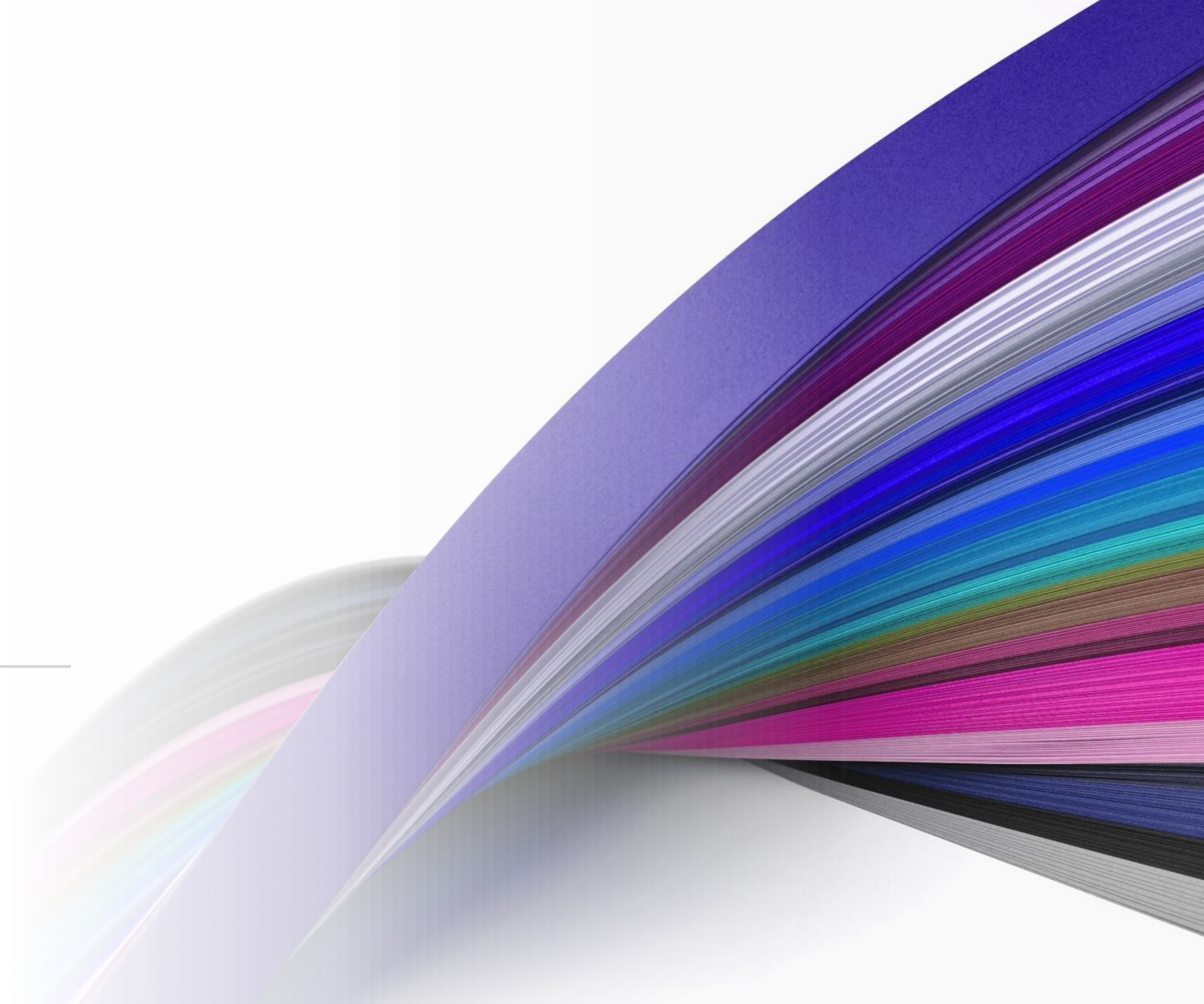
Building Information Modeling



Objective

- Literature
- Energy simulation

INTRODUCTION

Building Information Modeling (BIM)

- Transformative technology in the construction industry
- Revolutionizing the way construction projects are planned, designed, constructed, and maintained.
- Digital representation of the physical and functional characteristics of a building or infrastructure project.

LEVEL OF DEVELOPMENT (LOD)

Level of Development is a term that defines the detailing, information, and visuals of a model at different stages of a BIM project

1) LOD 100 – CONCEPT DESIGN
2) LOD 200 – SCHEMATIC DESIGN
3) LOD 300 – DETAILED DESIGN
4) LOD 350 – CONSTRUCTION DOCUMENTATION
5) LOD 400 – FABRICATION AND ASSEMBLY
6) LOD 500 – AS-BUILT

"Transformative Applications of BIM: Enhancing Processes and Innovating Industries"

3D Modelling

Data Integration

Analysis and Simulation

Construction Documentation

Clash Detection

Energy Simulation, Cost optimization, minimize Carbon Footprint

Lifecycle Information Managem ent

Clash Detection
Case Studies

Mumbai airport: April 2008 – December 2014
The clash-free 2D drawings led the D/B contractor to embrace BIM for the entire project

Apr. 2008 – Dec. 2014

Feb.–May 2012

A leading group of hotels: Feb 2012–May 2012
3D visualization, efficient service routing, and early clash detection.

Cost Optimization(Application of BIM)

Optimal Efficiency: The total cost of a combination is derived from multiplying the cost of each layer by its thickness. The insulating design with the lowest U-value and cost reflects the pinnacle of efficiency, ensuring maximum thermal performance at minimal expense.

In BIM (Building Information Modeling), time is maximized by enabling parallel workflows, allowing efficient multitasking and enhancing productivity, thereby equating time to money.

Carbon footprint

- A carbon footprint is the total greenhouse gas emissions resulting from human activities, primarily CO2, impacting climate change. It reflects the environmental impact of daily activities like fossil fuel use for electricity, heating, and transportation.

Carbon Equivalent

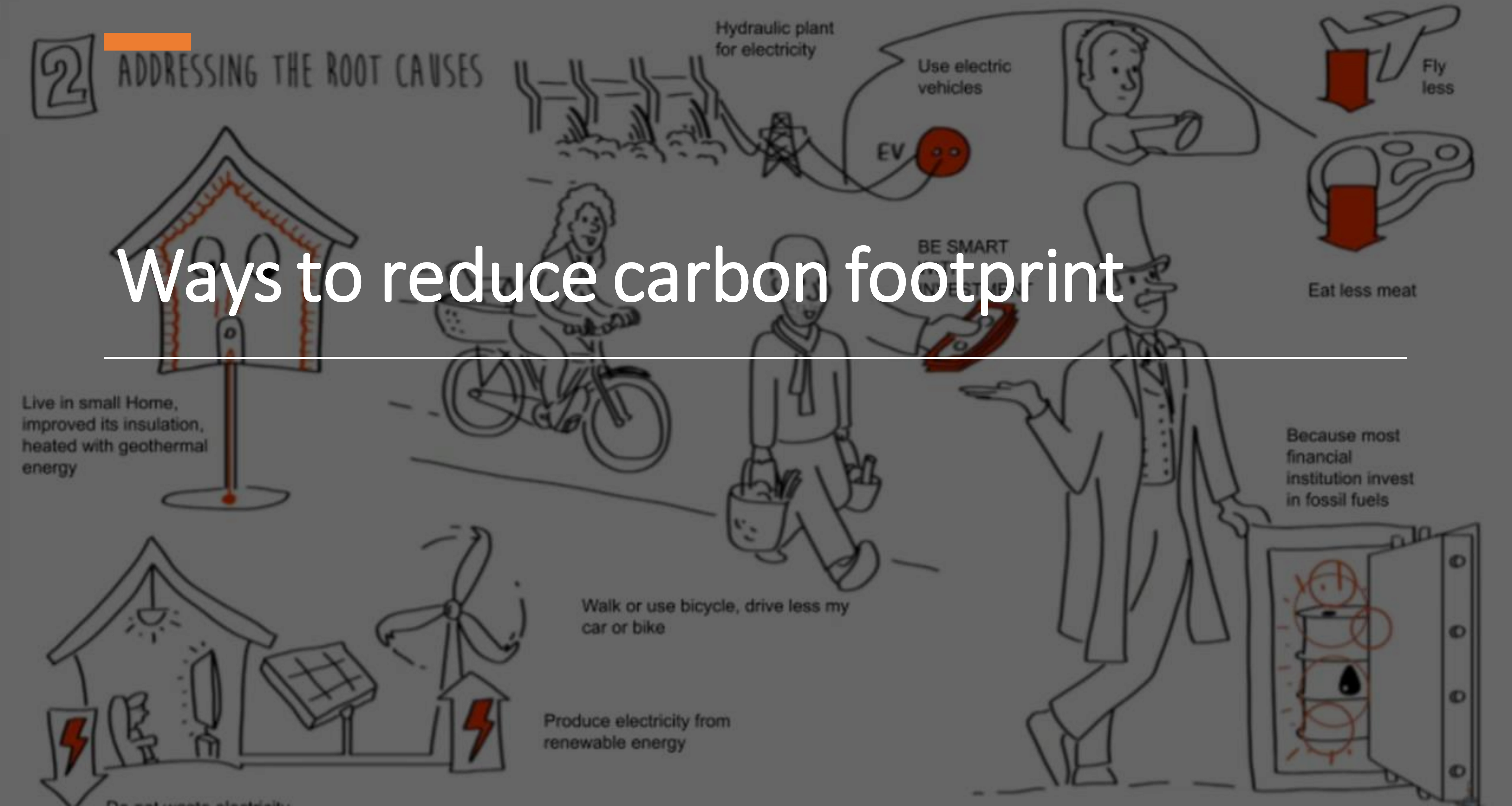
Carbon dioxide (CO2) is used as the reference gas with a GWP of 1

$$CO_2e = Emissions\ of\ a\ greenhouse\ gas\ (in\ metric\ tons) \times GWP\ of\ that\ gas$$

Global warming potential measures a greenhouse gas's ability to trap heat in the atmosphere over a specific time horizon, typically 20 years, 100 years, or 500 years.

The GWP values are calculated by comparing the radiative forcing (energy trapped in the Earth's atmosphere) caused by a given mass of a greenhouse gas to the same mass of carbon dioxide over a given time period.

Ways to reduce carbon footprint



Energy Simulation: To Decrease Carbon Footprint

BIM enables architects and engineers to optimize building designs for energy efficiency, incorporate sustainable materials, and implement efficient water management strategies, thus reducing environmental impact throughout the building lifecycle.

Modular Construction : Modular construction refers to a process in which building components are constructed off-site. These components are then transported as a completed component to a building site. The modular construction institute reported that modular construction allowed projects to be completed in half the time of the conventional construction.

- Prefabricated buildings: Their origins can be traced back to the late European colonial period and the post-World War I period, when there were numerous temporary and emergency prefabricated edifices. The majority of these systems were used to build edifices at minimal cost in short timeframes, often at the expense of quality.
- The adoption of Life Cycle Assessment (LCA) in the building industry enables a low carbon transition by evaluating energy use and environmental impacts across material production, construction, operation, and end-of-life, addressing issues like high construction costs, waste generation, safety risks, and energy use. Integrated BIM-based LCA allows for parallel execution of trades, reducing project duration, and real-time evaluation and improvement of prefabricated/modular construction to minimize life cycle impacts of buildings.

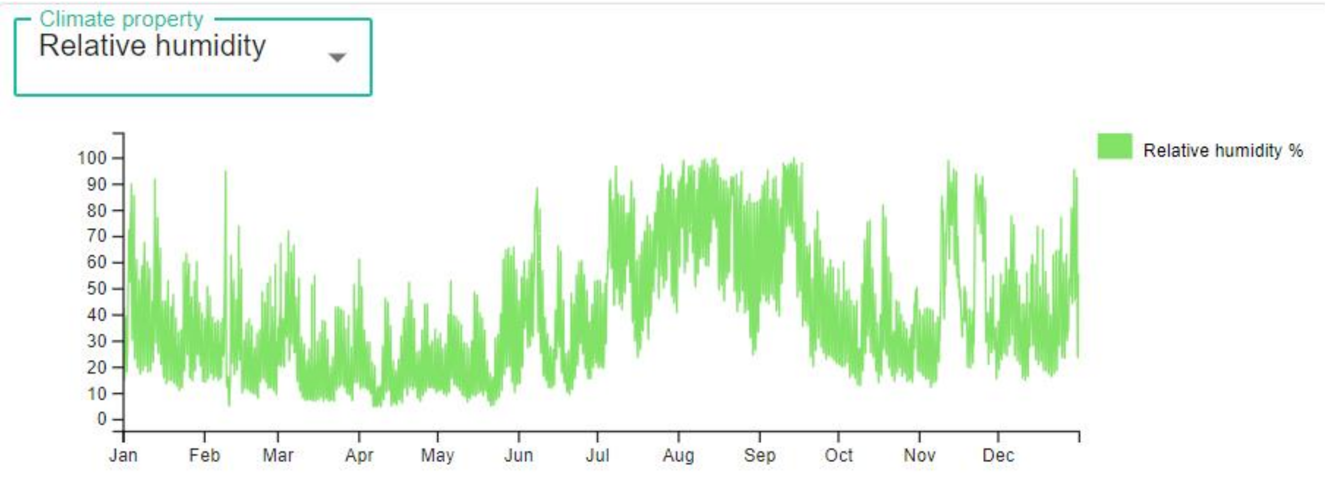
Energy Simulation Practical Model

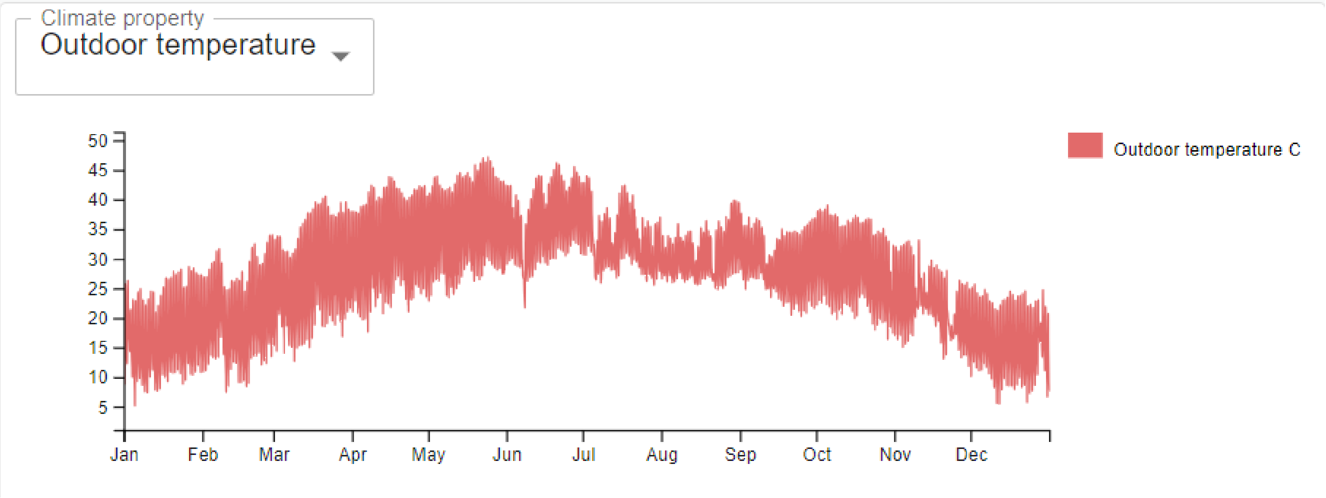
Poor Insulated Heavy Building

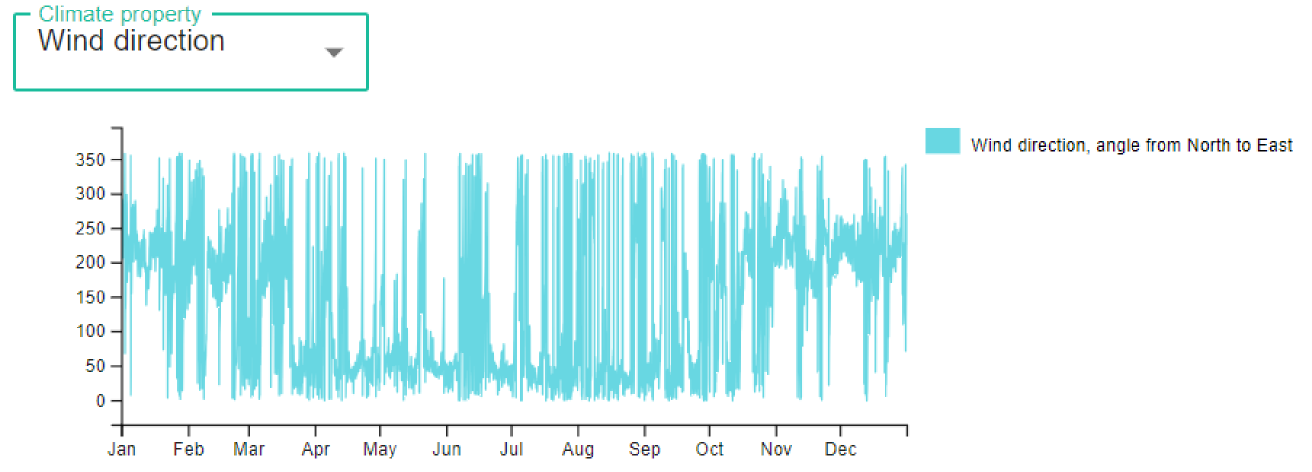
- **Location : Paota, Jodhpur**
- **Climate Data Time Period : 1981-2010**

Platform Link:

https://evaluation.bim.energy/







Climate property
Wind direction
Wind direction, angle from North to East
350
300
250
200
150
100
50
0
Jan
Feb
Mar
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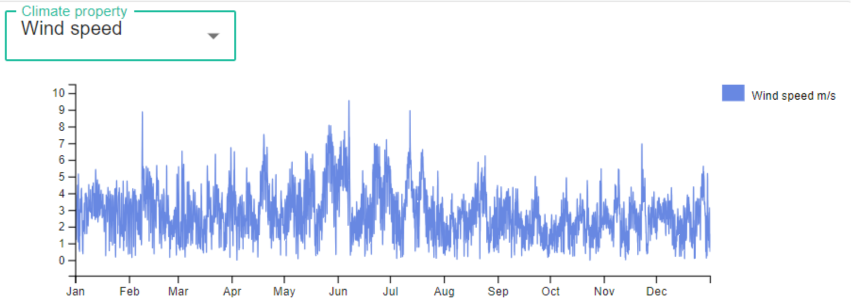
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec



Climate property
Wind speed
Wind speed m/s
10
9
8
7
6
5
4
3
2
1
0
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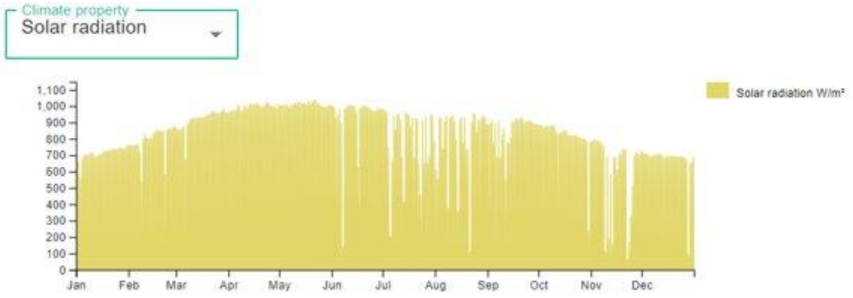
Dec



Climate property
Solar radiation
Solar radiation W/m²
1,100
1,000
900
800
700
600
500
400
300
200
100
0
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Building

Settings for basic geometry

Building height

11.024 m

Story height (inner measure)

2.5 m

Number of storys

4

Number of basement storys

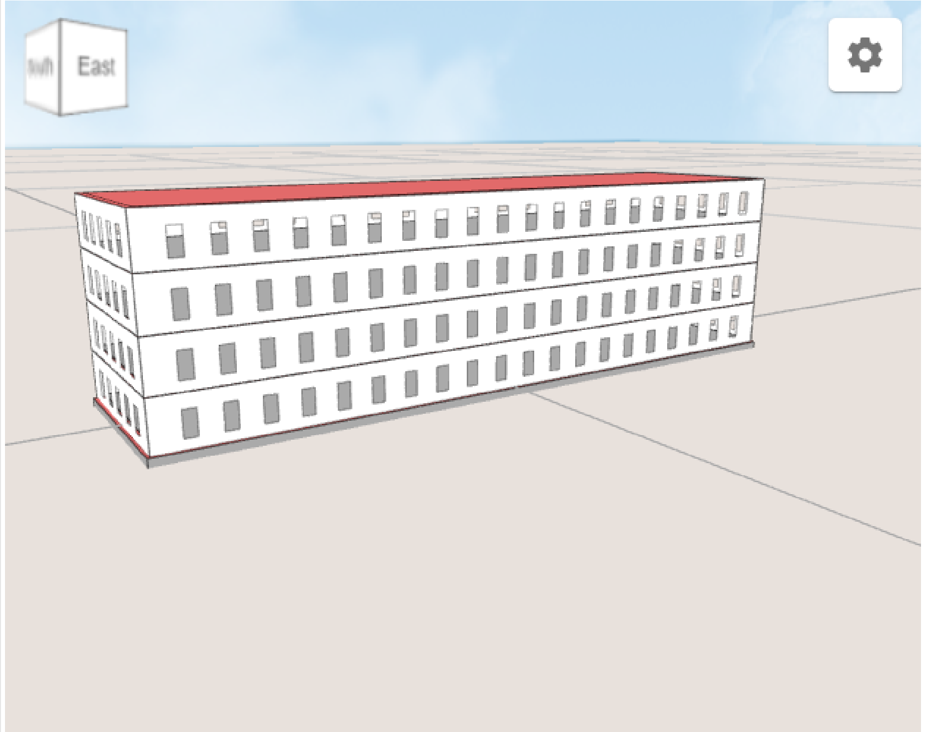
1

Width

10 m

Depth

40 m



Time Scheduling and Modular Construction

Name	Orientation	Type	Lowest Level (m)	Highest Level (m)	Amount	Area (m²)
Basement floor	BF 0-6M	Underground slab	-2.5	-2.5	1	500.0
Poorly insulated heavy building, interior floor	INNER	Interior floor	0.0	8.5	8	4000.0
Basement wall	BW 0-1M	Underground wall	-1.0	0.0	7	120.0
Basement wall	BW 1-2M	Underground wall	-2.0	-1.0	7	120.0
Basement wall	BW >2M	Underground wall	-2.5	-2.0	7	60.0
Poorly insulated heavy building, exterior wall	WEST	Exterior wall	0.3	11.0	4	320.0
Poorly insulated heavy building, exterior wall	SOUTH	Exterior wall	0.3	11.0	8	160.0
Poorly insulated heavy building, exterior wall	EAST	Exterior wall	0.3	11.0	8	320.0
Poorly insulated heavy building, exterior wall	NORTH	Exterior wall	0.3	11.0	8	160.0
Poorly insulated heavy building, roof	ROOF	Roof	11.0	11.0	1	500.0
Poorly insulated heavy building, double glazed window	WEST	Window	0.5	10.2	80	80.0
Poorly insulated heavy building, double glazed window	SOUTH	Window	0.5	10.2	40	40.0
Poorly insulated heavy building, double glazed window	EAST	Window	0.5	10.2	80	80.0

Thermal bridge	Psi Value	Amount	Length
External wall / External wall	0.20	28	75.7
External wall / Internal slab	0.20	28	480.0
Windows and doors	0.04	240	1018.2
Underground wall / Underground slab	0.27	7	120.0
Underground wall / Underground wall	0.20	7	17.5
External wall / Roof	0.14	7	120.0

Thermal bridges, also known as cold bridges or heat bridges, refer to areas in a building's envelope (walls, roof, floor, or windows) where there is a higher rate of heat transfer than in the surrounding materials.

Wind Velocity % climate file : Freely exposed buildings 95%, Moderately protected buildings 70%, Inner city buildings 45%

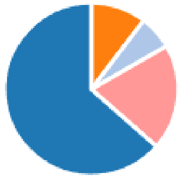
Azimuth angle is a measure of the sun's position relative to an observer's location and is influenced by the local topography, including surrounding buildings, hills, and other structures.

The U-value (also known as thermal transmittance or thermal conductivity) of a material refers to its ability to conduct heat. A lower U-value indicates that the material has better insulating properties, as it restricts heat transfer more effectively.

Before Energy Simulation

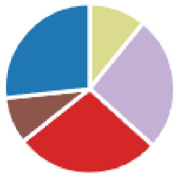
Emitted energy

- Transmission: -13.2 %
- Infiltration: 8.2 %
- Ventilation: 0 %
- Waste water: 24.7 %
- Cooling: 80.3 %



Supplied energy

- Energy recovery ventilation: 0 %
- Heat recovery tap water: 0 %
- Energy recovery heat pump: 0 %
- Solar energy through windows: 10.8 %
- Process energy room: 25.8 %
- Heat supply: 27.9 %
- Electricity use: 0 %
- Human heat gain: 8.6 %
- Latent energy: 26.9 %
- Photovoltaic power: 0 %



Average U-value:
1.03 W/m²,K

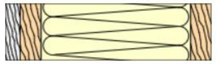
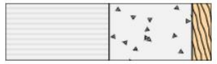
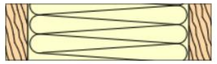
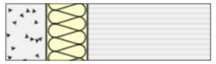
Average ventilation flow :
0 l/s,m²

Total energy use:
56697 kWh/year

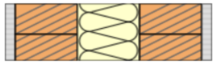
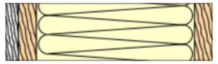
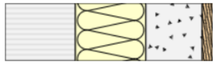
Energy performance:
22.7 kWh/m²/year

Construction

Constructions set for Poorly insulated heavy building

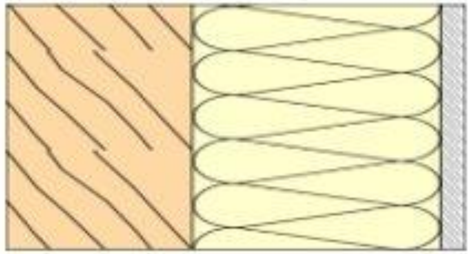
Type	Display	Name	Thickness (m)	U-value (W/m²,K)
Exterior wall:		Poorly insulated heavy building, exterior wall	0.34	1.41
Roof:		Poorly insulated heavy building, roof	0.28	0.61
Slab on grade:		Poorly insulated heavy building, slab on grade	0.30	1.56
Interior wall:		Poorly insulated heavy building, interior wall	0.16	2.44
Interior floor:		Poorly insulated heavy building, interior floor	0.26	0.71
Underground wall:		Basement wall	0.50	0.25

Constructions set for Highly insulated heavy building

Type	Display	Name	Thickness (m)	U-value (W/m²,K)
Exterior wall:		Highly insulated heavy building, exterior wall	0.40	0.25
Roof:		Highly insulated heavy building, roof	0.32	0.16
Slab on grade:		Highly insulated heavy building, slab on grade	0.44	0.21
Interior wall:		Highly insulated heavy building, interior wall	0.07	4.74
Interior floor:		Highly insulated heavy building, interior floor	0.16	3.79

Make Own Material

Outer Wall 1 U-value 0.33 W/m²K



☐ Show 3D

Properties	Value	Unit
U-value:	0.33	W/m²K
Delta U:	0	W/m²K
Solar Absorption:	50	%
Air leakage q50:	0.5	l/s, m²

Material layers from the outside

Wood	0.075 m
100 mm mineral wool 36 between wooden studs 45mm, cc600	0.1 m
Plywood	0.01 m

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Indicators

Average U-value:
0.63 W/m²,K

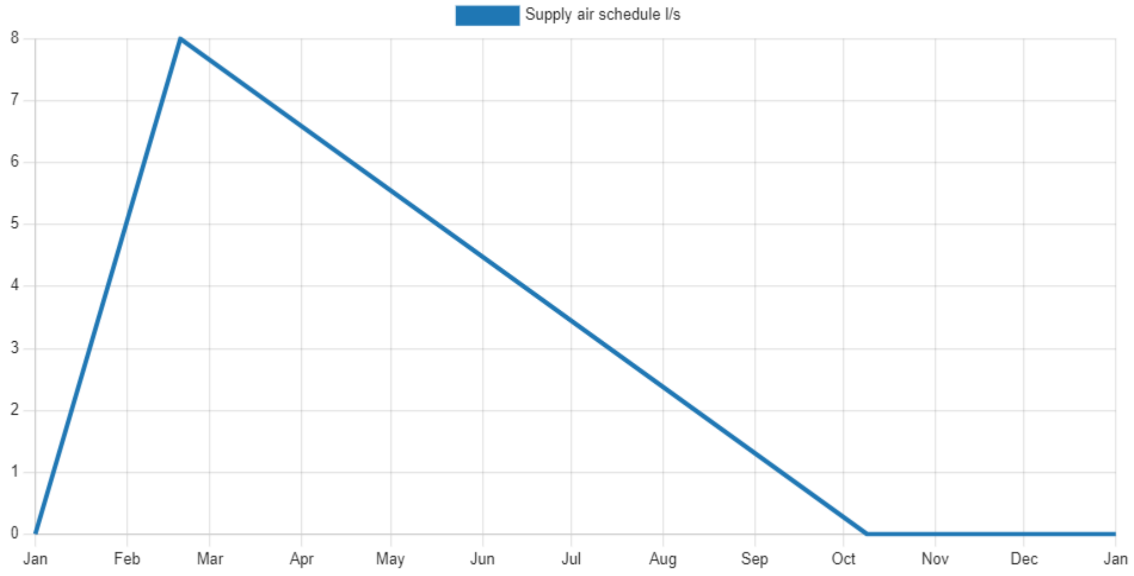
Average ventilation flow :
0 l/s,m²

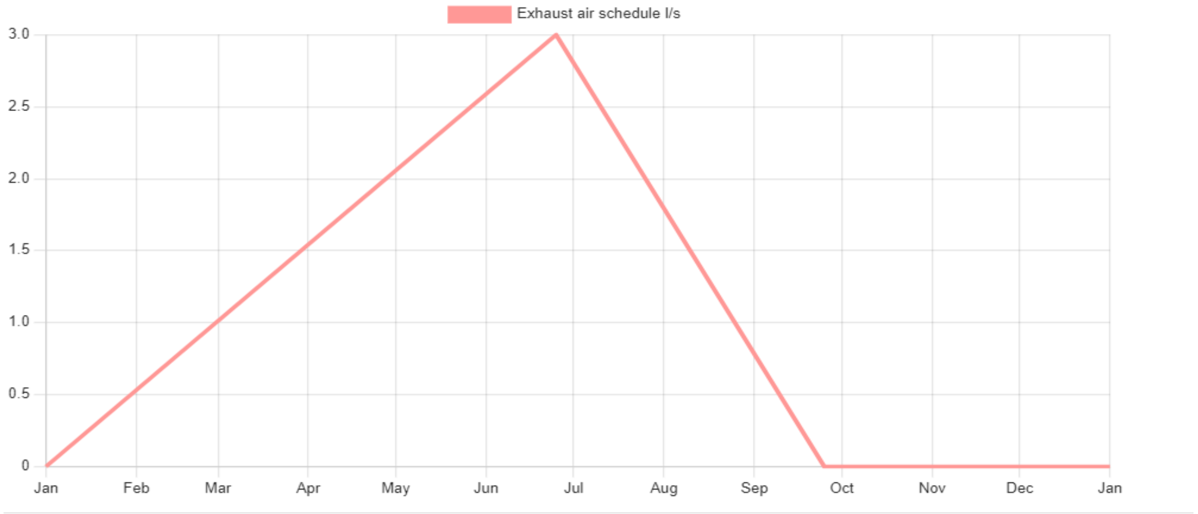
Total energy use:
50751 kWh/year

Energy performance:
20.3 kWh/m²/year

"Change Comes After One Material Change: Transforming the Exterior Wall"

Ventilation





Heating Water-Borne Heating vs. Electric Heating

Water-Borne Heating	Electric Heating
Water-borne heating, also known as hydronic heating or radiant heating, uses hot water as a heat transfer medium for space heating.	Electric heating relies on electrical resistance to generate heat.
Water-borne heating is more energy-efficient due to water's higher heat capacity, enabling effective heat storage and distribution.	Electric heating is less efficient as it directly converts electrical energy into heat.
Water-borne heating provides even and comfortable heating through radiant heat transfer from surfaces.	Electric heating may lead to local temperature variations and a less uniform heating experience.
Hydronic systems have higher upfront costs due to piping and boiler equipment installation.	Electric heating systems have lower initial costs and are easier to install.

Geothermal Heat Pump System and Geothermal Rock

Utilizes the Earth's thermal mass to extract heat in winter and reject heat in summer.

Highly energy-efficient and environmentally friendly heating and cooling solution.

Role of Geothermal Rock:

- Provides a stable and consistent temperature source or sink.
- Enhances the efficiency and performance of the geothermal heat pump system.

Conclusion:

- Water-borne heating offers efficient and comfortable space heating through radiant heat transfer.
- Electric heating may have lower initial costs but lacks the efficiency and uniformity of hydronic systems.
- Geothermal heat pump systems, leveraging the geothermal rock, are an eco-friendly and sustainable heating and cooling solution for buildings.

Cooling

- District cooling is a centralised cooling system that serves multiple buildings or a whole district from a central plant. In this system, chilled water is produced at the central plant and then distributed through a network of underground pipes to individual buildings. The chilled water is used to cool down air in buildings' air conditioning systems, providing a more efficient and sustainable cooling solution compared to individual cooling systems for each building. District cooling is an energy-efficient approach as it allows for the use of larger and more efficient cooling plants, waste heat recovery, and optimized operation.
- Geothermal Heat Pump

After Energy Simulation

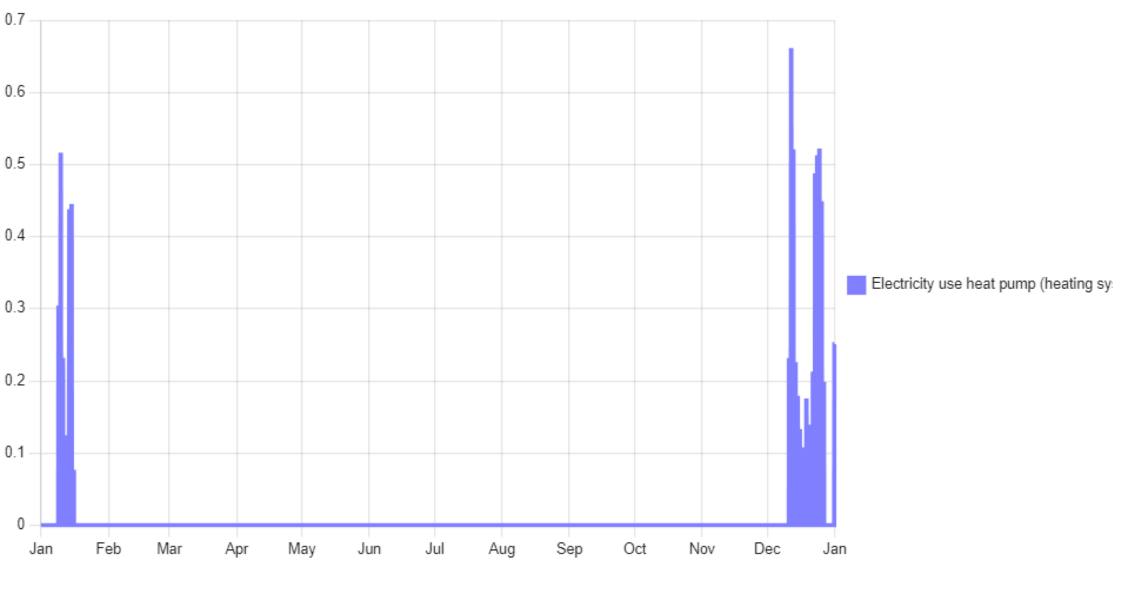
Indicators

Average U-value:
0.63 W/m²,K

Average ventilation flow :
0 l/s,m²

Total energy use:
9317 kWh/year

Energy performance:
3.7 kWh/m²/year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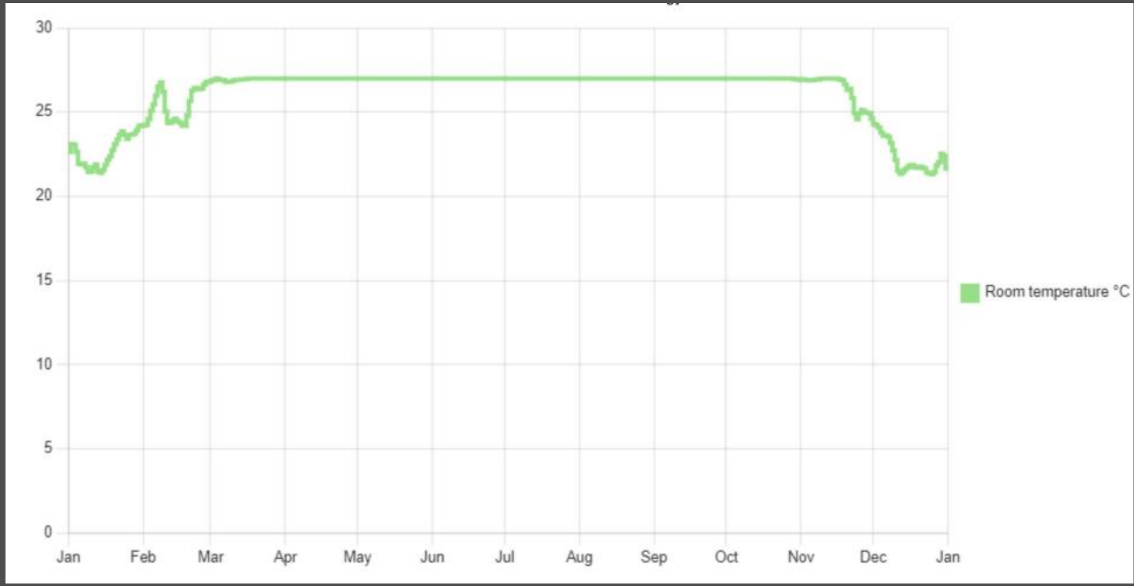
Electricity use heat pump (heating sy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Oct
Nov
Dec
Jan
Room temperature °C

Thank You

"Expanding with numerous plugins and properties, this model achieves unparalleled capabilities."