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: RENEWABLE ENERGY TECHNOLOGIES

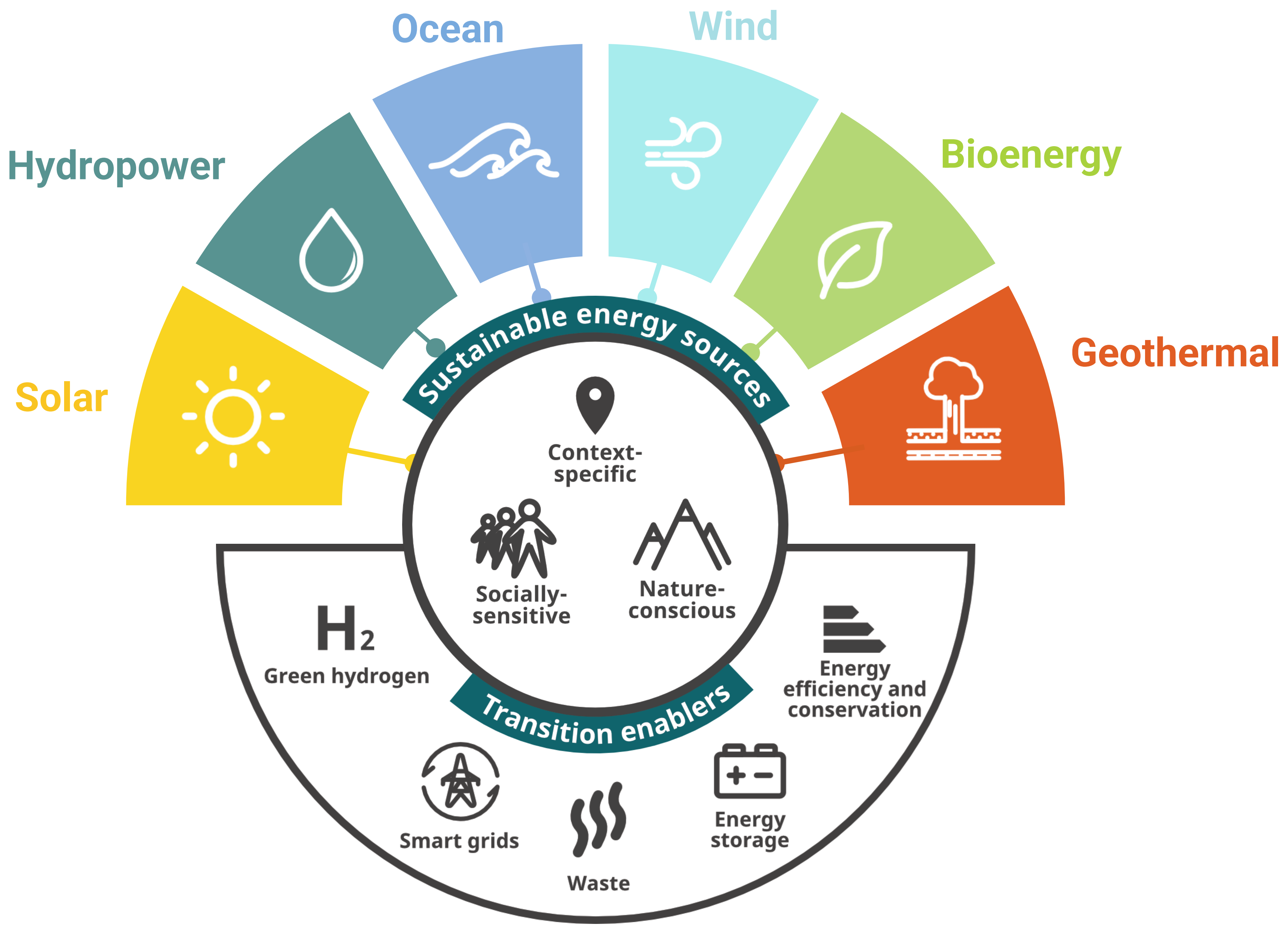
CONTENTS

PART 1

INTEGRATING RE IN AN URBAN CONTEXT

RENEWABLE ENERGY SOURCES FOR CITIES

- Energy sources can be sustainable in a city's specific context based on:
  - The local renewable energy (RE) **potential** and **energy use patterns**
  - Alignment with **socio-economic** realities and priorities
  - **Environmental/land-use** impacts
  - Possibility of integration into **urban planning**



ICLEI's conception of the sustainable energy transition

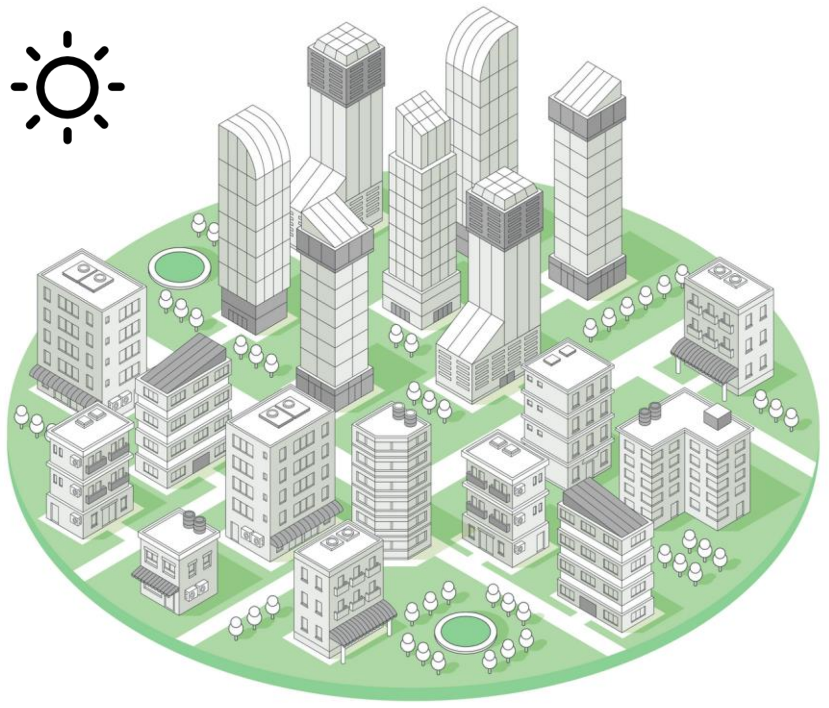
SOLAR ENERGY

*How can **solar energy** be leveraged as a viable and effective option for integrating renewable energy into urban environments?*

R. E. SOURCES – SOLAR ENERGY

Solar energy in urban areas addresses space constraints by using minimal land for PV systems

OPPORTUNITIES FOR CITIES



GROUND SURFACES

- Roads and pavements
- Parks and open surfaces
- Parking lots
- Topographical features

BUILDING SURFACES

- Roofs
- Facades
- Intermediate spaces

SOLAR PV COVERAGE

- Ground
- Water
- Object integrated

SOLAR ENERGY APPLICATIONS FOR CITIES

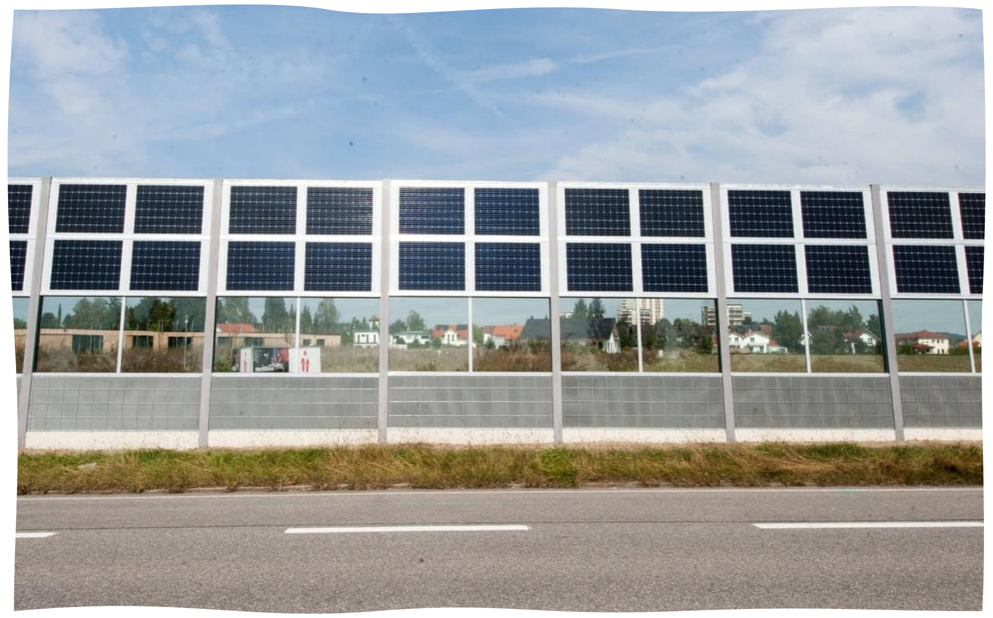
ROOFTOP

POLE-MOUNTED

GROUND-MOUNTED

RAILROAD TRACKS

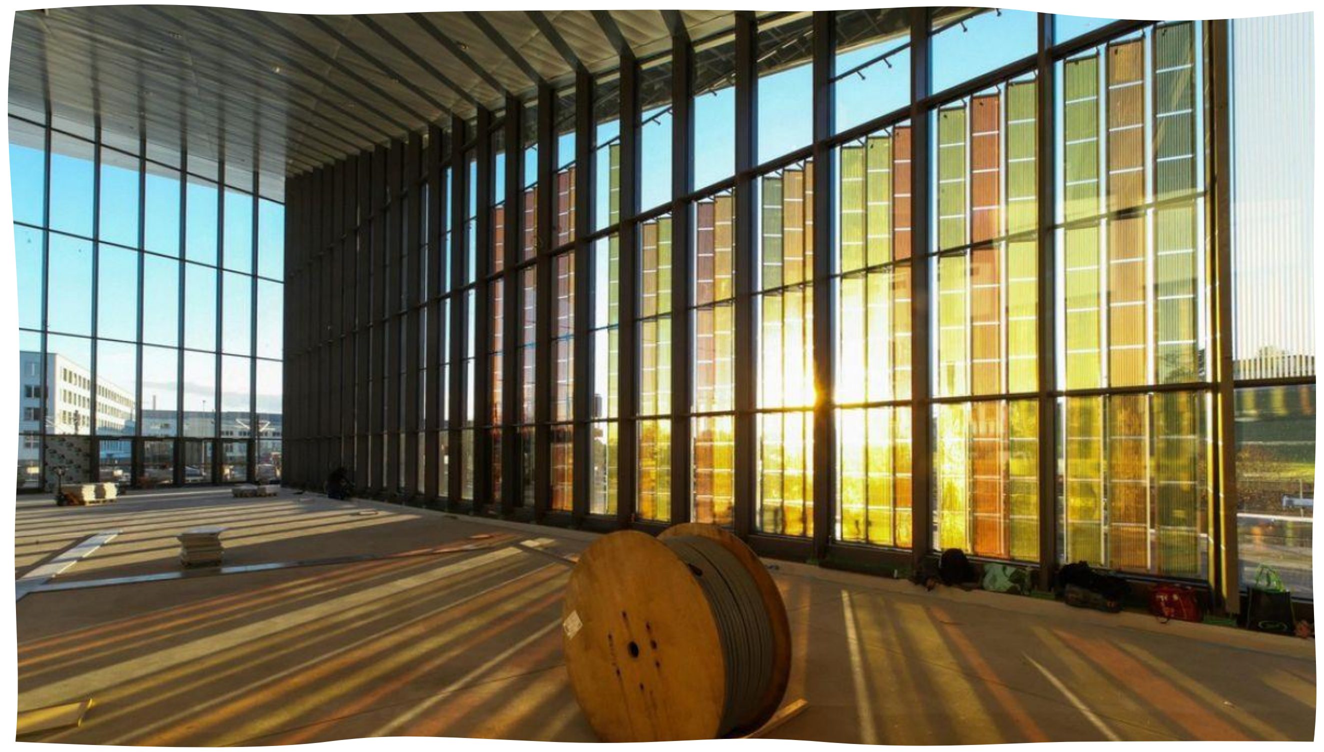
ROADSIDE PV

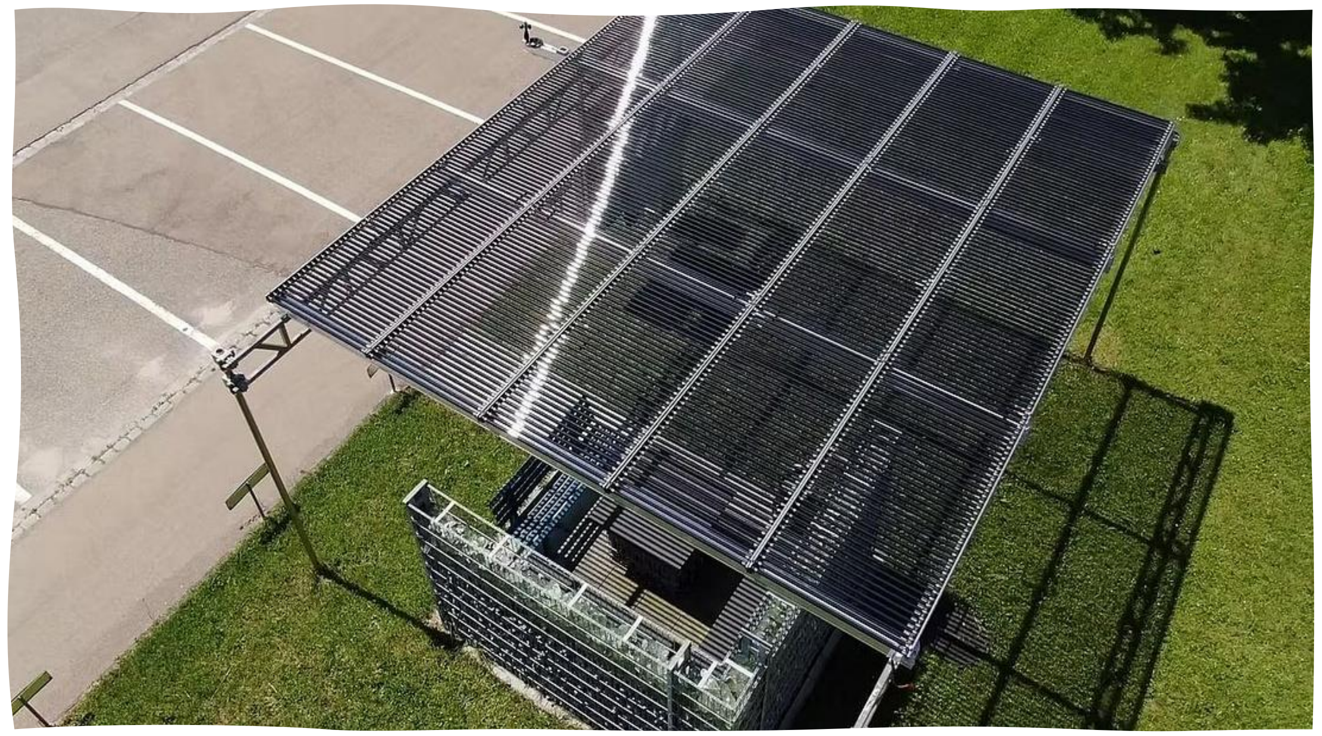


ROAD PV

SOLAR ENERGY APPLICATIONS FOR CITIES

TRANSPARENT

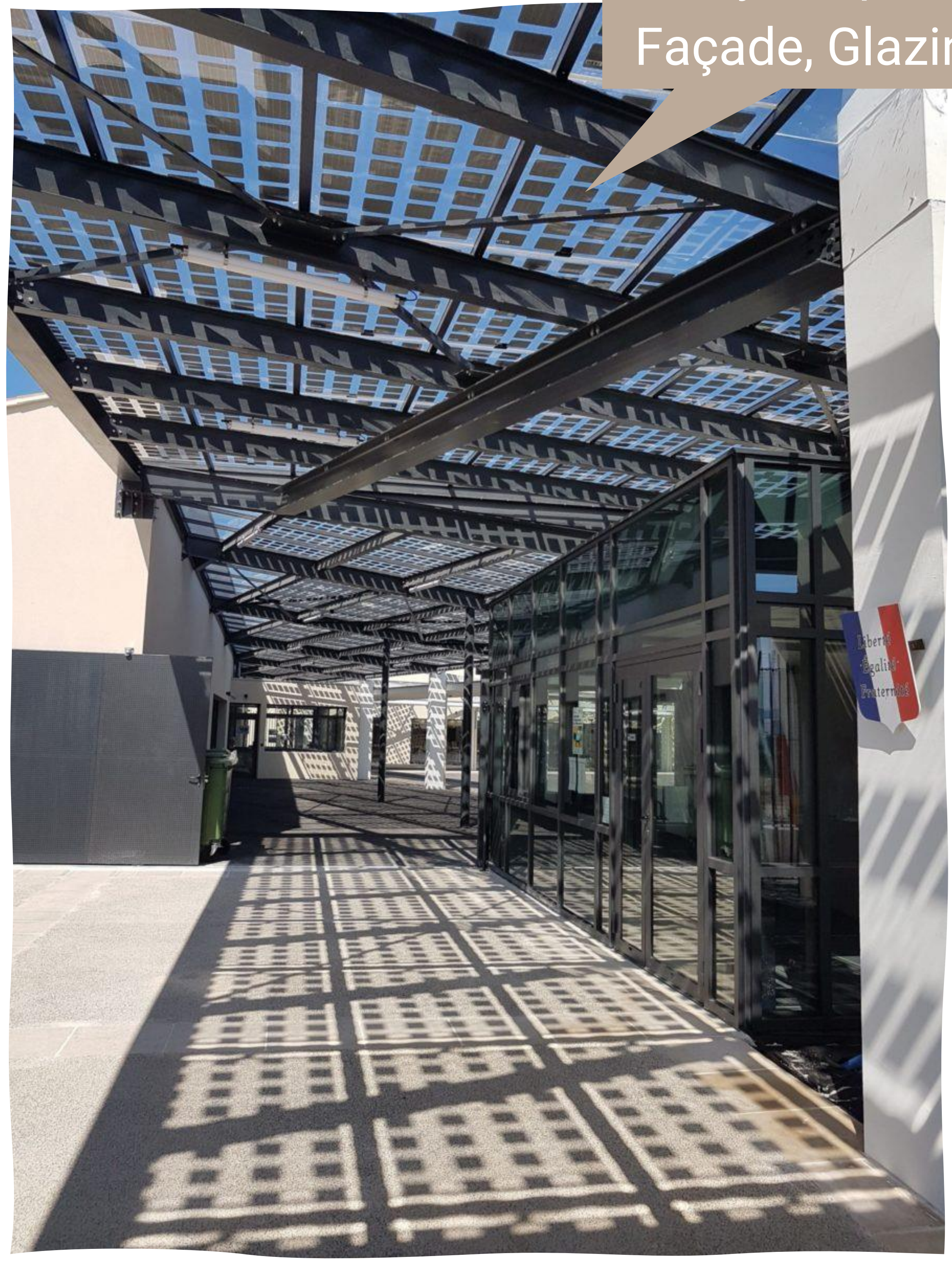





SOLAR ENERGY APPLICATIONS FOR CITIES

BUILDING INTEGRATED

Many shapes
Façade, Glazing



SOLAR ENERGY APPLICATIONS FOR CITIES

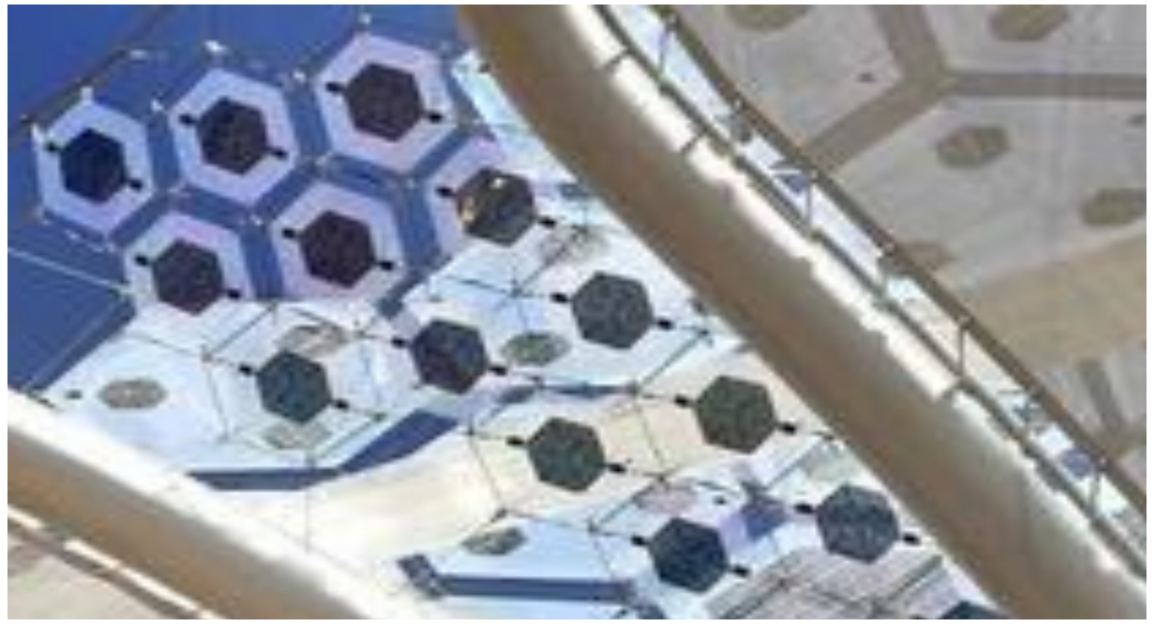
AGRO VOLTAICS

FOLDING/ROLL ON PANELS

CONTAINERIZED

FLOATING PV

ARTISTIC PV ASSET



SOLAR PV ON PUBLIC BUILDINGS

- Solar PV offers sustainable energy.
- It's financially viable for urban sustainability goals.
- Cost-effective and easy to install, empowering local governments in the energy transition.

- Municipalities are vital in tackling climate change and urban energy demand.
- Rooftop PV is critical for city energy planning and policy due to buildings' high energy consumption.

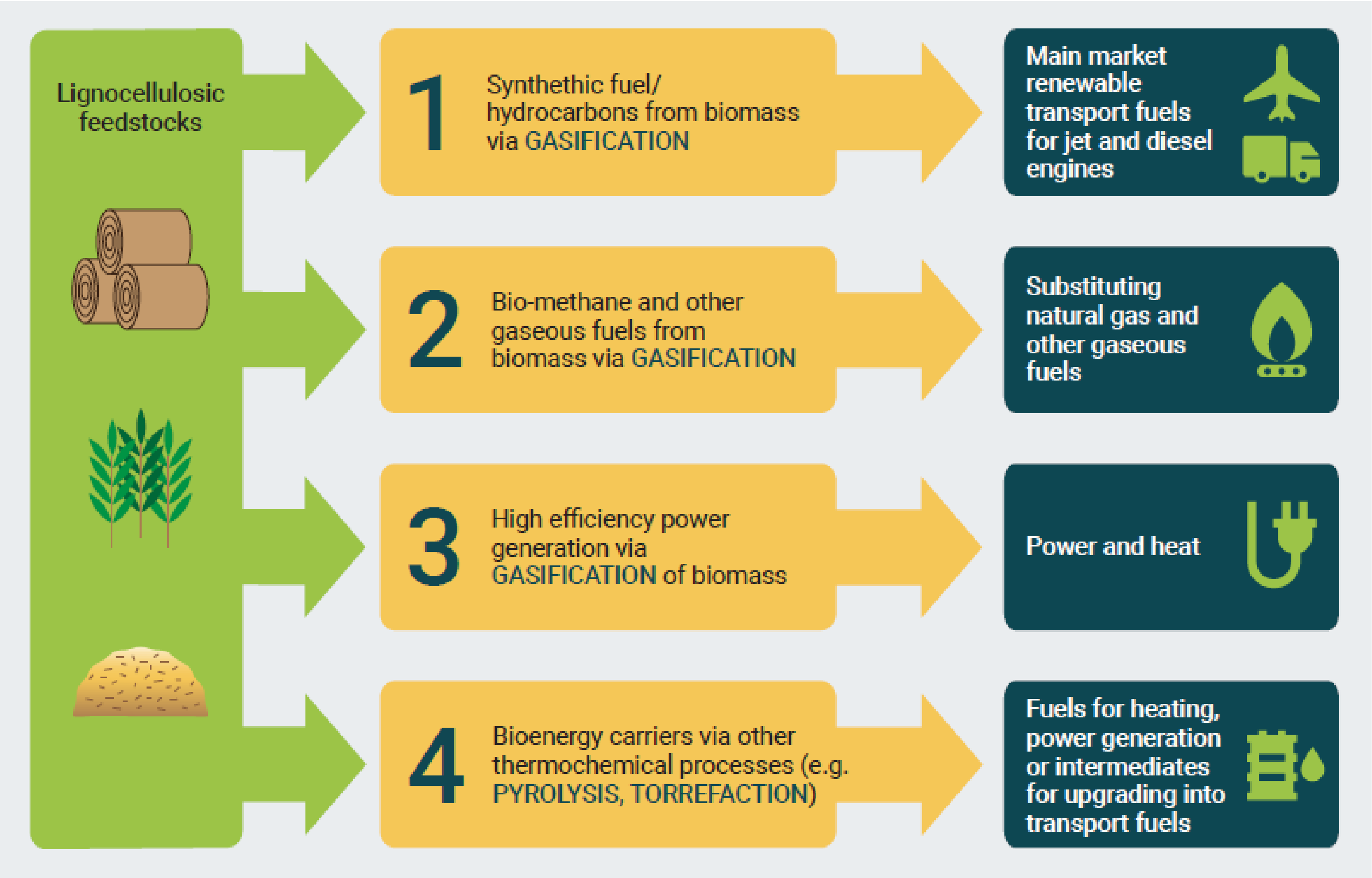
Source: 100 % Renewables solutions package: Solar PV on Public Buildings

BIOENERGY

What are the main applications of bioenergy as carbon neutral solutions?

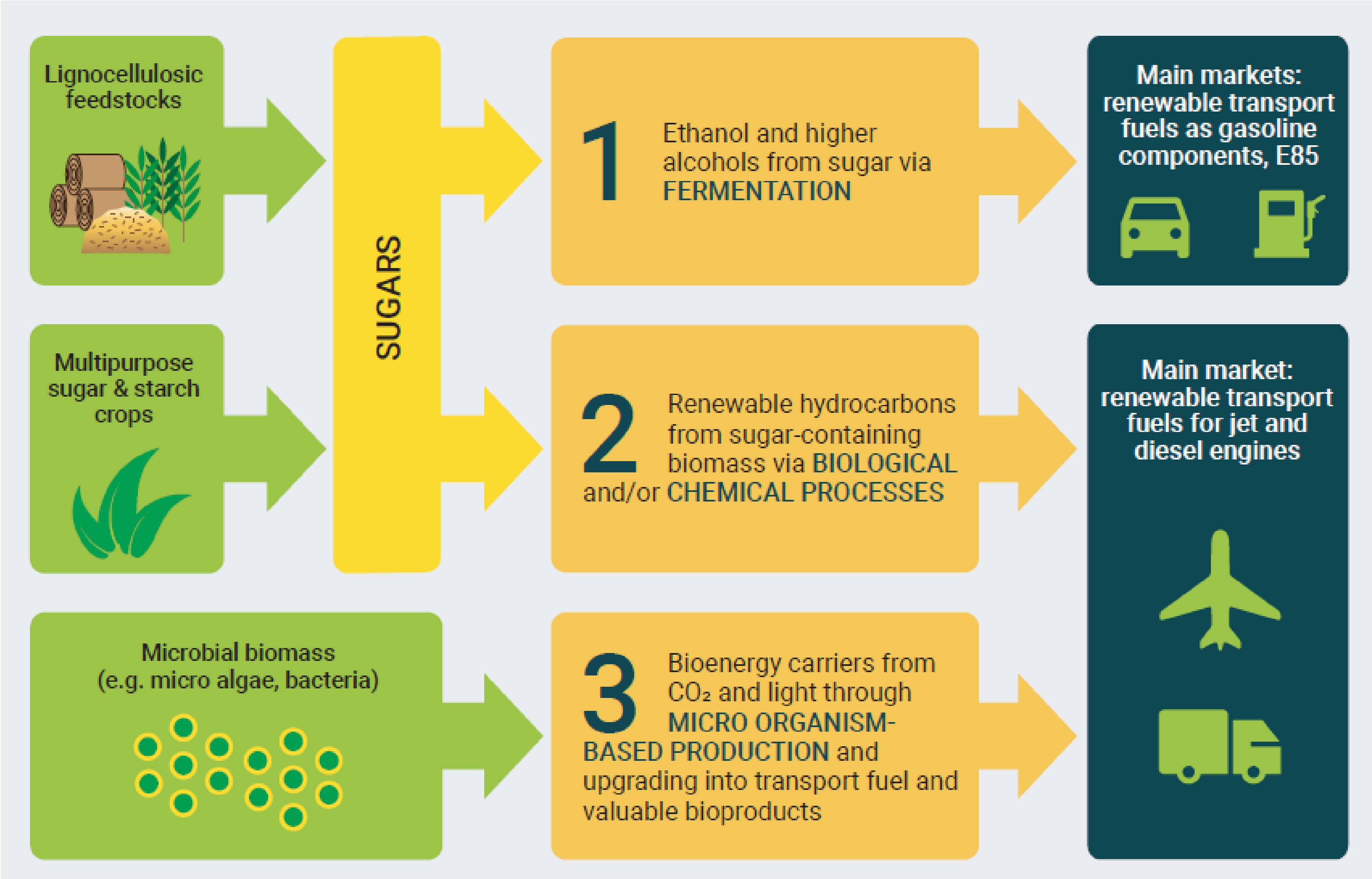
R. E. SOURCES—BIOENERGY

Biomass, derived from plants and animals and their wastes, produces heat when burned, which can be used to generate work and electricity. It can also be converted into biofuels through various processes, collectively known as bioenergy.



Source: European Biofuels Technology Platform

Thermo-chemical process

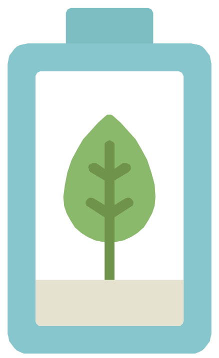


Source: European Biofuels Technology Platform

Biochemical process

Source: 100% RENEWABLES FACTSHEET SERIES - BIOENERGY

BIOMASS AND BIOFUELS



BIOMASS

Biomass is largely composed of organic material and water

- Crop waste
- Microalgae
- Agricultural waste
- Purpose-grown gasses
- Forest residues
- Woody energy crops
- Municipal solid waste
- Urban wood waste
- Food waste

BIOFUELS

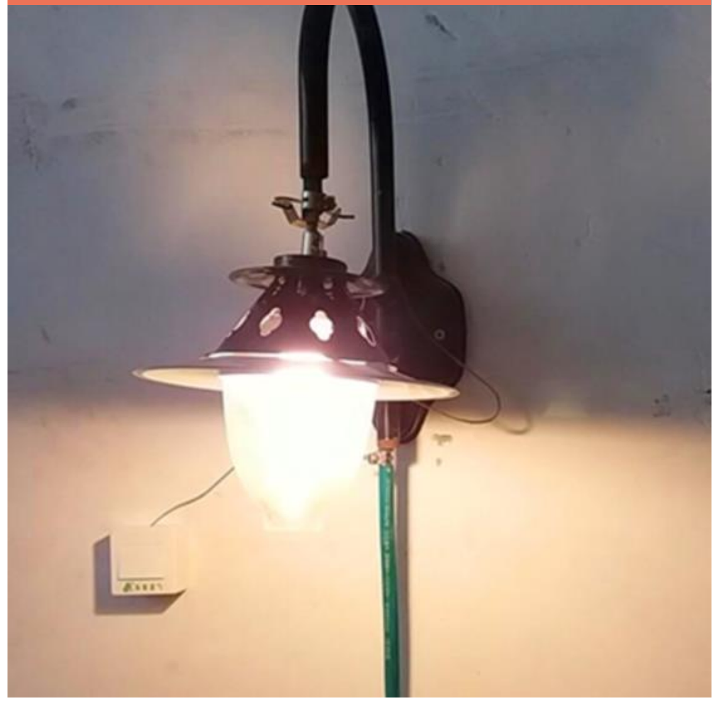
Biomass can be transformed by chemical and biological process to produce biofuels

- Methane gas
- Liquid
- Ethanol
- Methyl Esters
- Oils
- Solid
- charcoal

BIOFUEL APPLICATIONS

BIOGAS FOR COOKING

BIOGAS FOR LIGHTING



BIOGAS - UPGRADATION AND PURIFICATION

VEHICLE FUEL

ELECTRICITY GENERATION

ENERGY RECOVERY THROUGH CO=PROCESSING

A waste management technique that integrates municipal solid waste into industrial processes.

Environmental benefits:

- Reduces landfill reliance, minimizing. methane emissions.
- Lowers GHG emissions through resource recovery and greater efficiency.

Economic benefits:

- Cost-effective waste management solution.
- Generates revenue through resource utilization.

Social benefits:

- Improves public health by reducing pollution and promoting cleanliness.
- Creates employment opportunities in waste management and recycling sectors.

Source: 100 % Renewables solutions package: Co-Processing: An Energy Recovery Option for Cities

PART 2

TRANSITION ENABLERS

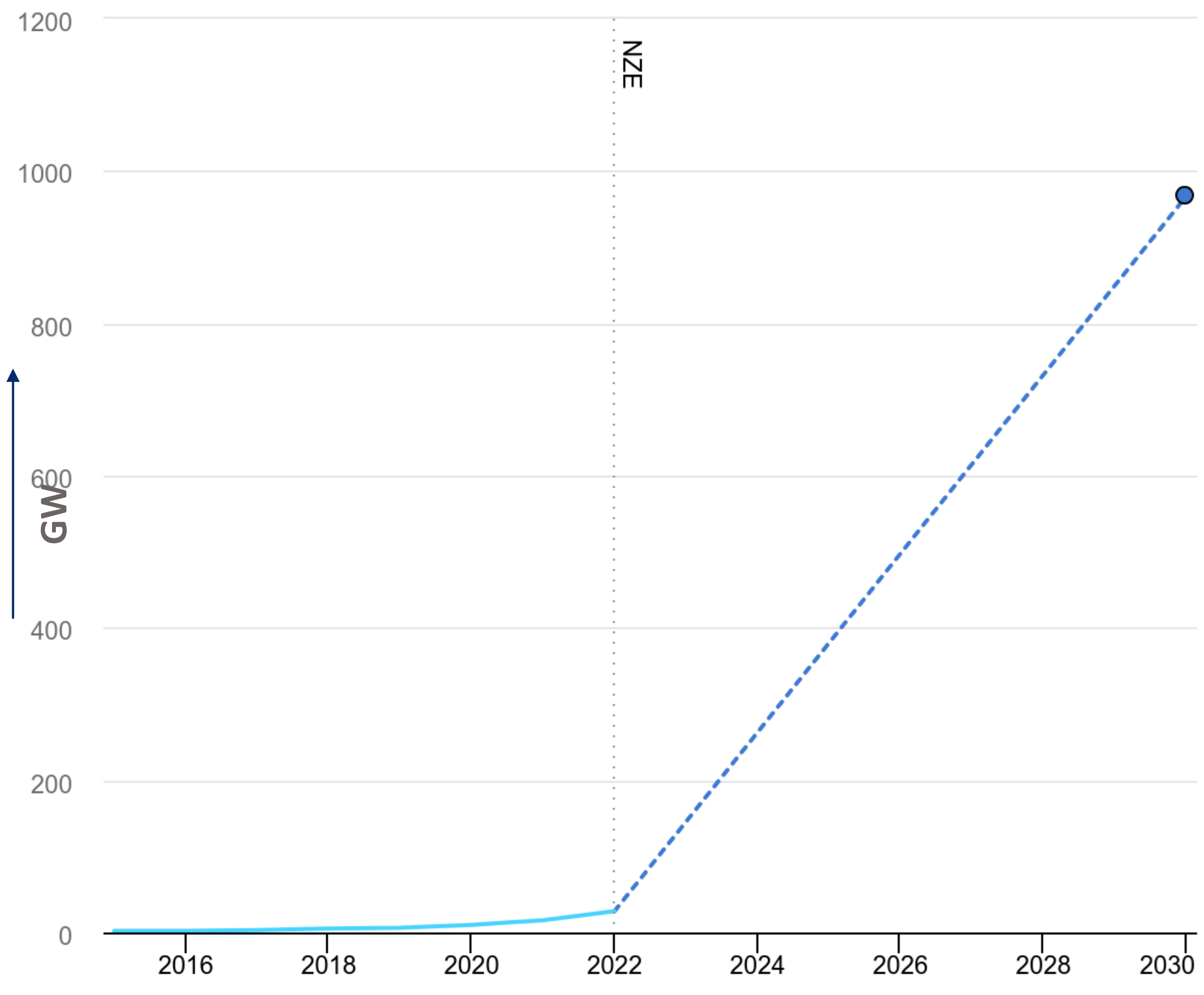
ENABLERS:
ENERGY STORAGE

BATTERY ENERGY STORAGE SYSTEMS (BESS)

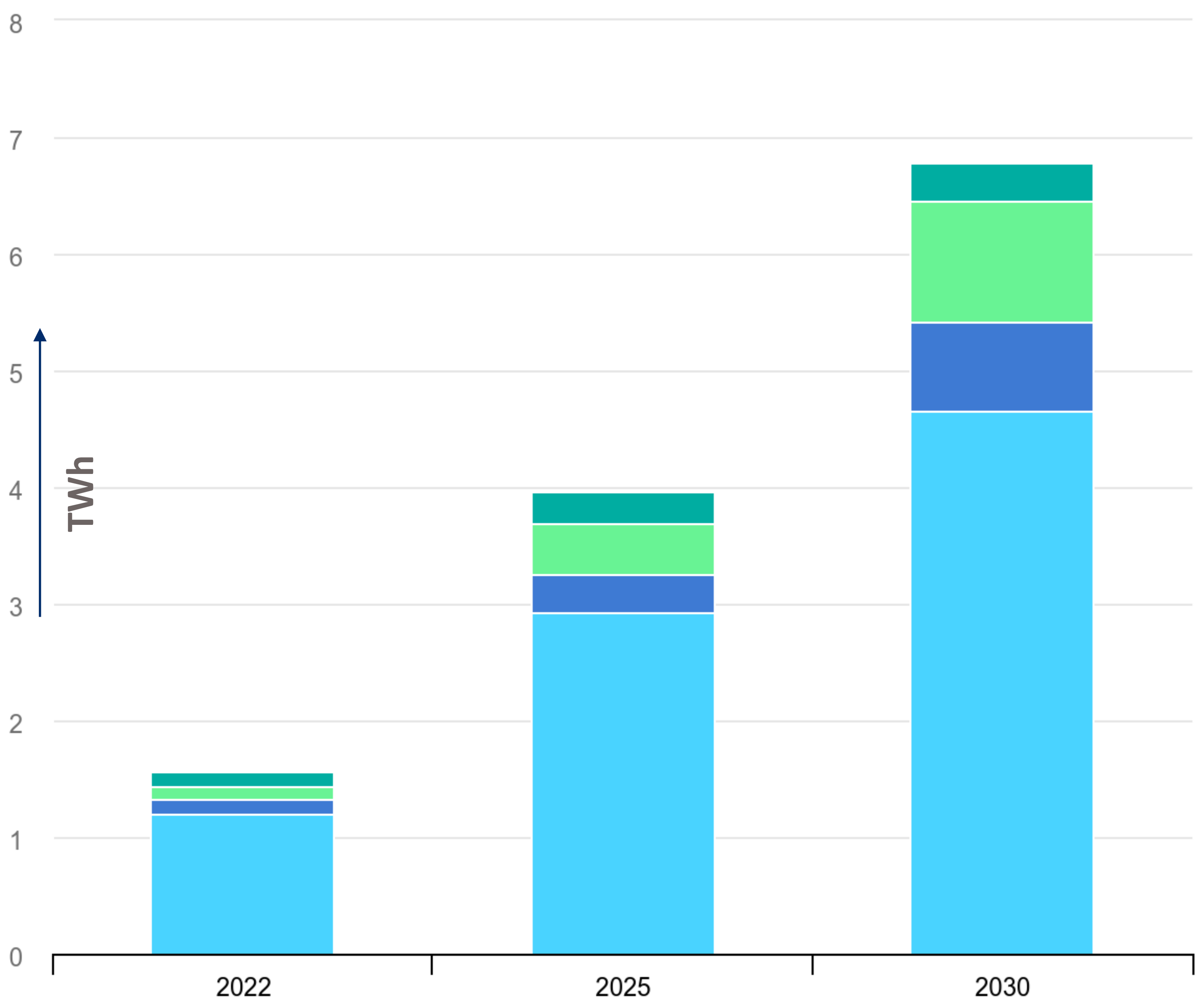
BESS is designed to store electrical energy in the form of chemical energy, which can be converted back into electricity when needed.

- Provides affordability & flexibility store electrical energy when RE generation exceeds immediate demand.
- The Battery Management System (BMS) in BESS efficiently manages energy charging and discharging according to grid conditions and demand.
- Can be used in utility-scale installations, commercial buildings, homes, and open lands to provide localized energy storage solutions for the grid.
- -Savings on electricity costs.
  -Uninterruptible power supply.
  -On-site power quality improvement.
- Contribute to improving the reliability of supply and emission reductions.

GLOBAL STATUS OF BESS



Source: IEA, 2023



Source: IEA, 2023

Global installed grid-scale battery storage capacity is expected to reach up to 967 GW by 2030 under the net zero scenario

A significant and progressive increase in Lithium-ion battery production. It is expected to increase from 1.57 TWh in 2022 in 2030.

*Energy Reports 10 (2023) 300-318

ROLE OF BESS

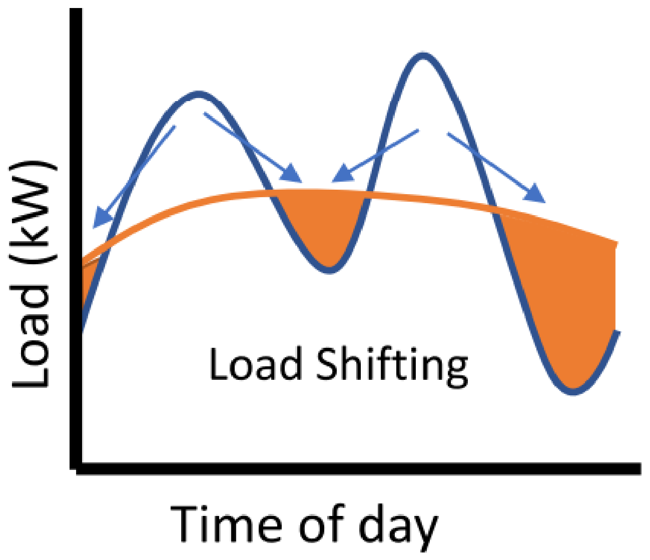
Role of BESS in integration of renewable energy

- Grid stability
- Load management: Peak shaving & Load shifting
- Demand response

O&M Fixed cost US $ / kW-year)*

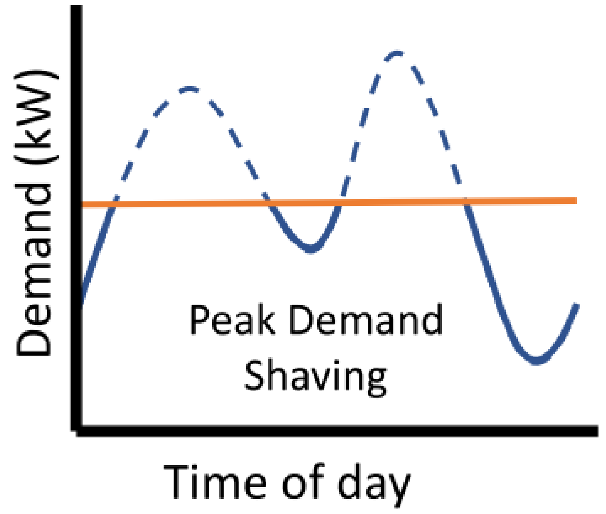
1	3.19 TO 4.51	Li-ion
2	5.11 TO 13.60	Lead Acid
3	5.89 TO 12.77	Redox Flow

LOAD SHIFTING



Original load
Shifted load

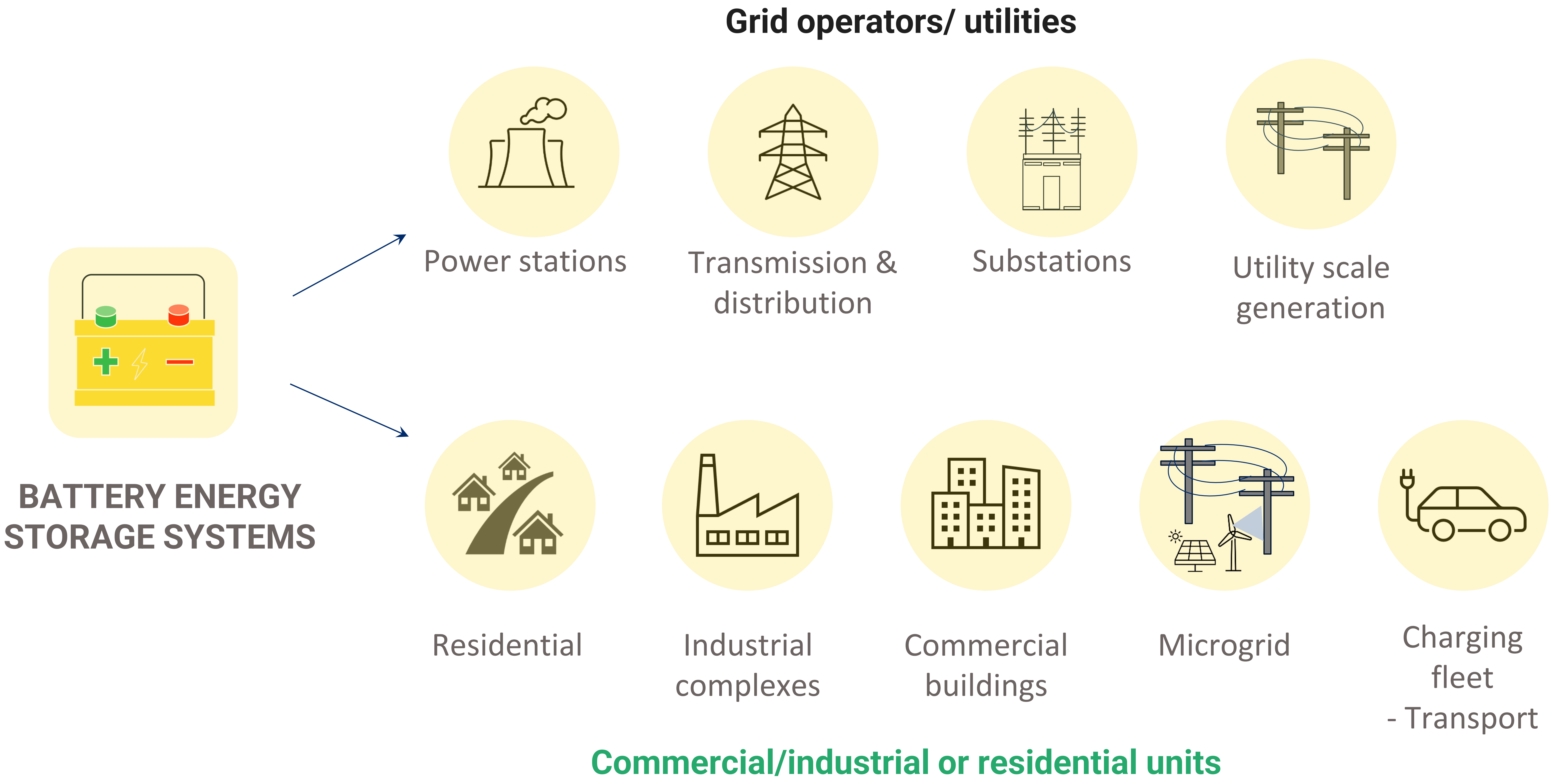
PEAK DEMAND



Original demand peak
Shaved demand peak

*Energy Reports 10 (2023) 300-318

BESS APPLICATIONS



ENABLERS: WASTE

WASTE-TO-ENERGY (WTE)

WTE plants thermally treat household and municipal waste that is left over after waste prevention and recycling efforts and generate energy from the waste material.

Key challenges of a city's municipal energy infrastructure due to waste

- Aging infrastructure poses challenges for municipal energy systems
- Utilities face financial constraints
- Creating landfills
- Limited space and regulatory barriers
- Some technical limitations in adopting renewable energy
- Quality Recycling
- Complexity, unawareness, ineffective collection, tech needs, funding
- Diverting waste from landfills
- Hygienic waste treatment

Source: *The Climate Change Mitigation Potential of the Waste Sector, Öko-Institut and IFEU on behalf of German Federal Environment Agency (UBA), 2015

WASTE-TO-ENERGY (WTE)

Cost effective secure energy

Replacing fossil fuels with renewables

Revenue generation & Local energy

Circular economy

Scope for waste to products

Source: *The Climate Change Mitigation Potential of the Waste Sector, Öko-Institut and IFEU on behalf of German Federal Environment Agency (UBA), 2015

WTE OPPORTUNITIES

Opportunities from WtE

- Resource recovery
- Renewable energy generation
- Waste Management Solutions
- Economic development
- Environmental benefits
- Energy security
- Promoting the circular economy
- Community engagement
- Partnerships
- Regulatory Compliance

Government role

- Government roles in waste-to-energy (WtE) vary by society type and development level.
- Local policies, public perception, and waste management practices impact WtE implementation.
- Municipal solid waste can be considered an energy source, which helps reduce emissions and improve circularity.
- Global policies on waste as a renewable fuel vary based on differing perspectives.

Source: Waste to energy in developing countries – Sustainability – MDPI 2022. What a waste 2.0: WB 2019

WTE TECHNOLOGIES

WASTE TO ENERGY TECHNOLOGIES

- **THERMAL**
  - Incineration → Heat, Power, Combined Heat Power
  - Gasification→ Hydrogen, Methane, Syngas
  - Plasma Gasification→ Hydrogen, Methane, Syngas
  - Pyrolysis → Char, Gases, Aerosol, Syngas
- **BIO-CHEMICAL**
  - Fermentation → Ethanol, Hydrogen, Biodiesel
  - Anaerobic Digestion→ Methane
  - Landfill with gas capture→ Methane
  - Microbial Fuel Cell → Power
- **CHEMICAL**
  - Esterification → Ethanol, Biodiesel

World Energy Resources – Waste to Energy, 2016

CASE STUDY: WTE IN SAN JOSE, USA

Zero Waste Energy – San Jose. CA. USA

San Jose's Waste Management:

- Achieves 74% diversion rate, a national leader.
- Started comprehensive waste reduction in the 1980s, including curbside recycling and landfill expansion.
- Implemented Zero Waste Strategic plan in 2008 and pioneered a commercial-scale anaerobic digestion facility.

Innovations:

- Incentivizes waste reduction and recycling through contracts.
- Divided city into three waste collection districts and shifted to exclusive commercial waste collection.
- Introduced recycling incentives, Pay-As-You-Throw rates, and innovative technologies for improved waste management practices.

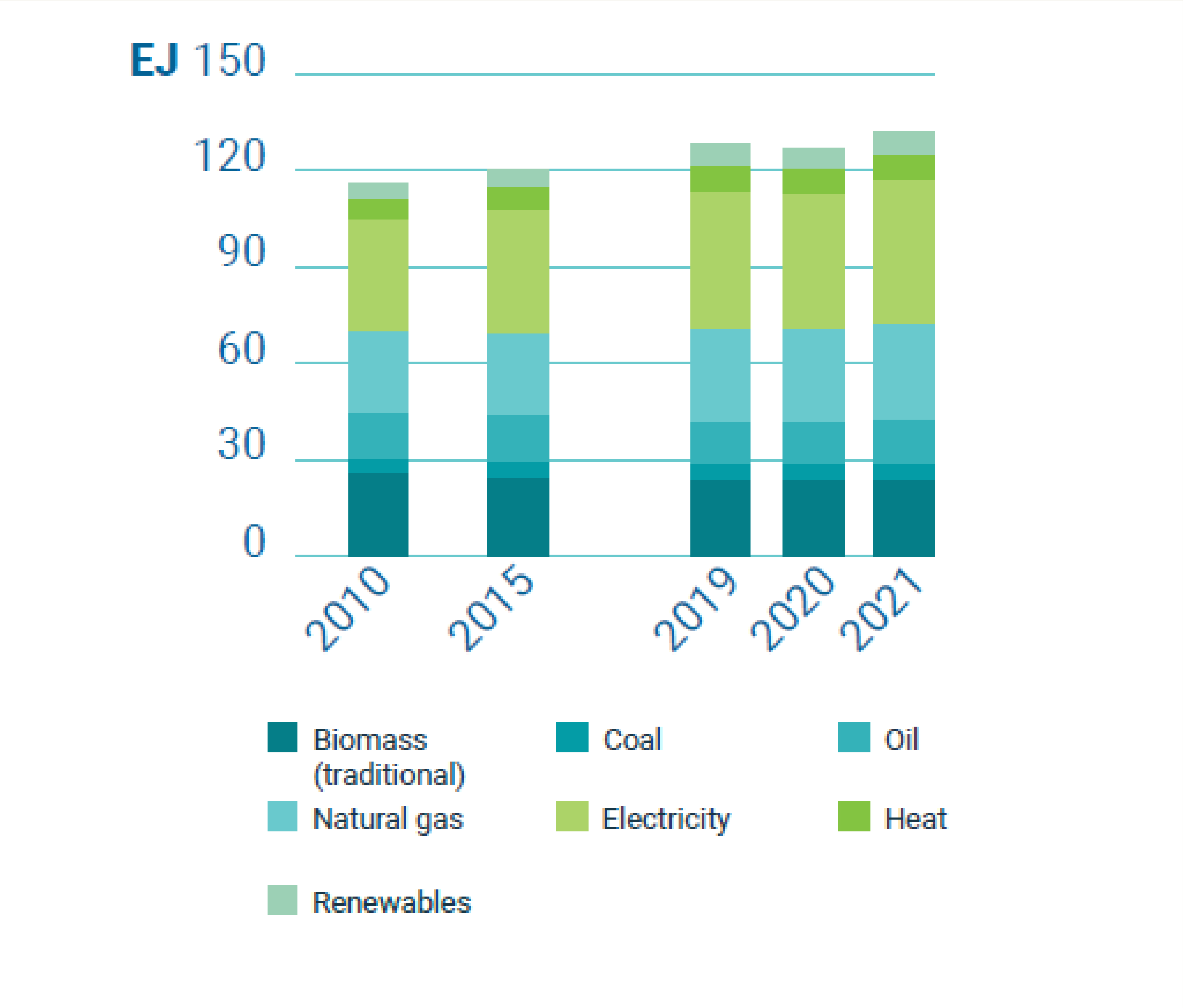
Bio gas power plant (Organic waste)
Energy 2× 800 kW

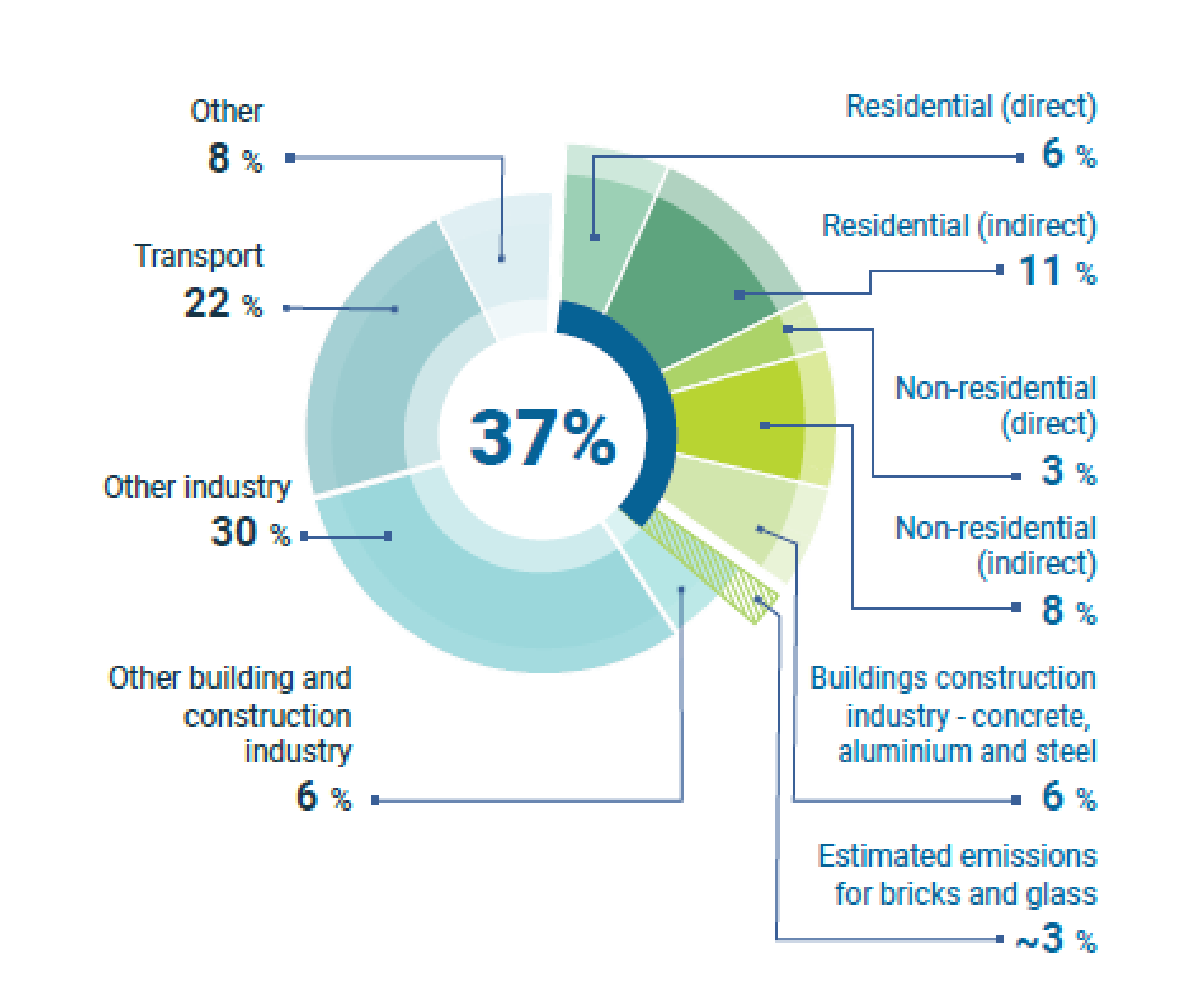
ENABLERS:
ENERGY EFFICIENCY AND CONSERVATION

ENERGY CONSUMPTION

ENERGY CONSUMPTION vs CURRENT ENERGY SOURCES IN BUILDINGS

- Buildings play a big role in global energy use and emissions
- Renewables play a smaller role





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

FACTORS AFFECTING ENERGY CONSUMPTION

ENERGY CONSUMPTION IN BUILDINGS

FORM



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

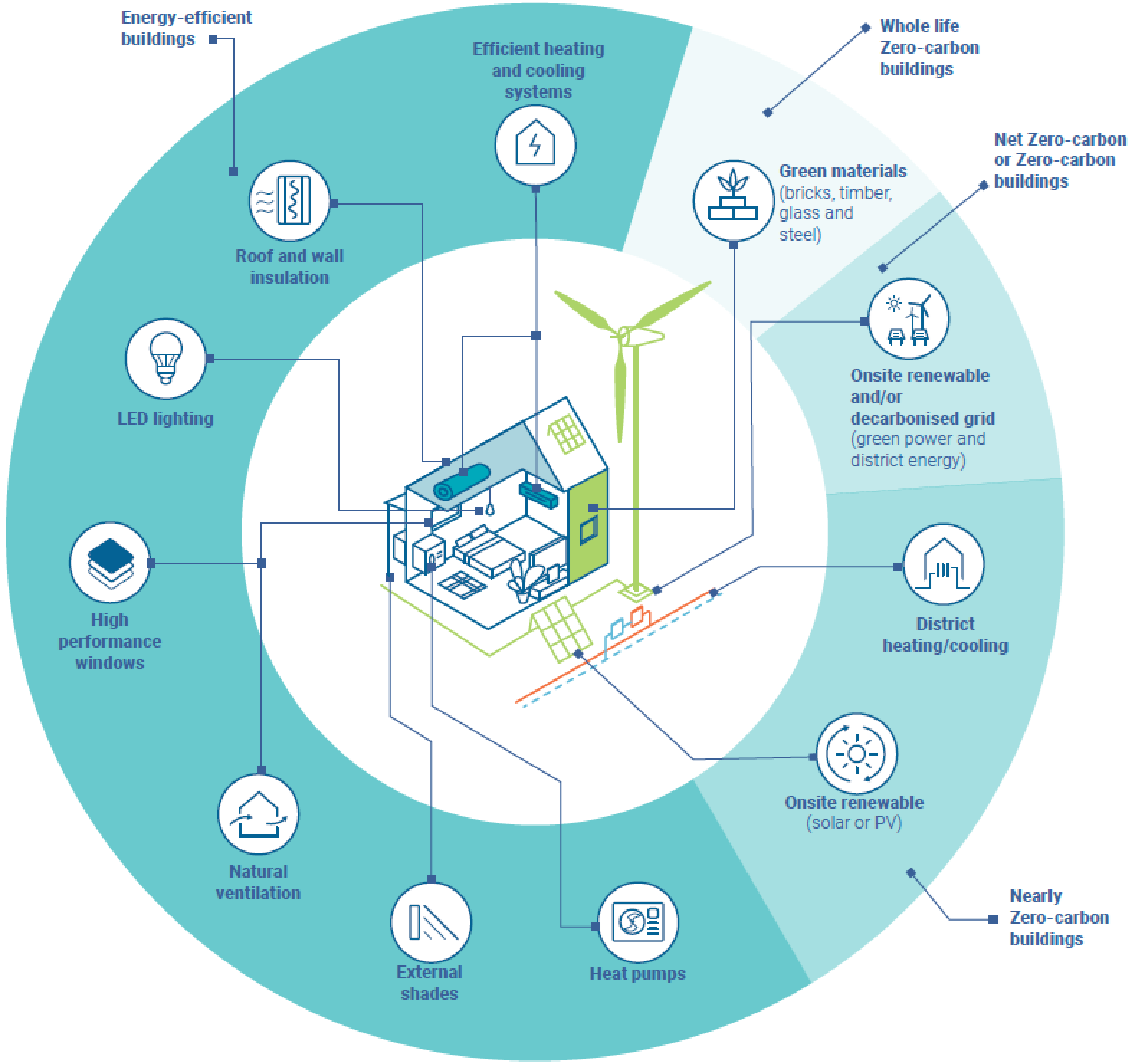
FUNCTION



- 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.

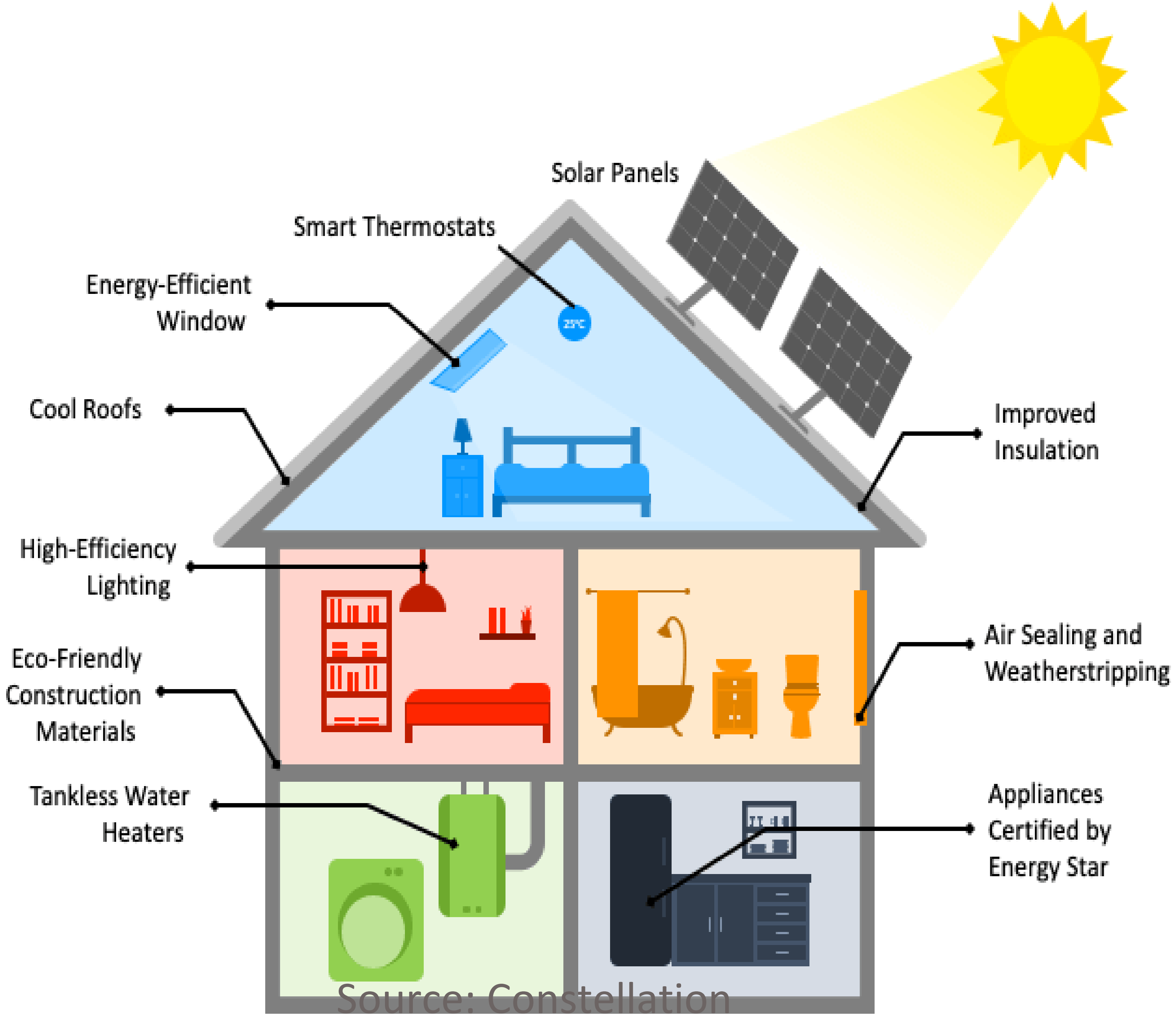
URBAN ENERGY EFFICIENCY MEASURES

- Smart streetlight retrofit
- 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

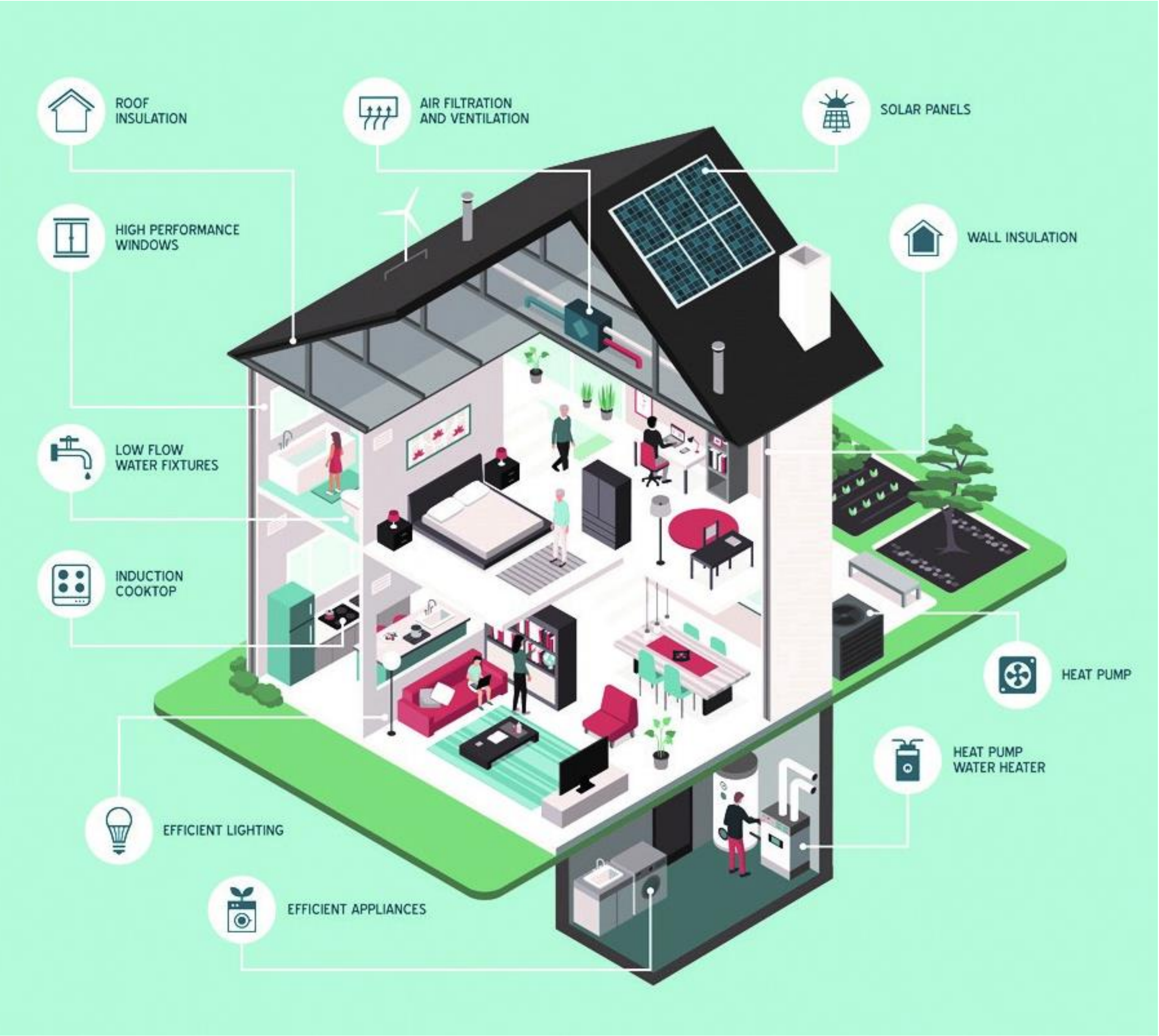


Source: IEA 2021 – Roadmap for Energy-Efficient Buildings and Construction in the Association of Southeast Asian Nations. IEA 2022e

ENERGY-EFFICIENT DESIGN



Source: Constellation



Source: EcoMENA

SOLUTION: ENERGY EFFICIENCY LABELING FOR BUILDINGS

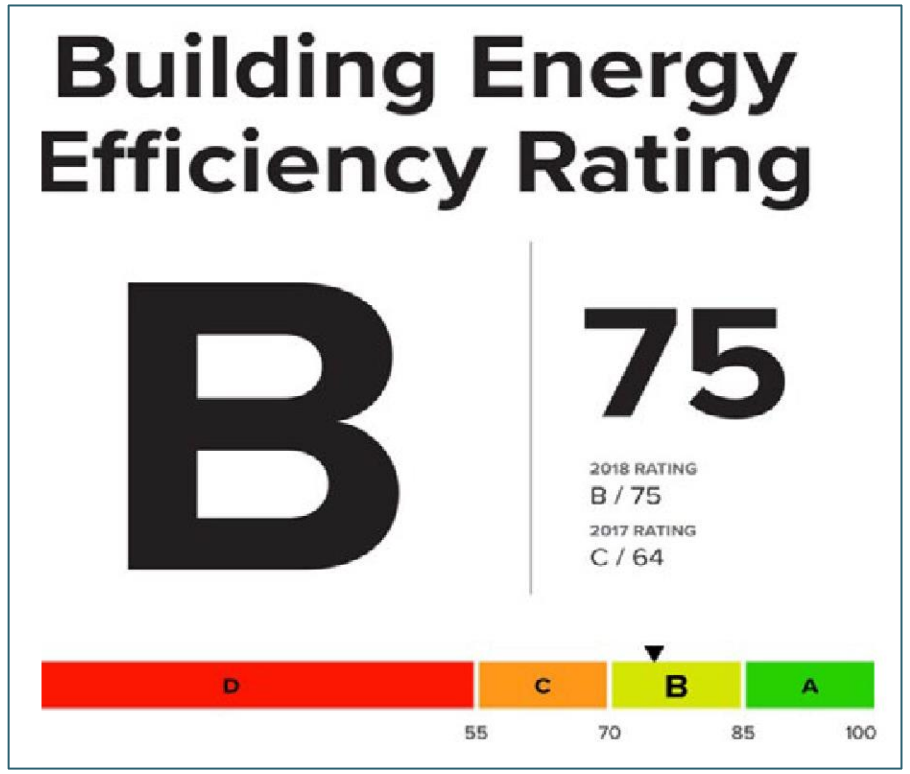
Energy efficiency labeling for buildings informs homeowners, tenants, and developers about a building's energy performance to guide decisions toward energy efficiency.

Importance:

- Governments are implementing regulations to achieve energy savings in buildings to combat climate change.
- Energy efficiency labelling raises awareness and promotes adoption of efficient buildings, reducing energy consumption and emissions.

Environmental impact:

- Buildings consume a significant portion of total energy, with residential buildings alone accounting for over 20%.
- Population growth and construction demand contribute to rising energy needs.



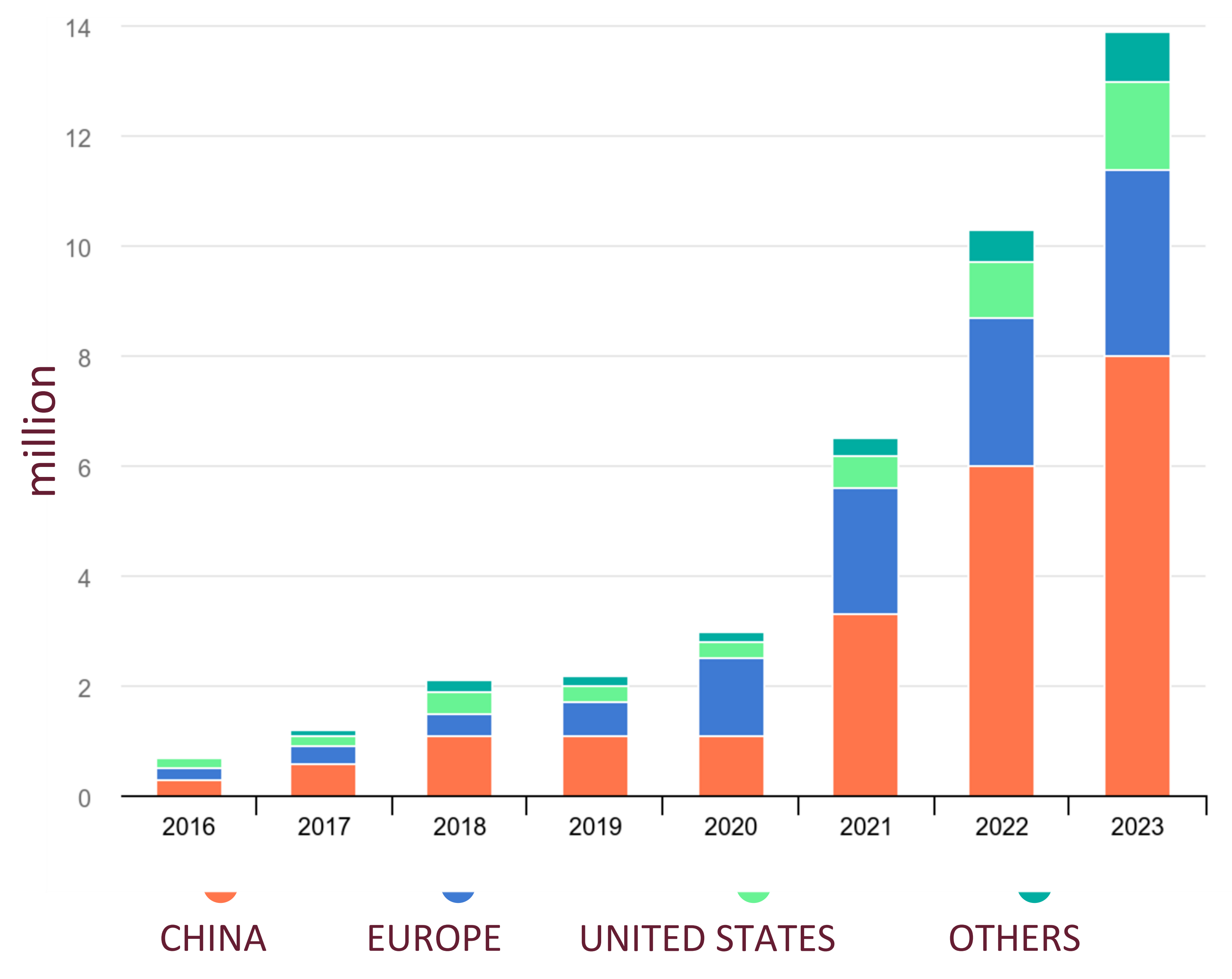
Source: 100 % Renewables solutions package: Energy Efficiency labelling for buildings

PART 3

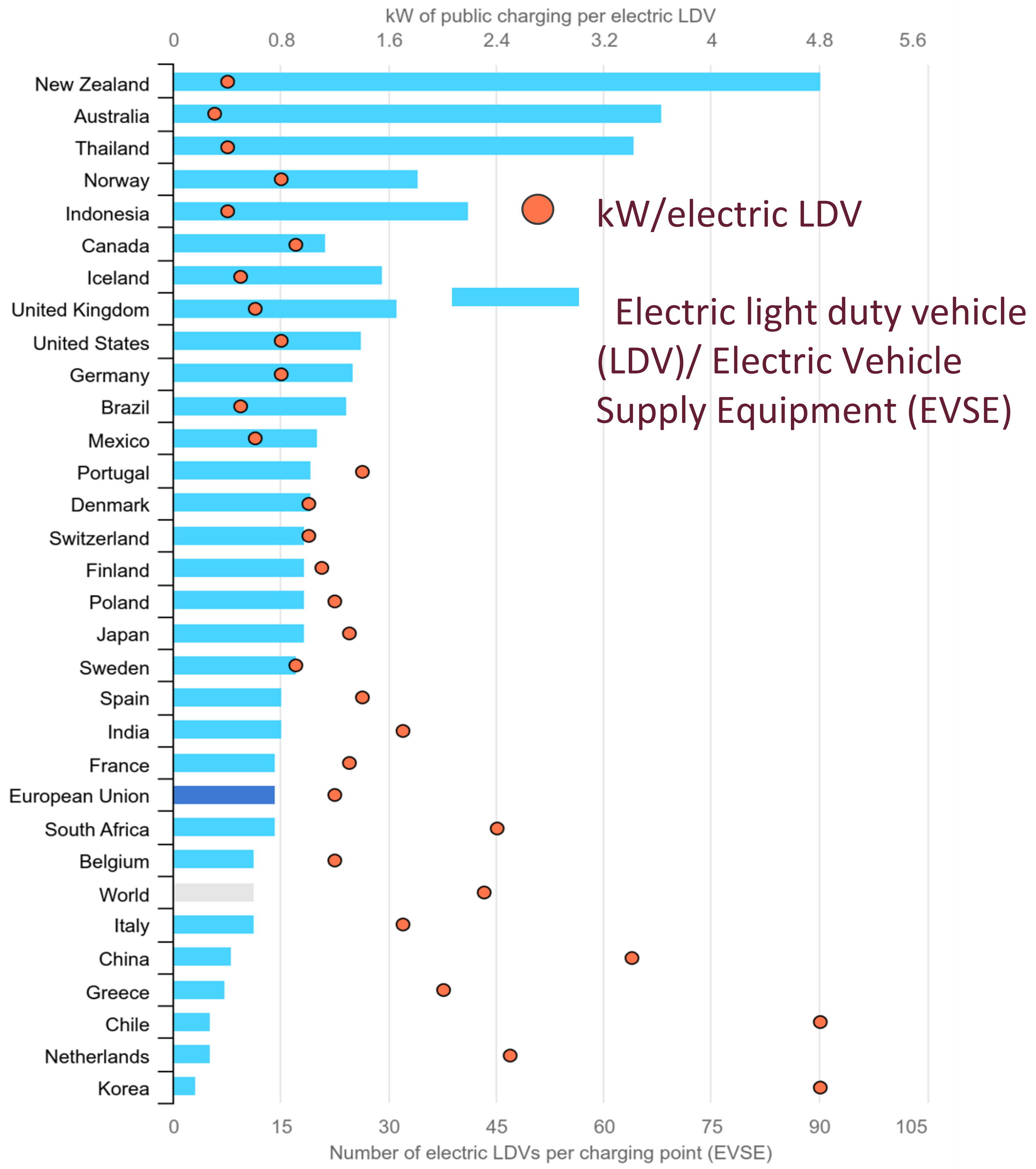
RE IN TRANSPORT

GROWING EV DEMAND

ELECTRIC CAR SALES



NUMBER OF ELECTRIC LIGHT DUTY VEHICLES PER CHARGING POINT



Source: a) Global EV sales by Scenario, 2020-2030. IEA, 2023 b) Global EV outlook 2024, IEA

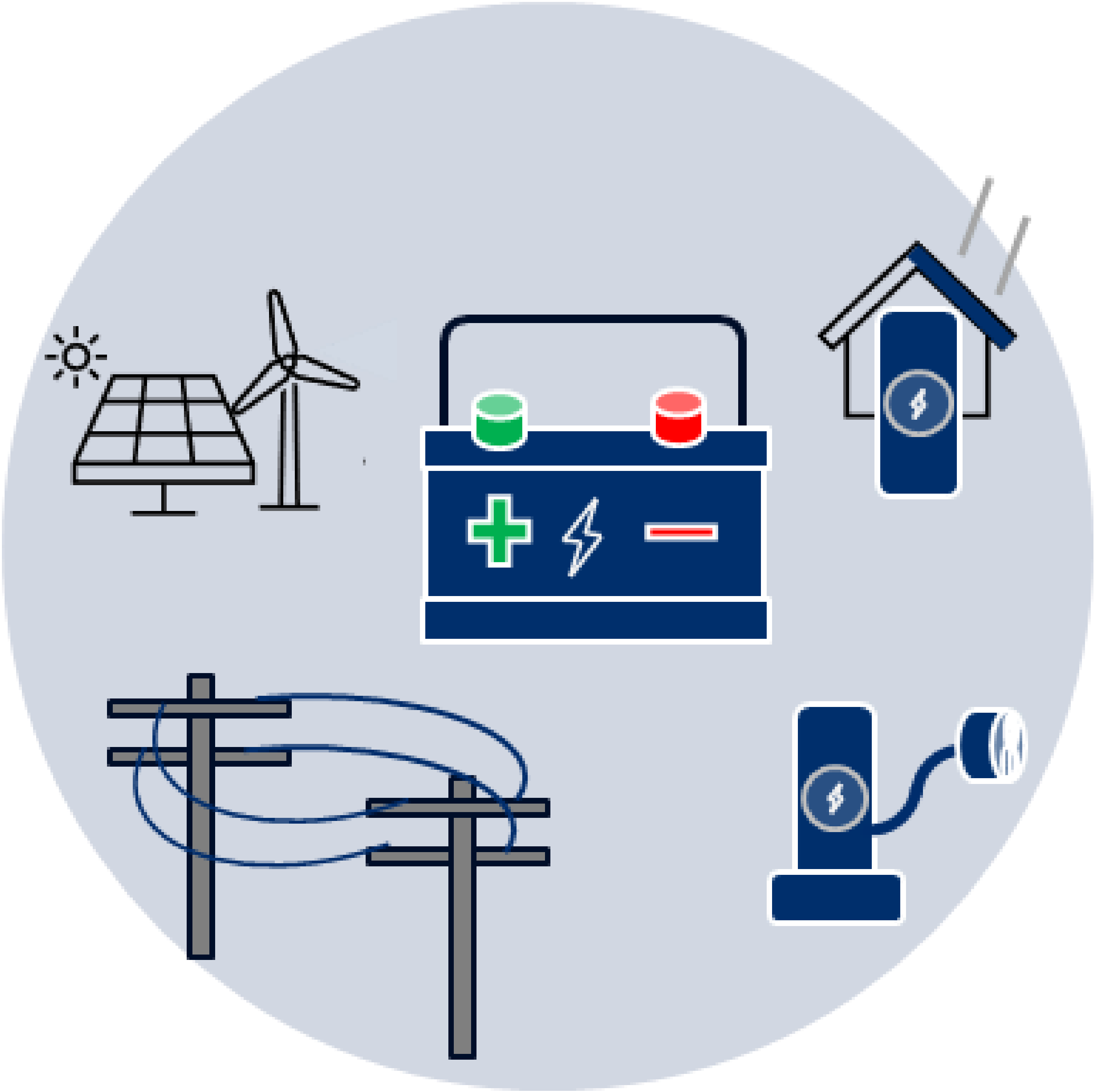
RE STORAGE INTEGRATION IN E-MOBILITY

Challenges EV penetration/Charging infrastructure

- Grid support for **increased electricity demand**.
- **Upgrade** to maintain distribution reliability.
- Solution RE integration and local energy storing.

Role of RE storage in EV

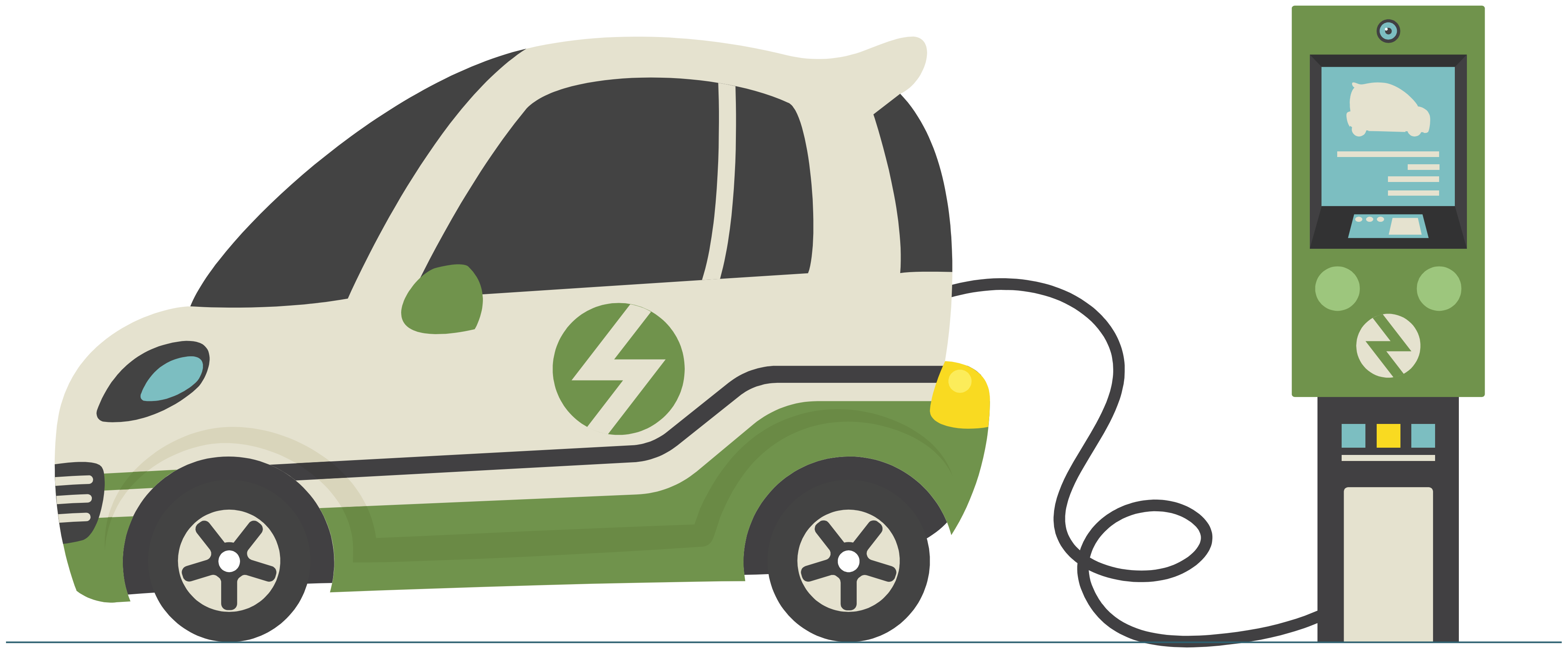
- **Intermittent nature** of solar PV and Wind – hindering acceptance in power grids.
- EVs can **store** surplus RE and feed it back to the grid through V2G protocol Upgrade to maintain distribution reliability.
- Grid stability, Cost savings, Energy independence, Public awareness.



EV DEPLOYMENT CHALLENGES

To reduce dependence on fossil fuel and reduction in global emissions from ICE vehicles, EVs are preferred.

- Match power generation from RE – meet electricity demand for charging infrastructure.
- Current challenges faced by municipalities in EV deployment:
  - Lack of data and understanding on transitioning fleets to EVs.
  - Uncertainty regarding funding and planning for EV infrastructure.
  - Need for expertise in developing policies for EV integration.



SOLUTION: RE-BASED EV CHARGING STATIONS

RE-based smart charging stations for EVs, using solar, wind, or hydro power:

- Cut GHG emissions
- Enhance energy independence
- Save costs
- Incentivize EV adoption.

Role of Local Governments

- Formulating and implementing policies - support - charging stations.
- Identify suitable sites and invest in infrastructure.
- Provide financial incentives and working with the private sector.
- Educating the public and stakeholders about Evs and RE.
- Aligning efforts with broader sustainability goals and monitoring impact.

Solar Energy Charging: Fastned

Renewable Energy Charging: EnBw

Source: 100% RE Solutions Package – RE Based EV Charging station

ELECTRIC MICRO-MOBILITY

Electric micro-mobility (EM) encompasses e-scooters, e-bikes, and e-motorcycles, perfect for short urban trips at speeds up to 45 km/h (28 mph),

Benefits

- Offers flexible and eco-friendly personal transportation.
- Facilitates e-commerce and sustainable tourism, creating economic opportunities.
- Drives job creation, economic growth, and resilience.

Social impacts:

- Provides accessible and comfortable transport.
- Improves access to services, supporting community development
- Provides an alternative to cars, making public transport and walking more convenient

Source: 100 % Renewables solutions package: Electric Micro-Mobility for Decarbonization of the Transport Sector

RE-BASED EV CHARGING STATIONS

Transport Challenges:

- Rapid technology advancements increase GHG emissions.
- Heavy reliance on fossil fuels in transport leads to CO_2 emissions.

Shift to Greener Transport:

- Global promotion of EVs for climate mitigation.
- EVs are crucial for achieving zero-emission transport.

EV Charging Challenges:

- Fossil fuel dependence persists despite EV adoption.
- Renewable energy-based charging stations (solar, wind, hydro) support cleaner energy for EVs.

Source: 100 % Renewables solutions package: RE Based EV Charging Station

CASE STUDY: CHARLOTTE, NC, USA

Charlotte, NC

-Vehicle miles travelled: 14,180
-GHG reduction: 49%
-Operational savings: US $18,000 – US $ 21,000
-TCO change and %: US $9,000 – US $12,000 and 21%

Key challenges

- Higher upfront costs and procurement barriers for EVs.
- Limited heavy-duty EV options for street sweeping and garbage collection.
- Challenges in setting up comprehensive EV charging infrastructure for large-scale fleet transitions.

Achievements

- Cost savings, environmental impact, efficiency, innovation, equity, and inclusion.
- Positive social and environmental impacts observed, with employee behavior changes.
- Use of NASA's Technology Readiness Levels tool for EV adoption decisions.

Source: Image L, R, Content

PART 4

OTHER SOLUTIONS AND CASE STUDIES

COMMUNITY-OWNED RENEWABLE ENERGY

- Community involvement in renewable energy projects for electricity generation is key.
- Community-owned renewables benefit remote or underserved areas reliant on traditional energy.
- Community energy projects align with climate change mitigation efforts per ICLEI's Green Climate Cities Handbook and MRV tool.

Main impacts

-Local economic impact

-Environmental impacts

-Social impact

Benefits

-Enhanced grid flexibility and resilience

-Expanded deployment of distributed renewables

-Improved energy access and lower community costs

-Socio-economic advantages

Source: 100 % Renewables solutions package: Community-owned Renewable energy

GREEN HYDROGEN

Green Hydrogen, made through renewable energy electrolysis, is a clean and versatile energy carrier used in transport, industry, and power generation to reduce carbon emissions.

Key impacts:

- Reduced dependence on fossil fuels.
- System integration of renewable energy.
- Attracting investment.

Benefits:

- Reduced energy expenditure
- Innovation hub creation
- Decarbonization in transport and industry
- Job creation and economic development energy sector.
- Enhanced energy security

Source: 100 % Renewables solutions package: Local Strategies for Green Hydrogen

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END OF MODULE

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