सत्यमेव जयते

Ministry of Housing and Urban Affairs
Government of India

Fossil Fuel Consumption In The City

TRAINING MANUAL

Climate Centre for Cities

ClimateSmart Cities Assessment Framework

Energy and Green Buildings

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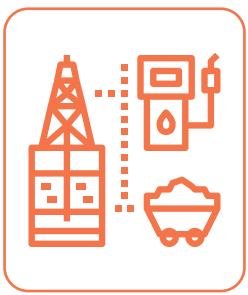

Fossil Fuel Consumption In The City

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ClimateSmart Cities Assessment Framework

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NIUA | C3
Climate Centre for Cities

Fossil Fuel Consumption
Training module

Developed by:
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Executive Summary

On one hand, cities are a significant contributor of carbon emissions aggravating climate change and on the other, cities are considerably impacted by climate disasters. The recently released Global Climate Risk Index 2021 ranks India as the 7th most affected country from climate related extreme weather events (storms, floods, heatwaves etc.). Further, studies indicate that poor planning and urban management are expected to cost Indian cities somewhere between $2.6 and $13 billion annually.1 Cities are increasingly at the forefront of addressing both urbanization and climate change and to strengthen climate-sensitive urban development, a holistic understanding of the urban development from a climate lens is crucial. The ClimateSmart Cities Assessment Framework (CSCAF) launched in 2019 by the Ministry of Housing and Urban Affairs (MoHUA), Government of India aimed to address this gap. This first-of-its-kind assessment with 28 progressive indicators across 5 thematic areas helps cities to benchmark their development, understand the gaps and further prioritize climate relevant development.

With a focus on building local capacities to develop and adopt climate measures, the Climate Centre for Cities (C-Cube) at the National Institute of Urban Affairs (NIUA) initiated a series of training aligned to the thematic areas of CSCAF - Energy and Green Buildings, Urban Planning, Green Cover & Biodiversity, Mobility and Air Quality, Water Management, Waste Management. The focus of the training is to provide a step-by-step approach of conducting studies, assessments and stakeholder consultations, establishing

[1] Mani, M. et al., 2018. South Asia's Hotspots: The Impact of Temperature and Precipitation Changes on Living Standards, Washington D.C.: World Bank Group.

committees, developing action plans and implementing relevant measures that not only makes the cities climate resilient but also helps them progress across the assessment of CSCAF. This training focuses on the 'fossil fuel consumption of the city' under the thematic areas of energy and green buildings in the CSCAF.

Despite many pledges and efforts across the globe to tackle the causes of global warming, CO2 emissions from energy and industry have increased by 60% since the United Nations Framework Convention on Climate Change was signed in 1992. Fossil fuels are the world's most abundant and widely used energy sources. Despite the increased production and use of environmentally friendly renewable sources, fossil fuels continue to be critical to meet the world's energy needs. Approximately 84% of the world's energy consumption needs are met from fossil fuels, with oil accounting for 33.05% of the consumption in 2019 and natural gas and coal accounting for 24.2% and 27.3% respectively, according to BP Statistical Review of World Energy 2020.

The share of Indian fossil fuel consumption has increased from 54% in 1990 to 81% in 2019 as per the World Bank). India is the world's thirdlargest consumer of oil and refined products. This increase in the fossil fuel consumption is associated with the growing population and the needs for electricity, transport, and cooking.

As cities drive the accelerated economic growth of the country, the GHG emissions associated with the fuel consumption needs to be restricted in order to provide the sustainable future for the citizens of the present and the future. This training module is aimed at educating the city administrators and the officials working in electricity and transport departments on quantification of the fossil fuel use and its associated emissions, and in the identification and implementation of rectification measures to reduce the GHG emissions.

The module provides an overview of fossil fuel use in the cities and the methods to reduce the emissions associated with the fuel use. Several case studies explaining the technological solutions and regulatory frameworks for limiting emissions from the fossil fuel use are provided to help the city administrators understand the extent of the interventions possible in this area.

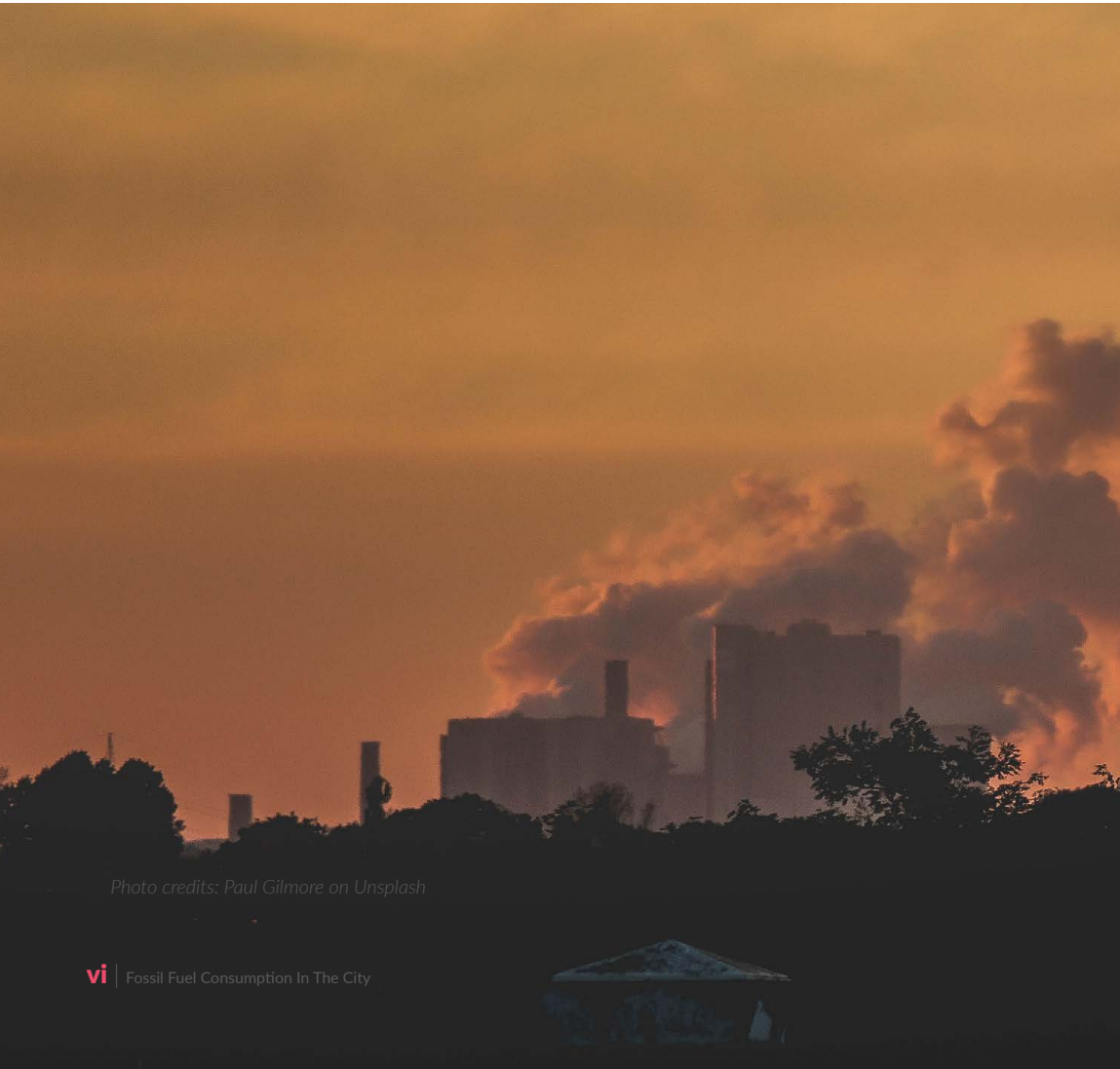

Photo credits: Paul Gilmore on Unsplash

The training on this indicator includes methods for GHG emissions reduction and ways for enhancing environmental quality. This training manual is aimed to act as a guidebook for the cities to understand the steps required to perform the scoping and implementation of intervention measures in the transportation, cooking and electricity use.

The expected outcome of the module is to help the municipality administrators and financial decision makers, municipal transport authorities, consumer services personnel, and the policymakers in the municipality to develop a roadmap for reducing the GHG emission footprint from fossil fuel use in the city. Additionally, the municipal authorities are expected to develop and implement projects in their cities for directly and indirectly the emissions associated with fossil fuel use based on the learnings form this training module.

Who is the training manual designed for?

What is the focus of the training manual?

How to make use of this manual?

What are the Learning outcomes of the training?

Scope and limitations of the training

The manual is designed to provide leadership-training on the fossil fuel use in the urban transport, cooking and electricity use coming under the jurisdiction of the city administration. The financial decision makers, technical and enforcement personnel operators working in the transportation, consumer services and electricity department may also benefit are the expected beneficiaries from this training module.

This training manual focuses on developing understanding of fossil fuel use pattern in the city, quantification of GHG emissions and developing and implementing intervention measures related to fossil fuel use emissions reduction.

The manual can be used as a guide for technical assessment of fossil fuel energy use in the municipal system.

The municipality administrators and financial decision makers, municipal transport authorities, consumer services personnel, and the policymakers in the municipality to be able to develop and implement the roadmap for reducing the GHG emission footprint from fossil fuel use in the city

The manual covers contents across the sectors governed beyond the jurisdiction of the municipalities, assuming that the cities might be able to govern all the energy associated infrastructure and services in the future.

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Abbreviations

BEE	–	Bureau of Energy Efficiency
CNG	–	Compressed Natural Gas
GHG	–	Green House Gases
LNG	–	Liquefied Natural Gas
LPG	–	Liquefied Petroleum Gas
MOHUA	–	Ministry of Housing and Urban Affairs
PNG	–	Pipeline Natural Gas
ULBs	–	Urban Local Bodies
WRI	–	World Resources Institute

1

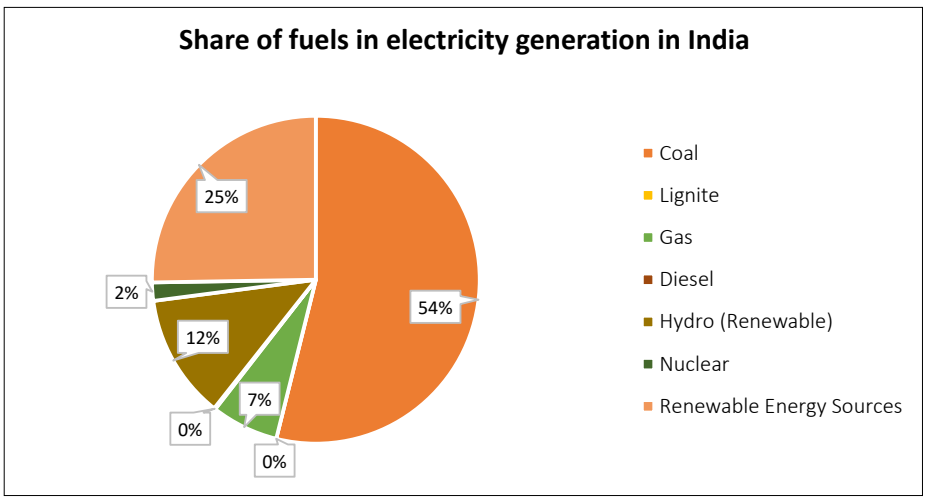
Fossil Fuel Consumption in The City

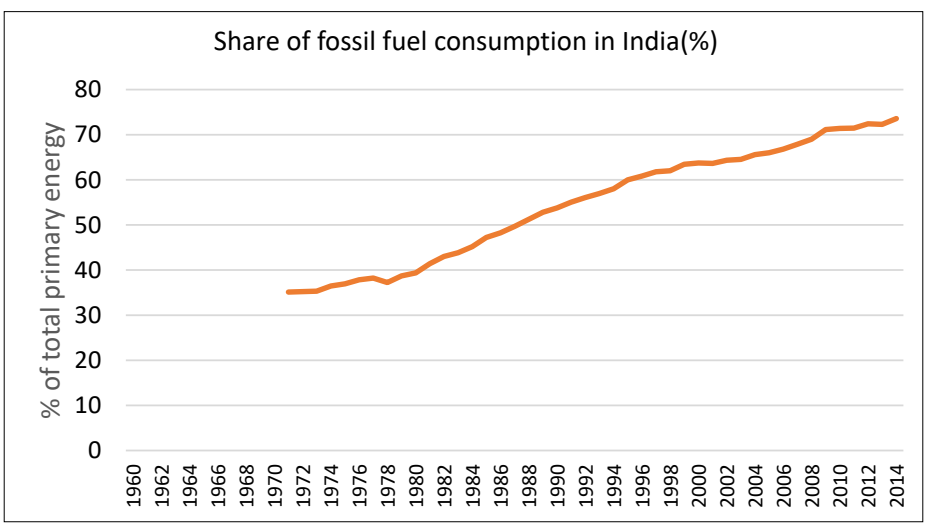
Fossil fuels were formed from the fossilized, buried remains of plants and animals that lived millions of years ago. Because of their origins, fossil fuels have a high carbon content. Fossil fuels have been used as the major primary source of energy for use in power generation, industrial production, transportation, and domestic use mostly for cooking. Common fossil fuels in use are coal, crude oil/ petroleum products and natural gas. The fossil fuel consumption is mostly in industries, energy generation, transport and cooking.

Due to their higher carbon content, fossil fuels when combusted, release gases like **Carbon Monoxide (CO), Carbon Dioxide (CO2), Sulfur dioxide (SO2), Nitrogen Dioxide (NO2), Nitric Oxide (NO), Volatile organic compounds (VOCs), and Hydrocarbons (HCs).** These gases are harmful to the human health and to the environment because they create air pollution and greenhouse effect in the atmosphere, thereby leading to severe effects like global warming and climate change. It is estimated that over 60% of the urban areas that will exist by 2050 have yet to be built, indicating that there will be massive new infrastructure requirements, particularly in Asia and Africa (World Bank, 2017). Simultaneously, existing cities worldwide are aging and much in need of infrastructure replacement. The impact of cities on the environment are numerous and multi-scalar, driven by the transboundary nature of their infrastructure. Cities rely on water, energy, fuel, and construction materials from beyond their jurisdiction and this consumption leads to higher use of fossil fuels as they need to be transported.

India, as one of the largest developing economies in the world, has seen an upward trend in the use of fossil fuel use mainly due to the use of locally available coal for power generation, and the use of petroleum products in transportation and domestic cooking. Cities, being the cornerstone of the economic development in India, share more than three quarters of the fossil fuel consumption. Power generation is the major application sector for fossil fuels, followed by industries and transportation. The share of the fossil fuels and renewable energy sources in the Indian electricity generation is as shown in the figure.

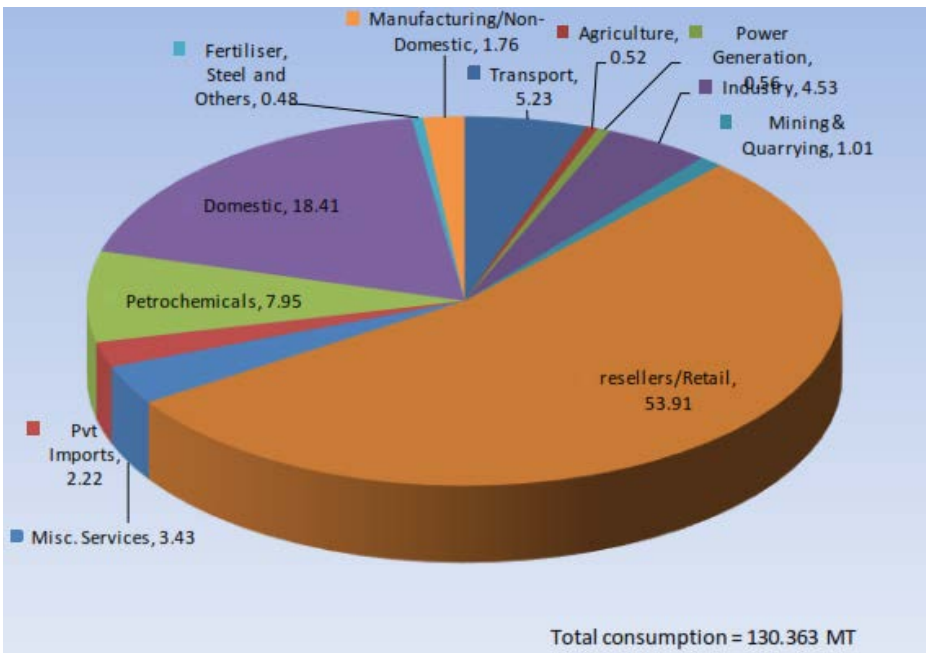
Figure 1 Share of fuels in electricity generation





In India, transport is largest oil consuming sector. Over the past decade, the volume of transport fuel use has increased by 91% (India Energy Outlook, 2020). Diesel, petrol, CNG, and LPG are the major sources of energy for municipal services in India, leading to increasing GHG emissions. Vehicular emissions account for a major chunk of the emissions in India owing to the fuels used to run them. The share of transport-based emissions contributes in a large measure to the release of GHGs. Fossil fuel consumption in the transport sector contributed to 17.8% or 245 million tonnes of CO2 emissions in India in 2015 (India Energy Outlook, 2020).

Figure 2 Sector wise Consumption of Petroleum Products during 2017-18[2]



Rapid urbanization and growth of motor vehicles impose a serious effect on human life and the environment in recent years. Motor vehicles are a significant source of urban air pollution and are increasingly important contributors of anthropogenic carbon dioxide and other greenhouse gases.

Of the three major sectors of fossil fuel use, the opportunities to reduce the GHG emissions from the transportation within the city is higher, as the power generation and industries are majorly governed by the state and central government entities. The potential for reducing the GHG emissions can be well understood from the impact of each fossil fuel type in use by the transportation sector.

[2]*Energy Statistics 2019*

1.1. Impact of Fossil fuel

Each fossil fuel contains varying carbon content, the emissions from them vary significantly. Coal and diesel has very high carbon content leading to emissions of around 2.6 tonnes of CO2 per cubic metre of fuel, whereas fuels like LPG and natural gas have 1.5 and 0.48 tonnes of CO2 per cubic metre of fuel respectively. This simply instructs us to shift from fuels like coal and diesel in power generation and transport respectively to natural gas, whereas transition from kerosene to LPG/ PNG can help reduce cooking emissions.

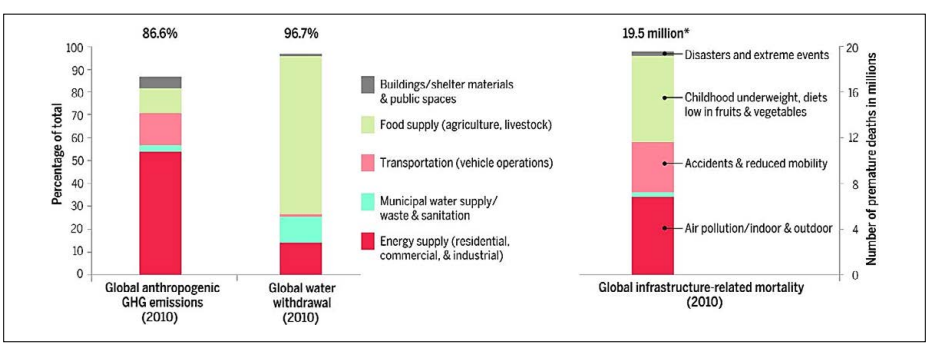
1.1.1. Impact on health

Burning fossil fuels for energy not only releases carbon dioxide and contribute to climate change but also releases particulate matter, sulfur oxides and sulfates, ozone, carbon monoxide, nitrogen oxides, formaldehyde, benzene, and 1,3 butadiene. Toxicity, level of exposure, and age (children are highly susceptible to the health effects of fossil fuels) are factors that have severe impact on human health such as asthma, pneumonia, bronchitis, upper respiratory and eye irritation, heart diseases, cancer and immune deficiency.

1.1.2. Impact of fossil on urban environment

The urban environment gets impacted by the choice of fuels used to power our cities. As shown in fig 4, 86% of the global GHG emissions arrive from the energy, water supply, buildings and public spaces like roads and utilities, and transportation in the urban environment. If we assess the impact of these activities with reference to mortality, like the bar graph in the figure, it is clearly understandable that around 19.5 million people around the world were subjected to premature deaths mainly from the global infrastructure. Major causes include air pollution, malnutrition, accidents and disasters & extreme climate events. So, reducing the fossil fuel use can directly save human lives in and around the cities, and protect ourselves from future extremities.

Figure 3 Impacts of key infrastructure sectors.[3]



[3]*Anu Ramaswami et al. Science 2016;352:940-943*

GHG and water impacts associated with buildings and shelter materials include those of producing cement and steel, disaggregated by the authors based on various literature sources. Non-energy GHG emissions are shown for waste and sanitation. Transportation-related premature mortality is from accidents and reduced mobility. The asterisk indicates that total deaths in the right column are non-additive because of overlap.

As the fossil fuels impacts both the environment and people, the dire need for action from the cities is required to control and reduce the use of fossil fuels.

1.2. ClimateSmart Cities Assessment Framework

The indicator "Fossil Fuel Consumption in the city" aims to incentivize cities to lower their CO2 emissions by encouraging them to switch to alternative cleaner fuel sources and to lower the per capita emissions from the consumption of fossil fuels by shifting to lower emitting fossil fuels and non-fossil fuel-based sources.

Diesel, Petrol, CNG, and LPG are the major sources of energy for direct use in the cities in India. The assessment of this indicator is aimed at collecting consumption data of the different fuels in use in each city, estimating the per capita GHG emissions from the fossil fuels and the grouping of cities according to their performance.

$$\frac{\text{Total CO2e of fossil fuel consumption (Diesel + Petrol + LPG + CNG + PNG) in the city}}{\text{Population of the city}}$$

Where, total TCO2e = Total diesel consumption (kL) x 2.62694 + Total petrol consumption (kL) X 2.20307 + Total LPG Consumption 9kL) X 1.51906 + Total CNG Consumption (kL) X 0.48066 + Total PNG Consumption (kL) X 0.48066

*Emission factors are calculated based on the carbon content of fuel.

1. Fuels like Diesel and Gasoline are recorded in Cubic Metres or Metric Tonnes
2. Gaseous fuels – LPG and CNG are recorded in Standard Cubic Metre or Metric Tonnes

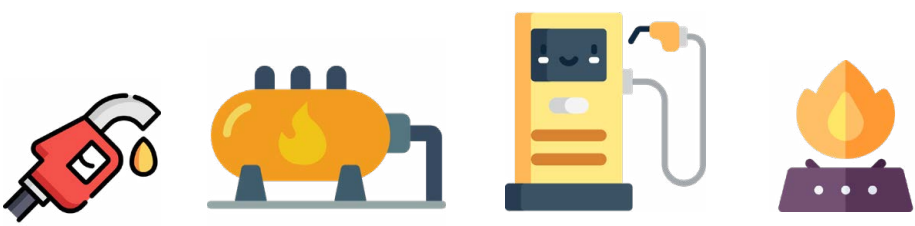
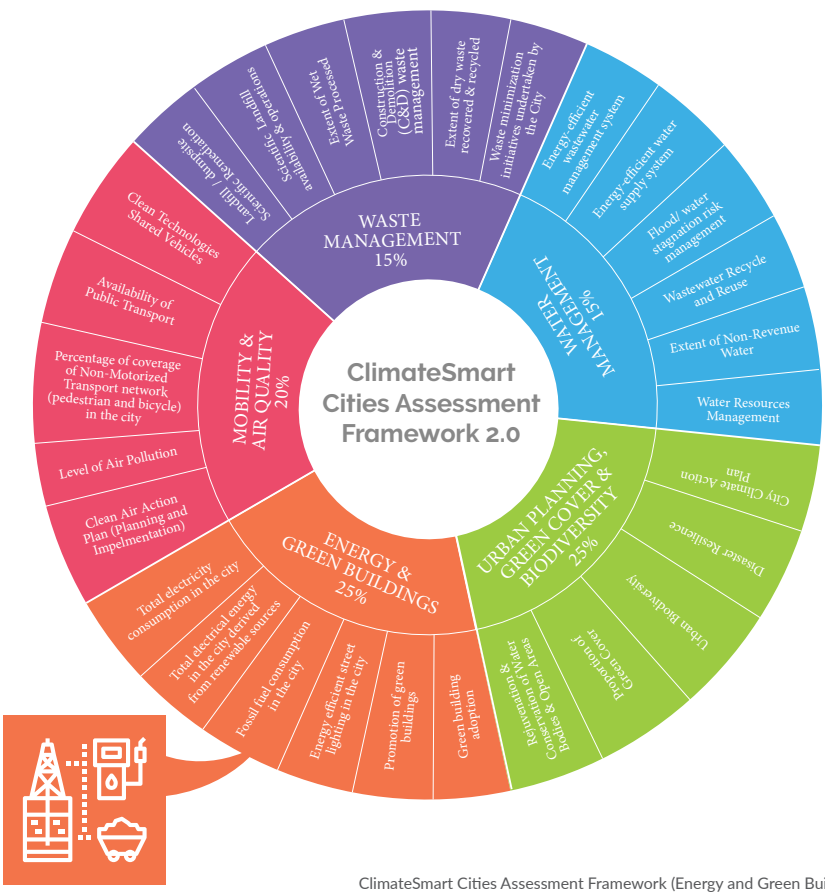


Table 1: Performance evaluation levels

	1	2	3	4	5
Progression Levels	> 10X compared to the city with lowest electricity consumption per capita	> 4X & < 10X as compared to the city with the lowest electricity consumption per capita	> 2X & < 4X as compared to the city with the lowest electricity consumption per capita	> 1.1 X & < 2X as compared to the city with the lowest electricity consumption per capita	Up to 1.1X as compared to the city with the lowest electricity consumption per capita
Evidence/ Data sources	The data on the consumption of petroleum products can be collected by reaching out to the petroleum products distribution companies (e.g. BPCL, IOCL, HPCL and SHELL, etc.) Census of India population figures indexed with average annual growth rate for the year 2019 as per SCP				
Responsible Department/ Agency	BPCL, IOCL, HPCL and SHELL, etc				
Reference Document	Draft National Energy Policy (NITI Aayog; 2017) https://niti.gov.in/writereaddata/files/new_initiatives/NEP-ID_27.06.2017.pdf				
Score	0	25	50	75	100



2

Methods of Reducing Fossil Fuel Consumption

Fossil fuel consumption can be reduced by the following three groups of measures:
1. Sufficiency (mobility)
2. Efficiency (mobility and electricity use)
3. Alternatives in the form of less-emissive fuels and renewable energy sources

These group of measures entail the implementation of rectification measures in the cities which include the following implementation components:
1. Capacity building of the stakeholders
2. Awareness and sensitization to the public
3. Implementation of data collection, analysis, and communication tools
4. Development of data-driven action plans
5. Piloting/Demonstration of the identified solutions
6. Implementation and monitoring of the measures at city scale

As the scale of the rectification measures will be larger (at a city level), the steps mentioned above should be essential for making a transition towards greener fuels.

2.1. Sufficiency

Sufficiency simply refers to the condition or quality of being adequate or sufficient. This terminology suits best to the strategies which can help avoid fossil fuel consumption in the first place. A few examples of these strategies are mentioned in the table:

Sector	Strategy	Description
Buildings	Use of solar passive building materials and design methods	Solar passive measures can help reduce energy consumption with respect to cooling, lighting and ventilation
Mobility	Adequate public transport	Buses, trains, metro rails, etc. can help reduce per capita fossil fuel use in mobility
	Adequate pedestrian and non-motorized transport network	This strategy can directly reduce the use of vehicles in the city and promote a healthy standard of living for the citizens

2.1.1. Pedestrian networks

Characteristics to the development of urban pedestrian zones are:

1. High rates of walking and cycling.
2. More independent movement and active play amongst children
3. Less land taken for parking and roads - more available green or social space
4. Very low levels of car use, resulting in much less traffic on surrounding roads

The main benefits found for pedestrian zone developments:

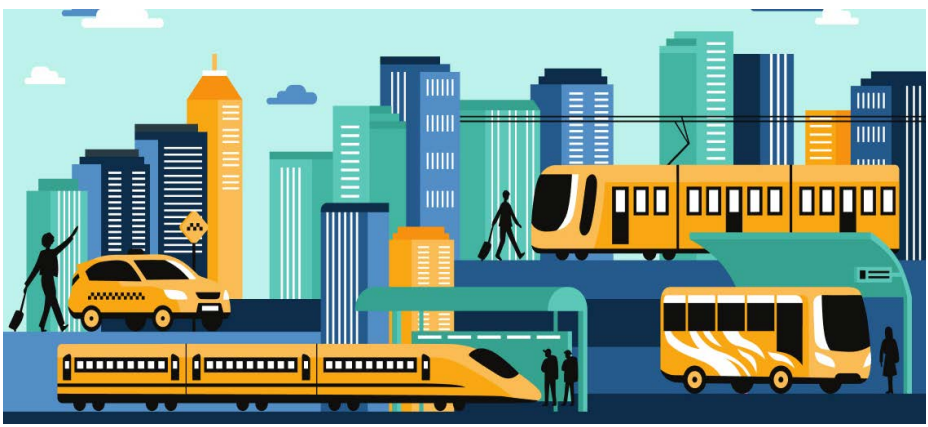
1. Low atmospheric emissions.
2. Low road accident rates.
3. Better built environment conditions.
4. Discouragement of private car and other motorized vehicles (measure of travel demand management).
5. Encouragement of active modes.

The main problem of pedestrian zones is related to parking management. Where parking is not controlled in the surrounding area, this often results in complaints from neighbors about overspill parking.

2.1.2. Public transport

As the population in the cities grow, the growing volume of private vehicles (Cars) becomes the major source for fossil fuel consumption, traffic congestions and air pollution. Public transportation helps avoid all the three issues. This is due to the ability to transport higher volume of passengers with lesser per-capita emissions and per-capita space in the roads. Public transport systems are required for the last-mile connectivity of the citizens in a climate friendly urban environment.

Figure 4 Public Transportation, Traffic Technology Today

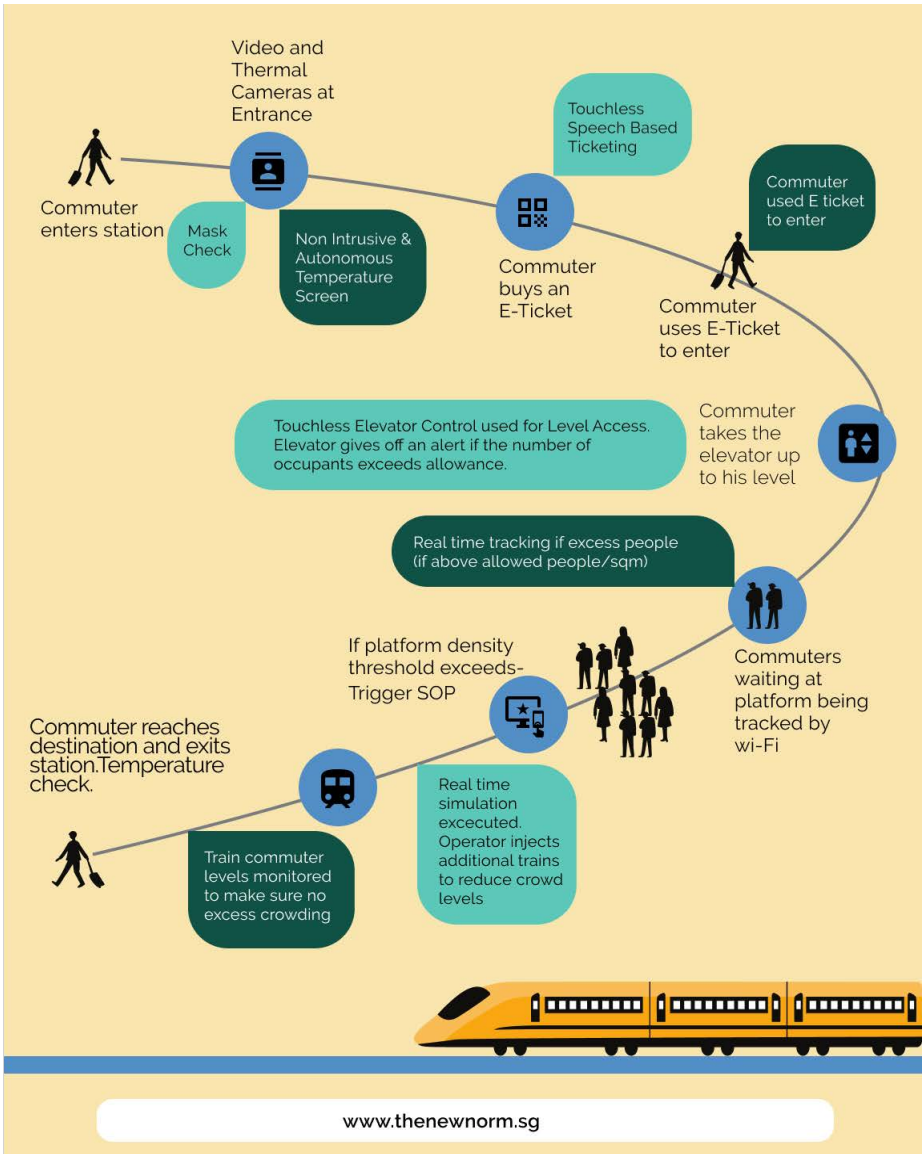


Smart transportation is often directed towards transitioning more people to use public transportation, which is greener and far more efficient than cars. To convince the public, many advances such as travel reliability, reducing downtime, and building more accurate signalling systems and time prediction tools can be considered.

In contrast, commuters of the post-Covid era are far more concerned with crowding. They also expect accurate temperature screening, mask screening, and better train and station hygiene. Secondly, train frequency optimisation models need to adapt well to the demands of social distancing and staggered peak hours. Headways, or the time interval between trains, are expected to be more responsive and adaptable according to the crowd level. Platform density must also be managed well in real time, in order to secure public confidence. For these tasks to be adopted efficiently, ingesting massive amounts of data and implementing incredibly complex analytics is required.

With the evolution of modern AI and IOT based technologies, the public transportation can be enhanced with the features like automatic mask detection and temperature detection system, E-Ticketing system, crowd-based train/bus supply system, etc. can be executed. One such example is provided in the figure:

Figure 5 Public commute with AI & IOT in post-COID Era, newnorm.sg



2.2. Efficiency

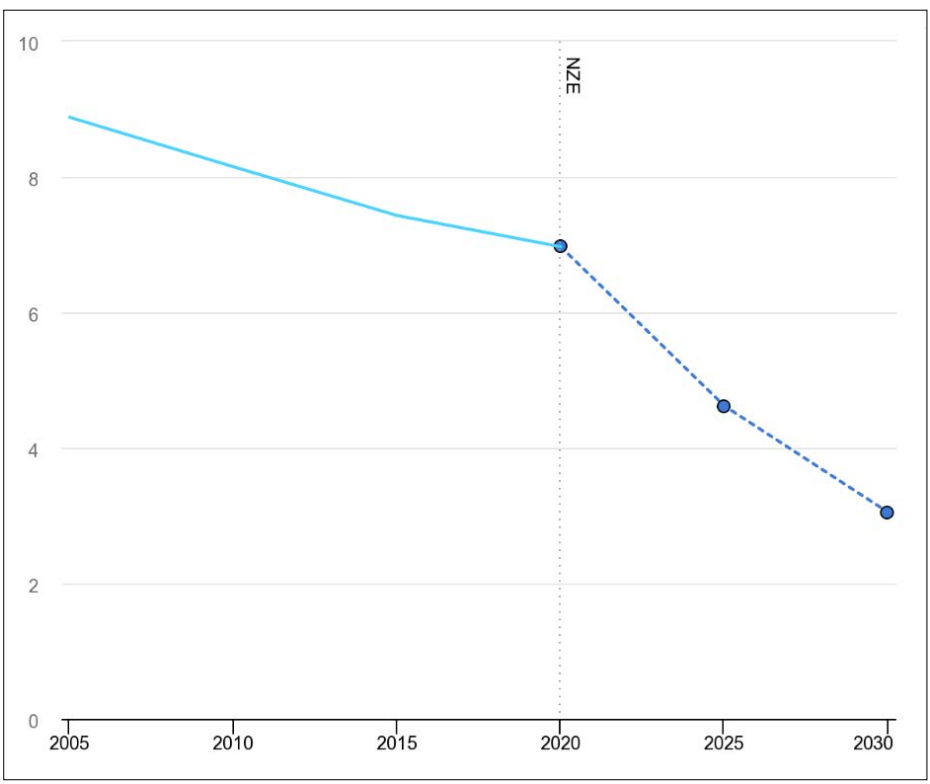
Efficiency in the use of fossil fuels is essential, as higher efficiency can lead to lesser demand for the fuels. Energy Efficiency in buildings, and mobility has the potential to reduce the consumption and the emissions by 35% (Efficiency, 2020), and 20% respectively. Municipal services like water supply, street lighting and wastewater treatment also pose a higher energy and indirect emissions reduction potential.

As the building and municipal services efficiency are detailed out in the other indicators of CSCAF 2.0, this section will detail the efficiency measures with respect to transportation. Efficiency in transportation can be achieved by three levels of participation, vehicle fuel efficiency, public transport efficiency, and vehicle operating efficiency.

2.2.1. Vehicle fuel efficiency

With the advances in the R&D of automobile industry, vehicle fuel economy or efficiency has been in an increasing trend. The global indicator for fuel economy (Litres of Gasoline per 100 km) has improved from 8.9 in 2005 to 7 litres/100 km in 2020.

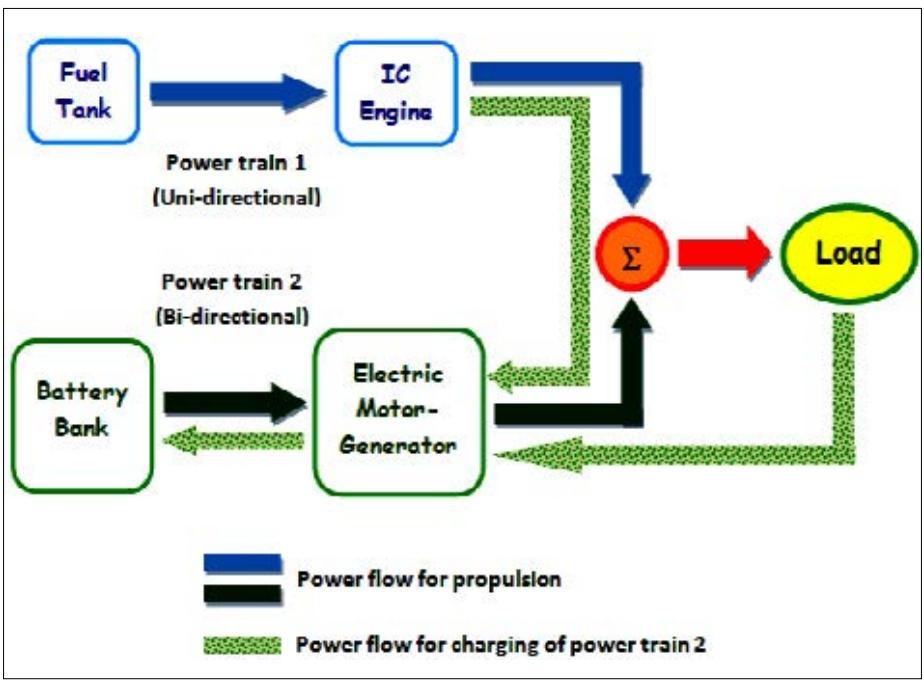
Figure 6 Vehicle Fuel Economy growth – IEA, 2020



This improvements in fuel economy have been reflected in the Bharat Stage VI vehicular emission standards, which demands reduction in vehicular emissions through use of efficient fuel combustion and control systems. As the new vehicles in India will be of BS VI standards, it does not necessarily mean that the existing vehicles cannot be improved.

Retrofitting of existing vehicles with components like internal combustion engine, power trains, and fuel flow controls can lead to efficiency improvements up to 25% (International Energy Agency, 2017). Even the existing IC engines can be converted into hybrid electrical vehicles by addition of electrical battery backup systems and interlacing with total power train.

Figure 7 Retrofitting of existing vehicle into hybrid vehicle, (Saiful Zulkifli, 2012)



Government of India is in the process of allowing these retrofits in existing vehicles. The municipal administration can induce the efficiency measures into the following sections of transport systems:

1. Municipal transport vehicles
2. Commercial and Private Vehicles through mandatory regulations for operating fuel consumption

2.2.2. Overall public transport efficiency

Also, a combined efficiency of the transport system has to be taken into account in order to be able to rectify the inefficiencies in a focused way. U.S Environmental has estimated the transportation efficiency indicators as listed below:

1. Transit Accessibility.
2. Bicycle and Pedestrian Mode Share.
3. VMT per Capita.
4. Carbon Intensity.
5. Mixed Land Uses.
6. Transportation Affordability.
7. Benefits by Income Group.
8. Land Consumption.
9. Bicycle and Pedestrian Activity and Safety.
10. Bicycle and Pedestrian Level of Service.
11. Average Vehicle Occupancy.
12. Transit Productivity.

These indicators can serve as the basis for municipal transport service benchmarking, as the overall efficiency of the transport system can be better arrived using these indicators. (Refer to *https://www.epa.gov/sites/default/files/2014-01/documents/sustainable_transpo_performance.pdf* for estimating the performance of municipal transport service)

2.2.3. Vehicle operating efficiency

Other than the efficiency measures discussed in the sections above, the vehicle operating or driving efficiency can effectively reduce emissions and conserve fuel consumption. 5 fuel-efficient driving techniques illustrated in the below mentioned document can lower vehicle's fuel consumption and carbon dioxide emissions by as much as 25%.

Read more here: *https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/personal-vehicles/fuel-efficient-driving-techniques/21038*

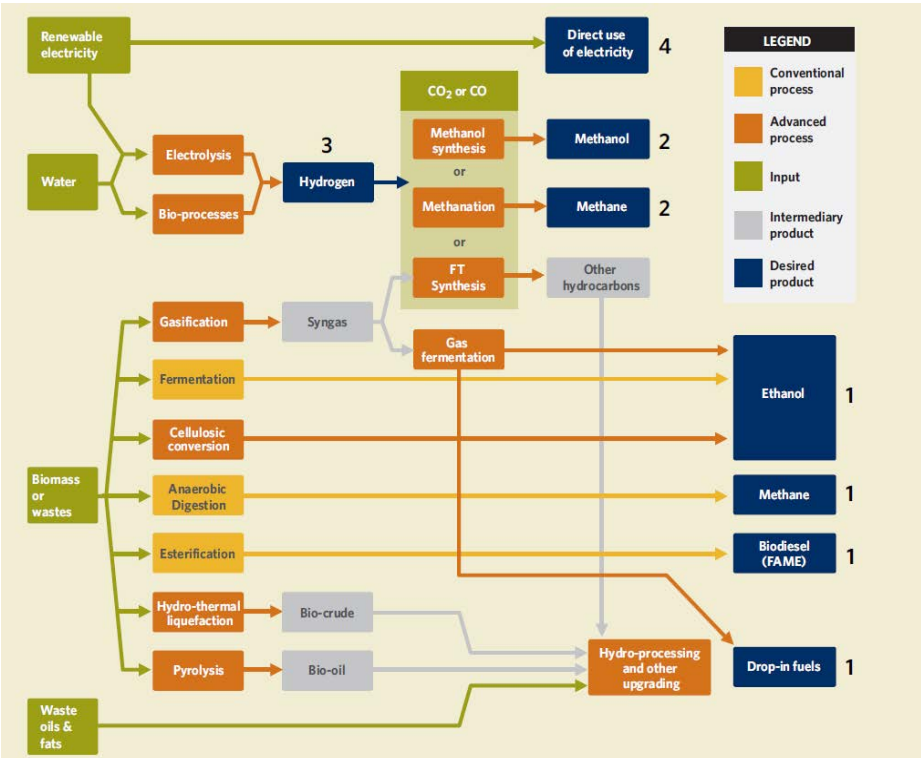
2.3. Alternatives

There are four general options for alternative or renewable energy use in the road transport sector: (1) gaseous or liquid biofuels, (2) renewable electricity-based synthetic fuels, (3) renewable electricity-based hydrogen and (4) the direct use of renewable electricity. Renewable electricity-based synthetic fuels and electricity-based hydrogen are often also referred to as power-to-X (PtX) as they include the conversion of renewable electricity to other forms of energy.

The most common alternatives widely used across the world include:

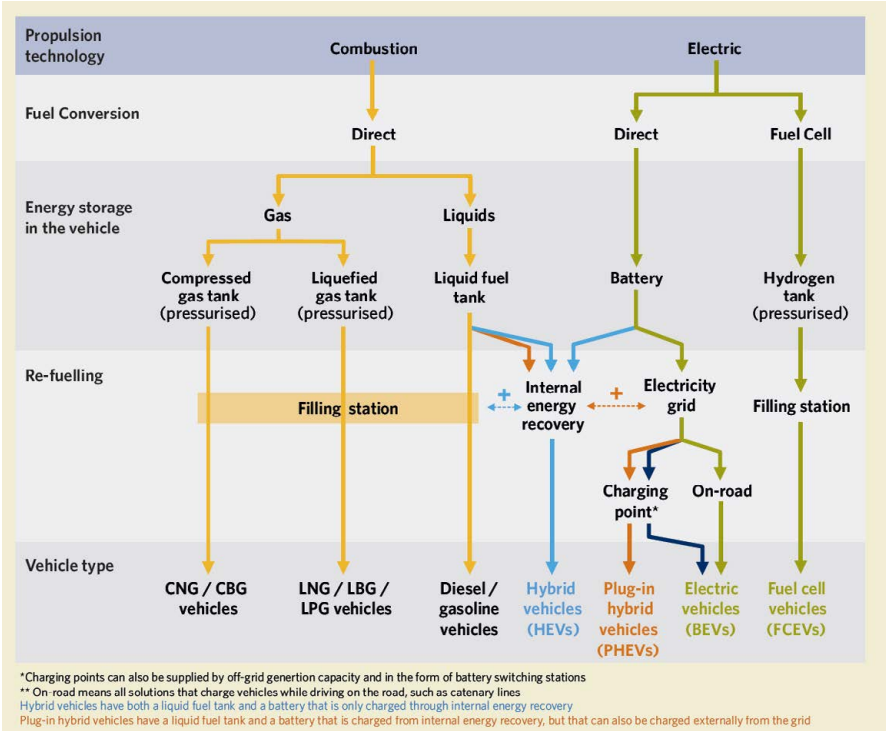
1. Electricity
2. Hydrogen Fuel Cell
3. CNG
4. Biofuels like Bio-CNG, Bio-diesel and Bio-Ethanol (mixed with petrol)

Figure 8 Alternative sources for fuels in transport, (REN21, 2021)



Notes: Syngas = synthetic natural gas, a mixture of gases, mainly carbon monoxide, hydrogen and methane; FT = Fischer Tropsch; FAME = Fatty acid methyl ester; Drop-in fuels include diesel substitute fuels (hydrotreated vegetable oil, or HVO, and hydrotreated esters and fatty acids, or HEFA); numbers relate to the options for renewable energy use in transport, as presented in Figure 21: 1) Gaseous and liquid biofuels; 2) Gaseous and liquid renewable electricity based synthetic fuels; 3) Renewable electricity based hydrogen; and 4) Renewable electricity.

Figure 9 Vehicle technologies for road transport, (REN21, 2021)

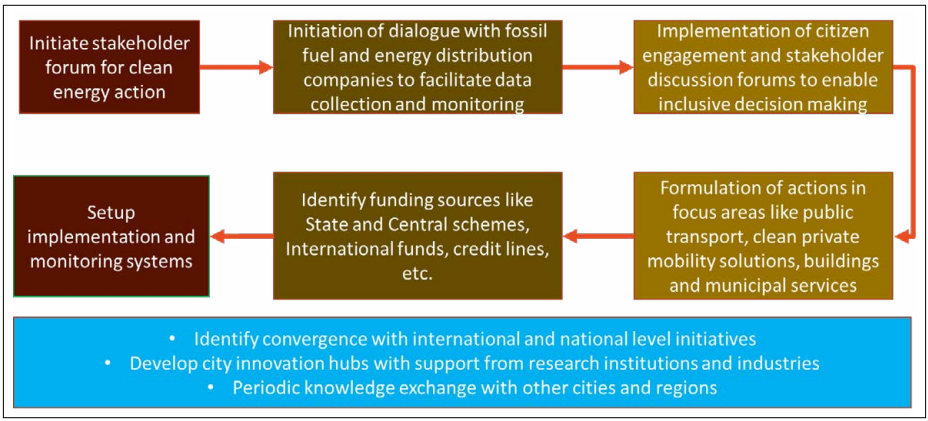


2.4. Clean energy plan

Cities can transform into a clean-fuel based economy by implementing local infrastructure provision like green buildings and public spaces, clean energy supply, clean and efficient transportation, efficient water supply system, food supply and waste and sanitation management. These transformations in individual sectors can be transferred to larger networks of cities in the region, so that the trans-boundary emissions can be reduced.

A clean energy action plan has to prepared by the municipal administration weighing in the information from the planning, transportation, water supply, buildings and consumer affairs departments for creating an actionable plan for eradicating the fossil fuel use. The methodology for developing a clean energy action plan is briefly shown in the figure.

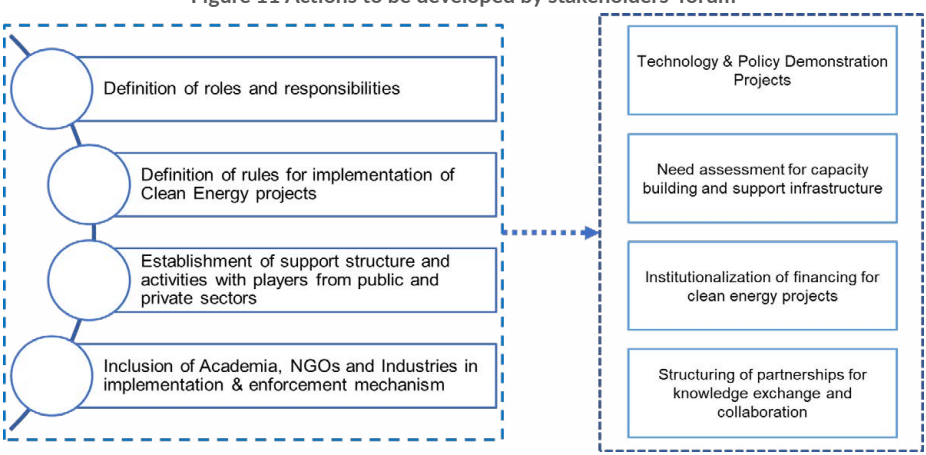
Figure 10 Steps in developing clean energy action plan



The steps mentioned above are similar in a way to the several Missions implemented by Government of India like Smart Cities Mission, AMRUT Mission, etc. The process requires as high level governing committee at the city level with participation from stakeholders at the national and state level policymakers and experts in the clean energy transition, so as to efficiently monitor the execution of the steps in the roadmap.

The stakeholder's forum for clean energy under the leadership of the governing committee is liable to formulate the actions in the further steps. Potential actions to be prepared by the forum is as shown in the figure below:

Figure 11 Actions to be developed by stakeholders' forum



As data shapes the basis for the actions to be prepared, setting up of a data collection mechanism is essential at the municipal administration level or at the user department levels. The climate data collection mechanism can also be setup as a body within the city, which can oversee the data collection for all the climate oriented data parameters. For the fossil fuel consumption indicator, data needs to be collected from the following sources:

1. Collection of Petrol, Diesel, and LPG consumption data from petroleum products distribution companies operating in the city
2. Collection of CNG and PNG data from City Gas Service provider company
3. Vehicle registration data from Department of Transportation
4. Diesel Generators data from the Buildings Department
5. Building Energy Use data from Electricity Distribution Companies (For full scale clean energy action planning)

As the primary data collected can be present with noises, the data collection body need to process the data based on the applicability and use of the data in the action planning. For example, while collecting petroleum products consumption data, cities can delineate the data from the service providers by restricting the fuel dispensing stations within the city limits. Cities can also avoid the stations which are more connected to areas in the roads connected to regional hubs.

The collected data provides an opportunity to identify the potential rectification measures, and their convergence with the on-going initiatives of the local, state and central governments. Data analysis using modern data analytics tools like Microsoft Power Bi (https://powerbi.microsoft.com/en-us/), Tableau (https://www.tableau.com/), etc. can be useful for acquiring insights based on the statistical methods, which can help in arriving at an evidence-based decision making.

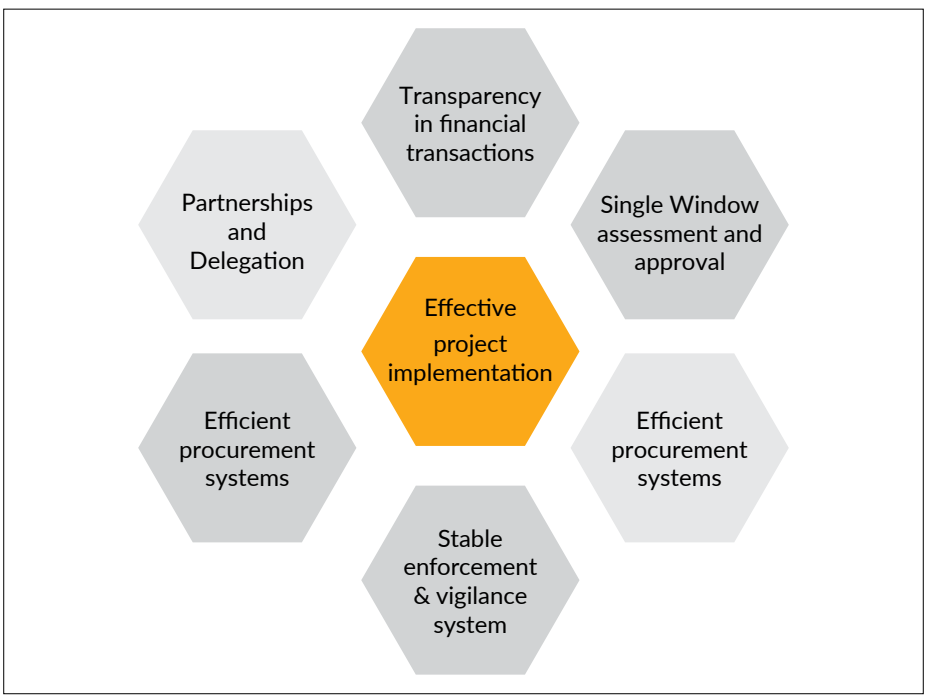
As there is a possibility for lack of data from some of the areal zones within a city, it is important to put in place a citizen engagement forum, where the rectification measures identified can be discussed. With the use of the social media platforms, it is far easier to conduct online surveys, polls and discussion forums with the citizens in the city.

The finalized measures post citizen feedback shall be formulated into actionable project documents. This is a crucial step as there is a need for strong collaboration between the technical, financial and administrative frameworks of the city. Technical experts from individual user departments, administrators, treasury officers, and operational executives will form the major players in this step and develop the techno-commercial and legislative roll-put of the action points. An example of such collaborative framework can be understood from the Sao Paolo City Sustainable Development Programme (Refer to the Report of Localization of Sustainable Development Goals in São Paulo- *https://unhabitat.org/sites/default/files/2021/06/sao_paulo_2020_en.pdf*)

The formulated project documents can be defined with implementation timelines based on the financial plan for the city. Several funding resources including debt, equity, grants and joint implementation development funds can be utilized for the final implementation of the projects in the city.

An effective project implementation and monitoring facility is essential for the city to perform continuous improvements to enhance the clean energy transition. The presence of an innovation and demonstration body like City Innovation Hubs can ensure the implementation of futuristic and reliable technological solutions in the city. The figure indicates the essential forces for effective implementation of clean energy projects in the city.

Figure 12 Implementation components



3

Institutional Framework

India's dependence on imported fossil fuels rising continuously due to the limited domestic petroleum resources. India ranked as the third-largest petroleum consumer in the world following China & the United States. Keeping in view the growing demand of fossil fuel and rapidly growing motor vehicle fleet in India, Govt. of India set a target to reduce 10% reduction on import by 2022.

Fuel Economy Norms for Heavy Duty Vehicles:

According to constant speed fuel consumption (CSFC) protocol, trucks should be driven at constant speed on a test track at 40 and 60 kilometers per hour (kph), and buses are run at 50 kph.

Fuel Economy Norms for Light & Commercial Vehicles:

Passenger vehicle fuel efficiency standards were adapted for LCVs, the fleet average CO_2 target for FY 2018-19 would be 141.6 g/km, or about 1% less.[4]

Bharat Standards (BS) provides the regulations related to tailpipe emissions from vehicles. India has transformed recently from BS IV to BS VI

National Policy on Biofuels – 2018

1. The Policy aims to increase usage of biofuels in the energy and transportation sectors of the country during the coming decade.
2. An indicative target of 20% blending of ethanol in petrol and 5% blending of biodiesel in diesel is proposed by 2030.

Pradhan Mantri Ji-Van Yojana

1. To support the National Policy on Biofuels, the government of India launched this scheme.

[4] *Fuel Efficiency | Bureau of Energy Efficiency (beeindia.gov.in)*

2. The current scheme envisages setting up of 12 Commercial scale Second Generation (2G) Bioethanol projects and 10 demonstration scale 2G Bioethanol projects based on non-food biomass feedstocks and other renewable feedstocks.

Bharat Stage VI

1. Nitrous oxide (NOx) emission will come down by approximately 25% for the petrol engine and 68% for the diesel engines.
2. The Particulate matter (PM) emission will see a substantial decrease of 80% in diesel engines.
3. On-board diagnostics (OBD) will become mandatory for every vehicle, and it will help monitor the pollution caused by the vehicle in real time.
4. Introduction of RDE (Real Driving Emission) that will measure the emission in real-world conditions and not just under test conditions.
5. Norms to change in the way the particulate matter is measured. It will now be measured by number standard instead of mass standard thereby, regulating the fine particulate matter as well.

Vehicle Scrapping Policy

1. Introduction of Vehicle Scrapping Policy with an aim to reduce population of old and defective vehicles, achieve reduction in vehicular air pollutants to fulfil India's climate commitments, improve road and vehicular safety, achieve better fuel efficiency, formalize the currently informal vehicle scrapping industry.
2. It will boost availability of low-cost raw materials for automotive, steel and electronics industry.
3. The policy would cover an estimated 51 lakh light motor vehicles (LMV) that are above 20 years of age, while another 34 lakh LMVs are above 15 years.
4. It would also cover 17 lakh medium and heavy motor vehicles, which are above 15 years, and currently without valid fitness certificates.

National Electric Mobility Mission Plan 2020 (NEMMP)

1. It was introduced towards the creation infrastructure and promoting the use of EVs in India.
2. The mission envisaged Electric and Hybrid vehicle sales in India to reach 6-7 million units by 2020.

Faster Adoption and Manufacturing of Electric Vehicles (FAME) I

1. The key areas of focus included demand creation through upfront subsidy, research and development of pilot projects, and charging infrastructure.
2. Subsidies were also provided for two-wheelers, three-wheelers, passenger vehicles, light commercial vehicles, and busses.

FAME II

1. The subsidy on EVs became applicable to commercial vehicles, public transport vehicles, and two-wheelers.
2. 2,700 charging stations were planned to be set up across different locations in tier-1 cities.

3.1. International examples- California Policy Roadmap

3.1.1. Light-duty vehicles

1. According to the regulation of 2004, automakers have to produce vehicles that, on average, reduce GHG by about 30% from 2002 levels by 2016 by increasing efficiency with improve vehicles technology.
2. In 2012, California updated the zero-emission vehicle (ZEV) program that requires increasing production of plug-in hybrid, battery electric, and fuel-cell electric vehicles from 2018 to 2025.

3.1.2. Heavy-duty vehicles

1. California Air Resources Board (CARB), in September 2000 recommended several control measures to achieve a goal of 75 percent PM reduction by 2010 and 85 percent by 2020.
2. In 2004, CARB adopted the Solid Waste Collection Rule to reduce emissions from solid waste collection vehicles.
3. In 2005, CARB approved the Fleet Rule for Public Agencies to reduce diesel PM emissions from fleets operated by public agencies and utilities.
4. In 2008, California adopted new GHG regulations to reduce emissions through the fuel efficiency improvement of tractor-trailers.
5. In 2018, CARB adopted the Innovative Clean Transit Regulation, requiring all public transit agencies to gradually transition to a 100% zero-emission bus fleet and encouraging them to provide innovative "first and last-mile connectivity" and improved mobility for transit riders.[5]

[5] *https://database.aceee.org/state/tailpipe-emission-standards*

Photo credits: Ather energy

4

Case Study

4.1. Växjö-Fossil Free City

A small city of Sweden with less 100,000 residents is on its way to become fossil free by 2030. Växjö also has a goal of achieving carbon neutrality (net zero GHG emissions) by 2050.

Renewable energy, energy efficiency, and urban planning are three of several high-priority methods the city has focused on to achieve a fossil-fuel-free Växjö. The fossil-fuel-free Växjö programs includes:

1. Use of biomass for district heating,
2. Renewable energy, mostly from biomass, for power generation,
3. Urban planning that reduces the need for cars,
4. An increase in the use of electric and biofuel cars/ buses
5. And the use of advanced construction techniques to produce green buildings throughout the city.

4.1.1. Description of the initiative

Växjö is expanding its sustainable low emissions transit, has a 150km bike-path system and a bus fleet running on biogas from waste.

Biomass, biofuel, and biogas, powers the municipality of Växjö, city buildings, residences, and public transit. Biogas from Växjö's biomass power plant is processed into liquefied natural gas (LNG) or compressed natural gas (CNG) for public transportation. Low emission Växjö city buses run on biogas/ LNG/ / CNG/ biodiesel/ or are hybrid electric + biofuel.

Växjö's biomass production has a low environmental impact; making good use of waste from the city's primary industry; forestry. Production of energy from biomass, and biofuel for cars/ buses, are main components of the fossil-fuel free plan.

Municipality of Växjö ensures that forestry waste is transformed into biomass energy, which supplies about 40% of the electricity and an estimated 80% of heating for the city. Växjö sources most of its district heating from one biomass combined heat and power (CHP, also referred to as cogeneration) plant.

Sandvik II, biomass combined heat and power plant

Another part of the plan includes the installation of solar panels in homes, municipal buildings, and industry buildings. Växjö derives over 50% of its energy from local renewables.[6]

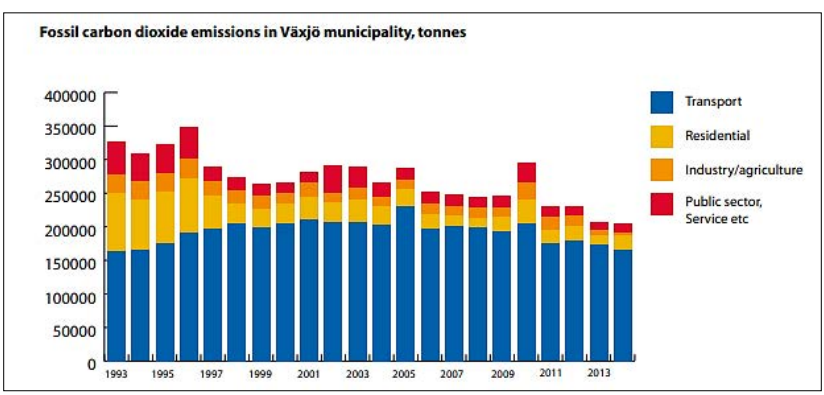
Växjö plans to become carbon-neutral, by using passive building techniques throughout the city. All-timber construction, the use of the latest insulation technology, as well as individual smart metering of heat, water, and electricity; are some of the ways in which energy efficiency is prioritized in new construction in Växjö.[7]

In addition to energy efficient means in construction, Växjö prioritizes renewable energy generation (solar, geothermal, biomass) in its new buildings; so that some of Växjö's new buildings are plus energy (generating more energy than the building consumes)

4.1.2. Achieved Milestone

1. Total CO2 emissions dropped by 24% till 2005.
2. Every inhabitant reduced their emissions by 30%, emitting just 3,232 tons of CO2 annually by 2006
3. Heating-In 2006 nearly 88% of heating came from renewable energy sources (total 877 GWh)
4. In 2014, 60% of the energy consumption was based on renewable energy sources such as biomass, hydropower, geothermal and solar energy.
5. The CHP (combined heat and power) plant generated 128 GWh (19%) of electricity in 2014.
6. By 2025, the city aims to be 70% CO2-free[8]

Fig 13: Fossil carbon dioxide emissions in Vaxjo municipality, tonnes



[6]*Green City: Vaxjo, Sweden | Green City Times*

[7]*Vaxjo Passive House Construction | Green City Times*

[8]*Växjö - Fossil Fuel Free City - Copenhagen Centre on Energy Efficiency (unepdtu.org)*

4.1.3. Financial aspects

1. In 1997, the Swedish government allocated €600 million for local environmental initiatives under its Local Investment Program (LIP)
2. EU provides financial support for national and municipal environmental programs, for instance, SESAC (Sustainable Energy Systems in Advanced Cities). SESAC funded projects in Växjö including energy efficient buildings and passive houses constructed from sustainable wood, biomass for district cooling, photovoltaics, pedagogic systems to educate residents in reducing energy use, and transfer of best practices. [9]

4.2. Adoption of Non-Motorized Transport Policy, Chennai

The Chennai Corporation's Council adopted a progressive non-motorised policy in October 2014 to make walking and cycling its priority. The policy aims to arrest the current decline in walking and cycling in the city by creating safe and pleasant network of footpaths, cycle tracks, greenways and other NMT facilities. Walking and cycling infrastructure—that until recently was at best an afterthought—will now take centre stage. The policy mandates that a minimum of 60 percent of the Corporation's transport budget is allocated to construct and maintain NMT infrastructure—a clear demonstration of the Corporation's commitment to creating safe streets that consider the needs of all users.

Photo credits: Pedestrian infrastructure in Chennai, ITDP India

[9] *Växjö, Sweden: The Greenest City in Europe | CRC Research*

Phot credits: Smart Bike Bicycle rental stand in Chennai, GCC Twitter

The city has set for itself ambitious goals: by 2018, build safe and continuous footpaths on at least 80% of all streets, increase the share of walking and cycling trips to over 40%, and, most significantly, eliminate pedestrian and cyclist deaths. The Corporation aims to achieve these goals by mandating various measures through this policy. (Refer to the policy through this link: https://itdp.in/wp-content/uploads/2014/10/NMT-Policy.pdf)

4.3. CNG Auto Rickshaw Program, Rourkela

Rourkela introduced CNG vehicles in the three-wheeler category in 2019. The program was formed through the implementation of "Comprehensive Action Plan for Non-Attainment Cities in Odisha" by State Pollution Control Board of Odisha.

Using the Urja Ganga Project, which provides pipelined natural gas delivery to several urban centres across India, the City of Rourkela initiated the program to convert its auto rickshaw fleet from Diesel as a fuel to CNG. Around 20 CNG Pumps were created across the city as the part of Urja Ganga project implemented by Gas Authority of India Limited (GAIL). Following the establishment of the CNG Pump infrastructure, the city administration setup an incentivization program for exchanging old petrol/diesel three wheelers.

This initiative can lead to reduction in emissions by auto rickshaws to up to 20% (Freightliner.com - https://freightliner.com/blog-and-newsletters/the-benefits-of-compressed-natural-gas-vs-diesel/).

Photo credits: E-rickshaw pilot, Udaipur, ICLEI South Asia

5

Interactive Exercise

The exercise introduces the steps to be taken for calculating the city's performance in fossil fuel consumption as per CSCAF. Consider a city 'A' that a population of 5,79,000 and consumes fossil fuels as given in the table.

Table 2 Fossil Fuel consumption in city.

Fuel	Quantity	Unit
Diesel	17,940	Kilolitres
Petrol	17,904	Kilolitres
LPG	8,942.4	Metric Tonnes
CNG	8,01,163	Standard Cubic Metres
PNG	28,80,000	Standard Cubic Metres

Step 1 - The first step is to standardize the units to kilolitres. The standard conversions are provided in the table.

Table 3 fuel consumption in the units required for the calculation.

Fuel	Quantity	Unit	Factor for conversion to kilolitres
Diesel	17940	Kilolitres	
Petrol	17904	Kilolitres	
LPG	4968	Kilolitres	Metric Tonnes of LPG/1.8 (1 kg of LPG = 1.8 litres)
CNG	440640	Kilolitres	Standard Cubic Metres/1.818
PNG	1872000	Kilolitres	Standard Cubic Metres/1.538

Table 4 CSCAF units to be used for CO2 per kilolitre

Fuel	Tons of CO_2 per kiloliter
Diesel	2.62694
Petrol	2.20307
LPG	1.51906
CNG	0.48066
PNG	0.48066

Step 2 - Referring to all the tables, calculate CO@ emissions for each of the fossil fuels.

1. Emissions from Diesel = 17940 (kiloliters) * 2.62694 (Tons of CO2 per kiloliter) = **47,127 Tons of CO2 emissions**
2. **Emissions from Petrol** = 17904 (kiloliters) * 2.20307 (Tons of CO2 per kiloliter) = **39,444 Tons of CO2 emissions**
3. **Emissions from CNG** = 440640 (kiloliters) * 0.48066 (Tons of CO2 per kiloliter) = **211,798 Tons of CO2 emissions**
4. **Emissions from LPG** = 4968 (kiloliters) * 1.51906 (Tons of CO2 per kiloliter) = **7,546 Tons of CO2 emissions**
5. **Emissions from PNG** = 1872000 (kiloliters) * 0.48066 (Tons of CO2 per kiloliter) = **899,795 Tons of CO2 emissions**

Step 3 – Calculate total emissions

1. Total Emissions = **47,127 + 39,444 + 211,798 + 7,546 + 899,795 = 1,205,710 Tons of CO2 emissions**

Step 4 – Calculate per capita emission using the formula shown

1. Per capita emissions in the city = Total emissions / Population

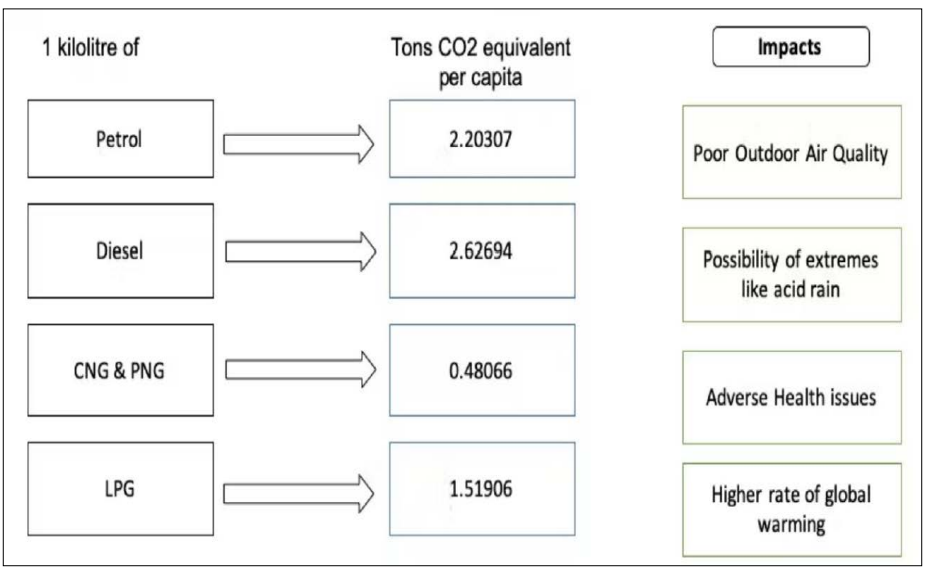
   = **1,205,710 / 5,79,000**

   = 2.08 Tons per capita

As per CSCAF performance evaluation, the city 'A' comes under Level 5 'champion' category.

5.1. Interactive exercise on the impact of fossil fuels

5.1.1. Please rank the fuels based on their GHG emissions in ascending order, based on the information from the image below.



Answer: CNG & PNG, LPG, Petrol and Diesel

5.1.2. Estimation of emissions from vehicles

A Diesel car in a year travels around 12,000 kilometres. If the fuel efficiency of the vehicle (Mileage) is 15 kilometres per litre of fuel, find out the CO2 equivalent emissions by the car. (Emission factor of Diesel = 2.62694 Tons CO2 equivalent emissions per Kilolitre of diesel).

Option A: 3.1 Tons
Option B: 10.4 Tons
Option C: 2.2 Tons
Option D: 2.8 Tons

Solution:
Use the formula below:
CO2 equivalent emissions = {Distance travelled / (Fuel Efficiency * 1000)} * CO2 emission factor of diesel

Answer: Option C- 2.2 Tons

5.1.3. Selection of mode of transport

Please select the best option for transporting 220 people over 20 kilometres everyday

100 diesel engine cars with fuel efficiency of 15 kilometres per litre
100 CNG engine cars with fuel efficiency of 29 kilometres per litre
4 buses with fuel efficiency of 5 kilometres per litre

Solution:
Estimate the emissions from each mode of transport in the options using the formula from the exercise above.

Diesel Cars – 127.8 Tons
CNG Cars – 62.9 Tons
Buses – 15.34 Tons

Answer: 4 buses with fuel efficiency of 5 kilometres per litre

5.1.4. How does Transport Oriented Development help reduce fossil fuel emissions? [Checkbox]

Option A: By reducing the necessity for motorized transport
Option B: By reducing travel costs
Option C: By increasing electrical vehicles
Option D: By maintaining high efficiency transport

Answer: Option A

6

List of additional materials

6.1. Technical documents

1. Renewable Energy Pathways for Road Transport by REN21 and FIA (*https://www.fiafoundation.org/connect/publications/renewable-energy-pathways-in-road-transport*)
2. Bureau of Energy Efficiency Fuel Consumption Standards *https://beeindia.gov.in/content/fuel-efficiency*
3. Urban Transport in India – Challenges and Recommendations (*https://iihs.co.in/knowledge-gateway/wp-content/uploads/2015/07/RF-Working-Paper-Transport_edited_09062015_Final_reduced-size.pdf*)
4. Policymaking Towards Green Mobility in India (*https://www.orfonline.org/research/policymaking-towards-green-mobility-in-india/*)
5. Sustainable Urban Transport in India by World Resources Institute (*https://www.wri.org/research/sustainable-urban-transport-india*)
6. Carbon Neutral Adelaide Action Plan (*https://d31atr86jnqrq2.cloudfront.net/docs/shared-vision-statement-carbon-neutral-adelaide.pdf?mtime=20190620170059&focal=none*)

6.2. Relevant videos

1. Fossil fuels, explained (https://www.nationalgeographic.com/environment/article/fossil-fuels#:~:text=Decomposing%20plants%20and%20other%20organisms,percent%20of%20the%20world's%20energy.)
2. Cities Rise to the Challenge – Sustainable Mobility by WWF (*https://www.youtube.com/watch?v=8Fj2ARn1WMY*)
3. Sustainable Energy: The changing face of urban mobility, by CNBC International TV (*https://www.youtube.com/watch?v=OcQ12Mf7Ew4*)
4. Urban Energy Transitions: A Clean Electrified Future | COP26 | Accenture (*https://www.youtube.com/watch?v=D7BaSlraJKE*)
5. Implementing Climate Action Plans by Municipal Climate Change Action Centre (*https://www.youtube.com/watch?v=RF7R9v6yVHY*)

6. Carbon Neutral Adelaide Action Plan (*https://vimeo.com/519769808*)
7. Climate Change and Cities: Learning Series | Session 7: Inclusive Climate Action Planning by WRI India (*https://www.youtube.com/watch?v=nyUqt9qioRc*)
8. Climate Change and Cities | Session 9: Local Climate Action – Plan, Prioritization & Market Outlook by WRI India (*https://www.youtube.com/watch?v=mD9mtmVwRkc*)

6.3. Toolkits:

1. Non-Motorized Transport Toolkit by ITDP (*https://nmttoolkit.itdp.org/guide/resources/*)
2. Fuel Economy Toolkit (*https://www.globalfueleconomy.org/toolkit*)
3. Smart Growth / Smart Energy Toolkit Modules - Smart Energy (*https://www.mass.gov/service-details/smart-growth-smart-energy-toolkit-modules-smart-energy*)
4. US EIA Electricity generation and carbon emissions FAQ (https://www.eia.gov/tools/faqs/faq.php?id=77&t=11)

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सत्यमेव जयते

Ministry of Housing and Urban Affairs
Government of India