AI-DRIVEN HVAC DESIGN AND SIMULATION FOR SOCALGAS INNOVATION HOME

Researchers:

Eyosias Oljira
Muath Abdulaal
Riku-Neil McLaughlin
Spencer Reed

Advisor:

Dr. Michael Thorburn

Sponsor:

Southern California Gas

AGENDA

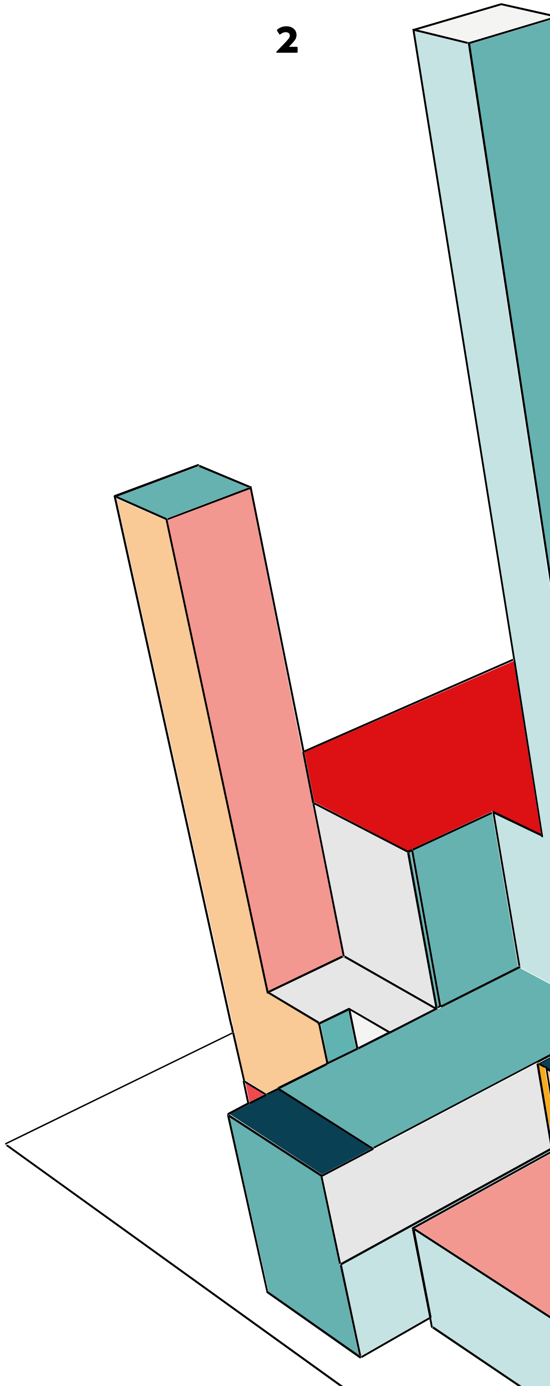
Introduction
- Problem/Objective
- Team Breakdown

Schedule
- Phase I (Spring 2024)
- Phase II (Fall 2024)

System/Tool Overview
- Flowchart - Riku

Design Overview
- Autodesk Revit
- MATLAB/Simulink

Conclusion



PROBLEM

- The push for renewable energy has increased energy usage efficiency
- Energy usage index from 2023 study shows significant usage for various fully electric-powered buildings
- Rising energy consumption in everywhere especially in extreme weather regions like Big Bear/ Palm Springs.

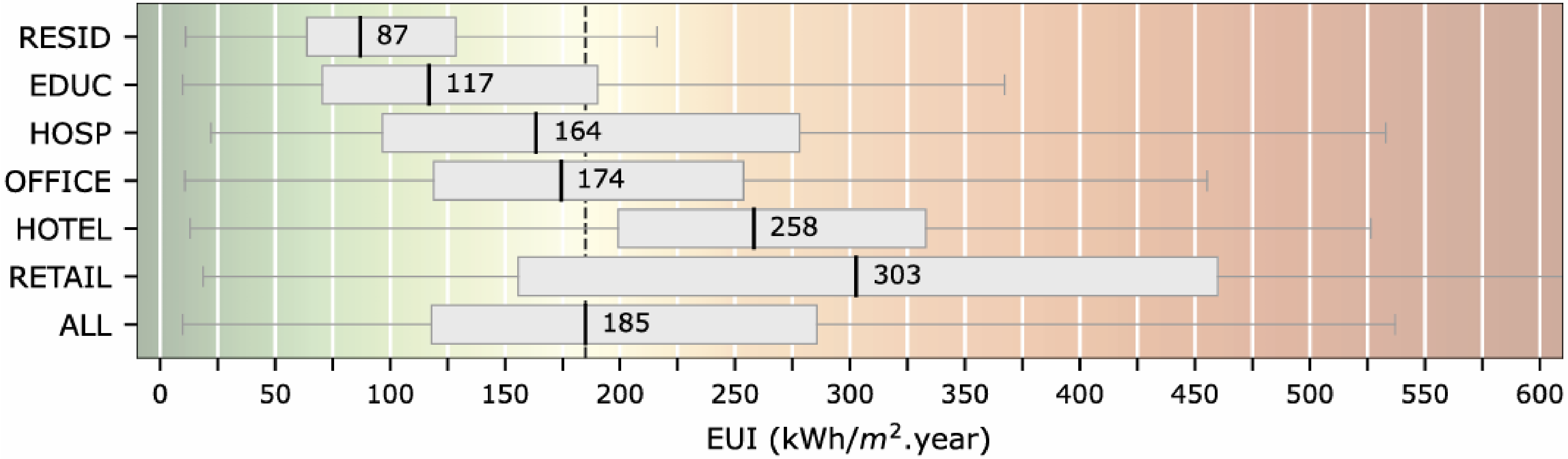


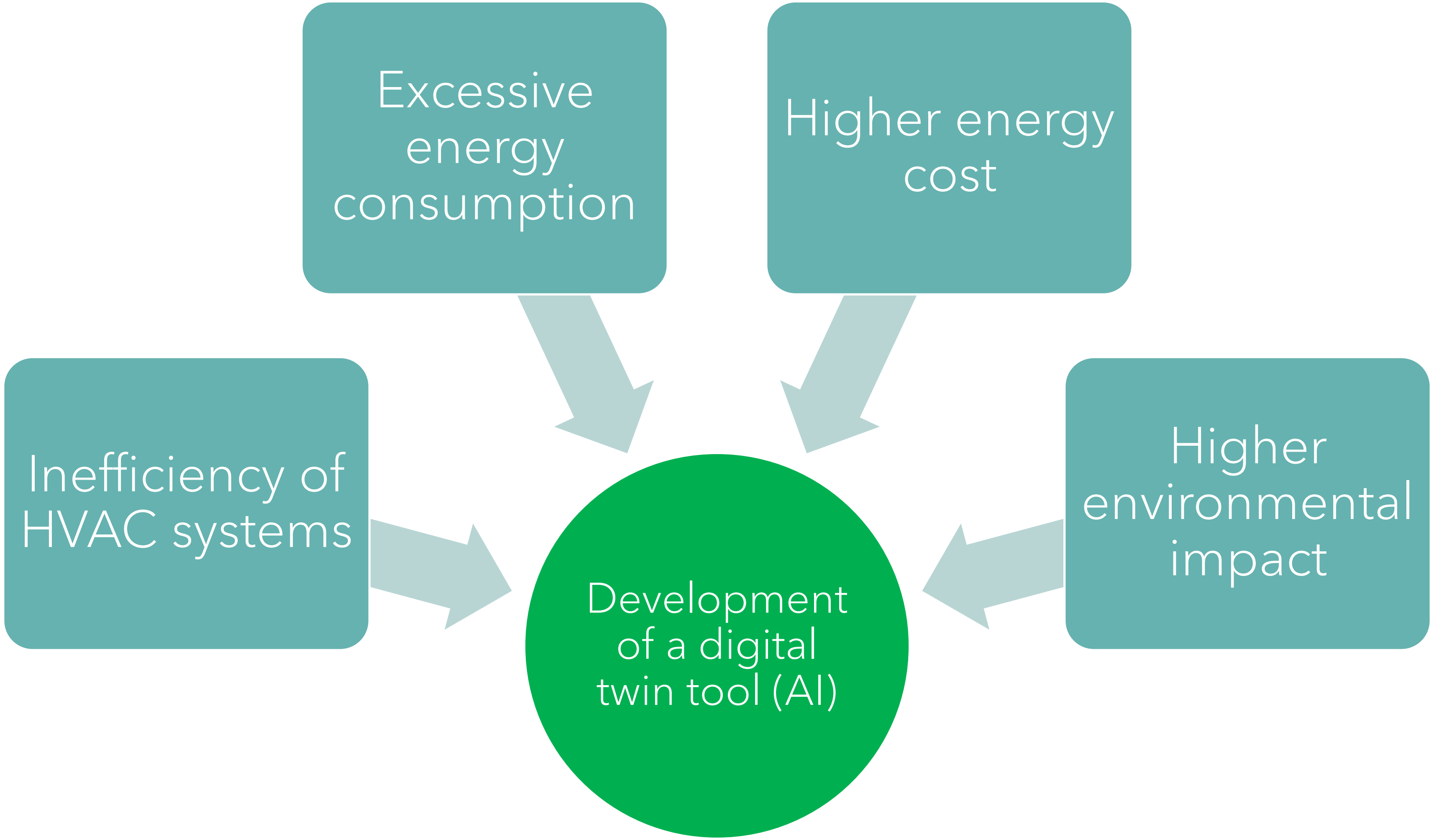
Figure 1. Boxplots of annual electricity by building category for fully electric-powered buildings [1].

OUR SOLUTION

- Use a Digital Twin (AI-powered simulation) to:
  - Model and optimize HVAC and energy systems.
  - Integrate HVAC and electrical systems for efficiency.
  - Adapt to environmental changes, reducing energy costs by up to 30%.

Impact: A scalable, sustainable, and energy-efficient design supporting net-zero goals.

OBJECTIVE


Excessive energy consumption
Higher energy cost
Inefficiency of HVAC systems
Higher environmental impact
Development of a digital twin tool (AI)

TEAM MEMBERS

Eyosias Oljira	Muath Abdulaal	Riku-Neil McLaughlin	Spencer Reed
ME Major	ME Major	ME Major	ME Major
MATLAB/Simulink HVAC Refrigeration Cycle	Weather data/ ASHRE Regulations	MATLAB/Simulink • House Thermal Model • Cost	Autodesk/Revit • 3D modeling • Building Parameters

SCHEDULE

Phase I (Spring 2024)

Program Kickoff → Statement of Work → Initial Concept and Design

Phase II (Fall 2024)

Integration → Testing → Optimization

INSPIRATION: SOCAL GAS [H2] INNOVATION EXPERIENCE

- First hydrogen-powered microgrid home in N. America (Downey, CA) ability to power 150 homes annually.

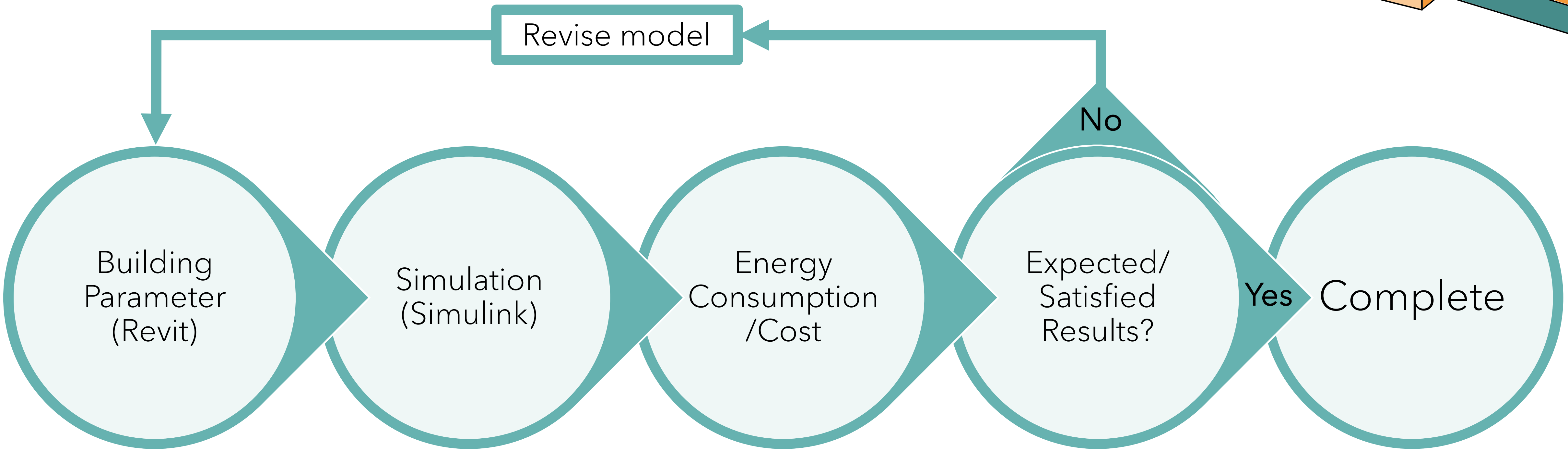
- Solar-to-hydrogen energy system for clean, net-zero power.

- Awards: Fast Company & US Green Building Council honors.

- Advances SoCalGas's 2045 net-zero carbon goal.

Figure 2 & 3 SoCal Gas [H2] Innovation Experience [4].

SYSTEM/TOOL OVERVIEW



- Dimensions
- Thermal Conductivity
- Density
- Specific Heat
- Area

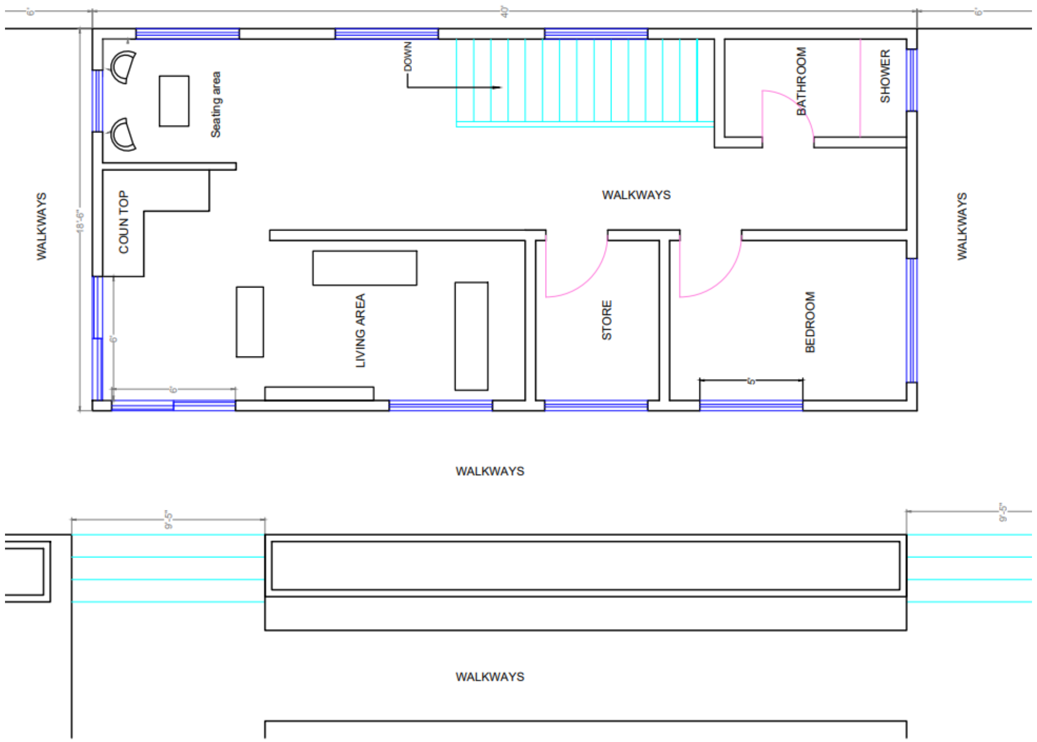
- Initial Temperature
- Exterior Temperature

- Electricity
- Natural Gas
- Hydrogen

DESIGN OVERVIEW- REVIT

2D Floor Plan

- Zones
- Square footage: 740 square feet
- Volume : 12,580 cubic feet.



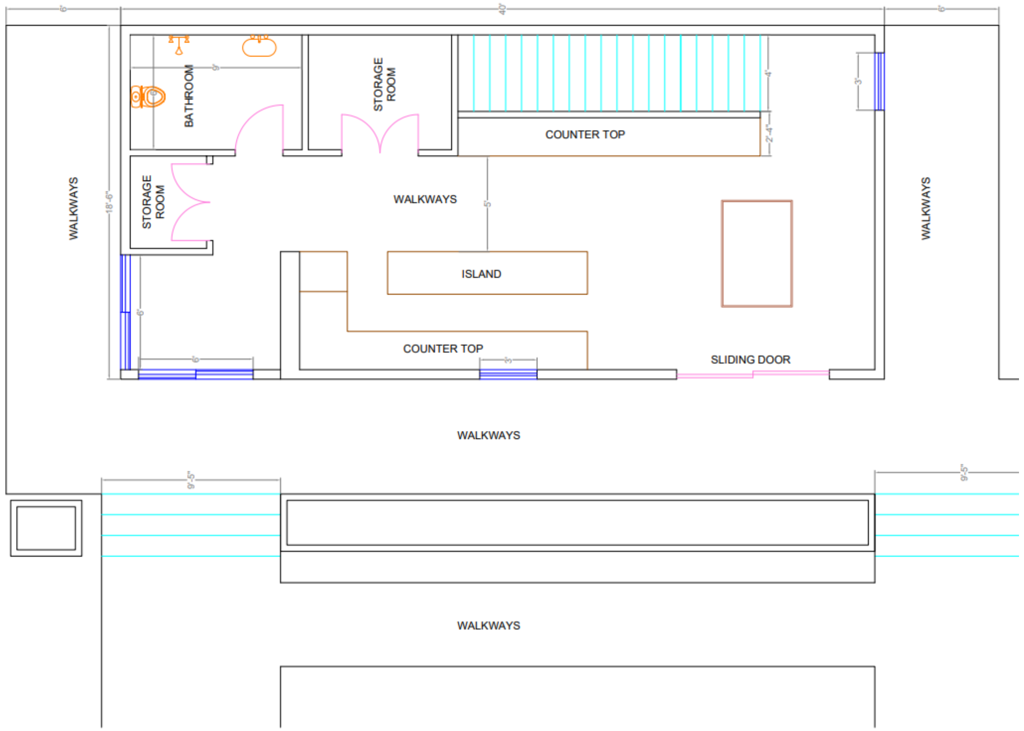
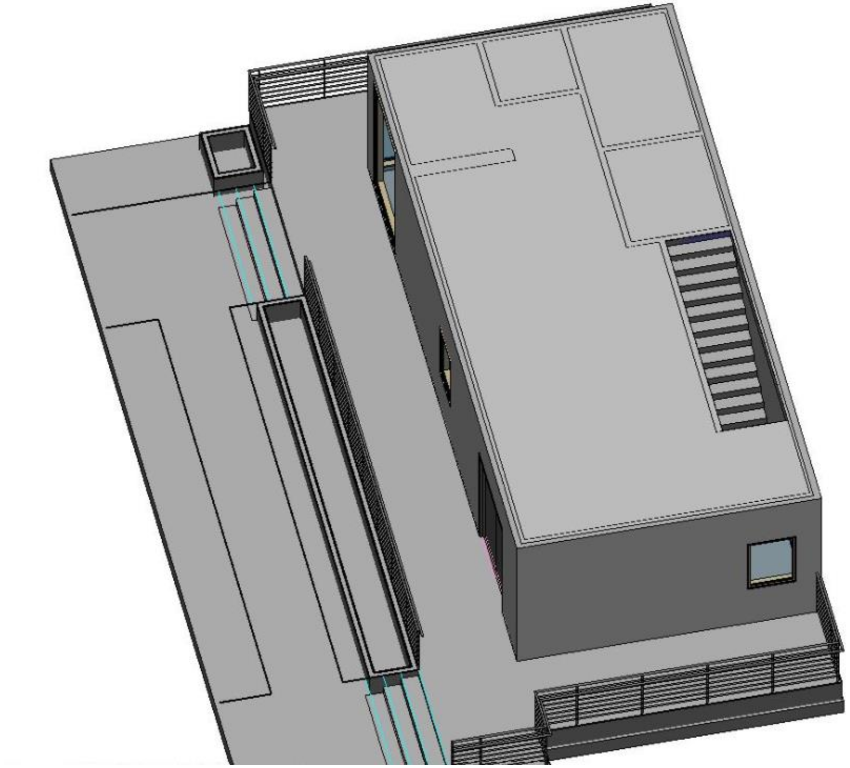


Figure 4 & 5 Revit Model Floor Plan.

REVIT -1ST 3D MODEL

Simple Model: Zone 1: Level 1



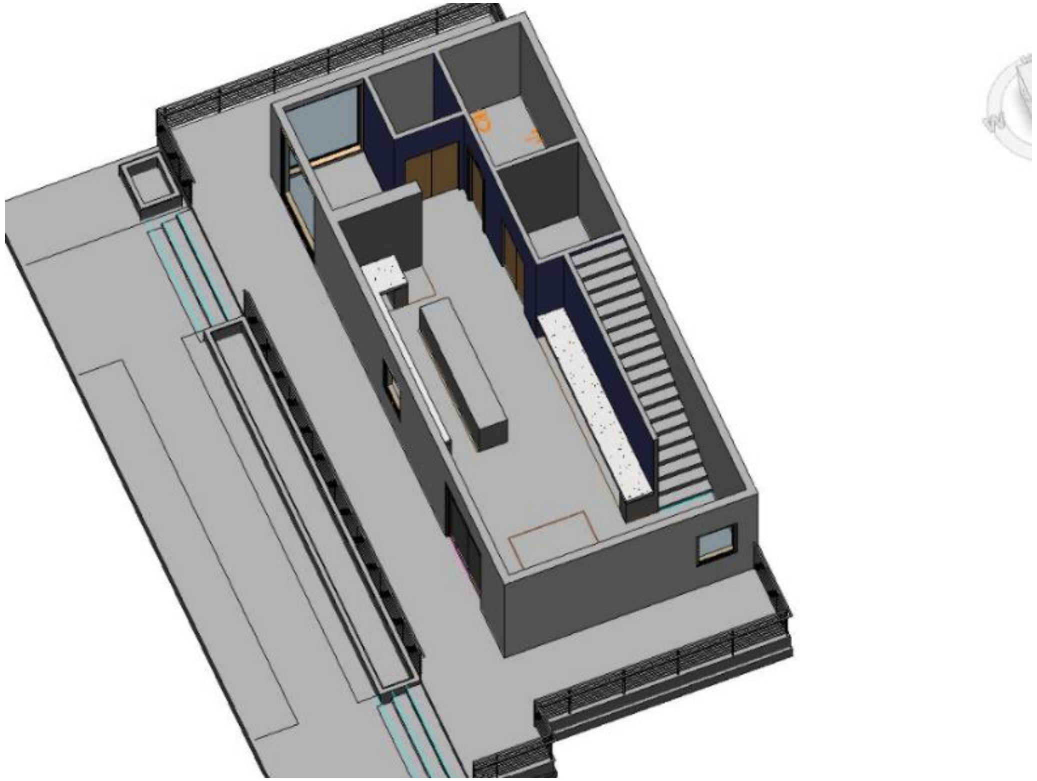


Figure 6 & 7 Revit Model Level 1.

REVIT-BUILDING PARAMETERS

- Creation of Components Properties by material layering
  - Floors, Walls, Doors, Windows

Windy Enviroment (Downey)

CSULA Interior Wall			
Exterior Layer			
	Function	Material	Thickness
1	Finish	Drywall	0.625
2	Strucutre	Studs/Wood	3.5
3	Finish	Drywall	0.625
Interior Layer			

CSULA Exterior Wall			
Exterior Layer			
	Function	Material	Thickness
1	Finish	Masonry Brick	3.5
2	Membrane Layer	Moisture/Vapor Barrier	0
3	Thermal/Air Layer	Air Barrier	0.05
4	Substrate	Plywood	0.5
5	Structure	Studs	3.5
6	Finish	Drywall	0.625
Interior Layer			

Interior		
Type of Wall	CSULA Interior Wall	
Thickness	4.75	in
Heat transfer Coefficient (U)	0.52	W/(m^2*K)
Thermal Resistance ®	1.9231	(m^2*K)/W
Thermal Mass	1155	kJ/(m^2*K)
Absorptance	0.1	
Roughness	1	

Exterior		
Type of Wall	CSULA Exterior Wall	
Thickness	8.175	in
Heat transfer Coefficient (U)	0.1761	W/(m^2*K)
Thermal Resistance ®	5.6785	(m^2*K)/W
Thermal Mass	969.42	kJ/(m^2*K)
Absorptance	0.1	
Roughness	1	

Hot Enviroment (Desert)

CSULA Interior Wall (desert)			
Exterior Layer			
	Function	Material	Thickness
1	Finish	Drywall	0.625
2	Thermal/Air Layer	batt insulation between stu	2
3	Strucutre	Studs/Wood	3.5
4	Finish	Drywall	0.625
Interior Layer			

CSULA Exterior Wall (desert)			
Exterior Layer			
	Function	Material	Thickness
1	Finish	Sun reflect Stucco	1
2	Membrane Layer	Moisture/Vapor Barrier	0.05
3	Thermal/Air Layer	Rigid Foam between studs	2
4	Substrate	Plywood	0.5
5	Structure	Studs	3.5
6	Finish	Drywall	0.625
Interior Layer			

Interior		
Type of Wall	CSULA Interior Wall	
Thickness	6.75	in
Heat transfer Coefficient (U)	0.0093	W/(m^2*K)
Thermal Resistance ®	107.1862	(m^2*K)/W
Thermal Mass	1213.88	kJ/(m^2*K)
Absorptance	0.1	
Roughness	1	

Exterior		
Type of Wall	CSULA Exterior Wall	
Thickness	7.675	in
Heat transfer Coefficient (U)	0.0281	W/(m^2*K)
Thermal Resistance ®	35.6388	(m^2*K)/W
Thermal Mass	2565.63	kJ/(m^2*K)
Absorptance	0.1	
Roughness	1	

Cold Enviroment (Big Bear)

CSULA Interior Wall (snow)			
Exterior Layer			
	Function	Material	Thickness
1	Finish	Drywall	0.625
2	Thermal/Air Layer	Moisture/Vapor Barrier	0.05
3	Strucutre	Studs/Wood	3.5
4	Finish	Drywall	0.625
Interior Layer			

CSULA Exterior Wall (snow)			
Exterior Layer			
	Function	Material	Thickness
1	Finish	Concrete Siding	0.5
2	Membrane Layer	Moisture/Vapor Barrier	0.05
3	Thermal/Air Layer	air barrier	0.05
4	Substrate	Plywood	0.5
5	Structure	Studs	3.5
6	Finish	Drywall	0.625
Interior Layer			

Interior		
Type of Wall	CSULA Interior Wall	
Thickness	4.8	in
Heat transfer Coefficient (U)	0.52	W/(m^2*K)
Thermal Resistance ®	1.9231	(m^2*K)/W
Thermal Mass	1155	kJ/(m^2*K)
Absorptance	0.1	
Roughness	1	

Exterior		
Type of Wall	CSULA Exterior Wall	
Thickness	5.225	in
Heat transfer Coefficient (U)	0.1624	W/(m^2*K)
Thermal Resistance ®	6.1565	(m^2*K)/W
Thermal Mass	1724.97	kJ/(m^2*K)
Absorptance	0.1	
Roughness	1	

Tailored Wall Layers based on the Environmental Conditions

WEATHER: A KEY DRIVER FOR HVAC EFFICIENCY

Temperature, precipitation, and seasonal cycles dictate heating and cooling needs.

Seasonal Challenges :

- Big Bear: Freezing winters with lows of 2°C demand robust heating .
- Palm Springs: Summer highs exceeding 100°F increase cooling loads.

Data-Driven HVAC Design :

- Incorporates real-time weather data for adaptive system performance .
- Aligns with ASHRAE standards for energy efficiency and thermal comfort.

Environmental and Economic Relevance :

- Accurate weather modeling optimizes energy usage and reduces costs.
- Supports sustainable practices and occupant comfort.

ENVIRONMENTAL MODELS

These models support predictive accuracy and regulatory compliance:

•ASHRAE 62.1: Ensures indoor air quality by defining ventilation rates and maintaining healthy air conditions for occupants.

•ASHRAE 90.1: Establishes energy efficiency standards for sustainable HVAC performance, reducing energy consumption without compromising system performance.

•ASHRAE 55: Defines thermal comfort parameters, such as temperature, humidity, and air movement, ensuring a comfortable environment for occupants.

•ASHRAE 189.1: Focuses on sustainable practices in design and building operations, emphasizing energy efficiency and environmental stewardship.

WEATHER DATA & STATISTICS

Weather Data Collection

Collected temperature and precipitation data for Palm Springs and Big Bear, including seasonal and daily cycles.

Big Bear Dataset

Data recorded every second over seven days across all seasons, focusing on critical times like sunrise, midday, and sunset.

MATLAB Integration

Data was used to create a MATLAB file for HVAC system modeling. .

Temperature Insights

Highs in Palm Springs exceed 100°F in summer; lows in Big Bear highlight freezing winter conditions..

Precipitation Patterns

Rainfall data for Palm Springs and snowfall for Big Bear provide a complete climate overview for energy planning.

HVAC Integration

Real-world data enables HVAC systems to adapt to temperature changes, enhancing comfort and reducing energy waste.

WEATHER DATA IN BIG BEAR (MONTHLY)

	Month											
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. Temperatures High (°C)	10	11	13	17	21	27	30	29	27	21	15	10
Avg. Temperatures Low (°C)	2	2	3	6	9	14	18	18	15	10	6	2
Avg. Wind Speed (km/h)	9	10	11	11	11	10	8	8	8	8	9	9
Avg. Precipitation (mm)	43	49	31	22	15	8	44	43	20	15	16	54
Average Humidity (%)	48	49	48	41	40	32	30	30	33	36	39	49
Avg. Cloud Cover (%)	21	21	21	14	10	6	11	10	7	9	14	23
Pressure Average (mb)	1019	1017	1016	1013	1012	1010	1012	1012	1012	1014	1017	1018
Average Dry Days	25	21	25	26	27	28	23	25	26			25
Avg. Precip. Days	4	4	4	3	4	2	8	6	4	2	2	4
Avg. Snow Days	2	3	2	1	0	0	0	0	0	0	1	2
Average Fog Days	0	0	0	0	0	0	0	0	0	0	0	0
Average UV Index	2	3	3	4	5	6	6	6	5	4	3	2
Avg. Hours of Sun	280	256	291	313	333	336	322	327	330	338	314	280

Figure 8. Monthly data in Big Bear.

The coldest month of the year in Big Bear City is December, with an average low of 2°C and high of 10°C.

WEATHER DATA IN BIG BEAR (SEASONAL)

	Seasons			
Month	Winter	Spring	Summer	Fall/autumn
Avg. Temperatures High (°C)	10.33	17.00	28.67	21.00
Avg. Temperatures Low (°C)	2.00	6.00	16.67	10.33
Avg. Wind Speed (km/h)	9.33	11.00	8.67	8.33
Avg. Precipitation (mm)	48.67	22.67	31.67	17.00
Average Humidity (%)	48.67	43.00	30.67	36.00
Avg. Cloud Cover (%)	21.67	15.00	9.00	10.00
Pressure Average (mb)	1018.00	1013.67	1011.33	1014.33
Average Dry Days	23.67	26.00	25.33	26.00
Avg. Precip. Days	4.00	3.67	5.33	2.67
Avg. Snow Days	2.33	1.00	0.00	0.33
Average Fog Days	0.00	0.00	0.00	0.00
Average UV Index	2.33	4.00	6.00	4.00
Avg. Hours of Sun	272.00	312.33	328.33	327.33

Figure 9. seasonal data in Big Bear.

The coldest month of the year in Big Bear City is Winter, with an average low of 2.00°C and high of 10.33°C.

REVIT -FULL 3D MODEL

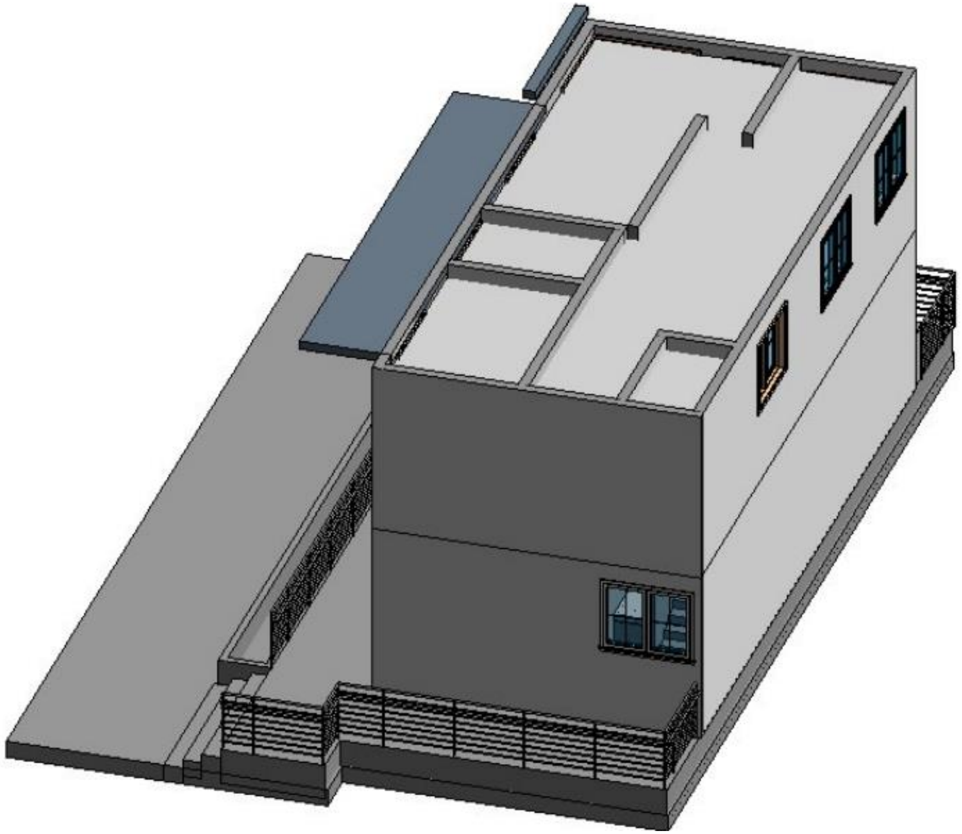


Figure 10 & 11 Complete Revit Model.

REVIT MEP : COMPLETE HVAC PLANS

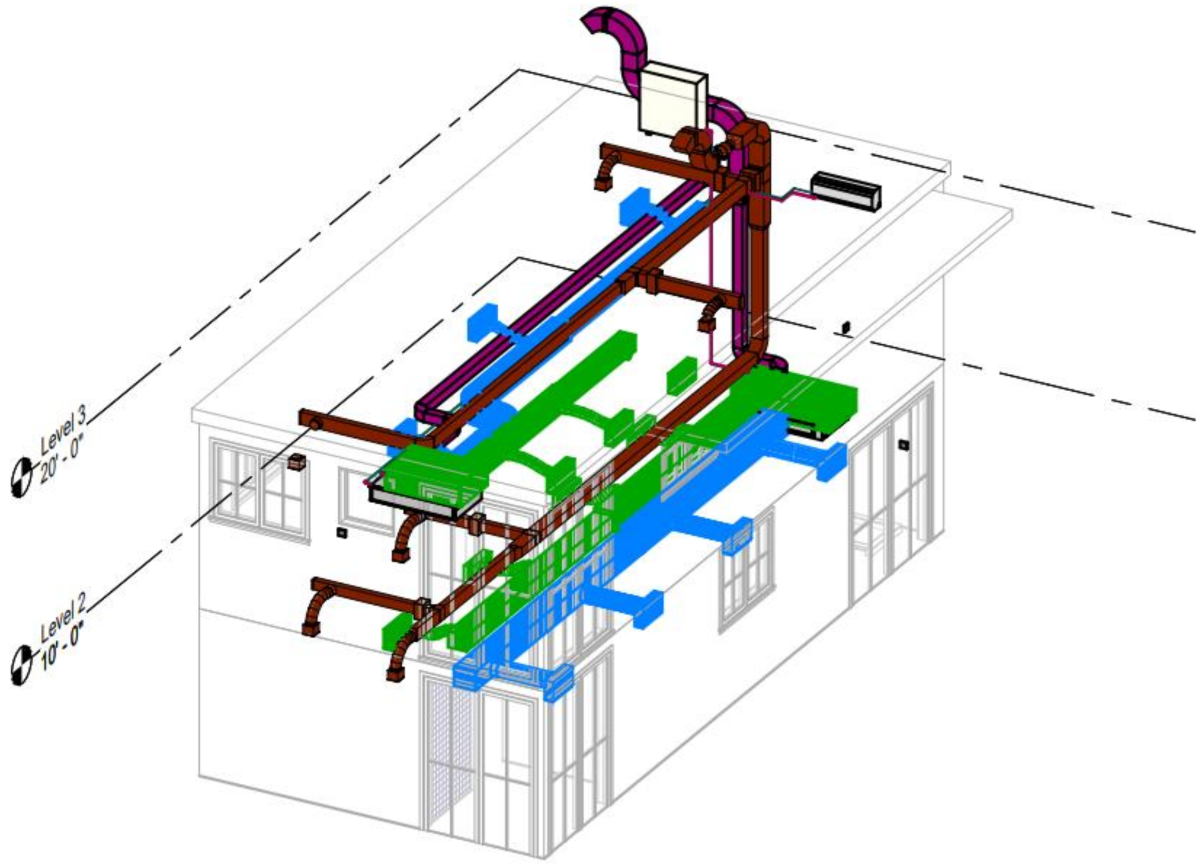
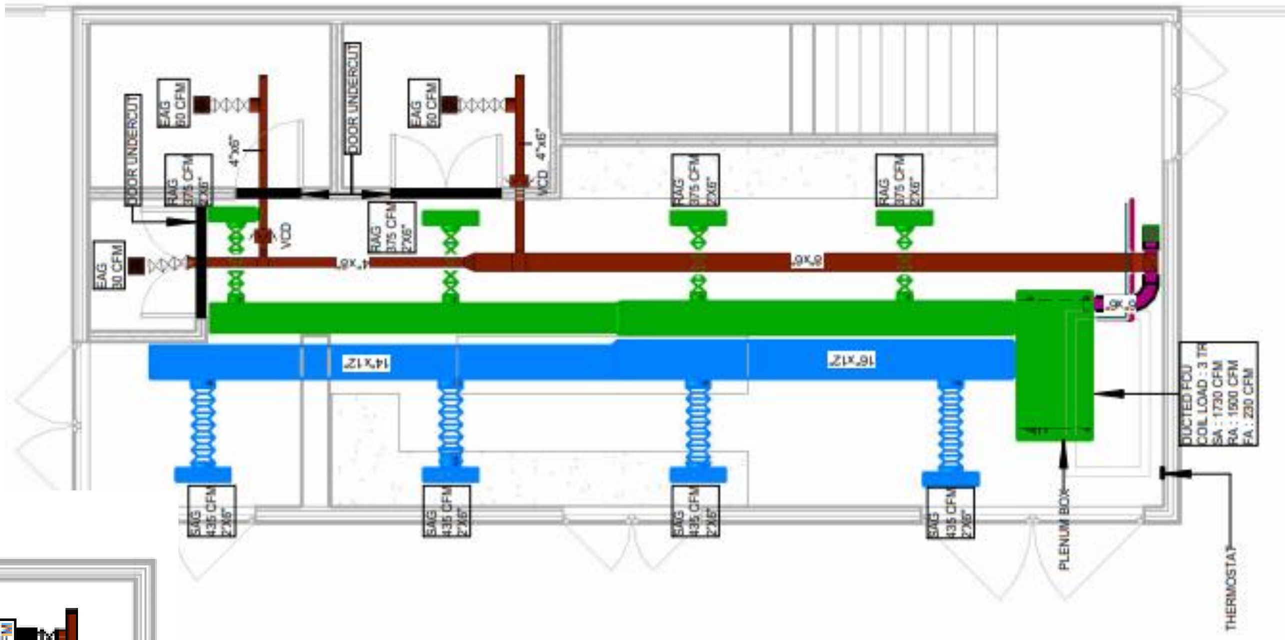


Figure 12. Revit Model Complete HVAC System.

Components Matching the Colors:

- **Supply Ducts (Blue)**: Bring conditioned air to rooms.
- **Return Ducts (Green)**: Bring air back to the HVAC system.
- **Exhaust Ducts (Red)**: Remove stale air, often from bathrooms or utility areas.
- **Refrigerant/Chilled Water Lines (Purple)**: Carry cooling agent in certain systems.
- **Vertical Risers (Brown)**: Transfer air or refrigerant between the ground and first floors

REVIT MEP- HVAC SELECTION AND ZONES



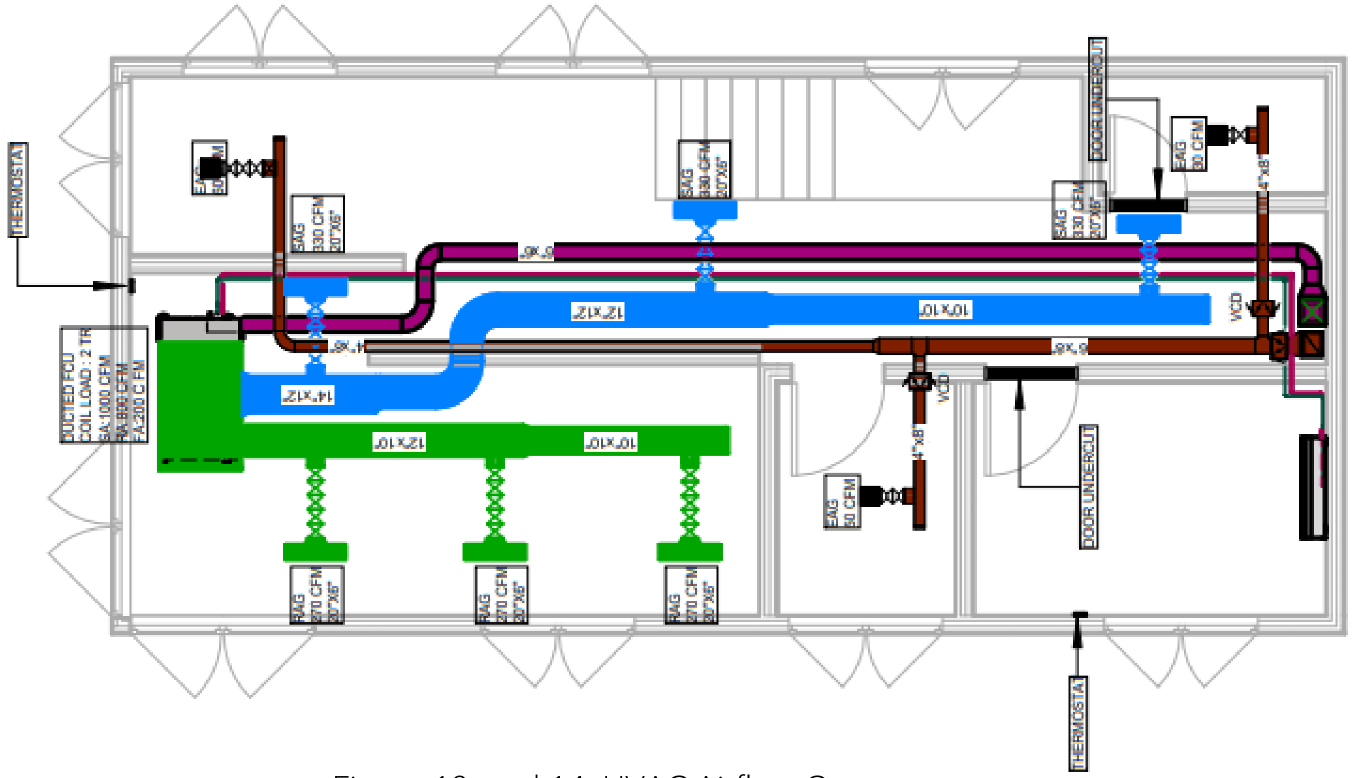


Figure 13 and 14 HVAC Airflow Components

- **Recommended System**: Zonal HVAC with Variable Speed Blowers
- **Why?**: Adapts to varying room occupancy and usage patterns.
- **Key Benefits**:
  - Individual thermostats for tailored temperature control.
  - Enhanced comfort and energy efficiency.
  - Variable speed blowers adjust airflow to meet specific room demands, reducing energy waste.

REVIT MEP HVAC PLAN- FRONT VIEW

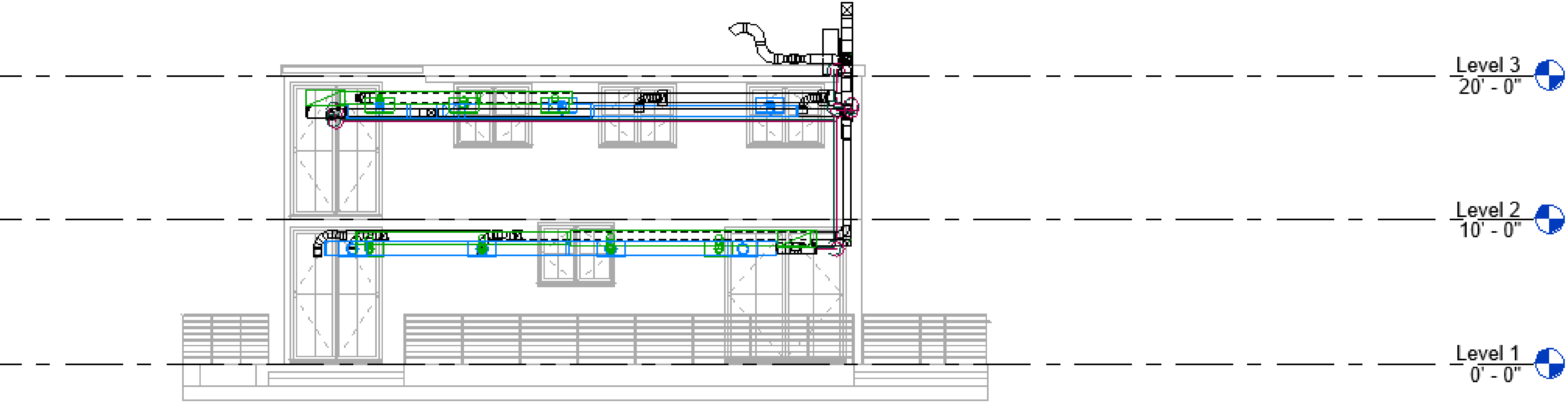


Figure 15: Revit HVAC Front View Model

DESIGN OVERVIEW – MATLAB/SIMULINK

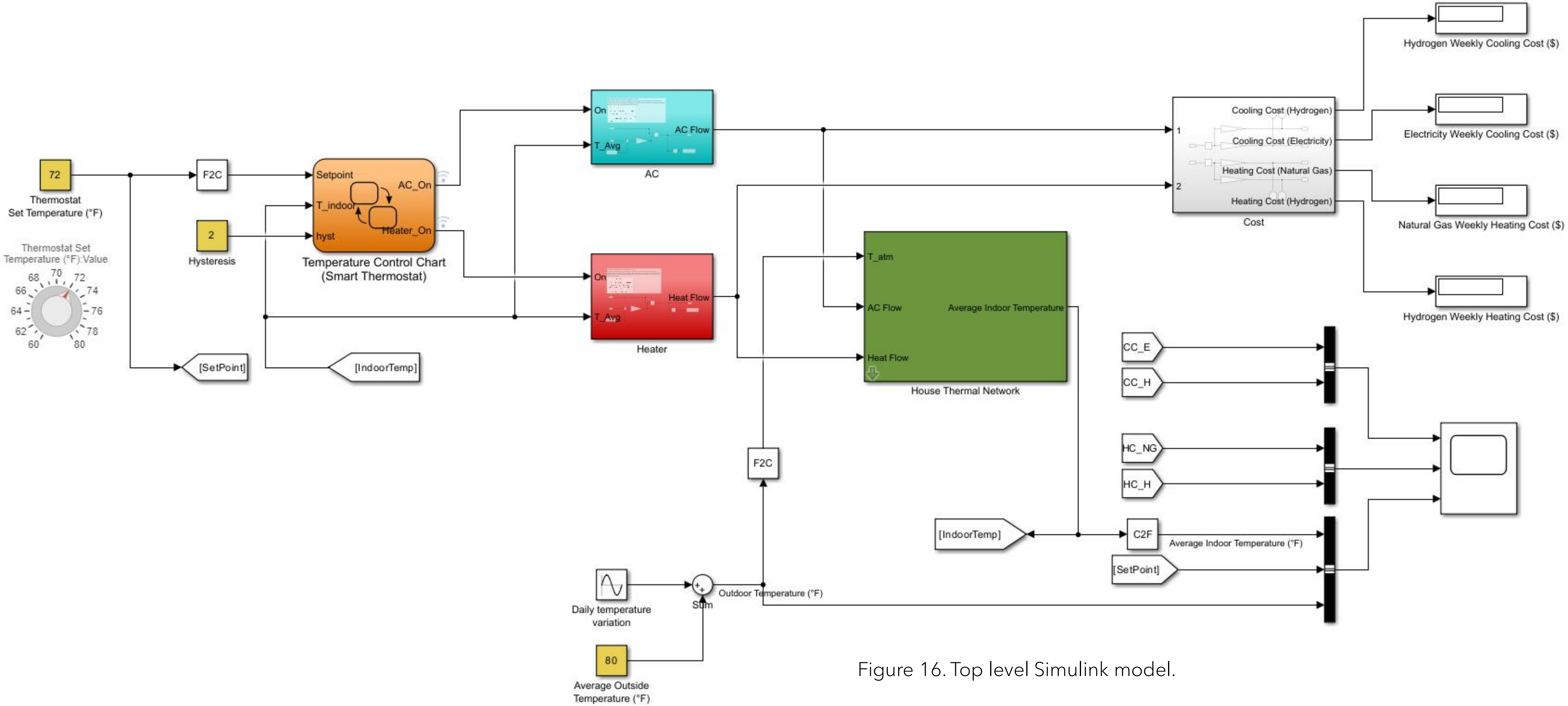
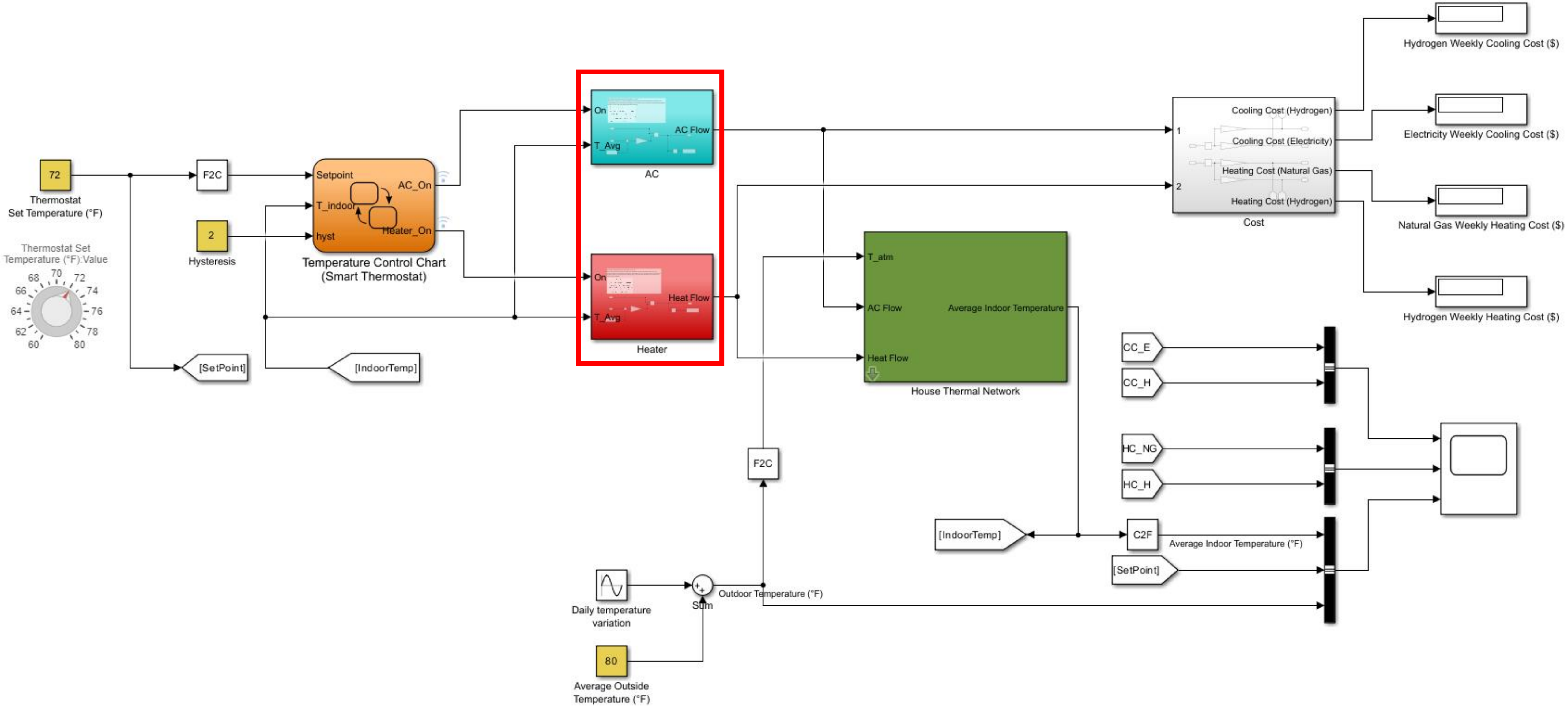


Figure 16. Top level Simulink model.

HEATER/AC MODEL



MATHEMATICALLY DRIVEN HEATER/AC

- Equation used for heater/AC:

For heat gain due to heater (adding heat into house):

$$\frac{dQ}{dt} = \dot{m}c_p(T_{heater} - T_{room})$$

For heat gain due to AC (removing heat from house:

$$\frac{dQ}{dt} = \dot{m}c_p(T_{room} - T_{AC})$$

Where:

- $\dot{m} = mass\ flow\ rate\ of\ air\ \left(\frac{kg}{s}\right)$
- $c_p = specific\ heat\ of\ air\ at\ constant\ pressure\ @\ 273K = 1005.4\,\frac{J}{kg \cdot K}$
- $\frac{dQ}{dt} = heat\ or\ AC\ flow\ into\ the\ room\ (W)$

HEATER/AC MODEL IN SIMULINK

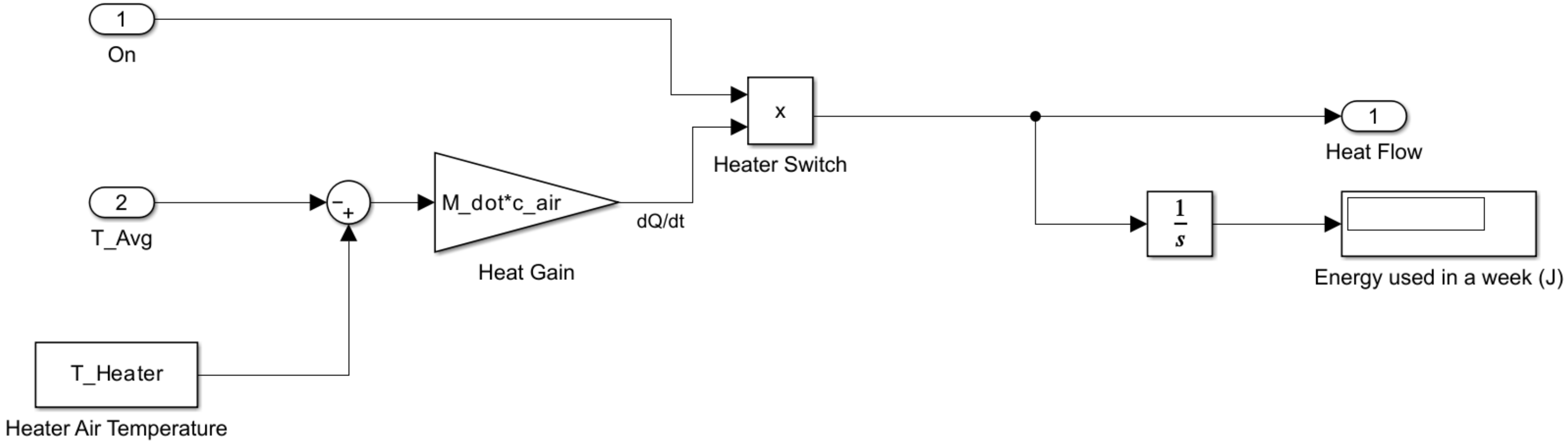


Figure 17. Heater Model.

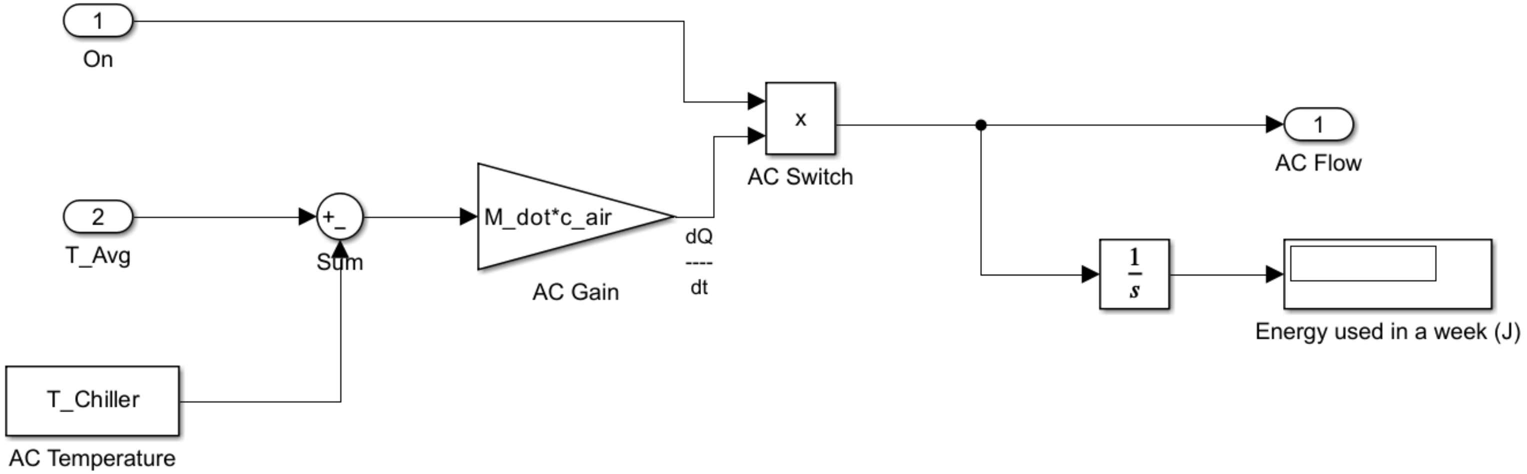
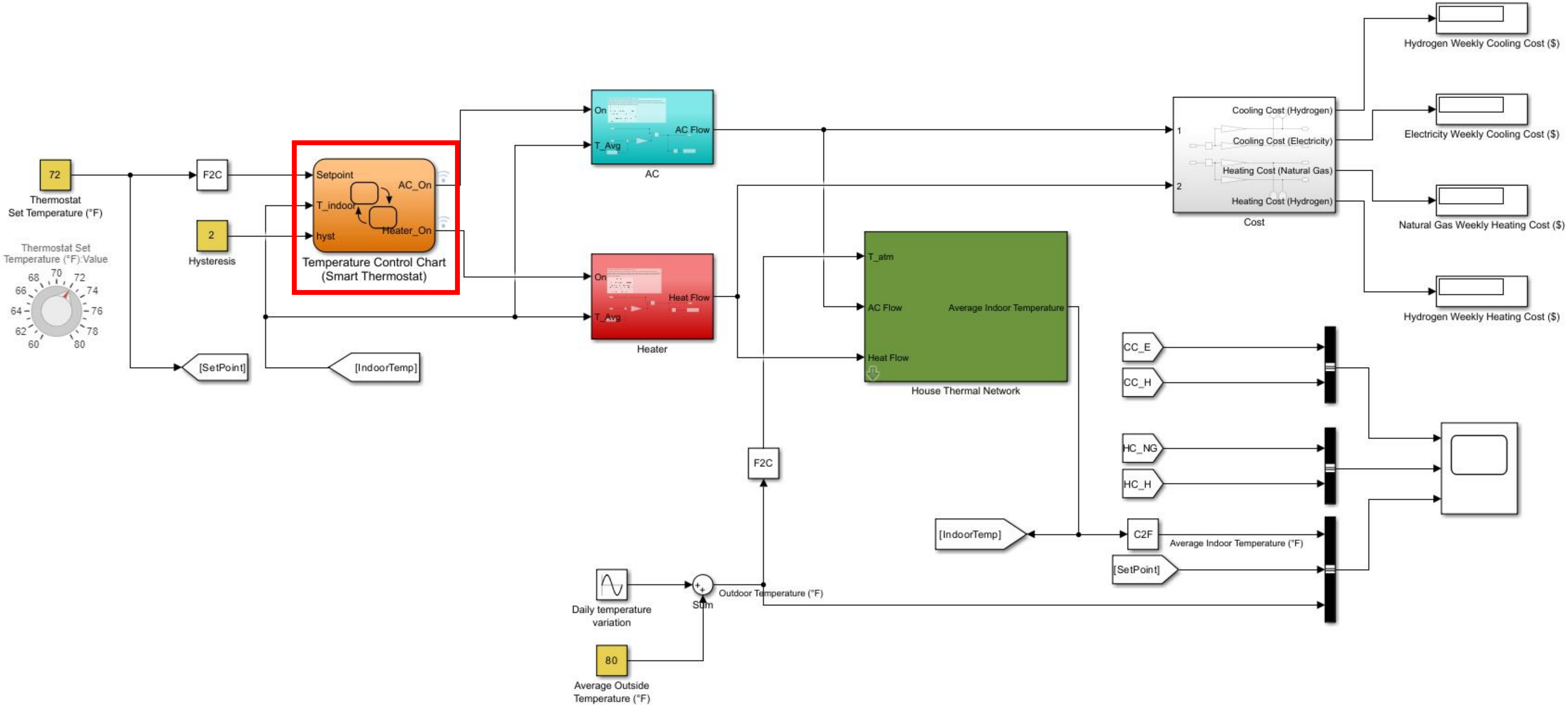


Figure 18. AC Model.

THERMOSTAT MODEL IN SIMULINK



THERMOSTAT MODEL IN SIMULINK

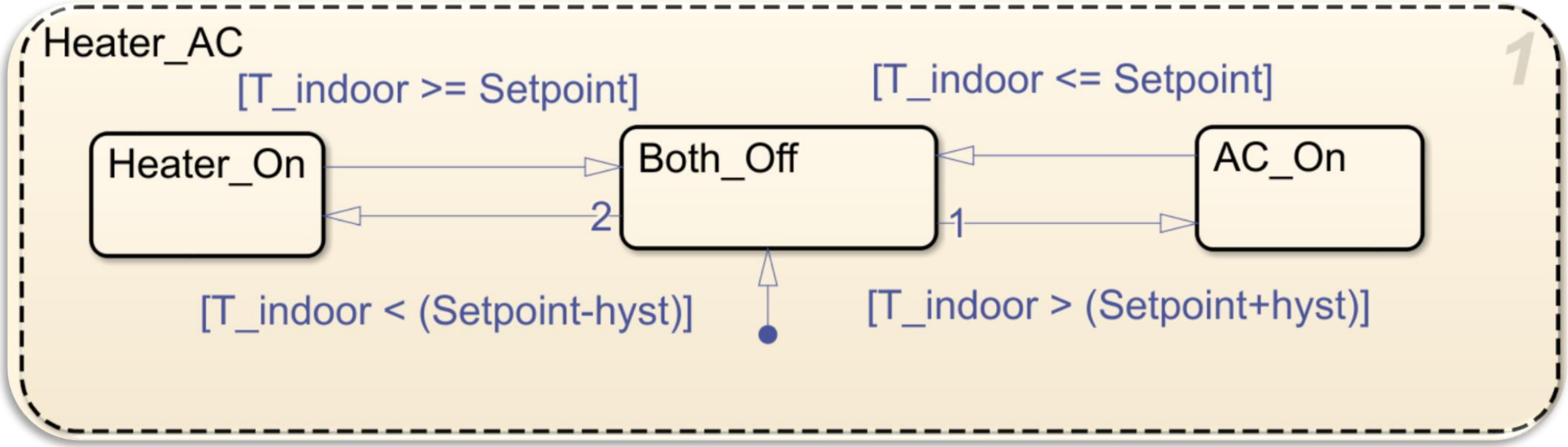


Figure 19. StateFlow Thermostat.

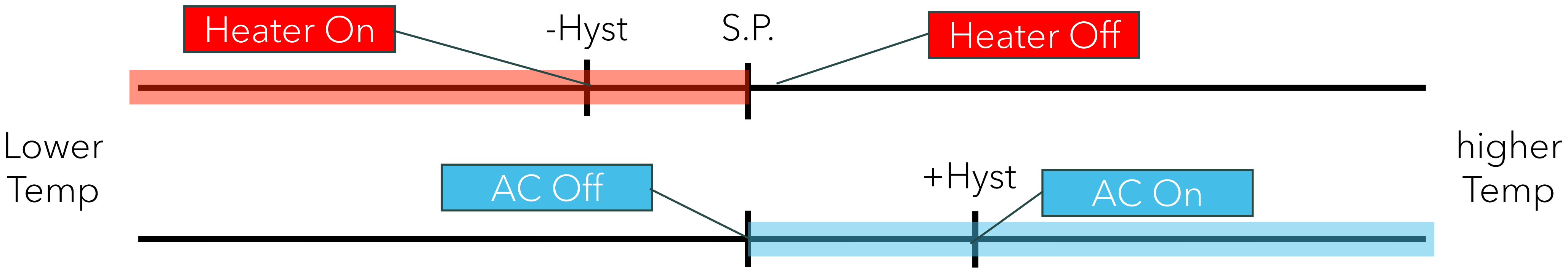
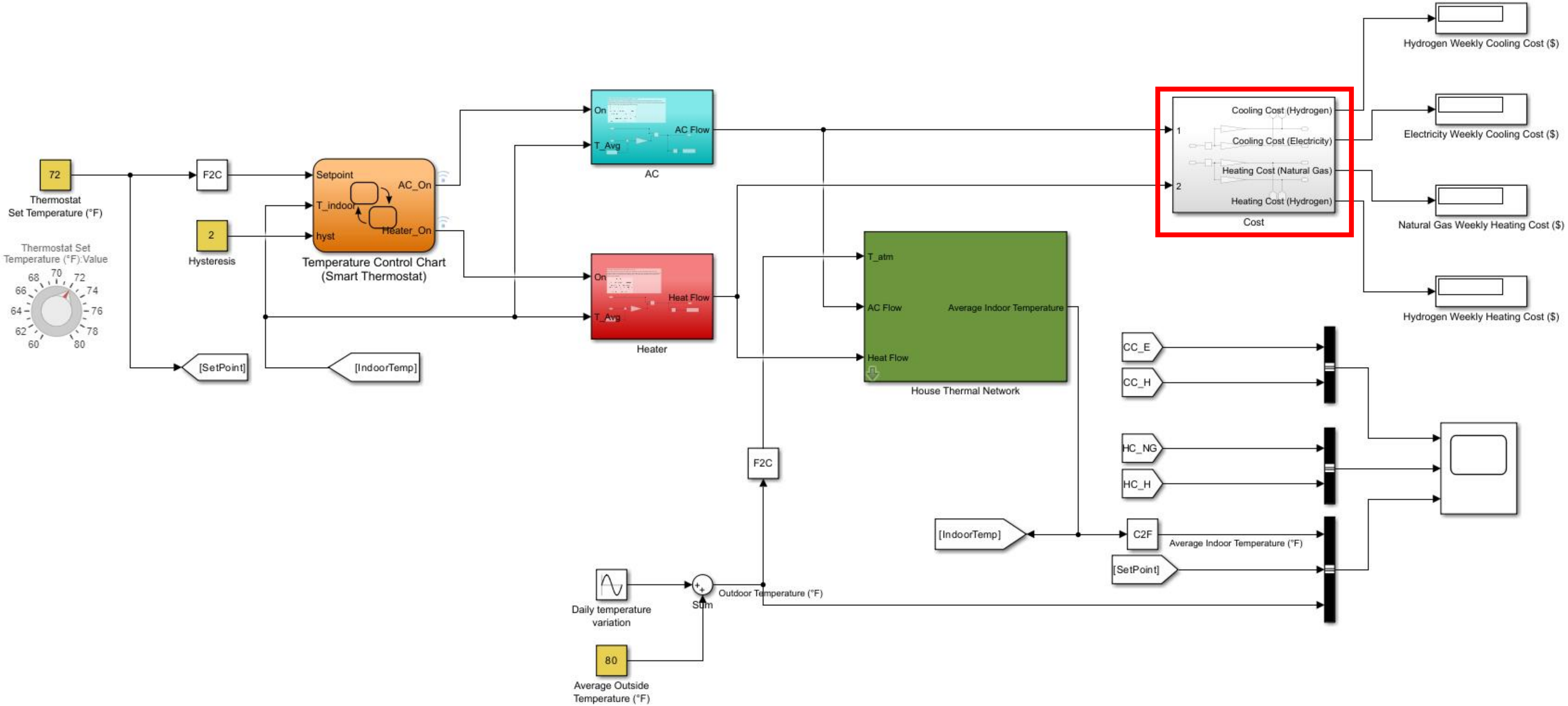


Figure 20. Visual representation of StateFlow Thermostat.

COST CALCULATION



COST CALCULATION

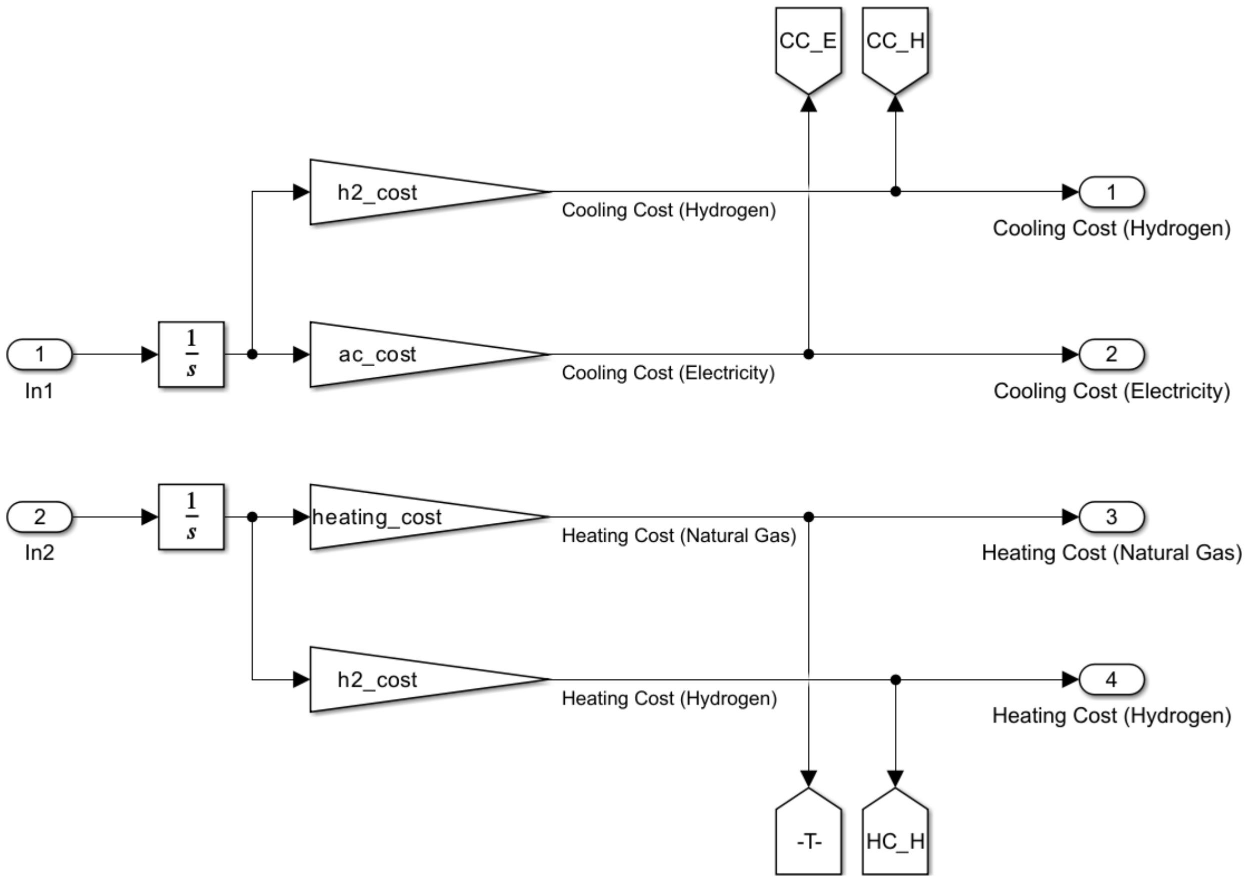


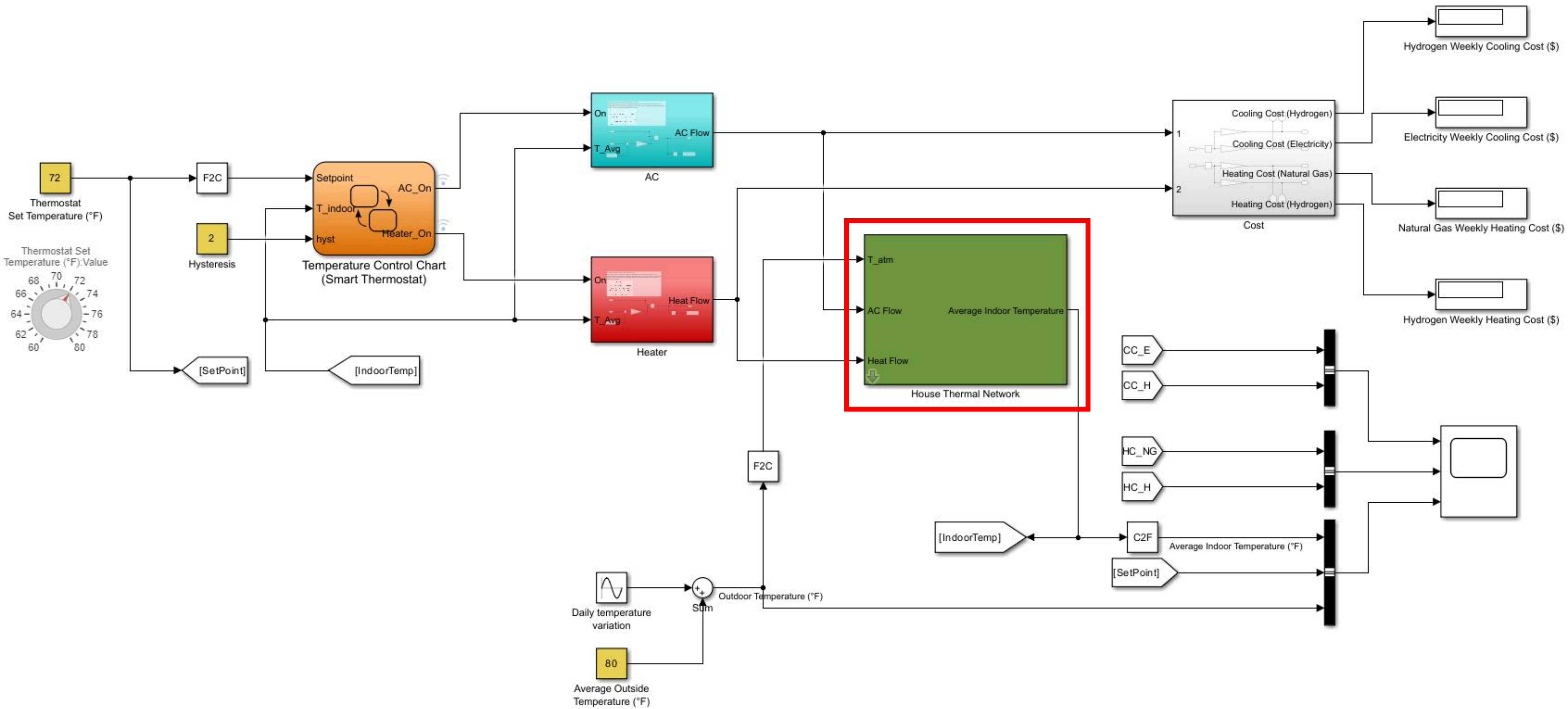
Figure 21. Cost calculation model based on weekly energy usage.

Model initialization function:

```
%% Natural Gas
% Cost estimation
% Assume the cost of natural gas to be $1.628 per therm
% 1 Therm = 100,000 BTU = 105,500*10³ Joules
% Cost = $ 1.625/(105,500*10^3) * Joules
heating_cost = 1.625/(105500*10^3);

%% Electricity
% Cost estimation
% Assume the cost of electricity to be $0.28 per 1 kWh
% 1 kWh = 3600000 Joule
% Cost = ($0.28/1 kWh) / 36000000 Joules
ac_cost = 0.28/(3600000);

%% Hydrogen
% Cost estimation
% Assume the cost of Hydrogen to be $1.39 per 1 kg
% Energy density = 131*10^6 Joules / 1 kg
% Cost = $1.39 / 131*10^6 Joules
h2_cost = 1.39/(131*10^6);

%% Equipment
% The air exiting the heater/chiller has a constant temperature.
T_Heater = 45; % [°C]
T_Chiller = 14.5; % [°C]

%% Air
c_air = 1005.4; % cp of air at 273 K [J/(kg*K)]
Density_Air = 1.2550; % [kg/m³]

% Mass flow rate
M_dot = 1; % 1 kg/sec

%% Initial temperature of the entire house
InitialIndoorTemperature = 31; % [°C]
```

Figure 22. Cost calculation parameter. Values obtained from [2], [3], [4].

HOUSE THERMAL NETWORK



DIMENSIONS AND REFERENCE DESIGNATORS FOR WALLS AND ROOMS

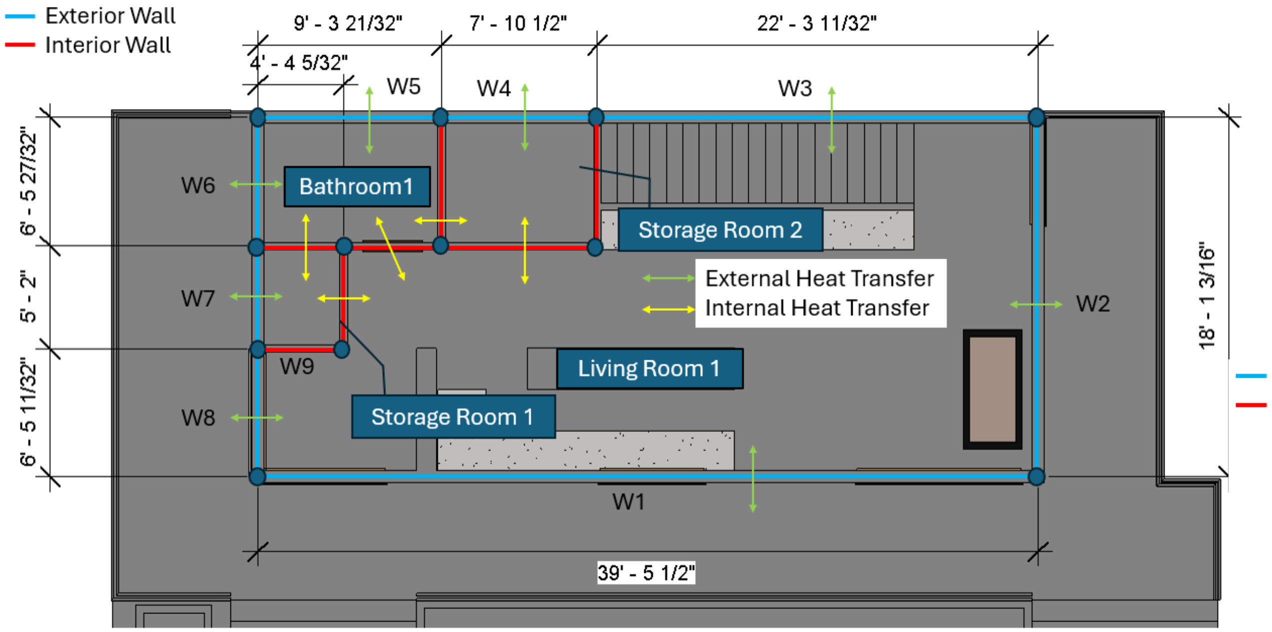


Figure 23. 1st Floor.

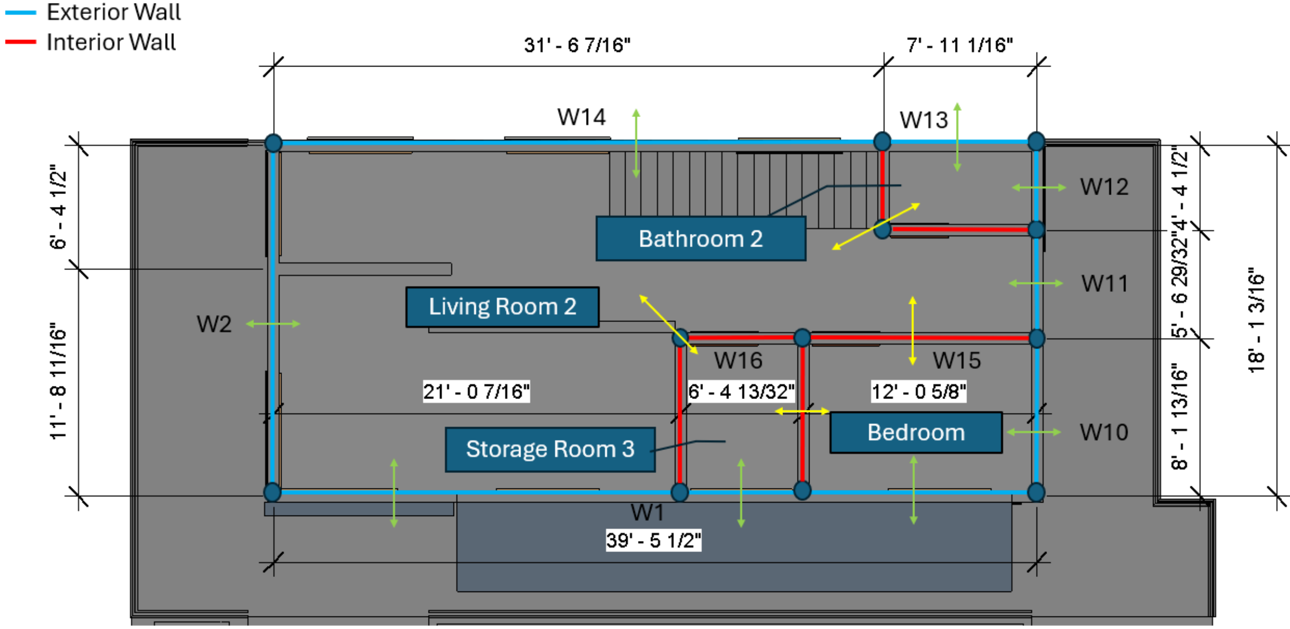


Figure 24. 2nd Floor.

HOUSE THERMAL MODEL

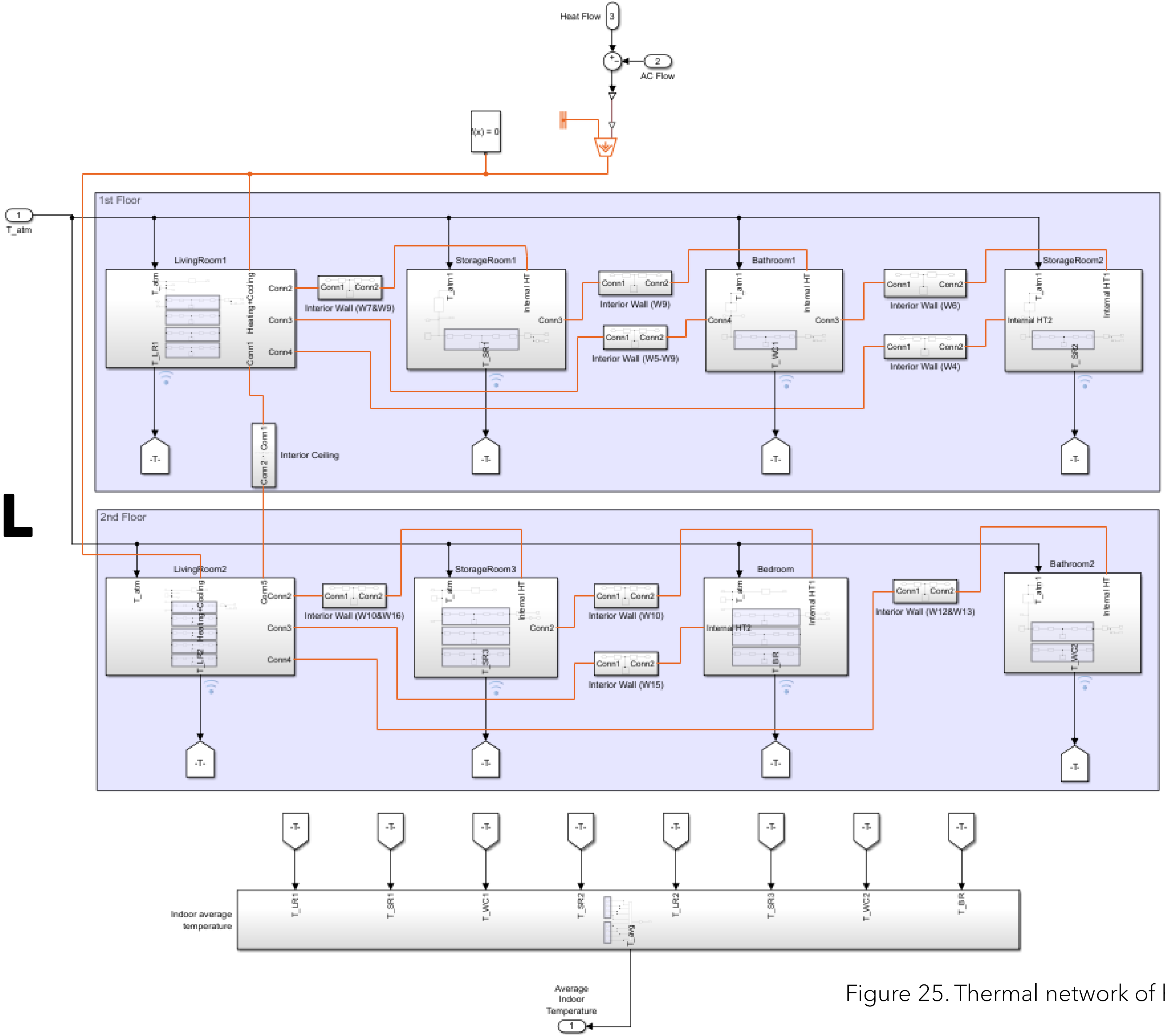


Figure 25. Thermal network of house.

EXAMPLE OF HOW A ROOM IS MODELED

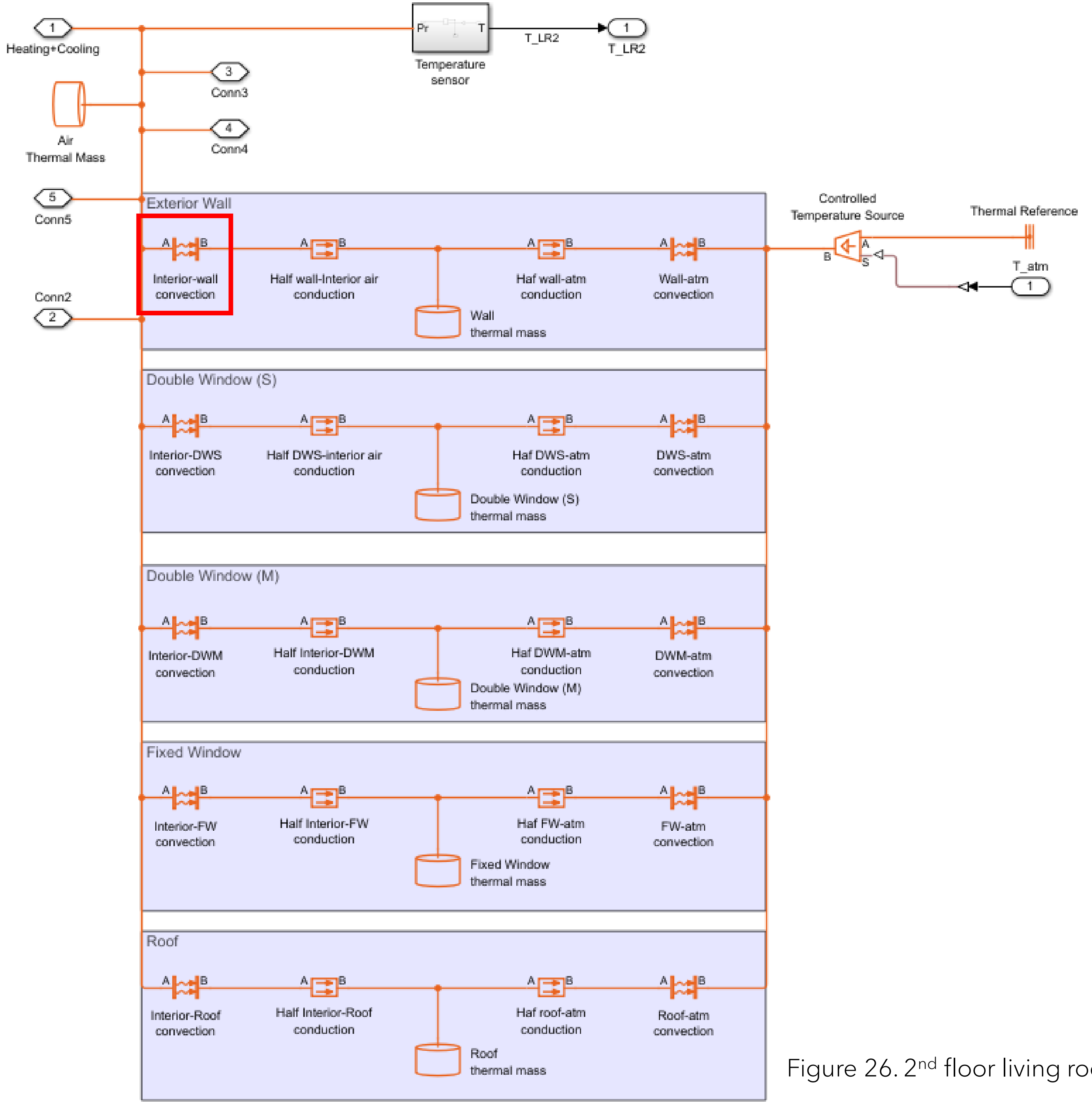


Figure 26. 2nd floor living room thermal model.

CALCULATION METHOD

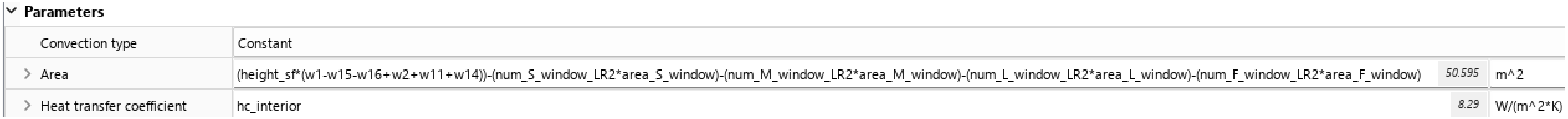


Figure 27. Interior air – wall convection calculation.

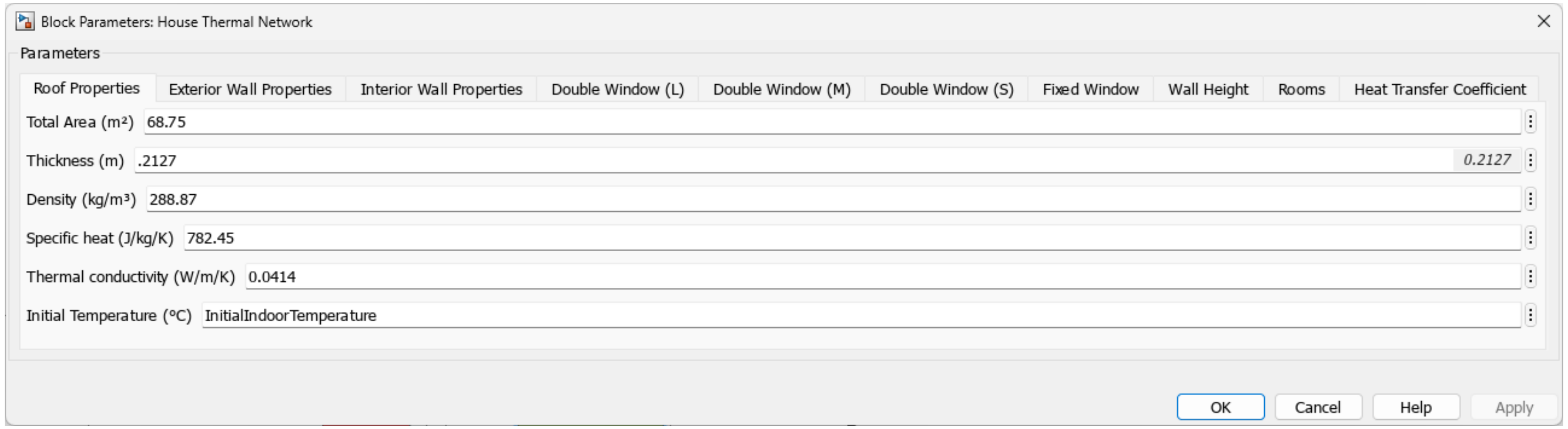


Figure 28. Input prompt window for all parameters.

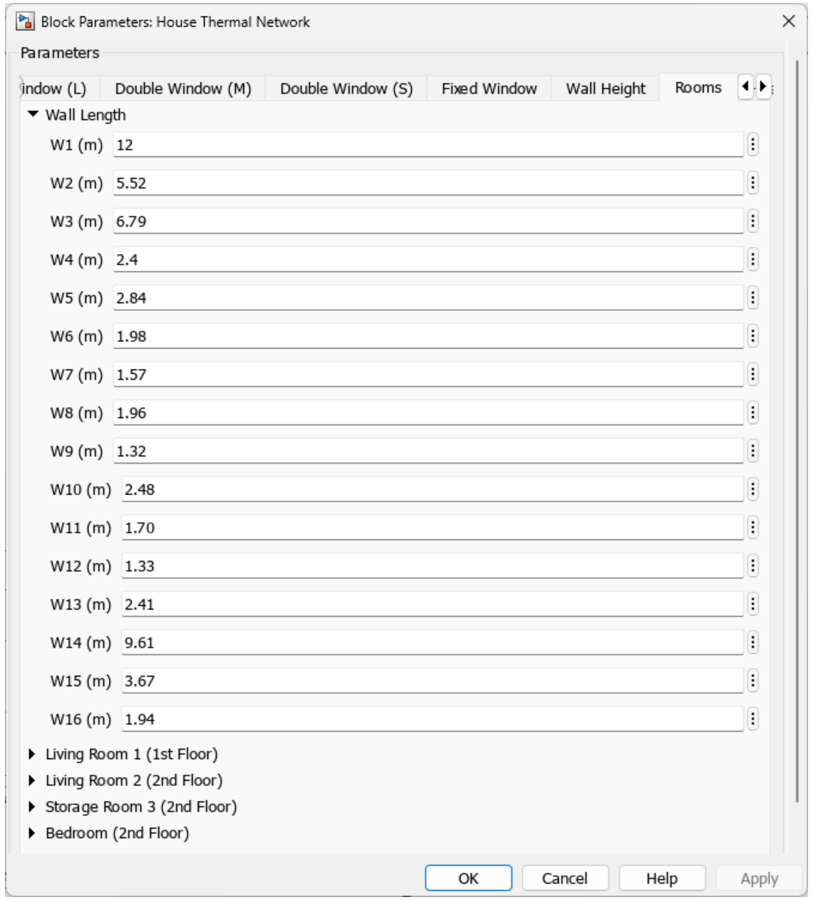


Figure 29. Wall length input prompt window.

SIMULATION RESULTS – COOLING

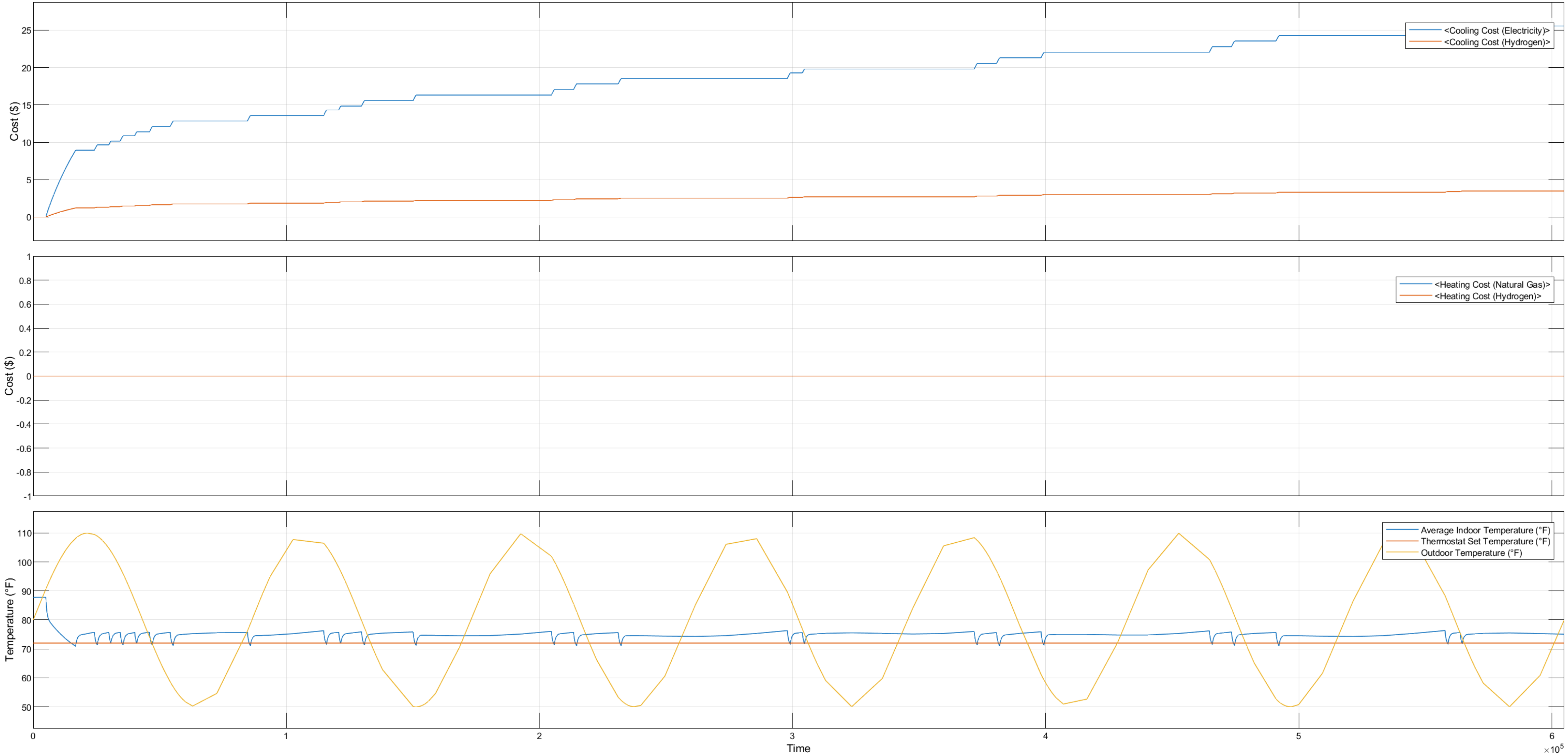


Figure 30. Temperature vs. Time (7 days) Simulation and cooling costs for 72°F set point and 88°F±30°F outdoor temperature with 87.8°F initial temperature.

SIMULATION RESULTS – COOLING

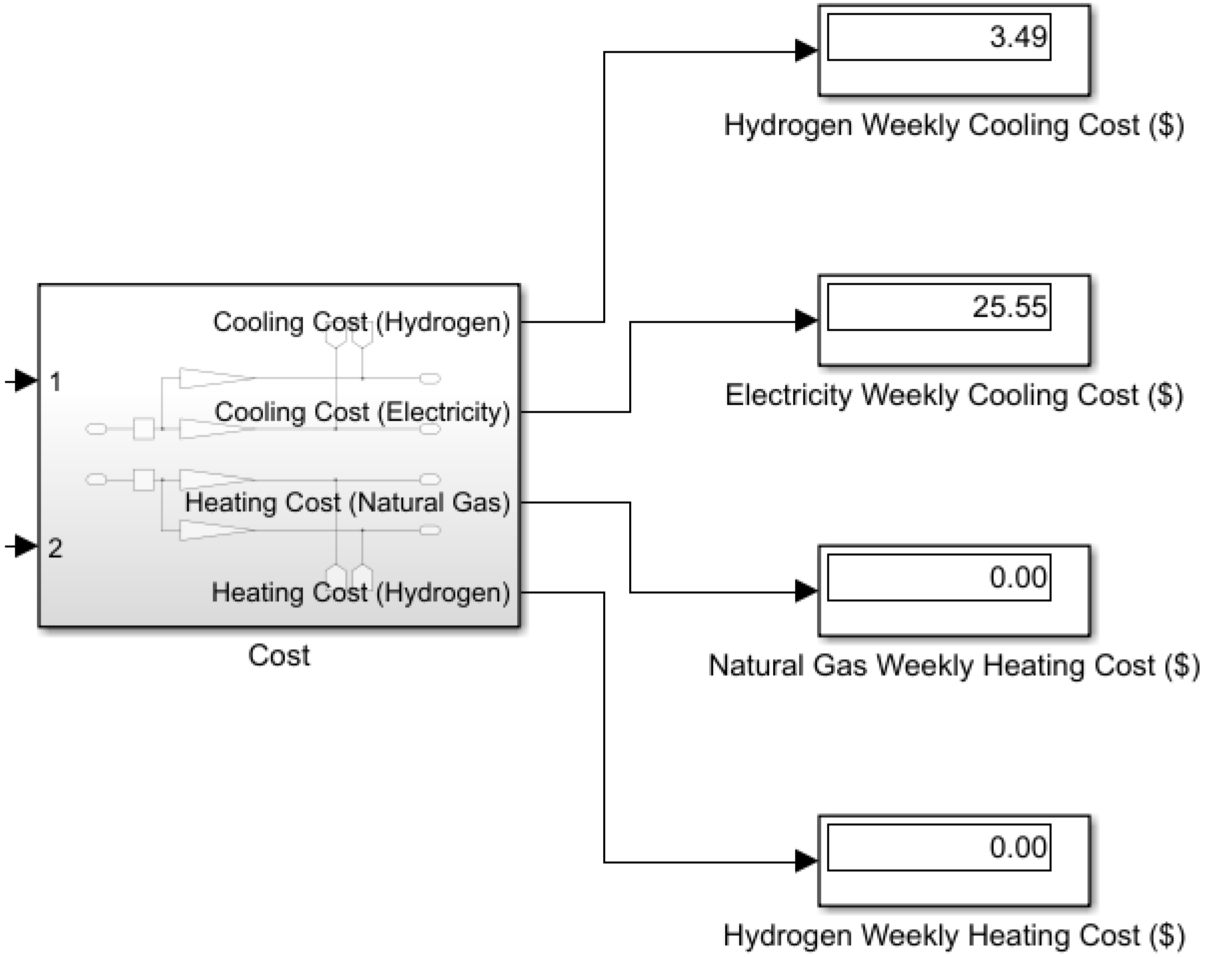


Figure 31. Numerical results for cooling cost on simulation from Figure 22.

SIMULATION RESULTS – HEATING

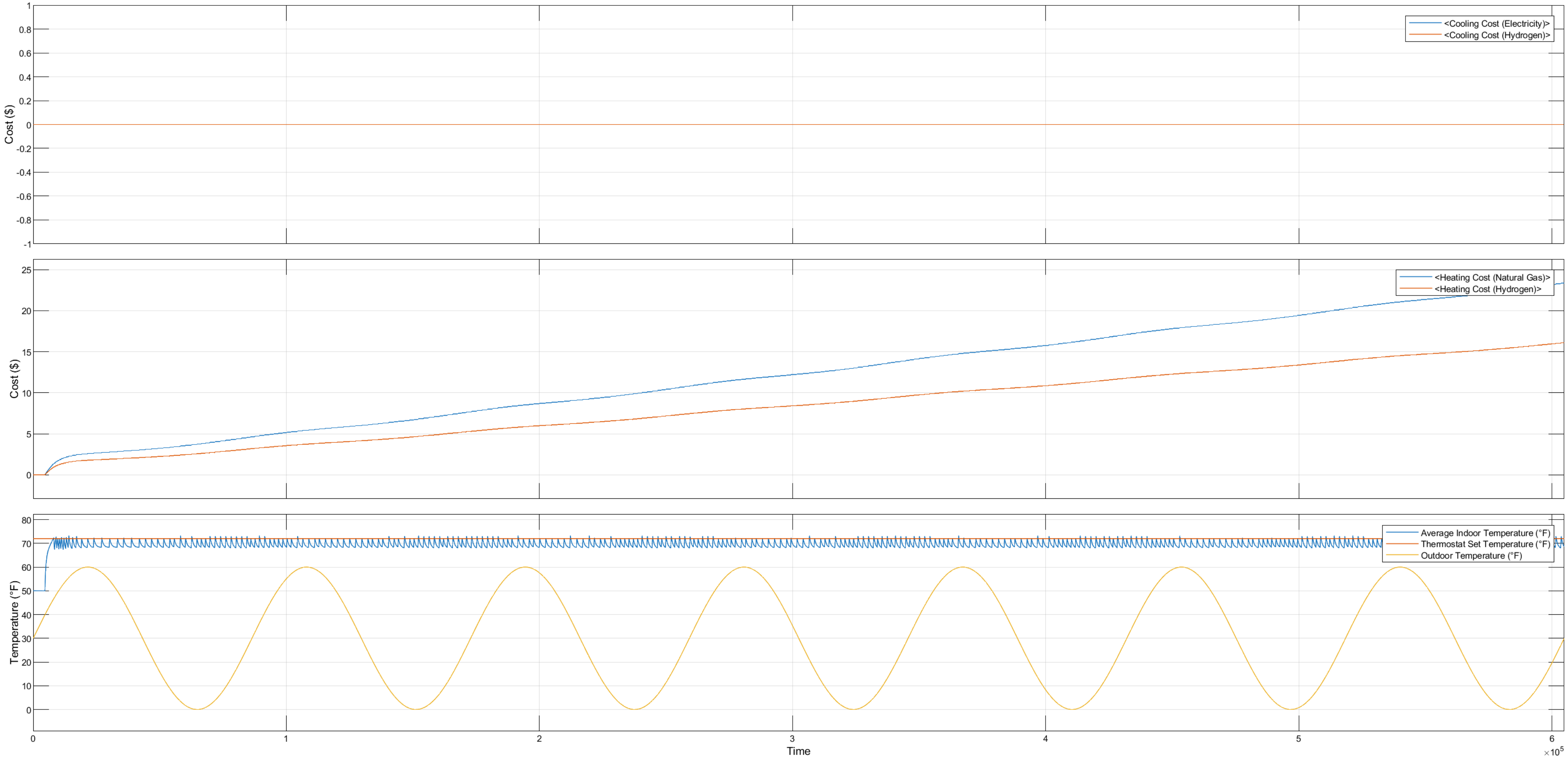


Figure 32. Temperature vs. Time (7 days) Simulation and heating costs for 72°F set point and 30°F±30°F outdoor temperature with 50°F initial temperature.

DESIGN OVERVIEW HVAC – MATLAB/SIMULINK

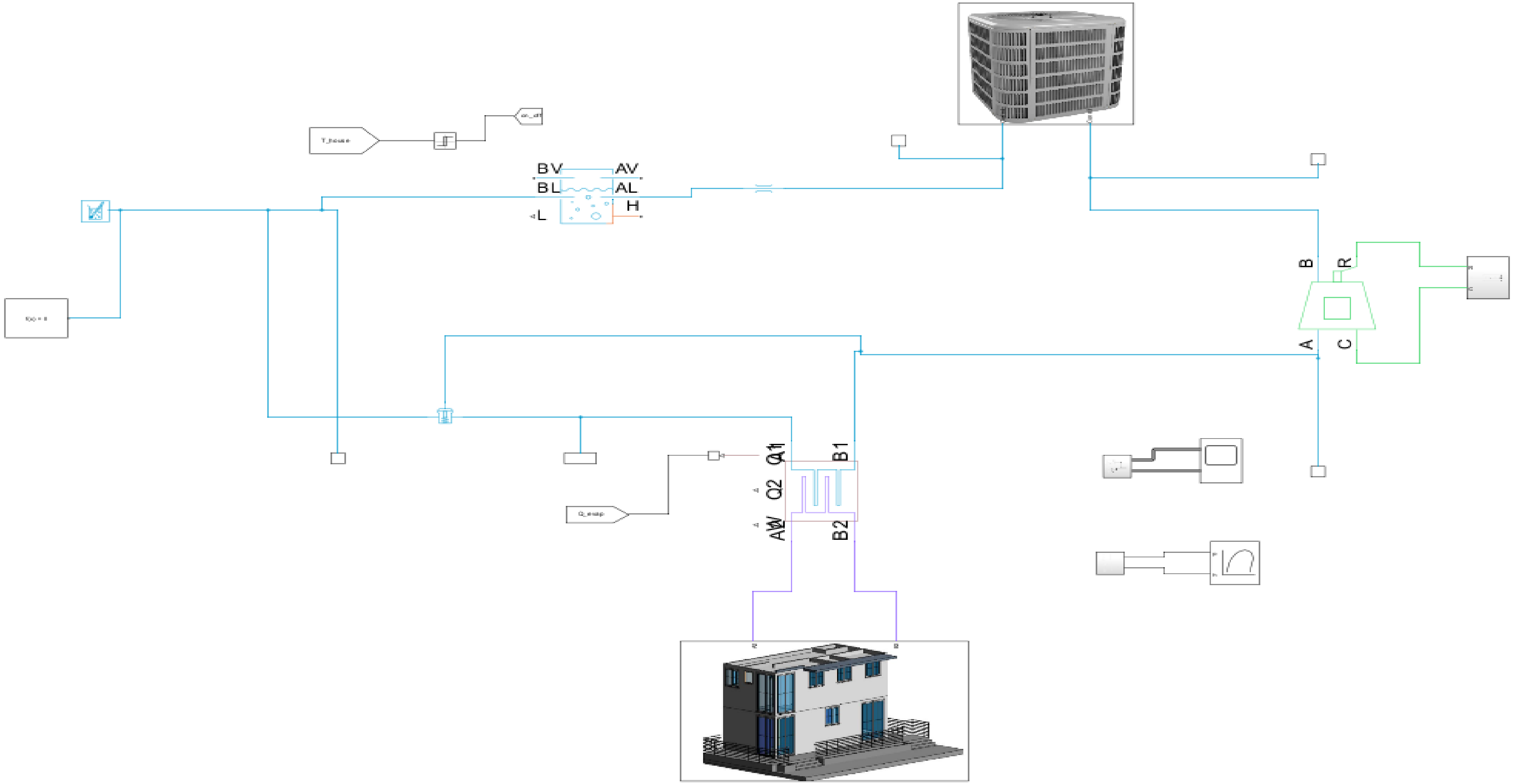


Figure 33. Simulink model Refrigeration cycle

INTERIOR FLOW – MATLAB/SIMULINK

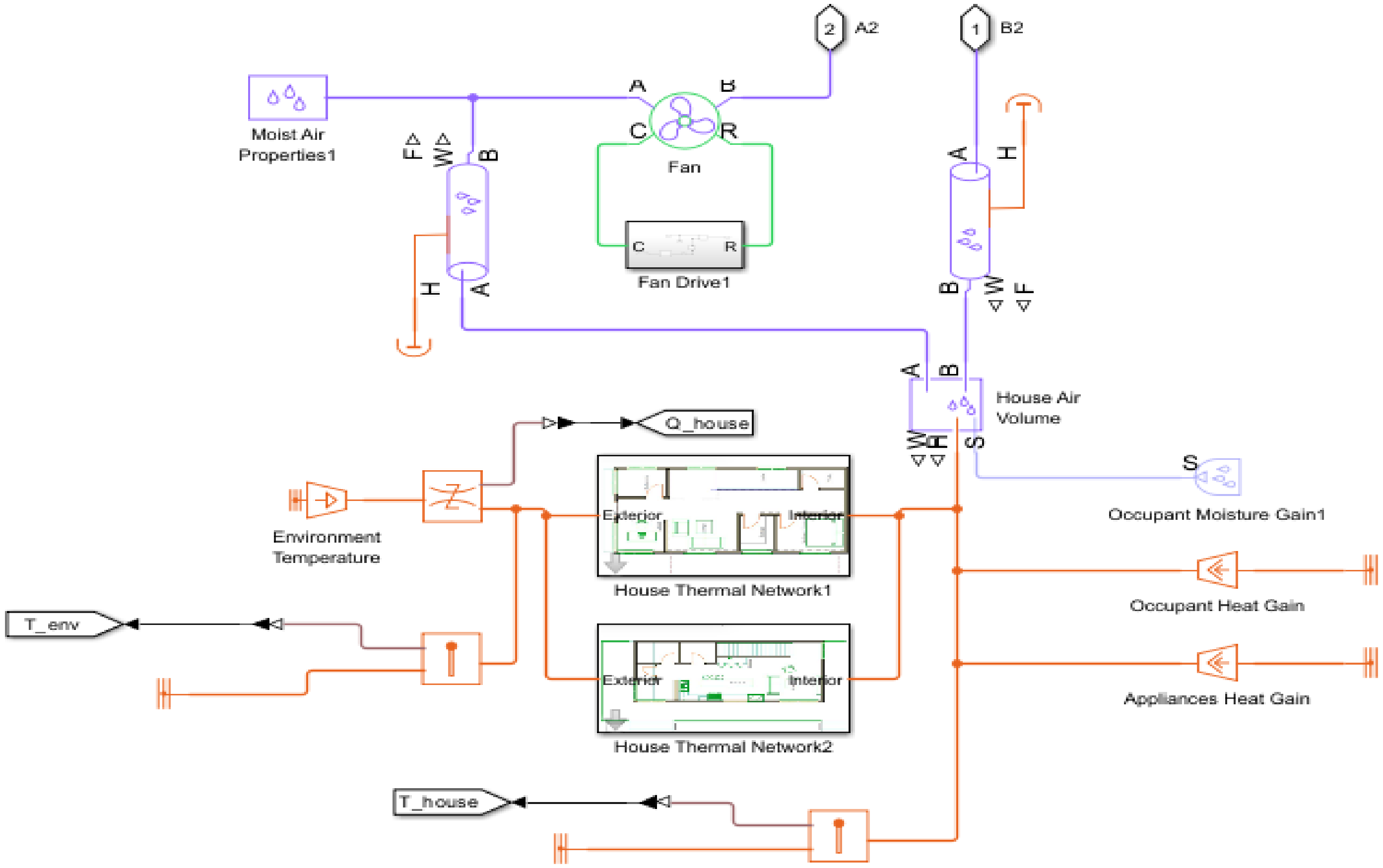


Figure 34. House subsystem

SIMULATION RESULTS

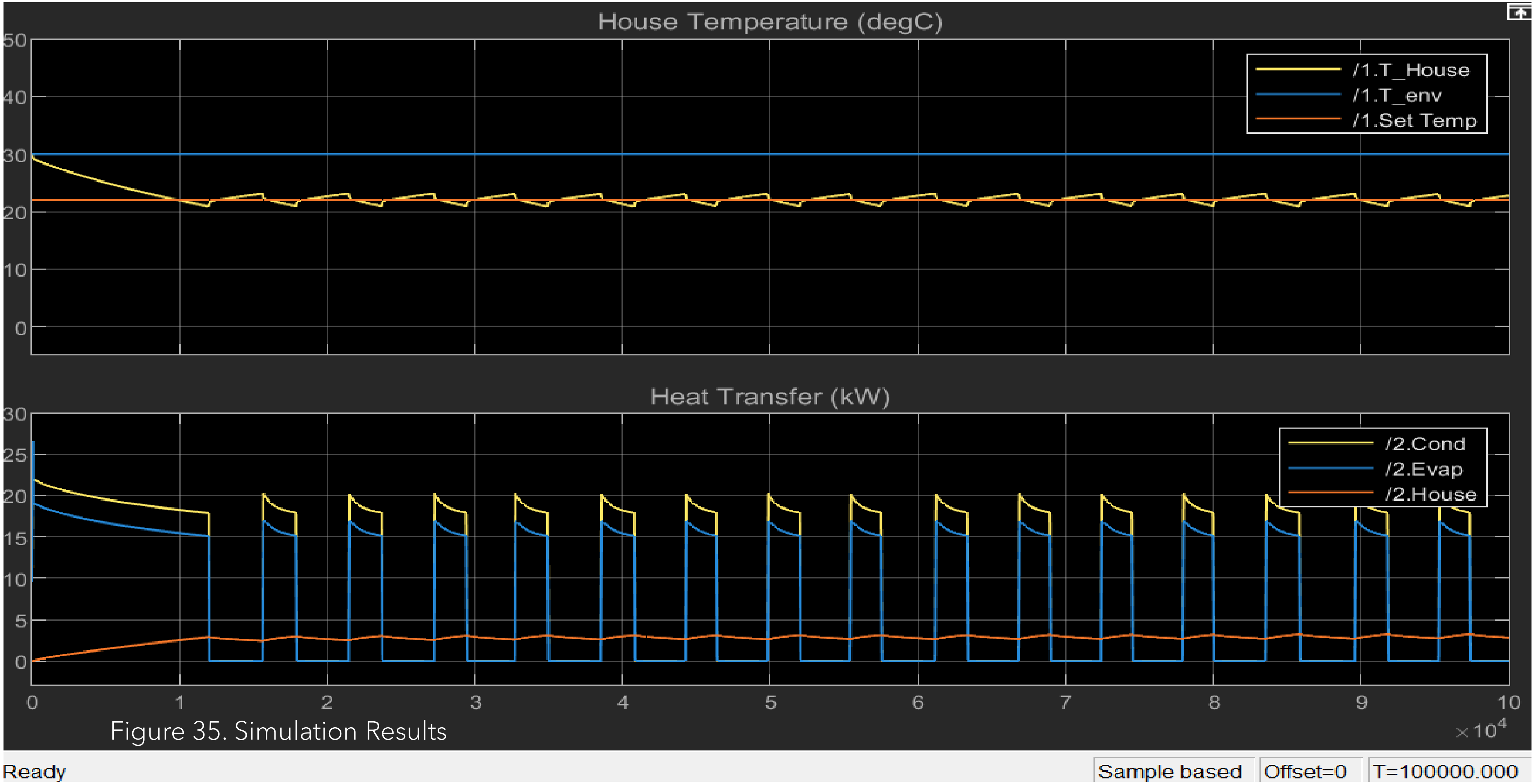


Figure 35. Simulation Results

OTHER DATA: FOR FUTURE INTEGRATION AND RESEARCH

Duct Sizing and Optimization

- **Duct Diameter Formula**:
  - $D = \pi \times \text{Velocity}(4 \times CFM)$
    - D = duct diameter, CFM = airflow requirement, Velocity = desired speed.
- **Design Choices**:
  - Round ducts for reduced friction losses.
  - Sound-dampening elements for occupant comfort.
- **Fresh Air System**:
  - ASHRAE 62.1 standards for air quality.
  - Stale air exhaust in moisture-prone areas improves air quality by up to 30%.

OTHER DATA: FOR FUTURE INTEGRATION AND RESEARCH HVAC System Design

- $CFM = \frac{BTU}{1.08 \times \Delta T}$
  - **CFM**: Airflow in cubic feet per minute.
  - **BTU**: Heating/cooling load.
  - ΔT: Temperature difference between supply and return air.
- **Standards & Targets**:
  - **Main ducts**: 600–900 ft/min airflow velocity.
  - **Branch ducts**: 400–700 ft/min airflow velocity.
- **Conversion Example**:
  - Airflow = 477 L/s = **1,011 CFM** (1 L/s = 2.11888 CFM).
- **Verification**: Compliance ensured via HVAC modeling software.

OTHER DATA: FOR FUTURE INTEGRATION AND RESEARCH

HVAC System Parameters

- **System Information**:
  - Air System: VRF (Variable Refrigerant Flow).
  - Floor Area: 35.1 m^2 (1 zone).
- **Cooling and Heating Data**:
  - Cooling Load: 5.4 kW (peak in July).
  - Heating Load: 1.6 kW.
  - Airflow: 477 L/s.
- **Key Sizing Metrics**:
  - Coil Temperatures: Entering at 24.8°C, Leaving at 15.5°C.
  - Water Flow: Designed for 5.6 L/s.
- **Design Considerations**:
  - Space airflow rates tailored to individual zones.
  - Peak sensible loads calculated for optimal efficiency.

Efficiently sized to meet cooling, heating, and airflow demands for the specified zone.

Zone Sizing Summary for 1F-01

Project Name: 9240-FIRESTONE BLVD
Prepared by:

10/13/2024
10:48PM

Air System Information

Air System Name 1F-01
Equipment Class .... TERM
Air System Type .... VRF

Number of zones 1
Floor Area .... 35.1 m^2
Location .... Long Beach, California

Sizing Calculation Information

Calculation Months .... Jan to Dec
Sizing Data .... Calculated

Zone L/s Sizing .... Sum of space airflow rates
Space L/s Sizing .... Individual peak space loads

Terminal Unit Sizing Data - Cooling

Zone Name	Total Coil Load (kW)	Sens Coil Load (kW)	Coil Entering DB / WB (°C)	Coil Leaving DB / WB (°C)	Water Flow @ 5.6 K (L/s)	Time of Peak Coil Load	Zone L/(s·m²)
Zone 1	5.4	5.4	24.8 / 18.1	15.5 / 14.8	-	Jul 1500	13.59

Terminal Unit Sizing Data - Heating, Fan, Ventilation

Zone Name	Heating Coil Load (kW)	Heating Coil Ent/Lvg DB (°C)	Htg Coil Water Flow @11.1 K (L/s)	Fan Design Airflow (L/s)	Fan Motor (BHP)	Fan Motor (kW)	OA Vent Design Airflow (L/s)
Zone 1	1.6	20.5 / 23.3	-	477	0.000	0.000	11

VRF Outdoor Unit Sizing Data

	Cooling [kW]	Heating [kW]
Peak Coincident Indoor Unit Loads	5.4	1.6
Estimated Piping / Line Losses	0.0	0.0
Total Required ODU Capacity	5.4	1.6

Note: VRF piping / line losses are based on typical loss factors for this class of equipment. Actual line loss varies widely from one product to another. Therefore, when selecting equipment it is critical to consult manufacturer's guidance to utilize actual line loss data.

Zone Peak Sensible Loads

Zone Name	Zone Cooling Sensible (kW)	Time of Peak Sensible Cooling Load	Zone Heating Load (kW)	Zone Floor Area (m²)
Zone 1	5.4	Aug 1500	1.5	35.1

Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (kW)	Time of Peak Sensible Load	Air Flow (L/s)	Heating Load (kW)	Floor Area (m²)	Space L/(s·m²)
Zone 1							
1F-01	1	5.4	Aug 1500	477	1.5	35.1	13.59

Hourly Analysis Program 5.10 — Page 1 of 6

Figure 36. Zone Sizing Summary based in Downey

OTHER DATA: FOR FUTURE INTEGRATION AND RESEARCH

Electrical System Overview

- **System Design**:
    - Includes power layout, lighting circuits, and distribution board (DB) scheduling.
    - Lighting follows IES standards for efficiency and visual comfort.
- **Lighting Power Density (LPD)**:
    - $LPD = \frac{\text{Total Lighting Power}}{\text{Floor Area}}.$
- **Integration with HVAC**:
    - Vent placement complements lighting design.
    - Combined systems reduce energy consumption by 15%.

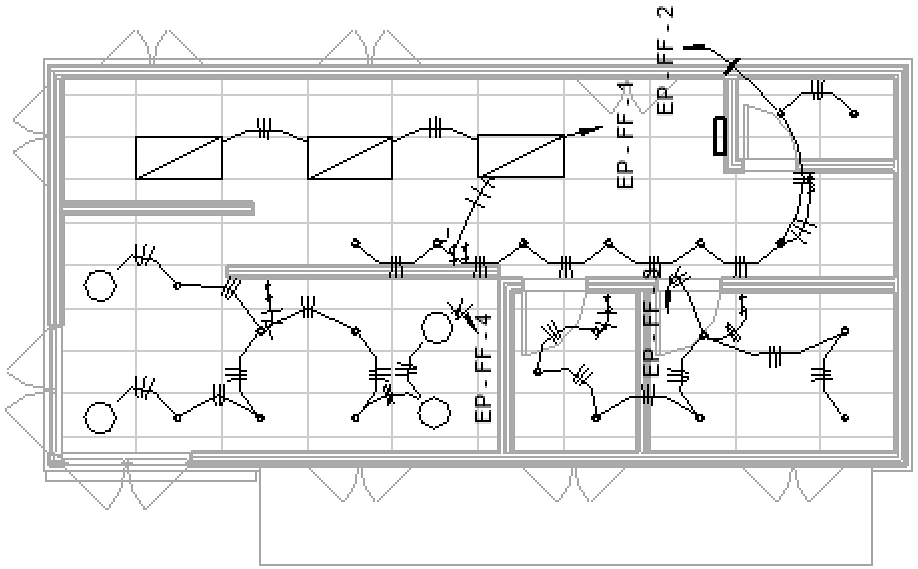


Figure 37. Electrical Placement System

LOCATIONS OF LIGHTING AND POWER CIRCUITS

LOCATIONS OF LIGHTING AND POWER CIRCUITS

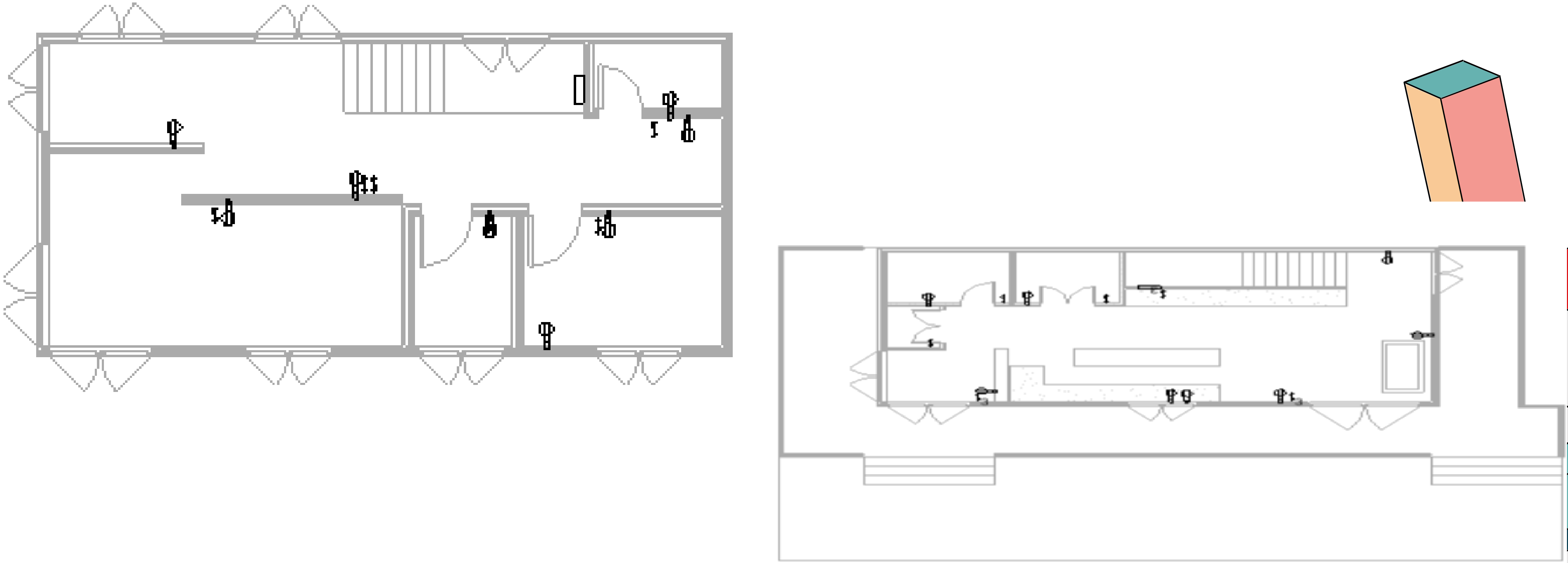


Figure 38 & 39. Lighting and Power Circuit Locations

OTHER DATA: FOR FUTURE INTEGRATION AND RESEARCH

Panel and Circuit Management

- **Panel Details**:
  - EP panels distribute power with labeled circuits for safety.
  - Circuit identifiers (e.g., "FF-1") organize loads like lighting and outlets.
- **Load Distribution**:
  - Balanced across three phases (A, B, C) to ensure efficiency.
  - Total load calculations ensure safety and prevent overload.

OTHER DATA: FOR FUTURE INTEGRATION AND RESEARCH

Panel and Circuit Management

Branch Panel: EP - FF

Location:		Volts:	120/208 Wye	A.I.C. Rating:	
Supply From:		Phases:	3	Mains Type:	
Mounting:	Recessed	Wires:	4	Mains Rating:	100 A
Enclosure:	Type 1			MCB Rating:	1 A

Notes:

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting	20 A	1	53 VA	0 VA					1	20 A	Lighting	2
3	Oświetlenie	20 A	1			70 VA	140 VA			1	20 A	Other	4
5	Lighting	20 A	1					123 VA	540 VA	1	20 A	Receptacle	6
7	Receptacle	20 A	1	360 VA	540 VA					1	20 A	Receptacle	8
9													10
11													12
			Total Load:	948 VA		205 VA		653 VA					
			Total Amps:	8 A		2 A		6 A					

Legend:

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Other	140 VA	100.00%	140 VA		
Receptacle	1440 VA	100.00%	1440 VA	Total Conn. Load:	1799 VA
Lighting	176 VA	100.00%	176 VA	Total Est. Demand:	1799 VA
Oświetlenie	70 VA	100.00%	70 VA	Total Conn.:	5 A
				Total Est. Demand:	5 A

Notes:

Figure 40. Circuit Details for first floor

Circuit Details:

- Circuit Number (CKT): Identifies individual circuits.
- Description: Specifies loads (e.g., lighting, receptacles).
- Trip Rating: 20A per circuit, single-pole.
- Phase Loads (A, B, C): Power distributed across phases:
  - Phase A: 948 VA (8A)
  - Phase B: 205 VA (2A)
  - Phase C: 653 VA (6A).

Load Classification:

- Other: 140 VA.
- Receptacles: 1,440 VA.
- Lighting: 176 VA.

•Panel Summary:

- Total Load: 1,799 VA, Demand: 5A.
- Operates on 120/208V three-phase with 100A mains and 1A MCB.

VA-Volt Amperes

This ensures safe, balanced, and efficient power distribution.

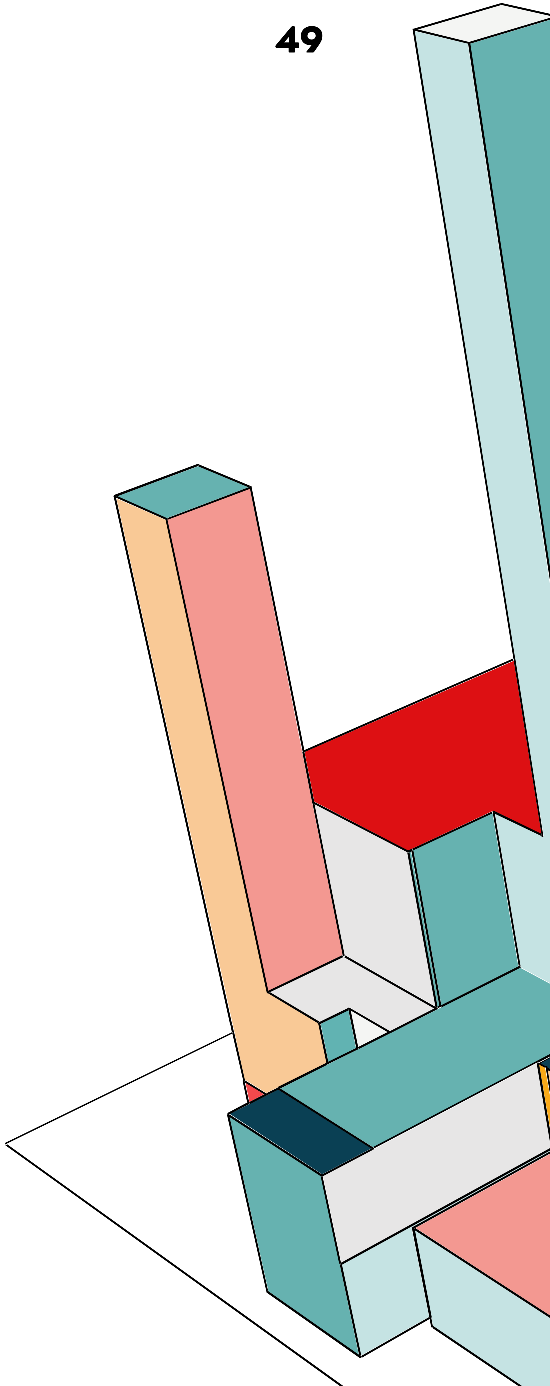
OTHER DATA: FOR FUTURE INTEGRATION AND RESEARCH

Heat Transfer and Ventilation

- **Heat Transfer Formula**:
  - $Q = U \times A \times \Delta T$, where Q = heat transfer rate.
- **Ventilation Load Formula**:
  - $Q_{\text{ventilation}} = CFM \times 1.08 \times \Delta T$.
- **Environmental Impact**:
  - Digital twin modeling simulates energy costs and efficiency.
  - Predictive AI adjusts HVAC settings to reduce energy costs by 30%.

BENEFITS OF ADDING ADDITIONAL FACTORS TO SIMULINK MODEL

- **Improved Accuracy**: Reflects real-world conditions by including airflow, heat transfer, and load balancing.
- **Enhanced Efficiency**: Optimizes energy use and reduces operational costs.
- **Better Integration**: Simulates HVAC and electrical system interactions for streamlined design.
- **Dynamic Adaptation**: Enables predictive controls for energy savings in changing conditions.
- **Result**: A more efficient, sustainable, and occupant-friendly system design.



REVIT RESULTS- FINAL FLOOR PLAN

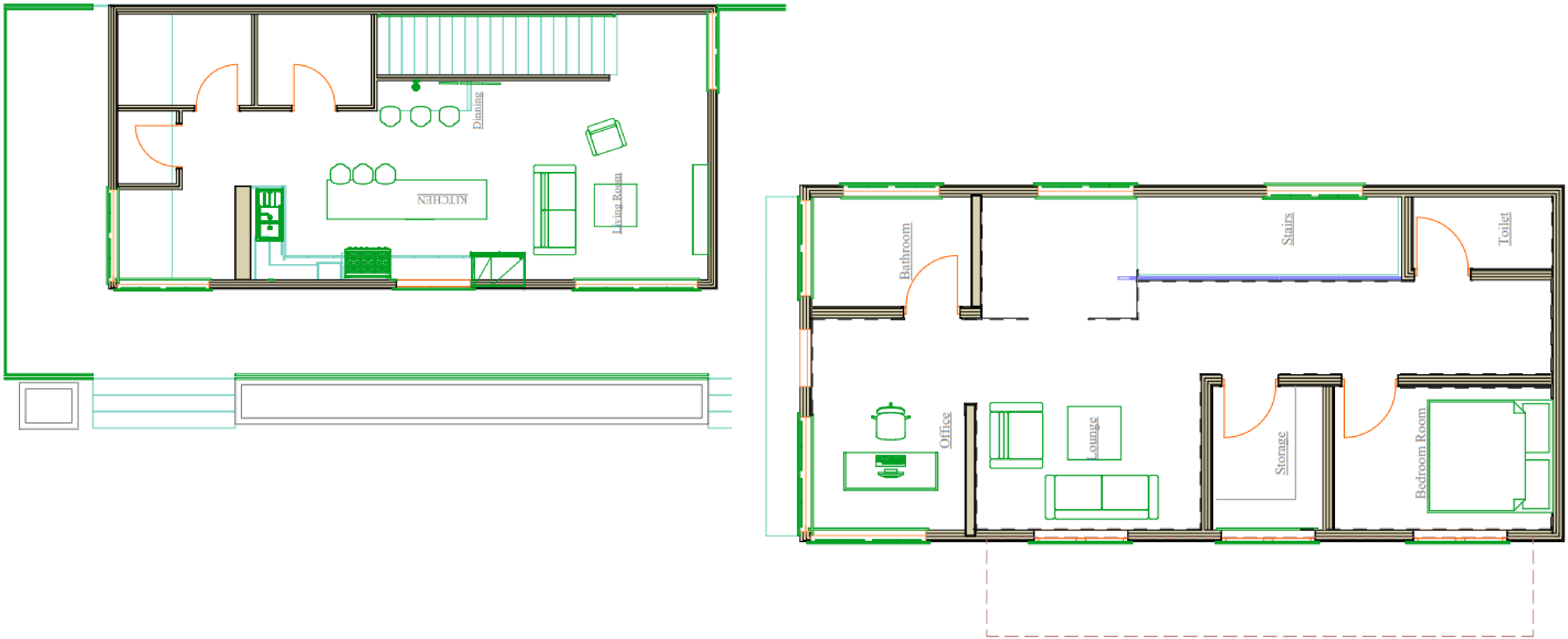


Figure 41 and 42. Complete Floor Plan of both levels including furniture

REVIT/ ENSCAPE RESULTS – RENDERS

Figure 43 and 44. Complete Floor Plan

REVIT/ ENSCAPE RESULTS – RENDERS

Figure 45 and 46. Complete Floor Plan

REVIT/ ENSCAPE RESULTS - RENDERS

Figure 47 and 48. Complete Floor Plan

REVIT/ ENSCAPE RESULTS - RENDERS

Figure 49 and 50. Complete Floor Plan

CONCLUSION

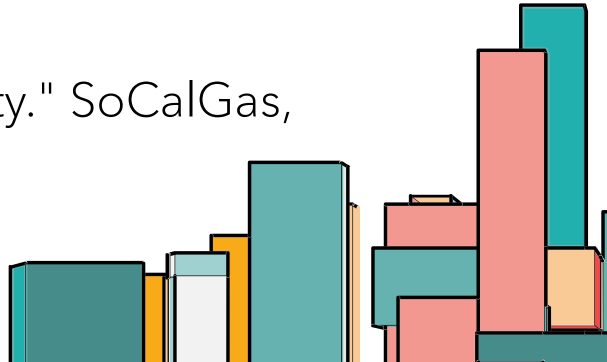
- Developed tool that allows the end user to rapidly change input parameters and evaluate thermal performance of the house and its energy cost based on heating/cooling.

Table 1. List of input parameters for Simulink model/tool.

List of input parameters for all material (walls, windows, room)
Dimensions (length, width, height, thickness)
Density
Thermal Conductivity
Specific Heat
Initial Temperature
Exterior Temperature
Cost (electricity, natural gas, hydrogen mass)

REFERENCES

1. F. C. Melo, G. Carrilho da Graça, and M. J. N. Oliveira Panão, "A review of annual, monthly, and hourly electricity use in buildings," Energy and Buildings, vol. 293, p. 113201, Aug. 2023, doi: https://doi.org/10.1016/j.enbuild.2023.113201.
2. "Average Energy Prices, Los Angeles-Long Beach-Anaheim – November 2019 : Western Information Office : U.S. Bureau of Labor Statistics," Bls.gov, Dec. 17, 2019. https://www.bls.gov/regions/west/news-release/averageenergyprices_losangeles.htm
3. "Hydrogen Innovation: SoCalGas Awarded $750,000 California Energy Commission Grant to Develop Renewable Hydrogen from Biogas | SoCalGas Newsroom," Socalgas.com, 2022. https://newsroom.socalgas.com/press-release/hydrogen-innovation-socalgas-awarded-750000-california-energy-commission-grant-to.
4. SoCalGas. "Hydrogen Home – Exploring Hydrogen's Role in Sustainability." SoCalGas, 2022. https://www.socalgas.com/sustainability/hydrogen/h2home.



ANY QUESTIONS?