Energy Efficiency Policy Training Week: Buildings – Day 2 - Introduction

Energy Efficiency Training Week: Buildings trainers

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International Energy Agency

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Energy Efficiency Training Week: Buildings Content Programme

Training Day 2:

Part A: Key concepts towards Zero-Carbon:

- Where to start (current status, benchmarks)
- Zero-carbon buildings (concepts)
- Smart / grid-interactive buildings

Part B: Overview of energy efficient and low-carbon solutions

- Energy efficient building design practices
- Low/zero-carbon materials
- Energy efficient building systems and operations

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Training Day 3:

Part A: Policy Package

- What is a policy package and how to construct it
- Policy package approach to supporting energy efficiency and zero-carbon buildings performance
- Building codes and standards: what are they, how do they work, how to develop and adopt
- MEPS: what are they, how do they work, how to develop and adopt
- Regional and international examples of codes and regulations

Part B: Multiple benefits of energy efficiency

- Type of multiple benefits
- Methods and indicators
- Regional and international examples

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Training Day 4:

Part A: Zero-carbon buildings strategies and action areas

- What are the Roadmaps for Buildings and Construction
- Building collaborations to enable strategies
- International examples

Part B: Zero-carbon buildings indicators and evaluation

- Data and indicators for tracking building energy efficiency and zero-carbon adoption
- Approaches to evaluation for assessing policy and programme progress and direction

Part C: Financing energy efficiency and zero-carbon buildings

- Types of financing for efficient and zero-carbon buildings
- Incentives (financial and non-financial) for efficiency and zero carbon

Breakout group activities

- Each day we will split into three Breakout groups
- Groups are defined in advance (you will be automatically assigned into the Breakout during the session)
- Group leads are:
    1. Group 1: Ian Hamilton & Estefania Mello & María Mora
    2. Group 2: Ksenia Petrichenko & Elisete Cunha
    3. Group 3: Cornelia Schenk & Liliana Campos

- In each group, you will discuss the self-assignment and your reflections on a series of questions.

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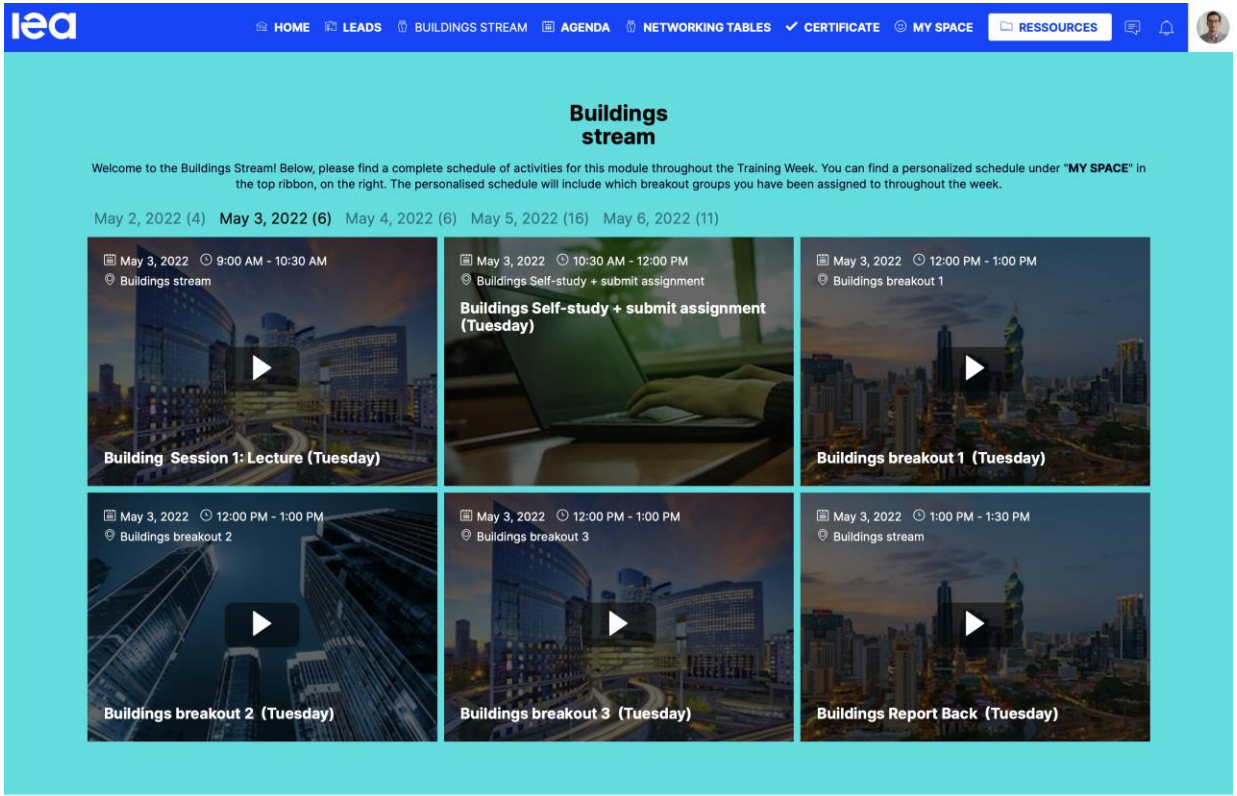
Be sure to:

- Participate
- Share your experience
- Ask questions
- Do the assignments
- Have fun!

Source: People matter, 2022

Energy Efficiency Training Week: Navigating



Team starter activity

Buildings Training Session Assignment

By the end of **Day 3**, please take a photo of something in your home or place of work that you think most represents building energy efficiency!

Submit the photo here: Google Form Link

International Energy Agency

Energy Efficiency Policy Training Week: Buildings – Day 2 – Part A – Towards Zero Carbon

Energy Efficiency Training Week: Buildings Content Programme

Training Day 2:

Part A: Key concepts towards Zero-Carbon:

- Where to start (drivers of energy use)
- Zero-carbon buildings (concepts)
- Smart grid-interactive buildings

Part B: Overview of energy efficient and low-carbon solutions

- Energy efficient building design practices
- Low/zero-carbon materials
- Energy efficient building systems and operations

Key concepts towards Zero-Carbon

Drivers of building energy use

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

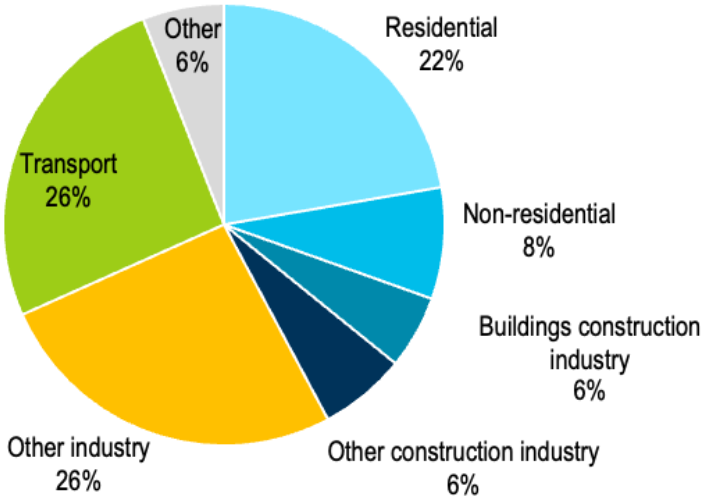
Drivers of building energy use: function

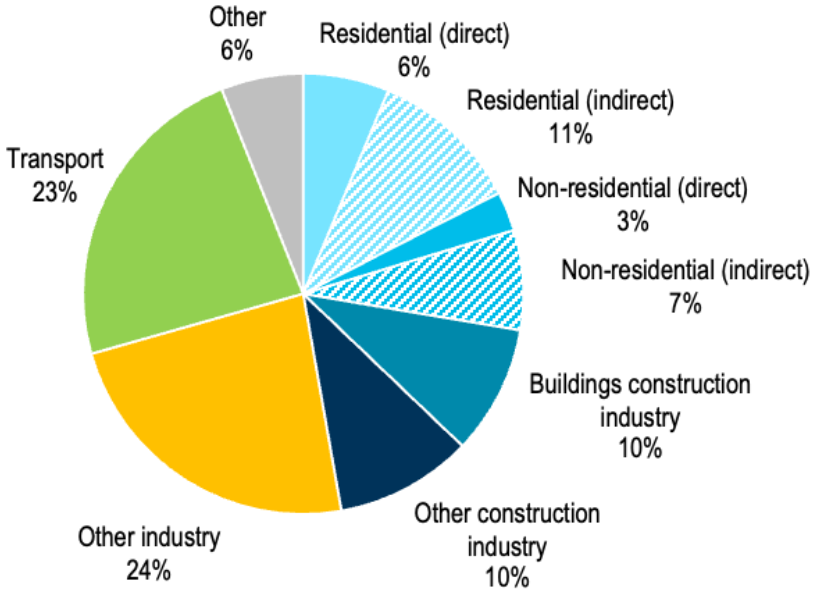
Energy follows function : people don’t demand energy, they demand energy services.

Sources: GBPN

Building energy use: globally

Buildings account for…

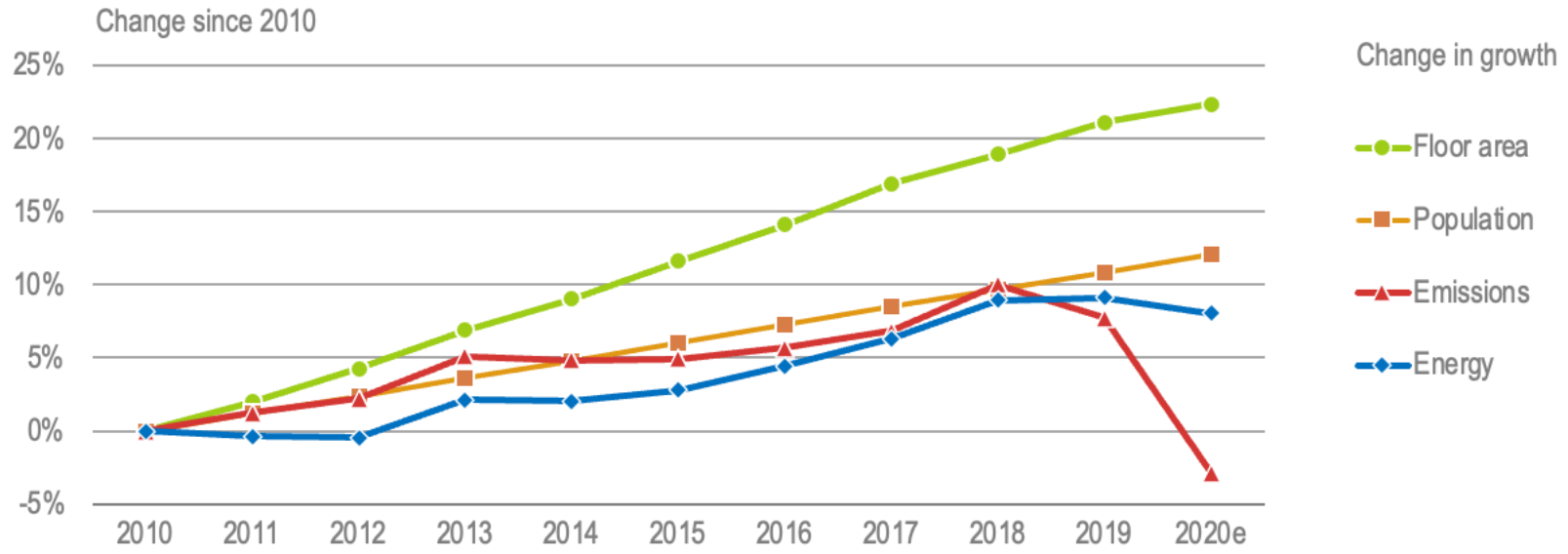




Building energy use plays a large role in the global energy system.

 Source: IEA Energy Technology Perspective 2021

Drivers of building energy use:

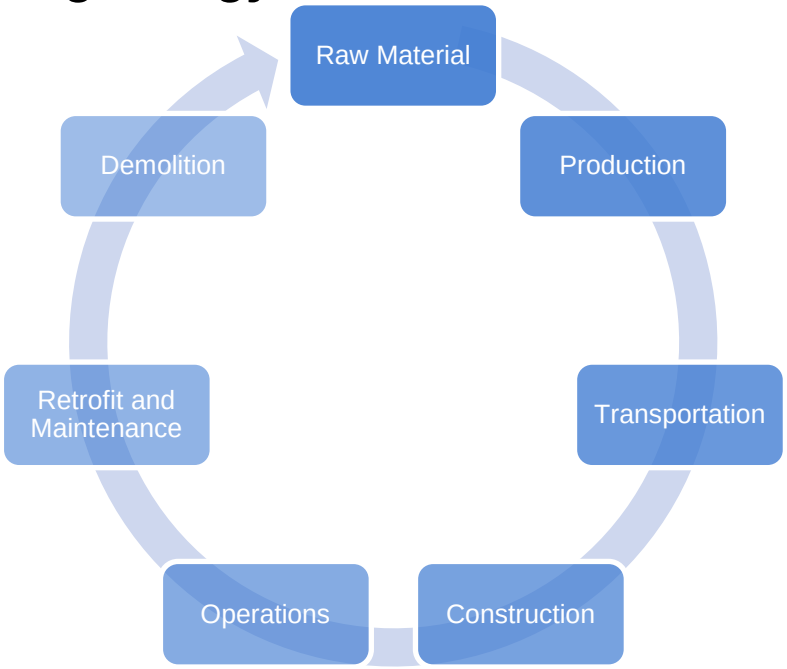


Despite energy efficiency improvements, the energy consumed in buildings is still highly correlated to population growth.

Sources: IEA ETP 2021

Building energy use

Building energy use: over the building lifecycle



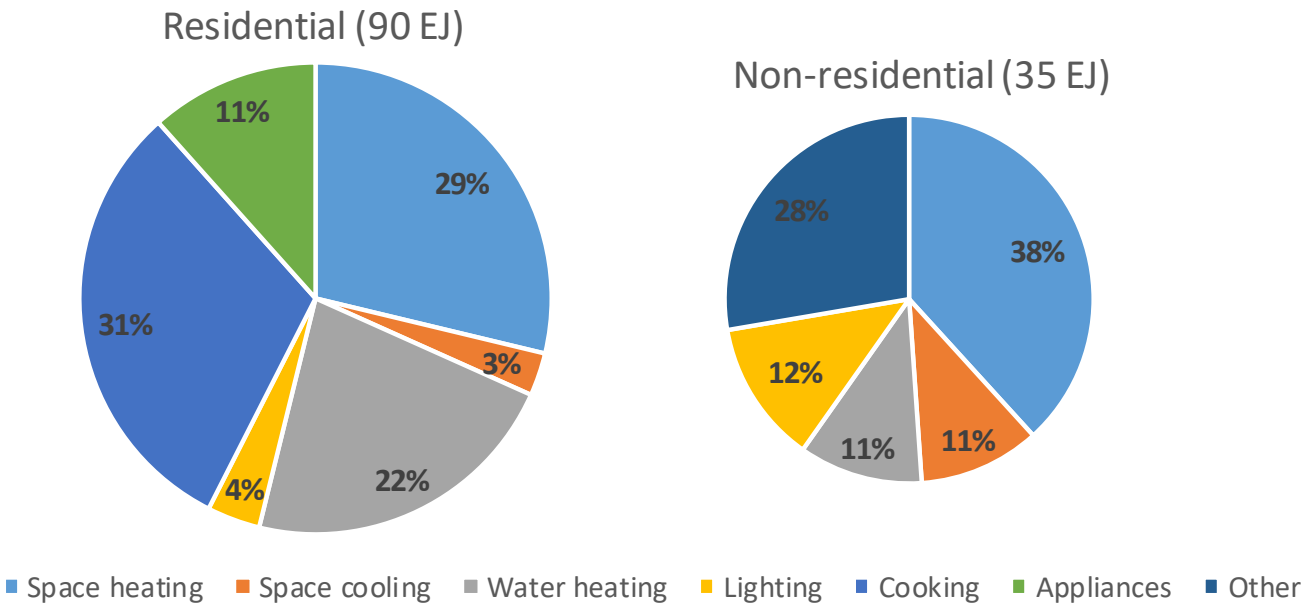
- Lifecycle analysis can estimate the impacts of each stage of the building life.
- The lifecycle includes embodied plus operational energy and emissions.

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: by building type

Residential and non-residential buildings…



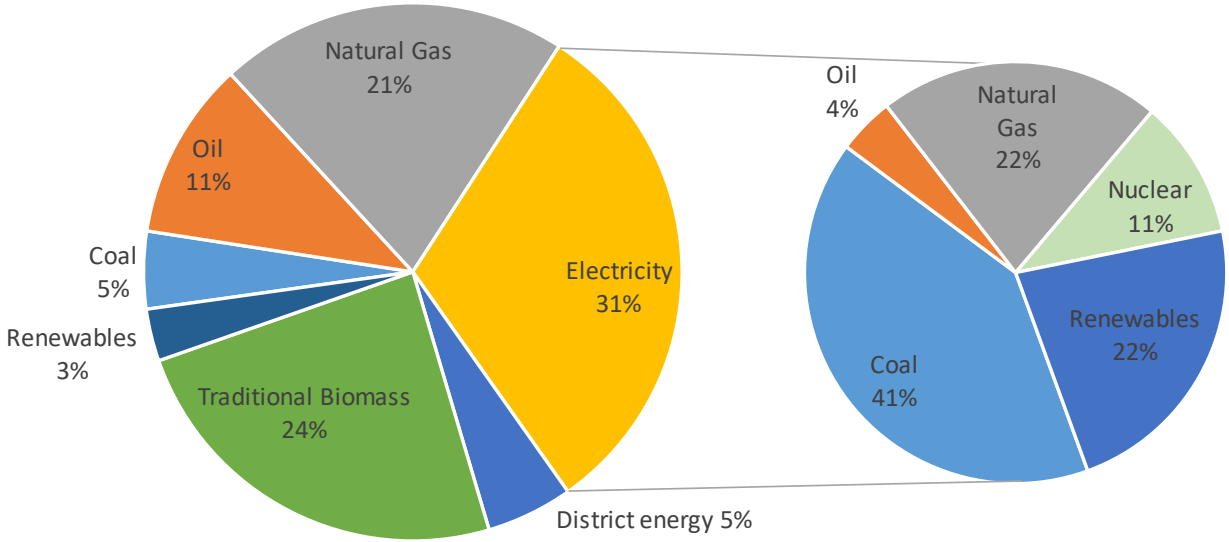
Residential buildings use more energy for cooking and water heating.
Non-residential buildings use more energy for space cooling, lighting and other equipment.

Source: IEA Energy Technology Perspective 2017

Building energy use: impact on energy markets

Primary energy use depends on energy utilities…

Buildings sector final energy consumption (125 EJ)

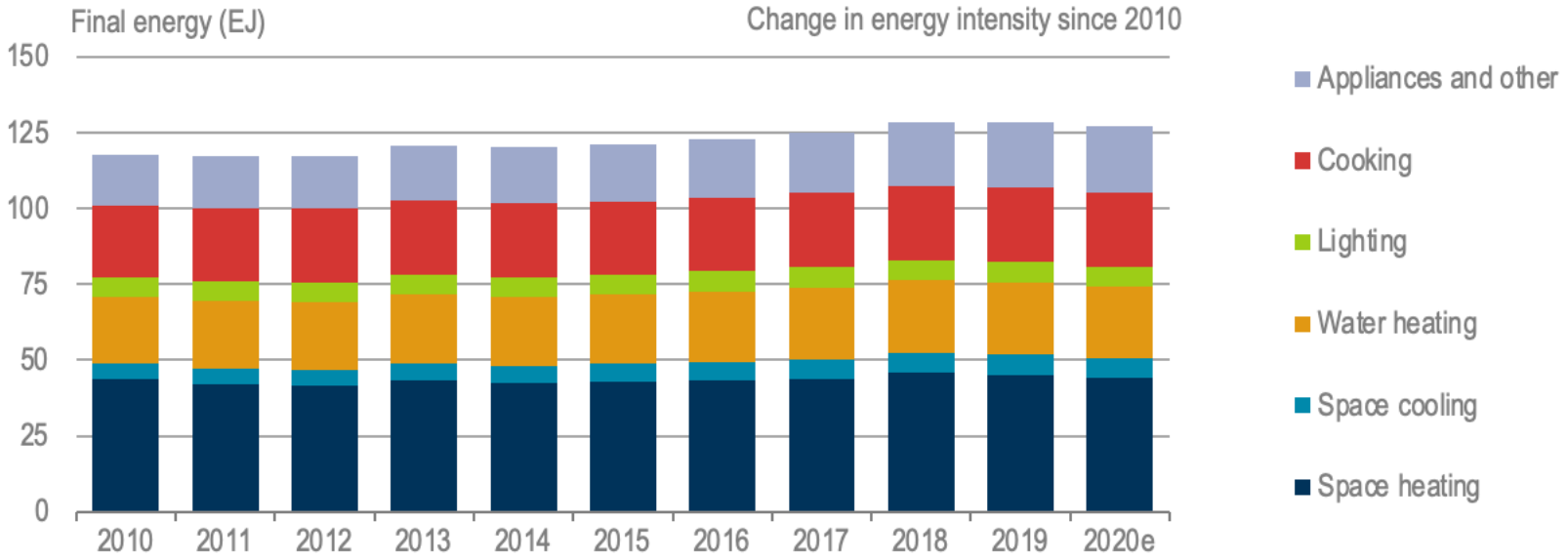


Buildings depend heavily on upstream energy and emissions (electricity and commercial heat).

Source: IEA Energy Technology Perspective 2017

Building energy use: by end-use

Historic and projected buildings energy use

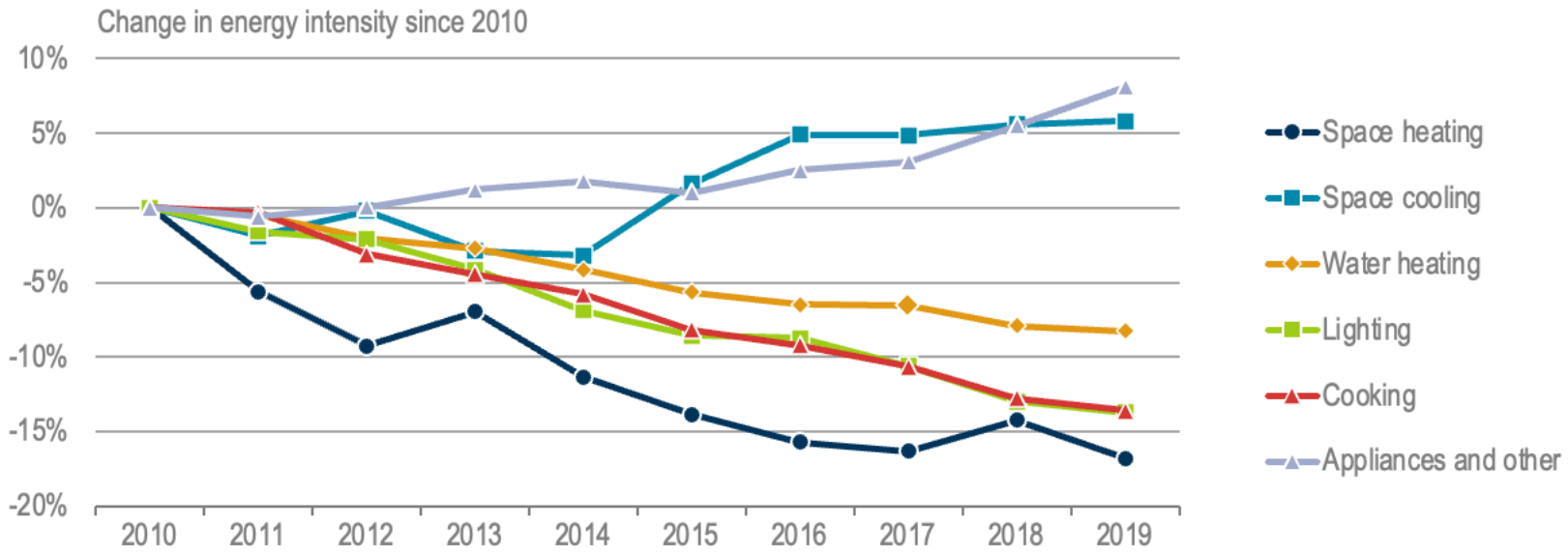


Building energy use in business as usual scenario (RTS) is expected to increase further.

Source: IEA Energy Technology Perspective 2021

Building energy use: by end-use

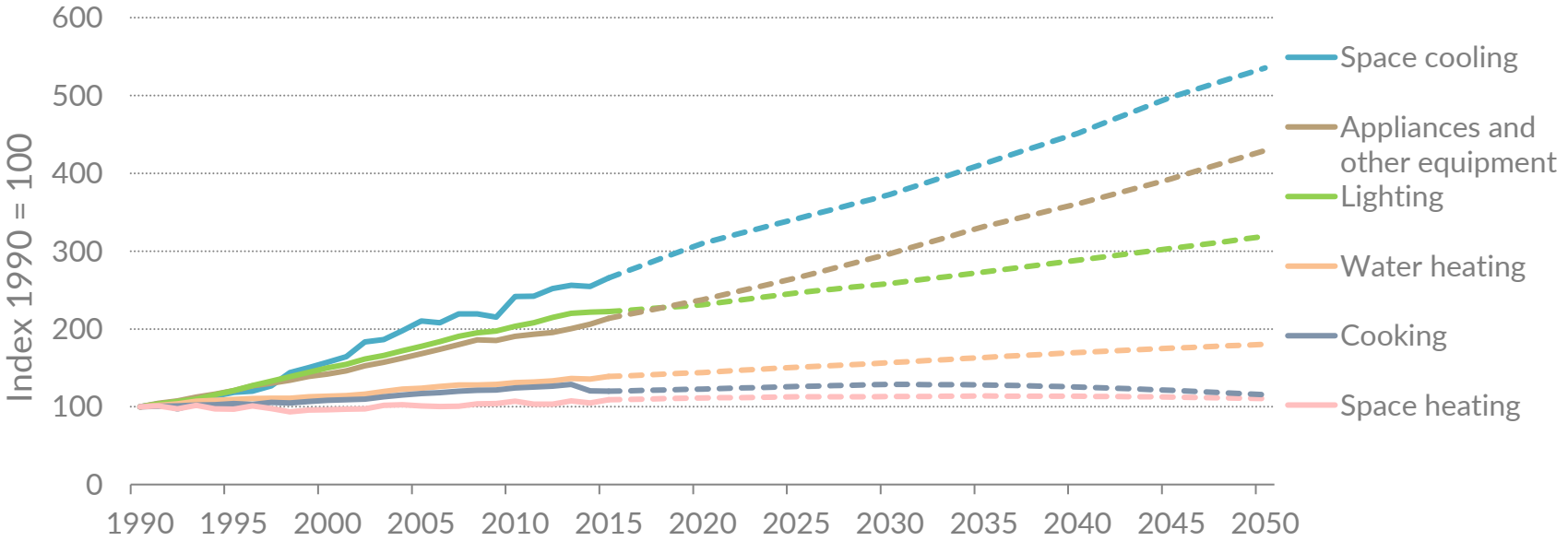
Historic and projected buildings energy use



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

Source: IEA Energy Technology Perspective 2021

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

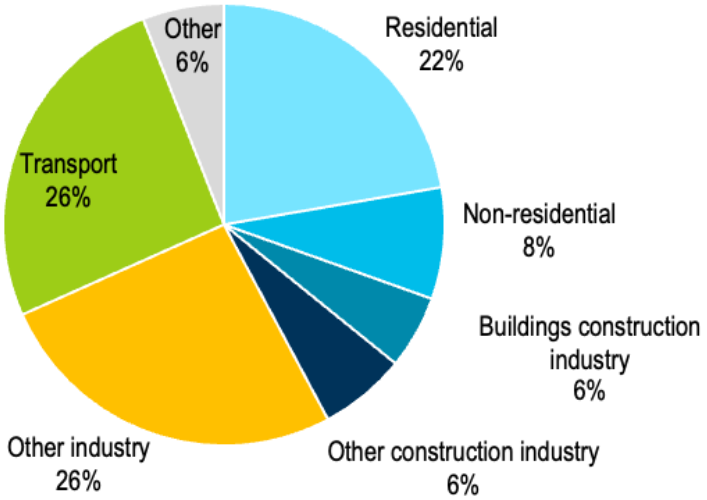
Key concepts towards Zero-Carbon

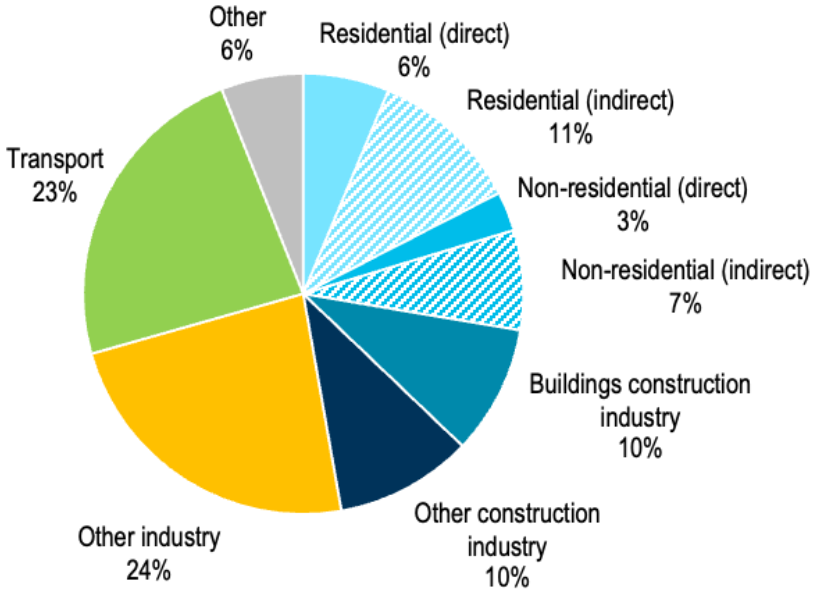
Driving energy use down

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

Why is buildings decarbonisation so critical?

Buildings account for…



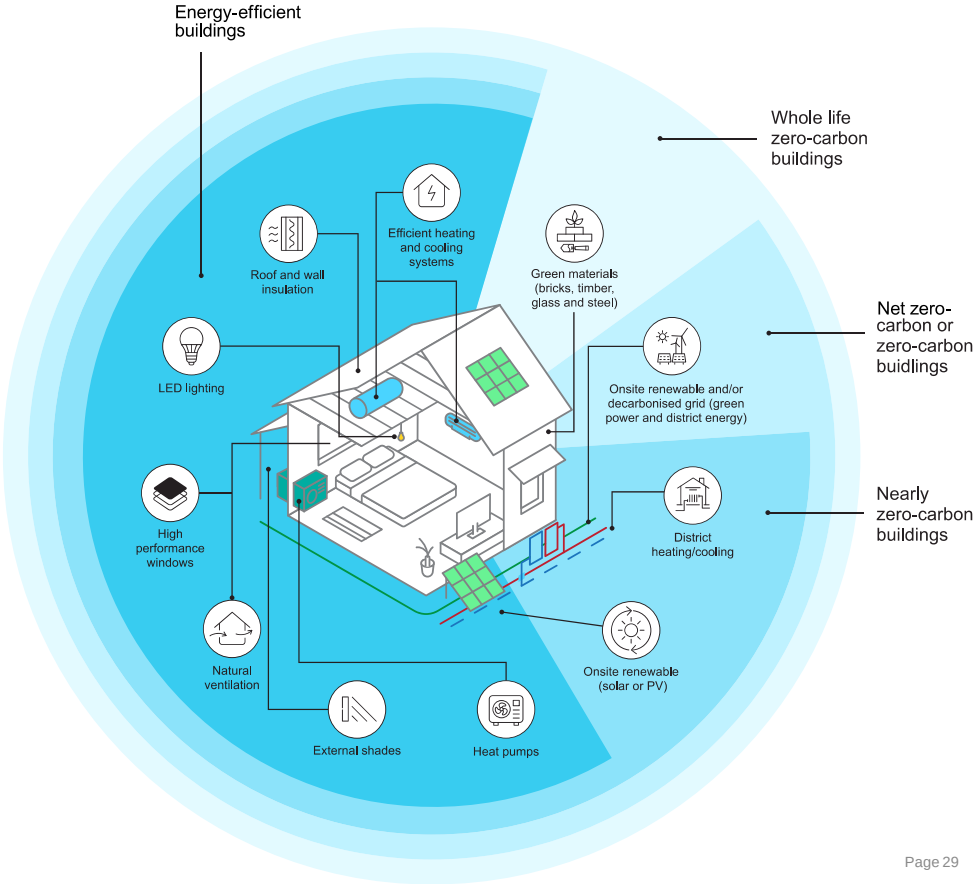


Buildings and construction are a key sector for the clean energy transition, and for the goals of the Paris Agreement

 Source: IEA Energy Technology Perspective 2021

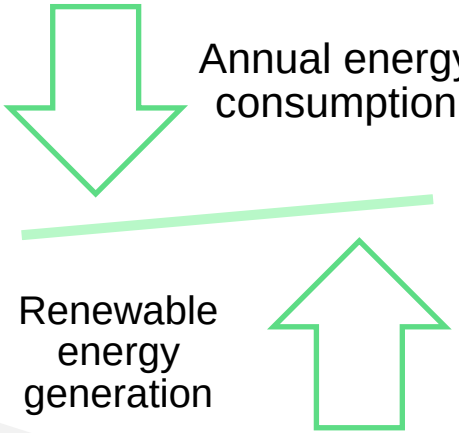
Concept of zero carbon buildings

- **Energy-efficient:** a building with a high degree of energy efficiency in its fabric and building services that consume energy, e.g. heating, cooling, cooking, lighting, ventilation, hot water, and appliances.
- **Low-carbon:** a building that is energy efficient (low-energy) and is supplied by low-carbon energy.
- **Nearly-zero carbon:** a building that is energy efficient and may have some available renewable energy supply (onsite or offsite), but complete demand offset.
- **Net-zero carbon:** a building that is energy efficient and relies on renewable energy sources that meet the energy demand over the course of a period.
- **Zero-carbon:** a building that is energy efficient and its energy demand is completely met through renewable energy generated either onsite or offsite.
- **Whole life-cycle net-zero carbon:** zero-carbon buildings, in which embodied carbon emissions from the materials used in their construction



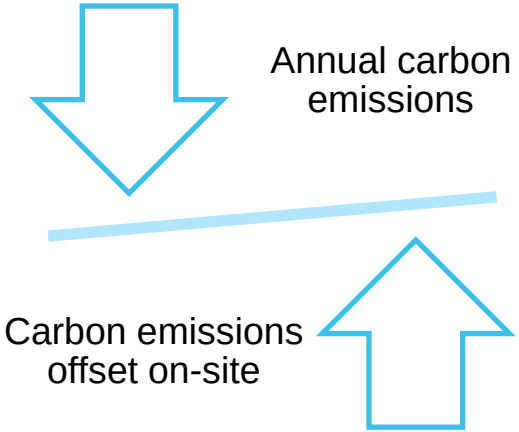
Concept of net zero

- **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?

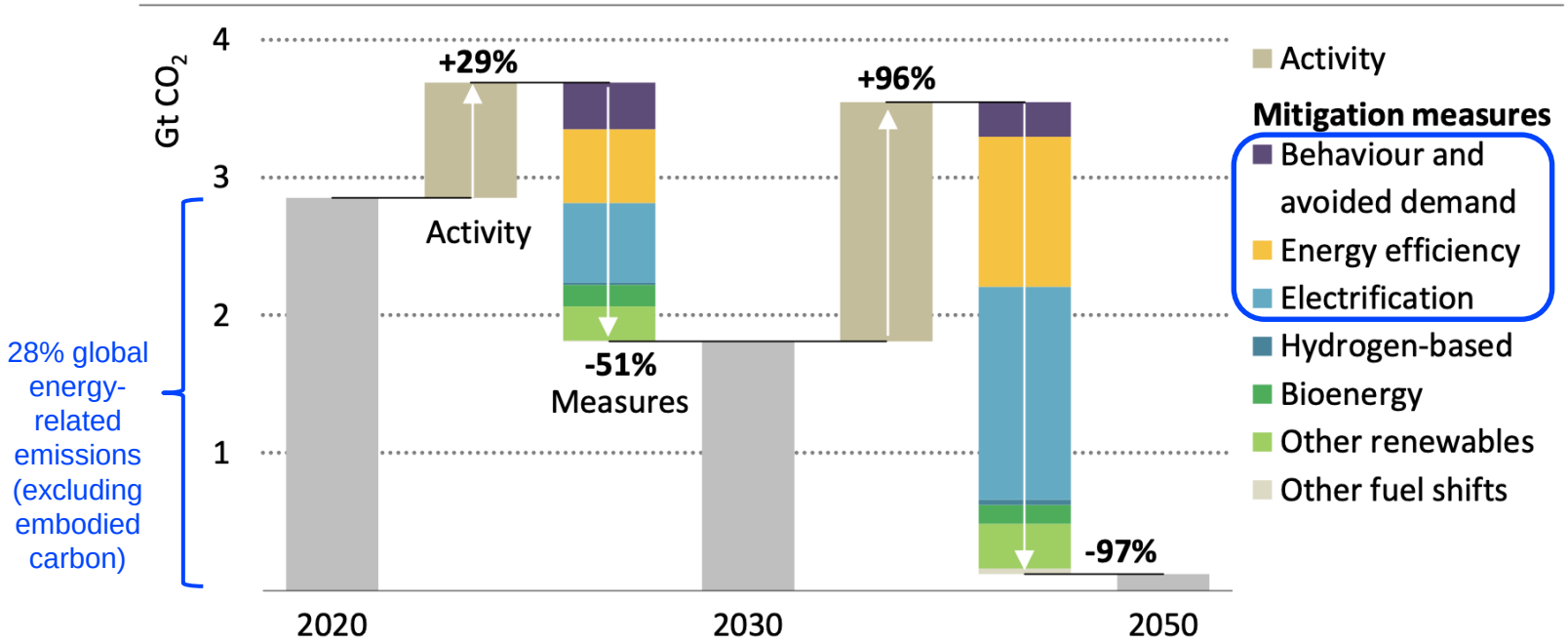
- **Net-zero carbon:** over the course of a year, the building has emitted as many carbon emissions as have been offset on site, resulting in a net-zero annual carbon emission.



What about embodied carbon?

Towards Net Zero Carbon Buildings: Developing a Roadmap for Energy Efficiency in Buildings

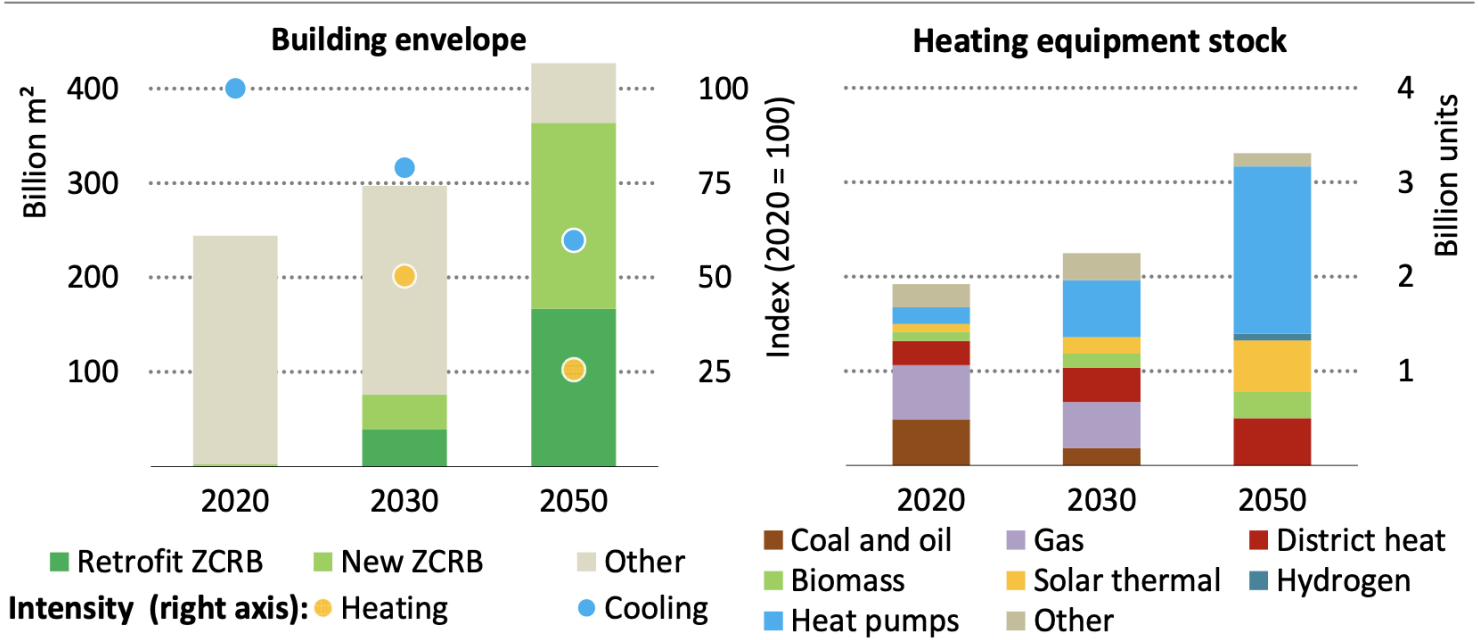
Buildings in a Net Zero Emissions Scenario



Electrification and energy efficiency account for nearly 70% of buildings-related emissions reductions through to 2050

Source: IEA (2021), Net Zero by 2050, IEA, Paris https://www.iea.org/reports/net-zero-by-2050

Final energy consumption by fuel and end-use in buildings in NZE



By 2050, over 85% of buildings are zero-carbon-ready, reducing average useful heating intensity by 75% and average useful cooling intensity by almost 50%

Source: IEA (2021), Net Zero by 2050, IEA, Paris https://www.iea.org/reports/net-zero-by-2050

The Road to Net Zero: What is needed to get there?

	2020	2030	2050
Energy intensity	Improve by 6% per year 2020-2030	4% per year 2030-2040	3% per year 2040-2050
Share of existing buildings net-zero ready	<1%	20%	>85%
Avoided demand in homes from behaviour	-	12%	14%
Stock of heat pumps	180 million	600 million	1 800 million
Dwellings with solar thermal	250 million	400 million	1 200 million
Appliances unit consumption (relative to 2020)	-	-25%	-40%
Distributed PV generation	320 TWh	2 200 TWh	7 500 TWh

And also:

- ✓ 100% lighting by LEDs by 2030
- ✓ Universal access to electricity and clean cooking by 2030
- ✓ **All new buildings are zero-carbon-ready by 2030**
- ✓ **2.5% buildings are retrofitted to be zero-carbon-ready every year by 2030**

Source: IEA (2021), Net Zero by 2050, IEA, Paris https://www.iea.org/reports/net-zero-by-2050

What is a zero-carbon-ready building?

Scope

- Operational carbon (scopes 1 and 2)
- Embodied carbon (scope 3)

Energy use

- Reduce demand through passive design, high performance building envelope, high performance equipment

Energy supply

- Integrate locally available renewable resources, with energy storage where relevant

Integration with power systems

- Connectivity and automation to provide a flexible resource to the energy system

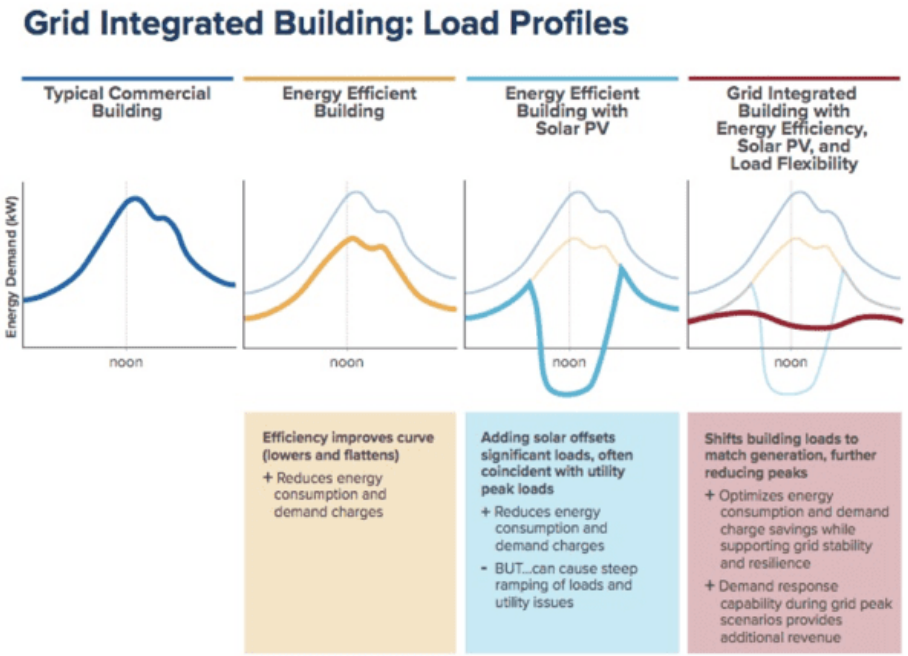
Net zero carbon construction value chain

- Promote material efficiency to reduce material demand
- Alternative materials and construction practices to lower embodied emissions

Smart Grid Interactive Buildings

What is a smart grid interactive efficient building?

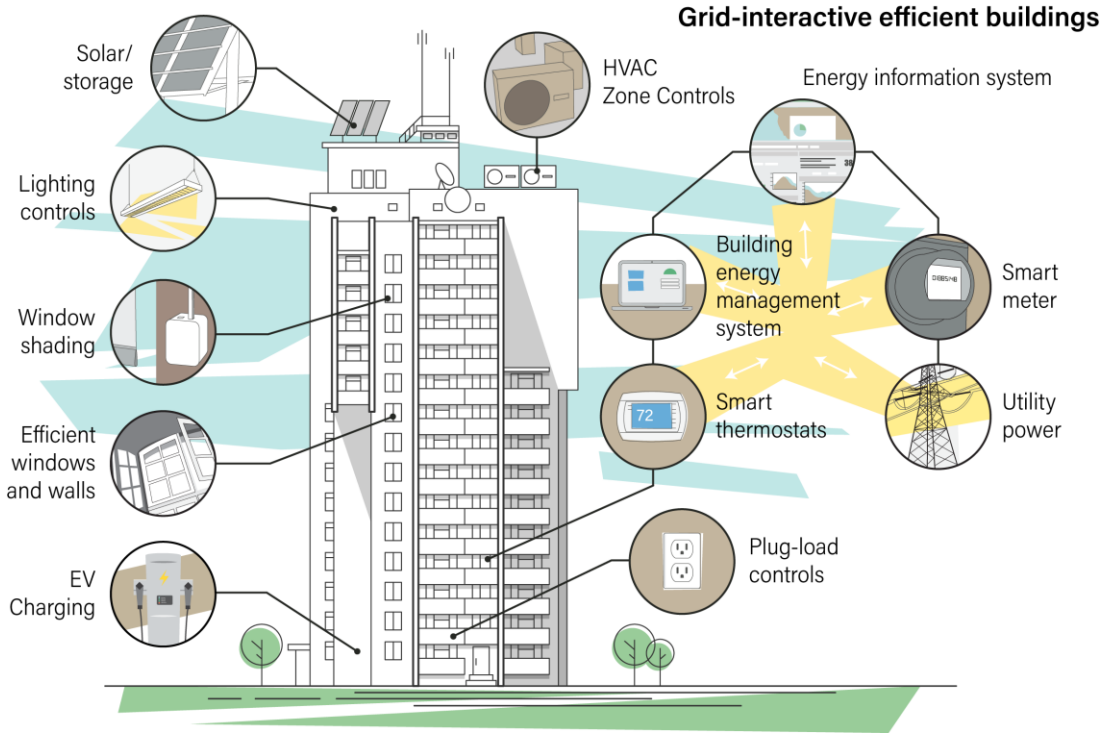
- An efficiently designed building that has adopted smart systems for its operation and that is two-way grid interactive with the utility grid to enable further efficiencies and grid management opportunities.
  - "Grid-Interactive Buildings have a holistically optimized blend of energy efficiency, energy storage, renewable energy, and load flexibility technologies enabled through smart controls.
  - This results in a lower, "flatter," more flexible energy load profile, which in turn delivers a more resilient and productive building, optimizes capital investments, reduces operating costs, and provides access to new revenue." [Rocky Mountain Institute, 2022]



Source: [RMI, Value potential for Grid Interactive Efficient Buildings. 2019]

Why are GEBs important?

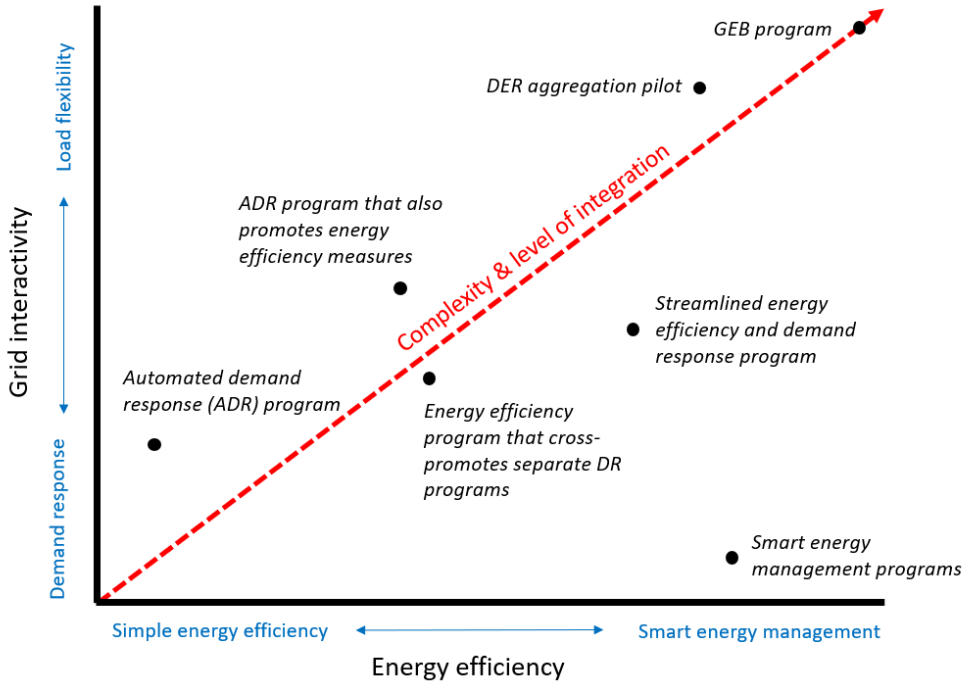
- Grid interactive buildings:
  - Allow utilities to communicate with building systems to manage load profiles and respond to changing technologies and energy demands (i.e. heat pump ownership)
  - Allow buildings to optimize services during periods time-use pricing or periods of grid capacity challenges.
  - Allow greater optimization of building integrated renewable generation for onsite and grid use.



Source: ACEE, State of the Market: Grid-Interactive Efficient Building Utility Programs

Challenges for GEBs

- Grid interactive buildings need:
  - Open, fair and accurate programs for grid-building interactions to enable energy and cost savings.
  - Well designed interoperability standards with building energy management systems.
  - Multi-stakeholder coordination towards GEB system policy design and organization structure (i.e. responsibility)



Source: ACEE, State of the Market: Grid-Interactive Efficient Building Utility Programs

Where to learn more

IEA Energy Efficiency in Buildings MOOC

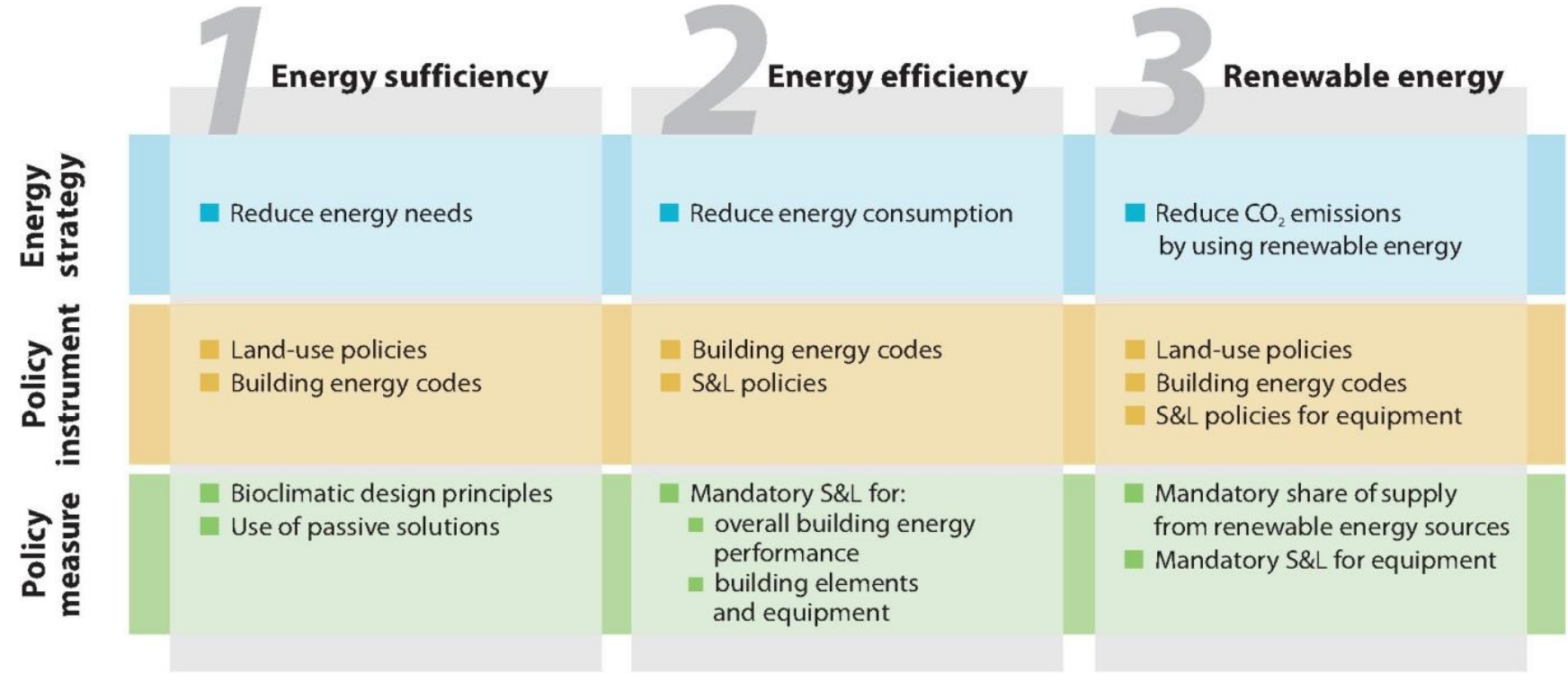
- Find more on the above topics in the MOOC here: https://elearning.iea.org/courses/course-v1:IEA+BUILDINGS1+Open/about
  - Module 1 – Energy Use:
    - Lesson 1
      - The lifecycle of buildings
      - Drivers of building energy use (Part I and II)
      - Building energy use
    - Lesson 2 - Energy efficiency potential
      - How much potential is there

International Energy Agency

Energy Efficiency Policy Training Week: Buildings – Day 2 – Part B – Design and Systems

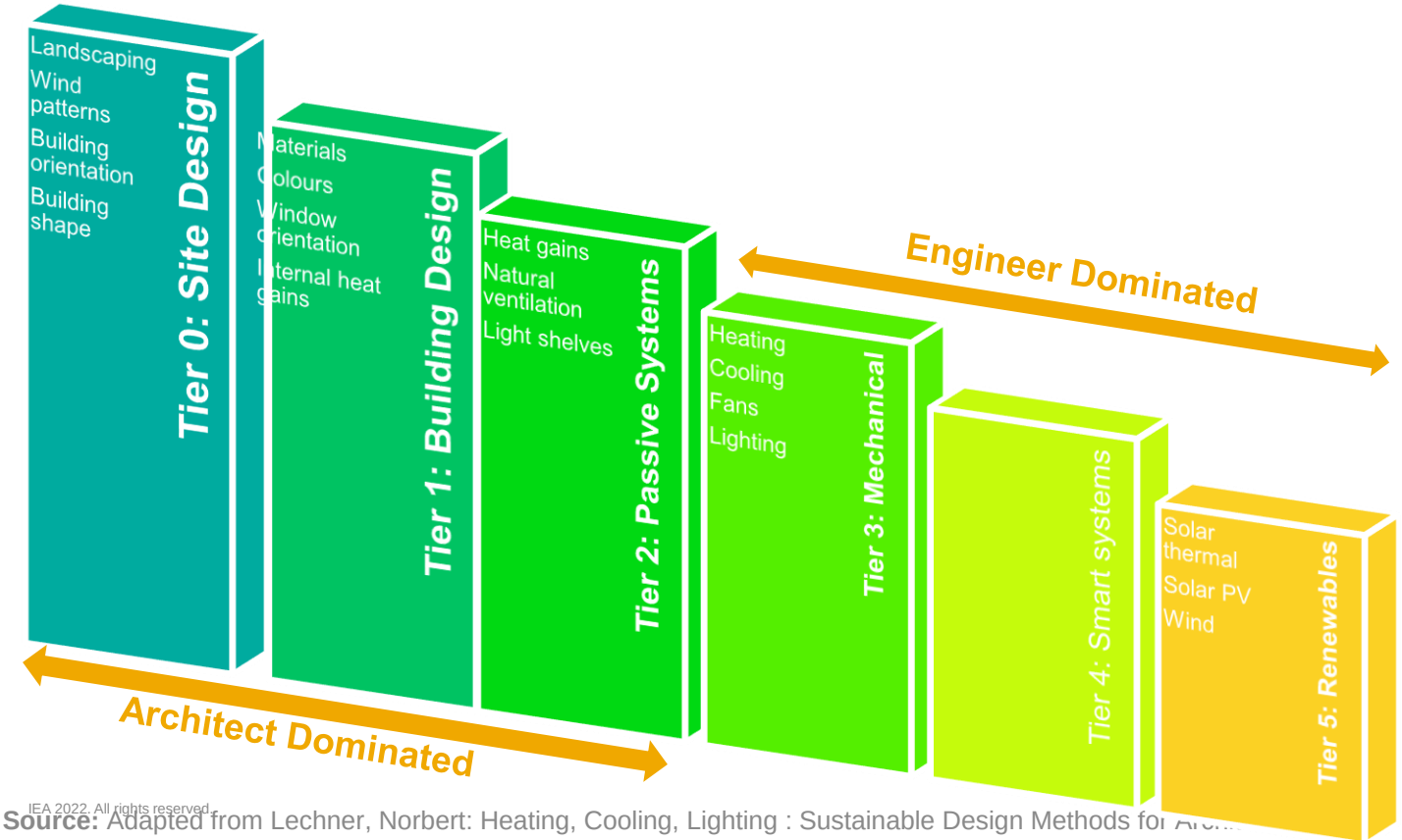
Efficient building design

Path to zero emissions or net zero energy buildings



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

The tiered approach for the integrated design process



Integration of:

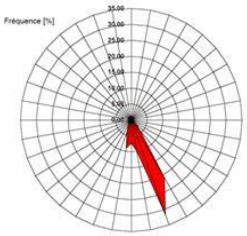
- Multiple design professionals
- Multiple aspects of building design and construction

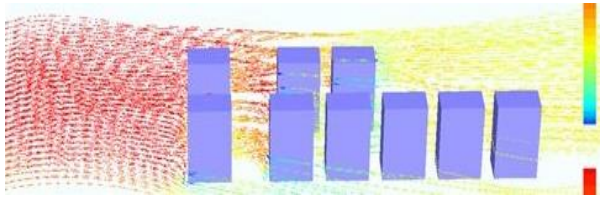
Source: Adapted from Lechner, Norbert: Heating, Cooling, Lighting : Sustainable Design Methods for Arc...

Integrated Design Process: Tier 0 – Site Design

Landscaping

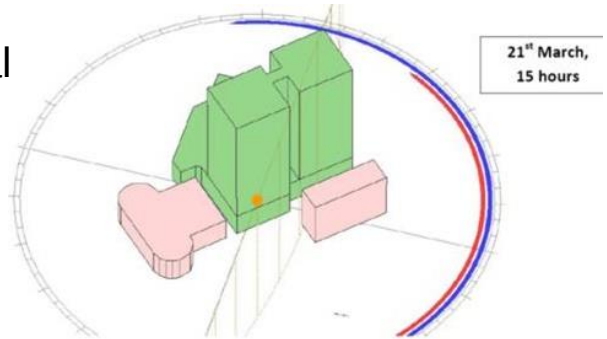
- Impact on solar gains on building
- Impact on airflow
- Seasonal variation





Wind patterns

- Dominant wind direction in hot summer
- Layout of buildings for natural ventilation potential



Building orientation & building shape

- Solar gains on facades
- Optimal orientation of facades

Source: Adapted from Lechner, Norbert: Heating, Cooling, Lighting : Sustainable Design Methods for Architects

Integrated Design Process: Tier 1 – Building Design

Building envelope is often the main source of heat gain/loss

- Walls, windows, roof, uncontrolled air infiltration
- There is a wide variation in the quality of building envelopes:

U ~ 3.5 W/m^2.K
Monolithic concrete wall

35% Windows with inadequate shading

U ~ 0.5 W/m^2.K

10% Windows with shading

Source: Adapted from Lechner, Norbert: Heating, Cooling, Lighting : Sustainable Design Methods for Architects

Integrated Design Process: Tier 2 – Passive Systems

“ancient” architecture (low window to wall ratio, natural ventilation, …

“modern” architecture 70-100% glazed, no natural ventilation, all air systems

“sustainable” architecture 15-40% window to wall ratio, bioclimatic design approach, natural/hybrid ventilation, external movable solar protection, radiant cooling

Source: BEEP India

Integrated Design Process: Tier 3 – Mechanical Systems

After all of the passive options are used, mechanical systems can deliver the designed comfort:

- Active heating systems
- Active cooling systems
- Fans
- Active lighting

Intelligent controls Flexibility

Source: Adapted from Lechner, Norbert: Heating, Cooling, Lighting : Sustainable Design Methods for Architects

Integrated Design Process: Tier 4 – Smart systems

Adopting smart technologies to monitor and manage system operations and user interfacing offers an opportunity to further achieve efficiencies through:

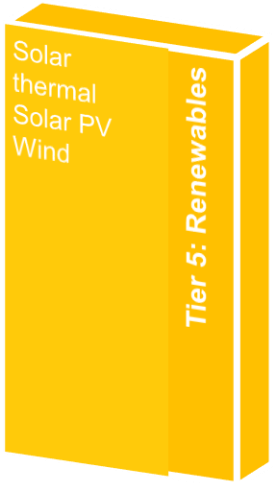
- Smart occupant sensing
- Daylight/artificial light shifting
- Automated weather adjusted comfort controls
- Grid interactive buildings

Source: Adapted from Lechner, Norbert: Heating, Cooling, Lighting : Sustainable Design Methods for Architects

Integrated Design Process: Tier 5 – Clean Renewable Energy

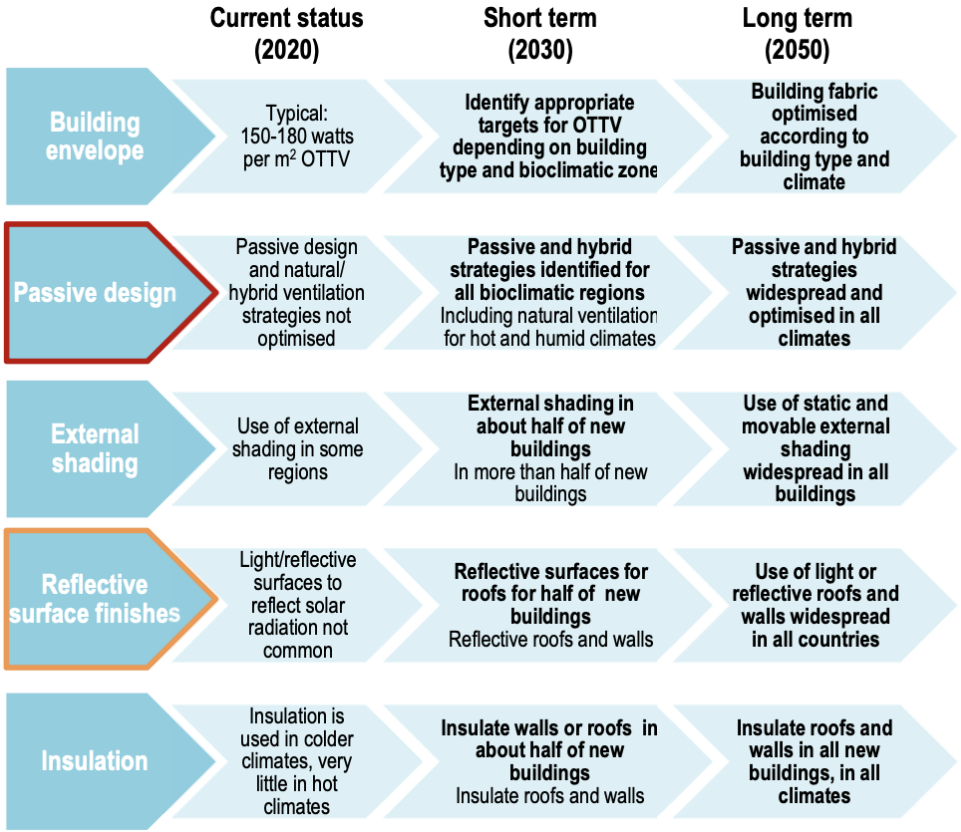
Onsite zero carbon clean energy provides an opportunity to meet building energy demand through:

- Lowering cost of energy bills through onsite generation
- Producing clean energy and helping to reduce air pollution
- Increasing building and grid resilience
- Be a “Prosumer” by selling excess energy

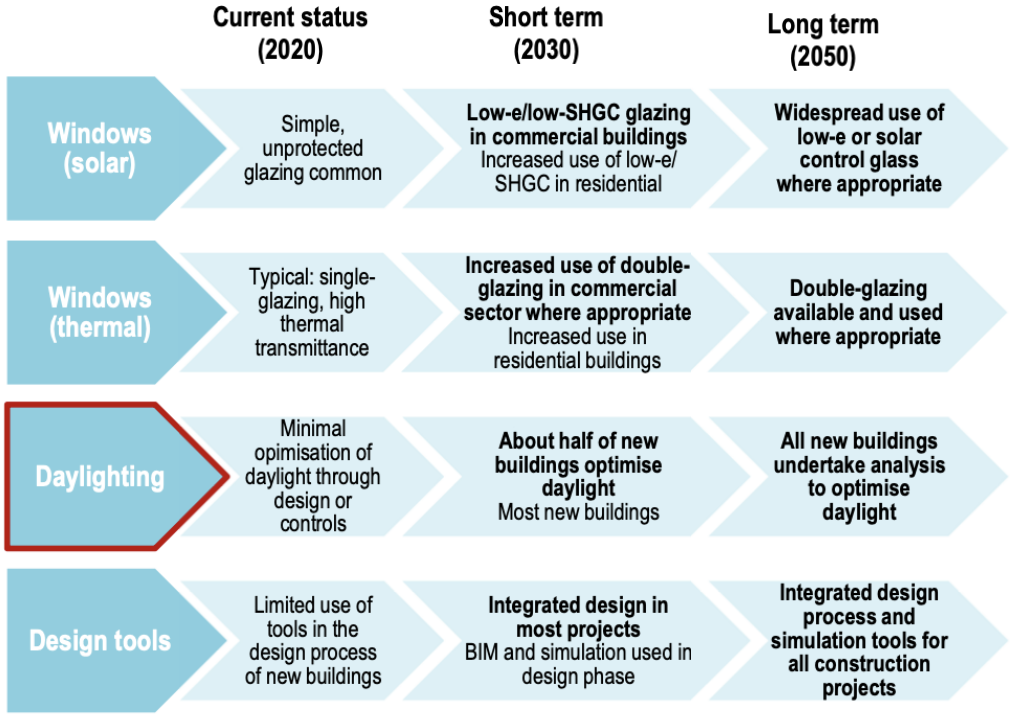


Source: Adapted from Lechner, Norbert: Heating, Cooling, Lighting : Sustainable Design Methods for Architects

Path to net zero emission buildings



Path to net zero emission buildings

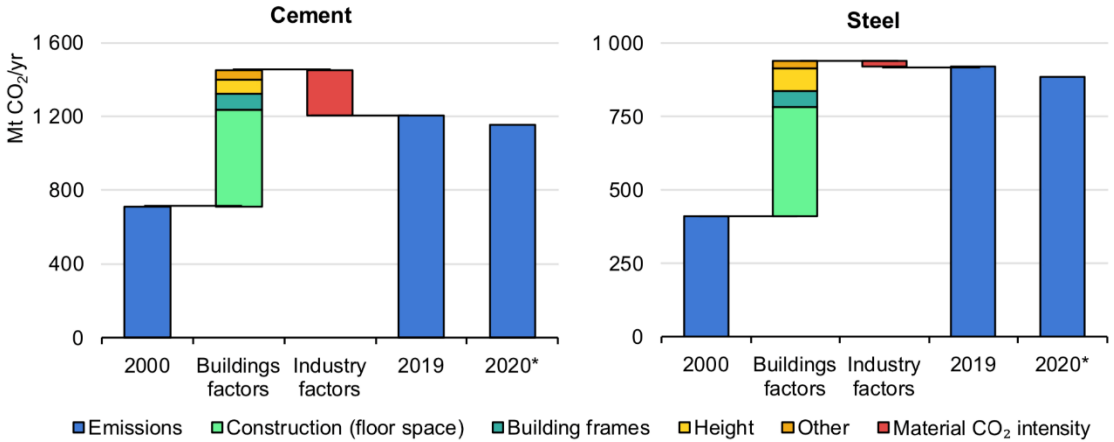


Low/Zero-Carbon Materials

Decarbonising materials

- The manufacturing, transportation and use of all construction materials for buildings resulted in energy and process CO2 emissions of 3.5 Gt in 2019, or 10% of all energy sector emissions.
- Reducing the embodied carbon of buildings construction materials is a key part of achieving net zero carbon buildings.

Decomposition of embodied cement and steel sector CO2 emissions in buildings construction, 2000-2020

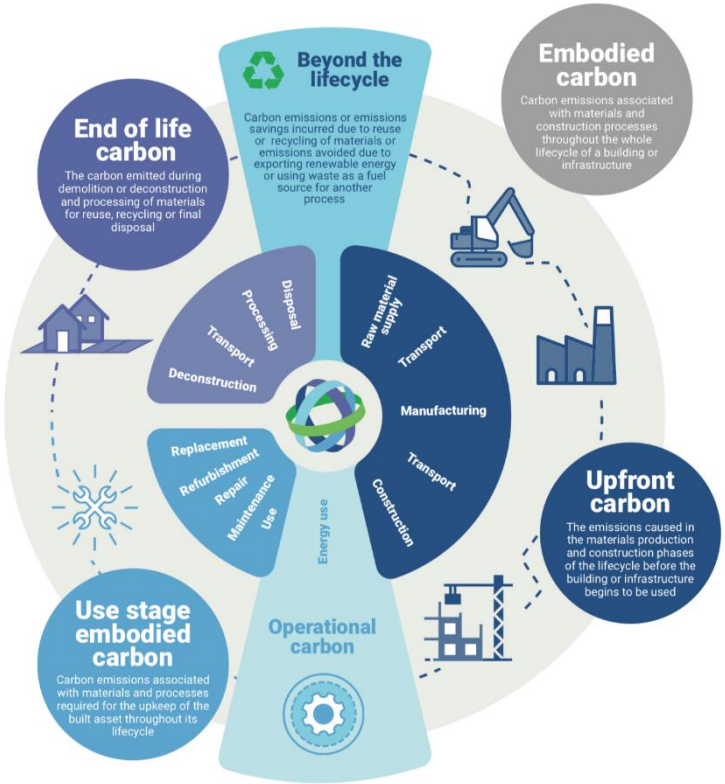


* Projected emissions for the year 2020 account for construction activity indicator for the first half of 2020 followed by an assumed economic recovery facilitated by no further major lockdowns for the second half of 2020.

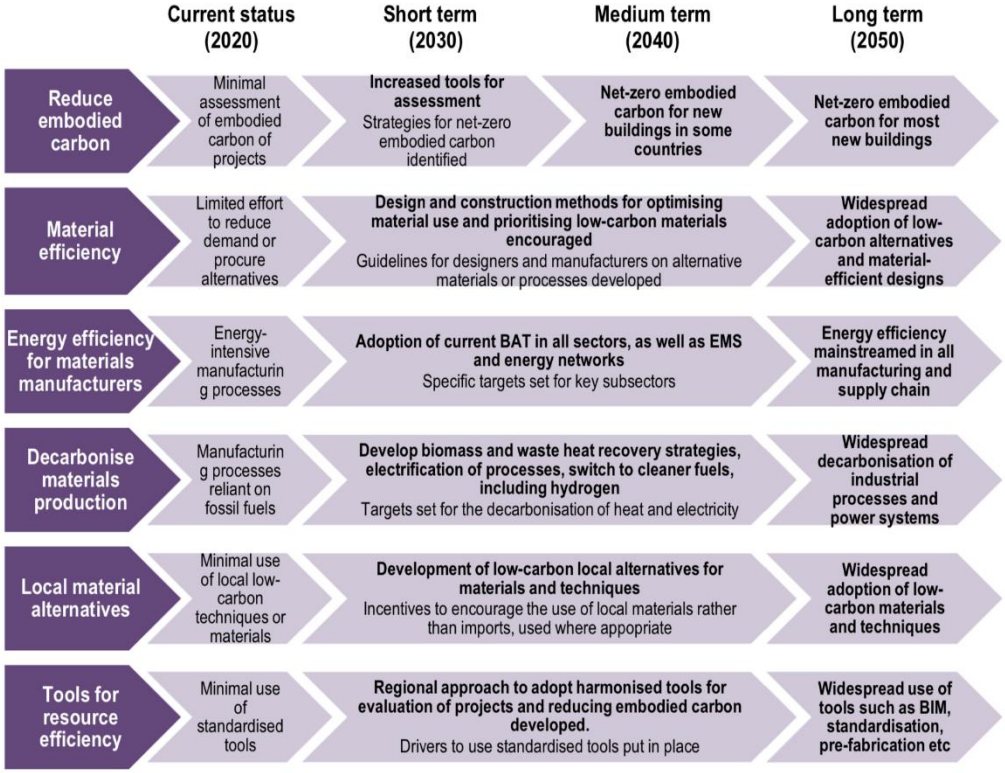
Notes: This figure is based on a logarithmic mean divisia index which compares each influencing factor contributing to embodied emissions in 2019 relative to 2000 to assess their contribution to the change in emissions. *Other* includes increased material use per unit of new floor area related to changes in building code enforcement and construction practices, as well as the effect of existing floor area renovation.

Decarbonising materials

- The factors that influence embodied carbon include:
  - Construction technique,
  - Material demand,
  - Durability,
  - Origin (recycled versus virgin and location),
  - Composition,
  - Manufacturing processes, and
  - Reusability and recyclability.



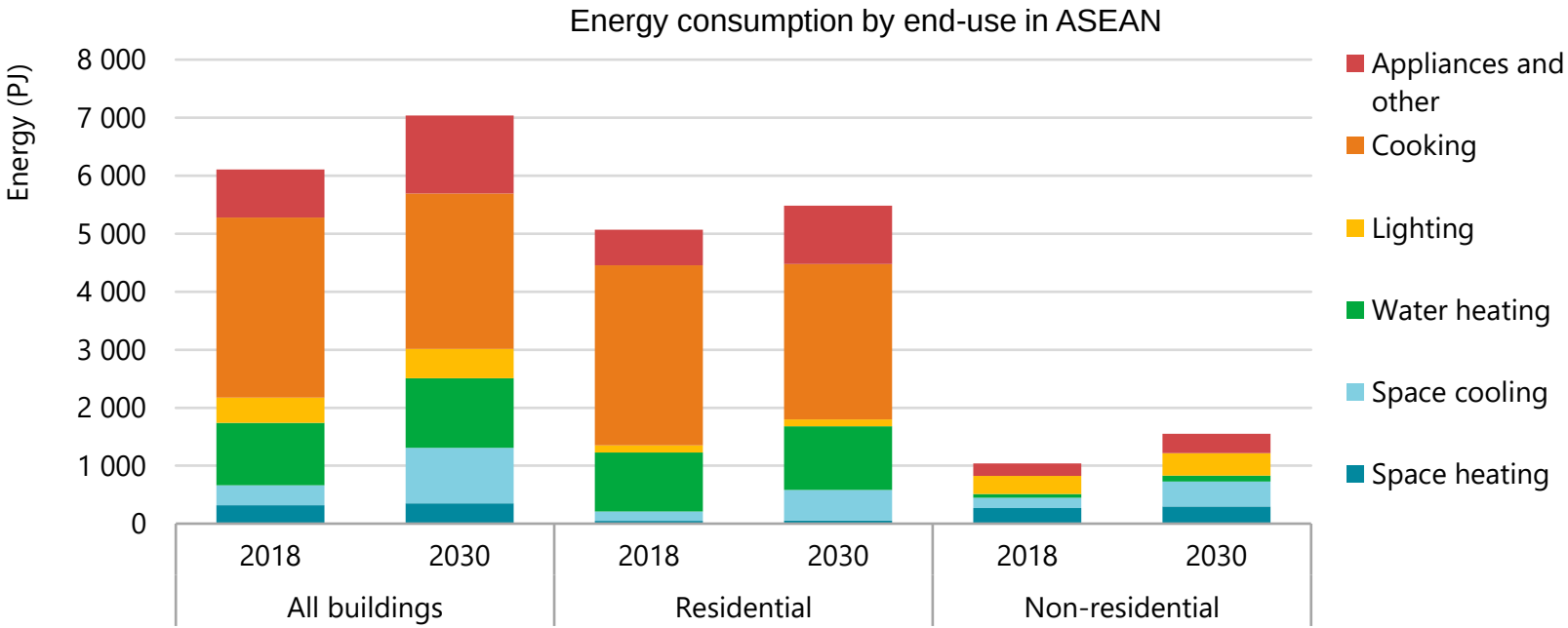
Path to net zero emission buildings



Notes: The **proposed global target** is in **bold**. Below that is the proposed accelerated target.

Energy efficient systems and operations

What systems are we talking about ?



Prioritise water heating and appliances (residential) and lighting, cooling and appliances (non-residential). BUT AC ownership in households is growing.

Setting the level of ambition: what are we trying to achieve?

Building systems and operations:

What are we trying to achieve	What are the factors	How might we measure that ?
• **Low operational energy** • **Low capital cost** • **Comfortable** • **Easy to maintain** • Resilient • Low emission	• Climate • Typology • Choice of systems • Operation and maintenance	• Annual energy consumption, EPI (kWh/m²/year) • Efficiency of systems • Use of procedures

Drivers of building energy use: systems

Once energy needs have been reduced through passive measures, the principle factors become:

Responsible:	• Designer	• Manufacturer	• Facilities manager	• Operator/ occupant

What operations are we talking about?

- Building operations consists of the activities necessary to **operate**, **maintain**, and **manage** buildings. This includes maintaining the HVAC systems, plumbing, electrical, and building system configuration.
- Operation and management activities, methods, and approaches should **enable energy savings** while maintaining or enhancing **indoor environmental quality** and **equipment reliability**.
- Good operation and management practices will lead to the efficient operation of buildings. Can also lead to increased **productivity** of occupants, and a **longer lifetime** of the building and its components.
- Operation management Improvements focus on:
  - Management: goals, planning, accounting
  - Teamwork: staffing, training, outsourcing
  - Resources: documentation: tools, assessments
  - Energy-Efficient operation and maintenance: Tune-up, automated controls, scheduling, tracking, prevention

Asys smart management, 2019

System and operations technology gaps

Technologies that are relevant to building systems and operations include:

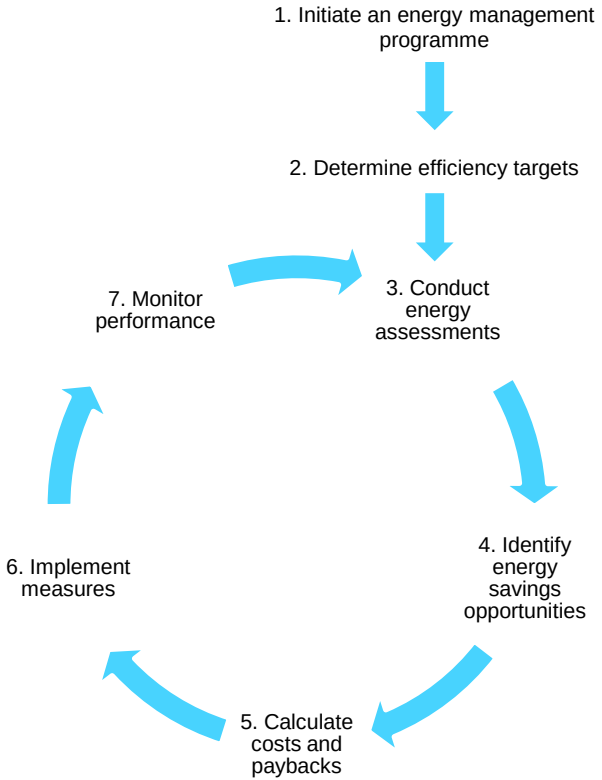
Residential	
Cooking & water heating	**Space cooling**
- More efficient fuels eg. Electricity or gas - Heat pump - Solar thermal - District heating	- Split systems - Inverters - Window units, portable ACs - Fans
Appliances & lighting	**Ventilation**
- Efficient appliances with low standby power - “Smart” devices - LEDs - Smart meters	- Properly sized and positioned kitchen extract

Non-residential	
HVAC	
- Central HVAC, pumps and fans, commissioning - Air cooled vs water cooled chillers - Split systems, inverters, heat pumps - District systems - Evaporative cooling, heat recovery, free cooling - Temperature set point	
Lighting	**Controls & Energy management**
- LED - Dimming, daylight harvesting	- Variable speed drives - Smart and connected sensors - Building management systems - Daylight control of lighting - Audit tools, metering - Maintenance tools
Appliances and other loads	
- Efficient data centres - Efficient and low standby losses	

Consider for implementation: which are available locally? Which are currently affordable? Expensive? Are specially skilled workers or tools required?

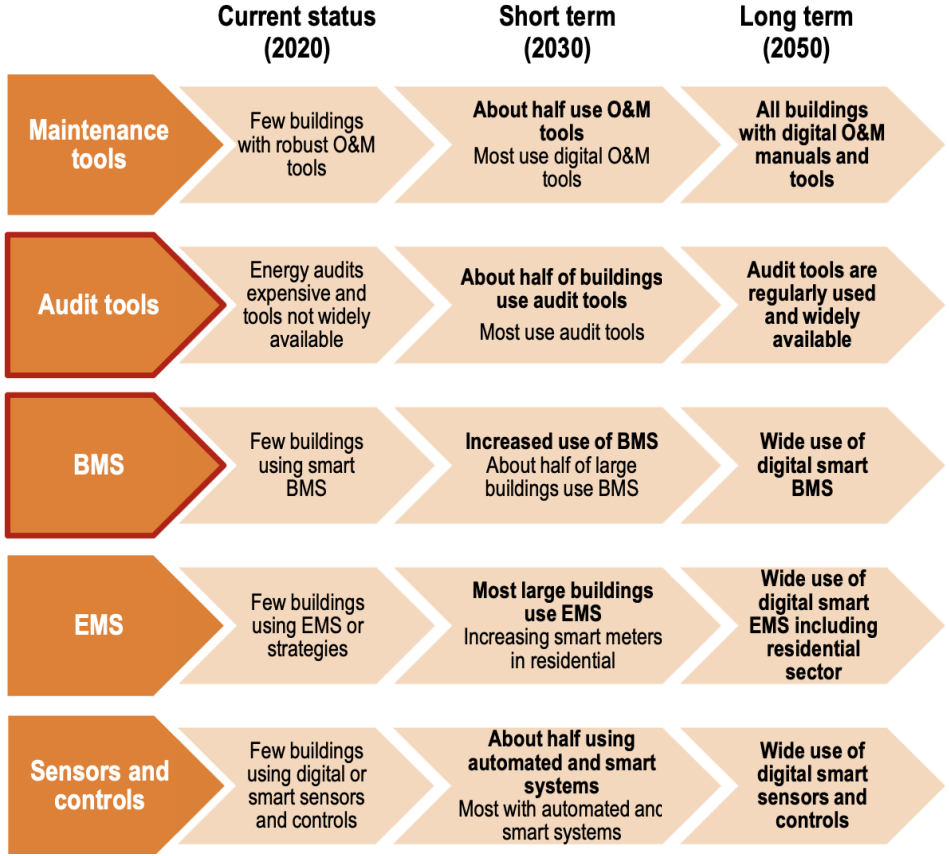
Energy management in buildings: 7 key steps

- Implement energy efficiency measures
  - All cost effective measures that have benefit to owners and occupants
- Monitor performance
  - Evaluation of energy efficiency
  - Data collection / sensors / energy management systems
- Continuous improvement
  - Use the information collected to continue the process again back at step 3 to identify more energy savings opportunities for continuous improvement

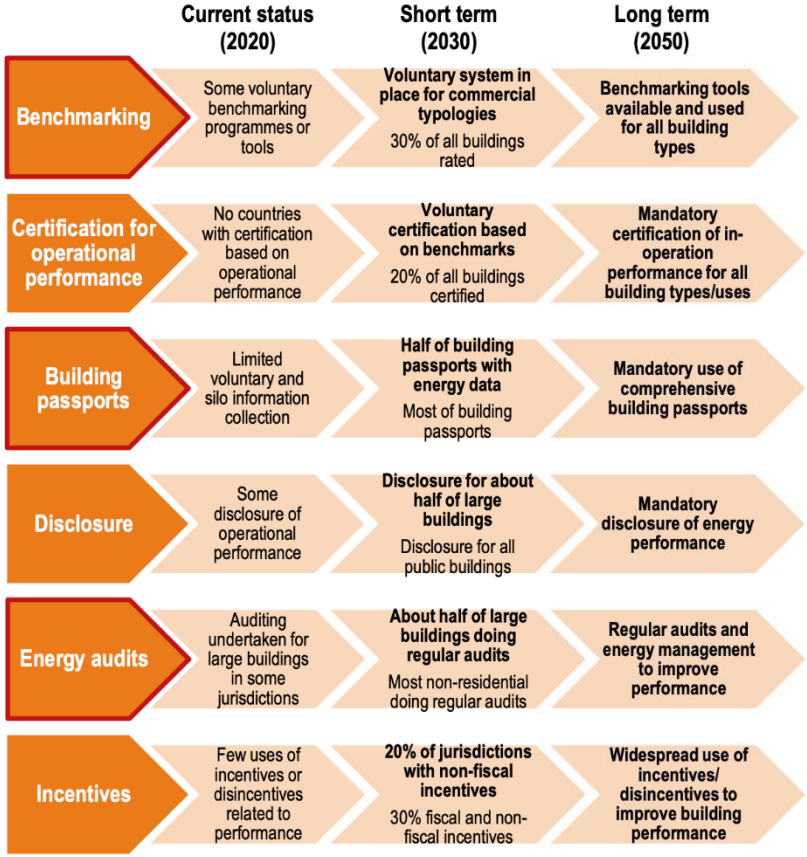


Adapted from: India Bureau of Energy Efficiency, Energy Management in your School, Hospital, Hotel.

Path to net zero emission buildings



Path to net zero emission buildings



Where to learn more

IEA Energy Efficiency in Buildings MOOC

- Find more on the above topics in the MOOC here: https://elearning.iea.org/courses/course-v1:IEA+BUILDINGS1+Open/about
  - Module 1 – Energy Use:
    - Lesson 1
      - The lifecycle of buildings
      - Drivers of building energy use (Part I and II)
      - Building energy use
    - Lesson 2 - Energy efficiency potential
      - How much potential is there
    - Lesson 3 - Energy efficient building design
      - Integrated design process
    - Lesson 4 – Energy efficient building technologies
      - Envelop technologies

Energy Efficiency Policy Training Week: Buildings – Day 2 – Self-study

International Energy Agency

Self-study activity

Question 1 – Written assignment

- Rank the selected energy efficient and low-carbon technologies in order of their importance for transitioning the buildings sector in your country toward zero-carbon.

Question 2 - Written assignment

- In your opinion, explain why your top-three choices are crucial for enabling the transition towards zero-carbon buildings in your country? Feel free to describe the importance of other energy efficient and low-carbon strategies that are not included in the ranking question.

Self-study activity

Question 3 – Written assignment

- Rank the selected barriers in terms of their impact on limiting the uptake of energy efficient and low-carbon buildings in your country.

Question 4 – Written assignment

- In your opinion, explain why your top-three choices for barriers are the most impactful ones? Feel free to discuss the importance of other barriers that may not be included in the ranking question.

Energy Efficiency Policy Training Week: Buildings – Day 2 – Breakout Session

International Energy Agency

Breakout group activity

- We will now be split into three groups:
- Group leads are:
    1. Group 1: Ian Hamilton & Estefania Mello & María Mora
    2. Group 2: Ksenia Petrichenko & Elisete Cunha
    3. Group 3: Cornelia Schenk & Liliana Campos

- In each group, describe the key actions needed to move towards energy efficient and zero-carbon buildings, their current status, their advanced practice, and timelines for their potential adoption, as well as needs for capacity building and other support.

Okay – now to your groups!

International Energy Agency

Energy Efficiency Policy Training Week: Buildings – Day 2 - Closing

Energy Efficiency Training Week: Day 2 Coursework

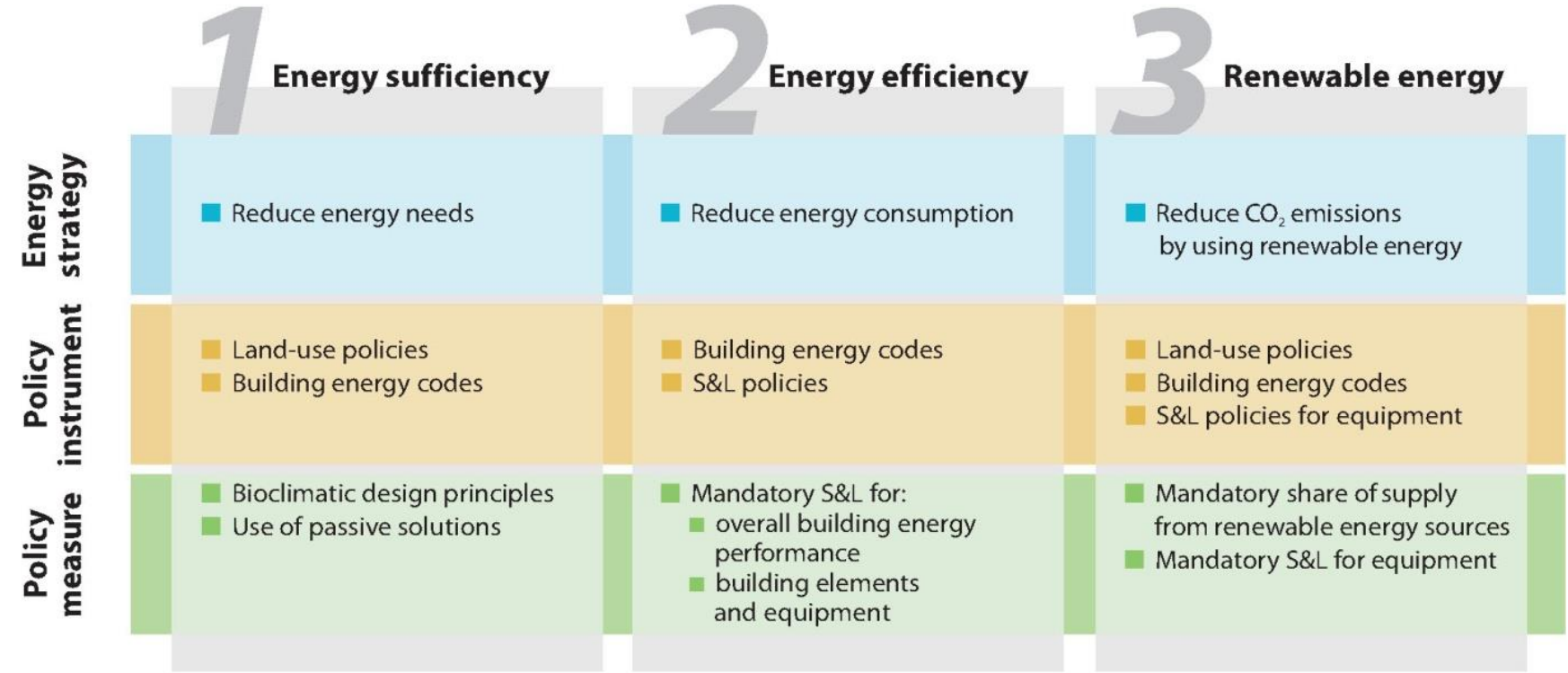
Buildings Training Activity

Use Mentimeter.com and provide a few words on:

https://www.menti.com/fxnn1wbbyn

Results

Key learning points of Day 2



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

Energy Efficiency Training Week: Buildings Content Programme

Training Day 3:

Part A: Policies and regulations

- What is a policy package and how to construct it
- Policy package approach to supporting energy efficiency and zero-carbon buildings performance
- Building codes and standards: what are they, how do they work, how to develop and adopt
- MEPS: what are they, how do they work, how to develop and adopt
- Regional and international examples of codes and regulations

Part B: Multiple benefits of energy efficiency

- Type of multiple benefits
- Methods and indicators
- Regional and international examples

Team starter activity

REMINDER: Buildings Training Session Assignment

For **Day 3**, please take a photo of something in your home or place of work that you think most represents building energy efficiency!

Submit the photo here: Google Form Link

Energy Efficiency Training Week: Day 2 Learning Objectives

Key Learning Objectives:

- Understanding key energy efficiency and zero-carbon buildings concepts
- Understanding energy efficient building design practices
- Understanding energy efficient building systems and operations
- Understanding embodied carbon and low/zero carbon materials