International Energy Agency

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Where to start? Energy use in buildings

Buildings: Maxine Jordan, IEA and Ian Hamilton, UCL Energy Institute

Pretoria, Monday 14th October 2019

Buildings energy efficiency sessions in partnership with:

UCL ENERGY INSTITUTE

UCL

Energy Efficiency Training Week: Buildings programme

1. Where to start: Energy use in buildings

2. Where to start: Energy efficiency potential in buildings

   Special session: GlobalABC Regional Roadmaps

3. Toolkit: Energy efficient building design technologies

4. Toolkit: Energy efficient building system technologies

   Special session: Green Building in Africa – *Elizabeth Chege, KGBS*

   Special session: The GlobalABC Africa Roadmap for buildings and construction

5. What are the steps? Determining the current status of policies

6. Toolkit: Energy efficiency policies and target setting *with guest speaker: Hlompho Vivian, GBC SA*

7. What are the steps? Implementing codes and standards

8. What are the steps? Building operations and procurement *with guest speaker: Christelle Van Vuuren, Carbon Trust*

   Special session: The multiple benefits of energy efficiency

9. Did it work? Evaluation and energy efficiency indicators

   Special session: Financing energy efficiency in buildings

10. Buildings quiz

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Energy Efficiency Training Week: Buildings

1. Where to start: Energy use in buildings

Trainers: Ian Hamilton, UCL Energy Institute

Purpose: To teach the fundamentals of how and why buildings use energy.

Scenario: An influential NGO is urging for all new construction to be zero emission or net zero energy.

Discussion question: What processes and which factors are key to delivering zero emission or net zero energy buildings?

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Drivers of building energy use

Building form

Building function/services

Population and wealth

Climate and weather

Drivers of building energy use: form





Form causes energy use: including through shape, size, materials, window placement.
Form enables energy efficiency: including thermal mass, passive solar and natural ventilation.

Sources: GBPN and IEA

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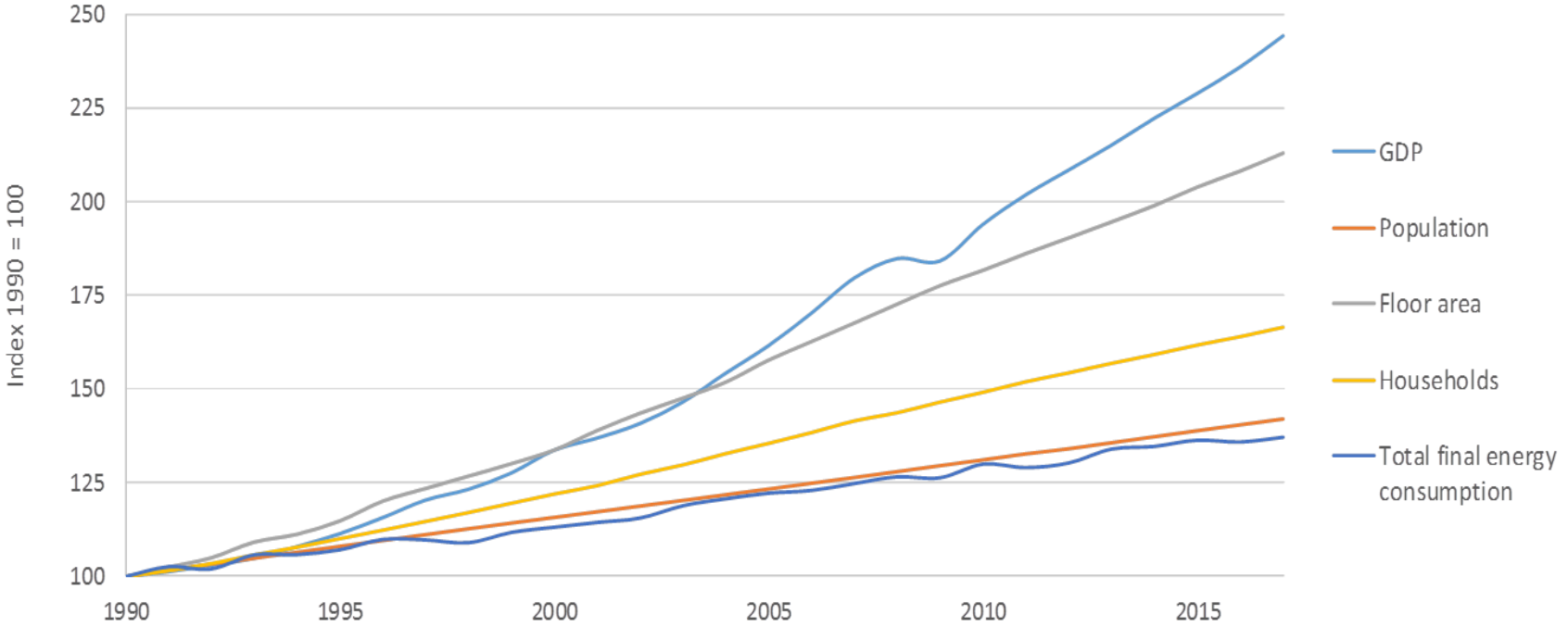
Drivers of building energy use: function

Energy follows function : people don’t demand energy, they demand energy services.

Sources: GBPN

Drivers of building energy use: people (population)



Despite energy efficiency improvements, the energy consumed in buildings is still highly correlated to population growth.

Sources: IEA Energy Statistics, IMF 2014, UN DESA 2014

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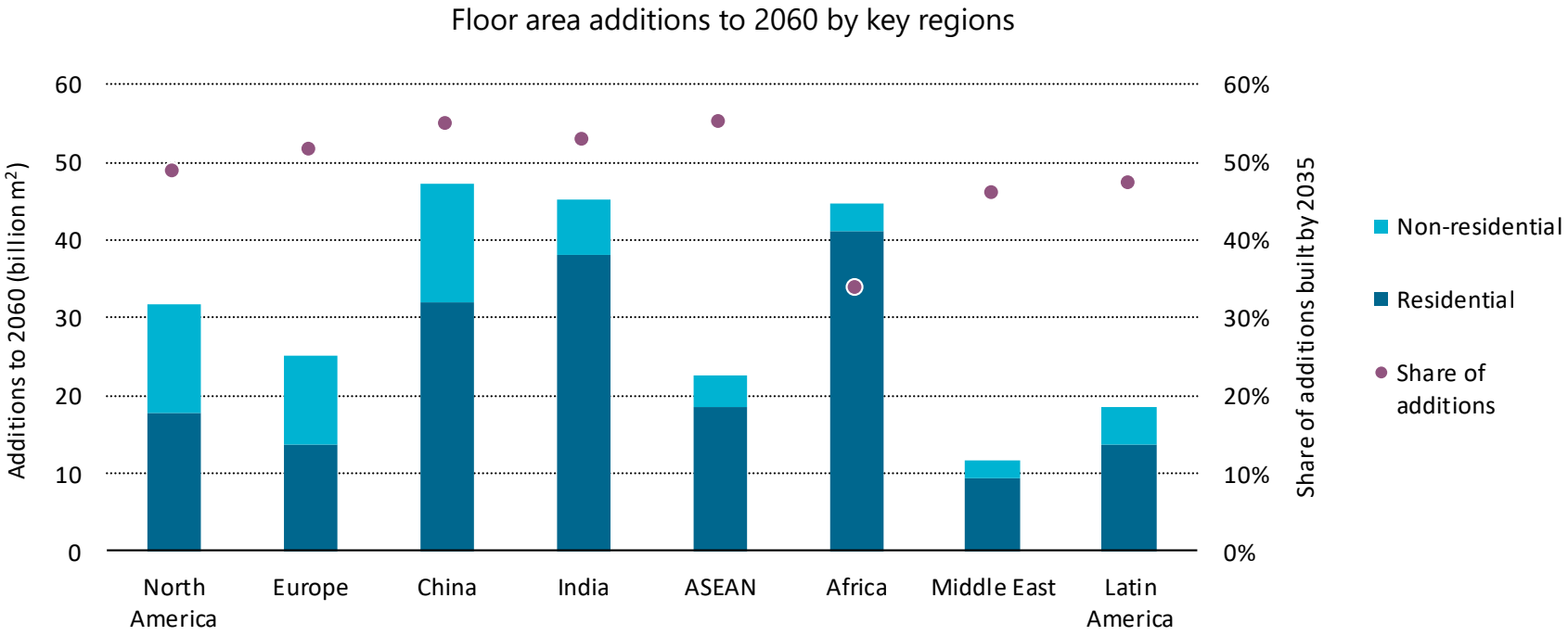
Drivers of building energy use: floor area (population and wealth)

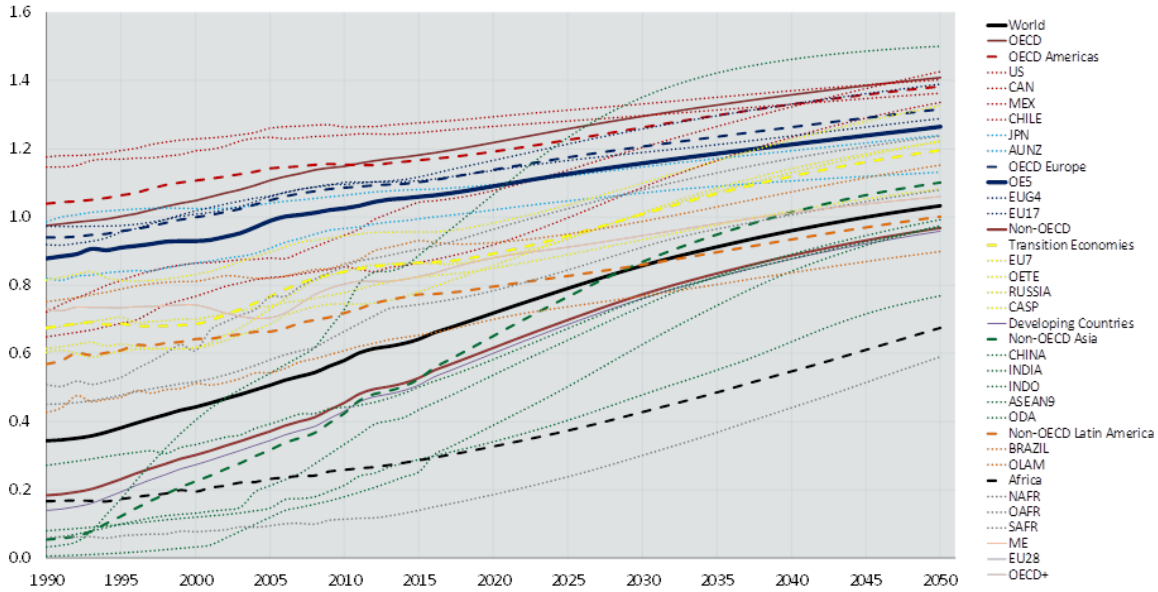


Population and wealth are both driving increased floor area in buildings.

Source: IEA Energy Technology Perspective 2017

Drivers of building energy use: ownership (population and wealth)

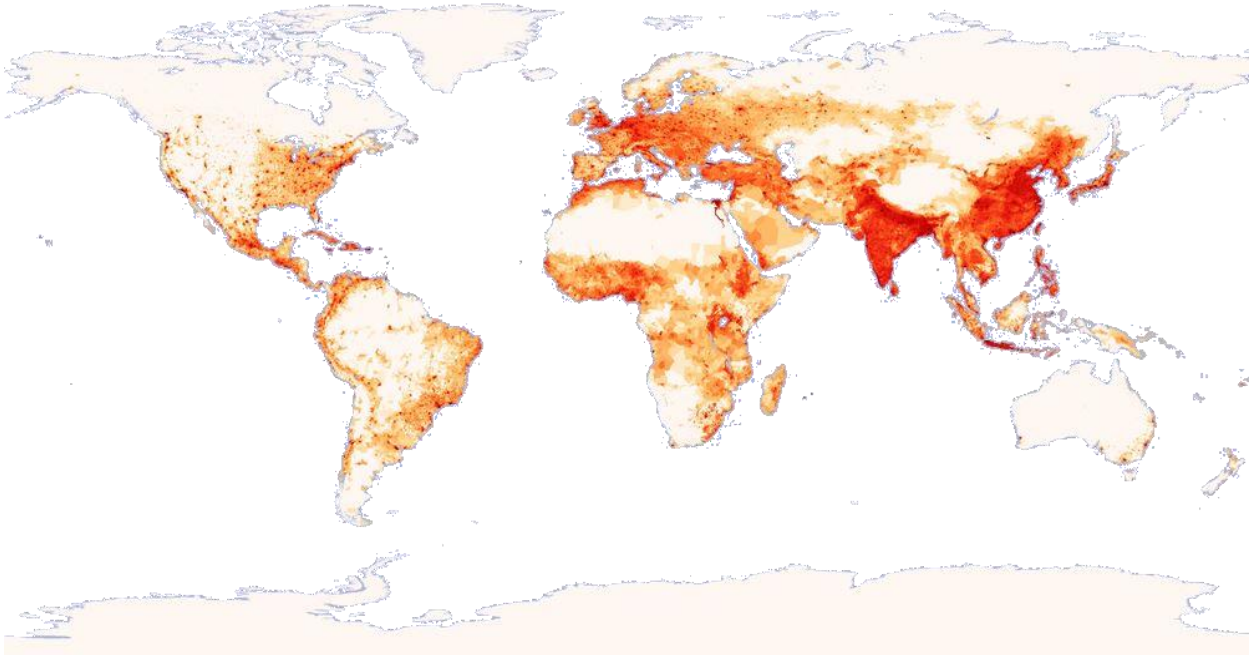
Appliance ownership is increasing…



Global refrigerator ownership doubled in the last 25 years.

Source: IEA Energy Technology Perspective 2017

Drivers of building energy use: population location



Hot locations with large population: India, South East Asia, Africa, Central America, South America
~50% of world population suffers from hot weather, while <10% have access to mechanical cooling.

Sources: BEEP India and http://allthatsinteresting.com/map-population-density

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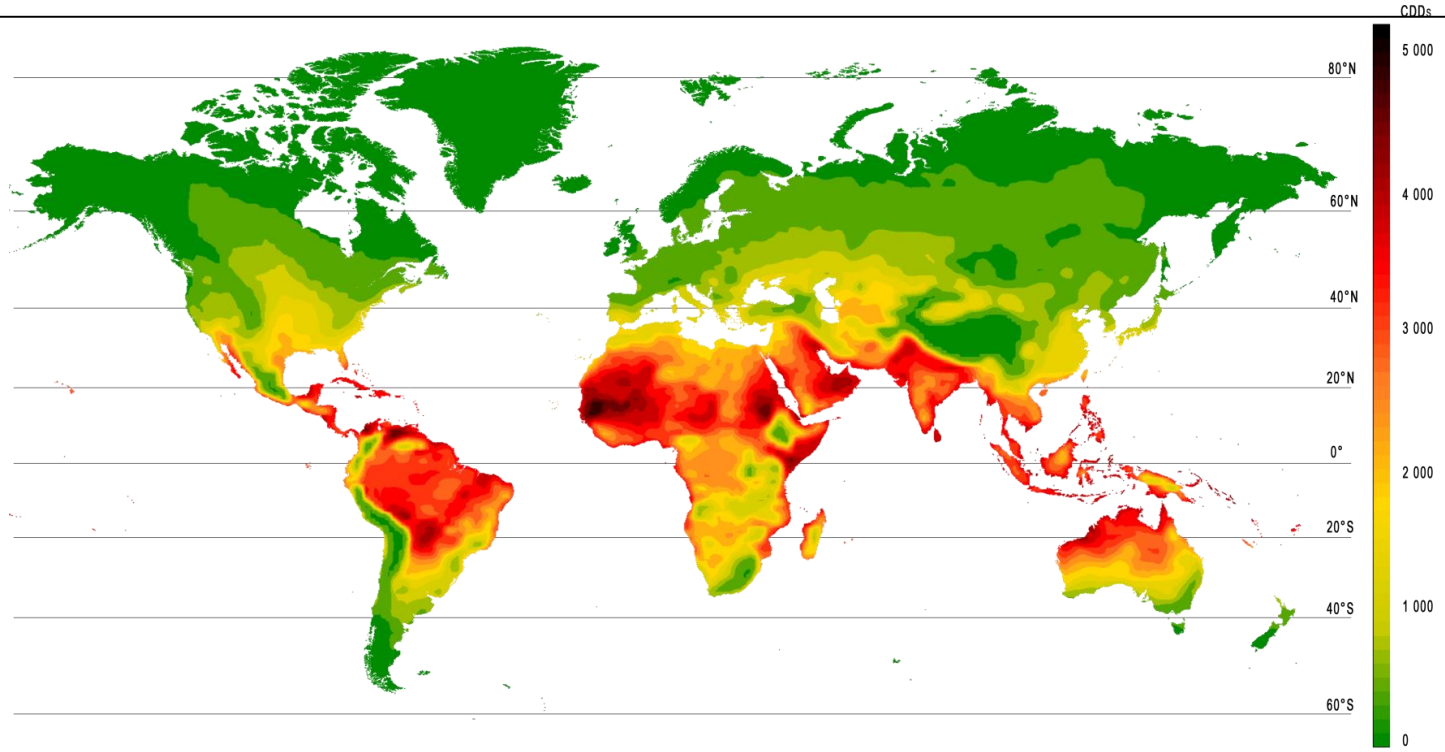
Drivers of building energy use: climate



Climate impacts occupant comfort and building energy use.
Climate can also impact where people live.

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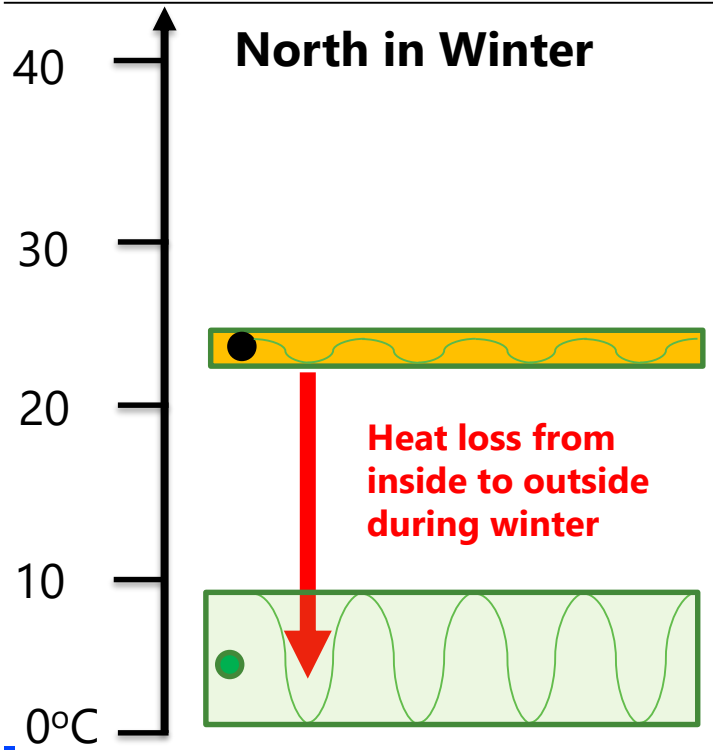
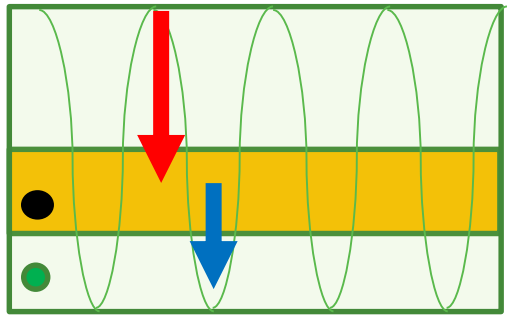
Drivers of building energy use: climate





Heat is incoming during the day

and

outgoing during the night

● T inside

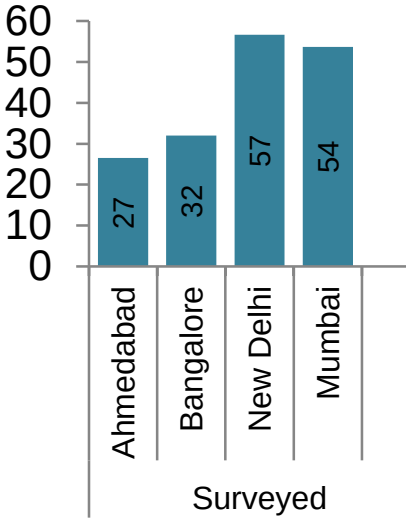
● T outside

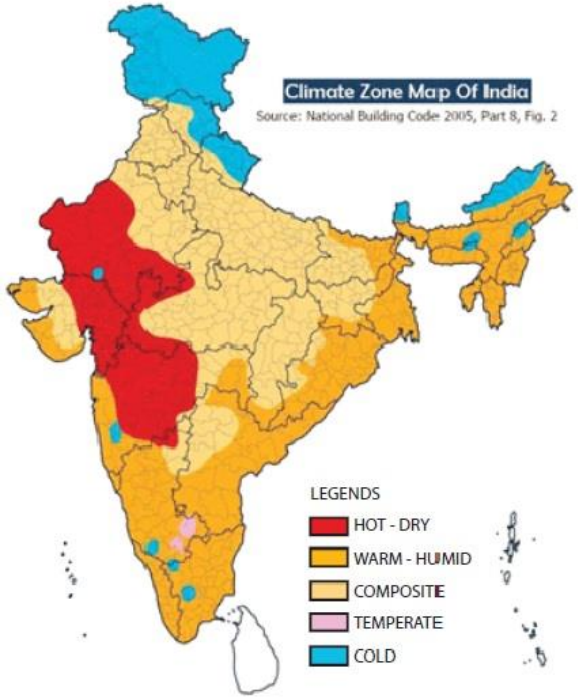
Building physics are the same everywhere, but, buildings in cold and hot climates have different dynamics depending on temperatures

Sources: BEEP India

Drivers of building energy use: climate example in India

Energy intensity (kWh/m2)





Four Cities and Climate Zones

Ahmedabad:

- Hot and Dry

Bangalore:

- Moderate

New Delhi:

- Composite

Mumbai:

- Warm and Humid

Building energy use is dependent on both climate and energy efficiency standards.

Sources: GBPN, India BEE

Building energy use

Building lifecycle

Historic and projected

End-use consumption

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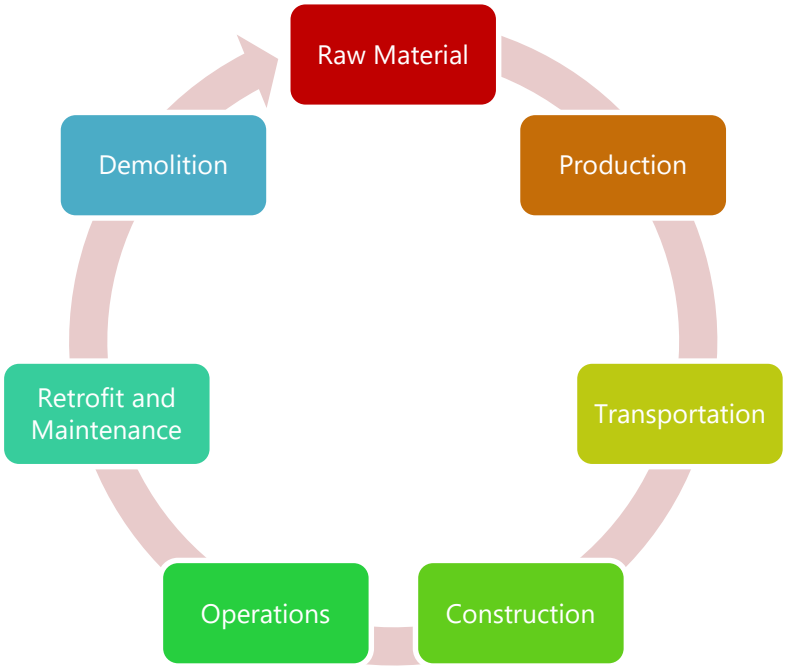
Building energy use: over the building lifecycle



- Lifecycle analysis can estimate the impacts of each stage of the building life.
- The lifecycle includes embodied plus operational energy and emissions.

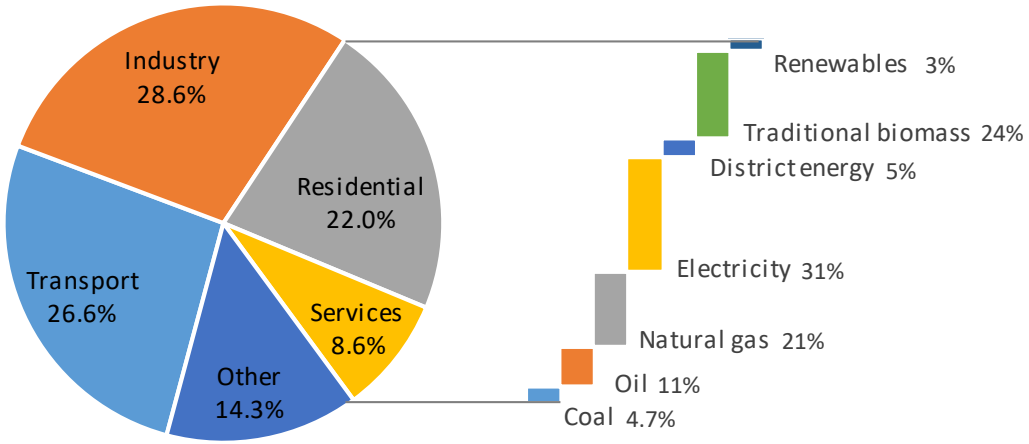
Each step of the lifecycle of the building results in energy input and emissions output.

Source: Adapted based on Built Constructions Magazine

Building energy use: globally

Buildings account for…

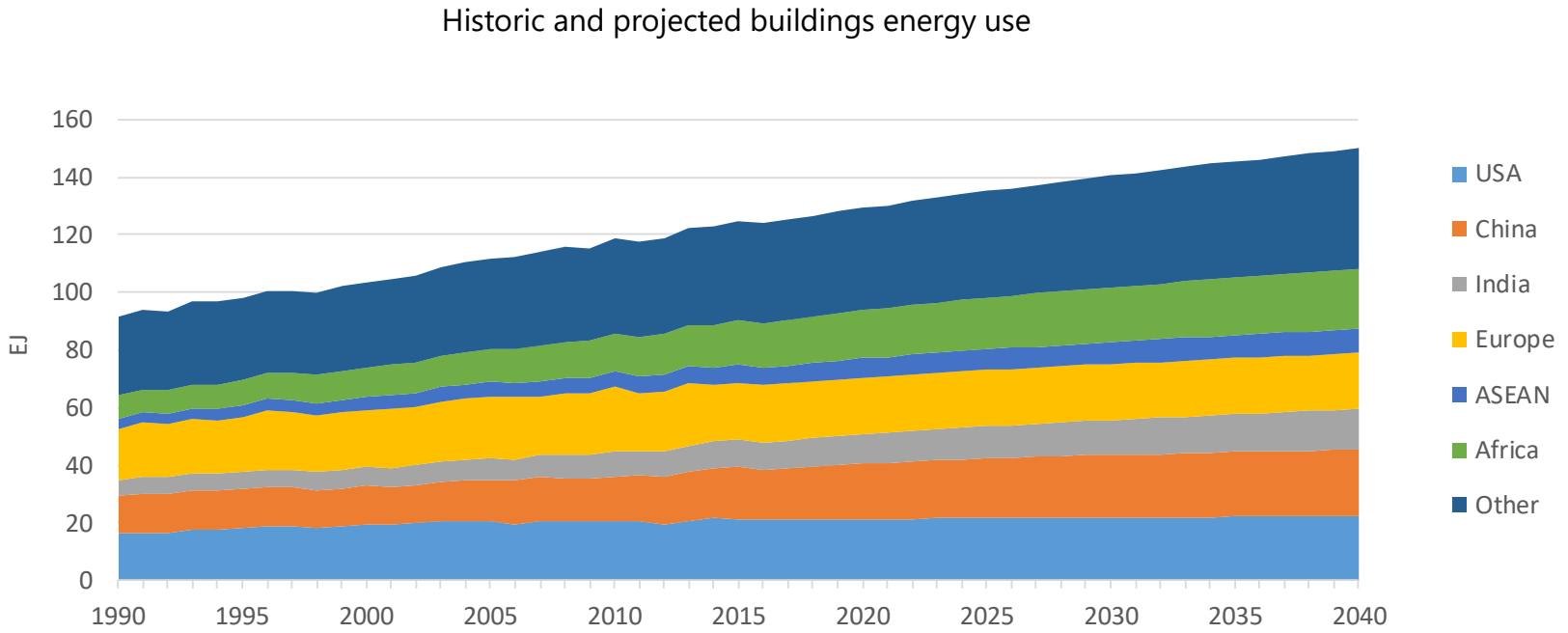
- over 30% of global final energy demand
- 55% of global electricity use,
- more than a quarter of energy-related CO2 emissions,
- two-thirds of halocarbon,
- and 25–33% of black carbon emissions (GEA 2012)



Building energy use plays a large role in the global energy system.

Source: IEA Energy Technology Perspective 2017

Building energy use: by region

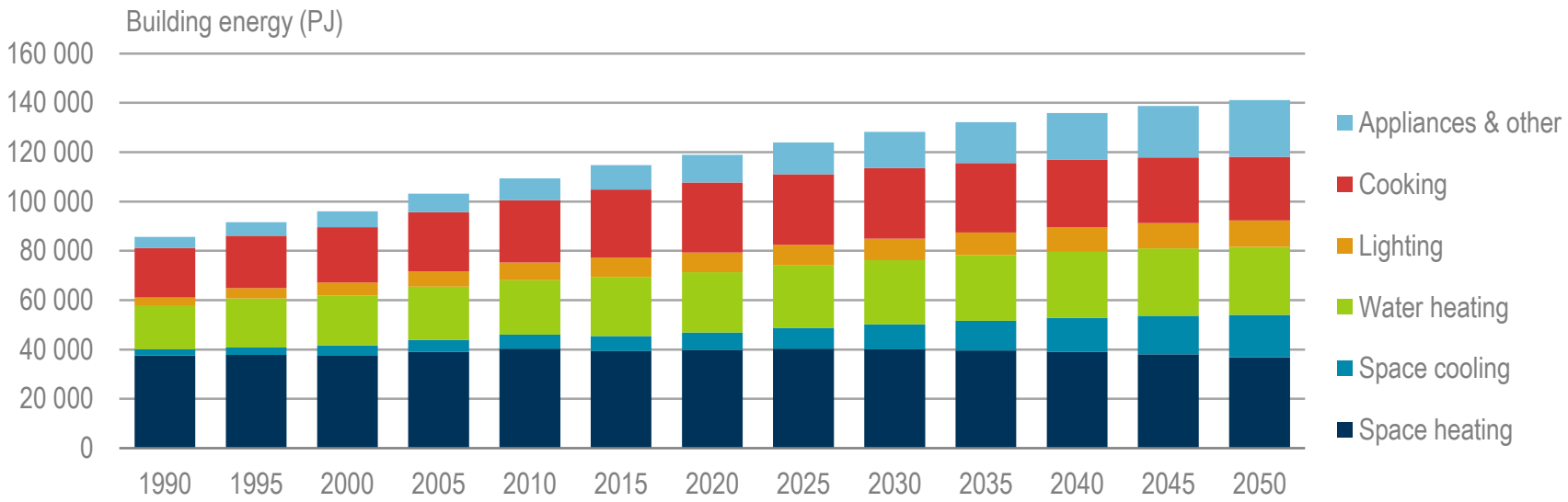


Building energy use in business as usual scenario (RTS) is expected to increase further.

Source: IEA Energy Technology Perspective 2017

Building energy use: by end-use

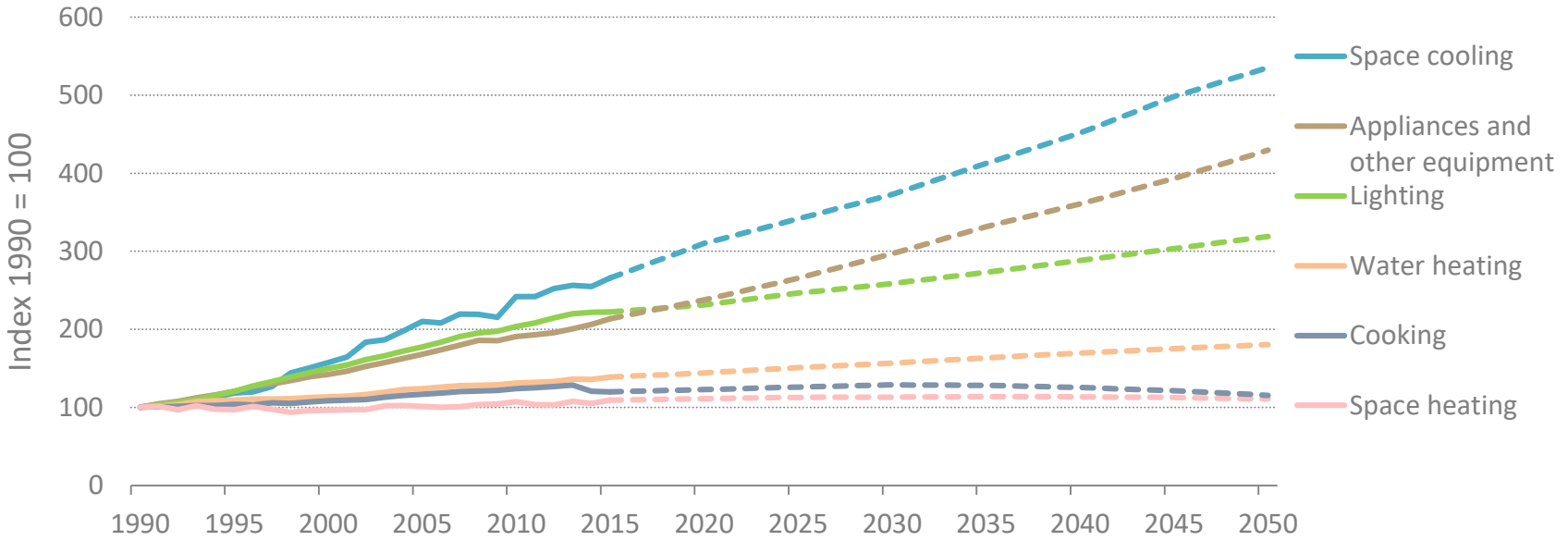
Historic and projected buildings energy use



Building energy use in business as usual scenario (RTS) is expected to increase further.

Source: IEA Energy Technology Perspective 2017

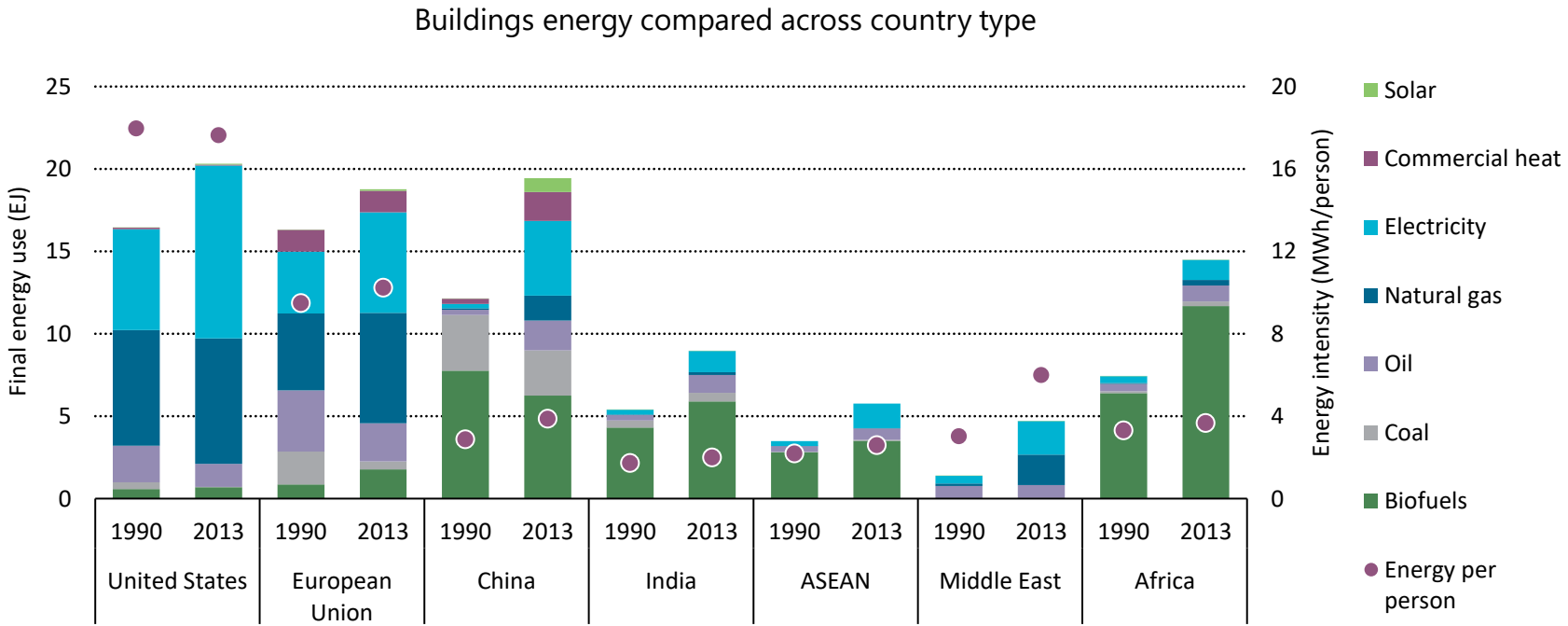
Building energy use: how important is space cooling becoming?



Space cooling energy use in business as usual scenario (RTS) is expected to have significant increases due to increased ownership.

Source: www.iea.org/eemr16

Building energy use: comparison

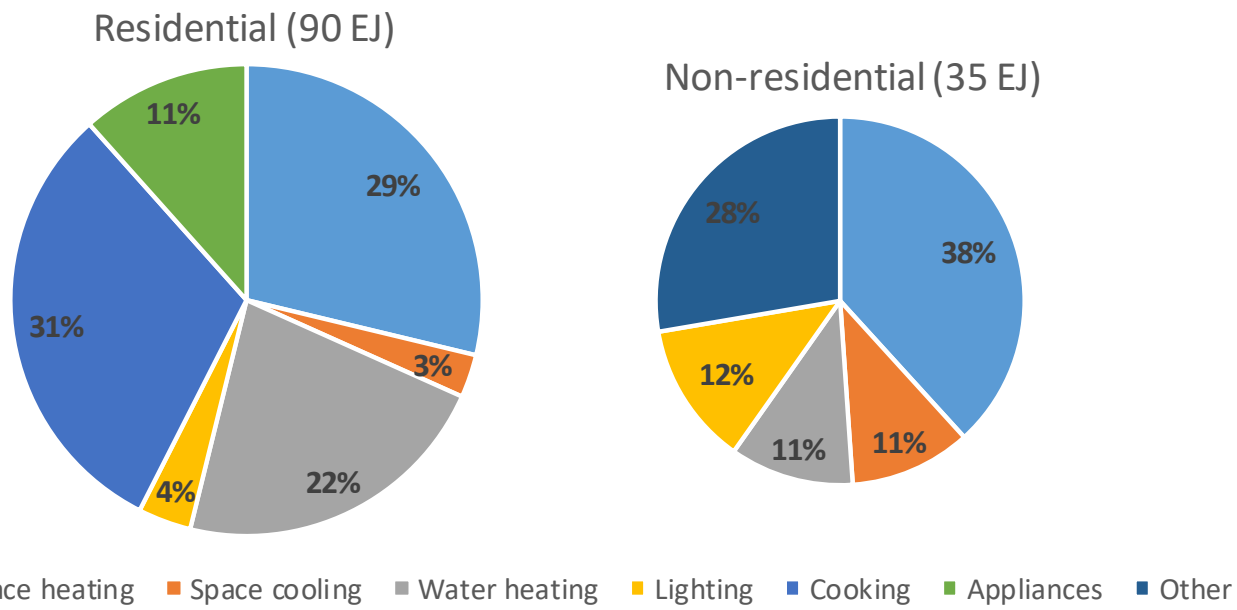


Building energy use is different between countries, especially in their use of biomass.

Source: www.iea.org/eemr16

Building energy use: by building type

Residential and non-residential buildings…

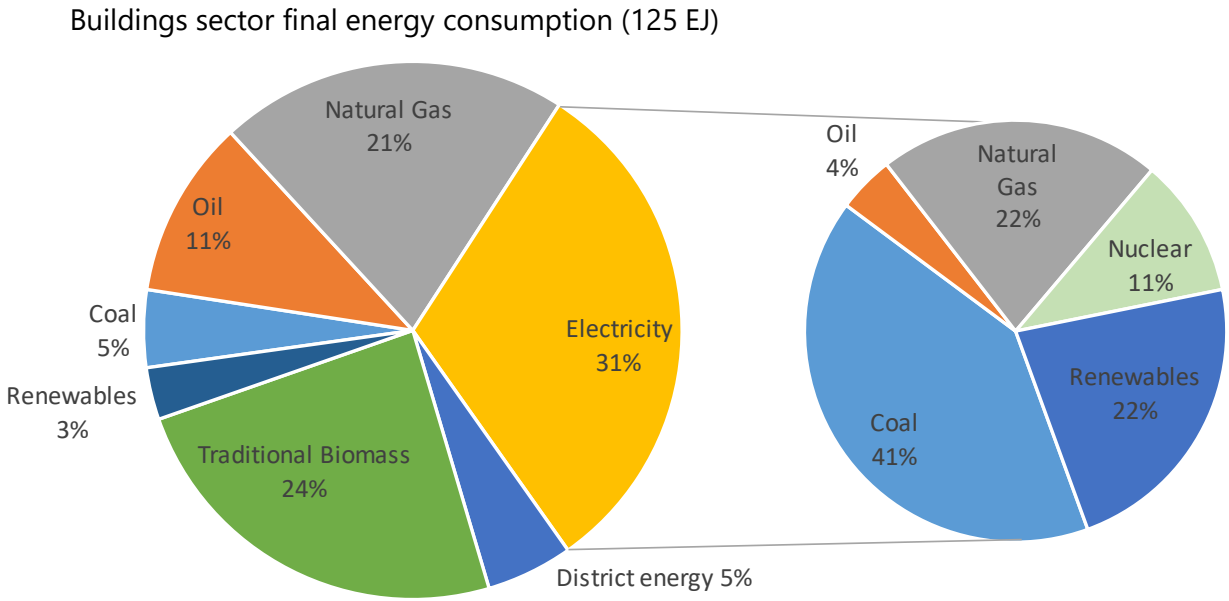


Residential buildings use more energy for cooking and water heating.
Non-residential buildings use more energy for space cooling, lighting and other equipment.

Source: IEA Energy Technology Perspective 2017

Building energy use: impact on energy markets

Primary energy use depends on energy utilities…



Buildings depend heavily on upstream energy and emissions (electricity and commercial heat).

Source: IEA Energy Technology Perspective 2017

Driving energy use down

The path to “net zero” and “low-energy”

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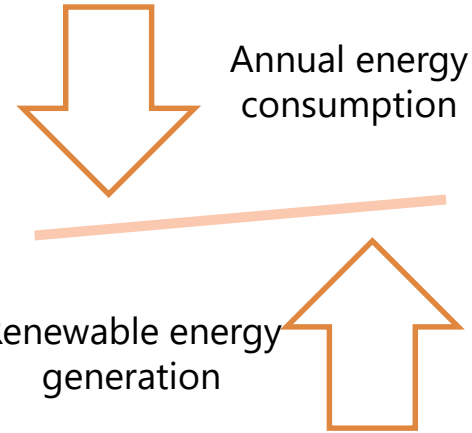
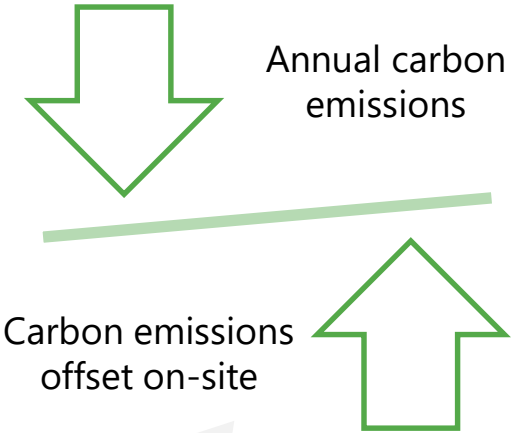
Concept of net zero

- **Net-zero energy:** over the course of a year, the building has consumed as much energy as has been generated on site, resulting in a net-zero annual energy consumption.



Final or primary energy?
Allow off-site generation?
Is net zero = efficient?

- **Net-zero carbon:** over the course of a year, the building has emitted as many carbon emissions as have been offset on site, resulting in a net-zero annual carbon emission.



What about embodied carbon?

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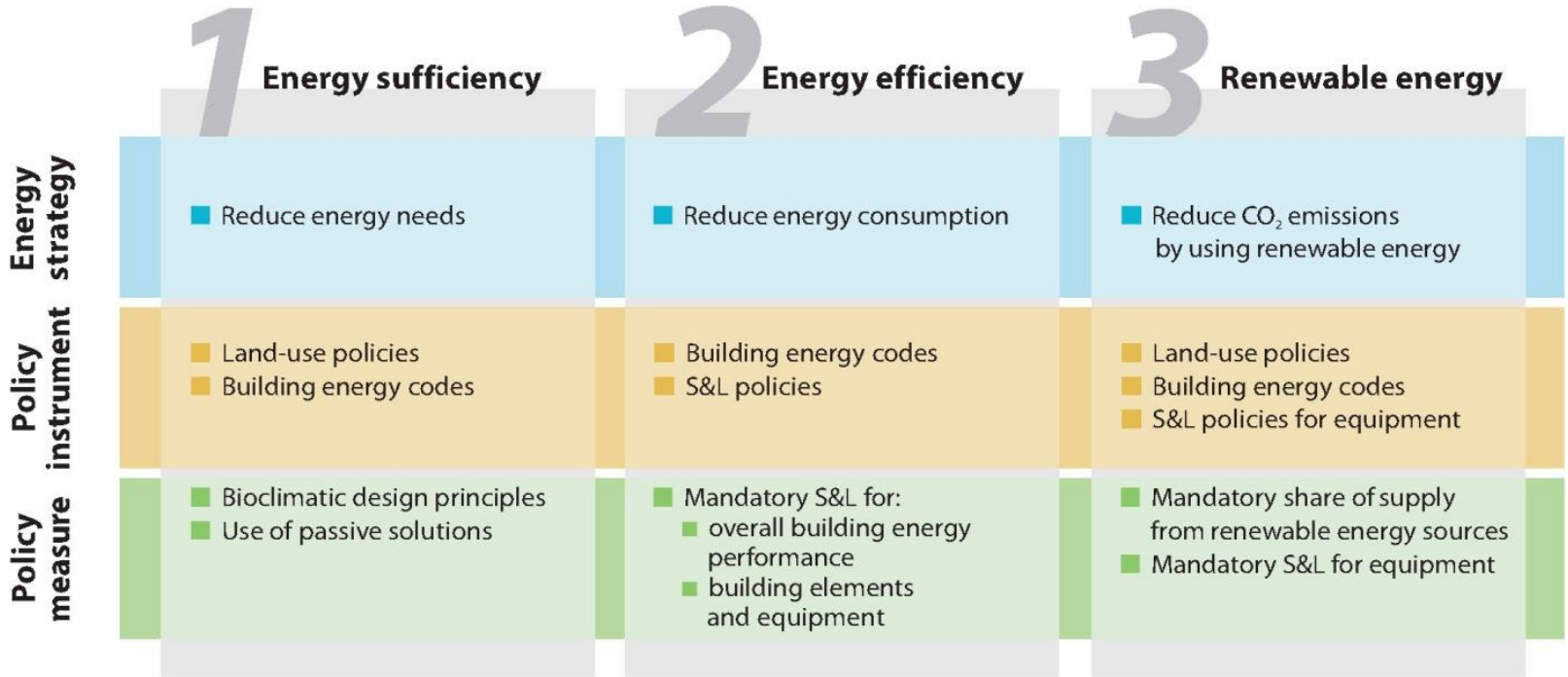
Path to zero emissions or net zero energy buildings

Items to consider for building renovation or construction:



Source: www.iea.org/publications/policypathwaysseries/

Path to low-energy existing buildings

- **Reduce electrical loads**: ensure all lighting is upgraded, ensure all appliances and electronic devices are high efficiency and emit less heat.

- **Improve building envelope**: highly cost effective insulation and air sealing are essential. Window measures can also dramatically reduce building energy and increase thermal comfort.

- **Systems**: Improve the existing systems if they are not being replaced.
  - Otherwise, upgrade to advanced systems including heat pump or other high efficiency technology that can be integrated with renewable energy (grid or on-site).

- **Retro-commission**: ensure that all systems are properly installed and operating as they were designed to operate.

Source: Adapted from ENERGY STAR

Path to low-energy new buildings

- **Design it right**: have integrated design team that examines life-cycle energy use in each design and construction phase.
  - **Electrical loads**: ensure all lighting is latest technology, ensure all appliances and electronic devices are high efficiency and emit less heat.
  - **Building envelope**: highly cost effective insulation and air sealing are essential. New buildings also have minimal upgrade costs for energy efficient window measures that can also dramatically reduce building energy and increase thermal comfort.
  - **Systems**: Include advanced systems such as heat pump or other high efficiency technology that can be integrated with renewable energy (grid or on-site).

- **Construct with commissioning**: ensure that all technologies are properly installed and operating as they were designed to operate.

Source: Adapted from ENERGY STAR

The path to net zero

Scenario:

An influential NGO is urging for all new construction to be zero emission or net zero energy.

What processes and which factors are key to delivering zero emission or net zero energy buildings?

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