ICLEI
Local Governments for Sustainability

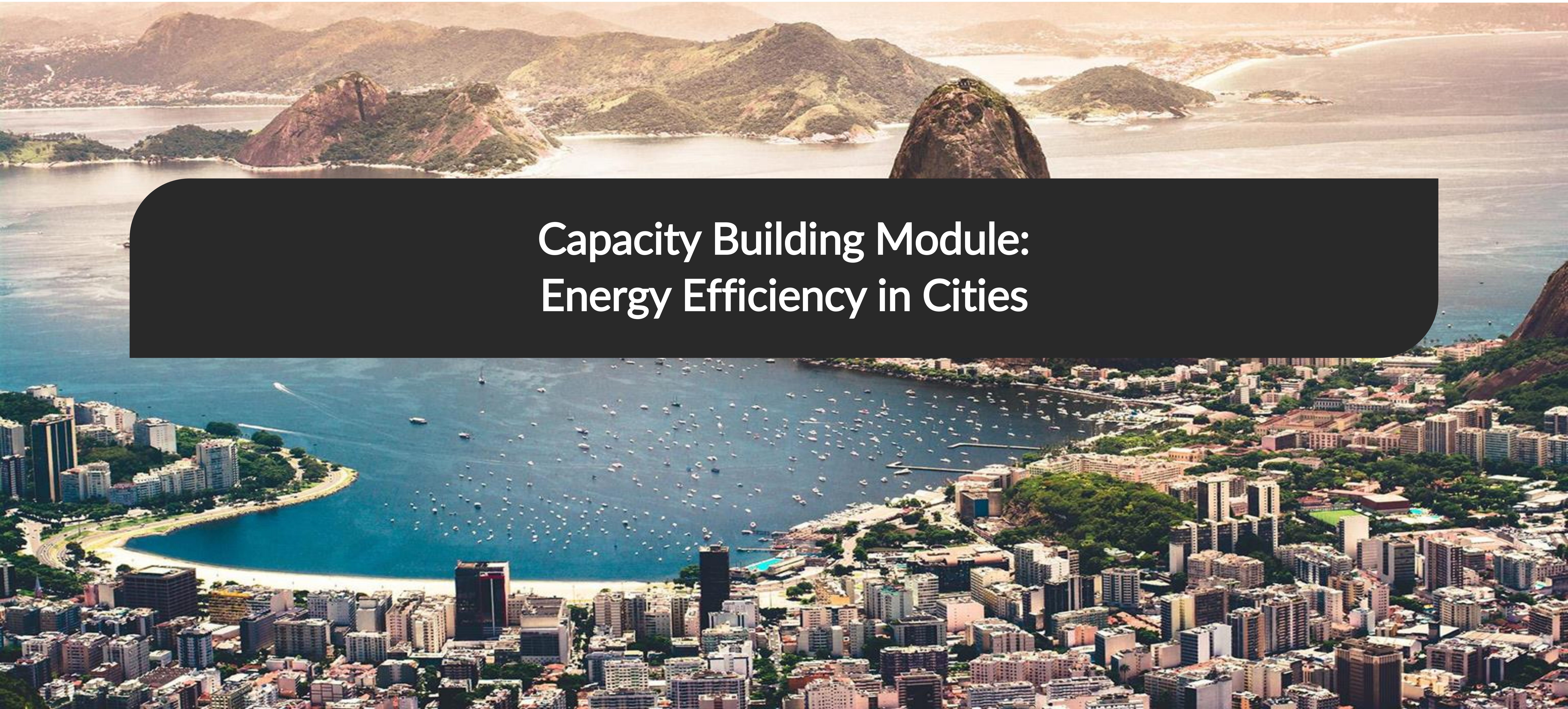
100% RENEWABLES
CITIES & REGIONS ROADMAP

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 1:

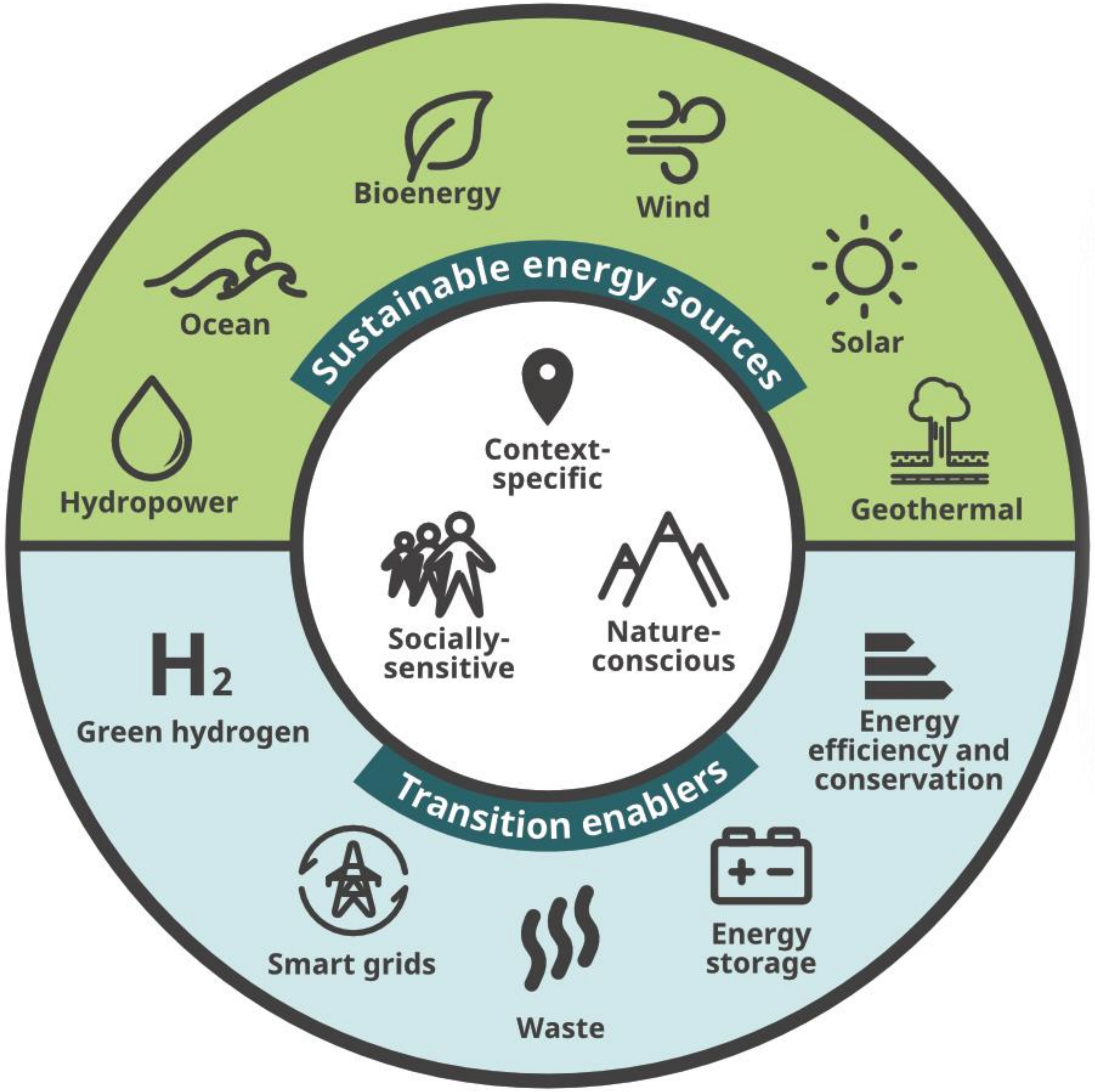
Introduction to energy efficiency

CONTENTS

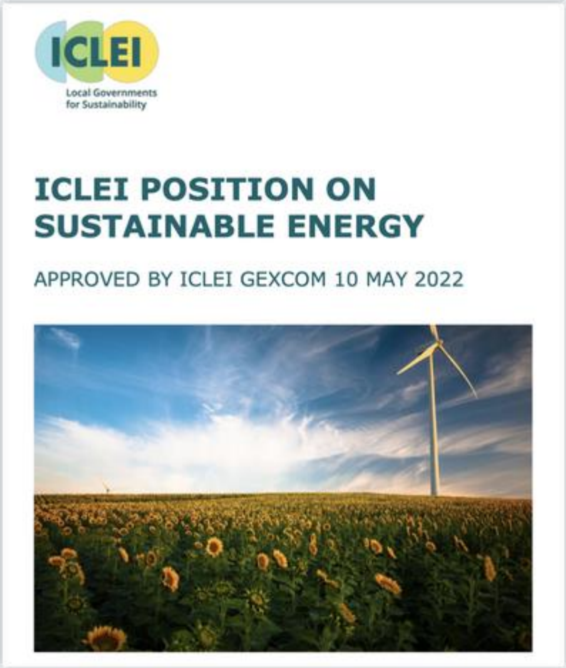
INTRODUCTION

SUSTAINABLE ENERGY & 100 % RENEWABLES

SUSTAINABLE ENERGY SOURCES



ICLEI’s Sustainable Energy Position

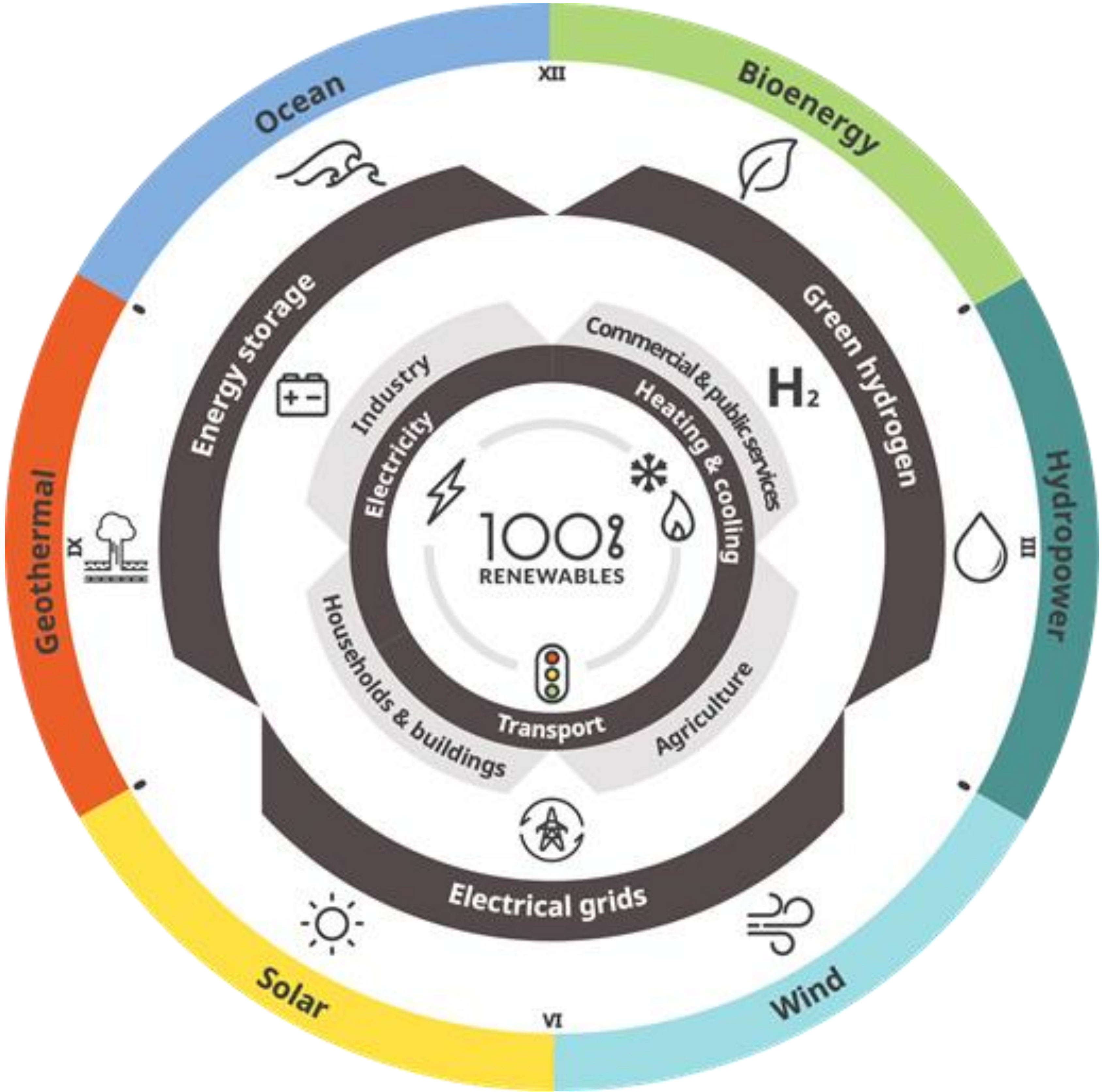


Scan to read the full text:

100% RENEWABLES CITIES AND REGIONS

“ Renewable energy encompasses all renewable resources, including **bioenergy, geothermal, hydropower, ocean, solar and wind energy**. One hundred percent renewable energy means that all sources of energy to meet all end-use energy needs in a certain location, region or country are derived from renewable energy resources **24 hours per day, every day of the year**. Renewable energy can either be produced locally to meet all local end-use energy needs (power, heating and cooling, and transport) or can be imported from outside of the region using supportive technologies and installations such as **electrical grids, hydrogen or heated water**. Any **storage facilities** to help balance the energy supply must also use energy derived only from renewable resources.

-IRENA Coalition for Action

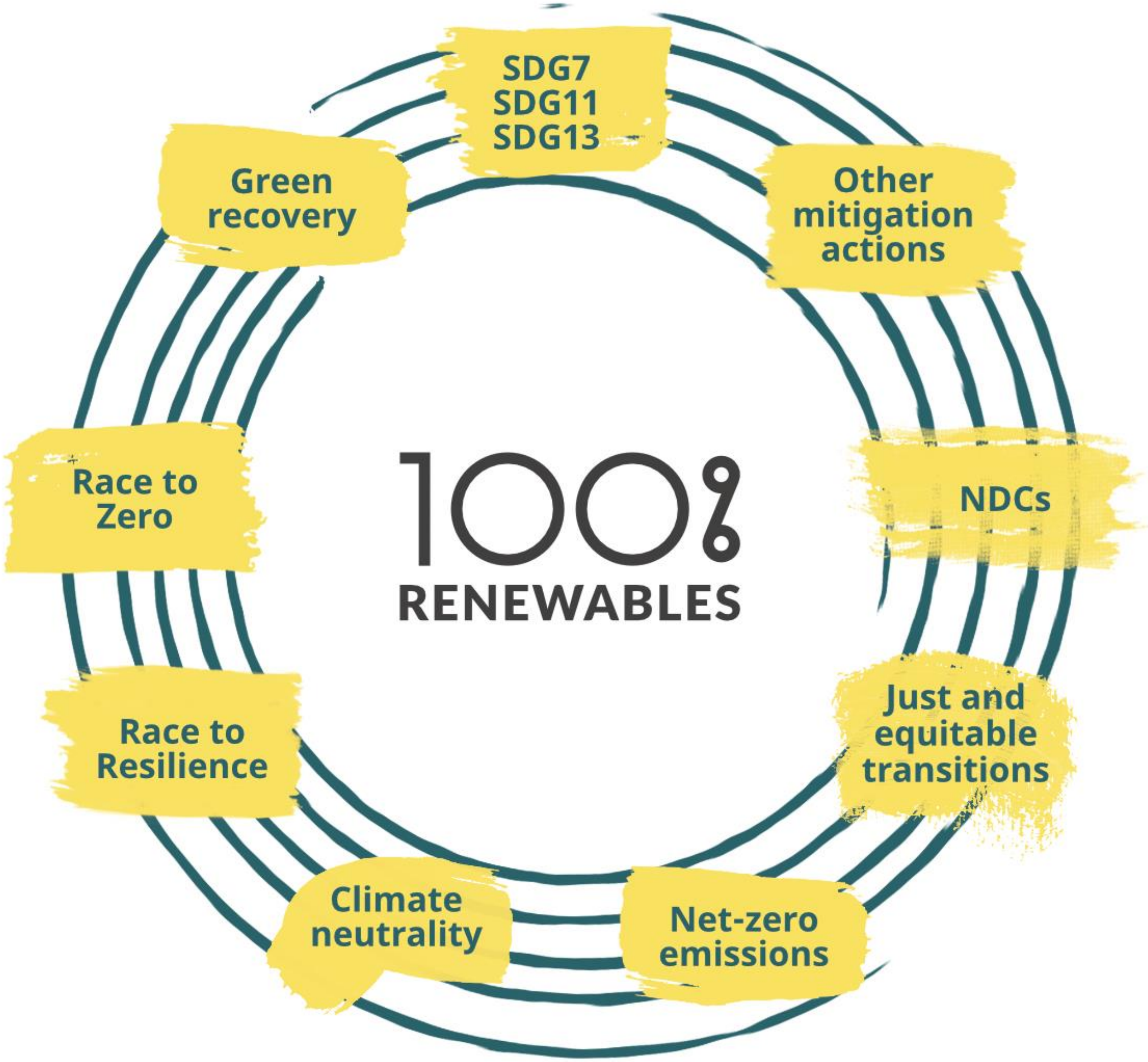


Graphical representation of 100% renewable energy by ICLEI - Local Governments for Sustainability

100% RENEWABLES AS A CORNERSTONE

Decarbonizing energy supply through renewable energy sources, deployed in a socially- and environmentally-conscious way, is key to achieving various climate and socio-economic goals:

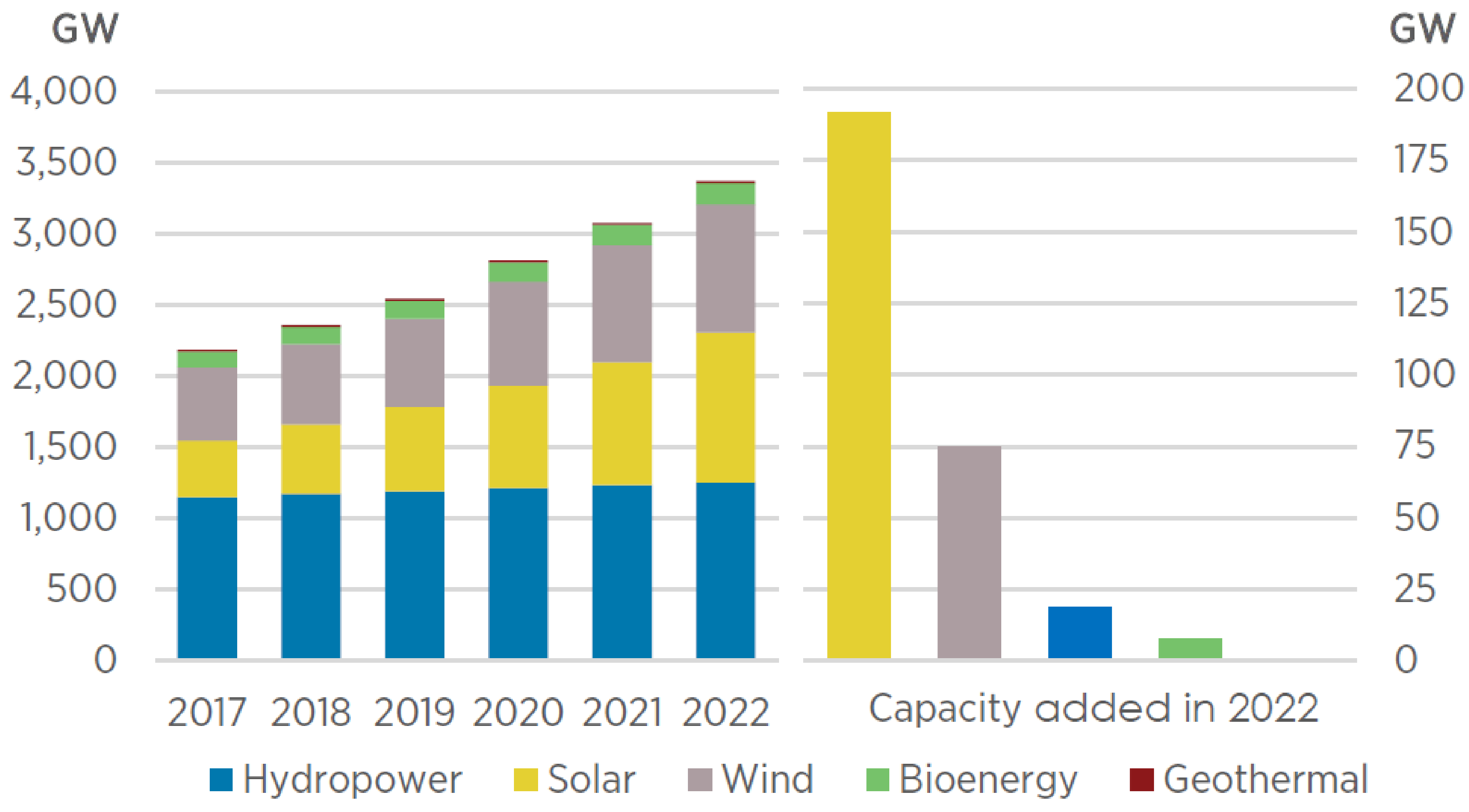
- Transitioning towards a renewables-based energy system is a cornerstone on the way to net-zero emissions and a ensuring a just transition
- Renewable energy can help enhance climate adaptation and resilience efforts
- Improved access to clean and modern energy and associated welfare benefits
- Use of SE sources will improve energy security and independence at local and national levels
- Zero operational emissions from SE (incl. pollutants) brings additional health benefits compared to fossil fuels



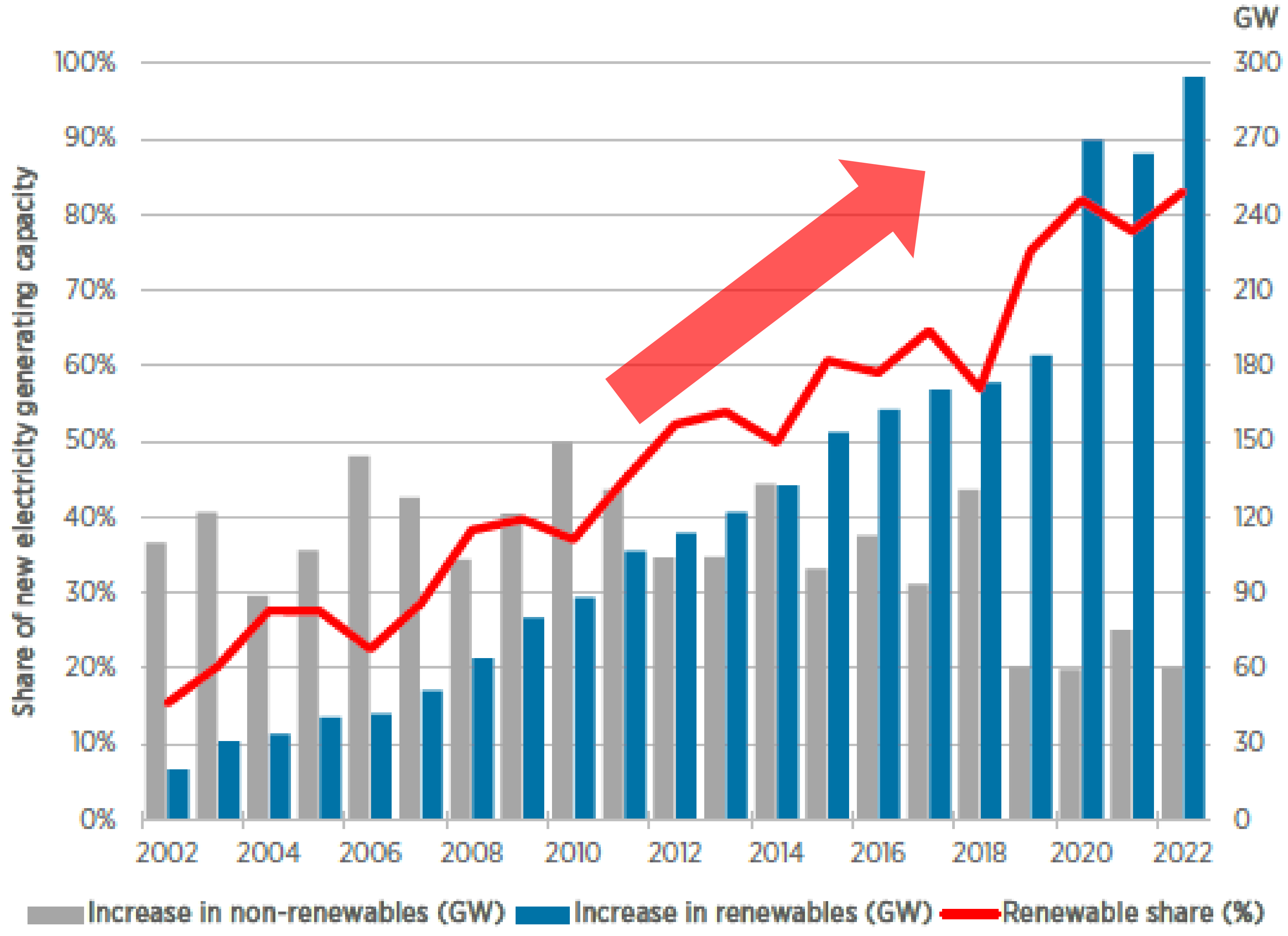
100% RENEWABLES CITIES & REGIONS ROADMAP

GLOBAL STATUS OF RENEWABLES

Graph 1: Renewable power capacity growth in 2022

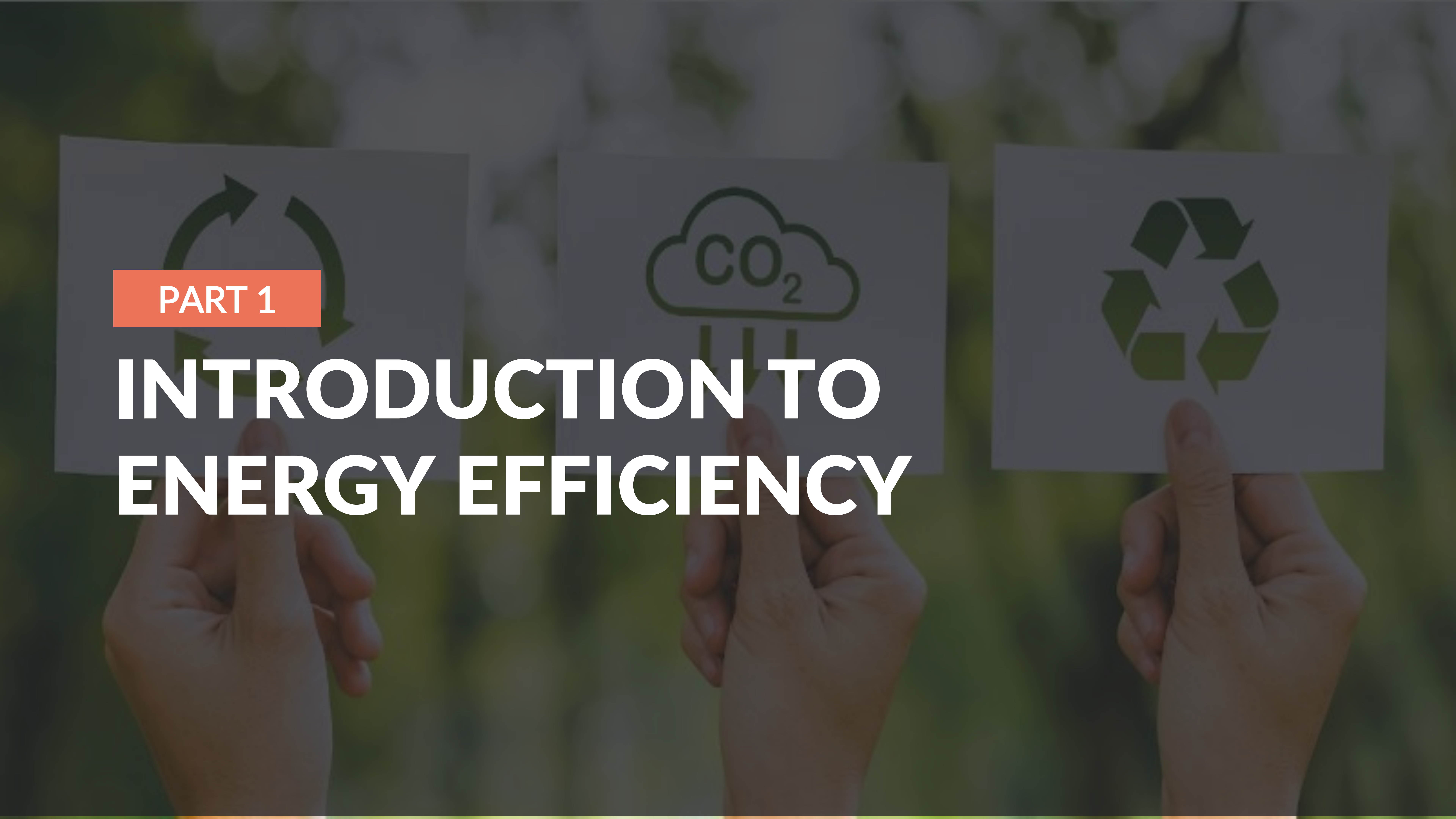


Graph 2: Renewable share of annual power capacity expansion



Solar energy dominated RE capacity expansion, surging by 192 GW (+22%) in 2022.

Source: Graph 1, 2: IRENA, Renewable Capacity Highlights 20



PART 1

INTRODUCTION TO ENERGY EFFICIENCY

PRINCIPLES OF ENERGY EFFICIENCY

Energy efficiency = Using less energy to perform the same task

Reducing demand and consumption

Demand-side measures

- Behavioral changes
- Equipment standards
- Peak load management

Reducing energy waste

Identifying and eliminating energy losses

- Leaking ducts
- Equipment repair and maintenance
- Energy management
- Insulation

Decarbonization

Integrating renewable energy technologies

- Fuel switching
- Increased electrification
- Distributed energy sources

ENERGY TERMS

Energy efficiency

Using less energy to perform the same task or achieving a greater output using the same amount of energy

Energy conservation

Using less energy by adjusting your behaviors and habits.

Energy intensity

A measure of how much energy is required to produce one unit of output or activity

Energy sufficiency

Similar principle to energy conservation, but on a more systemic level rather than individual behaviors

Energy management

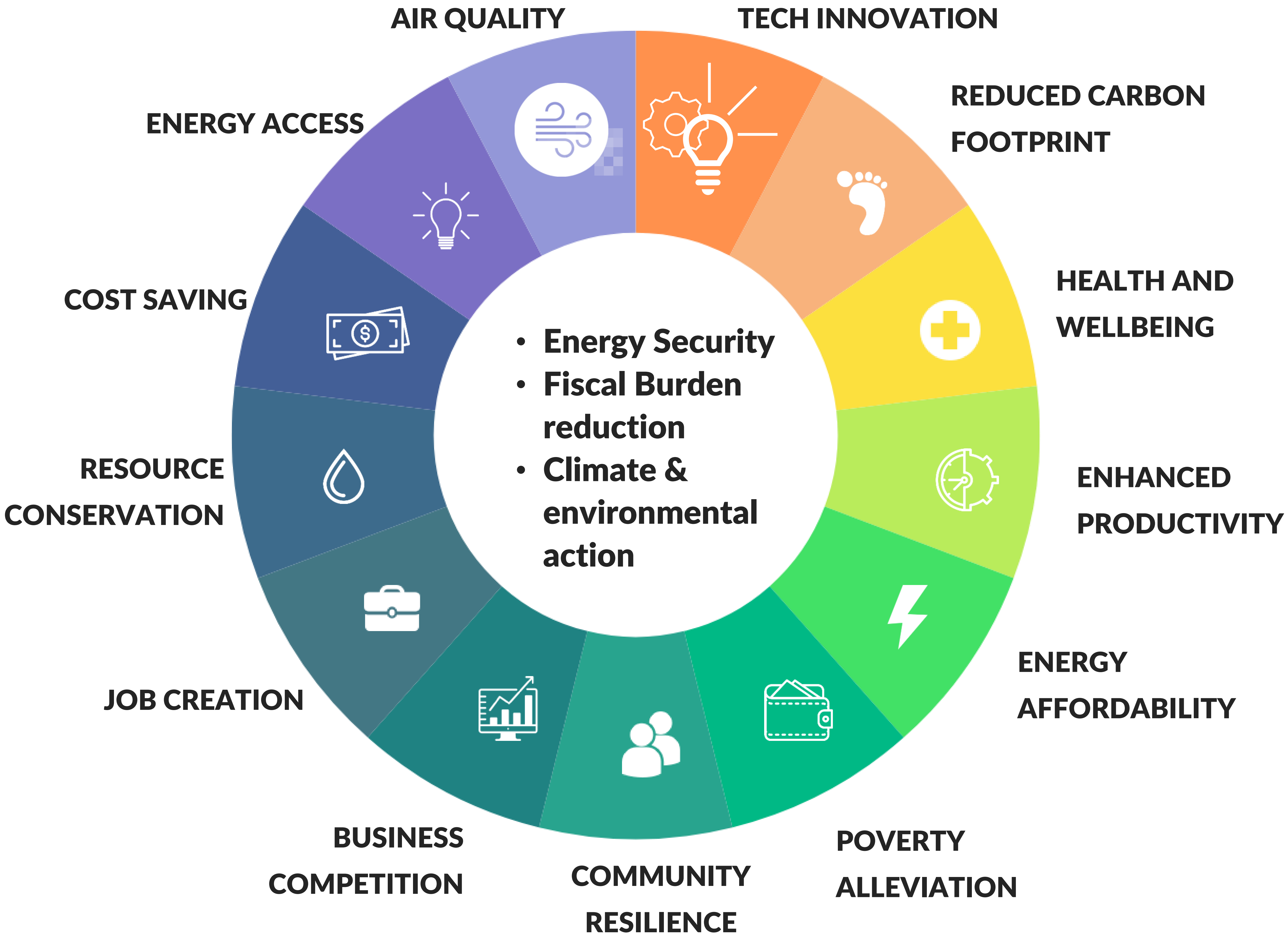
It is the efficient and effective use of energy to maximize profits (minimize costs) and enhance competitive positions.
The control of energy use and cost while maintaining indoor environmental conditions to provide comfort and fully meet functional needs (ASHRAE)

Ref: Capehart, B.L., Turner, W.C. and Kennedy, W.J. (2012) Guide to Energy Management, Energy Management. 7th Edition, The Fairmont Press, Lilburn.

WHY ENERGY EFFICIENCY IS OFTEN OVERLOOKED

- Invisible – gains may not be tangible; high upfront costs
- Lack of knowledge/insight
- Many small actions needed – complex
- Need to change habits/way of thinking – adopting a long-term view
- Lack of sufficient or aligned incentives – complacency

BENEFITS OF ENERGY EFFICIENCY



POLICIES AND REGULATORY FRAMEWORKS FOR ENERGY EFFICIENCY

Energy efficiency measures

- Waste reduction
- Demand and consumption reduction
- Renewables integration and electrification

Regulatory instruments

- Minimum energy performance standards (MEPS)
- Emissions limits
- Compliance & reporting requirements

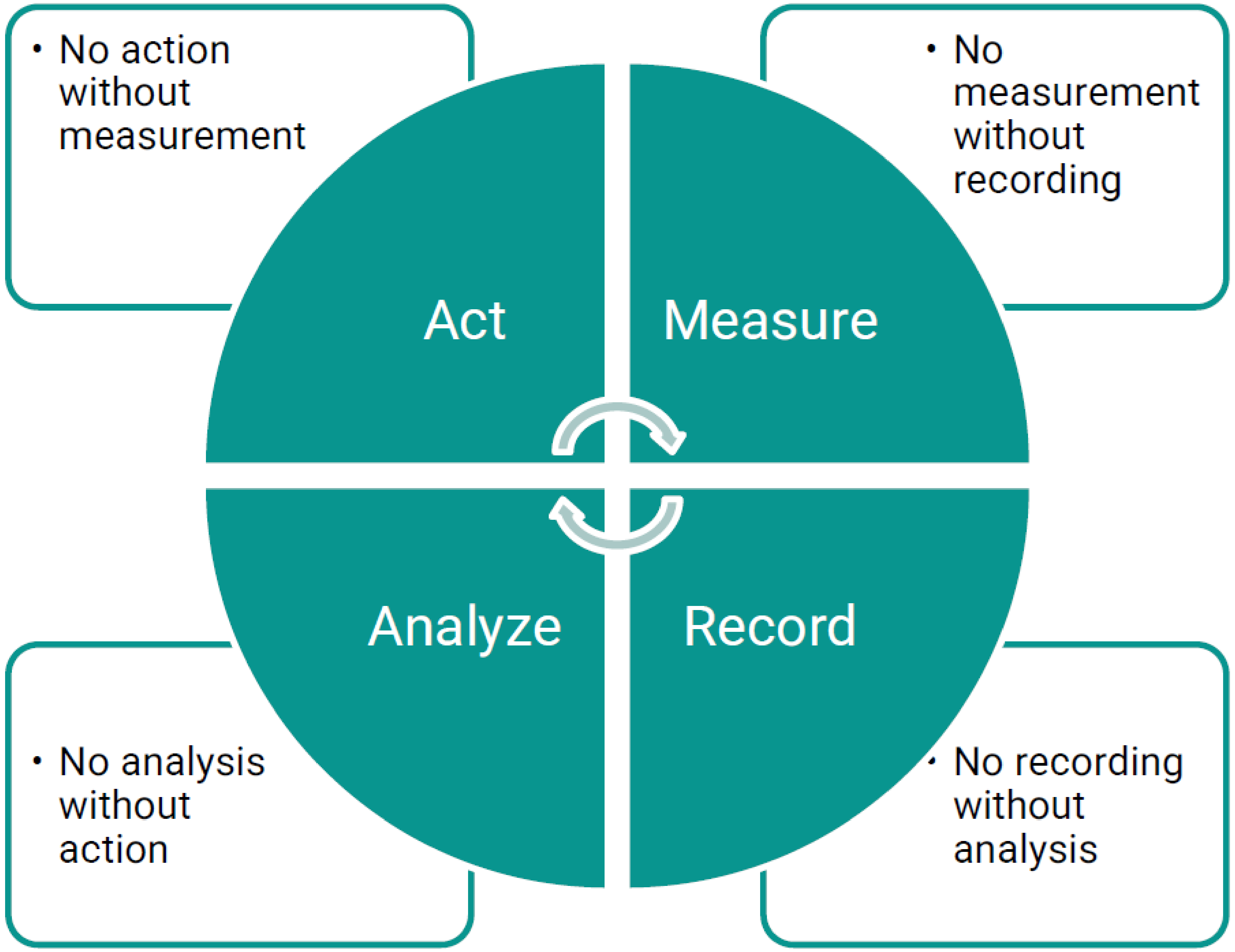
Fiscal instruments and incentives

- Energy audit subsidies
- Tax benefits and subsidies
- Grants and funding
- Case rebates

Information and behavioral instruments

- Education and awareness programs
- Benchmark and data sharing
- Research and innovation promotion

ENERGY MANAGEMENT CYCLE

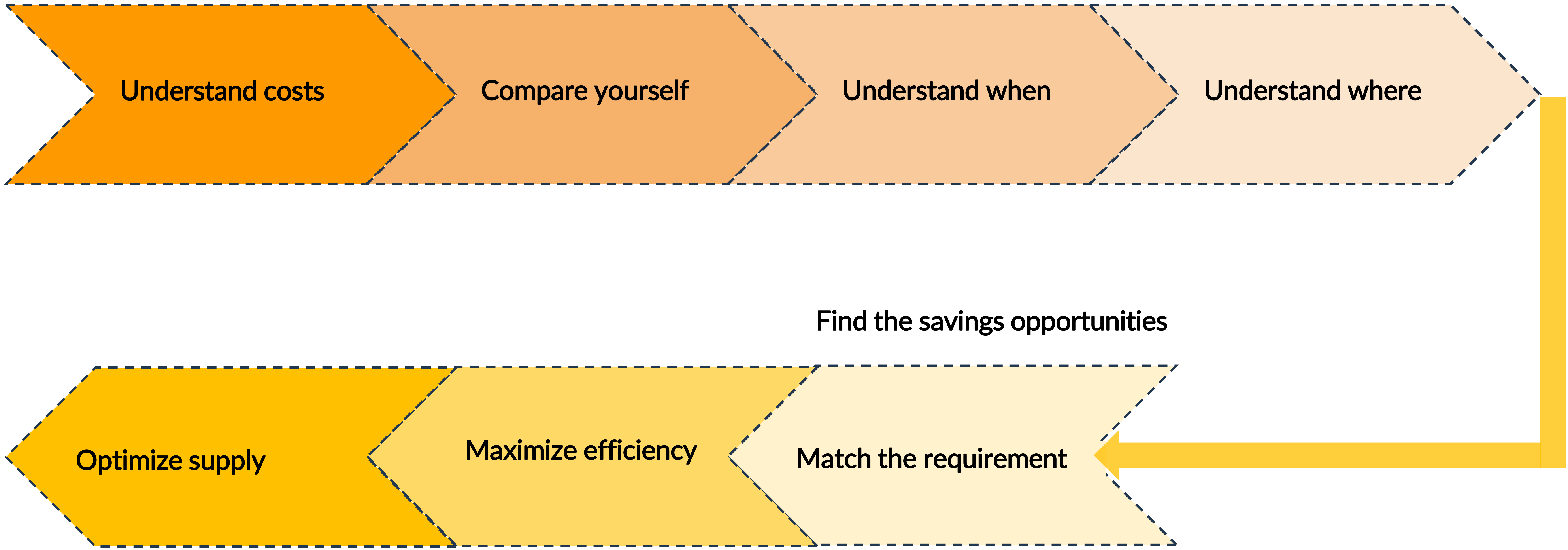


Energy monitoring tip

- Do not estimate when you can calculate
- Do not calculate when you can measure

ENERGY MANAGEMENT STEPS

Understand present usage



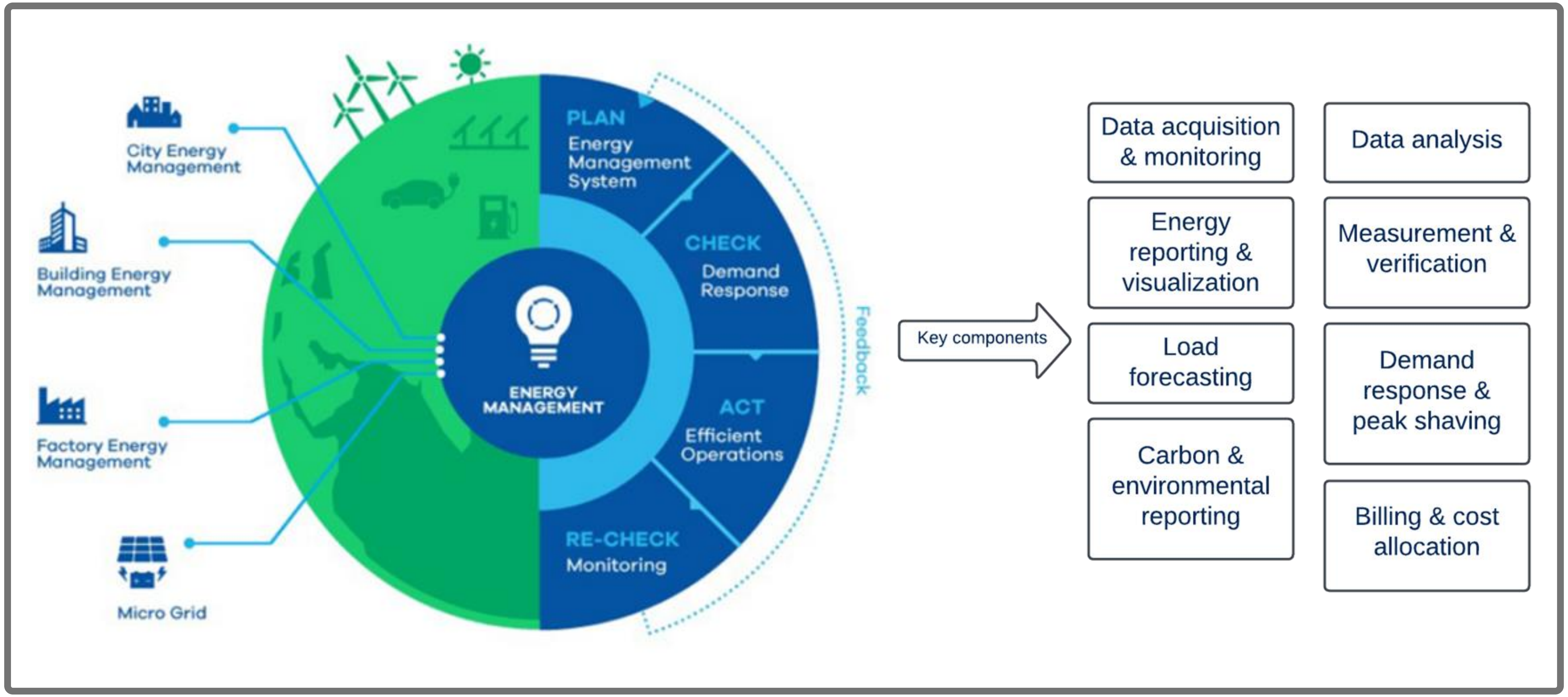
ENERGY MANAGEMENT SYSTEM (EMS)

A comprehensive software and hardware solution

It is designed to monitor, control, and optimize energy use and consumption within buildings, industrial facilities, or entire organizations.

Examples of EMS:
BEMS, IEMS, HEMS, EEMS, SGEMS, UEMS, DRMS, REMS, IEMS etc.

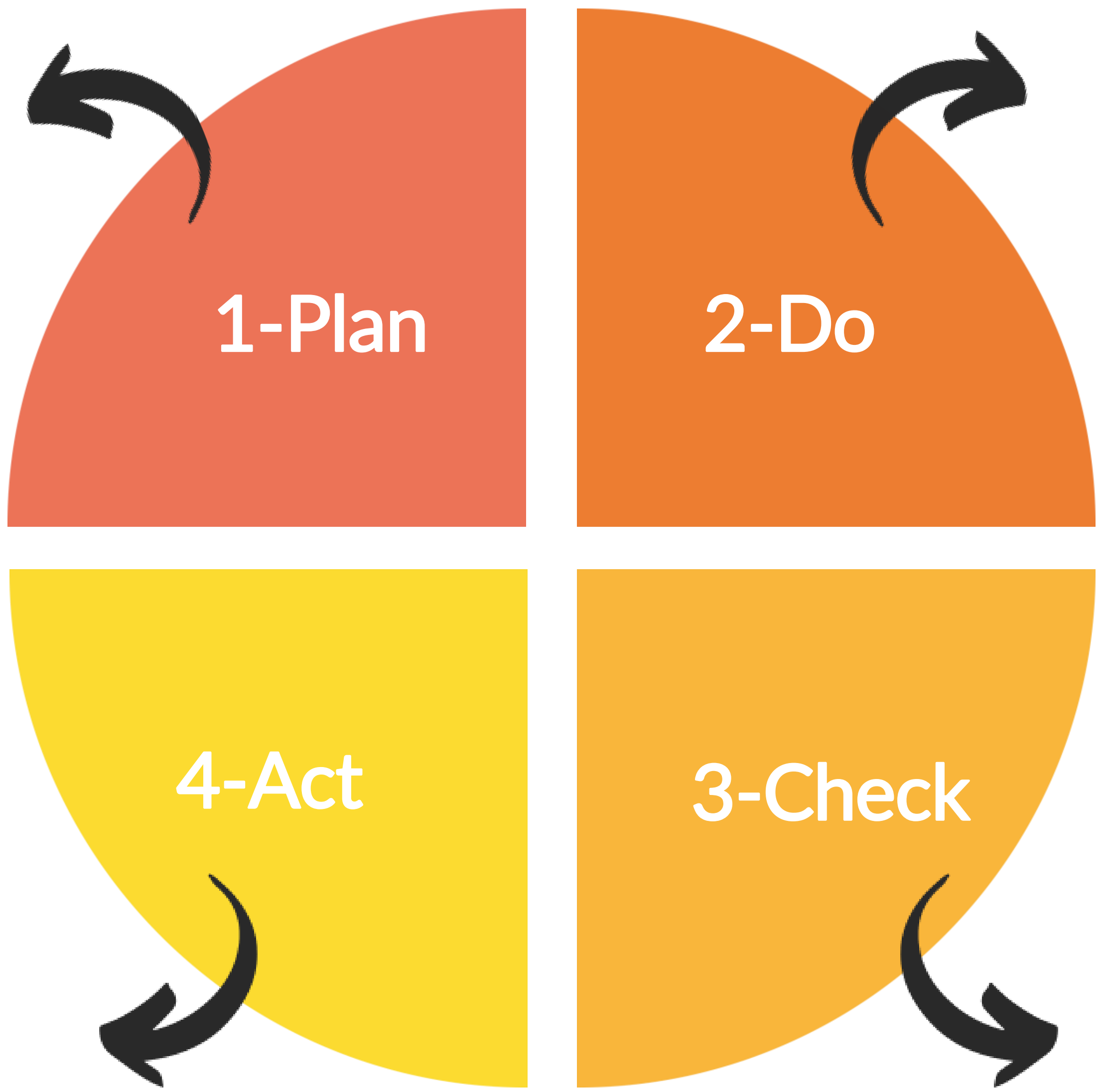
EMS Standards:
ISO 50001: Energy Management System, ISO 50003, 50004, 50006, 14001



ENERGY MANAGEMENT – CONTINUOUS IMPROVEMENT

- EnMS establishment
- Commitment of top management
- Energy manager appointment
- Energy policy defining
- Energy planning
- Legal and other requirements evaluation
- Energy review
- Energy baseline establishment
- Defining energy performance indicators
- Defining objectives, tasks, action plans

- Energy management review



- Implementation of the plans
- Involving employees
- Internal and external communication
- Managing documentation and recording
- Auditing the operation consuming energy
- Energy-efficient design and renewal of
- facilities, equipment, and processes
- Energy-efficient procurement

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

ISO 50001 Energy management requirements in PLAN-DO-CHECK-ACT (PDCA) cycle

100% RENEWABLES CITIES & REGIONS ROADMAP

Activity: 1

Match THESE activities : ENERGY CONSERVATION / ENERGY EFFICIENCY

Turn your refrigerator temperature down

Use lights minimally

Install a high efficiency refrigerator

Upgrade to LED lights

ENERGY CONSERVATION

ENERGY EFFICIENCY

Only run full loads in your dishwasher

Set thermostat hotter in the summer and cooler in the winter

Install an energy efficient dish washer

Upgrade to energy efficient HVAC, use proper insulation and upgrade windows

Source: https://www.ecowatch.com/energy-efficiency-101.html

ANSWER

ENERGY CONSERVATION

- Turn your refrigerator temperature down
- Use lights minimally
- Only run full loads in your dishwasher
- Set thermostat hotter in the summer and cooler in the winter

ENERGY EFFICIENCY

- Install a high efficiency refrigerator
- Upgrade to LED lights
- Install an energy efficient dish washer
- Upgrade to energy efficient HVAC, use proper insulation and upgrade windows

Source: https://www.ecowatch.com/energy-efficiency-101.html

Energy conservation Vs Energy Efficiency

https://www.youtube.com/watch?v=lqJ3ckBncyY

Activity 2: LIGHTING

QUESTION 1

Would you use an incandescent light bulb if it was given to you free of charge?

QUESTION 2

How does the initial cost and operational cost of a 60W incandescent bulb and a 10 W LED compare in one year?

Assumptions:

- Both bulbs have 700 lumens
- Each bulb operates for 8 hours a day.
- Energy cost of US $ 0.30 / kWh;
- Assume the house has 6 such bulbs
- LED bulb cost is 11 $ and incandescent bulb 3 $

Activity 2 – Answer

1. It is unlikely. While free stuff is always nice, incandescent bulbs consume more energy and have a shorter lifespan compared to newer, more energy-efficient options like LED bulbs. In the long run, the cost of operating incandescent bulbs could outweigh the initial savings of a free bulb of charge?

2. Upfront cost of LED is ~ 4 times than that of incandescent bulb.
However, on an annual basis, an incandescent bulb costs 1051.2 $ more than LED light!!

Details	INCANDESCENT	LED BULB
Rating , Watts (a)	60	7
Lumens	700	700
Unit cost of bulb (in US $)	3	11
Hours of operation per day, h (b)	8	8
Number of units (c)	6	6

Calculation	INCANDESCENT	LED BULB
Hours of operation per annum, h (d) (b) X 365 = 2920	2920	2920
Energy cost US $ /kWh (e)	0.3	0.3
Total energy cost US $/kWh (f) (a)×(c) ×(d) ×(e) /(1000)	1051.2	175.2

Activity 2. LIGHTING – EXAMPLES: CASE FOR ENERGY EFFICIENCY

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3. A street-light at a market in a county runs from 6 PM to 6 AM. A vendor has proposed two choices: A metal halide option of 2000 W and an alternative of LED lighting rated 500 W (both bulbs provide same lumen level).

Expected lifespan of the metal halide lamp is 2 years, with a purchase cost of US $ 100; The LED light has a life span of 10 years and costs US $ 200. Assume electricity tariff at 0.3 US $ / kWh

	Metal halide lighting bulb	**LED lighting bulb**
CAPEX (10 years)	**100 × 5 (1 initial cost & 4 replacements) = US $ 500**	**200 × 1 (1 initial cost only) = US $ 200**
Operating cost	**2000 W × 4380 h = 8760 kWh**	**500 W × 4380 h = 2190 kWh**
Annual electricity tariff (@ US $ 0.3 / kWh	**8760 × 0.3 = US $ 2628**	**2190 × 0.3 = US $ 657**
OPEX (Energy cost) 10 years	**US $ 26280**	**US $ 6570**
Total (CAPEX + OPEX)	**US $ 26780**	**US $ 6770**
Net CO_2 Savings		**Each kWh ~ 0.207 kgCO_2e (8760 – 2190) × 0.207 = 1360**

ENERGY AUDITING

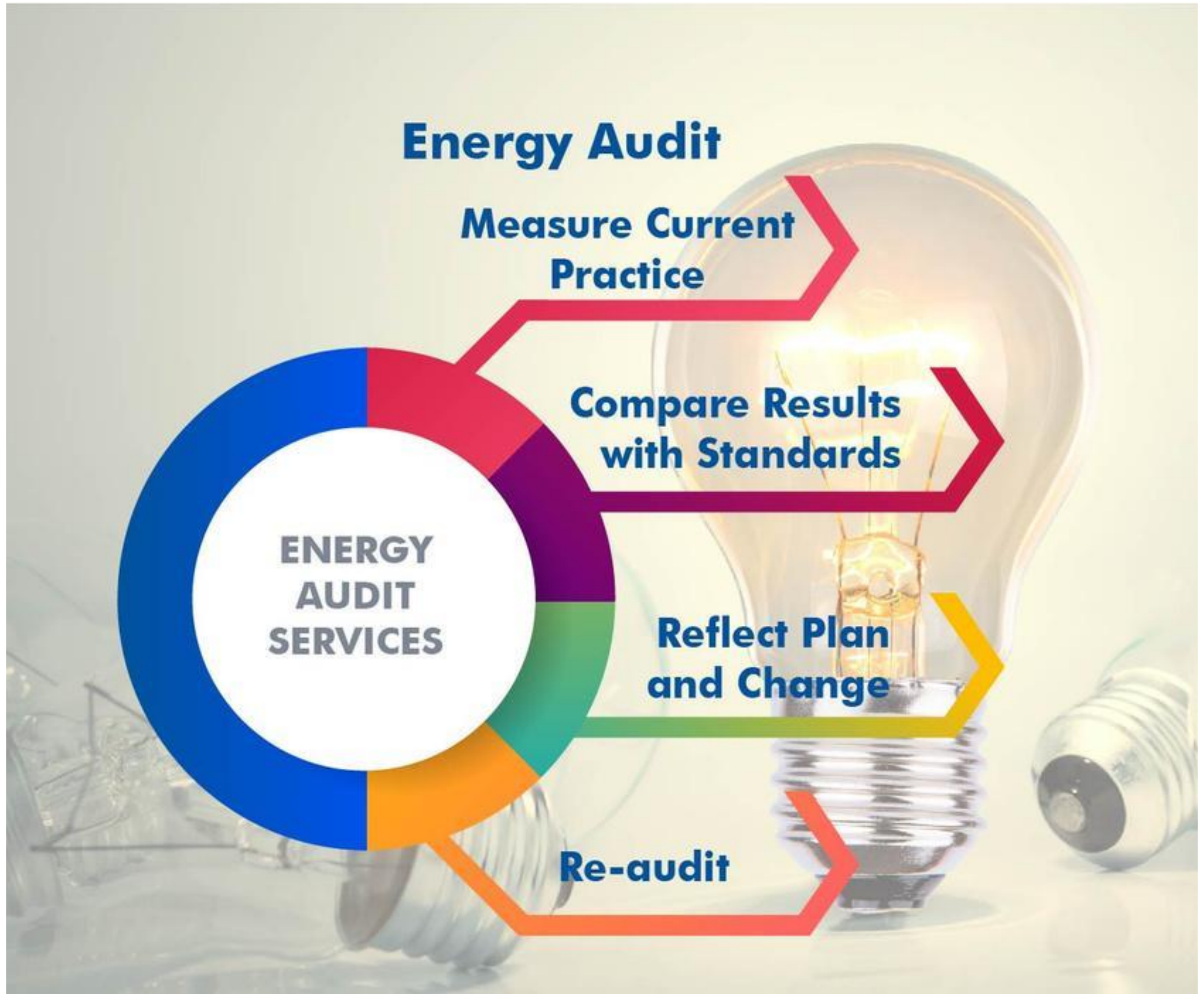
QUESTION

What do you understand by Energy audit?

Have you conducted any audits for your province/location/county facilities?

Energy Audits

- Inspection, survey and analysis of energy flows for energy conservation in abuilding, process or system to reduce the amount of energy input to the system without negatively affecting the outputs.
- Key to developing successful energy management
- Critical tool in energy efficiency



Credit: GeWis

OVERVIEW OF ENERGY AUDIT

Energy regulations in country prevails the importance of conducting energy consumption rating of facilities

Choosing the right type

- Expands on the preliminary audit
- Entails collecting more detailed information about the facility operation
- Performs a more detailed evaluation of energy conservation measures
- Considers 12-to-36 months' energy bills

Overview of energy audit

- The energy audit process
- Data to be collected during field measurements
- Tools and instruments needed for data collection
- Safety considerations when conducting energy audits

Types of energy audit

- Walk-through/preliminary audit; benchmark analysis
- Energy modelling
- Level I Audit (Walk-through audit)
- Level II Energy Audit (Energy survey and analysis) (GENERAL)
- Level III Energy Audit (Detailed analysis of capital-intensive measures) (INVESTMENT GRADE)
- Level IV EA (Comprehensive Audit)
- Continuous commissioning and monitoring-based commissioning

TYPES OF ENERGY AUDITS

Walkthrough energy audit

- Quick and simple, easy to obtain data
- Only low-cost saving measures are identified
- Identified areas that require more detailed analysis
- Preliminary technical assessments before engaging experts as a cost saving measure and to enhance the understanding of province/region on their installations

General energy audit

- Expands on the preliminary audit
- Entails collecting more detailed information about the facility operation
- Performs a more detailed evaluation of energy conservation measures
- Considers 12-to-36 months' energy bills

Investment grade energy audit

- Low cost and high-cost measures
- Comprehensive and accurate cost savings estimate
- Detailed analysis of process flows
- Detailed technical and financial analysis
- Detailed inventory of all energy consuming equipment

LINKING ENERGY EFFICIENCY TO EMISSIONS

Every unit saved through energy management points to reduced emission

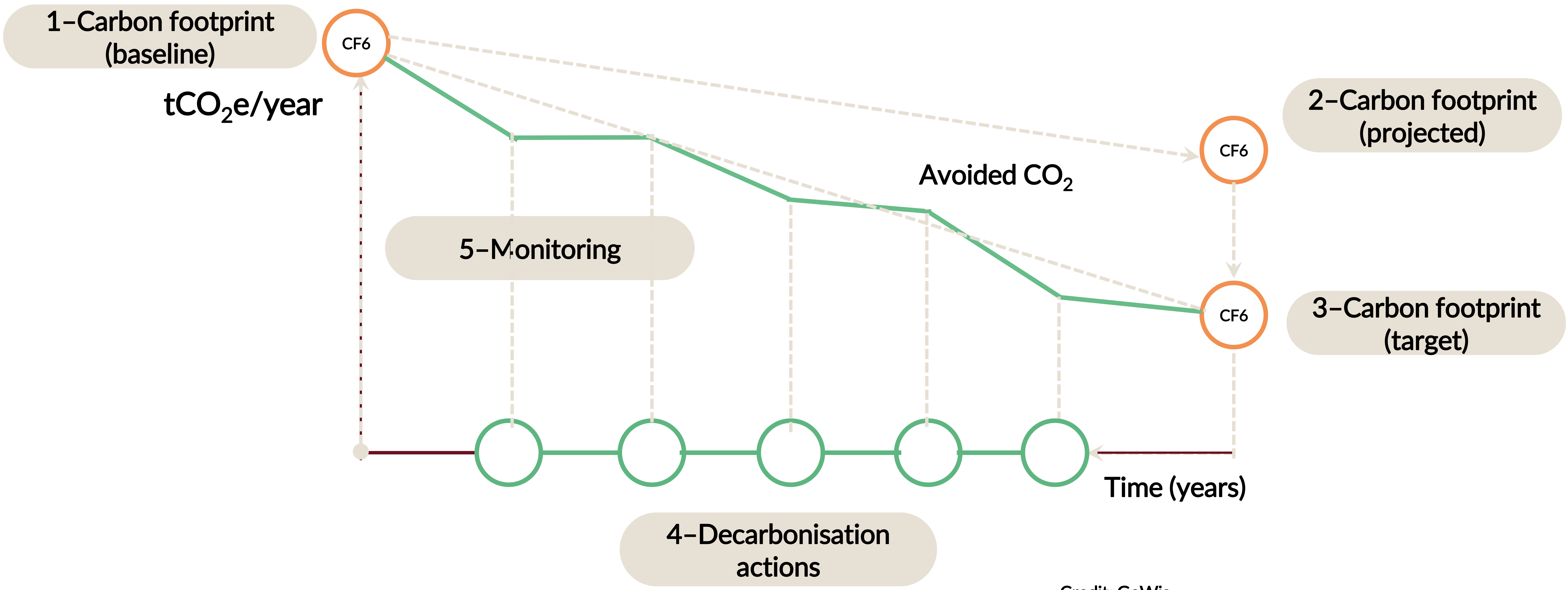
Scope 1:Direct GHG emissions of a company. These emissions arise from sources that are owned or controlled by the company.

Scope 2: indirect GHG emissions of the product. These are emissions from the generation of purchased electricity consumed by the company. E.g. Utility power

Scope 3: emissions resulting from the activities of the company but occur at sources owned or controlled by another company: eg Purchased goods and services business travel, Employee commuting, Waste disposal, Use of sold products, Transportation and Distribution (up- and downstream) Investments Leased assets and franchises

DECARBONISATION PLAN

Every unit saved through energy management points to reduced emission



Credit: GeWis

STAGES INVOLVED IN CONDUCTING AN ENERGY AUDIT

Steps involved in an energy audit

Walkthrough survey
- Understanding of existing energy sourcing, storage and distribution facility.
- Assessing the energy demand and consumption areas/processes.

Secondary data collection
- Analyze historic production and energy data
- Field measurements for estimating current energy use eg power
- Understanding of site operations

Detailed measurements
- Conducting field measurements to quantify energy streams
- Power measurement of pumps/motors and other electrical equipment
- Determine key opportunities

Detailed energy audit report
- Documentation of collected and analyzed measurement details
- Projects and procedures to maximize energy savings and minimize / eliminate losses

Details collected in each stage

Walkthrough survey
- What are the existing energy sources?
- What are the current energy demand and consumption areas/processes?

Secondary data collection
- Historic energy data – past energy bills, fuel consumption, production etc.

Detailed measurements
- Conducting field measurements to quantify energy streams – install meters and data loggers, equipment inventory, operating hours
- Measure power of pumps/motors and other electrical equipment
- Determine key opportunities

ENERGY UTILITY BILL (ELECTRICITY BILL)

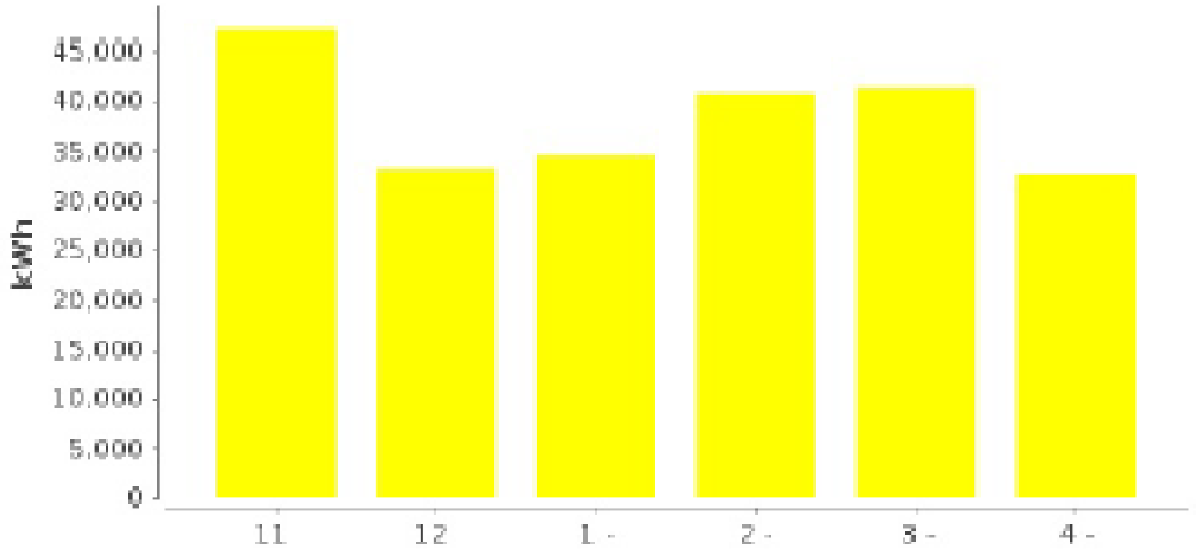
Road P.O. Box 30099-00100 Nairobi. Tel: 3201000 Fax: 3514485 VAT Reg. No.: 0010608 PIN: 000591096X

CONSUMPTION DATA

Meter Number	Previous Reading	Current Reading	Reading Type	Cons.	Cons. Type
040016111201	0	93	Real	93	Demand KVA
040016111201	0	87	Real	87	Demand KW
040016111201	2297552	2314847	Real	17295	High Rate
040016111201	1971913	1987337	Real	15424	Low Rate

Consumption Period: 02/04/2023-01/05/2023
Method of Charge: C1-3 Commercial-Industrial Method CI1 -

CONSUMPTION TREND



MESSAGES

BILLING DETAILS

Billing Concepts		Amount (Ksh)
Bill-202305BC0007816218		
Energy		
HighRateConsumption	17295kWh x 14.7	254,236.50
LowRateConsumption	15424kWh x 14.7	226,732.80
MaximumDemandKVA	93kVA x 1100	102,300.00
Fuel Energy Cost	32719kWh x 3.9	127,604.10
Total Energy		710,873.40
Levies and Adjustments		
Forex Exchange Adj. (FERFA)	32719kWh x 0.9646	31,560.75
Inflation Adj. (INFA)	32719kWh x 0.85	27,811.15
ERC Levy	32719kWh x 0.03	981.57
REP Levy	480969.3 x 5	24,048.47
WRA Levy	32719kWh x 0.006747	220.76
Total Levies and Adjustments		84,622.70
Rounding Adjustment		0.16
V.A.T.	710873.4 x 0.16	113,739.74
Total Monthly Bill		909,236.00
BALANCE BROUGHT FORWARD		1,060,096.00
APPLIED CREDIT		-0.00
Payment by Wire Transfer		-1,060,096.00
TOTAL AMOUNT PAYABLE		909,236.00

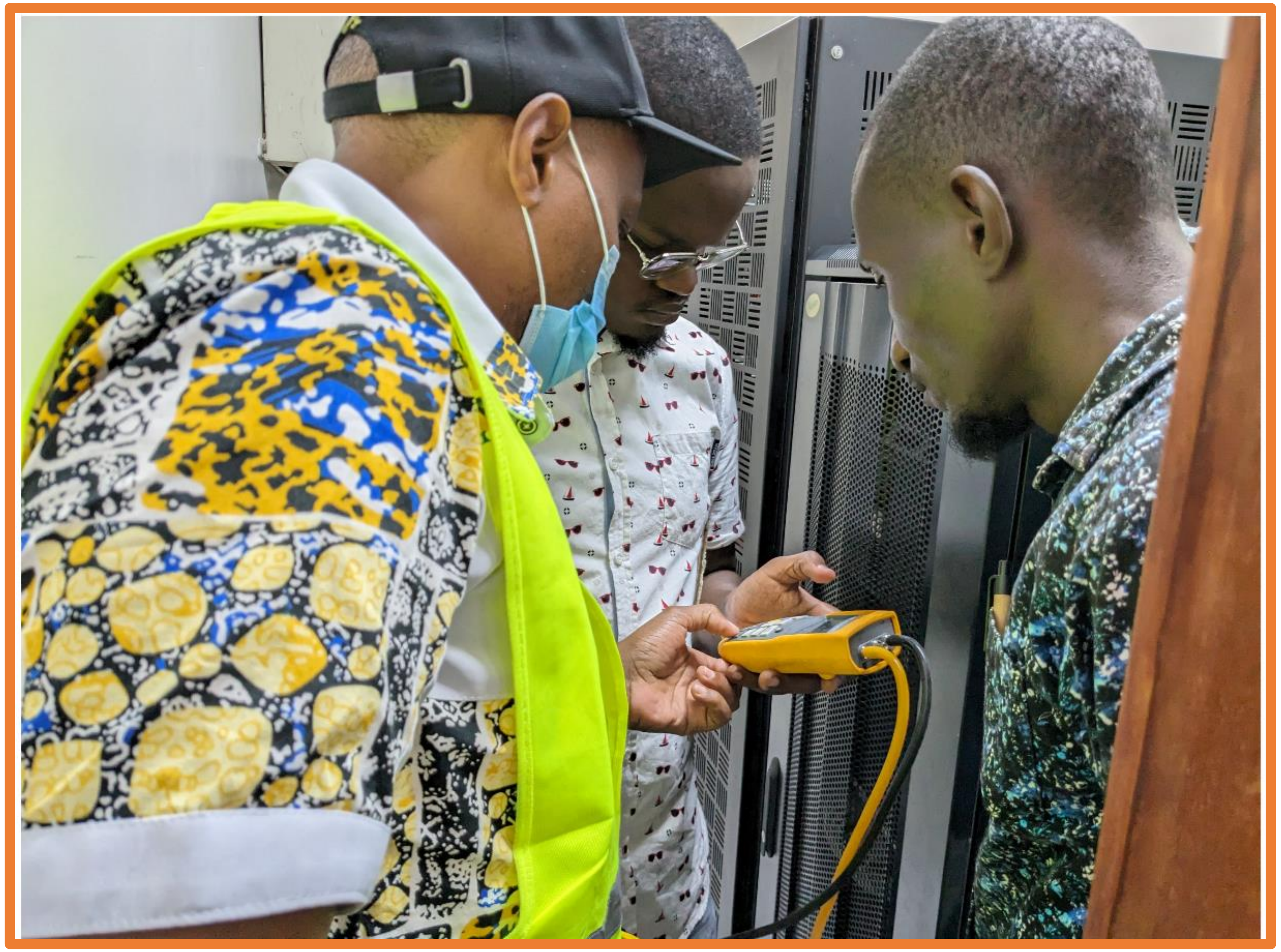
VARIOUS INSTRUMENTS FOR ENERGY AUDIT

- Tape measures
- Lux meter, clamp meter
- Ultrasonic flow meter, Ultrasonic leak detector
- Infrared Thermometer, Temperature data logger
- Power and Energy Logger
- Flue gas oxygen omega data logger, Combustion Analyzer
- Digital camera and infrared thermal imaging camera
- Laptop

HAZARDS WHILE CONDUCTING ENERGY AUDITS

- Working in narrow and confined spaces like the main electrical distribution and "mains"
- UV radiation
- Extreme temperatures
- Falling from at heights
- Risk of injury in the eyes from dust / flying particles
- Falling from slippery floors
- Chemicals and hot molten metals
- Risk of electrical shock which could range from mild to fatal
- Risk of burns from electricity and furnaces / hot places
- Fire

SAFETY EQUIPMENT DURING ENERGY AUDIT



- Safety shoes
- Helmets
- Earplugs
- Rubber insulating
- Gloves
- Overall / Dustcoat
- Reflector Jackets

CASE STUDY 1: HOSPITAL

HOSPITAL

S No	Equipment/System	Existing status	Recommended for	Annual energy savings		Investment	Payback	ROI (%)	Savings (%)	Annual kgCO2e Reduction
			Energy savings	Energy (kWh)	Money (KSH)	(KES)	Period (Years)			
ENERGY CONSERVATION MEASURES (ECMs)										
1	Energy optimization unit	High incoming voltage raising as high as 439 V and averaging at 420 V	Install a voltage optimization unit manage the voltage at 380-390 V to optimize electrical energy consumption	30324	678948	1500000	2.21	17.73	7.83	10007
2	Lights retrofits	Flourescent, Halogen and Mercury vapour which are high consumers are majorly used	Replace remaining system with LED lighting technology	72165	1615774	328000	0.20	89.73	18.64	23814
3	Real-time monitoring	There is no real-time energy monitoring at the facility. There is also apparent offsets in consumption efficiency.	Install a totally integrated monitoring and automation system for energy monitoring and control with various meters installed at the major consuming units. Also benchmark production and consumption efficiencies.	16488	369175	500000	1.35	29.87	4.26	5441

CASE STUDY 1: HOSPITAL

HOSPITAL

S No	Equipment/System	Existing status	Recommended for	Annual energy savings		Investment	Payback	ROI (%)	Savings (%)	Annual kgCO2e Reduction
			Energy savings	Energy (kWh)	Money (KSH)	(KES)	Period (Years)			
4	Power factor correction	The facility's power factor averages at 0.85, making the facility to be charged more on demand kVA and incur surcharge for power factor correction	Rectify the capacity bank to ensure rectification yields unity or close to unity power factor to lower demand costs	-	750136	200000	0.27	79.67	8.67	-
ALTERNATIVE ENERGY SOURCES (AES)										
5	Solar Photovoltaic	With the facility having good radiations with average peak sun hours standing at 5.71 kWh/ square metre.	Install a tie in solar PV system to tap solar energy. There is potential of tapping on solar renewable energy to supplement the grid.	62829	1406755	5350000	3.80	5.62	16.23	20734
TOTAL				181806	4820788	7878000	1.63	25.05	55.62	59996
TOTAL (Excluding Solar Photovoltaic)				118977	3414033	2528000	0.74	46.49	39.39	39262

CASE STUDY 2: WATER SERVICE PROVIDERS

WATER SERVICE PROVIDERS

In the baseline period of June 2019 to May 2020 the company consumed approximately 11,274,844 kWh of electricity equivalent to 40,589 GJ, to pump 14,006,364 m3 of Water

- Existing EE measures
- Installed Soft Starts
- Skylights at the Briquetting Plant
- Recovery of Volatile Gases for Carbonizing at the Briquetting Plant
- Installed Management System for Pumps
- LED Lighting
- Natural Lighting
- Sub Metering of Water
- Installed Soft Starts on Motors
- Installed Pump Management System
- Manufacturing of Briquettes from Sludge

CASE STUDY 2: WATER SERVICE PROVIDERS

WATER SERVICES

S No	Recommended measures	Estimated of annual energy savings in kWh	Estimated annual savings in KSH	Estimated investment cost (KSH)	Payback period (years)	ROI (%)
1	Replace low efficiency pumps	2080120	40312120	120000000	2.9	33.6
2	Voltage management and repair of level sensor		11200000	3500000	0.3	320
3	Installation of power factor correciton banks		237827	200000	0.8	118.9
4	Reduciton of water leakages		1734400	542000	0.3	319
5	Tariff migration for some pump stations		12117099	4200000	0.3	288.5
6	Reduction of pump vibrations	109760	2173248	370000	0.2	587.4
7	Replacement of standard efficiency motors with HEMs	1046477	20280724	23772724	1.3	85
8	Replacement of electromagnetic lighting with LEDs	51015	1651071	1598700	0.9	103.3
9	Installation of solar PV for pumping	1555200	30139776	94500000	3.1	32
10	Adoption of energy management system	171200	13572162	5460000	0.4	234.8
TOTAL		5013772	92078651	254143424	1.1	212.3

CASE STUDY 2: WATER SERVICE PROVIDERS

WATER SERVICE PROVIDERS

- Attractive return on investment
- Every unit (currency) spent, return of 10 X
- Behavioral aspects play a critical contribution to energy management
- Major reduction in CO_2 emissions

Supported by:
Federal Ministry for Economic Affairs and Climate Action
INTERNATIONAL CLIMATE INITIATIVE
on the basis of a decision by the German Bundestag

END OF CHAPTER 1 OF 2

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