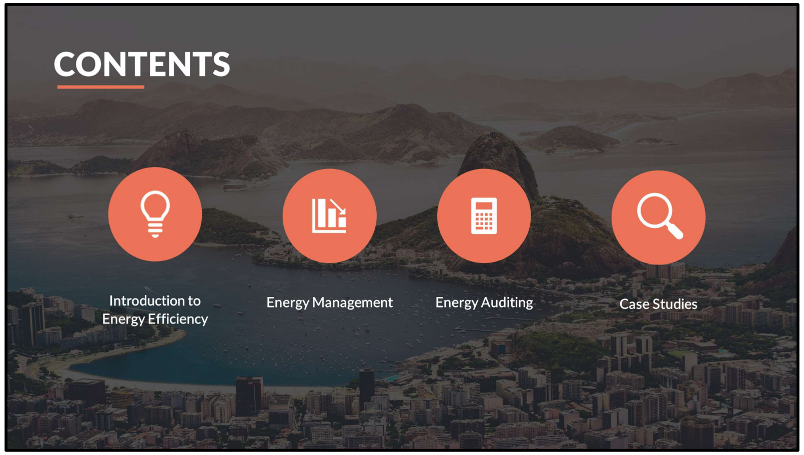
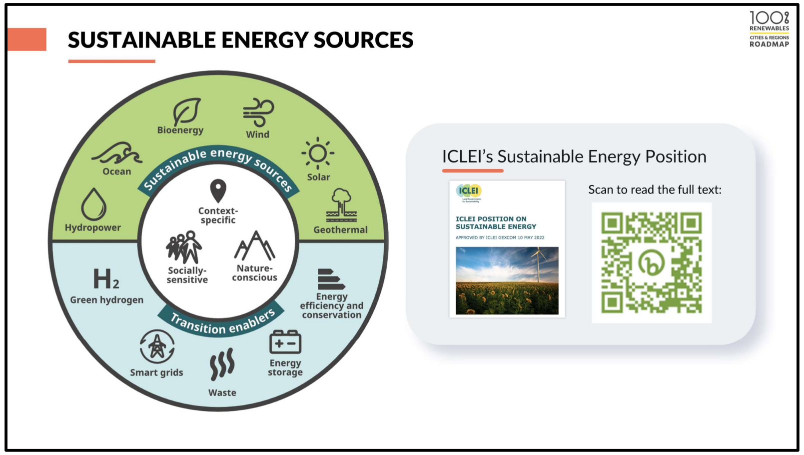

ICLEI
Local Governments for Sustainability
100% RENEWABLES
CITIES & REGIONS ROADMAP
Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag
IKI INTERNATIONAL CLIMATE INITIATIVE
Capacity Building Module:
Energy Efficiency in Cities




Introduction to 100 % Renewables Cities & Regions, ICLEI's Sustainable energy position
Why renewables, Global status of renewables in power capacity growth & power capacity expansion

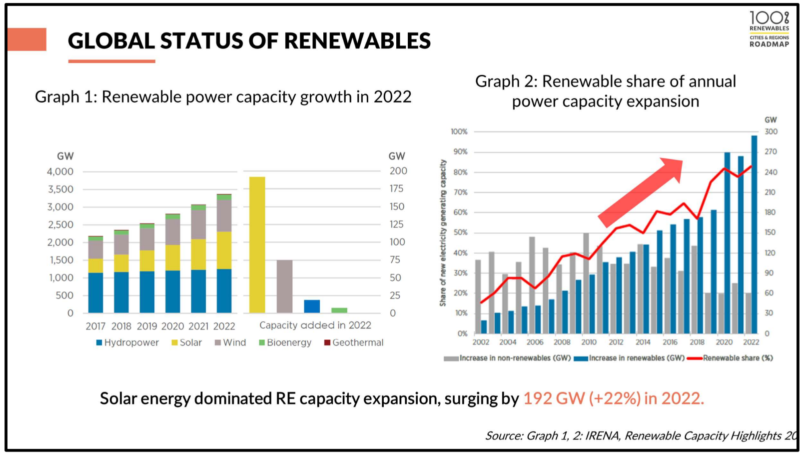
Introduction to the solar energy:
Energy from the sun, Solar energy received on earth, sun path geometry, radiation distribution on earth surface, peak sun hours, global horizontal irradiation

Introductoin to solar photovoltaic (PV) systems: Solar PV cell operation, key milestonesin history of PV technologiy, Solar PV cell current voltage characteristics, solar cell parameters, solar cell – module – PV panel – PV array, available technologies, linear vs non-linear PV module, area required by technology, technical specifications of PV module, standard test conditions and normal operating cell temperature, working of PV module with varied radiation and temperature.



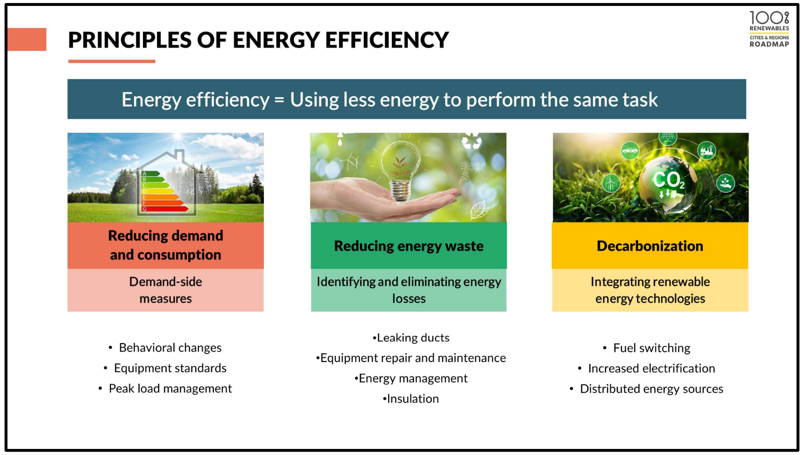

Energy sources can be harnessed without depletion, ensuring a continuous supply of energy meeting our energy needs with minimum (no) environmental impact – Sustainable energy sources.

Energy from sun – solar energy
Kinetic energy from wind – wind energy
Potential energy from water – hydro energy
Steam present at the underground – geothermal energy
Decomposition of bio-materials – bioenergy
Continuous movement from tides – ocean energy




At the end of 2022, global renewable generation capacity amounted to 3372 GW. Solar and wind energy accounted for most of the remainder, with total capacities of 1053 GW and 899 GW respectively.

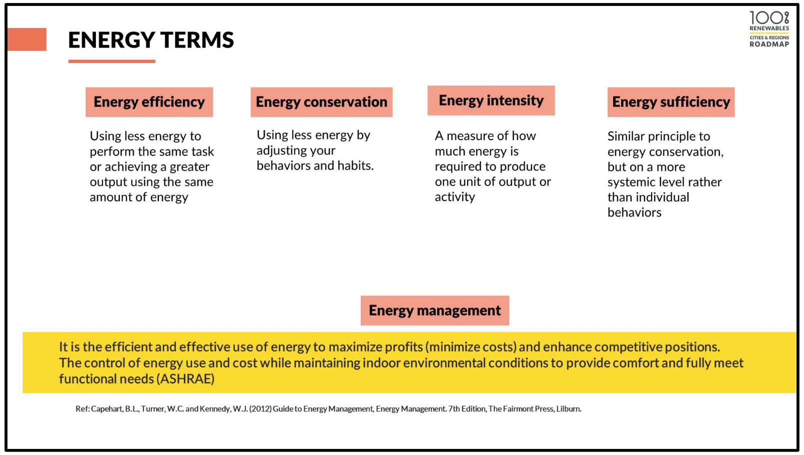
Renewable generation capacity increased by 295 GW (+9.6%) in 2022. Solar energy continued to lead capacity expansion, with a massive increase of 192 GW (+22%), followed by wind energy with 75 GW (+9%). Renewable hydropower capacity increased by 21 GW (+2%) and bioenergy by 8 GW (+5%). Geothermal energy increased by a very modest 181 MW.




Energy efficiency in its simplest definition is using less energy to carry out the same task. The main goals are reducing energy demand and waste, as well as reduction of emissions from energy use.

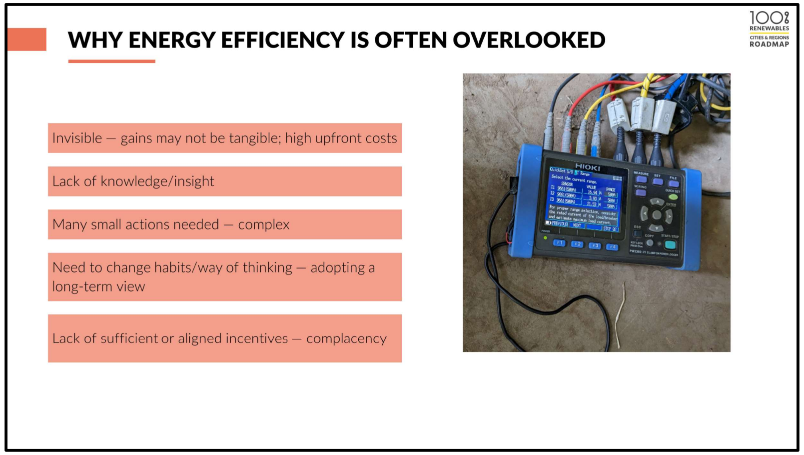
Achieving efficiency can occur through an array of strategies such as Reducing energy wastage, energy audits, energy-efficient tech, proper maintenance, behavioral changes, smart building design, EMS, Energy-efficient transport, Energy conservation policies, education and training, incentives and rebates, lifecycle analysis – Some of which are discussed in detail later.

Reducing demand and waster mainly occurs through demand side management strategies such as behavior changes like switching off lights during the day, using less heating energy etc. While reducing waste occurs mainly at the supply side, stretching through to the demand side. On the demand side, we are talking about strategies like fixing leaking ducts, equipment repair and maintenance to mention. The third goal of decarbonization entirely focuses on reducing emissions from energy production and consumption. This can be through approaches such as fuel switching, and use of renewable energy technologies such as solar PV.




The importance of energy management lies in its ability to enhance competitive positions, minimize costs and maintain indoor comfort and functionality.

Looking at the definitions, it's clear that energy efficiency involves using less energy to achieve the same results, often through technology that requires less energy to perform comparable functions. Energy conservation, on the other hand, focuses on reducing energy consumption by changing behavior and habits. Energy intensity, calculated by dividing total primary energy supply by GDP, indicates how much energy is required to produce a unit of economic output. Renewable energy comes from naturally replenished sources that never run out. Energy management, according to ASHRAE, involves controlling energy use and costs while ensuring that indoor environmental conditions are comfortable and functional.




Energy efficiency is sometimes overlooked for several reasons:

1. Upfront Costs: Initial expenses to implement energy-efficient technology or practices can be higher. This discourages immediate adoption, despite long-term cost savings.

2. Lack of Awareness: Many people aren't fully informed about the benefits of energy efficiency or don't understand how to implement it effectively.

3. Complexity: Understanding and implementing energy-efficient technologies or practices can be daunting due to their technical nature or perceived complexities.

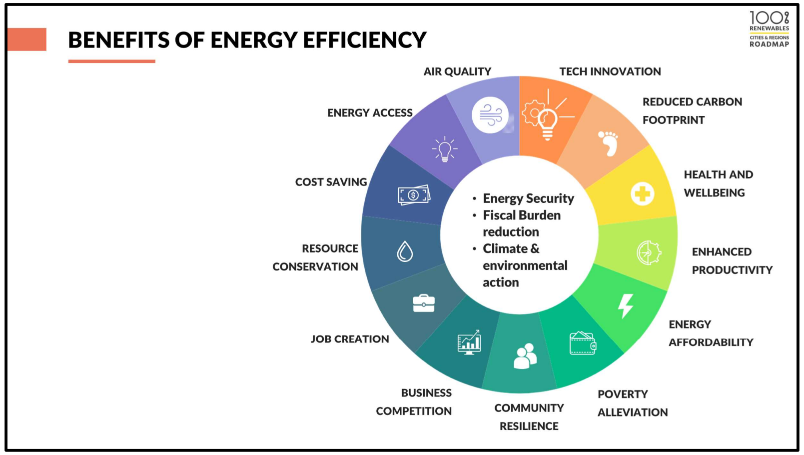
4. Short-term Focus: Businesses or individuals may prioritize short-term gains over long-term benefits, leading them to overlook energy efficiency measures that pay off in the long run.

5. Behavioral Habits: People might resist changing their habits, even if it leads to energy savings. For instance, leaving appliances on standby or using inefficient lighting out of habit.

6. Regulations and Standards: In some cases, lax regulations or standards might not mandate energy efficiency, leading to complacency in adopting better practices.

7. Split Incentives: In rental properties or shared spaces, the person responsible for energy bills might not be the one investing in energy-efficient upgrades, causing a lack of motivation to improve efficiency.

To combat these issues, education about the long-term benefits, financial incentives, clearer regulations, and promoting simple steps for energy efficiency are crucial. Governments, businesses, and individuals play vital roles in promoting and adopting energy-efficient practices to mitigate these challenges.

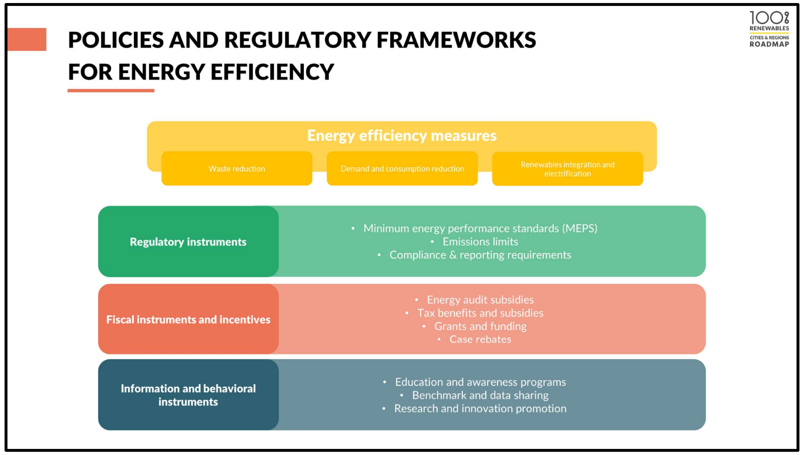



Energy efficiency has several benefits beyond its primary goals of reducing consumption, decarbonization and waste. First, it exemplifies the adage that the cheapest energy is the energy not consumed, resulting in significant cost savings. In addition, as energy consumption decreases, so do the associated carbon emissions, contributing to environmental health and climate change mitigation efforts. Another benefit is avoided capital investment, as reduced energy demand reduces the urgency to build new energy infrastructure. In addition, energy efficiency supports the creation of green jobs thereby promoting economic growth and sustainability. Technological innovation spurred by energy efficiency not only increases the profitability and competitiveness of companies, but also opens up new business models and resource efficiency. Ultimately, improving energy efficiency is imperative in the context of global energy consumption and emissions intensity, in line with climate change, environmental protection, energy security and fiscal responsibility objectives.

Cost Saving: The cheapest energy is energy not consumed.
Reduces Carbon Emissions: As the energy consumption reduces, the associated emissions also reduce.
Avoided capital investment: With EE there is reduced demand, hence the urgency to put up new energy infrastructure is reduced.
Green jobs: Energy managers, biogas technicians ,solar installers, energy audit firms, consultancies

Despite the three main goals of energy efficiency being reducing consumption, decarbonization, and waste reduction, energy efficiency can also be driven by several other interconnected rationalities that are associated to the multiple co-benefits accrued from energy efficiency. Most of these rationalities as indicated here fall within the sphere of climate action and positive environmentalism, promoting energy security, and fiscal burden reduction.

For instance, low emissions associated with process and equipment efficiency is highly crucial for environmental health and climate mitigation. Process efficiency is contributing towards cost savings, which in a way enhances profitability and competitiveness, especially in businesses. It is well understood that energy efficiency goes together with technological innovations. These technological innovations are crucial in unlocking new business models, create jobs and promote resource efficiency. For now, let us try to place energy efficiency in the context of global energy consumption and emissions intensity – and see why it is necessary for us to advance energy efficiency.

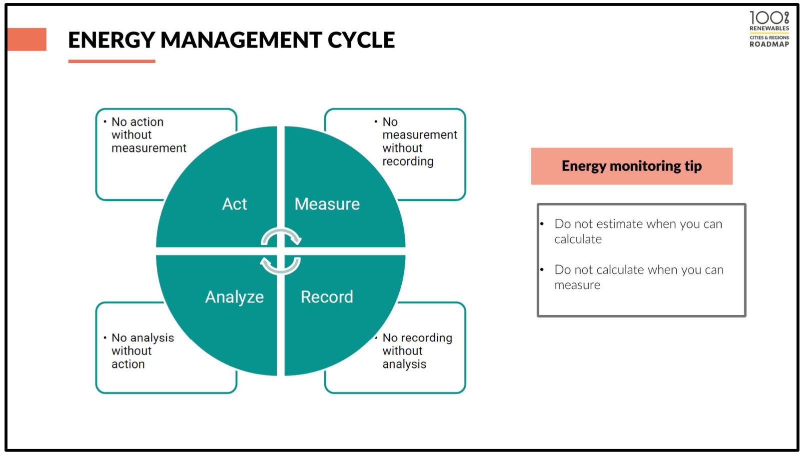



Comprehensive policy packages and frameworks are very crucial for achieving energy efficiency. To do so, the policy packages must be targeted towards waste reduction, demand and consumption reduction, and renewables integration. There are three key policy instruments that fall into the categories of regulatory, fiscal, and information instruments.

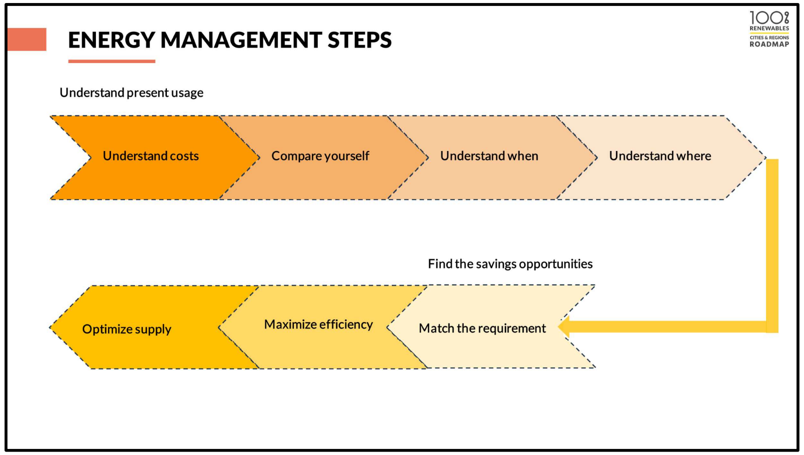
Regulatory instruments basically apply compliance strategies to eliminate the worst performing equipment and practices from the market and set the rules for performance standards. An example includes compliance and reporting requirements and carbon tax and emissions limits.

Fiscal instruments attempt to promote energy efficiency through availing incentives, tax waivers, cash rebates and grants and funding, among others. They are aimed at enhancing the attractiveness of the most efficient practices and equipment.

Information instruments help consumers to make the most informed choices and decisions that leads them towards energy efficient choice-making. Some of the strategies include education and awareness programs, and benchmark and data sharing.




This picture sets the foundation by introducing the Energy Management Cycle framework, The Energy Management Cycle, consisting of Act, Measure, Analyse and Record, outlines the essential actions required to achieve effective energy management. This system ensures systematic and efficient management of energy resources while optimizing performance and sustainability through informed decision making.



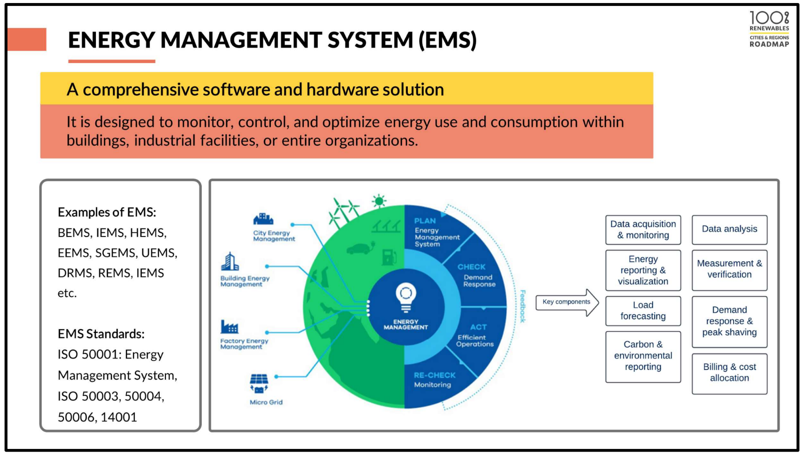

Expanding on the concepts introduced in the previous slide by providing specific principles and actions related to energy management.

Each point elaborates on a key aspect of energy management

In energy management:

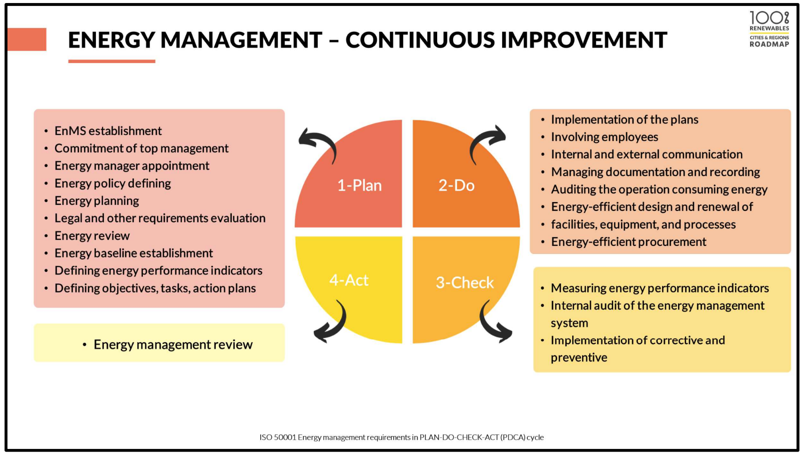
- Understanding Costs: Analyze energy expenses to identify savings opportunities.
- Comparing Performance: Benchmark against peers for insights and goal-setting.
- Timing Energy Use: Recognize peak periods to optimize scheduling and reduce costs.
- Locating Consumption: Identify areas of high energy use for targeted efficiency improvements.
- Matching Demand: Ensure energy supply aligns with actual requirements for efficiency.
- Minimizing Waste: Address inefficiencies to reduce unnecessary consumption.
- Optimizing Supply: Select cost-effective and sustainable energy sources.

These principles guide efficient resource allocation, cost reduction, and sustainability enhancement.

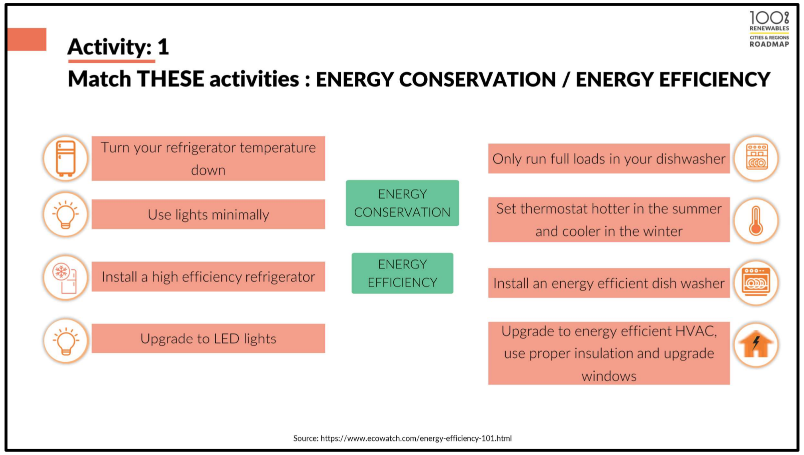



An energy management system essentially works complementarity with the energy audit systems. It combines software and hardware solutions that are designed for continuous monitoring, control and optimization of energy use and consumption in different end-use points such as buildings and industrial processes. It essentially involves a continues or one time process of energy data collection, analysis and use for decision support. A few of the energy management systems are listed here – such as the building energy management system (BEMS), Industrial EMS (IEMS) among others.

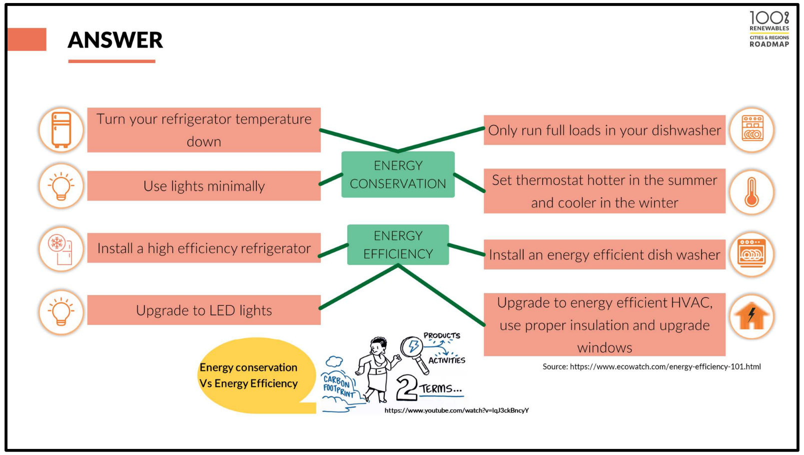
Little to mention, the energy management systems also conform to certain standards as a guide – which can be country specific or sector specific, or even generic. A typical example of this standard is the ISO 50001 which is an international energy management system standard that gives organisations of any size a tool to systematically optimise energy performance and promote more efficient energy management.



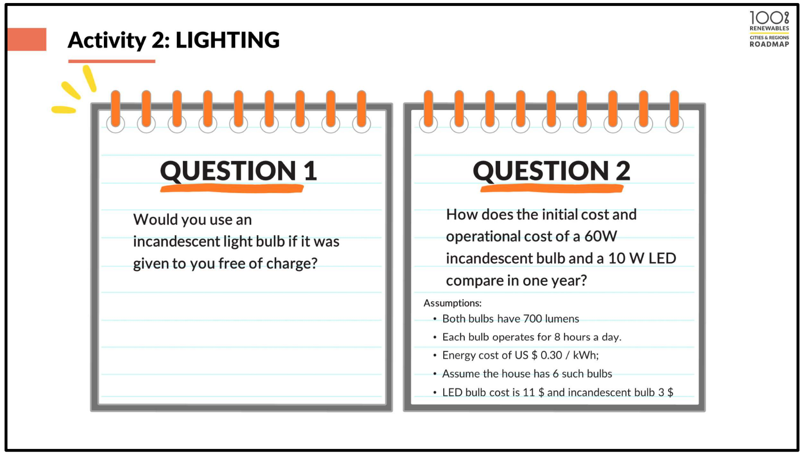

ISO 50001 requirements are intended for adoption by organizations across industries, although compliance is not obligatory. Implementing ISO 50001 offers numerous benefits, including improved energy management, cost reduction, and regulatory compliance. Integrating ISO 50001 Energy Management requirements into the PDCA cycle provides a structured framework for organizations to effectively manage energy, drive continuous improvement, mitigate risks, and demonstrate commitment to sustainable practices.




Let's align these activities: Energy conservation and energy efficiency.




Understanding energy conservation and energy efficiency - conservation efforts to reduce overall energy demand, while efficiency measures optimize energy use for maximum output resulting in greater overall savings,. Combined, these approaches contribute to reduced energy consumption (in bills), environmental benefits, improved resource utilization over time. An example will help us understand.




This example illustrates the importance of energy efficiency and its long-term benefits.

## 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 |

By switching to energy-efficient appliances, individuals can have the annual energy savings and resulting cost reductions. This change in behavior has the potential to have a significant impact on the whole energy system. To initiate this change, households, buildings, cities and regions should prioritize energy efficiency measures as a crucial step forward.

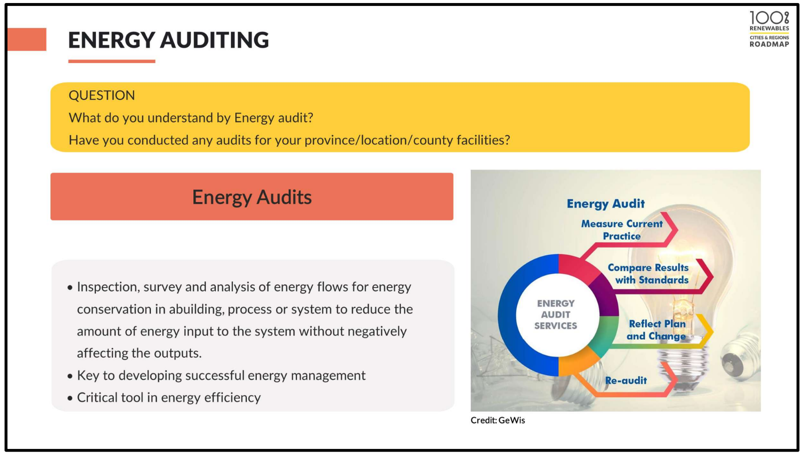
## **Activity 2.** LIGHTING – EXAMPLES: CASE FOR ENERGY EFFICIENCY

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

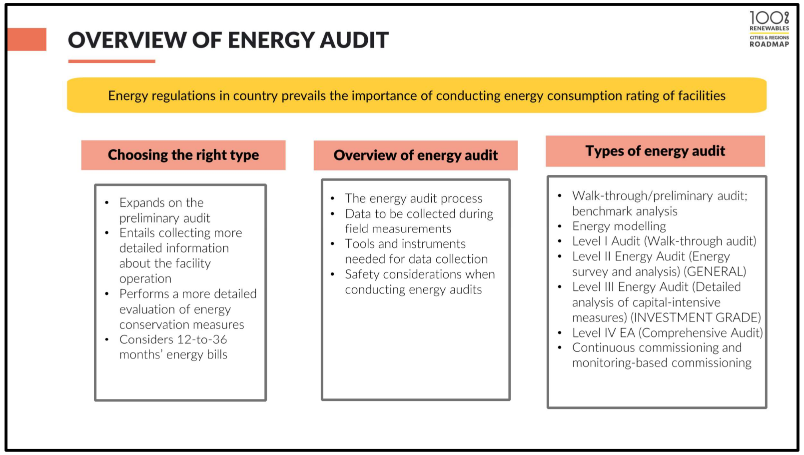
| | Metal halide lighting bulb | LED lighting bulb |
|---|---|---|
| CAPEX (10 years) | 100 × 5 (1 initial cost & 4 replacements) = US $ 500 | 200 × 1 (1 initial cost only) = US $ 200 |
| Operating cost | 2000 W × 4380 h = 8760 kWh | 500 W × 4380 h = 2190 kWh |
| Annual electricity tariff (@ US $ 0.3 / 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 $kgCO_2e$<br>(8760 – 2190) × 0.207 = 1360 |

Certainly, the net savings vary in terms of operational and annual costs across different cases. As well as reducing overlll operating costs and net CO2 emissions, energy efficiency offers many other advantages.




Energy auditing is a core part of actioning energy efficiency – because it allows us to understand the benchmark, we are working from to set energy efficiency targets, at allows for an understanding of the energy systems and energy flows through various functions, spotting points of energy waste and opportunities for energy saving and recovery. It can be thought of as a one-time (but preferably continuous) process that essentially establishes the basis for energy management systems [which are tackled in the next slide], and it can be conducted across different scales and allows for checks and balances in energy management in imports and exports, generation and demand side management.

Listed here are some of the types of energy audits – this entirely depend on the level of complexity of the process, which is in turn dependent on the level of details needed from the energy audit. For instance, a walk-through energy audit is rather more simplistic and only getting surface level data on energy use and efficiency, while level 3 and 4 audits are rather more complex and apply an array of software, and/or hardware to undertake the energy audits.




Objectives

To ascertain the different types and costs of energy use

- Understand how energy is being used/wasted
- Identify & analyze more cost-effective ways of using energy equipment, processes, technologies, operations
- Economic analysis of possible alternatives
- Prioritization of energy projects

Importance:

Energy is among the top expenses in any facility. Conducting Energy audits

Helps to understand the energy consumption

Helps to identify areas of possible savings

Leads to better energy use intensity which boosts competitiveness.

Objectives of energy audits:

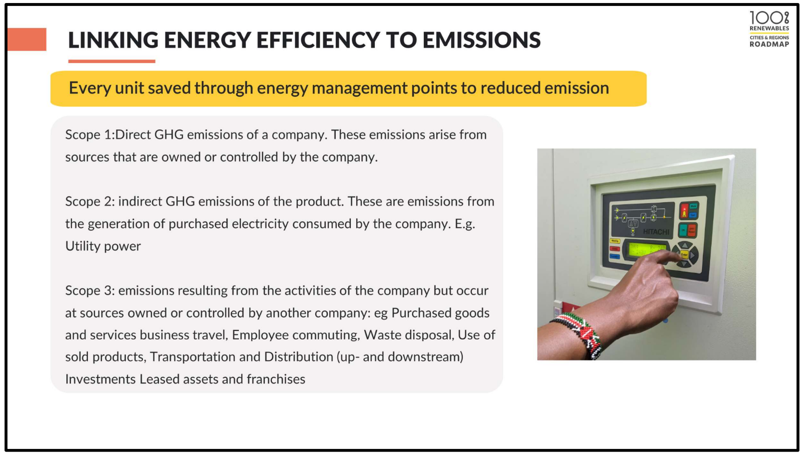
To ascertain the different types and costs of energy use

Understand how energy is being used/wasted

Identify & analyze more cost-effective ways of using energy equipment, processes, technologies, operations

Economic analysis of possible alternatives

Prioritization of energy projects

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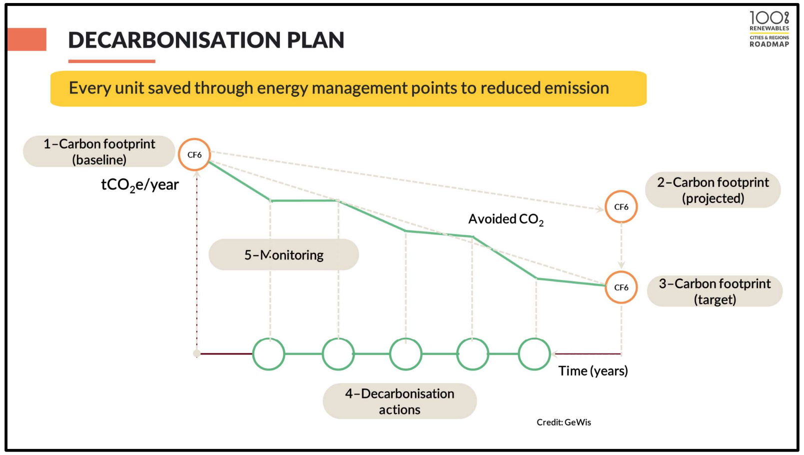



- The overarching decarbonization framework and emission reduction targets.
- The desired outcomes of these initiatives, including reduction of carbon footprint and achievement of emission reduction targets.

This structure allows current emissions to be assessed and facilitates comparisons with predetermined benchmarks to track progress towards emission reduction targets. The decarbonization strategy outlines the path towards a decreasing carbon footprint over time, starting with the initial measurement of the baseline carbon footprint (CF6) in tCO2e/year. The projected reduction in carbon footprint is achievable through the implementation of CO2 reduction measures. Given the different levels of carbon footprint projections and target thresholds, a consistent monitoring system for the decarbonization plan over time is essential.

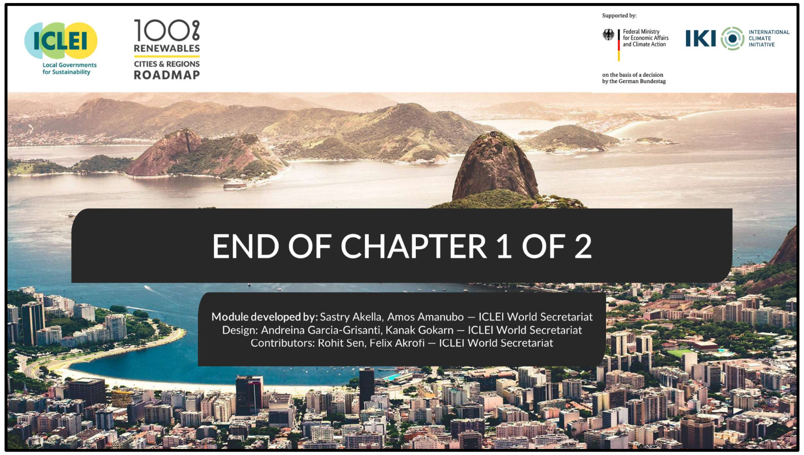
## CASE STUDY 2: WATER SERVICE PROVIDERS

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

At County Level_ Water Service Providers
Regions/provinces/counties are often in charge of water services
Energy and water are closely interlinked
Non-revenue water has a high impact on EE and water cost
How does the energy use intensity of the WSP compare?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END OF CHAPTER 1 OF 2
Module developed by: Sastry Akella, Amos Amanubo — ICLEI World Secretariat
Design: Andreina Garcia-Grisanti, Kanak Gokarn — ICLEI World Secretariat
Contributors: Rohit Sen, Felix Akrofi — ICLEI World Secretariat