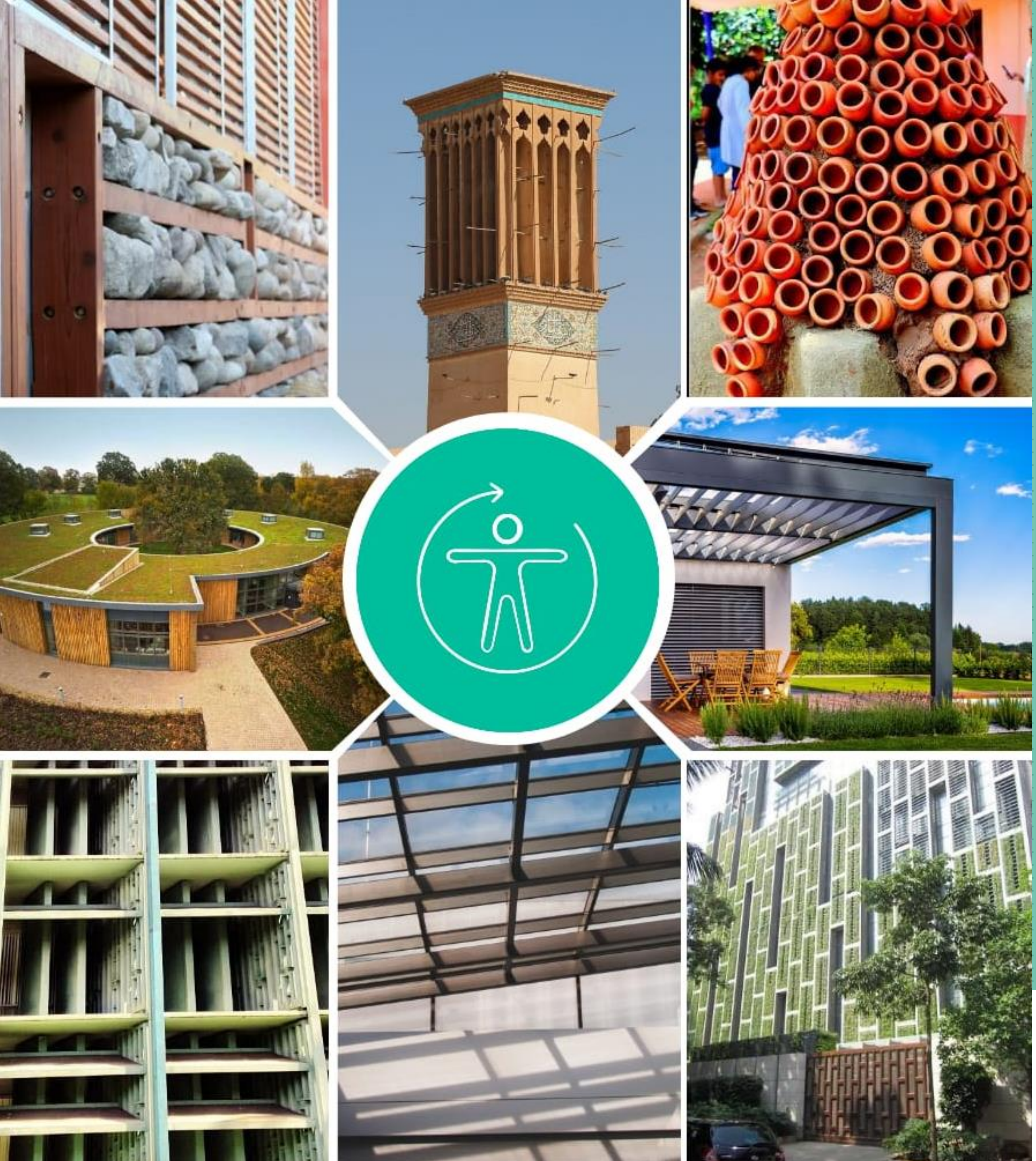


GGGI

ASIA LOW CARBON BUILDINGS TRANSITION PROJECT
Life Cycle Assessment for Transitioning to a Low-Carbon Economy

3.1 Concept of Net Zero Carbon Buildings

November 2024

ASEAN CENTRE FOR ENERGY · ACE

EESL

HEAT

Supported by:

Federal Ministry for Economic Affairs and Climate Action

IKI INTERNATIONAL CLIMATE INITIATIVE

on the basis of a decision by the German Bundestag

WHAT WILL YOU LEARN?

01 Climate Change and Carbon Footprint

02 Net Zero Carbon Buildings: Concepts and Approaches

03 Global Net Zero Building Commitments

04 Net Zero Building: Case Examples

Climate Change and Carbon Footprint

Emissions and Global Warming

CLIMATE CHANGE AND CARBON

Greenhouse gases

Since the 1800s, greenhouse gases (GHGs) from human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil and gas.

Key GHGs emitted by human activities are:

- **Carbon dioxide** (CO_2): Primarily from burning fossil fuels. Also, through deforestation, land clearance for agriculture or development, degradation of soils and land management
- **Methane** (CH_4): From agricultural activities, waste management, energy production and use, and biomass burning
- **Nitrous oxide** (N_2O): From agricultural activities, such as fertilizer use, chemical production and fossil fuel combustion
- **Fluorinated gases** (F-gases): From industrial processes, refrigeration, and the use of a variety of consumer products including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF6)

Global net anthropogenic GHG emissions

65% from CO_2 (fossil fuels and industry)

18% from CH_4

11% from CO_2 (land use, land use change and forestry)

6% from N_2O and fluorinated GHG gases

Source: United States Environmental Protection Agency, 2024

CLIMATE CHANGE AND CARBON

Global warming potential and CO_2 equivalent

- The global warming potential (GWP) allows comparisons of the global warming impacts of different GHGs
- It is a measure of how much energy the emission of 1 ton of a gas will absorb over a given time duration, relative to the emission of 1 ton of carbon dioxide (CO_2)
- The time duration usually used for GWPs is 100 years
- The metric used for measuring GWP of a GHG is CO_2 equivalent (CO_2e)

Global warming potential of greenhouse gases

Greenhouse gases	GWP over 100 years
Carbon dioxide (CO_2)	1
Methane (CH_4)	27–29.8
Nitrous Oxide (N_2O)	273
Sulfur hexafluoride (SF_6)	24,300
Perfluorocarbon (PFC)	7,380 – 12,400
Hydrofluorocarbon (HFC)	4.84–14,600

Table source: IPCC, 2021

CARBON EMISSIONS

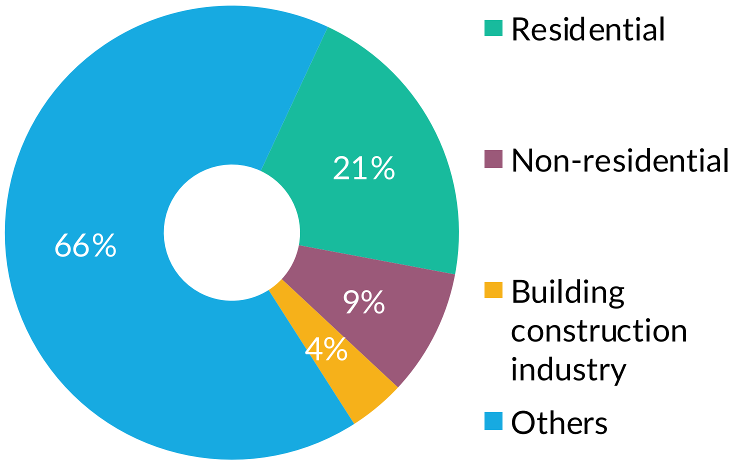
Global impact of the construction and building industry

Globally, buildings consume more than 30%–34% of the total energy demand for operational requirements and production of construction materials. In 2022, CO_2 emissions from building operations and construction reached a new high of 37% of total emissions (*Direct emissions are from resources owned and controlled by the user, while indirect emissions are due to generation of purchased electricity)*

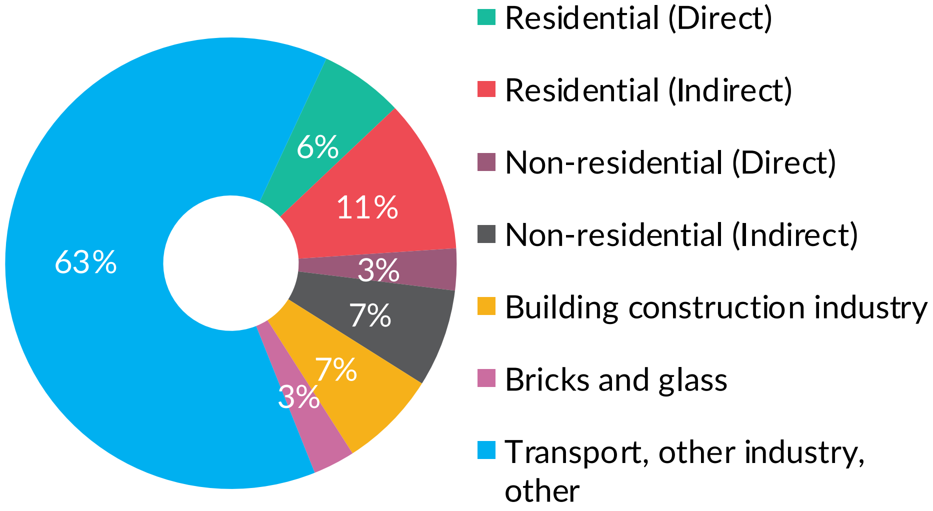
30%–34%
of total energy
consumed by buildings

37%
of total CO_2 emissions

Share of buildings in total final energy consumption (2022)
Energy demand by sector 2022



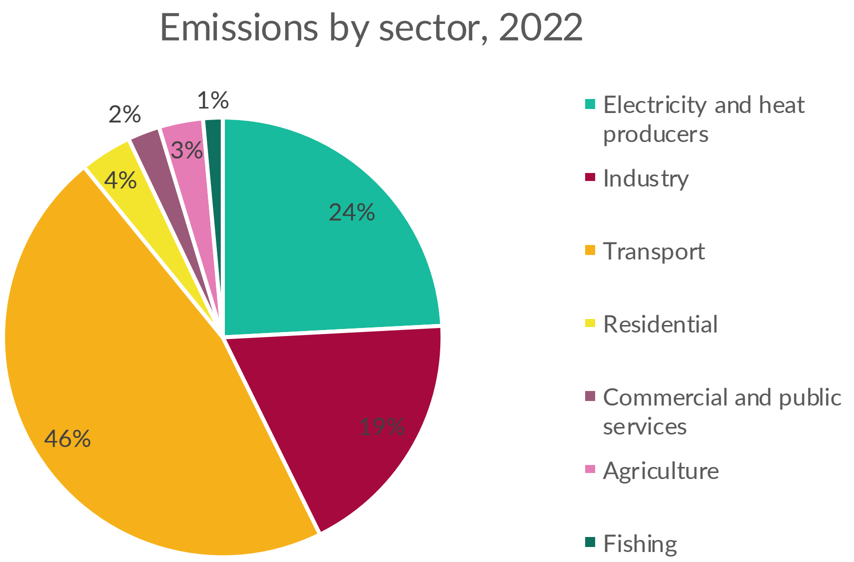
Share of buildings in global energy and process emissions (2022)
Emissions by sector 2022

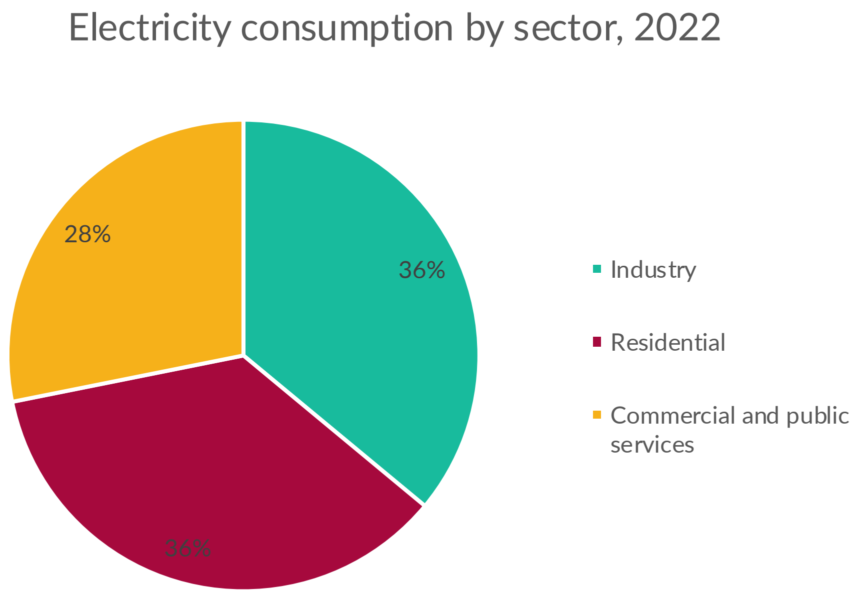


Sources: International Energy Agency, 2023a; United Nations Environment Programme, 2024

EMISSIONS AND ELECTRICITY CONSUMPTION

Cambodia





Largest sources of emissions:

- Transport = 46%
- Electricity and heat producers = 24%

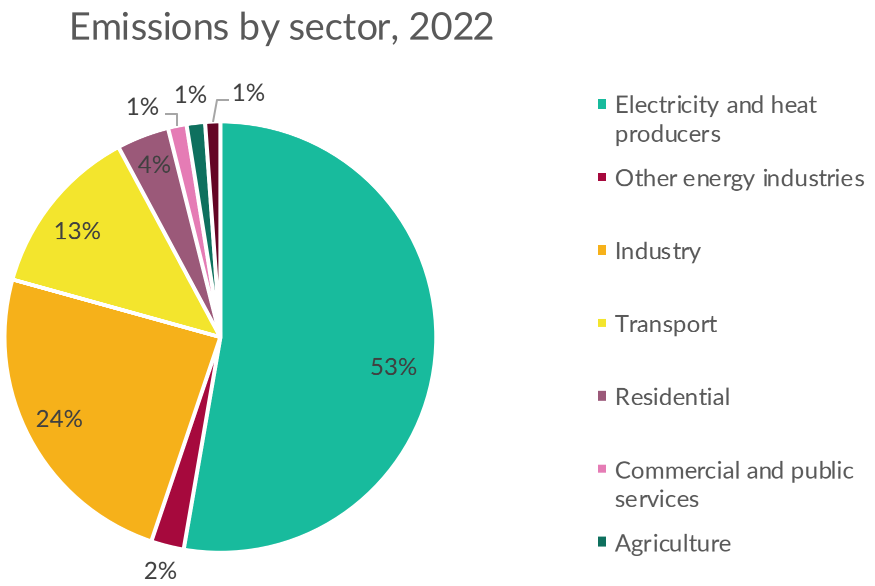
Largest consumers:

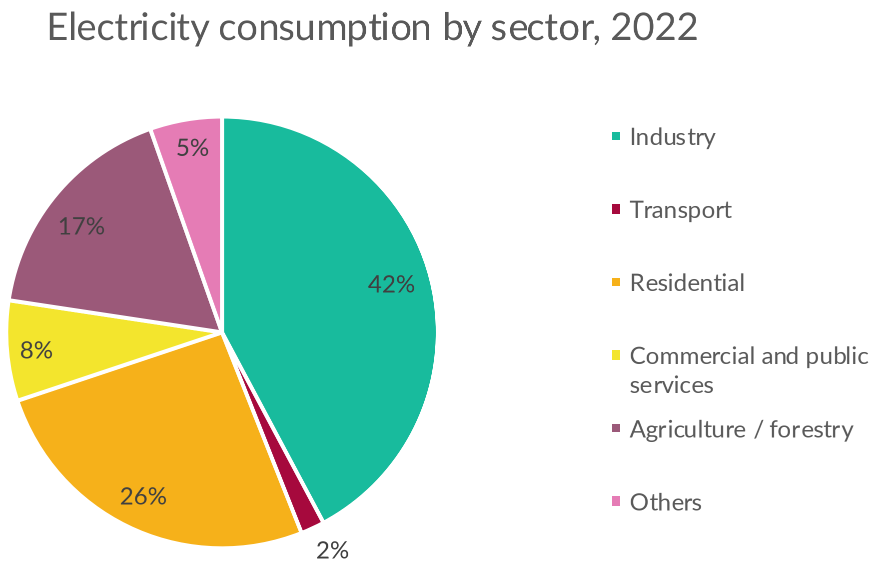
- Industry = 36%
- Residential = 36%

Source: https://www.iea.org/countries/cambodia

EMISSIONS AND ELECTRICITY CONSUMPTION

India





Largest sources of emissions:

- Electricity and heat producers = 53%
- Industry = 24%

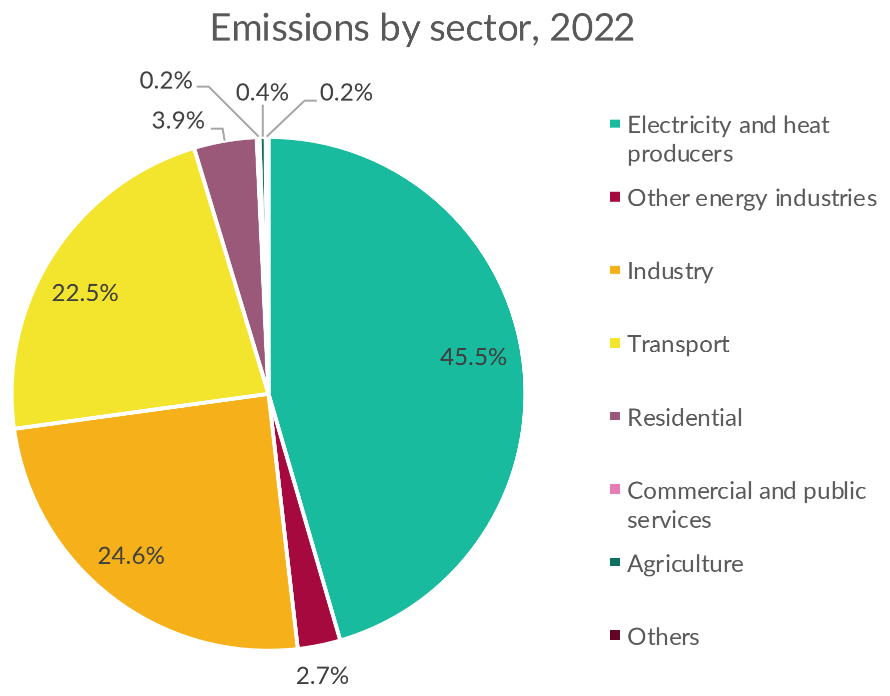
Largest consumers:

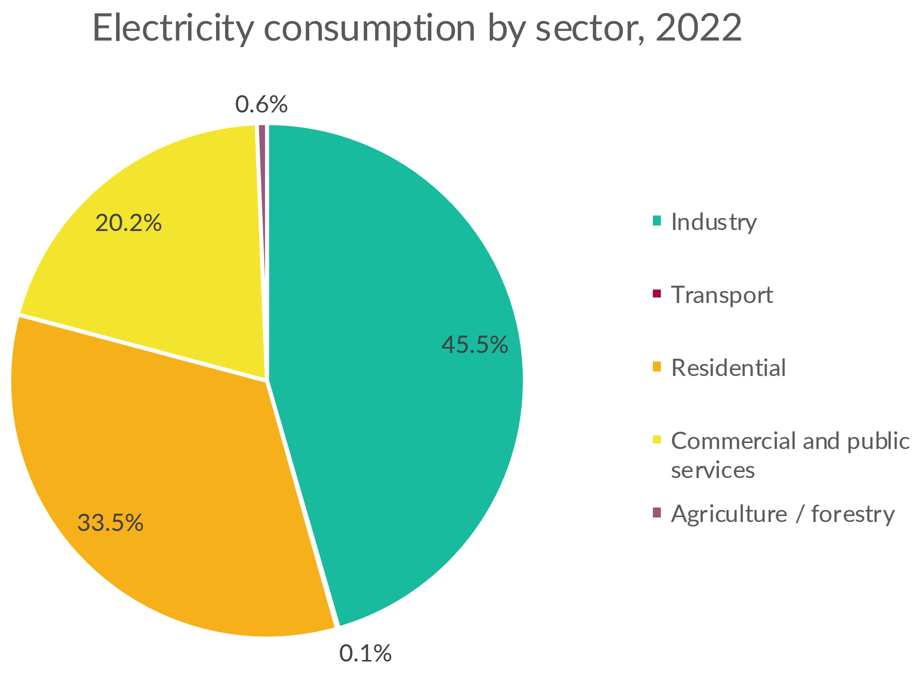
- Industry = 42%
- Residential = 26%

Source: https://www.iea.org/countries/india

EMISSIONS AND ELECTRICITY CONSUMPTION

Indonesia





Largest sources of emissions:

- Electricity and heat producers = 45%
- Industry = 25%

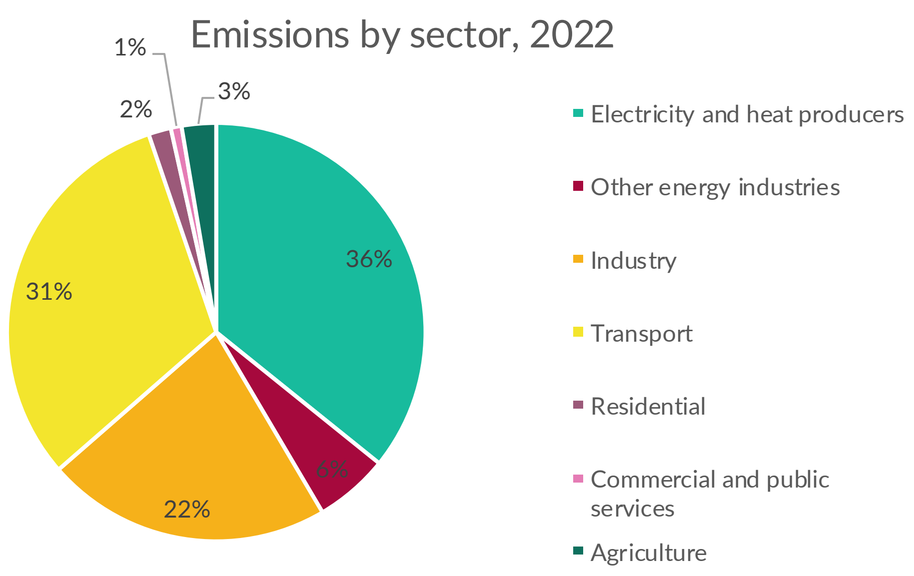
Largest consumers:

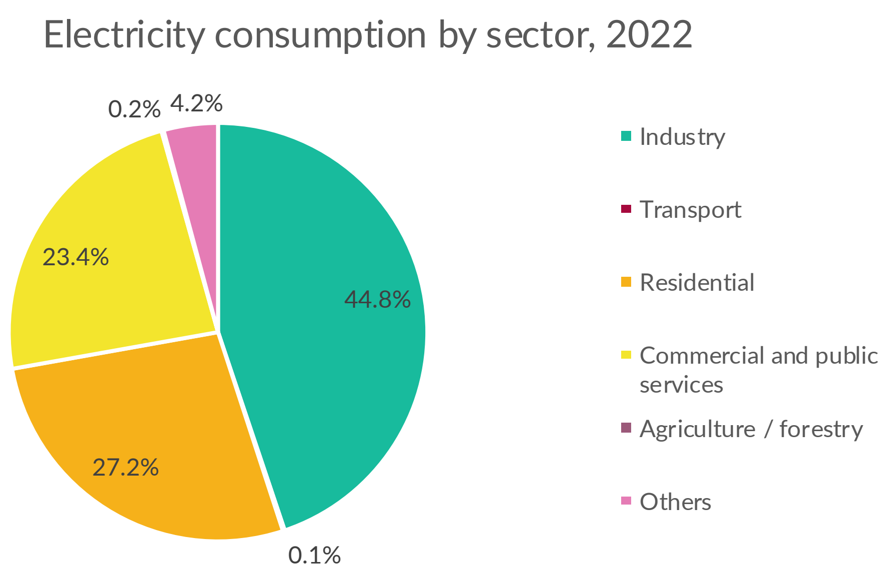
- Industry = 46%
- Residential = 34%

Source: https://www.iea.org/countries/indonesia

EMISSIONS AND ELECTRICITY CONSUMPTION

Thailand





Largest sources of emissions:

- Electricity and heat producers = 36%
- Transport = 31%

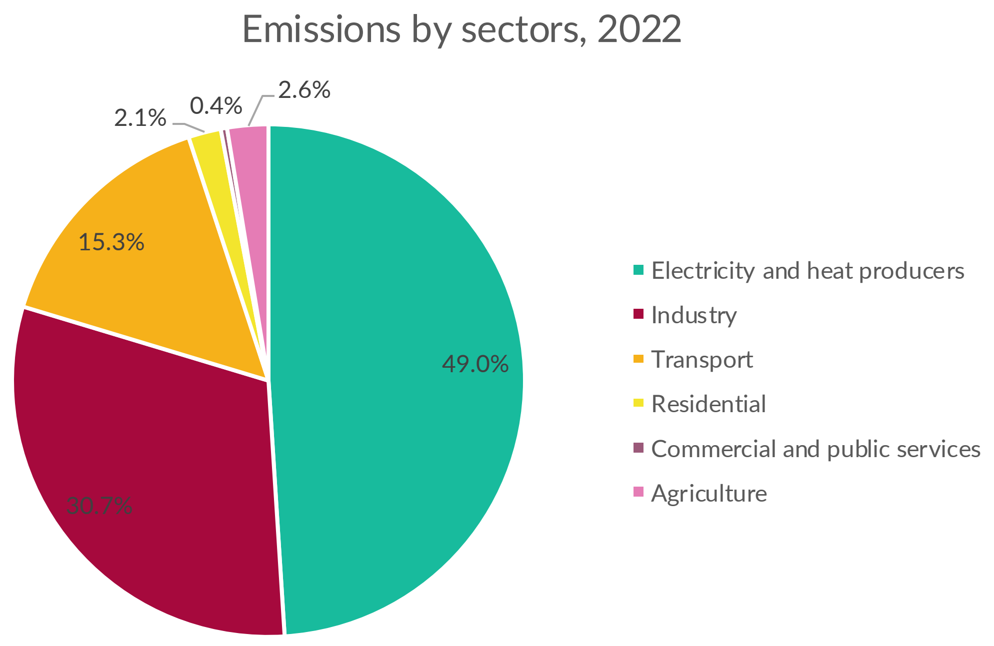
Largest consumers:

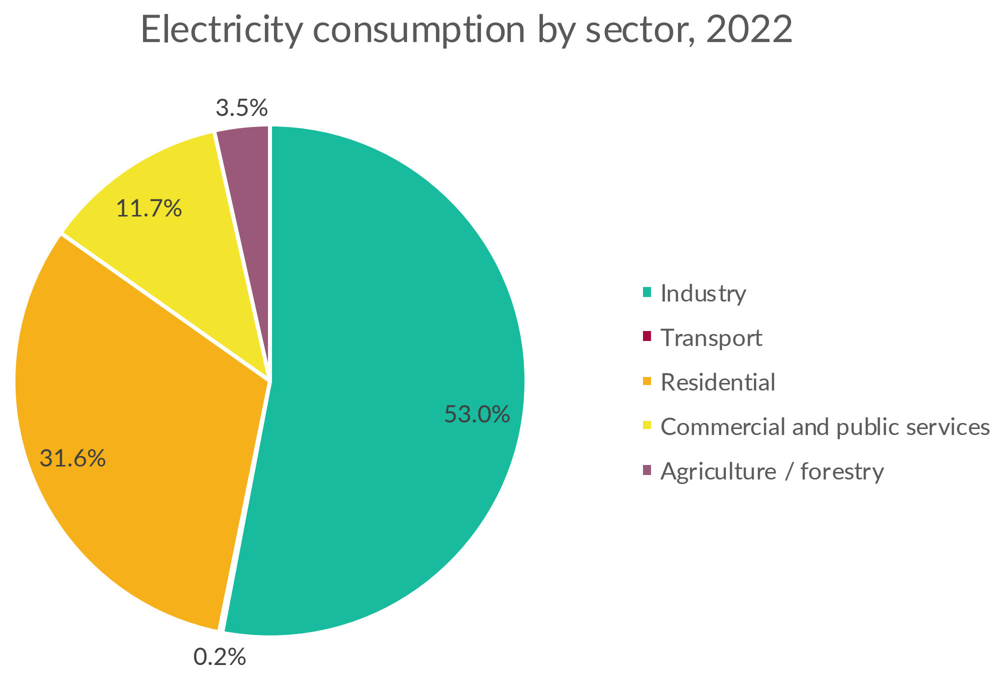
- Industry = 45%
- Residential = 27%

Source: https://www.iea.org/countries/thailand

EMISSIONS AND ELECTRICITY CONSUMPTION

Vietnam





Largest sources of emissions:

- Electricity and heat producers = 49%
- Transport = 31%

Largest consumers:

- Industry = 53%
- Residential = 32%

Source: https://www.iea.org/countries/vietnam

Net Zero Carbon Buildings

Concepts and Approaches

NET ZERO CARBON BUILDINGS

The concept

- **Net zero carbon** means cutting carbon emissions to a small value of residual emissions that can be absorbed and durably stored by nature and other carbon dioxide removal measures, leaving zero in the atmosphere[1]
- **Net zero carbon buildings** are designed so that the total greenhouse gas emissions from their entire life cycle amount to zero or less[2]
- However, there are different definitions and types of net zero buildings depending on the scope

[1] *Source: United Nations Climate Action*
[2] *Source: Ramachandran, 2024*

NET ZERO CARBON BUILDINGS

Definitions

- **Net zero carbon – construction** when the amount of carbon emissions associated with a building's product and construction stages up to practical completion is zero or negative, through use of offsets or the net export of onsite renewable energy
- **Net zero carbon – operational energy** when the amount of carbon emissions associated with the building's operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from onsite and/or offsite renewable energy sources, with any remaining carbon balance offset
- **Net zero carbon – whole life** when the amount of carbon emissions associated with a building's embodied and operational impacts over the life of the building, including its disposal, are zero or negative

Source: UK Green Building Council, 2019

NET ZERO CARBON BUILDINGS

Levels of adoption

The adoption of net zero carbon buildings will need various approaches:

i. **Energy efficient buildings:** Provide significant energy savings through optimized construction and systems for heating, cooling, lighting and other services

ii. **Low carbon buildings:** Incorporate low carbon energy sources and may require upgrades in existing equipment to reduce carbon emissions fully

iii. **Nearly zero carbon building:** Achieve high energy efficiency and include some form of zero-emission energy but fall short of completely neutralizing their energy consumption

Source: United Nations Environment Programme, 2024

Image source: https://theleaflet.in/indias-challenges-towards-achieving-net-zero-goals/

NET ZERO CARBON BUILDINGS

Levels of adoption (continued)

iv. **Net zero carbon buildings:** Meet their energy needs with zero-emission sources over a set period, typically a year. Zero carbon buildings are similar but ensure that all energy demands are met with zero-emission energy throughout the period

v. **Carbon negative buildings:** Produce more renewable energy than they consume, contributing the surplus to the grid for external use

vi. **Whole life cycle net zero carbon buildings:** Represent the pinnacle of sustainability, maintaining a zero-carbon energy status while also ensuring that the embodied emissions from their construction materials are net zero, achieved through either decarbonization or offsets

vii. **Green buildings:** Also known as green construction, sustainable building, or eco-friendly building, refer to both a structure and the application of processes that are environmentally responsible and resource-efficient throughout a building's life cycle from planning to design, construction, operation, maintenance, renovation and demolition

Source: United Nations Environment Programme, 2024

Image source: https://theleaflet.in/indias-challenges-towards-achieving-net-zero-goals/

NET ZERO CARBON BUILDINGS

Whole life carbon approach

Total decarbonization of the built environment calls for the industry to adopt the **whole life carbon approach** that addresses emissions from operational energy use in buildings, and the embodied carbon, which comes from the building materials and construction or renovation processes

Source: World Green Building Council

WHOLE LIFE CARBON

Embodied and operational carbon

- The **whole life** of a building is the entire life of a building from the material sourcing, manufacturing, construction, use over a given period, demolition, and disposal or reuse
- **Whole life carbon** refers to the carbon impacts over the entire life cycle of a built asset, from its construction through to its end of life
- The whole life carbon of a building broadly consists of **embodied carbon and operational carbon**
- In addition, there are user carbon impacts from the activities of the users of a built asset, outside of the use of energy and water to operate the asset

Source: Royal Institute of Chartered Surveyors, 2023

Image source: Gensler, Garett Rowland

Global Net Zero Buildings

Commitments

REDUCING CARBON EMISSIONS

Way forward for buildings

Lower reliance on fossil fuels by reducing operation energy consumption

- Passive design and improve building envelope
- Systems efficiency
- Energy management

Minimize embodied carbon, both upfront and during building life cycle

- Repurpose existing buildings and materials
- Reduce the need for material replacements
- Optimize material usage and design with low carbon materials
- Use low carbon construction technologies and eliminate waste

Increase renewable energy use

- Prioritize onsite renewable energy generation
- Procure offsite renewable energy

Offset any remaining carbon

Sources: UK Green Building Council, 2019; Ramachandran, 2024

NET ZERO BUILDINGS

Global commitments

World Green Building Council Commitment

By 2030, all new buildings, infrastructure and renovations must reduce embodied carbon by at least 40%, with significant upfront carbon reduction. Additionally, all new buildings must achieve net zero operational carbon. By 2050, all buildings, including existing ones, along with new infrastructure and renovations, must achieve net zero embodied carbon and net zero operational carbon

UK Green Building Council Advancing Net Zero Program

Aims to drive the transition toward net zero carbon buildings in the UK, focusing on reducing emissions from the construction and property sectors

The 2030 Challenge for Embodied Carbon by Architecture 2030

The target is to achieve a GWP of 40% below the current industry average immediately, with the following goals:

- 45% or better by 2025
- 65% or better by 2030
- Zero GWP by 2040

Source: Ramachandran, 2024

NET ZERO BUILDINGS

Global commitments

Race to Zero

UN-backed global campaign rallying non-state actors — including companies, cities, regions, financial and educational institutions — to take rigorous and immediate action to halve global emissions by 2030 and deliver a healthier, fairer zero carbon world in time

The American Institute of Architects (AIA) 2030 Commitment

A climate strategy that sets standards and goals for achieving net zero emissions in the built environment, with architects, engineers and owners urged to take immediate and decisive action to reach net zero emissions by 2030

C40 Cities Pledge

Aims to inspire and mobilize stakeholders to take action and implement policies that:

- Reduce embodied emissions by at least 50% for all new buildings and major retrofits by 2030, with a target of 30% by 2025
- Reduce embodied emissions by at least 50% for all infrastructure projects by 2030, with a target of 30% by 2025
- Procure and, where possible, use only zero-emission construction machinery from 2025 and ensure all construction sites are zero emission by 2030

The Royal Institute of British Architects (RIBA) 2030 Climate Challenge

A framework that sets ambitious targets for architects to help reduce the built environment's carbon footprint and contribute to global climate goals

Source: Ramachandran, 2024

Net Zero Buildings

Case Examples

ENERGY EFFICIENT BUILDINGS

Case example: Indira Paryawaran Bhavan, India

- Indira Paryawaran Bhawan, the new building of the Ministry of Environment and Forest, located in New Delhi is India's highest green rated building. It has achieved an **LEED platinum and GRIHA 5-star rating**
- The building uses **70% less energy** than a conventional building by applying several passive design strategies like adequate **natural light, shading and landscaping to reduce ambient temperature and energy use**

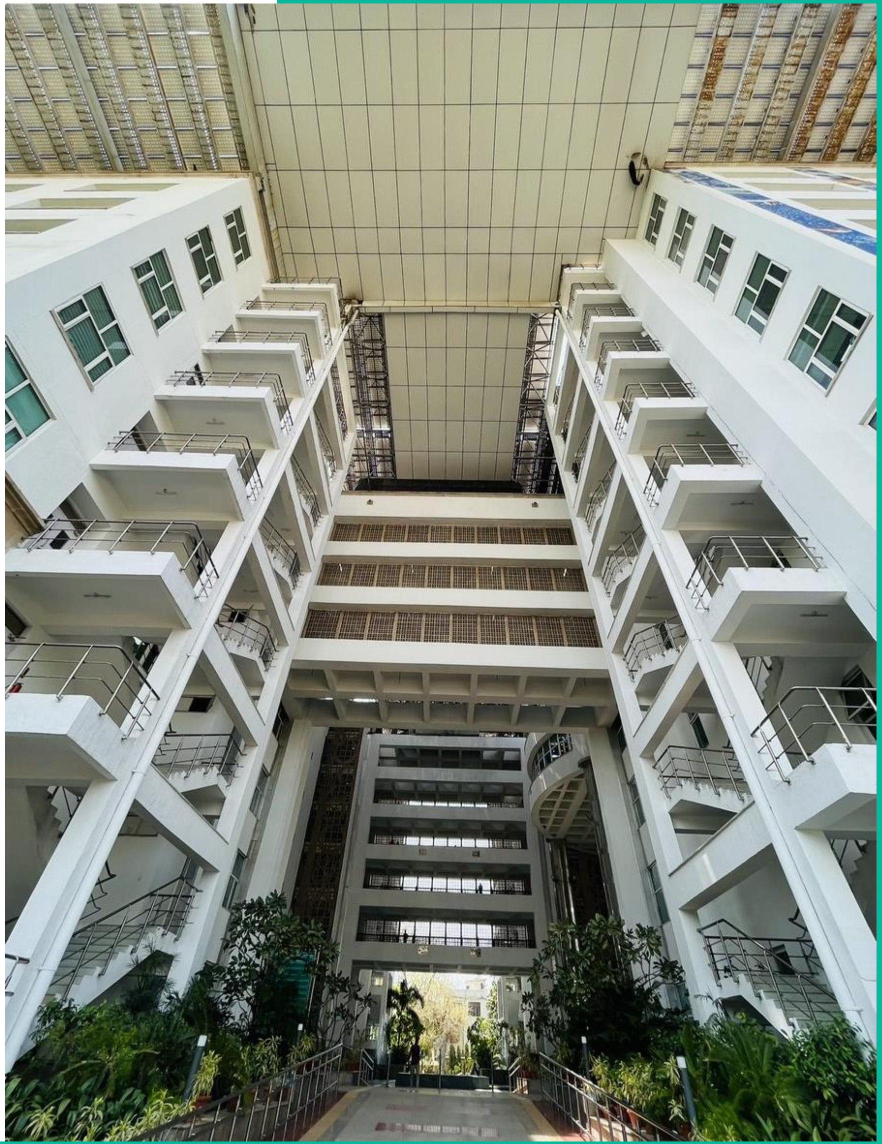
Image source: NBM and CW, 2018

Source: Bureau of Energy Efficiency, Government of India and United States Agency for International Development

ENERGY EFFICIENT BUILDINGS

Case example: Indira Paryawaran Bhavan, India (continued)

- Received **several awards** for exemplary demonstration of renewable energy technologies
- Demonstrates an **Energy Performance Index of 44 kWh/sqm/year**
- Generates about **1.43 million units per year** through solar panels that power the facility, and exports surplus power to the grid
- Integrates several effective passive and active measures:
  - Optimum orientation and building envelope
  - Energy efficient lighting systems
  - Sustainable cooling using strategies like chilled beams
  - Variable speed screw chillers
  - Precooling of fresh air is by a geothermal system
- Heating, ventilation and air conditioning (HVAC) load is 40 sqm/TR, surpassing India's Energy Conservation Building Code requirement of 20 sqm/TR



Source: Bureau of Energy Efficiency, Government of India and United States Agency for International Development

ZERO ENERGY BUILDINGS

Case example: Santa Monica City Hall East, USA

- The new city hall of Santa Monica is a **mid-rise office building** with a gross area of **50,000 sq. ft.**, designed to meet the standards of **Living Building Challenge aiming for a net zero energy performance certification**
- Modeled **Energy Use Intensity (EUI) is 7.9 kWh/ sq. ft. /year**
- The project has a **292 kW DC solar PV system that produces 7.9 kWh/sq. ft./year,** achieving the net zero energy goal

Source: Dean, 2022

ZERO ENERGY BUILDINGS

Case example: Santa Monica City Hall East, USA (continued)

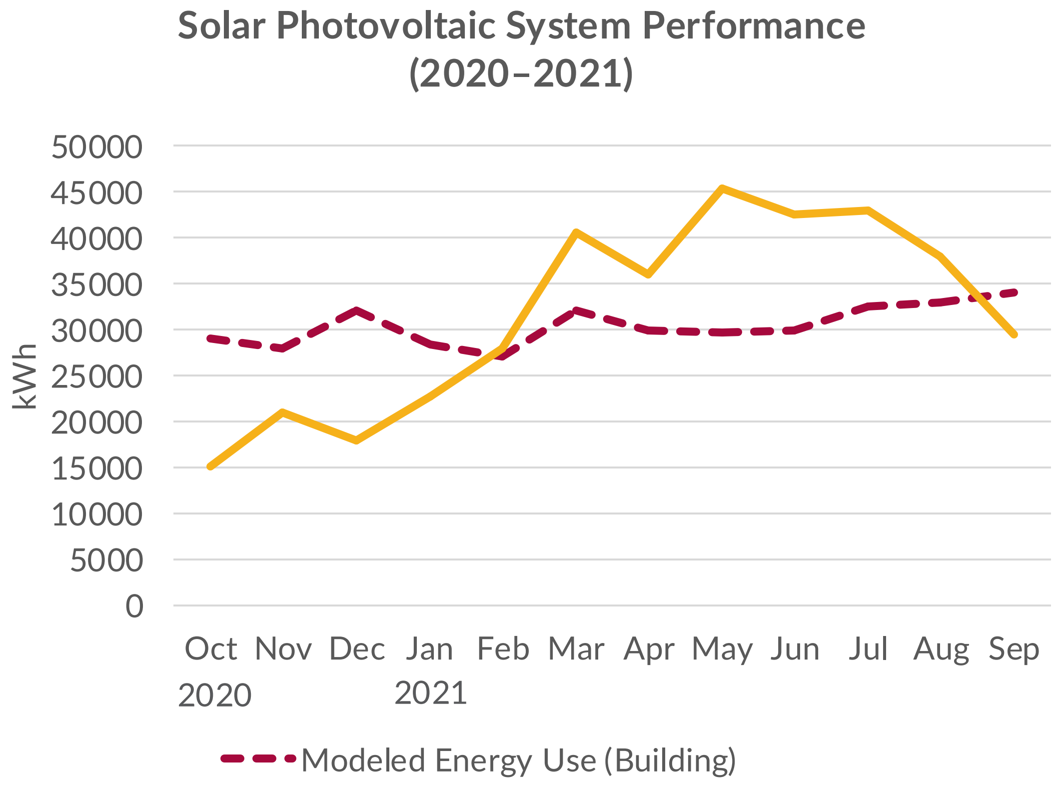
Salient sustainable design features of the **building envelope**:

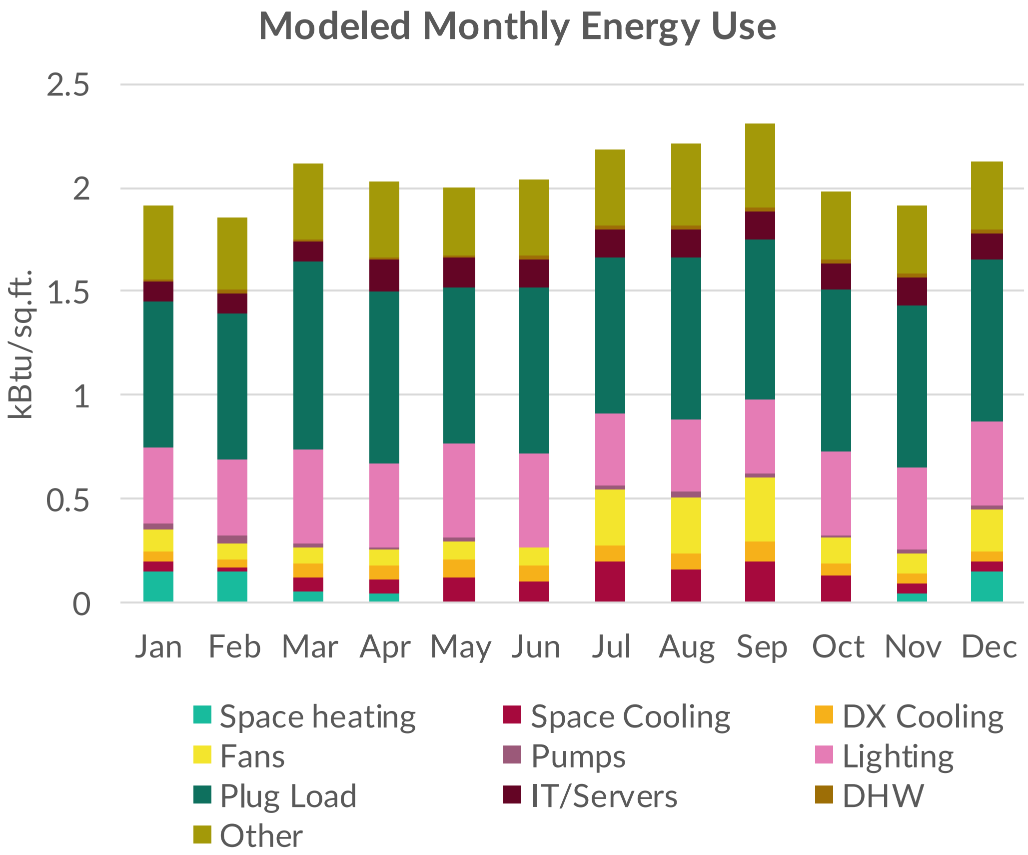
- The design requirement was to have a strong architectural contrast to the historic city wall where in the proposal for an all-glass curtain wall was approved
- **A highly-optimized double curtain wall design** with a **balance of openable windows** and choice of glass with **low-e coating** was chosen to optimize the daylighting and control solar loads
- The envelope could not have a very low U-value; however, several energy efficient strategies were integrated

Source: Dean, 2022

ZERO ENERGY BUILDINGS

Case example: Santa Monica City Hall East, USA (continued)





Source: Dean, 2022

ZERO ENERGY BUILDINGS

Case example: Santa Monica City Hall East, USA (continued)

Strategies for energy efficiency

Thermal storage and phase change material

- Added phase change material to certain ceilings and walls and spandrel glass of the curtain wall as thermal mass to reduce peak load
- Installed large operable windows located at two heights on each floor, one at occupant level and a second one just below the ceiling, controlled by building management systems for optimum **cross ventilation and night purging**
- HVAC uses **air source heat pumps** to generate chilled water or hot water to circulate through concrete slabs
- **Reduced plug loads by having staff use only laptops**
- Conducted training for occupants on using the energy efficient features of the building

Source: Dean, 2022

NET ZERO BUILDING

Case example: Godrej Office Building, India

- Plant-13 Annexe Building of Godrej & Boyce Ltd., located in Mumbai, India, is a multi-use office built in the year 2010

- The building is equipped with facilities like offices, conference and meeting rooms, training rooms, auditorium, banquet rooms, cafeteria, food court, and 24x7 kitchen facilities

- The building is constructed over a site area of 4 acres and has ground + 4 floors with an area of 250,000 sq. ft.

- The building is occupied by around 400 employees and common facilities like cafeteria, and conference and meeting rooms are shared by over 2,000 staff members

Source: Confederation of Indian Industry and Shakti Sustainable Energy Foundation, 2022

NET ZERO BUILDING

Case example: Godrej Office Building, India (continued)

Main features:

- Optimized window to wall ratio, north-south orientation, punched windows and light wells for daylight
- Double glass with low heat (25%) and high-light transmission values (40%)
- Walls with autoclaved aerated concrete (AAC) blocks and roof with thermal insulation and green vegetation to reduce heat ingress and mitigate urban heat island effects
- Central air-conditioning system with chilled water system and water-cooled screw chillers with coefficient of performance (COP) of 5.9 at full load, and COP of 8–9 at 50% load; and 2x250 TR (with twin compressors) and 2x125 TR distributed sizing for operational flexibility
- Variable frequency drives (VFDs) on cooling tower fans, chilled water pumps and AHU fans with temperature-based controls
- A building management system controls the air conditioning system

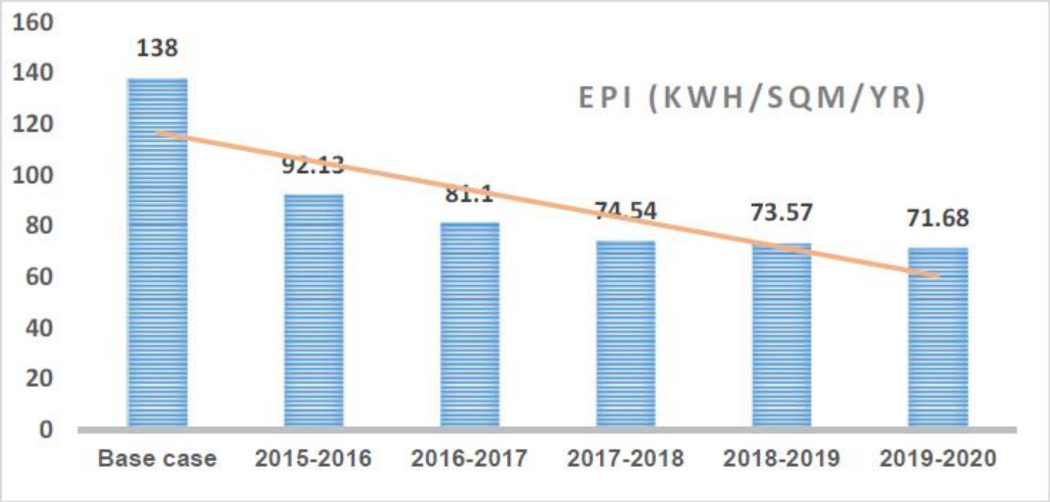
Source: Confederation of Indian Industry and Shakti Sustainable Energy Foundation, 2022

NET ZERO BUILDING

Case example: Godrej Office Building, India (continued)

Main features (continued):

- A 120 kWp solar PV installed to provide 8% of the annual energy demand
- A tripartite power purchase agreement signed to receive wheeled solar power of approximately 1,200 kWp from a solar plant located at Sangli, India
- With the combination of 120 kWp onsite and 1,200 kWp offsite, Plant-13 Annexe Building can meet the Net Zero Energy targets



Source: Confederation of Indian Industry and Shakti Sustainable Energy Foundation, 2022

Thank you!

For more information, visit us at https://ALCBT.GGGI.ORG
or scan the QR code below

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