ICLEI Local Governments for Sustainability

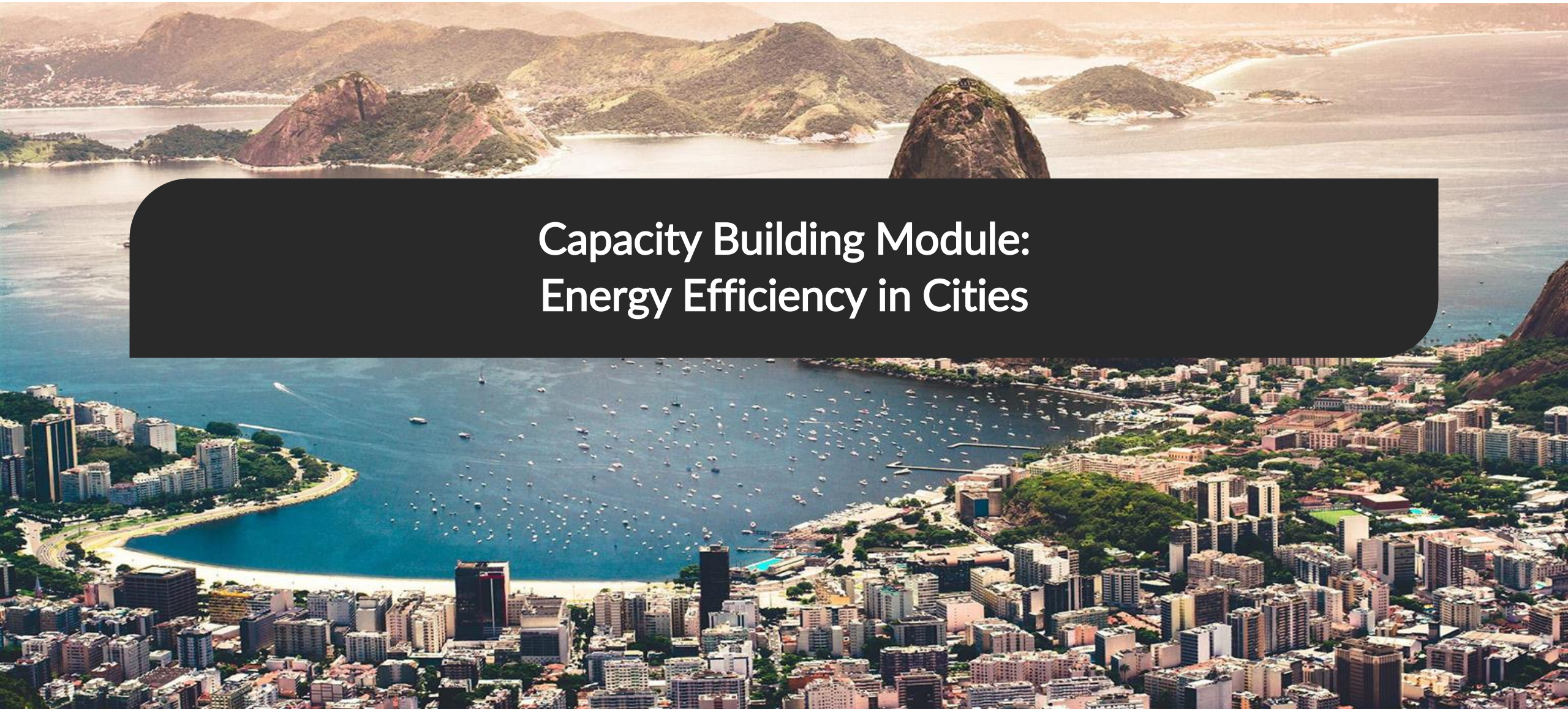
100% RENEWABLES CITIES & REGIONS ROADMAP

Supported by:

Federal Ministry for Economic Affairs and Climate Action

IKI INTERNATIONAL CLIMATE INITIATIVE

on the basis of a decision by the German Bundestag



Capacity Building Module: Energy Efficiency in Cities

CHAPTER 2:

Energy efficiency across sectors

CONTENTS

Energy Efficiency in the Building Sector

Energy Efficiency in the Industrial Sector

Energy Efficiency in Transport and Mobility

Section structure:

- Overview of energy consumption
- Strategies and measures for promoting energy efficiency
- Policy packages and instruments for energy efficiency

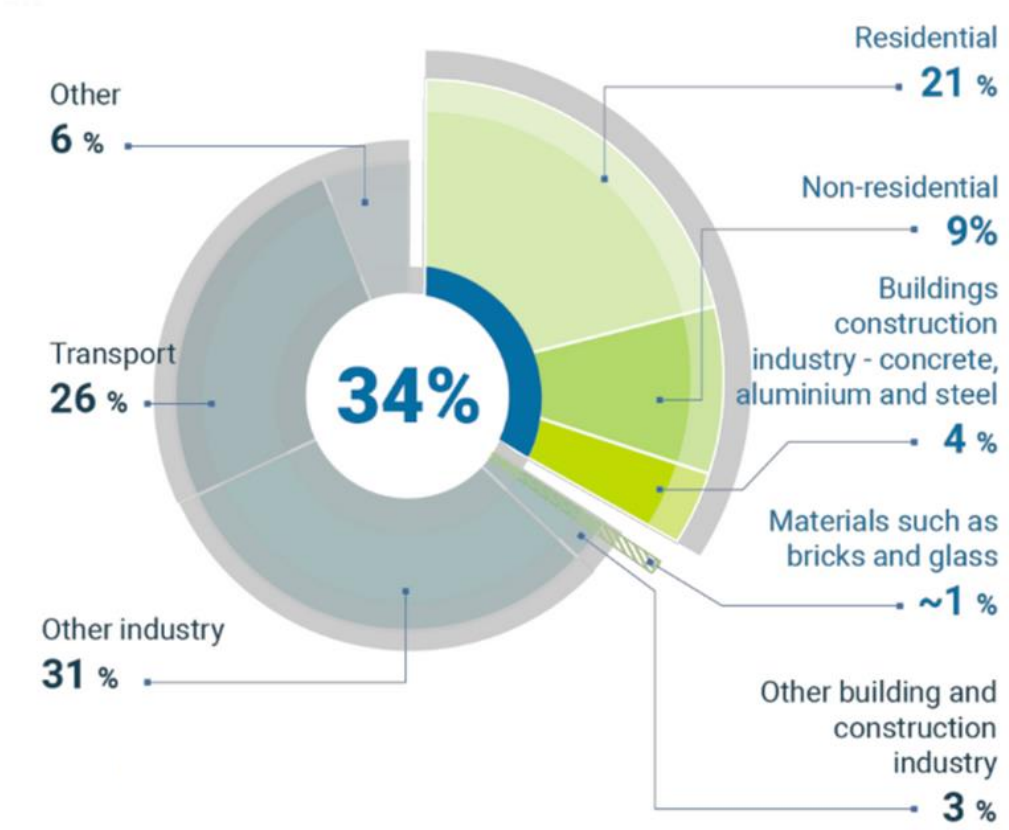
PART 1

ENERGY EFFICIENCY: BUILDINGS SECTOR

BUILDING ENERGY CONSUMPTION: GLOBAL OUTLOOK

Energy Consumption Breakdown

Buildings play a big role in global energy use and emissions



Current Energy Sources

Renewables play a smaller role

SOURCE: United Nations Environment Programme (2022). 2022 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Nairobi.

ENERGY USE OVER BUILDING LIFECYCLE

LIFE CYCLE IMPACT

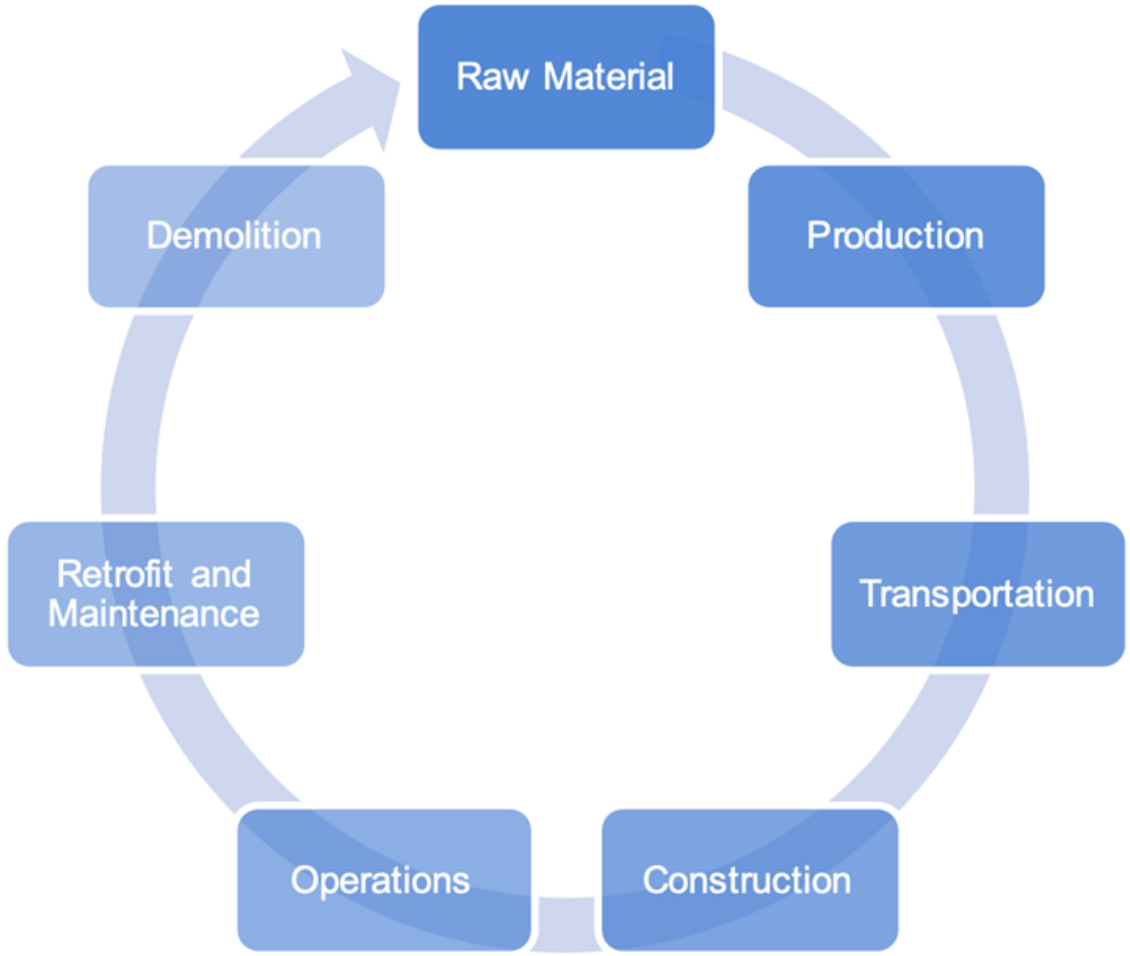
Energy input and emissions output occur throughout a building's entire life, from production to demolition

IMPORTANCE OF LIFECYCLE ANALYSIS

Conducting a lifecycle analysis is crucial.
It helps understand embodied (production-related) and operational (use-related) energy and emissions

INFORMED DECISION-MAKING

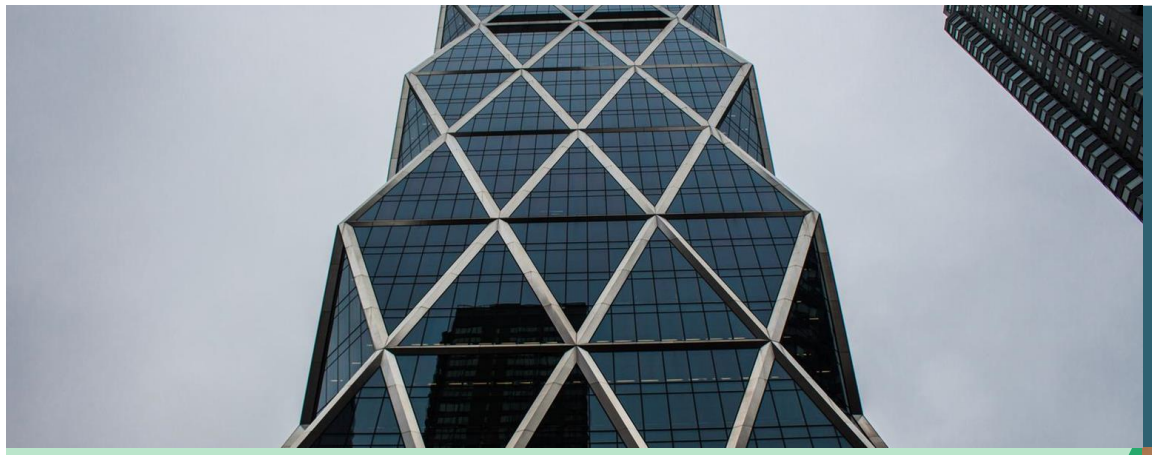
Life cycle analysis (LCA) informs decisions for planning energy efficiency in buildings



Source: Adapted based on Built Constructions Magazine, IEA 2019

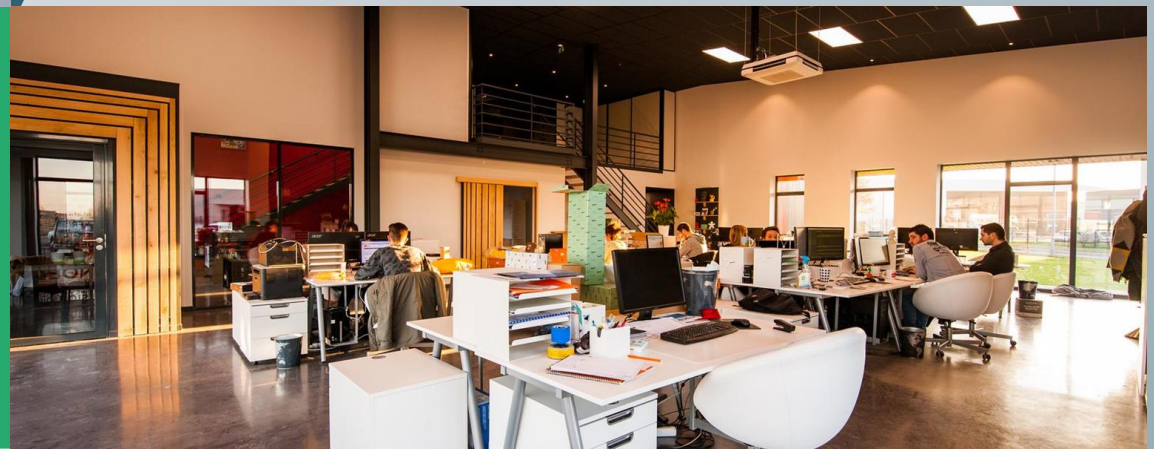
DRIVERS OF BUILDING ENERGY CONSUMPTION

Building energy consumption is driven by:



Form

Function
i.e., services



FORM AS A KEY DRIVER OF BUILDING ENERGY CONSUMPTION

- Form includes shape, size, materials, and window placement.
- Mostly fixed during building planning, hard to adjust later.
- Retrofits can help optimize form for energy efficiency.

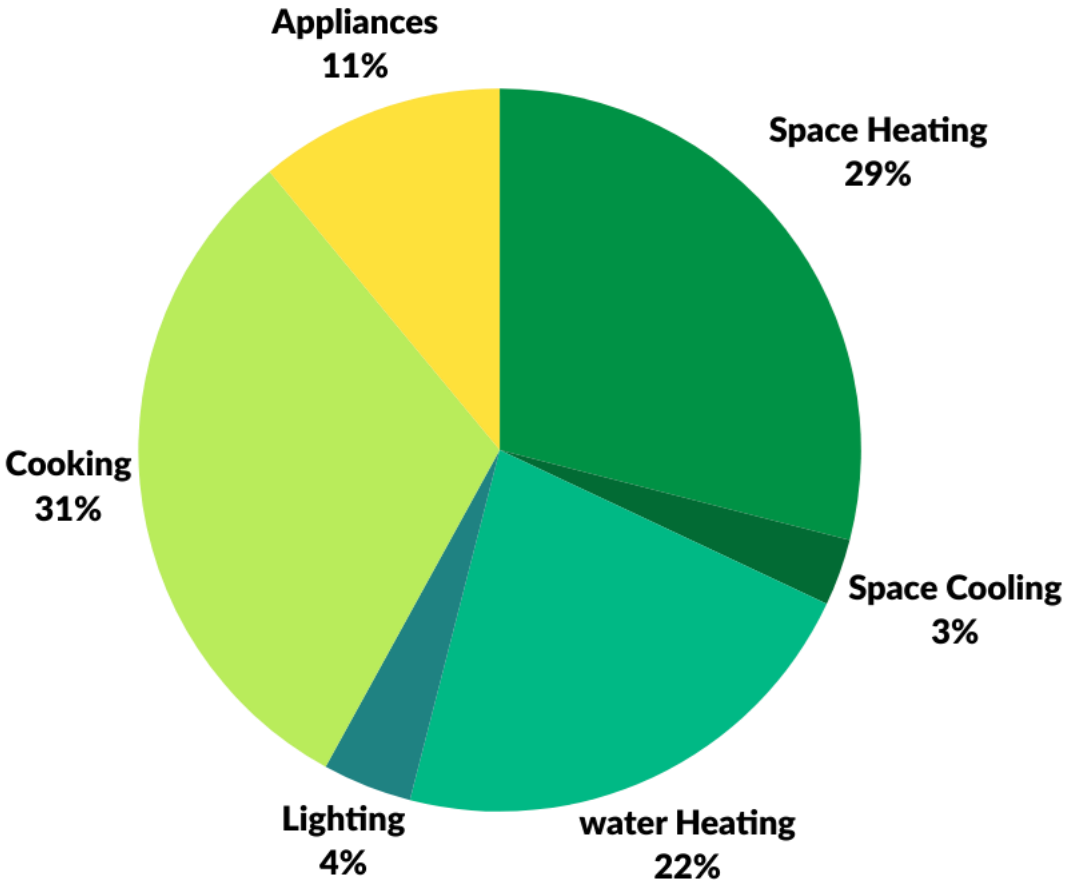
FUNCTION AND SERVICES AS DRIVERS OF BUILDING ENERGY CONSUMPTION

- People demand functions and services, not just energy.
- Design optimization from the start can reduce energy needs for functions and services.
- Common functions and services include lighting, air conditioning, ventilation, appliances, etc.

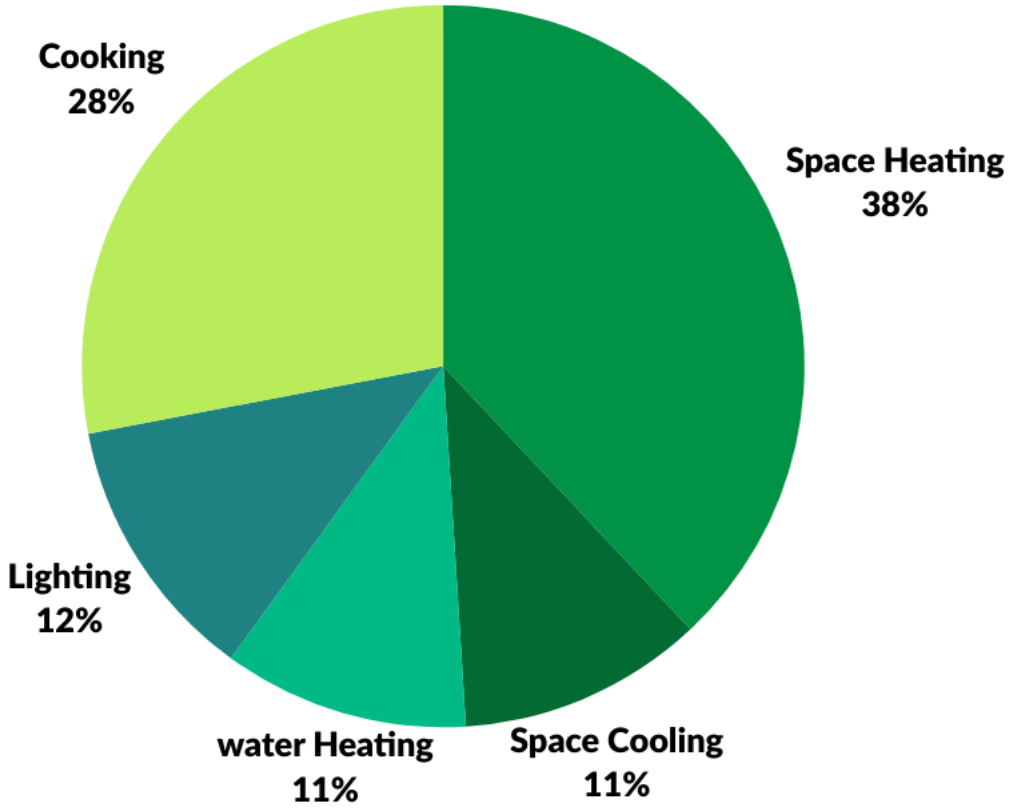
ENERGY CONSUMPTION BY BUILDING TYPE AND FUNCTIONS

100% RENEWABLES CITIES & REGIONS ROADMAP

Residential (90 EJ)



Non-residential (35 EJ)



Source: Energy Technology Perspectives, IEA 2017

COMMON ENERGY EFFICIENCY MEASURES IN BUILDINGS

100% RENEWABLES CITIES & REGIONS ROADMAP

AT BUILDING LEVEL

- Lighting retrofitting
- Install building management systems
- Install occupancy sensors for offices and photo sensors/timers for security lights
- Check energy rating on appliances (choose high ratings)
- Windows/building envelop upgrades
- Cooking:
  - Position refrigerators away from cookers and direct sunlight
  - Avoid frequent opening & closing of refrigerators
  - Cool the food first before putting in the refrigerator and set the correct temperature

AT CITY LEVEL

- Replacing streetlights with more efficient models
- Implement regional energy management systems
- Deploy occupancy sensors for public spaces
- Utilize regional photo sensors / timers for outdoor lighting
- Promote high efficiency appliances regionally
- Regional guidelines for appliance usage
- Promote regional refrigeration strategies in homes and businesses
- Public awareness campaigns
- Promote efficient food storage practices

ENERGY EFFICIENT BUILDING DESIGN

Definition: Optimizing construction and services for minimal energy consumption

Key Features:

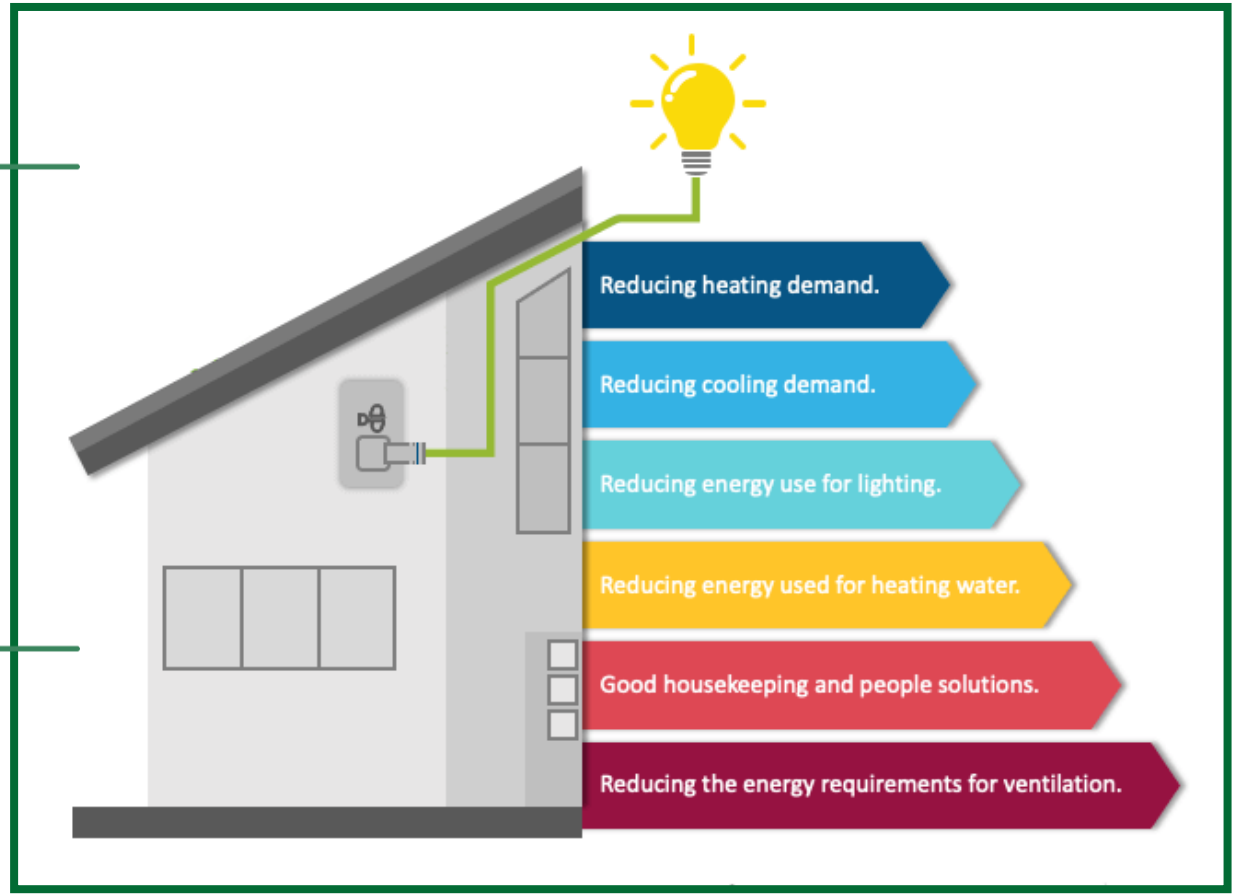
Optimized energy usage

Low/zero carbon emissions

Efficient services

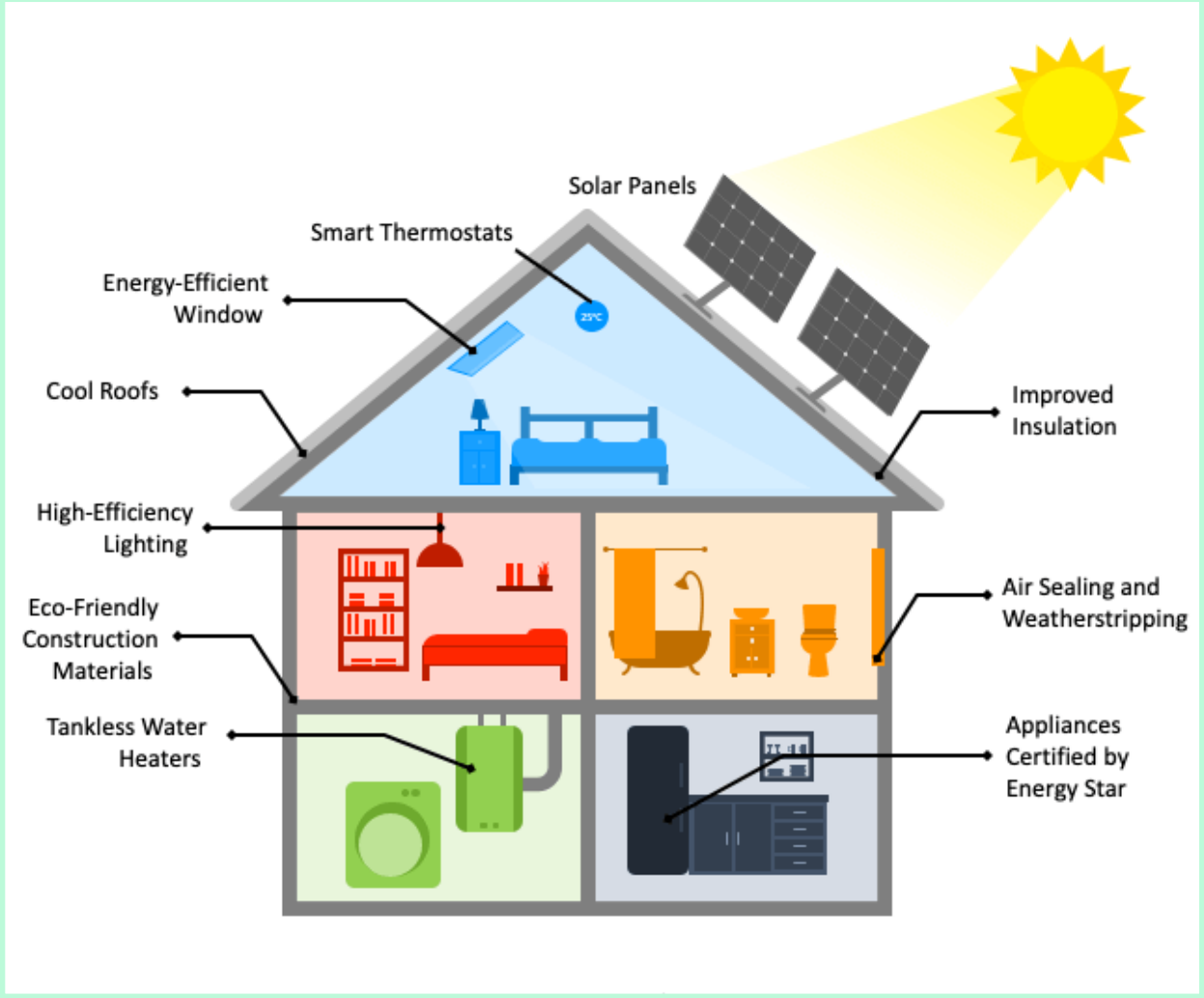
Low embodied carbon

Renewables integration

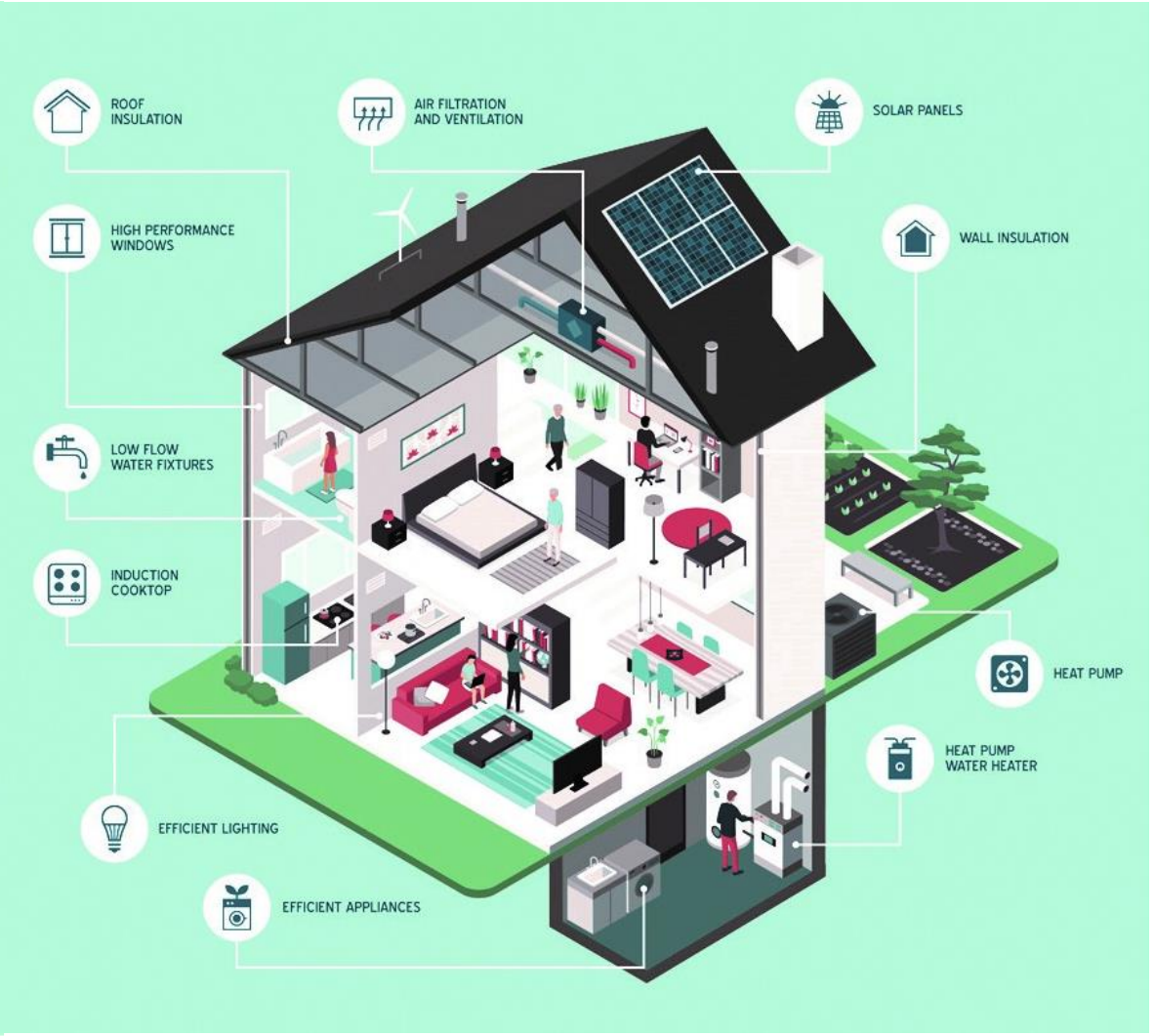


Credit: UNIDO renewable energy and energy efficiency partnership

AN ENERGY-EFFICIENT BUILDING DESIGN MODEL



Credit: Constellation



Credit: EcoMENA

ENERGY SERVICES IN THE BUILDING SECTOR

100% RENEWABLES CITIES & REGIONS ROADMAP

HVAC Systems & Controls

Lighting

Appliances and Equipment

In both residential and commercial sectors, heating, ventilation, and air conditioning (HVAC) dominates, constituting about 40% of building energy demand.

HVAC SYSTEMS OVERVIEW

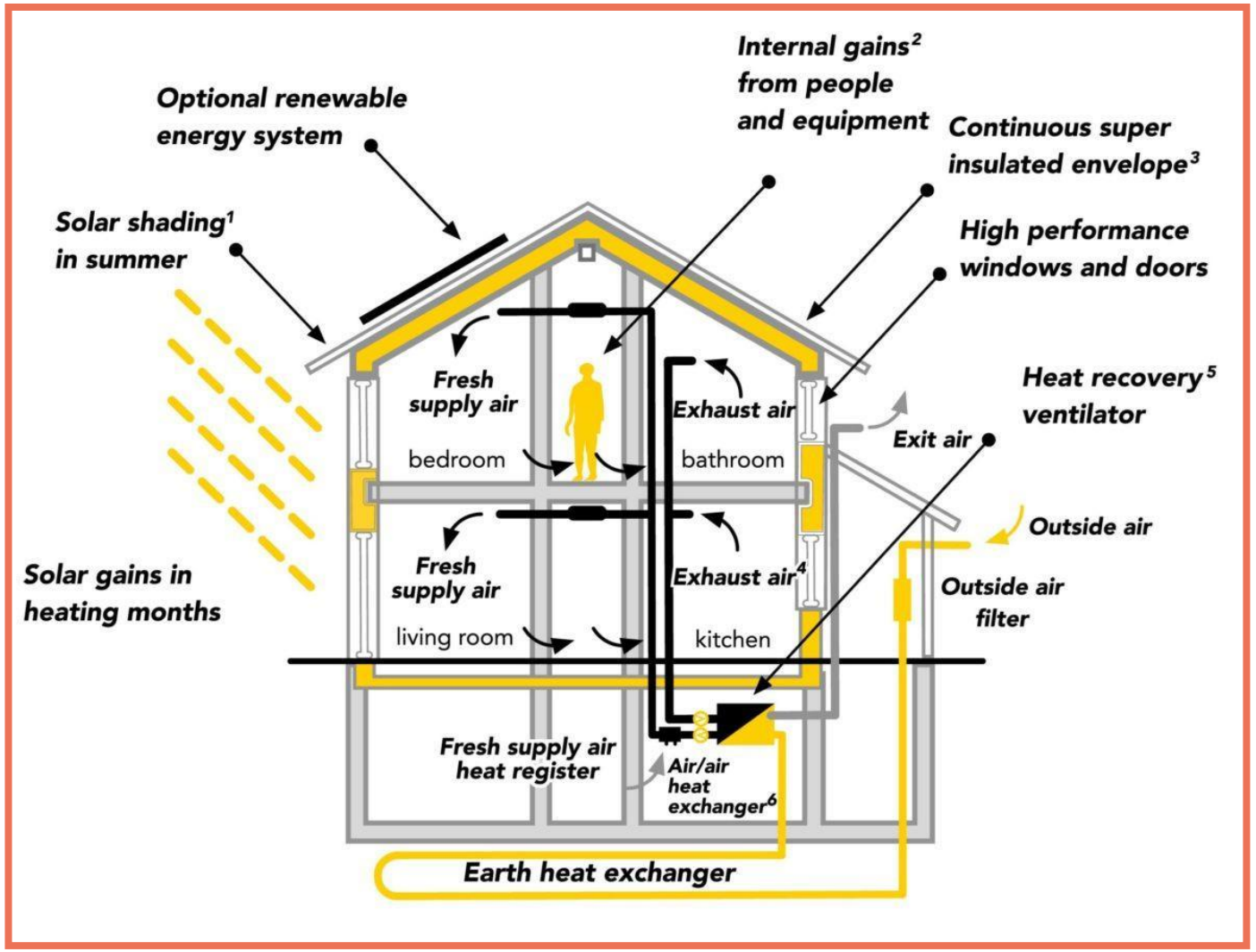
Types of HVAC Systems:

- Natural HVAC Systems
- Electronic HVAC Systems

Electronic HVACs for energy efficiency

Key Steps:

- Selection: Choose energy-efficient HVAC equipment
- Repair and maintenance: Ensure regular upkeep for sustained efficiency.



Source: Invest consult

LIGHTING EFFICIENCY


Credit: Ted Morrison

Energy Impact

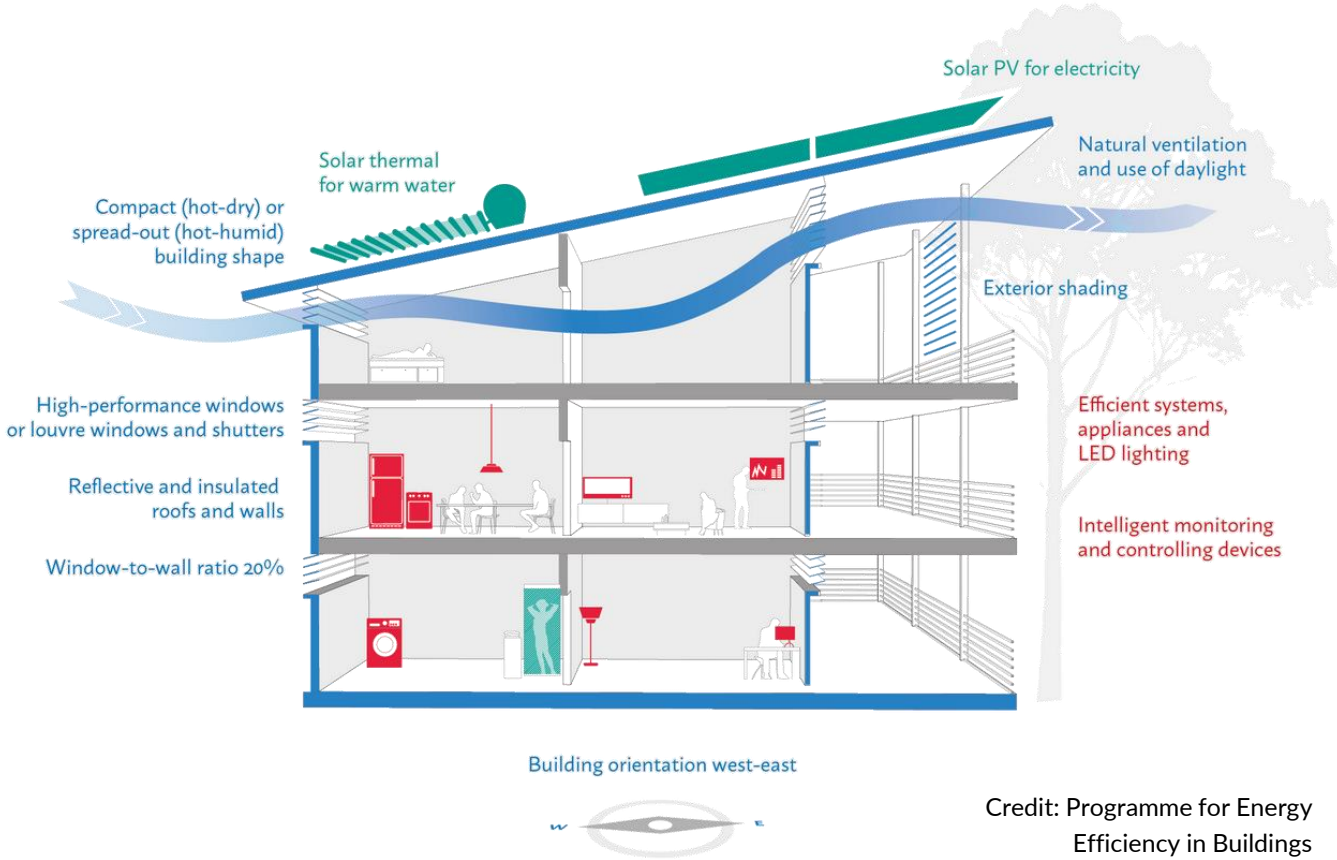
Lighting contributes 9%–20% of residential and commercial building energy demand

Design Planning

Efficient layouts and controls: Start planning in the building design phase

Technology Choices

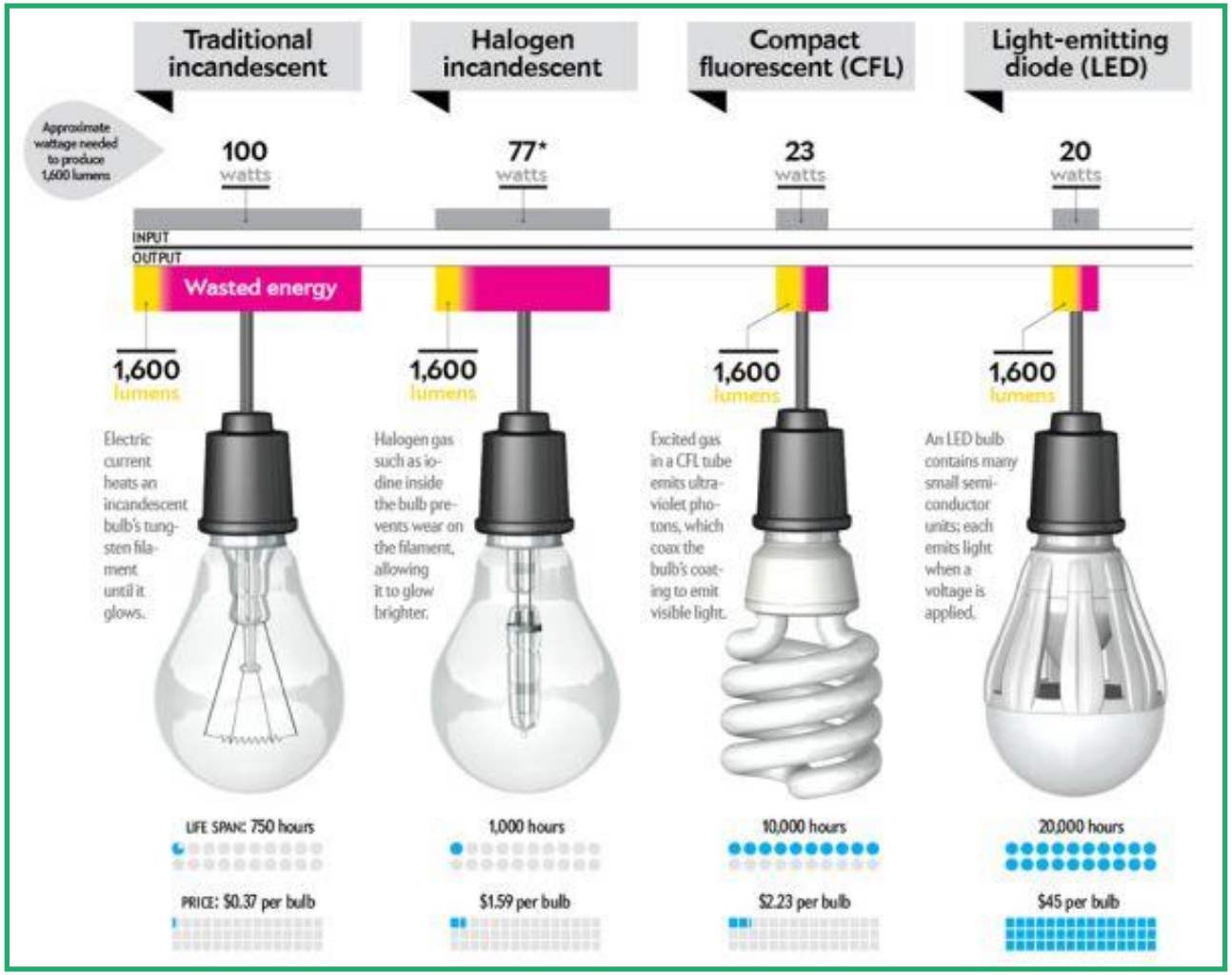
- Different technologies: Varying energy consumption levels
- Daylight harvesting and LED: Incorporating these saves energy



Credit: Programme for Energy Efficiency in Buildings

COMMON ENERGY EFFICIENCY MEASURES IN LIGHTING

Various bulbs



Source: https://www.homedit.com

- Lighting upgrade from metal halides and incandescent to LED
- Use of translucent roofing
- Natural lighting
- Use of sensors

Sensor

Source: https://www.legrandintegratedsolutions.com/

EQUIPMENT AND APPLIANCES

ENERGY EFFICIENCY MEASURES

Energy STAR qualified
Windows, Doors, Window film, Roof installations, Air sealing, etc.

Energy STAR qualified
Hot water pumps, Temperature controls, Radiator controls, Thermostats, Insulated water tanks, etc.

Energy STAR qualified
Appliances – Refrigerators, Cookstoves, Cloth washers, Dishwashers, Window AC units, etc.

Energy STAR qualified
Lighting, Exit signs, Lighting controls, Common area lighting, etc,

ENERGY MANAGEMENT SYSTEM

ENERGY CONSERVATION MEASURES

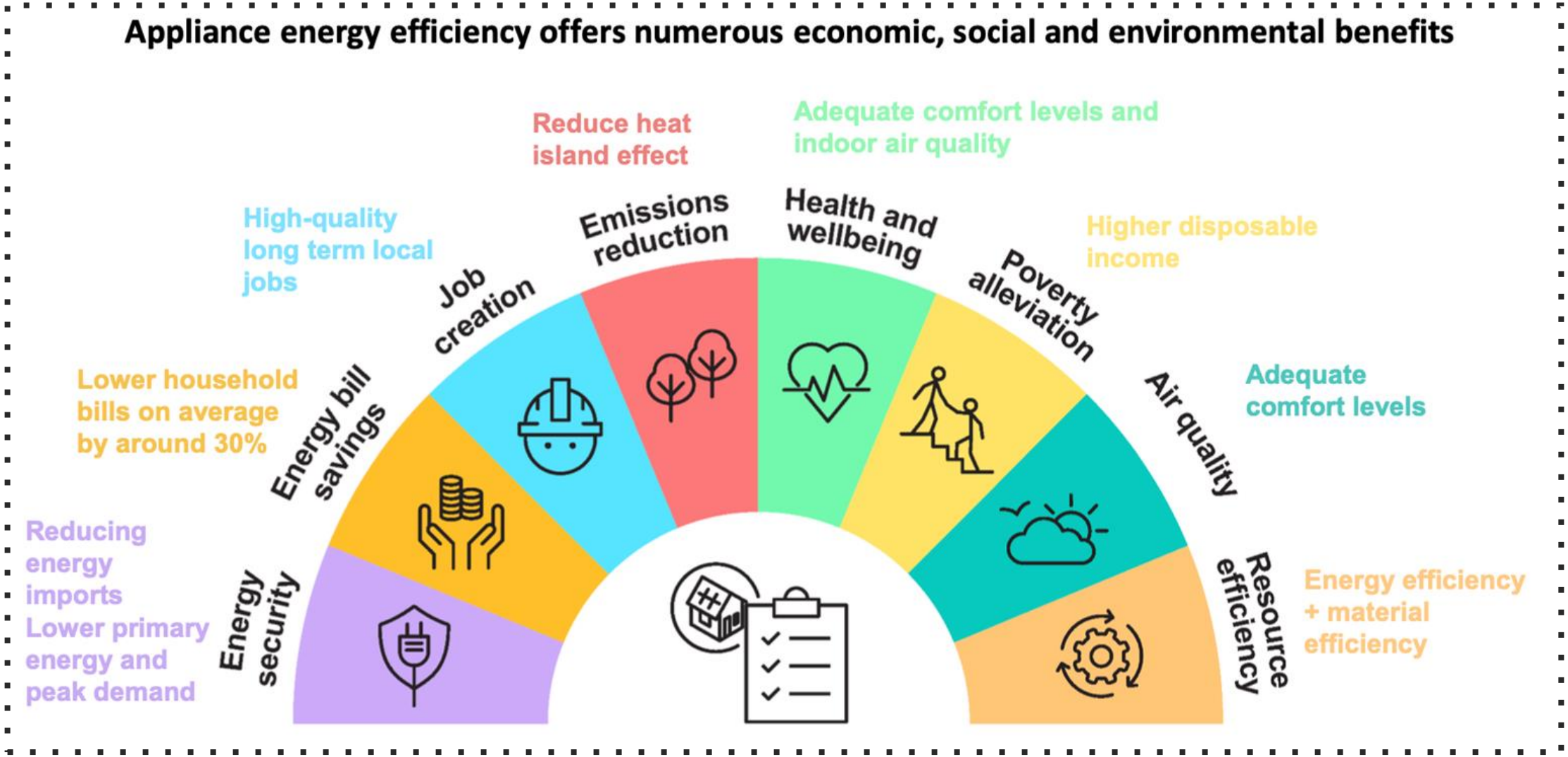
Demand response management

Regular management

Water conservation

Load management

BENEFITS OF EFFICIENT APPLIANCES AND EQUIPMENT

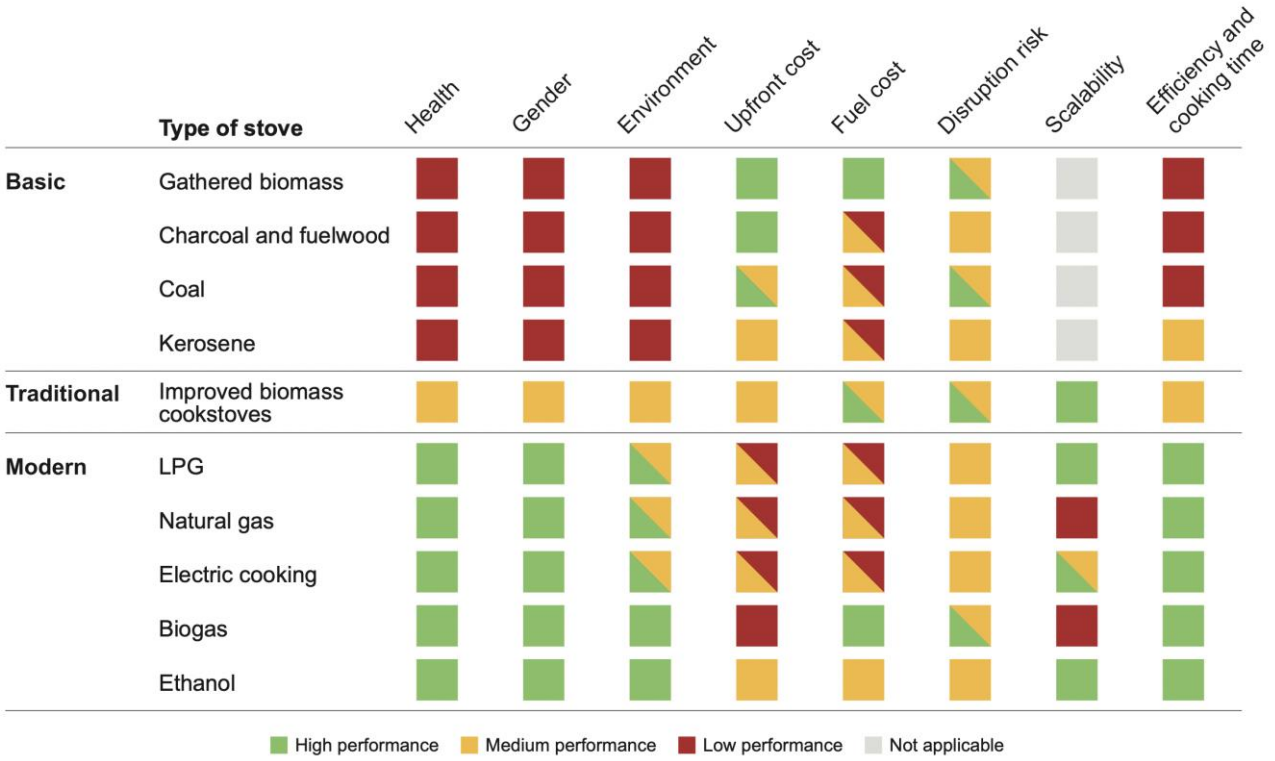


Source: Roadmap for energy efficient buildings and construction in ASEAN – 7th IEAIEA-Tsinghua Joint Workshop. Achieving carbon neutrality pledges: The role of buildings - 2021

COMMON ENERGY EFFICIENCY MEASURES IN COOKING

- Past and present energy use and patterns
- Relevant variables for significant energy use
- Performance of stove
- Type of fuel

1. Analyse energy use and consumption
2. Identify areas of significant energy use and consumption
3. Identify opportunities for improving energy performance



Source: A Vision for Clean Cooking Access for All, International Energy Agency

BUILDING ENERGY EFFICIENCY POLICIES

ENERGY EFFICIENCY POLICY PACKAGES

Regulation

Minimum Energy Performance Standards (MEPS) are rules that prevent the sale of the least efficient products. These standards aim to follow global best practices but also consider the specific needs of our local area.

Incentives

- Rebates, grants, and financial offers.
- Finance or taxation benefits.
- Well-designed procurement processes.
- Dynamic electricity pricing.

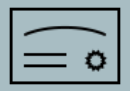
Information

- Labels
- High efficiency performance specifications.
- Consumer information campaigns.
- Smart meters.

POLICY MEASURES

MEPS/Labels

- MEPS
- Comparative labels
- Endorsement labels



Mandatory Obligations on Utilities

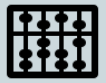
- White certificates

Financial Incentives

- To consumers/retailers/suppliers/ third parties

Information

- Appliances labels
- Retail and/or trade staff training
- Advice centers, hotlines, publications, etc.



Education

- School programmes
- Professional training and qualifications /accreditation

R&D

- Research
- Demonstration
- Commercialization

Awareness raising and campaigns

Procurement by Institutions/Governments

BENEFITS OF ENERGY LABELS AND STANDARDS

01

To the manufacturer:

- **Motivates continuous R&D to improve energy efficiency**

02

To the environment:

- **Lower direct and indirect CO_2 emissions**

03

To power generation companies:

- **Reduced power generation and peak load**

04

To society

- **Enables sustainable growth with incentives to raise efficiency**

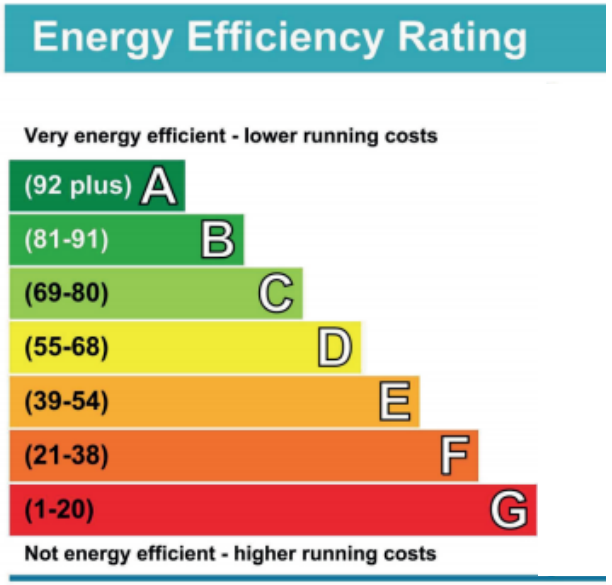
05

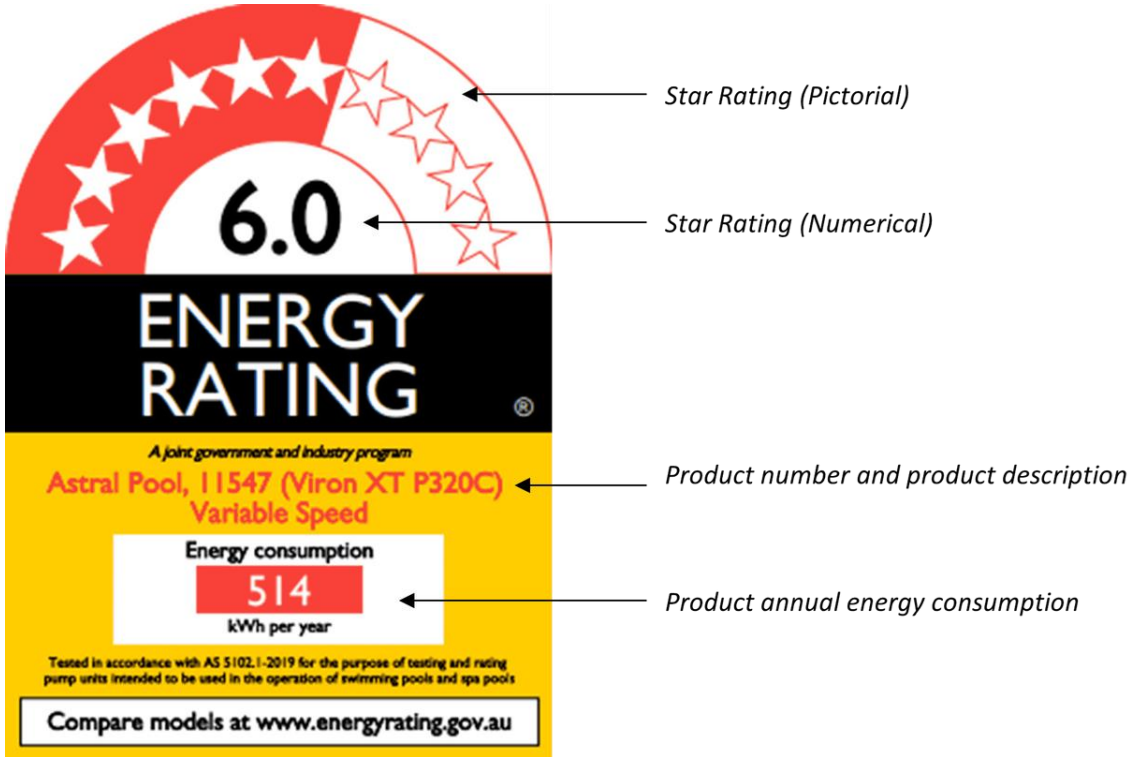
To the end user

- **Provide a fair way to make informed choices based on the estimates of annual electricity consumption and the total cost of ownership**

MINIMUM ENERGY PERFORMANCE STANDARDS (MEPS)

MEPS specify the minimum level of energy performance that appliances, lighting and electrical equipment must meet or exceed before they can be offered for sale or used for commercial purposes





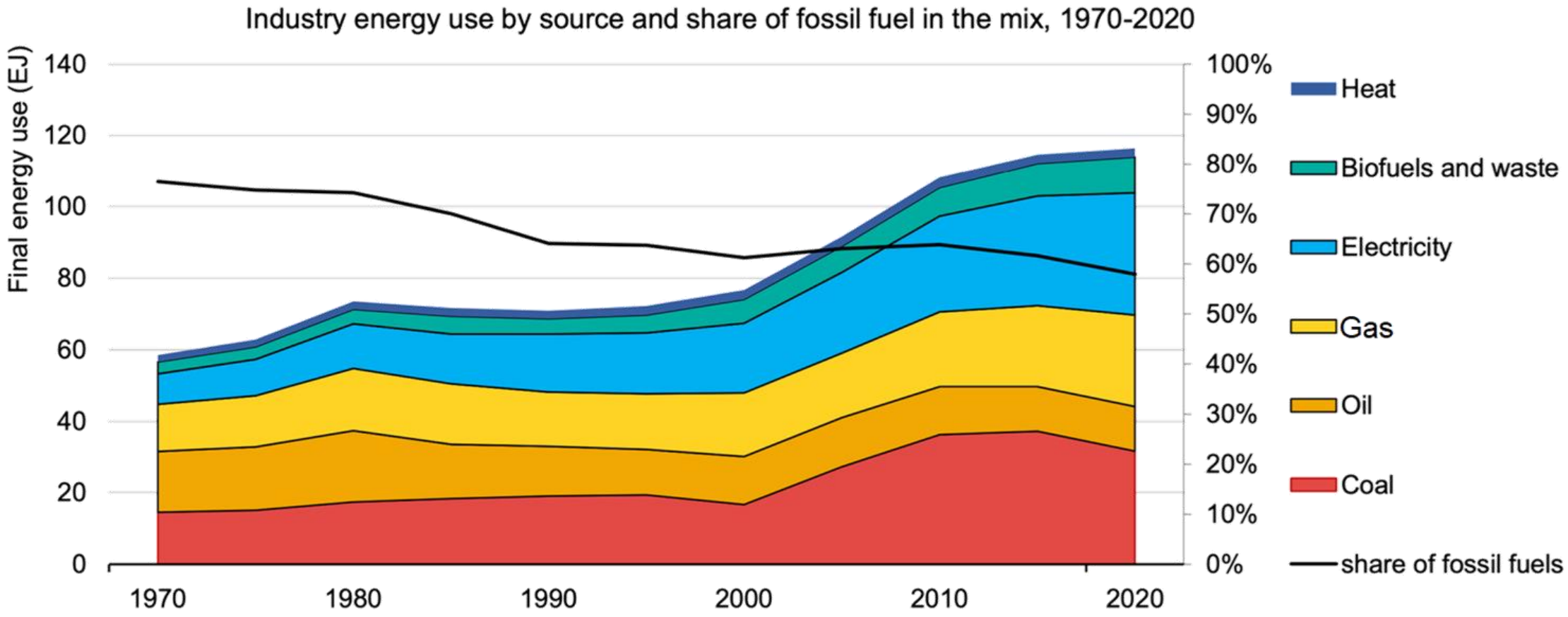
Credit: Energy Consult

PART 2

ENERGY EFFICIENCY: INDUSTRIAL SECTOR

INDUSTRIAL ENERGY CONSUMPTION & FOOTPRINT

Fossil fuels power over 60% of industry and electricity worldwide. In the last 50 years, their use dropped by around 15%. Coal, oil, and gas remain the primary energy sources.



Source: Material efficiency in clean energy transitions, IEA

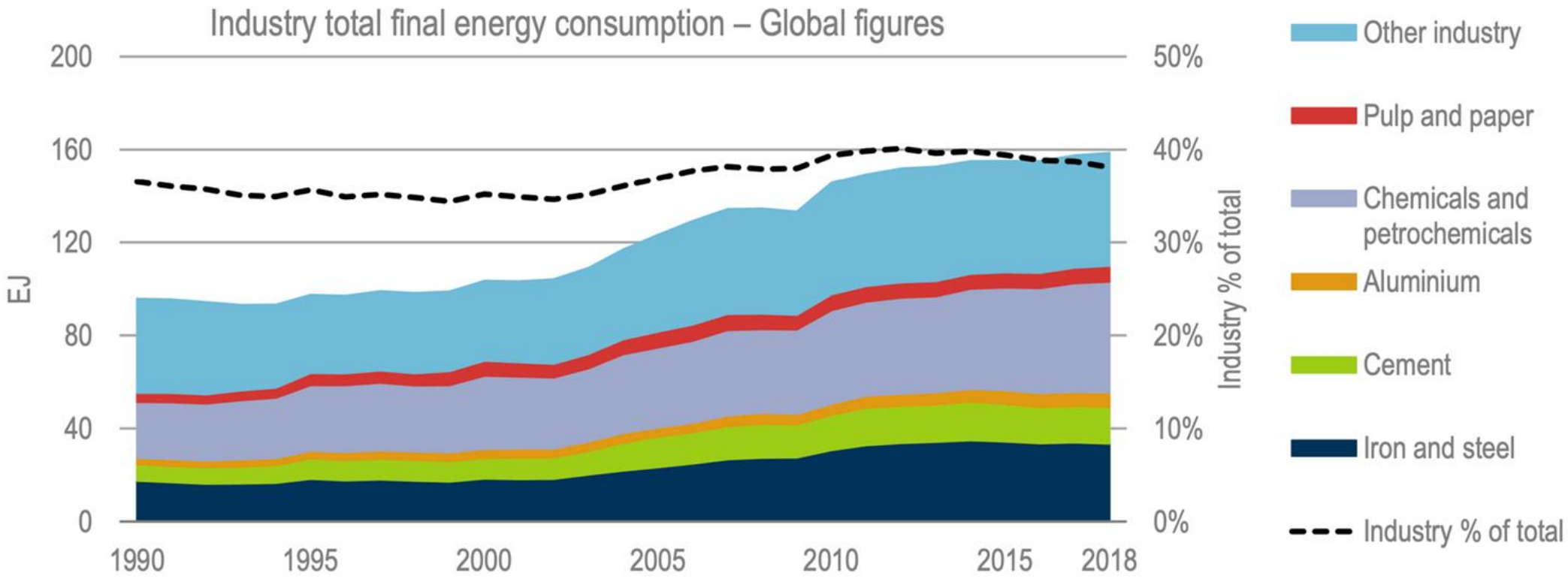
GLOBAL INDUSTRIAL ENERGY CONSUMPTION

Global Energy Intensity

Doubled in 25 years
Contributes 31% to final energy use

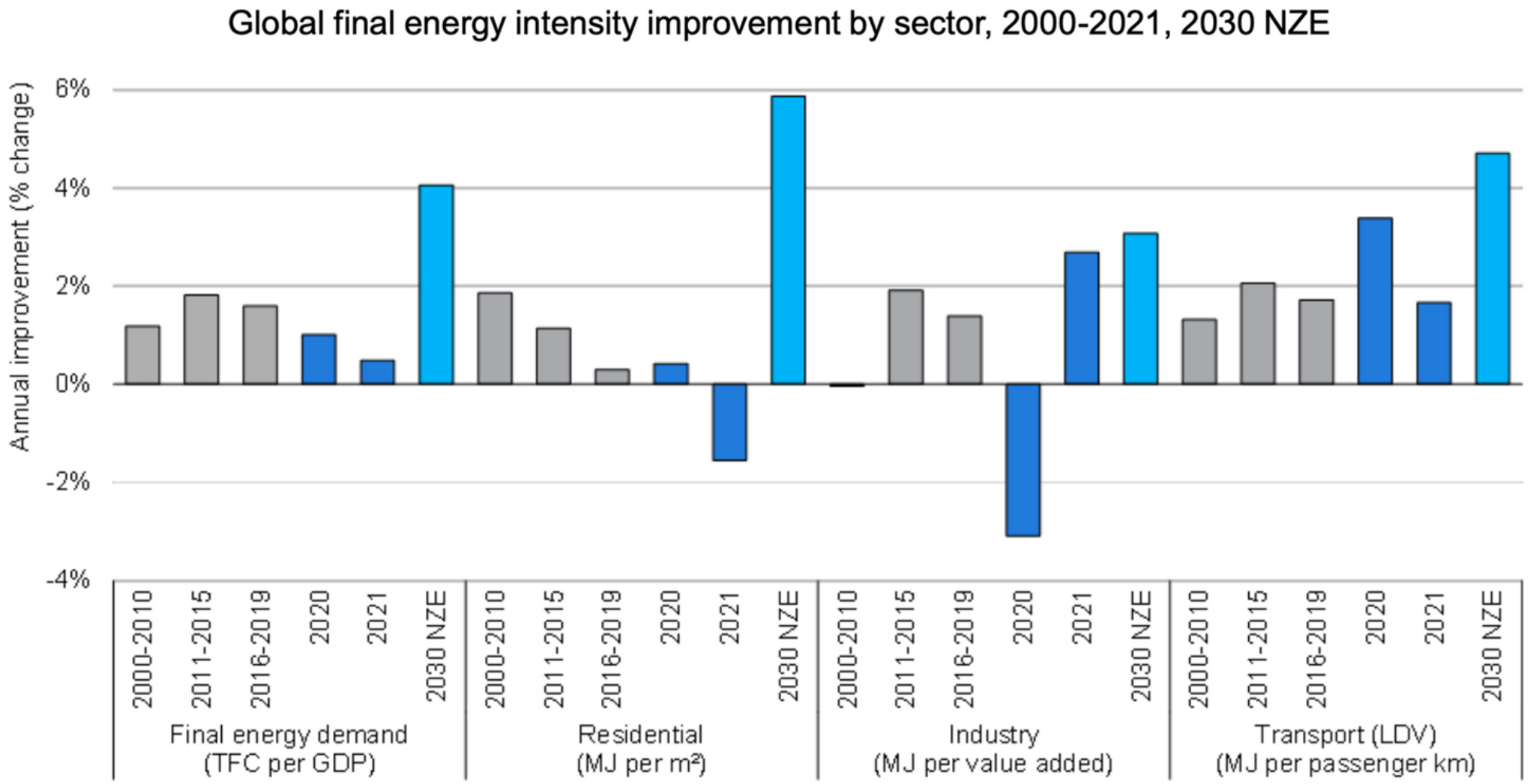
Key Contributors to Intensity Surge

+60% from iron & steel, chemicals, petrochemicals



Source: Material efficiency in clean energy transitions, IEA

PROGRESS OF INDUSTRIAL ENERGY EFFICIENCY



Global energy efficiency progress is not on track to achieve net zero emission goals

Source: Material efficiency in clean energy transitions, IEA

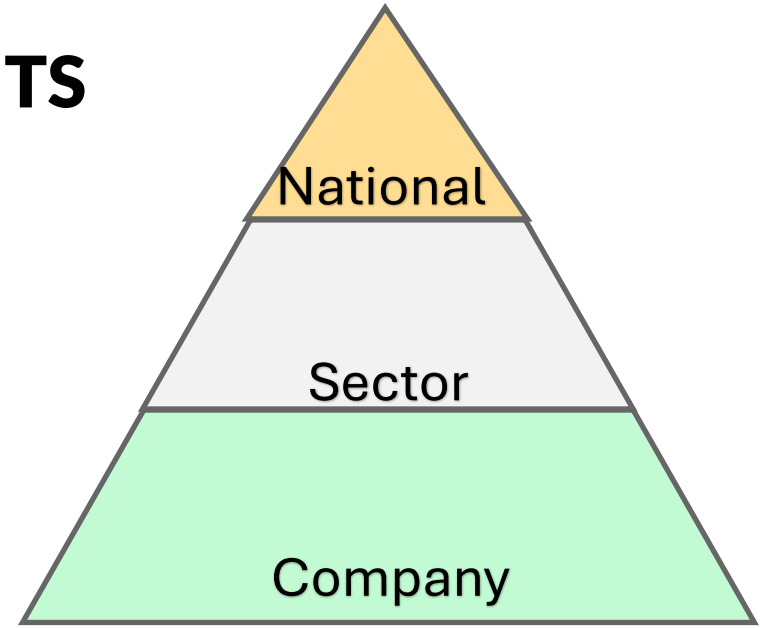
INDUSTRIAL ENERGY EFFICIENCY BENEFITS

Energy efficiency

- Reduced energy use
- Improved efficiency
- GHG emissions reductions (climate action)
- Energy cost savings

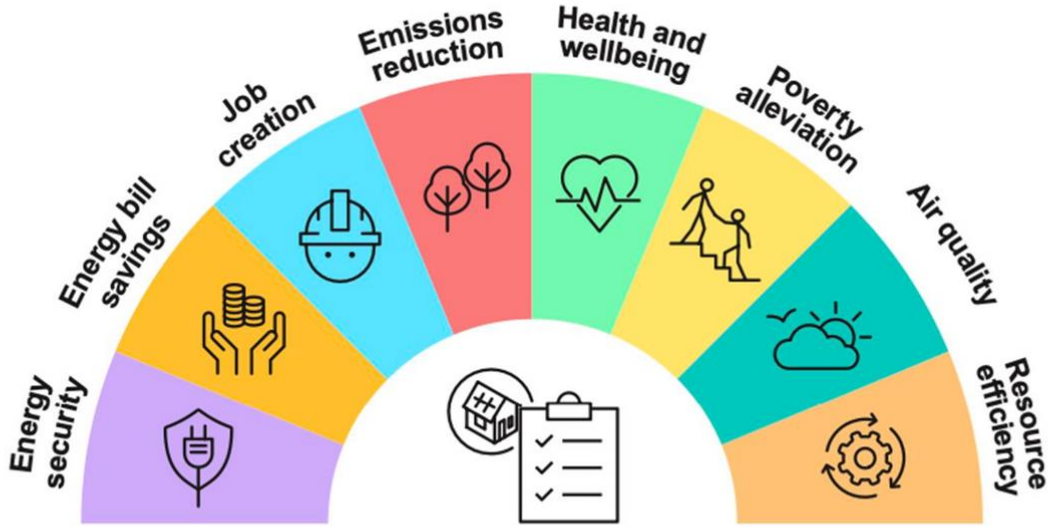
Multiple co-benefits

- Enhanced air quality
- Enhanced energy security
- Improved security of supply
- Improved competitiveness
- Innovations stimulation
- Environmental health benefits



Benefits occur at different economic levels

Credit: IEA



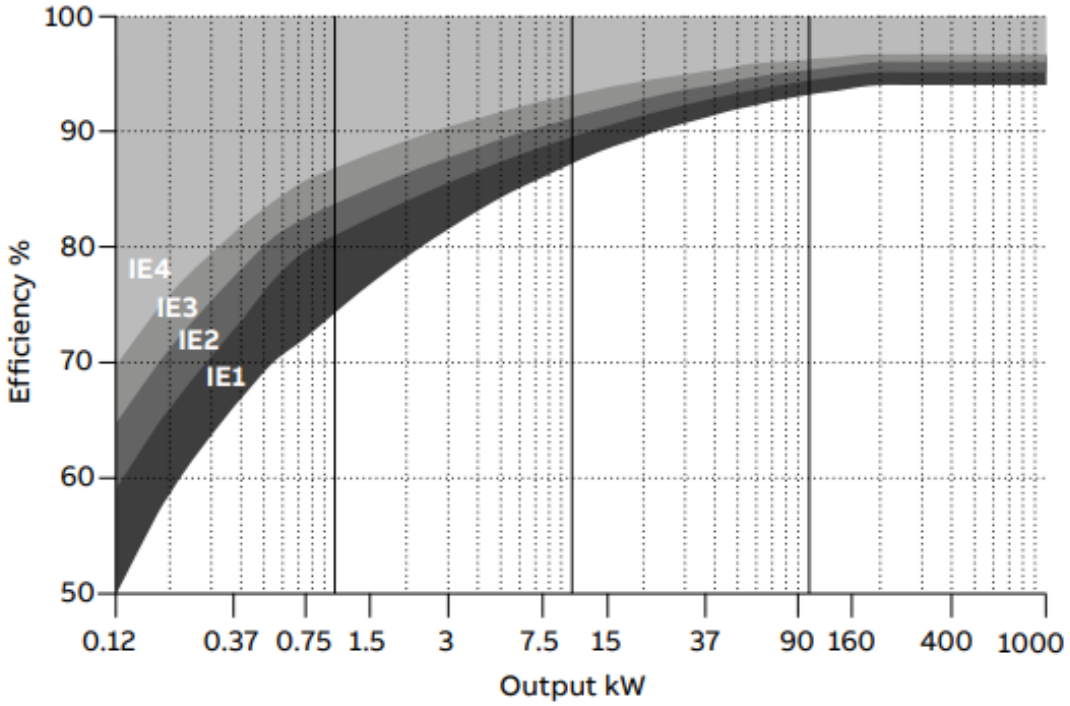
Source: Roadmap for energy efficient buildings and construction in ASEAN – 7th IEAIEA-Tsinghua Joint Workshop. Achieving carbon neutrality pledges: The role of buildings - 2021

COMMON ENERGY EFFICIENCY MEASURES IN INDUSTRY

Various Electric motors used in industry

Source: ABB TECHNICAL NOTE IEC 60034-30-1 standard on efficiency classes for low voltage AC motors

Efficiency (%) vs Output power [kW] of a 4 Pole, 50 hz Electric motor



- Boilers Tuning
- Arresting compressed air leaks
- Variable speed drives
- Control of oxygen level in fuel-fired equipment such as boilers and furnaces
- Energy Management systems
- Upgrade to High Energy Efficiency motors

- Fuel substitution
- Heat recovery
- Insulation Fixing steam leaks
- Combined heat and power generation

HEAT RECOVERY AND COGENERATION

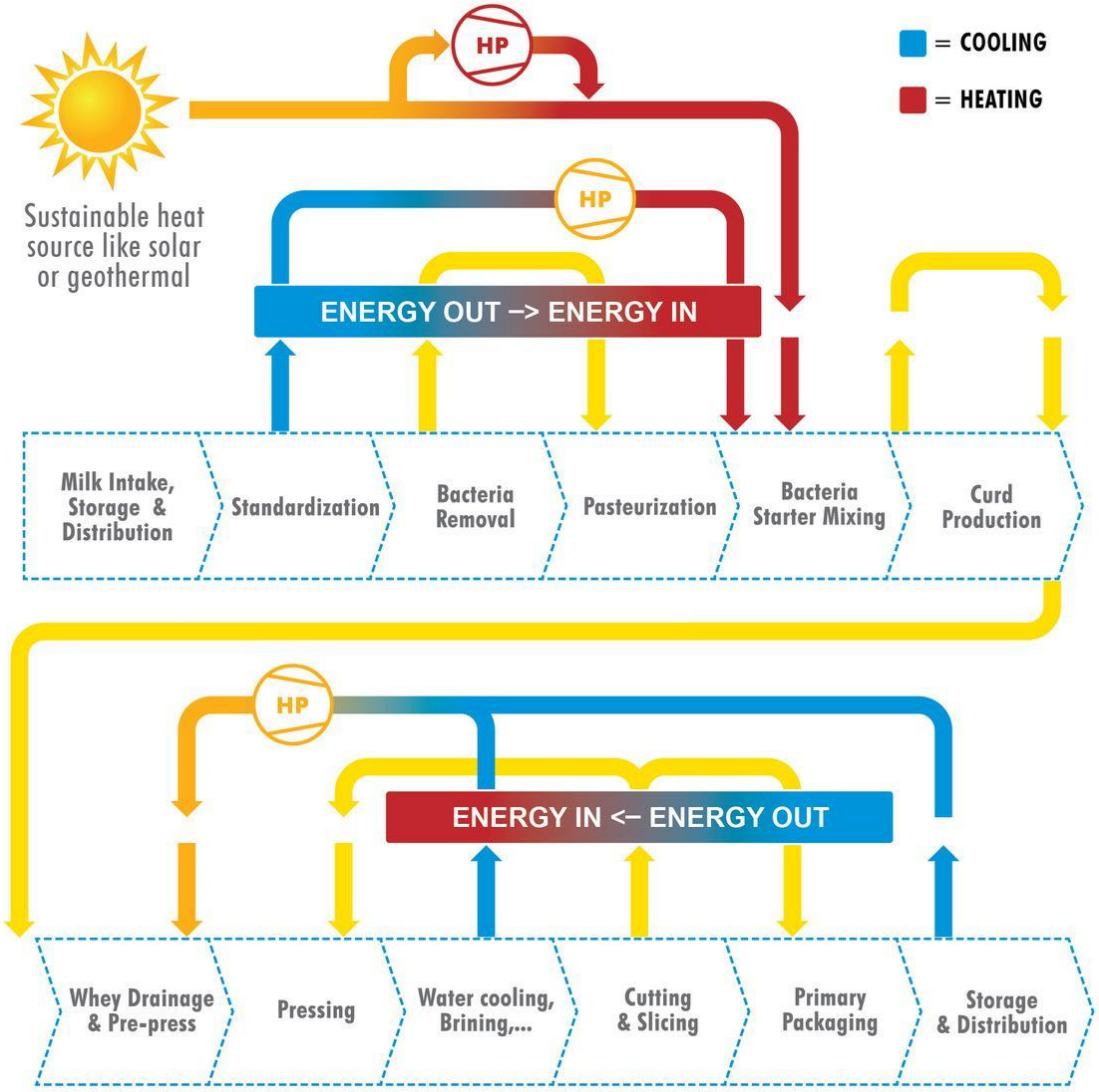
Heat recovery

- Captures waste heat
- Repurposes for other processes
- Enhances space heating

Cogeneration (CHP)

- Combined heat & power
- Increases efficiency
- Calculate energy & cost savings

Credit: Studio van Assendelft



Credit: GEA

INTEGRATION OF RENEWABLES

Credit: Mysun


Credit: Seppo Kaksonen

- Incorporating renewable energy sources into industrial operations
- Sizing and designing solar, wind, or biomass systems for industry
- Hybrid systems and storage solutions for reliable energy supply

INDUSTRIAL ENERGY EFFICIENCY POLICIES

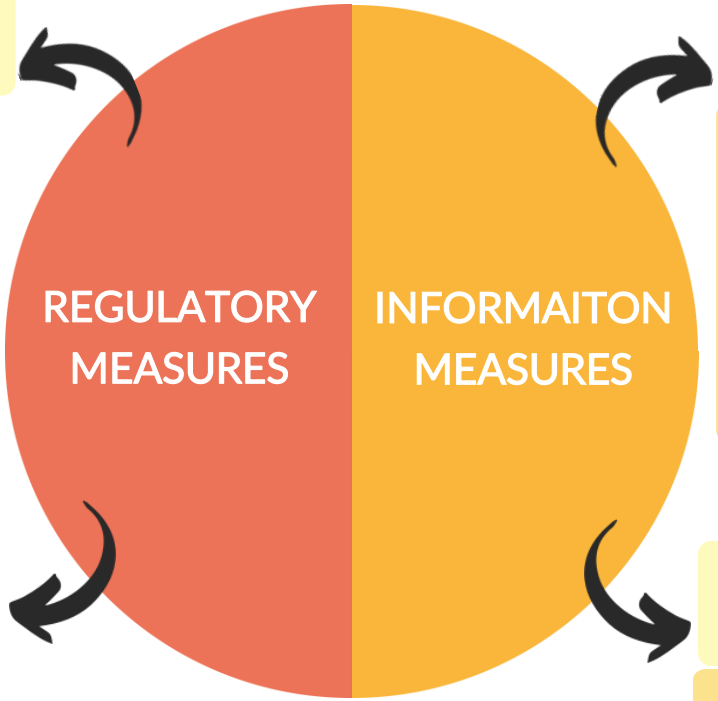
POLICY AND REGULATORY ECOSYSTEM

STRENGTHS

- Very high participation rate
- High confidence to achieve quantifiable savings

POTENTIAL LIMITATIONS

- Costly for business to implement
- Compliance focus for business
- Costly for governments to enforce



Examples of information packages:
Factsheets, case studies, workshops, webinars, advice hotlines, energy efficiency networks, "How to" guidance materials

STRENGTHS

- Measuring energy performance indicators
- Internal audit of the energy management system
- Implementation of corrective and preventive

POTENTIAL LIMITATIONS

- Verification/validation of information can be flawed
- Information can be unactionable if it is not contextualized, targeted and tailored

ENERGY EFFICIENCY POLICY PACKAGES

Regulation

Standards boost efficiency
- Set for key equipment (motors etc.)
- Enhance industrial efficiency

Broad regulatory impact
- Covers R&D, auditing, reporting
- Requires energy management
- Upskills workforce

Effective regulations
- Tailored to local context
- Regular ambitious updates

Incentives

Tracking progress & comparison
- Benchmarks & detailed data
- Governments monitor policies
- Industries assess performance

Real-time tracking with tech
- Digital tools monitor energy
- Unlocks savings opportunities

Sharing best practices
- Industry networks exchange
- Boosts energy performance

Information

Driving efficient decisions
- Incentives: finance, carbon links
- Motivate tech transitions

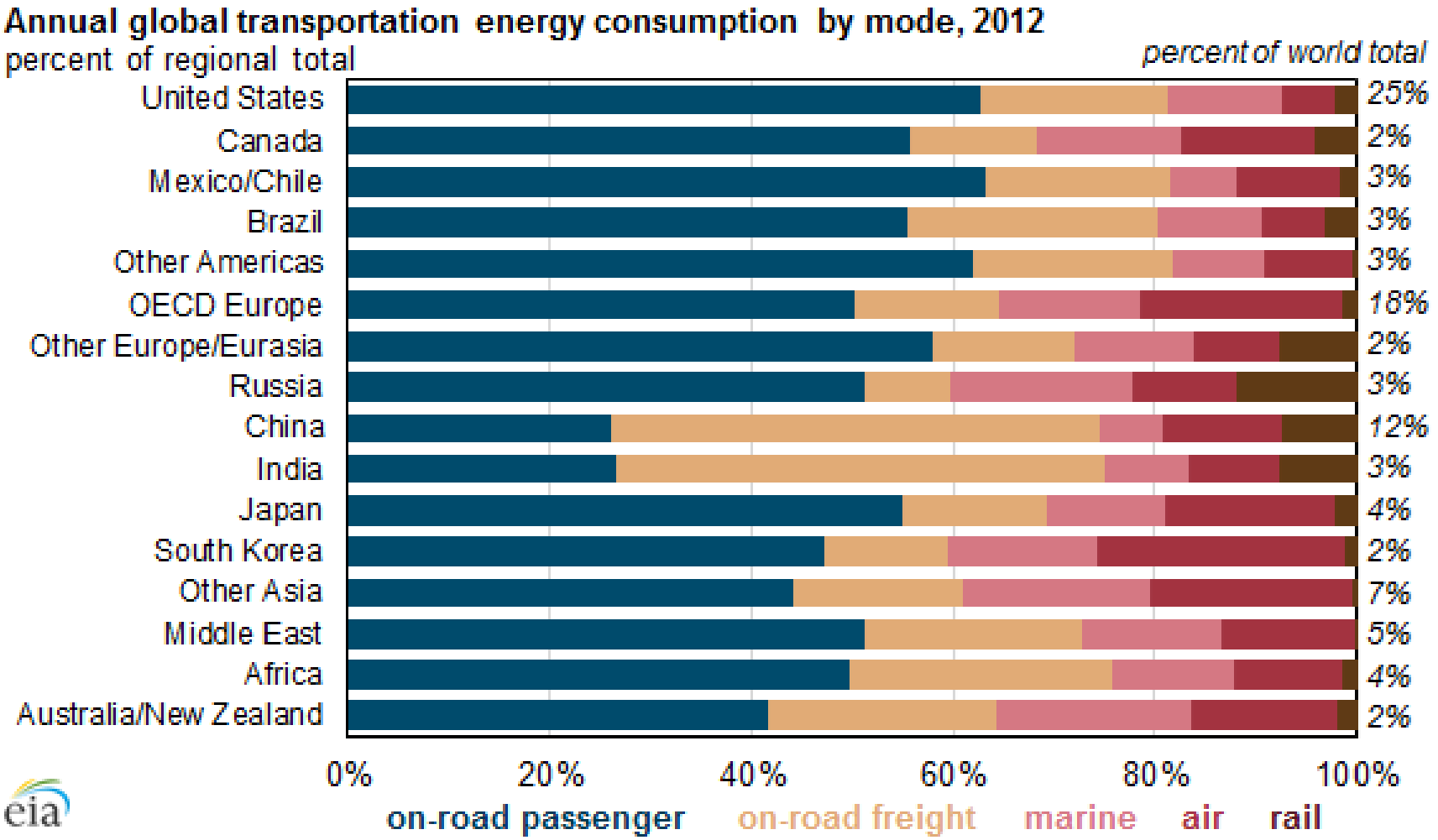
Boosting efficiency quickly
- Free/subsidized audits
- Targets SMEs, strategic sectors

Energy service companies
- Offer expertise & finance
- Support industry efficiency

PART 3

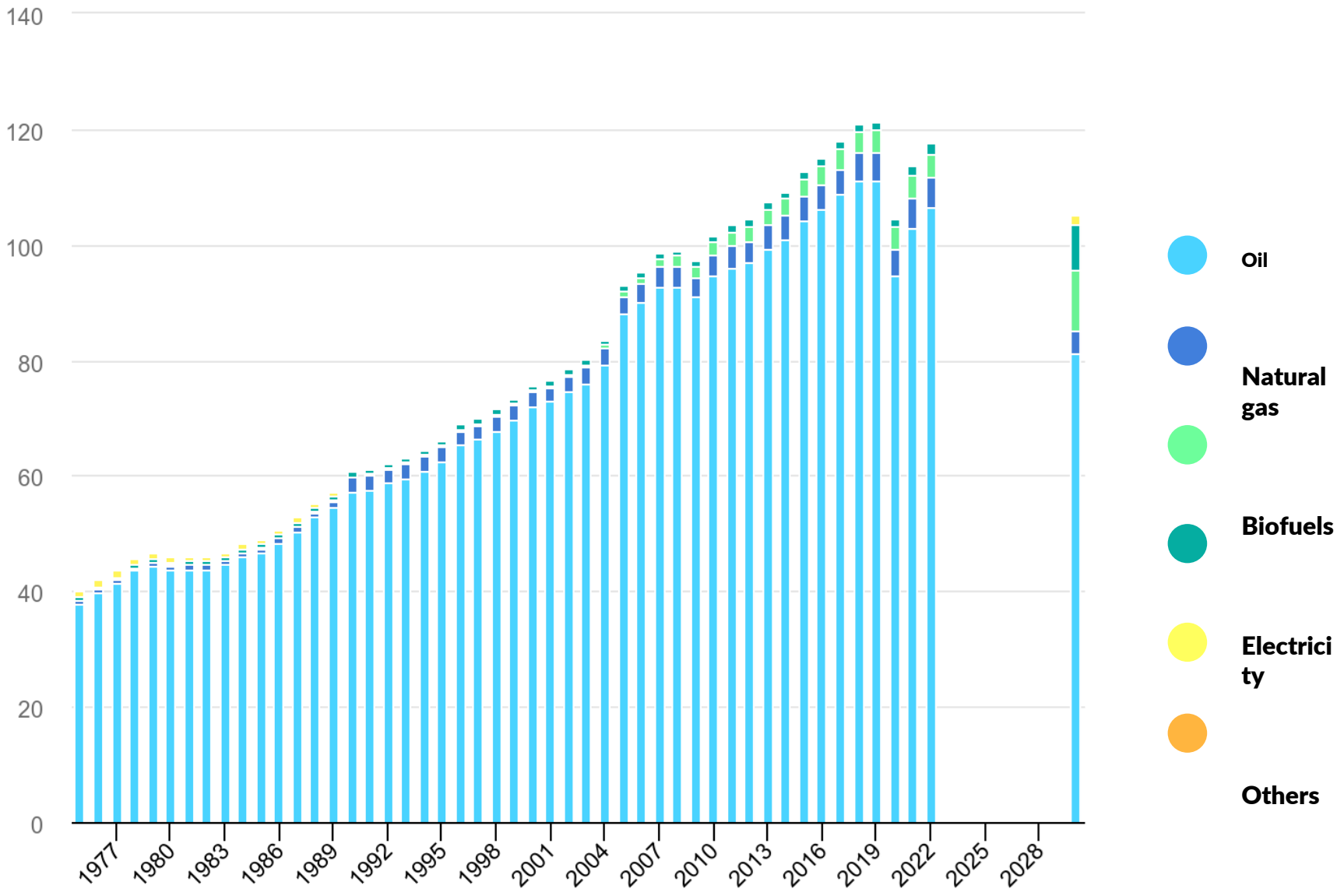
ENERGY EFFICIENCY IN TRANSPORT AND MOBILITY

URBAN MOBILITY CHALLENGES AND TRENDS



Source: U.S. Energy Information Administration, International Transportation Energy Demand Determinants (ITEDD-2015) model estimates

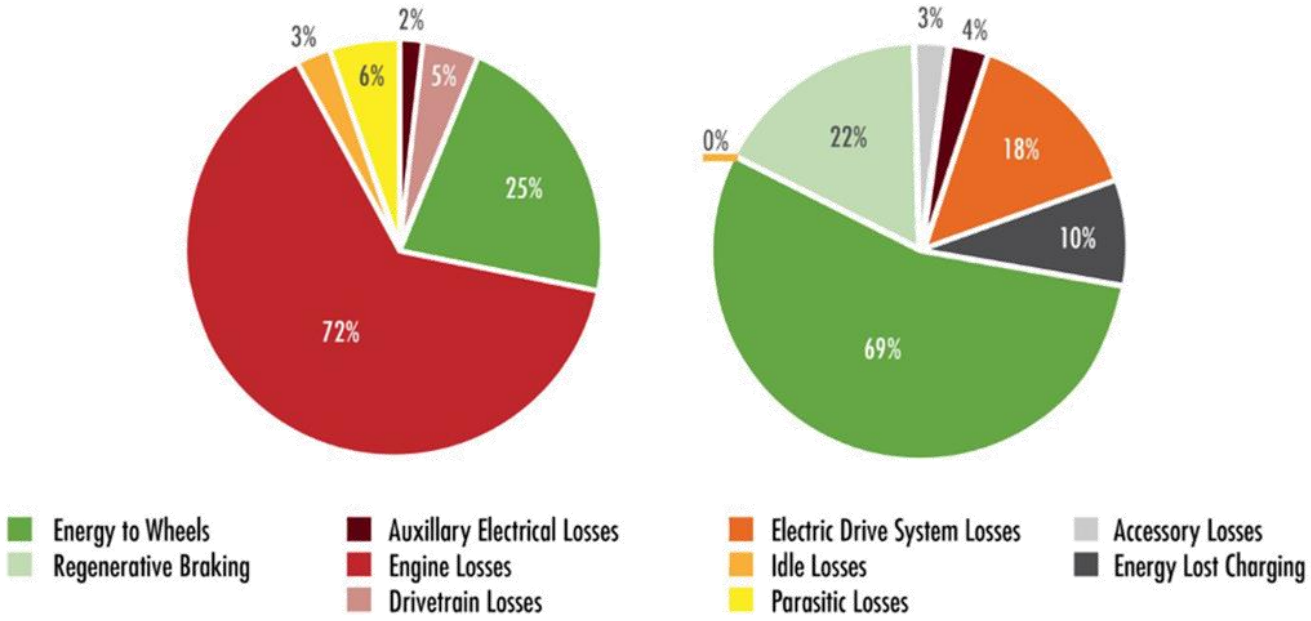
URBAN MOBILITY CHALLENGES AND TRENDS



Energy consumption in transport by fuel in the Net Zero Scenario, 1977 - 2030

Source: IEA (2023), World Energy Balances. Weblink:

CLEAN FUELS



Energy requirements per vehicle type ICE vehicle (left) vs Electric vehicle (right)

Conventional fuel for Internal Combustion Engine (ICE)

Biofuel

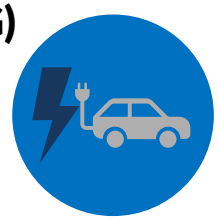
All electric

Hydrogen fuel cell

Hybrid electric

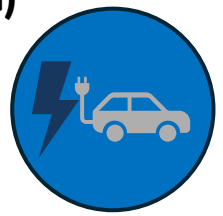
INTEGRATION OF EV CHARGING WITH MICRO-GRID

Vehicle to grid (V2G)



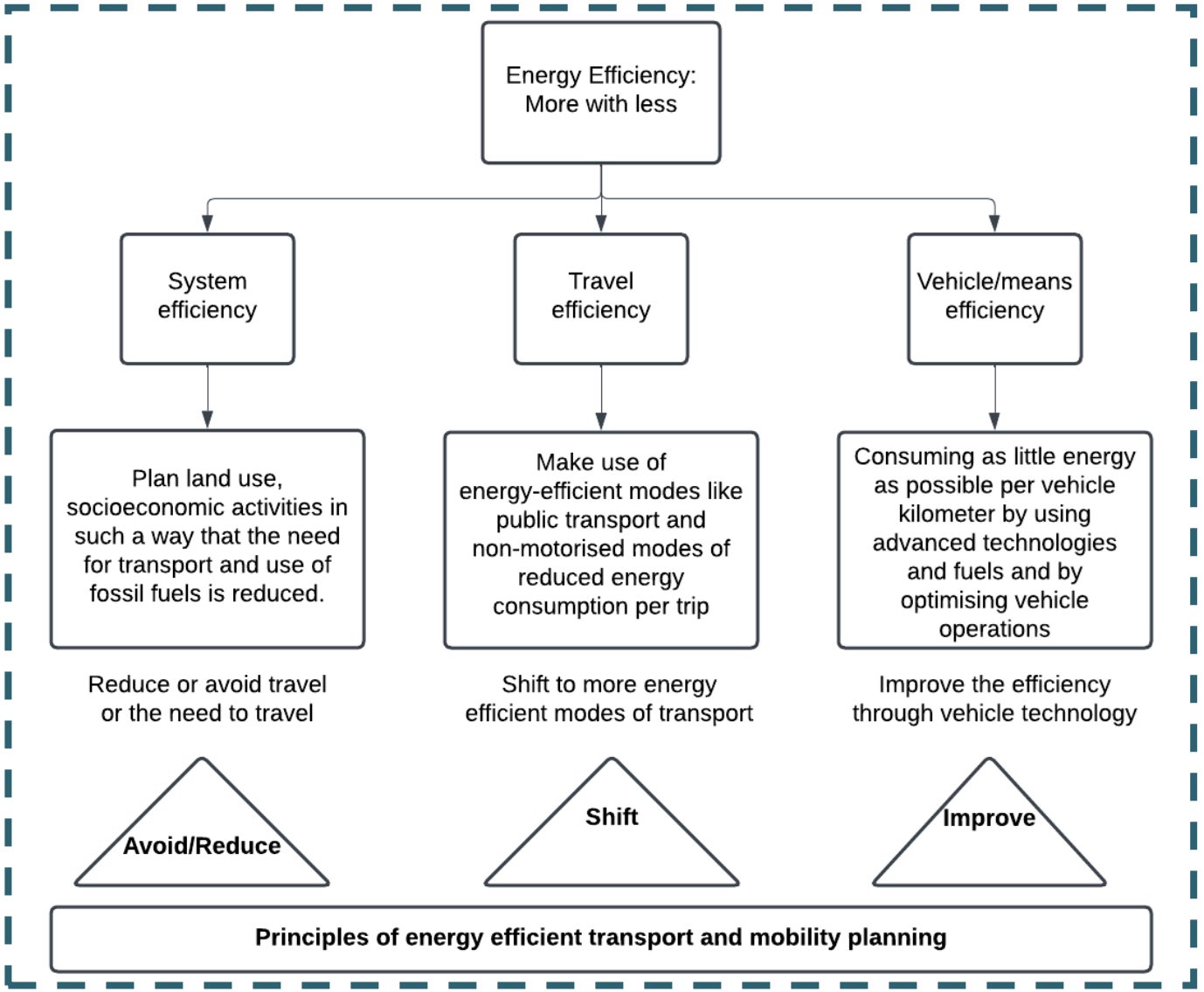
- Bidirectional charging
- Technology that enables energy to be pushed back to the power grid from the batter of an electric vehicle
- Battery charged or discharged by signals (energy production & consumption) nearby

Vehicle to grid (V2G)



- Vehicle to home
- Vehicle to building
- Vehicle to grid

ENERGY EFFICIENT TRANSPORT PLANNING



TRANSPORT ENERGY EFFICIENCY POLICIES

ENERGY EFFICIENCY POLICY PACKAGES

Regulation

Effective standards save fuel
- Updated, monitored, enforced
- Reduce vehicle fuel use

Driving electric vehicle adoption
- Stringent standards drive tech
- Encourage manufacturers

Infrastructure support via regulation
- Ensures standardized charging
- Facilitates EV infrastructure

Incentives

Making vehicles affordable
- Grants, lower fees
- Reduced ongoing costs

Government infrastructure support
- Grants for charging infrastructure
- Encourages electric vehicle adoption

Phased incentives for early adoption
- Facilitate uptake initially
- Adjust as adoption grows

Information

Informed actions for savings
- Carsharing & efficient driving
- Behavioral insights boost effectiveness

Efficiency labels guide choices
- Identifies cost-effective vehicles
- Empowers informed decisions

ICLEI Local Governments for Sustainability

100% RENEWABLES CITIES & REGIONS ROADMAP

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END OF CHAPTER 2 OF 2

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