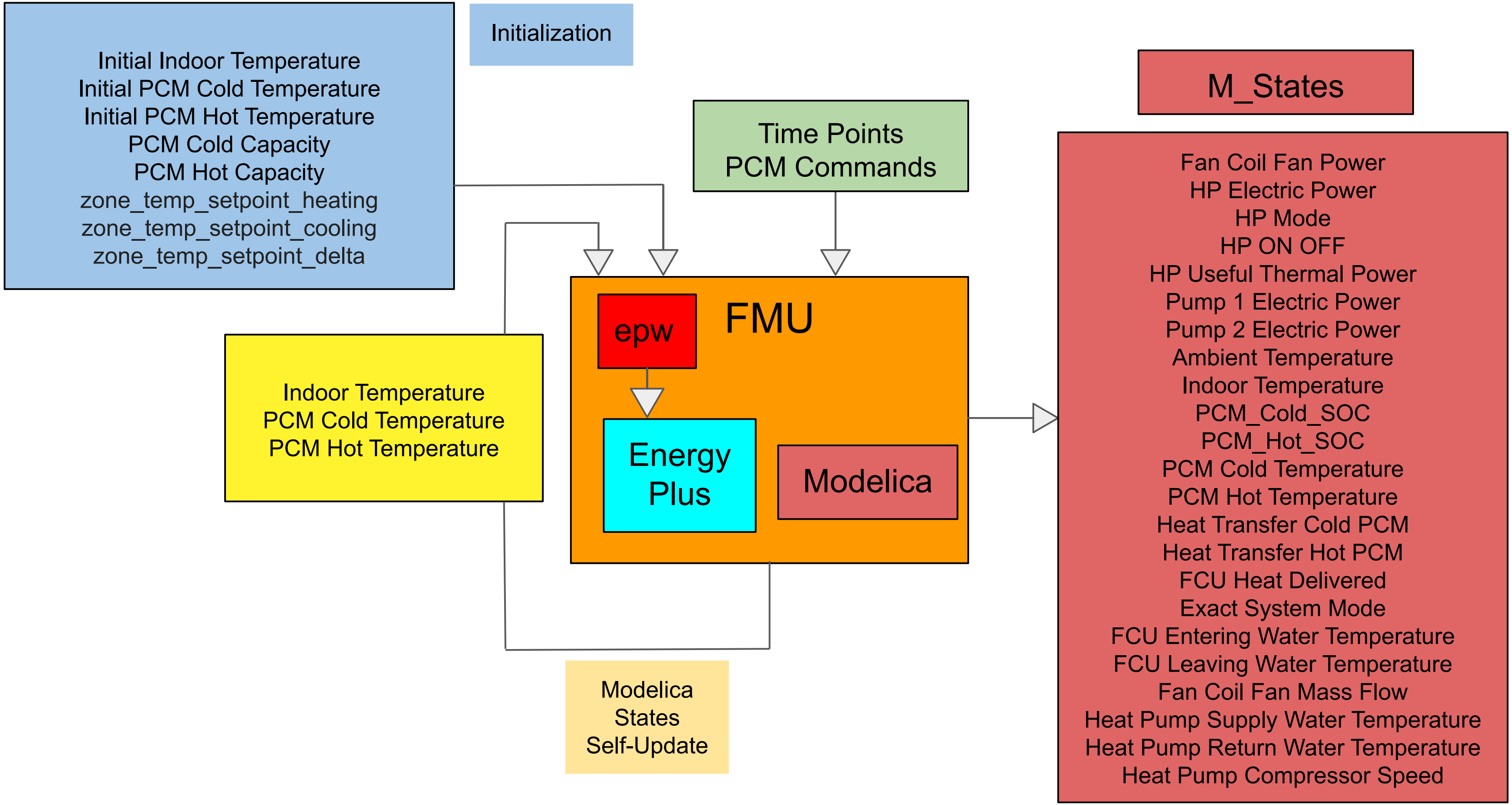
Cooling Mode	HP Cooling	PCM Cold Discharging
0	0	0
1	0	1
1	1	0
1	1	1

PCM Hot / Cold can be charged at anytime as long as its SOC < 1 and there is sufficient thermal power.

MILP Optimization



Modelica Output



Next Steps

- Update epw file (sub-hourly?)
- Improve forecast error modeling
- Finalize passive model and update Julia MPC
- Better modeling parameters such as COP, HP power rate, PCM charge & discharge rate etc.
- Consider more edge cases and make the system more robust