ICLEI Local Governments for Sustainability

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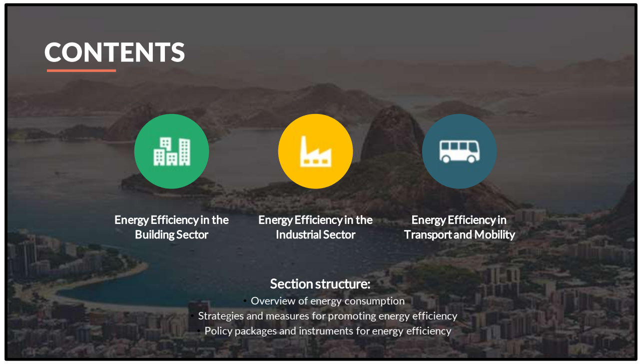
on the basis of a decision by the German Bundestag

Capacity Building Module: Energy Efficiency in Cities

CHAPTER 2:

Energy efficiency across sectors

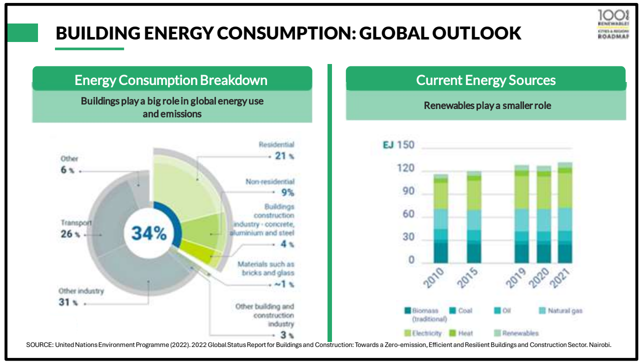


Introduction to 100 % Renewables Cities & Regions, ICLEI‘s Sustainable energy position
Why renewables, Global status of renewables in power capacity growth & power capacity expansion

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

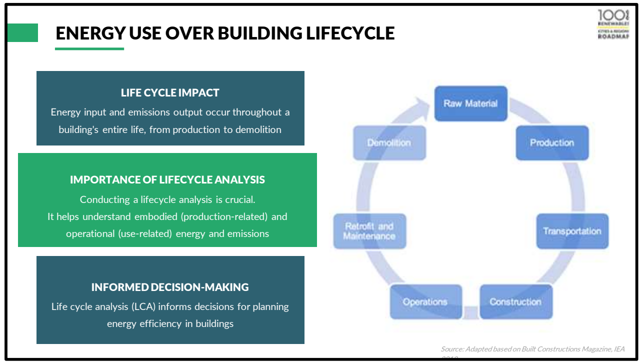
Introductoin to solar photovoltaic (PV) systems: Solar PV cell operation, key milestonesin history of PV technologiy, Solar PV cell current voltage characteristics, solar cell parameters, solar cell – module – PV panel – PV array, available technologies, linear vs non-linear PV module, area required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


PART 1
ENERGY EFFICIENCY:
BUILDINGS SECTOR



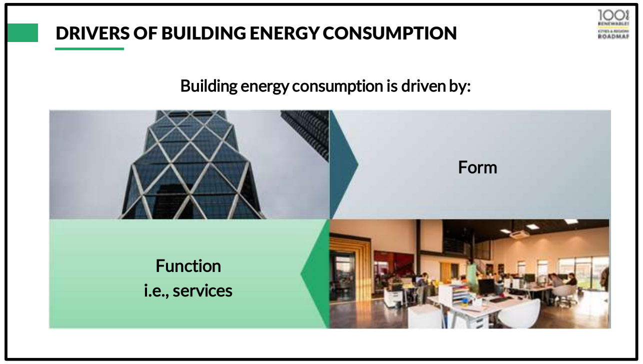
Building energy use plays a large role in the global energy system and emissions footprint of the energy sector. The building sector, both commercial and residential consume up to 34% of the global energy produced. This energy consumption is spread across the entire life cycle of buildings from construction, to use and deconstruction. On the right chat, we can see the distribution of energy consumption in the building sector, with residential buildings taking the leading edge and non-residential buildings following – the main use of energy being electrification and heating.

Unfortunately, the energy use in the building sector is far from sustainable, looking at the sources of energy on the chat to the left. Over the past decade to date, natural gas, oil, and coal have been the most dominant sources of energy, with renewables playing a small part in supplying building energy needs. Let us see what the implications of this proportions are in the next slide.

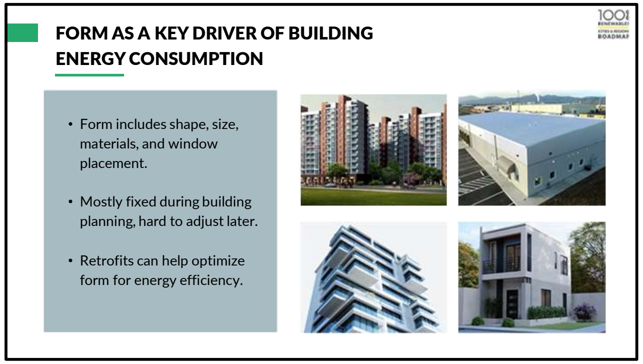


As mentioned earlier, energy input and emissions output is spread through the entire lifecycle of a building be it residential or commercial – from production of the raw materials, transportation, to construction, use and maintenance, and eventually demolition.

Undertaking a lifecycle analysis is crucial to understand the embodied and operational energy and emissions – which sort of helps us to make informed decisions for planning energy efficiency in the building sector. Some of the common lifecycle analysis methods and standards are discussed in the upcoming slide.



There are mainly two key drivers of building energy consumption – i.e., form, and functions and services. Let us take a quick look at form:
Form causes energy use through shape, size, materials, window placement – it is mostly fixed (determined at the planning of the building construction) and hard to adjust at later stages, though retrofits can help in adjusting form for building energy efficiency optimization. Form enablers energy efficiency: including thermal mass, passive solar and natural ventilation.
Here we see different forms of buildings which have different energy needs, consumption and efficiency rates



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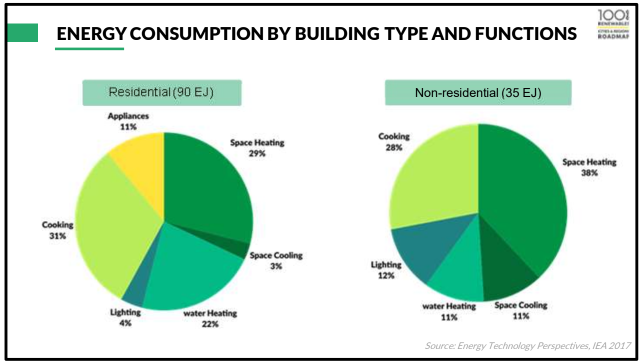
Functions and services also significantly contribute to building energy consumption – and they are rather operational lasting through the operational stages of the building lifecycle. It is important to remember that people don't demand energy, they demand functions and service that are driven by energy. Building design can be optimized from the start of building design construction to ensure that some of the functions and services can run with less or no energy.

Some of the common functions and services include lighting, air conditioning and ventilation, appliance use among others.

Besides optimizing building design, providing information/awareness, and fostering behaviour change practices towards sustainability can be a key strategy for reducing energy consumption through building functions and services.



As we saw in the earlier slides, residential buildings use more energy and have higher emissions footprint than other buildings such as commercial buildings. Hew we can actually see some of the key drivers of energy consumption in terms of functions and services. The disparity is that residential buildings use more energy for cooking and water heating, while non-residential or commercial buildings use more energy for space cooling, lighting and other equipment. Also noteworthy, is the amount of energy consumption that goes into running thermal functions both in the residential sector and the non-residential building sector. Let us zoom in further reconstructing historical patterns and future scenario projections to see how important these functions have become…

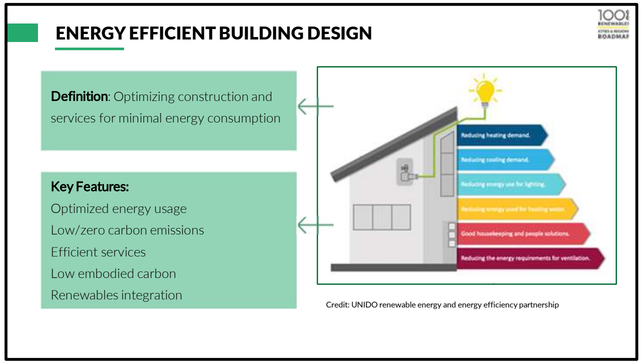
COMMON ENERGY EFFICIENCY MEASURES IN BUILDINGS

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: a building with a high degree of energy efficiency in its fabric and building services that consume energy, e.g. heating, cooling, cooking, lighting, ventilation, hot water, and appliances.

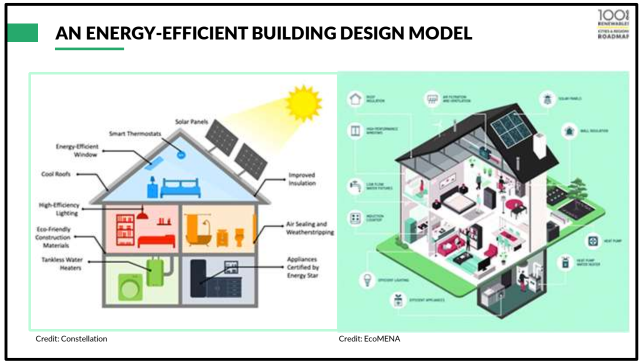
Low-carbon: a building that is energy efficient (low-energy) and is supplied by low-carbon energy.

Nearly-zero carbon: a building that is energy efficient and may have some available renewable energy supply (onsite or offsite), but complete demand offset.

Net-zero carbon: a building that is energy efficient and relies on renewable energy sources that meet the energy demand over the course of a period.

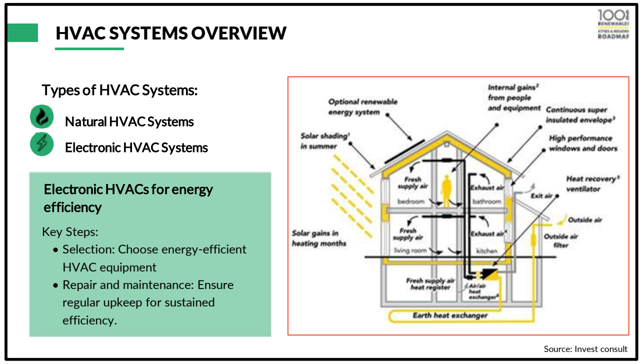
Zero-carbon: a building that is energy efficient and its energy demand is completely met through renewable energy generated either onsite or offsite.

Whole life-cycle net-zero carbon: zero-carbon buildings, in which embodied carbon emissions from the materials used in their construction



This is a demonstrative model of an energy efficient building design that demonstrates opportunities for optimizing energy efficiency in both the form and functions and services of the building. Firstly, we can see that the building generates its own energy in form of renewable energy. The we see that energy wastage is minimized and consumption reduction is highly maximized and integrated in several aspects of the building. The emphasis on eco-friendly materials also highlights and opportunity to reduce the embodied carbon in the building design. From the building sector, let us now dive a little deeper into specific aspects of building such as HVAC and Lighting, which are some of the key drivers of building sector energy consumption.

In both the residential and commercial building sector, HVAC takes the biggest amount of energy consumption, accounting for around 40% of building energy demand. Optimizing HVAC systems and control can generate significant energy and cost savings. But what are some of the ways to optimize the HVAC systems and controls?

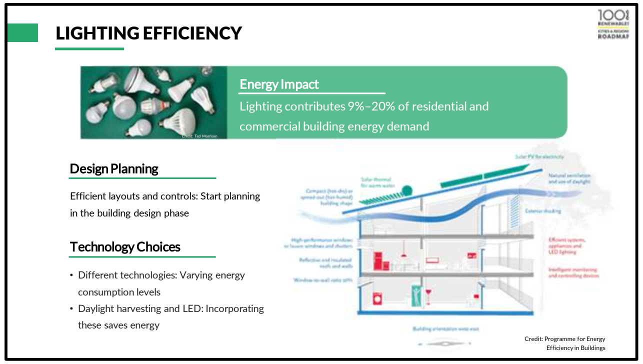


Optimizing HVAC systems and controls for energy efficiency should start right from the planning the building design. It stretches to selection of equipment for the HVAC systems, and the maintenance and use patterns of the equipment.

At the design phase, buildings can be designed to utilize natural ventilation, air conditioning and heating/heat recovery – as seen in this diagram. This design significantly reduces electronic HVAC systems since it uses building design integrated insulation and air conditioning.

At the operational phase of the building, depending on the building design, electronic HVAC systems may become necessary. This is where the energy demand of the building starts to increase, and this is where attention needs to be paid to the energy efficiency of the equipment – a question answerable by manufacturers design of the HVAC equipment. It is advisable to purchase low energy consuming and efficient HVAC systems. This information is usually available on the HVAC manufacturer's manual where one can see the energy consumption of the system.

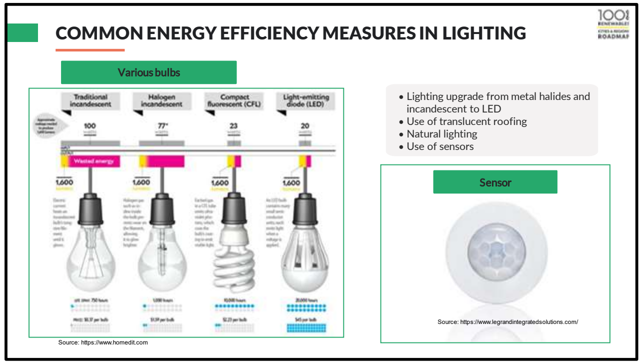
During the operational life of the HVAC system, it is also advisable to perform energy audits and keep track of the HVAC systems energy demand. It is a common phenomenon for HVAC systems to become less energy efficient overtime. Keeping note of this can inform the periodic HVAC system repair and maintenance to maintain the high energy efficiency performance ability



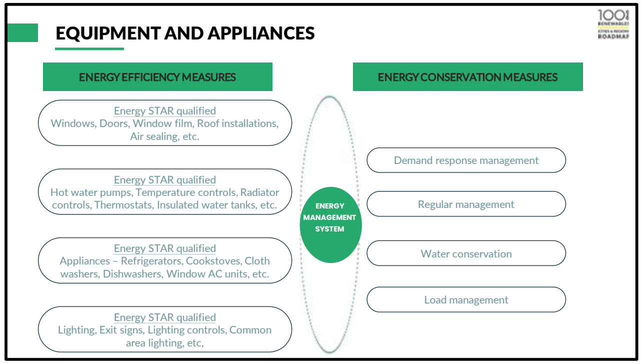
Lighting consumers a considerable amount of energy in both the residential and commercial building sector. Similar to HVAC systems and controls, buildings can be optimized for lighting energy efficiency right from the building design – which is ideal, because in so doing, buildings are designed in such a way that they can incorporate daylight harvesting.

Where buildings are not designed to harvest daylight, they can be retrofitted, and building envelop adjustments can be made to integrate daylight. This is usually costly in many cases.

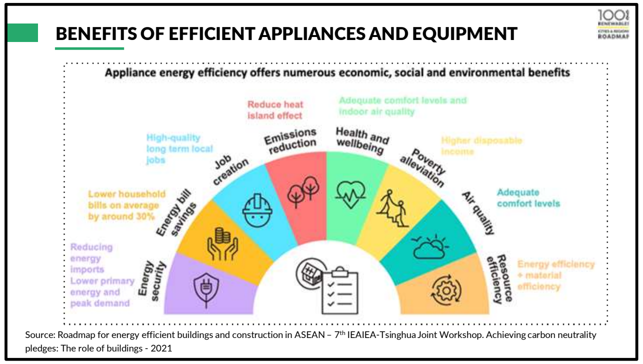
However, in event of building designs not suited to harvest natural light, or lighting needs at night, the the question of lighting energy efficiency comes down to the selection of the lighting technology/electronics used



. It is important to note that different lighting technologies use different levels of energy. This information is also usually available on the manufacturer's user manual. LED lighting systems and Compact fluorescent lamps are known for being highly energy efficient, saving up to 80% energy. These can be integrated in the building lighting system to save energy.



Implementing energy conservation and efficiency measures to achieve the ultimate goal of an efficient energy management system. These efficiency measures include energy-efficient equipment, such as ENERGY STAR certified products, and conservation measures, such as demand management, load management and regular maintenance practices. By effectively integrating these measures, one can achieve your energy management goals.

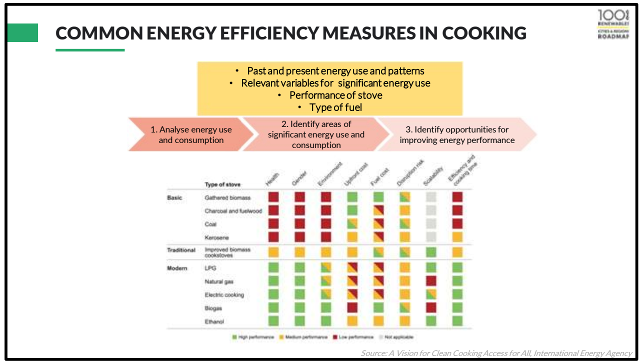


Appliance energy efficiency offers numerous cascading economic, social and environmental benefits.

Some of the immediate benefits include energy bill savings. Household bills can be lowered by up to 30%, which can translate into household income savings and poverty reduction in the long run. Emissions reduction and reduction of heat island effect also come with energy efficient appliances.

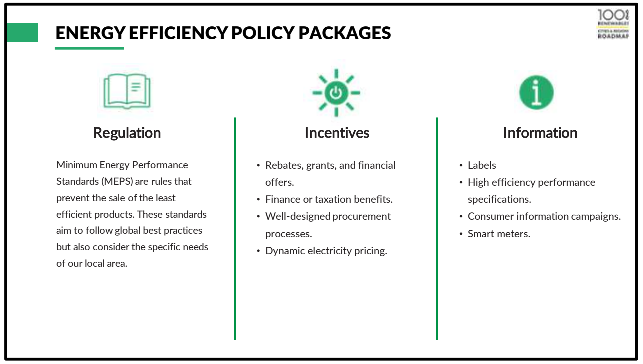
Appliance energy efficiency comes with innovations and creation of new business opportunities – which can translate into job creation and income generation.

Low primary energy and peak demand lead to reduced energy imports and promote energy security.



The selection of clean fuel sources and the use of efficient cooking appliances are crucial to reducing the health risks associated with conventional fuels. Examples such as modern biomass, LPG, biogas and ethanol help to reduce indoor air pollution levels. However, challenges remain in achieving respiratory health benefits from cookstove interventions, as shown in the graph. Limited access to cleaner alternatives such as LPG and ethanol further complicates improvements in respiratory health.

BUILDING ENERGY EFFICIENCY POLICIES



Regulation

MEPS: These regulations are essential for moving the market towards the best available technology in line with achieving net zero targets. Regulatory instruments such as MEPS can also ensure that new appliances are demand response ready in order to offer flexibility to the end-user and the overall system and reduce peak demand.

Incentives

Rebates, grants and other financial offers motivate consumers to buy highly efficient appliances

Finance or taxation benefits encourages manufacturers to produce appliances that are more efficient

Well-designed procurement processes can increase market share of highly efficient appliances and drive innovation

Dynamic electricity pricing helps incentivize flexible demand

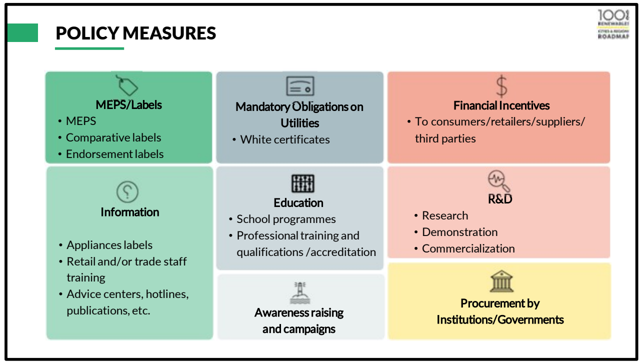
Information:

Labels inform consumers, identifying the most efficient appliances and encouraging purchases based on lifetime costs

High efficiency performance specifications identify the best performing products and are often used as the basis for labels and incentives.

Consumer information campaigns help people make informed decisions. These are most effective when based on behavioral insights and targeted strategies

Smart meters enable feedback and targeted guidance to consumers about their energy use and how they can make savings

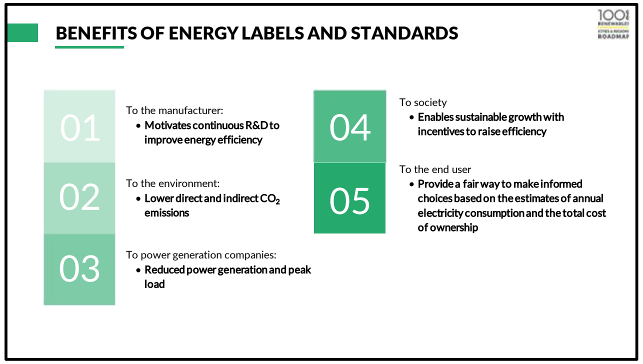


This is a continuation from the previous slides to expand further on policy measures for energy efficiency in appliances and equipment. It gives us the opportunity to look at specific policy tools as examples of what can be used to support policy implementation.

MEPS and labels support direct energy efficiency initiatives especially through labels. Labels in this case can be comparative labels that compare energy efficiency of the same or different appliances for users to make informed decisions. Or they can be endorsement labels aimed at directly influencing the users' decisions.

Mandatory obligations such as white certificates relate more to regulatory tools that are enforcement based.

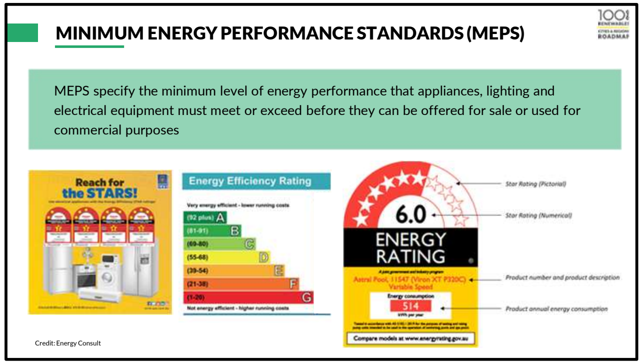
Financial incentives enable retailers, producers and users to embrace energy efficient technologies. Some of these incentives include tax waivers, loans, grants and subsidies specifically targeting energy efficient appliances and equipments.



Besides promoting energy efficiency and reducing emissions from energy use, energy labels and standards generate several benefits to different groups of people.

For the manufacturer, it generates the motivation for continuous research and development to improve energy efficiency. This can translate to enhanced sustainability and business competitiveness. Likewise, to the power generating company, there are opportunities to reduce power generation and peak load.

For the end-user it is an opportunity to make informative decisions based on the data from their energy audits and the operational energy cost of the appliance. To the broader society, these programs unlock opportunities for sustainable growth and offer incentives to raise efficiency.

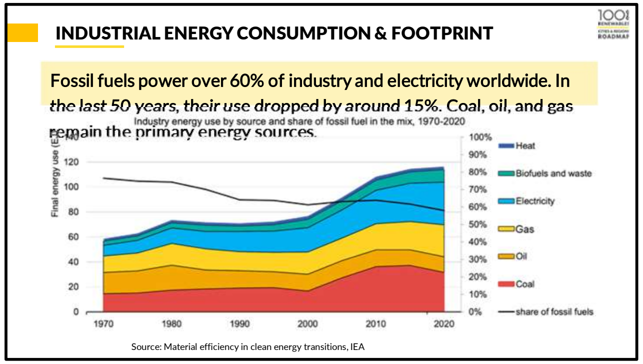


MEPS are more of an informational policy tool (sometimes regulatory). They specify the minimum level of energy performance that appliances, lighting and electrical equipment must meet or exceed before they can be offered for sale or used for commercial purposes.

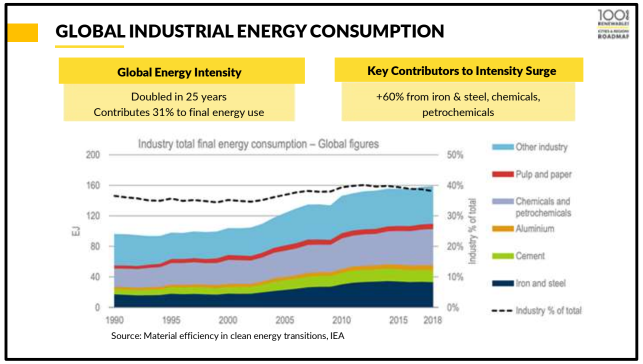
MEPS are an effective way to increase the energy efficiency of products sold

In essence, the prevent inefficient products from entering the marketplace and manufactures are given appropriate signals to increase their product efficiency. For the consumers, MEPS mean that products available in the market use less energy and have lower running costs over their lifetime.

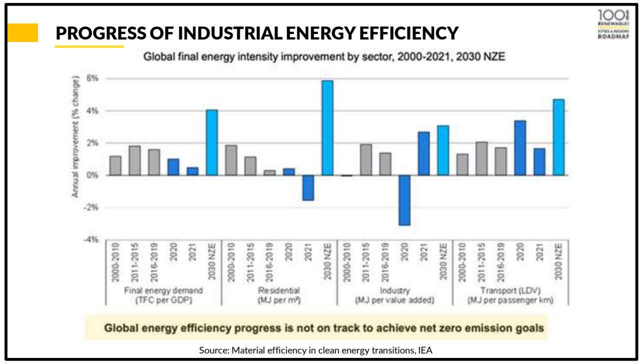
In this section we dive deeper into looking at the key issues around industrial energy efficiency, an equally energy intense sector – that is even more valuable in the context of urban development



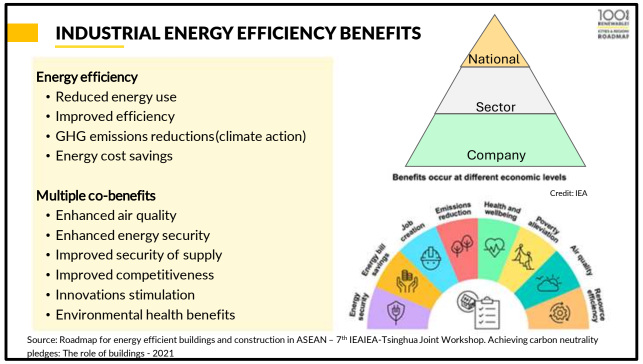
From the previous slide we saw how changes have been unfolding in industrial energy consumption intensity. Here, we can now judge the level of sustainability that accompanies the changes. From this graph, we can of course judge that the changes have no good new. As it seems the past three decades of rapid increases in industrial energy intensity have been mainly serviced by fossil fuels which account for over 60% of end-use industrial energy and electricity production globally, with coal, oil and gas being a dominant force. But on the fair side, we see a gradual decline in the use of fossil fuels decline by over 15% from around the 1970s. Let’s dive a little bit deeper and see these developments through the lens of emissions foot print.



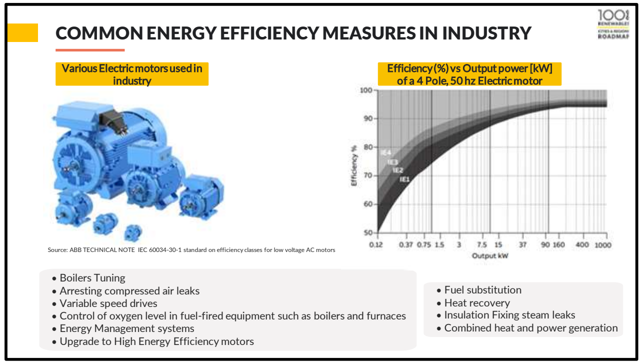
From this graph, we can see that global industrial energy consumption has almost doubled over the past 3 decades. And here we notice the industries that are culprits of this intense energy use. We can confidently say that this growth in industrial energy intensity has mainly been driven by the chemical and petrochemical and iron and steel sectors which together account for more than 60% of the growth in industrial energy intensity. Let us see what these changes in energy intensity mean in terms of industrial emissions footprint in the next slides.



While the previous slides have painted a picture of unsustainable energy economies in the industrial sector, let us see how this generally compares across the other sectors. While global energy efficiency progress is off-track from achieving net zero emissions goals, overall progress and progress towards energy efficiency has been increasing across other sectors such as transport and and residential sectors. However, energy efficiency improvement progress is least in the industrial sector – which again correlates with the observations from the previous slides.

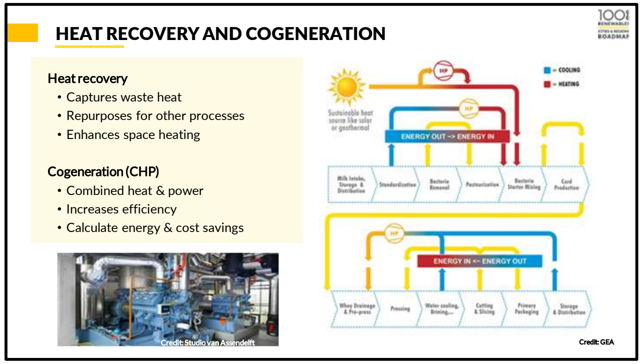


The benefits of industrial energy do not only remain behind the walls of the industrial buildings. Industrial energy efficiency generates industry business specific benefits and other multiple co benefits that span from company level, to sector and national levels…even reaching as far as transnational levels. In the former cases, we can see local air quality improvements which strategies such as fuel switching, reduction in energy investment costs, which enhance overall business profitability and competitiveness. In the latter case we see reduction in GHG emissions, environmental health benefits –if undertaken at large scale, can yield benefits beneficial to national and global scale climate action

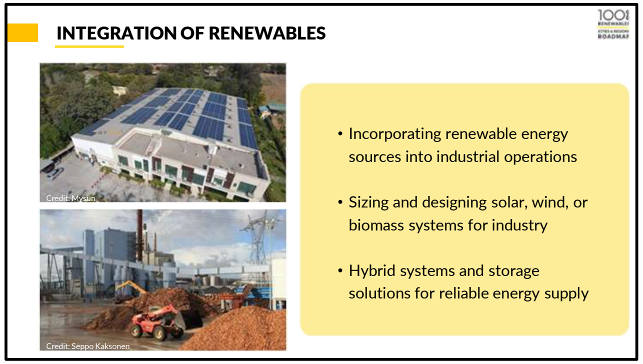


To promote energy efficiency and reap its benefits, we need to understand energy flows in the system and how to use this data-based understand to inform energy management for efficiency. This brings us to energy auditing and assessment. An energy audit involves an inspection survey and an analysis of energy flows. It may include a process or system with the aim of reducing the amount of energy input into the system without negatively affecting the output.

Conducting comprehensive energy audits for industrial facilities to identifying energy-saving opportunities and waste reduction, using data analysis tools and techniques for assessment is the way to go in energy audits. They are basically a 3-phase process of data collection and decision making, which involves pre-diagnosis, diagnosis, and action plan. These phases can target different aspects of energy flow such as indoor air quality, indoor air temperature, flue gas flows among others.



Here we see a typical industrial heat recovery and cogeneration process in a milk processing factory. Industrial heat recovery involves the retrieval and utilization of surplus thermal energy produced during industrial operations. This recovered heat can be repurposed within the facility to enhance energy efficiency and lower operational costs. On the other hand, Cogeneration, or combined heat and power (CHP), is a method where a single industrial plant or power facility generates electricity and useful heat in tandem. This approach optimizes energy resource utilization, potentially delivering higher efficiency and cost-effectiveness compared to separate electricity and heat generation systems.



Renewable energy integration in industry involves incorporating sustainable energy sources, like solar, wind, or biomass, into industrial processes. This typically requires:

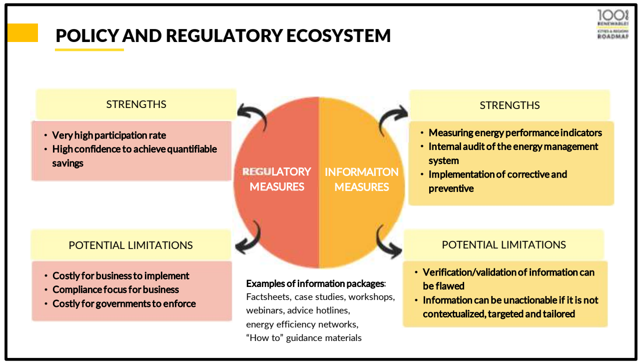
Sizing and Design: Properly sizing and designing renewable energy systems to match the energy needs of the industry. This involves evaluating factors such as energy demand, location, available space, and energy source availability.

Hybrid Systems: Often, a combination of renewable sources is used to ensure a reliable and consistent energy supply. Hybrid systems can balance the intermittent nature of wind and solar with more consistent sources like biomass or energy storage.

Energy Storage: Implementing energy storage solutions, such as batteries, to store excess energy generated during optimal conditions for use when renewable sources are less productive, ensuring a continuous and reliable energy supply.

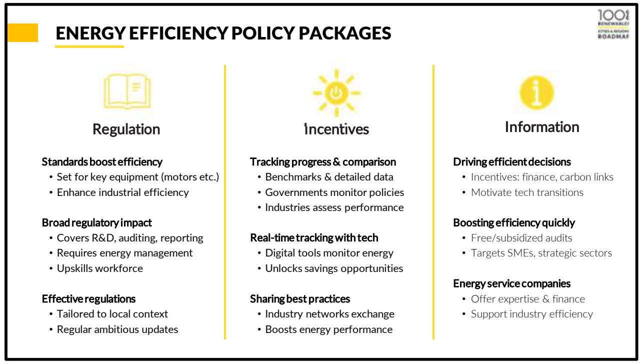
By effectively incorporating renewable energy and employing these strategies, industries can reduce their carbon footprint, lower energy costs, and enhance energy resilience.

INDUSTRIAL ENERGY EFFICIENCY POLICIES



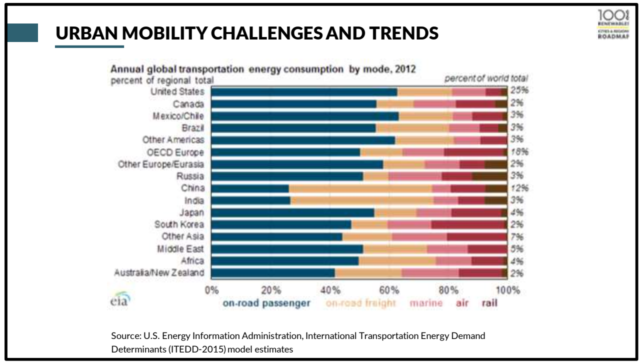
The identified policy package addresses limitations and capitalizes on strengths within the sector's policy and regulatory ecosystem to drive energy efficiency initiatives in heavy industry through strategic approaches:

Addressing constraints: The policy package addresses constraints by streamlining regulations and improving enforcement mechanisms.
Leveraging strengths: It uses existing strengths such as clear guidelines and information dissemination channels to facilitate the adoption of energy efficient practices.
By addressing constraints and leveraging strengths, the policy package aims to create an enabling environment for the uptake and implementation of energy efficiency initiatives in heavy industry.

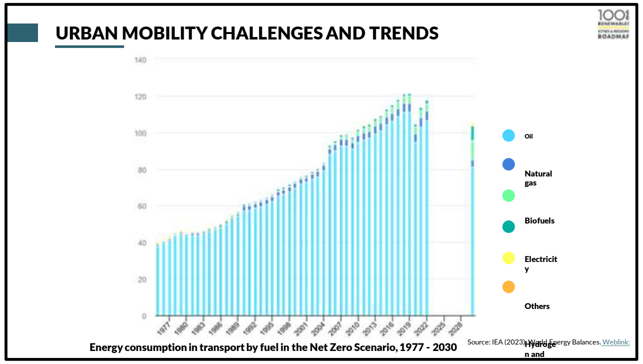


The heavy industry accounts for two-thirds of the global industrial emissions, while over 70% of short-term industrial energy efficiency savings are in light duty industry and SMEs. Implementing better energy management systems and practices has been shown to deliver savings up to 15% in the first 1-2 years, with little or no capital investment. But to reap these benefits, we need the policy and regulatory ecosystem here that traverses regulatory, informational, and incentive-based instruments.

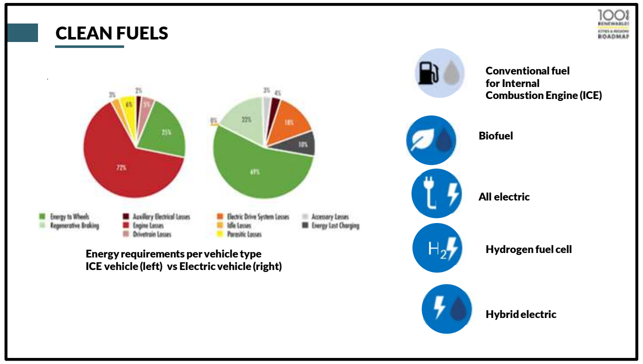
The transport and mobility sector is another point of intense energy consumption, mainly from fossil fuels, and copious amounts of greenhouse gas emissions. The transport sector is especially crucial in urban areas where a lot of urbanites depend on it for everyday commute and freight of consumer goods. But it is not only crucial for positive reasons, urban transport and mobility also ranks closely to industries in terms of urban air quality pollution.



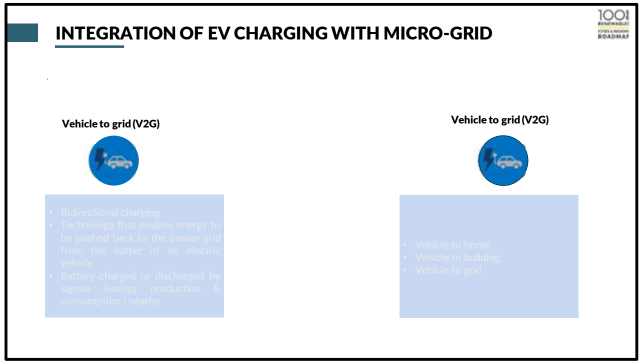
In this data, we can see that by far, on-road passenger transport and mobility accounts for the highest level of energy consumption and we can see how energy consumption varies by mode of transport and country. On-road freight is also another large consumer of energy. Unfortunately, these modes of transport mainly use liquid fuels (petrol and diesel) derived from fossils.



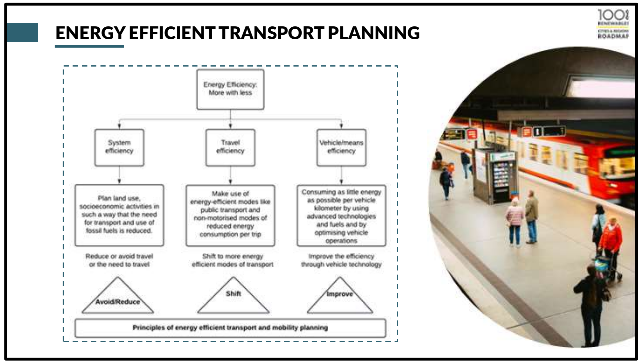
Correspondingly, in the above graph, we see trends in energy consumption by source of fuel over the past nearly five decades. There has been a progressively steady increase in the different types of fuel used for transport and mobility, but one thing remains constant – the dominance of oils as a leading supplier of energy. Let us see what this means in terms of the emissions footprint of the energy sector.



It's crucial to prioritize transport efficiency by transitioning to cleaner, more energy-efficient vehicles and fuels. The graph highlights the fuel conversion efficiency of electric vehicles, while alternative clean fuels underscore the importance of improving transport efficiency.

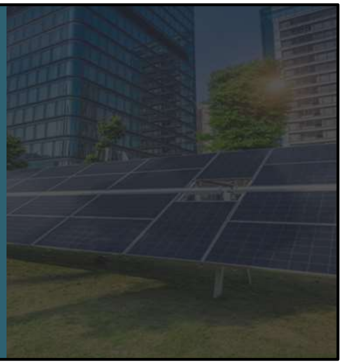


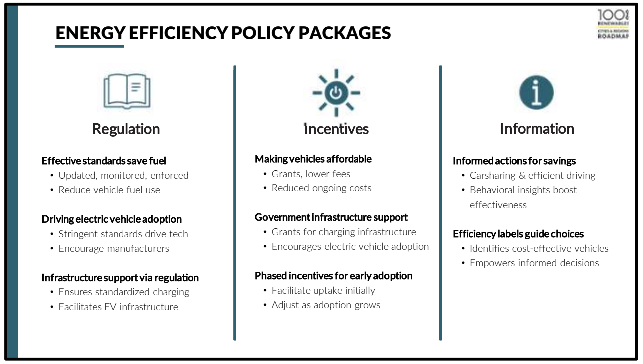
Advanced energy-efficient charging technologies incorporate features that enable both V2G and V2X functionalities. V2G facilitates the exchange of energy between electric vehicles and the grid, while V2X encompasses a wider spectrum of interactions, including communication between EVs and the grid, other vehicles, infrastructure, and buildings.



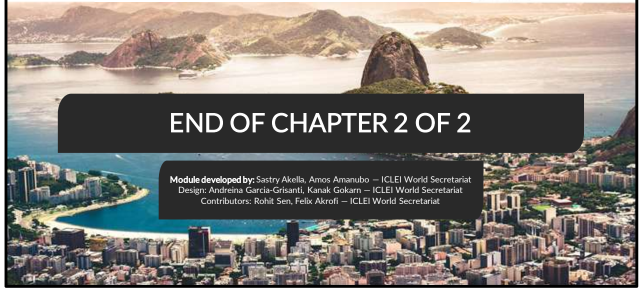
Energy efficient transport planning: Framework. The framework aims to improve energy efficiency in three critical areas: system efficiency, travel efficiency and vehicle/equipment efficiency. It elaborates further on principles of energy efficient transport and mobility planning. By implementing this framework, governments and organizations can effectively promote sustainable mobility and reduce energy consumption in the transport sector, ultimately achieving the desired results. However, a robust policy regulatory framework is imperative for the effective implementation of this strategy.

TRANSPORT ENERGY EFFICIENCY POLICIES





Given the significant role of the transport and mobility sector in emissions and energy consumption, there is a need to institute policies that facilitate energy efficiency in the sector. In the net zero emissions scenario milestones for 2030, electric cars are 60% of sales and the average fuel consumption of the conventional heavy trucks fleet reduces by 19%. Data shows that efficiency improvements rates for cars are 60% faster in counties with fuel economy regulations and purchase incentives than in those without. Significant reductions in fuel demand are available through immediate actions including lowering speed limits and the adoption of best practices for driving and vehicle maintenance.



END OF CHAPTER 2 OF 2

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