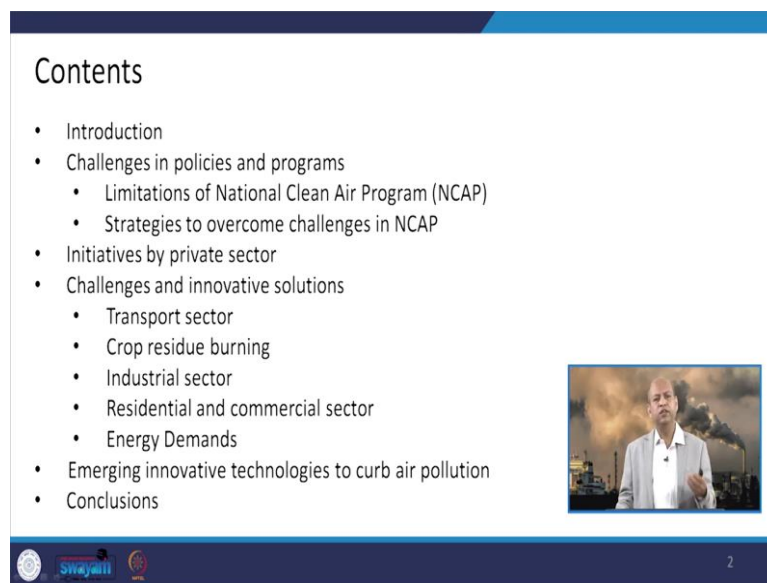


Air Pollution and Control
Professor Bhola Ram Gurjar
Department of Civil Engineering
Indian Institute of Technology, Roorkee
Lecture – 54
Challenges and the Way Forward

Hello friends. So, far we have discussed various aspects of air pollution and how to control it. So, like different kinds of sources from different sectors, how dispersion of air pollution occurs, how do we monitor air quality, how do we model it, what are its effects, all aspects of air pollution and control we have discussed.


So, today's lecture is basically concluding lecture, but in that lecture, we will also look into various challenges to address the issues related to air pollution and also the way forward means the new solutions which are coming up to deal with the air pollution related problem.


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Contents

- Introduction
- Challenges in policies and programs
 - Limitations of National Clean Air Program (NCAP)
 - Strategies to overcome challenges in NCAP
- Initiatives by private sector
- Challenges and innovative solutions
 - Transport sector
 - Crop residue burning
 - Industrial sector
 - Residential and commercial sector
 - Energy Demands
- Emerging innovative technologies to curb air pollution
- Conclusions





2

So, in this lecture basically, this is the content, which we will discuss today like brief introduction about the problem. And then, we will look into several challenges which are in terms of policies or programs focused on air quality improvement or reduction of air pollution emissions.

So, in that context, we will look into Limitations of the National Clean Air Program which is a big national level program in India. And then we will also look into some strategies which are needed to overcome those challenges which are related to NCAP. Then we will see some initiatives which have been taken by private sector to improve the air quality and to reduce the air pollution.

Then we will focus on challenges and innovation solutions or innovative solutions, which are focused on different sectors like transport sector or crop residue burning or industrial sector, then residential and commercial sector, then related to energy demands what are the new challenges and how to tackle those challenges. Then we will see into like emerging innovative technological solutions to curb the air pollution and after that we will conclude.

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So, if we look into this year pollution as this is a problem not of the local scale, but regional and global scale also and if we look into this air pollution related problem and link it with the health risk, which we have discussed in detail in several lectures basically. So, this is one of the key critical parameters or important parameters, which is related to human health as well as the environmental issues.

So, it has been like this air pollution has been ranked as one of the top five global risk factors of mortality by the health effects of this the data which was analyzed by the Health Effects Institute in Boston, Massachusetts, and the global ranking of risk factors by total number of deaths from all causes in 2017 are given in this particular chart. And you can see at the fifth location or fifth rank, this air pollution is there, which has significance in terms of human health effects and environmental health effects.

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Introduction (2/2)

- The continuous degradation of ambient air quality in the urban centres of India demands effective measures to curb air pollution.
- In India's context, the lack of infrastructural facilities, inadequacy of financial resources to implement advanced technological innovations, difficulty in relocation of the industries from the urban centres are some of the crucial obstacles on the road to environmental protection.



Source: <https://blogs.worldbank.org/>


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Challenges in policies and programs

National Clean Air Programme (NCAP)

- Government has undertaken many significant steps to curb air pollution, examples includes:
- An advanced approach with focused time bound initiatives at both city and rural level was required to tackle air pollution.
- In this context, the need for a National Clean Air Programme (NCAP)-India as national level strategies for reduction in air pollution levels at both regional and urban scales was felt.

- ✓ National Ambient Air Quality Standards
- ✓ CNG, LPG and ethanol blending
- ✓ Leapfrogging from BS-IV to BS-VI
- ✓ Banning of biomass burning
- ✓ Air Quality Index (AQI)



Source: <http://www.indiaenvironmentportal.org.in/files/file/NCAP.pdf>

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If we talk about like, what is the region and the region is so, many emissions from fossil fuel burning and continuous degradation of air quality, because of those emissions from various activities, which are related to burning of fossil fuels and using those kinds of sectors based on fossil fuel burning.

So, if we look into the regions in Indian context, there are several regions for this air pollution, emissions and degradation of air quality and they may be related like infrastructural facilities, which are quite limited in terms of quality, although slowly as economy is growing, so, infrastructure facilities are also growing, but over the past several decades, the regions which are linked with air pollution, emissions and degradation of air quality are linked with infrastructural facilities.

And in inadequate amount of financial resources, which are required to do something to intervene in terms of better technology, better policy measures, implementations of several programs to improve the, this ambient air quality.

And there are difficulties in relocating industries from, cities to other places, because it requires a lot of resources and there are limitations in resource allocation. So, there are several regions which are in terms of challenges, you can perceive that and can we address those challenges in a very judicious way so, that we can do those interventions and improve the air quality.

If we look into policies and programs related challenges so, one example is National Clean Air Program (NCAP) basically and before that government of India and state governments as well as other agencies, which are concerned about air quality improvement, they have taken they have taken so, many steps to curb the air pollution basically like National Ambient Air Quality Standards (NAAQS) were prescribed time to time then CNG LPG or ethanol blending related policies were implemented.

There are like leapfrogging from BS-IV to BS-VI that was great decision. So, that rather than going from BS-IV to BS-V we could go directly to BS-VI so, that we can have stringent norms and that way very less amount of air pollution emissions from transport sector to improve the air quality then there was like burning of this biomass and air quality indices related issues or ways to manage the air quality in and around urban areas.

So, there have been several ways and policies and programs, but an advanced approach which could be focused on time bound initiatives, so, that we could fulfill those requirements in a time bound manner. And for both cities and rural areas, we could address the air pollution related problem. So, that need has been felt basically.


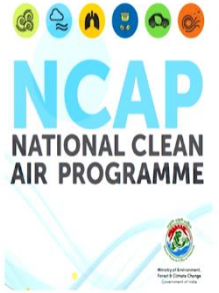
So, in this context the need for National Clean Air Program (NCAP) India as a national level strategies for reduction in air pollution levels at both regional and urban scale, it was felt very seriously.

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Challenges in policies and programs

National Clean Air Programme (NCAP)

- National Clean Air Programme (NCAP) was launched in early 2019.
- It sets a national level target of 20-30% reduction of $PM_{2.5}$ and PM_{10} concentration by 2024, with respect to 2017 as the base year.



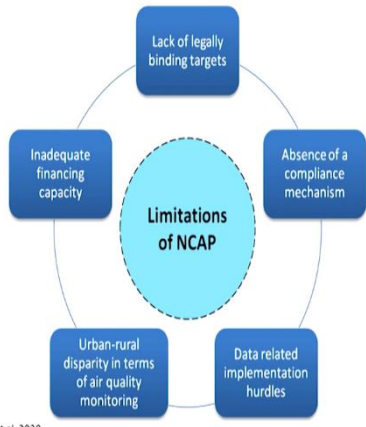
Source: Roy et al, 2020

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So, that is the reason this National Clean Air Program (NCAP) was launched in early 2019 with the focus on reducing these emissions or these $PM_{2.5}$ and PM_{10} concentrations by 20 to 30 percent reduction to achieve this target by 2024 with respect to the their levels in 2017. So, this was decided and it was implemented at a larger scale.


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Limitations of NCAP (1/5)



According to report published by **Observer Research Foundation (ORF)** on September 2020, the following limitations were observed in NCAP program.

Link for the report:
<https://www.orfonline.org/research/finding-solutions-to-air-pollution-in-india-the-role-of-policy-finance-and-communities-74311/>



Source: Roy et al, 2020

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But several limitations have been observed in case of NCAP like according to the report, which was published by Observer Research Foundation (ORF) on September 2020. The following limitations were observed in this particular program, which is of national scale like lack of legally binding targets are there means targets are there.

But if suppose, we do not achieve those targets then is there any penalty or other legal issues, those things are missing basically, then absence of a compliance mechanism that how to see whether it has been compliant or not or how to achieved those compliance then data related implementation hurdles are also felt, then urban and rural disparity in terms of air quality monitoring is there.

So, many air quality monitoring stations are concentrated in only urban centers or urban areas in cities, but rural areas are not covered by them. So, there is a big disparity in that sense. So, you do not know what is the air quality of rural area is basically, if you look into rural and urban air quality. Then there are inadequate financial resources for doing for implementing certain programs or having certain technological interventions to improve the air quality.

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Limitations of NCAP (2/5)

- 1. Absence of a legal mandate**
Due to absence of a legal mandate, there is a delay in implementation of the NCAP action plan to achieve its targets.
- 2. Absence of a compliance mechanism**
 - Lack of accurate, independent and easily accessible data on emissions creates hurdles in ensuring compliance to standards and law enforcement.

Source: Roy et al, 2020; NCAP, MoEFCC, 2019

So, there are limitations which have been, discussed here, like one by one absence of legal mandate, because of this absence of a legal mandate, there is a delay in implementation of NCAP action plan to achieve this target because, it is not a kind of legal binding.



So, if even if it is delayed people feel okay we can look into in another way around. Absence of compliance mechanism is also there like lack of accurate or independent and easily accessible data on emissions, which create hurdles in ensuring compliance to standards and law enforcement. So, this is also one gap or limitation.

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Limitations of NCAP (3/5)

2. Data related implementation hurdles

- The data-related implementation hurdles include the lack of appropriate methodology to monitor real-time data for reporting trends, and data cleaning methods to fill the gaps (missing/ inaccurate data) in the monitoring system.




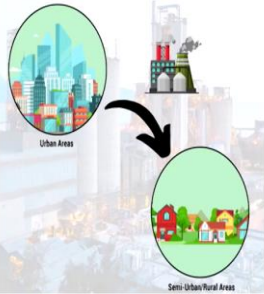
Source: Roy et al, 2020

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Limitations of NCAP (4/5)

3. Urban-rural disparity in terms of air quality monitoring

- There is still relatively sparse knowledge on difference in terms of air quality in the urban-rural areas.
- This means that only a small section of the country's population is closely being monitored for air pollution, with one monitoring station for every 6.8 million people.



Source: Roy et al, 2020, Image: <https://www.aqi.in/>

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Then there are data related implementation hurdles. Because this includes like lack of appropriate methodology to monitor real time data for reporting several trends and data cleaning methods to fill the gaps, which are related to missing accurate data in the monitoring system.



Of course, there are ways like statistical tools are also there and various agencies are using them, but it is still it was felt in this report they say that data related implementation hurdles are there. Then, urban and rural disparity in terms of air quality monitoring is huge and it requires a lot of resources to put in air quality monitoring stations in rural areas. So, that this disparity can be filled in or addressed properly.

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Limitations of NCAP (5/5)

5. Inadequate financing capacity

- Although various policy measures are formulated for pollution abatement, they still lack financial capabilities.
- Allocations for “Control of Pollution” have increased slightly, from Rs 460 crore last year (Budget, 2020-2021) to Rs 470 crore this year (Budget, 2021-2022). The environment ministry itself had projected a need for Rs 660 crore under this line item for 2020-2021 and Rs 550 crore for 2021-2022.



Source: Roy et al, 2020, Demands for Grants (2020-21, 2021-22), MoEFCC.

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Then inadequate financial capacity are there because like various policies and programs are, framed and implemented, but to achieve the targets sometimes there is a need for that much of financial resources which are not available.

For example, allocation of control of pollution have increased the funds for control of air pollution, from 460 Crore last year of 2020 to 2021 budget to 470 crore. So, this is a very slight increase otherwise, this need or estimated budget was like 660 crore in 2021 and this 550 crore in 2021-2022. But it was not met means there is a little bit gap in those projected amount of the financial resources and the allocation which was given.


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Strategies to overcome challenges in NCAP

- To make the NCAP more functional and focused, useful tools such as the **NCAP Tracker** have been developed.
- CarbonCopy and Respires Living Sciences introduced the NCAP Tracker – an online hub for the latest updates in India’s clean air policy.
- The tracker **compiles and analyses** information on air quality and budget allocation that is publicly available or provided by the Government of India.



Link: <https://ncaptracker.in/>



Source: <https://ncaptracker.in/>

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Then we can look into now strategies to overcome the challenges or some other challenges. And like there have been several initiatives in terms of let us NCAP tracker. So, this is basically carbon copy and raspier living sciences both have joined hands to launch the NCAP tracker. So, this Tracker basically compiles and analyze the information on air quality and budget allocation to tackle the air quality related programs. So, that is available publicly and they process those data and then they give some information about that.


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The slide is titled "Initiatives from private sector" and contains two bullet points. The first bullet point states: "Apart from government initiatives, there is also a need for the private sector to contribute towards green business and climate financing." The second bullet point states: "Private sector's role is important in designing and financing bold, cutting-edge innovations and unique technology solutions to address the challenge in air pollution." To the right of the text is a graphic of a lightbulb with a blue sky and white clouds inside, and the text "Clean air innovations" below it. Below the lightbulb is a small video thumbnail showing a man in a white shirt standing in front of an industrial facility with smokestacks. At the bottom left of the slide, there is a source citation: "Source: Roy et al, 2020. Image: <https://www.unicef.org/serbia/en/clean-air-challenge>". At the bottom center, there are logos for "Swayam" and "UNICEF". At the bottom right, the number "13" is displayed.

Apart from government initiatives private sector has also come forward with several initiatives to improve the air quality basically. And this private sectors role is very important in designing and financing also those programs, cutting edge innovations and unique technology solutions, which can be used for addressing the challenges in air pollution. So, those initiatives are also very important and we will discuss a few of them.

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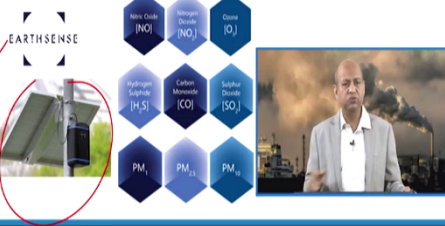
Initiatives from private sector: Example 1



IKEA introduces FORÄNDRING, a collection based on rice straw

- IKEA, a Swedish multinational group specializing in furniture and home accessories launched the 'Better Air Now' initiative with the aim to turn rice straws into raw material.
- IKEA's innovative solution showcases the potential of repurposing a waste product into an economically viable resource that reduces air pollution.

- Siemens Mobility Ltd has partnered with air quality experts EarthSense to provide the Zephyr® air quality measurement system.
- Zephyr sensors: Traffic related air quality measurements in real-time to identify pollution hotspots.



Source: <https://about.ikea.com/>

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For example, IKEA which is a Swedish multinational group, which is having a specialization in furniture and home accessories, it has launched better air now, initiative with the aim to the turn rice straws into raw material for making furniture. So, this particular new initiative of IKEA, it has kind of showcase the potential re-purposing a waste product otherwise which if it is burned, then it will emit a lot of emissions.



So, economically viable resource and it can reduce air pollution. So, both ways means financially it is beneficial as well as it is affecting very less amount of the environment because it is reducing the air pollution emissions. Then similarly, like Siemens mobility Limited has partnered with the air quality experts Earth Sense to provide this Zephyr. This is an air quality measurement system basically, related to traffic.

So, the sensor based system you can see here sensors and different kind of pollutants which it measures. So, that traffic related air quality measurements in real time live to identify the pollution hotspots so, that traffic can be diverted, if a particular hotspot is there so reduce the air pollution or improve the air quality there you can divert the traffic. So, this traffic management system, Air Quality Management System has been launched.

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Initiatives from private sector: Example 2

- Private sector can improve air quality is via investments made through the **Corporate Social Responsibility (CSR)** route.
- The CSR guidelines, which came into effect on 1 April 2014, state that **companies** with a **net worth INR 500 crore or revenue INR 1,000 crore or net profit of INR 5 crore** should **spend 2 % of their average profit** in the last three years on **social development-related activities** such as education, healthcare, poverty alleviation and **environmental sustainability**.



Source: <https://www.mca.gov.in/>, Image: <https://mobisoftinfotech.com/>

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Then, there are other examples like through corporate social responsibility CSR, many industries are coming forward to invest money for innovative solutions basically and there are guidelines of the CSR you might be knowing that like the companies with a net worth of 500 crore or revenue of 1000 crore rupees and net profit of 5 crore they have to spend 2 percent of their average profit.

So, that they can support or sponsor the programs for several activities like education, health care, poverty alleviation and environmental sustainability also. So, within the framework of environmental sustainability initiatives can be taken into improving the air quality.

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Initiatives from private sector: Example 2

- A notable CSR initiative to improve air quality is the **“Creating Oxygen Hubs”** drive, launched by **Cummins India Limited in Pune, Maharashtra**.
- As per 2013–14 reports **City of Pune emits 46 lakh tonnes of carbon in one year**. This directly affects level of oxygen in the environment.
- Cummins India Ltd. decided to fight against this pollution and started spend CSR funds for **“Creating Oxygen Hubs”** i.e. (**Converted Non Forest land to Forest**).



Source: <https://medium.com/@mycsrbox/10-green-csr-projects-by-indian-companies-a05538b0b81a>, Image: <https://csrbox.org/>



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So, in that way one more example is very good in terms of like CSR contribution, one company Cummins India Limited in Pune. They have invested lot of money through CSR to create oxygen hubs. Basically, these oxygen hubs are nothing but converting non forest land into forest area so, that the greenery can absorb the CO₂ and they can produce oxygen. So, those kinds of initiatives are coming in a very innovative way.

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Initiatives from private sector: **Example 2**

- **MATS Institute of Management and Entrepreneurship (MIME)** has been conducting various activities through its **CSR Club** to contribute to this wonderful initiative.
- The **tree plantation program** was organized in **Madiwala Lake, BTM Layout, Bengaluru**, in collaboration with Eco-Watch and Weather seal on a mission **"to build oxygen hubs"** on 10 July 2018.
- This contributes towards creating a carbon sink and increasing green cover.



Source: <https://www.mime.ac.in/On-a-mission-to-build-oxygen-hubs.php>; Image: <https://csrbox.org/>

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Now, then there are like tree plantation related initiatives in Bangalore, some companies are coming up. So, to build oxygen hubs in that way means when we increase the greenery naturally capacity to absorb or sequestration of carbon increases, and to emit lot of oxygen is also one way with these kinds of initiatives. So, this contributes towards creating a carbon sink basically and increasing the green cover as well as producing a lot of oxygen.

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Challenges in transport sector (1/3)

The infographic illustrates four key challenges in the transport sector. At the top center, a carpooling icon is labeled 'Growth in number of private vehicles'. To the left, a traffic jam icon is labeled 'Severe congestion'. To the right, a cloud of pollutants (NOx, SO2, PM, CO, HC) is labeled 'Deteriorating Air quality'. At the bottom center, a car emitting a CO2 bubble is labeled 'Increasing Greenhouse gas (GHG) emissions'. A central figure with a question mark is labeled 'Challenges in transport sector'. A small video inset shows a speaker. Source: (Intelligent Transport, 2016). Logos for Swayam and other institutions are at the bottom.

Then there are sector based challenges like if we consider transport related sector. So, there are several challenges for example, privately owned vehicles are increasing, we have discussed in several policy measures like how to reduce privately owned vehicles and promote the public transportation system.

Then there are like deteriorating air quality which is a big in urban areas, big issue related to air pollution emissions from transport sector. Then increasing greenhouse gases as well because greenhouse gases and air pollution emissions are together. So, they are related to this transportation sector because congestion increases, then emissions also increases. So, we have to address those transport sector related challenges.

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Challenges in transport sector (2/3)

Distribution of greenhouse gas emissions from the transport sector in India in 2014, by type

- Road transportation contributes to over 90% of GHG emissions from the Transportation sector in India (2014).

Transport Sector	GHG emissions (Gg CO ₂ e)
Road Transport	225,155.51
Civil Aviation	14009.68
Railways	7775.36
Water borne Navigation	3002.1
Total	250172.79 Gg CO ₂ e

Source: (MoEFCC, India, 2014). Logos for Swayam and other institutions are at the bottom.



And like 90 percent of greenhouse gas emissions is emitted from road transportation basically, if we consider within the transport sector related GHG emissions. If we focus on road transportation emissions, we can really help in improving air quality by reducing air pollution emissions from the road transportation or vehicles which are applying on the roads.

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Challenges in transport sector (3/3)

Declining share of Public Transport

- The share of public transport is just 18.1% of the total work trips.
- In 2015 the number of daily trips using a motorcycle for commuting was 35 million (excluding personal trips)
- More people use motorcycles than travel by bus (22.9 million)



Source: (Intelligent Transport, 2016)

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So, like declining share public transport is a worry some issue because it is just 18.1 percent of the total work trips basically in 2015 number of daily trips using a motorcycle for commuting was 35 million excluding personal trips. So, more people use motorcycle then they travel by bus.

So, that means there is a huge scope if you can transfer that population from two wheelers to these public transportation of buses etc that way we can reduce lot of emissions which are coming from two wheelers basically.

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Way forward in transport sector

Future Bus Technology

- GOI launched the full indigenous retro-fitted electric buses with hybrid technology, converting existing conventional fuel buses into electric buses.
- Main hindrance to this adoption of new technology was the financial implication and capital cost.
- The average cost of a hybrid bus in India is around INR 23 million, compared to INR 9 million for a premium diesel bus.

Source: (Intelligent Transport, 2016)



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Now, the way forward if we look into in transport sector, so, Government of India has launched this full indigenous retrofitted electric buses and with hybrid technology also which are converted existing conventional fuel buses into electric buses. So, this is a new policy, but main hindrance is there to this adoption of new technology and this is because of less availability of financial resources basically and capital cost is also very high.

Because, if you compare like the average cost of the hybrid bus in India is at present around 23 million rupees compared to 9 million for premium digital bus. So, huge difference is there. But it is expected that the way fuel prices are increasing and the way government is investing lot of resources to increase the renewable resources of electricity. So, that way maybe in future we can reduce this gap and popularity of buses can increase, electric buses.

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Way forward in transport sector

- **Non-Motorized Transport (NMT)** in India mainly includes walking, cycling and cycle rickshaws.
- Green modes of transport
 - Low Carbon footprint
 - Minimal energy consumption
 - Zero local emissions
 - Inexpensive compared to motorized transport
- NMT has immense health benefits
- Unfortunately, NMTs are still neglected as a mobility option in favour of capital and infrastructure intensive modes of transport.



Source: [NTDCP Final Report, 2013]

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Then, there are like scope, huge scope is there to motivate people to go for non-motorized transport like walking or cycling or using this rickshaw, cycle, etc, which emit zero emissions basically only you need to have those infrastructure which can help them to have a comfortable journey in that way like dedicated lanes etc.

But, unfortunately these NMTs or non-motorized transport are still neglected as a mobility option in favor of capital and infrastructure intensive modes of transport, like lot of investment is there on metros etc but very less investment is there in these low hanging fruits which are related to NMTs non-motorized transport sector.


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Way forward in transport sector

- **Non-Motorized Transport (NMT): Example**




- **Netherlands**
 - Separate bus and bicycle lanes through an intersection in Utrecht, The Netherlands.



Cycle lanes only, Amsterdam

- **Amsterdam**
 - Exclusive cycle lanes in Amsterdam



Separated Cycle Path at Highway, Auckland, NZ

- **Auckland**
 - Separate cycle path at Highway, Auckland, New Zealand



Source: <https://www.unescap.org/sites/default/files/3.3%20NMT%20Planning%20for%20Urban%20Areas%20-%20GIZ.pdf>

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But if you look into like in foreign countries, huge infrastructure has been developed. So, we should learn because, there is nothing wrong in learning from best practices around the world. In Netherland separate bus and bicycle lanes are there through even these intersections. Exclusive cycle lanes are there in Amsterdam and Netherland.

Then separate cycle path at highways also means people who can go for longer distances using their bicycles or other means so, they are dedicated cycle paths are there so, that people feel motivated, they are not scared that accidents may happen if mixed traffic is there on the highways and highways of course, it is not allowed in our case highways are dedicated for certain kinds of vehicles only.

So, if we can have for few kilometers people are nowadays having like they want to cycle because of health benefits also and they are environmentally sensitive many people like to use the cycles, but if there is no dedicated lane or path for cycling, then it is difficult to use those kinds of NMTs.

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The slide is titled "Way forward in transport sector" and focuses on "Electric vehicles". It lists four key points: 1) Electricity is a clean energy source for transport. 2) Other energy sources like coal, petroleum, biomass, and nuclear can be converted to clean electricity. 3) A successful EV needs a battery with less weight, more storage capacity, durability, rapid recharge, and lower costs. 4) EVs charge from the grid, resulting in no on-road emissions. The slide includes an icon of an EV with a charging plug and a small video inset of a speaker. Source: (Nailusamy Nailusamy, et. al, 2011). The slide number 24 is in the bottom right corner.

Way forward in transport sector

Electric vehicles

- Electricity is one of the clean source of energy available for transportation today.
- Other energy sources such as coal, petroleum, biomass and nuclear can be converted into clean source of electric energy.
- A successful Electric vehicle should have a battery with less weight, more storage capacity, durability, rapid recharge capacity, comparatively lesser costs.
- Electric vehicles can charge the battery by grid power supply, hence no on-road polluting emissions.

Source: (Nailusamy Nailusamy, et. al, 2011)

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Then there are way forward in transport sector in terms of electric vehicles for example hybrid bus and electric bus. Now, lot of focus and emphasis is on E-vehicles whether in terms of four wheelers or in terms of two wheelers also and only the challenge is that where this electricity is coming because those who are opponents having opponent views they always challenge that this electricity is coming from coal based power plants.

So, you are shifting the air pollution rather than reducing but catch is here because the emissions which are coming from motor vehicles or transport sector based on fossil fuel is

basically at the level of inhalation our respiratory system. So, if we can get rid of emissions of vehicles exhaust emissions that way we can improve, we can have the health benefits because that emission is not there.

So, improving air quality in urban areas, which are because of this transport sector is also a great benefit because coal thermal power plants or any thermal power plants, which are emitting emissions at very high these chimneys or stacks, then it gives dilution of the pollutants when it reaches to the ground level.

So, there is a big difference in that even if those emissions are coming to produce the electricity, but at the same time, government is enhancing and promoting generating the electricity from renewable resources like wind or solar etc. So, that way slowly I am very hopeful that this E-mobility will give great benefit in terms of cleaning the environment, having better air quality in urban areas and having health benefits.

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Types of Electric vehicles

The main types of Electric Vehicles includes:

1. Fuel-cell Electric vehicles
2. Hybrid Electric vehicles (HEVs)
3. Plug-in Hybrid Electric vehicles (PHEVs)
4. Extended-Range Electric vehicles (ER-EVs)
5. Battery Electric vehicles (BEVs)

Source: (Nafusamy Nafusamy, et. al, 2011)

You can see like types of electric vehicles here, fuel cell electric vehicles are promoted, then hybrid electric vehicles as I just talked about that bus, then plug in hybrid electric vehicles PHEVs, extended range electric vehicles, battery electric vehicles, and several kinds of electric vehicles are coming and new technologies are coming. So, that way a lot of focus is on there.


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Way forward in transport sector

Electric vehicles: Initiatives of EV Mission, NITI Aayog (1/2)

S No	Initiative	Date	Thrust Area	Impact
1.	State EV Policies	Since 2017	Regulatory	Inspired 25 states to come up with EV Policies (16 have already notified)
2.	Skill Development Programs and Establishment of Dedicated Centers	Since 2019	R&D	9 IITs have started dedicated programs for EVs
3.	Setting up National Mission for Transformative Mobility and Battery Storage	7th March 2019	Institutional	Improve air quality along with reducing India's oil import dependence and enhance the uptake of renewable energy and storage solutions.
4.	Faster Adoption and Manufacturing of Electric (&Hybrid) Vehicles in India (FAME) Scheme, Phase-II	8th March 2019	Fiscal Incentives	Support approximately 7000 e-Buses, 5 lakh e-3 Wheelers, 55000 e-4 Wheeler Passenger Cars and 10 lakh e-2 Wheelers

Source: <https://www.niti.gov.in/e-mobility-national-mission-transformative-mobility-and-battery-storage>




Way forward in transport sector

Electric vehicles: Initiatives of EV Mission, NITI Aayog (2/2)

S No	Initiative	Date	Thrust Area	Impact
5.	National Programme on Advanced Chemistry Cell (ACC) Battery Storage	9th June 2021	Manufacturing	Implementation of mega-scale ACC manufacturing facilities in India
	Revised FAME-II scheme	11th June 2021	Demand Aggregation	Increases upfront incentives for 2Ws, adopted 'Aggregation Model' for 3Ws and OPEX Model and 'Lighthouse Cities' approach for the Electric Buses. The validity of the flagship scheme is extended till 2024.
6.	Production-linked incentive (PLI) scheme for the automotive sector	15th Sept 2021	Manufacturing	Focus on electric and hydrogen fuel cell vehicles

Source: <https://www.niti.gov.in/e-mobility-national-mission-transformative-mobility-and-battery-storage>



Also from NITI Aayog electric vehicles related initiatives have been there through electric vehicle emission basically. You can see like this state EVs policies have been there since 2017. And those areas are related to regulatory is basically at the state level. So, it has inspired around 25 states to come up with the EVs policies and 16 have already notified. So, this is a big huge motivation in that sense.



Skill development programs and establishment of dedicated centers, which can give better training how to go for this EV related infrastructure. So, 9 IITs have started these dedicated programs for EVs basically. Then setting up national mission for transported this transformative mobility and battery storage.

Because battery related issues are there huge issues, that we need to have lightweight battery and which can capture a lot of energy and it can be long lasting. So, those kinds of batteries are needed. So, that way several initiatives and programs have been launched by government of India through NITI Aayog. And these are giving boost in E mobility.

(Refer Slide Time: 24:05)

Alternate fuels: Ethanol (1/2)

- **Ethanol** is considered to be one of most suitable alternative blending, transportation fuel due to its better fuel quality and environmental benefits.
- On the occasion of World Environment Day, 5 June 2021, Gov released the report of the **Expert Committee on Roadmap for Ethanol Blending in India by 2025**.
- According to the report, **20% ethanol blending** is within reach. The report further lays out an annual plan for the gradual rollout of **E20 ethanol** in the country.

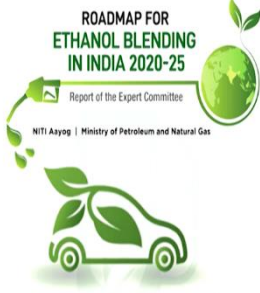

Source: <https://www.niti.gov.in/expert-committee-roadmap-ethanol-blending-india-2025>

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Alternate fuels: Ethanol (2/2)

The **E-20 roadmap** proposes the following milestones:

1. Raise pan-India ethanol production capacity from the current 700 to 1500 crore litres ✓
2. Phased rollout of E10 fuel by April 2022 ✓
3. Phased rollout of E20 from April 2023, its availability by April 2025 ✓
4. Rollout of E20 material-compliant and E10 engine-tuned vehicles from April 2023
5. Production of E20-tuned engine vehicles from April 2025
6. Nationwide educational campaign
7. Encourage use of water-sparing crops, such as maize, to produce ethanol
8. Promote technology for the production of ethanol from non-food feedstock.

Source: <https://www.niti.gov.in/expert-committee-roadmap-ethanol-blending-india-2025>

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Then there are also focused on alternate fuels like ethanol, which is considered to be one of the most suitable alternative blending in this transportation fuel due to its better fuel quality and environmental benefits. So, on the occasion of this World Environment Day 5th June of 2021, Government of India released one report on the expert committee of the expert committee on road map for ethanol blending in India for 2025. This report was launched basically.

So, according to this report 20 percent of ethanol blending can be easily achieved basically. So, this E20 ethanol related policies are there and roadmap has been prepared how to go there like a lot of investment is there and this to produce 700 to 1500 Crore litre of the ethanol for this particular purpose.


Then E10 by April 2022 means 10 percent of the ethanol blending, 20 percent by April 2023 and availability by and this April 2025 means rolling out by 2023 and making it available by 2025. So, those kind of targets or step by step initiations have been promoted by the Government of India.

(Refer Slide Time: 25:22)


Alternate fuels: Bio-CNG (1/2)

Bio-CNG plant in Indore ✓

- The plant is expected to process 550 tonnes of organic solid municipal waste per day to produce 17,000 kg of bio-CNG and 100 tonnes of organic compost.
- A **glaring problem** in the way of bio-CNG's success in India is waste segregation at source.



A bird's eye view of the newly inaugurated Indore bio-CNG plant





Source: <https://thewire.in/environment/heres-why-the-new-indore-bio-cng-plant-is-likely-to-succeed-though-others-like-it-havent>

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Alternate fuels: Bio-CNG (2/2)

Bio-CNG plant in Indore

- The demand for CNG vehicles in India has been increasing.
- If bio-CNG is produced from all biomass – agricultural residue, livestock dung, municipal solid waste and wastewater – we can replace about 50% of our current total diesel usage in the transport sector.



Source: <https://thewire.in/environment/heres-why-the-new-indore-bio-cng-plant-is-likely-to-succeed-though-others-like-it-havent>; <https://auto.economictimes.indiatimes.com/>

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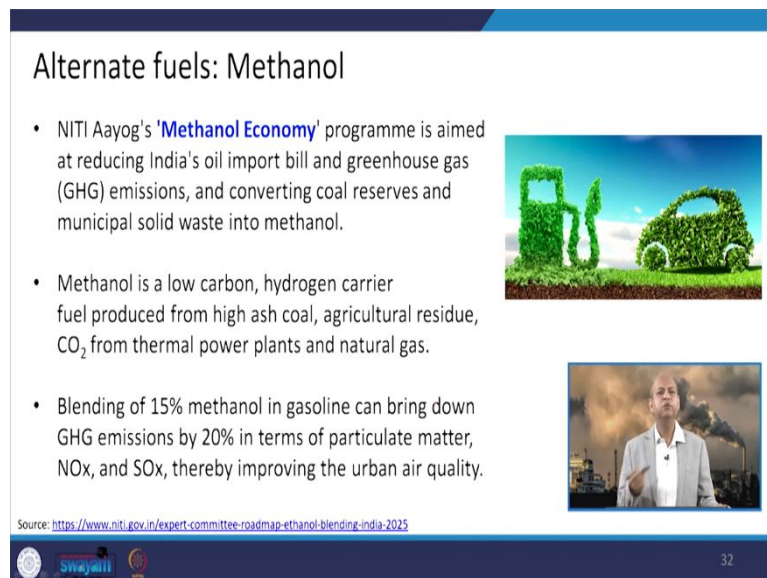
Then there is Bio-CNG related focus also, recently basically this in Indore Bio-CNG plant was inaugurated and this plant is expected to process 550 tons of organic solid municipal waste per

day to produce around 17,000 kilogram of the Bio-CNG and around 100 tons of the organic compost will also be a byproduct.

So, that way win win situation is there to clean the city as well as using the waste material into producing this biogas and compost material also. So, there is but little problem like in the way of Bio-CNG the waste segregation at the source is a big challenge. So, if we can change the behavior of the people and at the source itself we can segregate, this inorganic and organic waste and biodegradable waste, it can help a lot to achieve the targets basically.

So, you can see this plant in Indore, basically it is giving way we can replace basically about 50 percent of our current total diesel usage in the transport sector through Bio-CNG. So, huge scope is there means this is showing a way forward this Bio-CNG plant in Indore.

(Refer Slide Time: 26:43)



The slide is titled "Alternate fuels: Methanol". It contains three bullet points and two images. The first image shows a green car and a green gas pump made of plants. The second image shows a man speaking in front of a factory with smokestacks.

Alternate fuels: Methanol

- NITI Aayog's '**Methanol Economy**' programme is aimed at reducing India's oil import bill and greenhouse gas (GHG) emissions, and converting coal reserves and municipal solid waste into methanol.
- Methanol is a low carbon, hydrogen carrier fuel produced from high ash coal, agricultural residue, CO₂ from thermal power plants and natural gas.
- Blending of 15% methanol in gasoline can bring down GHG emissions by 20% in terms of particulate matter, NO_x, and SO_x, thereby improving the urban air quality.

Source: <https://www.niti.gov.in/expert-committee-roadmap-methanol-blending-india-2025>

swayamii 32


Then, alternate fuel also include this methanol. So, NITI Aayog's 'Methanol Economy' program is aimed at reducing India's oil import bill as well as reducing greenhouse gas emissions and converting coal reserves and municipal solid waste into methanol. So, this is also one more area where we can go for blending like 15 percent of Methanol in gasoline can bring down greenhouse gas emissions by 20 percent in terms of particulate matter NO_x and Sox.

So, that way huge benefits are there we can go for so, we can go in multiple ways means only not one policy can be targeted. But multiple policies and programs can be launched to address those issues.

(Refer Slide Time: 27:27)

Alternate fuels: Methanol

- Five methanol plants based on high ash coal, five DME (Dimethyl Ether) plants, and one natural gas-based methanol production plant with a capacity of 20 MMT/annum, in a joint venture with Israel, have been planned to be set up.
- Three boats and seven cargo vessels are being built by the Cochin Shipyard Limited for Inland Waterways Authority of India to use methanol as a marine fuel.
- Thermax Ltd has successfully developed a 5 KW methanol-based reformer on a Direct Methanol Fuel Cell (DMFC). This module is being tested to replace DG sets in mobile towers.



Source: <https://www.niti.gov.in/expert-committee-roadmap-ethanol-blending-india-2025>

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So, there are like in that way five methanol plants have been there and one natural gas based methanol production plant has been there. Which can produce 20 million metric ton per annum in a joint venture with Israel. So, those are in process. Then there are like three boats and seven cargo vessels are being built by this Cochin Shipyard Limited for Inland waterways Authority of India to use methanol as a marine fuel.

So, that way these are new initiatives which are giving new way forward for dealing these situations. Then there is this Thermax Limited which has successfully developed a five kilowatt methanol based reformer on a Direct Methanol Fuel Cell (DMFC). So, this module is being tested to replace the DG sets in mobile towers basically. Because lot of DG sets are there, wherever these mobile towers are there and a lot of fuel is burned but if it can replace them we can say reduction in pollution can be achieved.


(Refer Slide Time: 28:26)

Innovations in Transport sector

- [Chakr Innovation](#) developed world's first retro-fit emission control device for diesel generators called **CHAKR SHIELD™**
- The technology can capture over 90% of particulate matter emissions from the exhaust of diesel generators without causing any adverse impact on the diesel engine.
- Patent for Chakr Shield was filed in January 2016.



CHAKR SHIELD™

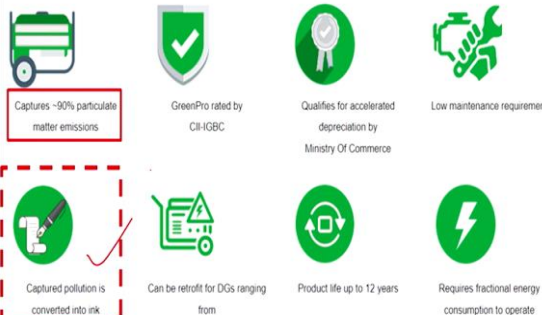


Source: <https://in.one.un.org/>; <https://chakr.in/particulate-matter-emission-control-device/>



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Innovations in Transport sector

Features of CHAKR SHIELD™



- Captures ~90% particulate matter emissions
- GreenPro rated by CI-IIGBC
- Qualifies for accelerated depreciation by Ministry Of Commerce
- Low maintenance requirement
- Captured pollution is converted into ink
- Can be retrofit for DGs ranging from 15 KVA to 2000 KVA
- Product life up to 12 years
- Requires fractional energy consumption to operate



Source: <https://in.one.un.org/>; <https://chakr.in/particulate-matter-emission-control-device/>


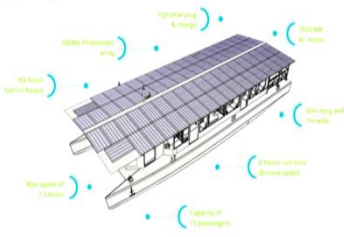
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Then there are several innovations also in transport sector like CHAKR innovation is there, which is basically capturing this 90 percent of particulate matter in these diesel engines basically. And then converting those particulate matter into a kind of ink. So, valuable product is being manufactured by reducing the carbon emissions. So, those are the innovations.

(Refer Slide Time: 28:58)

Innovations: Inland waterways (1/2)

- ADITYA, India's first solar ferry, was built by NavAlt Solar & Electric Boats, for Kerala State Water Transport Department and inaugurated on 12th January 2017.
- ADITYA is a **catamaran ferry boat** with GRP (Glass Reinforced Plastic also known as FRP (Fibre Reinforced Plastic)) hull and aluminium superstructure build under IR class (Indian Register) of Shipping, a member of International Association of Classification Societies.

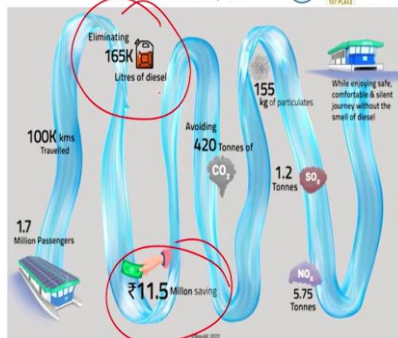


Source: <https://in.one.un.org/>; <https://navaltboats.com/indias-first-solar-ferry/>

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Innovations: Inland waterways (2/2)

ADITYA, 5 YEARS OF SUCCESS
The route says it all.



Eliminating 165K Litres of diesel

100K kms Travelled

1.7 Million Passengers

₹11.5 Million saving

Avoiding 420 tonnes of CO₂



155 kg of particulates

1.2 Tonnes SO₂

5.75 Tonnes NO_x

While enjoying safe, comfortable & silent journey without the smell of diesel

ADITYA redefined the country's inland water transportation is now celebrating 5 years of success.



Source: <https://in.one.un.org/>; <https://navaltboats.com/indias-first-solar-ferry/>

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Then there are innovations Inland waterways also like rooftop solar panels are being used in these vessels also. So, that way energy is being produced. So, new innovations, new ways of dealing with these problems are coming day by day and that way you can see these five years success story this ADITYA which was, which is the vessel basically using these solar panels. So, it has like 11.5 million savings and this eliminating 165,000 litres of the diesel basically. So, huge benefits are there in saving fuel as well as reducing emissions.

(Refer Slide Time: 29:44)

Challenges: Crop residue burning (1/2)

- Crop residue burning or Stubble burning can be defined as the intentional incineration of stubbles by farmers after crop harvest.
- On a global scale, stubble burning constitutes about one-fourth of the total biomass burning (inclusive of forest fires)
- Seasonal crop residue burning in the IGP region causes severe air pollution and poses a threat to human health problem.

Source: Abdurrahman and Saini, 2020





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Challenges: Crop residue burning (2/2)

- Most probable reason for the burning of the stubble is the shortage of time between the harvest and the sowing of the next crop.
- From the farmers' perspective, it is easier to burn the crop stubble after harvest to quickly prepare the farmland for the next sowing.
- This farmers' eagerness for the next planting forces them to simply burn the stubble on-field thereby emitting a large number of hazardous pollutants.

Source: Abdurrahman and Saini, 2020

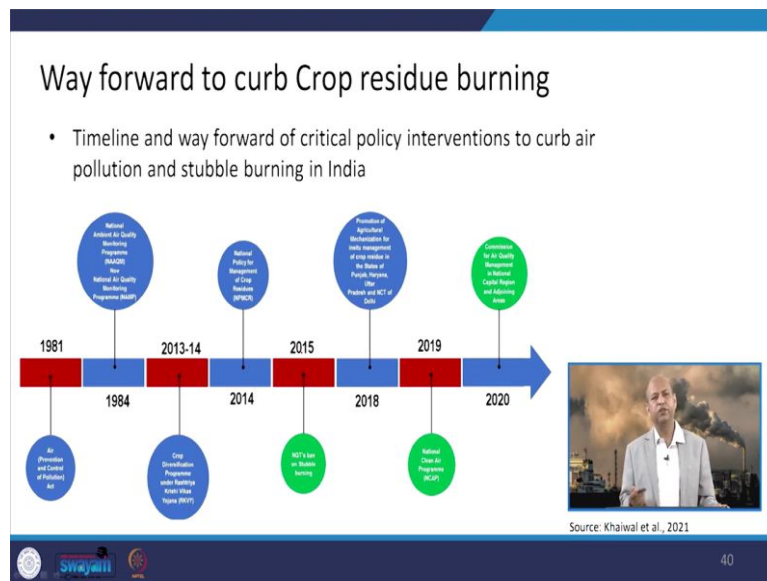


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So, you can see means farmers in northern part of the India basically, they want to prepare their land for next sowing purpose. So, they need to burn to quickly dispose of this crop residue. This is one way, easy way for them. But it also causes a lot of air pollution in this at the regional scale basically.

So, this seasonal crop residue burning in this Indo Gangetic plain has been a big problem over the years basically. So, if we can give some solutions for this management of the crop residue that can be a wonderful way of dealing with this problem.

(Refer Slide Time: 30:22)



Way forward to curb Crop residue burning

Year	Policy interventions	
2013-14	Crop Diversification Programme (CDP), a sub scheme of Rashtriya Krishi Vikas Yojana (RKVY)	Encouraging farmers area of paddy crops to alternate crops to reduce stubble.
2014	National Policy for Management of Crop Residues (NPMCR)	NPMCR policies focus on promoting in situ crop residue management, technological intervention, awareness of farmers and formulation and implementation of applicable laws.
2018	Promotion of Agricultural Mechanization for in-Situ Management of Crop Residue in the State of Punjab, Haryana, Uttar Pradesh and National Capital Territory (NCT) of Delhi	Providing subsidised machinery for in situ crop residue management in the states of Punjab, Haryana, Uttar Pradesh, and NCT of Delhi

Source: Khaiwal et al., 2021

So, like there have been some policy interventions, which are shown in this particular timeline in terms of technological interventions to convert that crop residue in a valuable product also or dealing with in other ways. So, there are several way forwards to curb this crop residue burning basically like there is crop diversification program from 2013 to 2014, it has been in place.

So, sub scheme of this Rashtriya Krishi Vikas Yojana has been there this crop diversification program. This encourages farmers this area of paddy crops to alternate crops to reduce the stubble. So, means a shift from rather than paddy to other crops so, that this kind of problem can be avoided. Then there is the national policy for management of crop residues.

So, they focus on promoting in situ crop residue management or technological intervention and awareness of the farmer so, that they avoid burning rather than converting into them converting into those valuable products.

(Refer Slide Time: 31:30)


Way forward to curb Crop residue burning

Incorporating the stubble into the soil


- The inclusion of the agricultural stubble into the soil is one of the best strategies for managing them.
- It increases soil fertility and helps in maintaining its organic matter content

Use of mechanized tools


- The use of mechanized tools such as **happy seeders** & **super seeder**, for straw incorporation into the soil has proven effective especially in tilling operations.
- The process of straw incorporation generally boosts soil fertility and increases carbon sequestration.



Happy seeder



Super seeder



Source: Abdurrahman and Saini, 2020

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So, there are also technological interventions like happy seeder is there, which can quickly deal with this stubble and it can be converted into proper kind of maneuver and that way.

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Way forward to curb Crop residue burning

Composting


- The compost from agricultural stubble is rich in nutrients and therefore improves the productivity of the soil.
- A popular composting method is the Vermicomposting that generates compost using earthworms which significantly improves the productivity of the soil

Biochar


- Another alternative approach is the production of Biochar from the crop stubble through the process of pyrolysis.
- Biochar is a finely-divided, carbon-rich, porous substance obtained by subjecting the biomass to a thermo-chemical conversion process with little to no oxygen (pyrolysis) at a temperature of about 350–700°C



VERMICOMPOSTING



BIO-CHAR



Source: Abdurrahman and Saini, 2020, Image: <https://extension.illinois.edu/>, <https://www.iffcoandkisan.com/>

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Then there are other ways also like composting is also biochar formation using these crop residues is also one way. But of course, this needs proper collection and then transporting that crop residue. So, challenges are there but possibilities of having these kinds of innovative solutions could deal with the crop residue burning.

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Way forward to curb Crop residue burning

Financial aspects

- As small-scale farmers and individuals do not have the capacity to create a long-lasting solution, **community based solutions are needed for sustainable crop residue management.**
- The linking of the **Mahatma Gandhi National Rural Employment Guarantee Act, 2005 (MGNREGA)** to community agriculture in villages can help in providing a community-based solution.



Source: Khaiwal et al., 2021



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Then financial aspects are also there. So, policymakers and researchers have suggested that maybe with like Mahatma Gandhi National Rural Employment Guarantee scheme is their MGNREGA act is there. So, within that scheme if we promote the community based solutions or community based initiatives where a lot of farmers can join hands to deal with this crop residue burning and using that crop residue in terms of some valuable products. Then we can deal with the, we can avoid the burning of that crop residue.

(Refer Slide Time: 32:44)

Challenges: Industrial sector

- Industry also emits **about 28 % of global greenhouse gas (GHG) emissions**, of which 90 % are carbon dioxide (CO₂) emissions.
- Between 1990 and 2014, GHG emissions from major sectors such as buildings, power, and transport increased by 23 % (0.9 % per year), while emissions from the industrial sector increased by 69 % (2.2 % per year).



Source: Decarbonization of industrial sectors: the next frontier, Arnout de Pee, 2018

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Way forward: Industrial sector

Example:

- To protect the shock absorbers against corrosion and at the same time improve their appearance, they are coated with a spray paint.
- The paint formerly used contained up to 85% solvents which **emit volatile organic compounds (VOC)** such as hydrocarbons into the air.
- Reducing the use of VOCs in industry is one of the main challenges.



Source: Industrial pollution, European solutions: clean technologies, LIFE & IPCC, EC, 2004



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Way forward: Industrial sector

- A tri-component epoxy paint based on water rather than solvents which met the highly specific needs of the metal industry.
- After partnership with the Dutch Hasco Lakfabrieken company new product was developed with truly minimal (1%) VOC content almost entirely meets the requirement.
- The LIFE project, undoubtedly opens the way to eliminating VOCs from industrial painting processes in Europe



Source: Industrial pollution, European solutions: clean technologies, LIFE & IPCC, EC, 2004




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Then there are industrial sectors or other sectors where there are challenges like greenhouse gas emissions are there. So, a lot of solutions are coming in that sector also. For example, removing of the VOCs by some innovative the paints etc are there which emit lots of VOCs but new paints are being promoted which can emit very less amount of the VOC basically. It reduces the VOC industry in because of some other chemical free kind of paints are there which can be used for reducing these emissions of VOCs.


(Refer Slide Time: 33:24)

Way forward: Industrial sector

- Fluid catalytic cracking (FCC) is a process which converts the heavy products from the first distillation of oil into high-grade light products.
- In the FCC process, carbon deposits are formed at the catalyser surface which contains sulphur, burning it converts it into sulphur dioxide (SO₂) which is emitted together with the flue gas.



- ✓ The **Sanazzaro** refinery in the **Po valley** forms part of the Refining & Marketing division of ENI SpA (formerly Agip Petroli).
- ✓ It is one of the most modern refineries in **Europe**.





Source: Industrial pollution, European solutions: clean technologies, LIFE & IPCC, EC, 2004

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Way forward: Industrial sector

- Using **Best Available Technique (BAT)** it is intended to **desulphurise flue gas** through a patented system (Belco/Labsorb) based on a solution containing an **absorbing agent with which the sulphur can be recovered for reutilization**.
- **Sulphur dioxide emission** can be reduced with an efficiency level of over 85% in removing SO₂ originating from the flue gas with negligible amount of solid waste generated.



Source: Industrial pollution, European solutions: clean technologies, LIFE & IPCC, EC, 2004

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So, these are ways then there are like reducing of the sulfur there are technologies sulfur emissions can be reduced. And that way SO₂ emissions can be reduced and regional scale that acid rain problem related which is not in India, but in other parts of the globe are there. So, new technologies are coming to dealing with these emissions.

(Refer Slide Time: 33:44)

Way forward: residential and commercial sector

- In rural households of India, indoor air-pollution is associated with the ineffective combustion of biomass (firewood, coal, and dung cakes) due to faulty processing and drying.
- Around 83 % of rural households and almost 20 % of urban households use solid biomass fuels for cooking.



Source: Roy et al., 2020, <https://www.downtoearth.org.in>; Image: <https://www.livemint.com/>



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Way forward: residential and commercial sector

- Inspired by the traditional Indian method of cooking on charcoal, **Agnisumukh** manufactures commercial kitchen equipment driven by innovative, energy efficient radiant heat gas burners.
- The good side of 'FIRE' is radiant heat that generates Far Infra-red Rays (FIR). FIR is the most potent energy format to transmit heat into the smallest water molecule.
- These waves cook food uniformly without burning and retain maximum moisture in food even after cooking



Source: <https://in.one.un.org/>; <https://www.agnisumukh.com/#about>



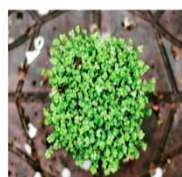
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Way forward: residential and commercial sector

- **Agnisumukh** claims that by implementing the platform we would be decreasing carbon emissions by 10 million tonnes per annum which is equivalent to 50% of India's pledge to bring down the greenhouse gases by year 2020.
- This translates to increasing the Green cover by 45 crore trees. Highest Energy Efficiency in renewable fuel.



OVER 30% LPG SAVINGS ZERO CARBON SOOT EMISSION



Source: <https://in.one.un.org/>; <https://www.agnisumukh.com/#about>



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Way forward: residential and commercial sector

- Pradhan Mantri Ujjwala Yojana (PMUY) was launched with the aim to safeguard the health of women and children by providing them with clean cooking fuel, so that they don't have to compromise their health in smoky kitchens.
- The PMUY scheme was launched by Hon'ble Prime Minister from Ballia district in Uttar Pradesh on 1st May 2016.



Source: <https://transformingindia.mv.gov.in/wp-content/uploads/2021/09/ujjwala.pdf>



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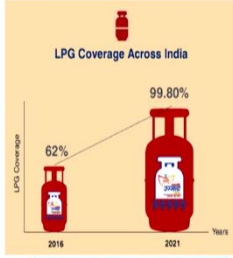
Then there are residential and commercial sector related challenges. For example, a lot of people still use bio mass they burn the biomass and to meet their energy needs. So, can we shift from biomass to better cleaning clean fuels. So, like there are this Agnisumukh manufacturing commercial kitchen equipment, which are driving innovative and energy efficient radiant heat gas burners.

So, that way efficient cooking appliances are also coming there. Plus you can see this particular Yojana or program of government of India, which is Pradhan Mantri Ujjwala Yojana (PMUY). This has also given a big boost in reducing emissions, which are coming from biomass burning because a lot of rural population has been given gas connections. So, the clean fuel if is available then biomass burning is reduced. So, naturally emissions which are coming from biomass burning are greatly reduced in that way.

(Refer Slide Time: 34:46)

Way forward: residential and commercial sector

- The LPG coverage in India has improved to 99.8% as on 1st April 2021, as compared to 62% as on 1st May 2016.
- Way forward; the government has now announced the **second phase of Ujjwala**.
 - An additional One Crore PMUY connections will be released under "Ujjwala 2.0" by the PSU Oil Marketing Companies (OMCs).
 - This will soon usher in an era of universal access to clean cooking fuels.



Source: <https://transformingindia.mv.gov.in/wp-content/uploads/2021/09/ujjwala.pdf>

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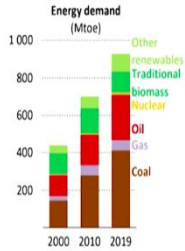

So, this is one big program which has been very successful and it has given our rural population to go for the clean energy rather than this polluting energy which is from biomass burning basically.

(Refer Slide Time: 35:03)

Challenges in Energy Demands

- India is a major force in the global energy economy. Energy consumption has more than doubled since 2000, propelled upwards by a growing population – soon to be the world's largest – and a period of rapid economic growth.
- The 19th Electric Power Survey (EPS) (published by CEA) projections for peak electricity demand and electrical energy requirement

Year	Electrical Energy Requirement (BU) Ex Bus	Peak Electricity Demand (GW)
2021-22	1566	225.751
2026-27	2047	298.774
2029-30	2325	339.973

Source: India Energy Outlook, 2021, https://ea.blob.core.windows.net/assets/1de6d91e-e23f-4e02-b1fb-51fd6283b22/India_Energy_Outlook_2021.pdf
 REPORT ON OPTIMAL GENERATION CAPACITY MIX FOR 2029-30, https://ea-pic.in/fold/reports/others/planning/roptimal_mix_report_2029-30_FINAL.pdf

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Way forward in Energy Demands

In continuing efforts to safeguard the environment and reduce emissions from power sector, India has made the following commitments in COP 21:

- India intends to reduce the emissions intensity of its GDP by 33 to 35 % by 2030 from 2005 level.
- To achieve about 40 % cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology and low cost international finance.



Source: India Energy Outlook, 2021, https://ea.blob.core.windows.net/assets/1de6d91e-e23f-4e02-b1fb-51fd6283b22/India_Energy_Outlook_2021.pdf
REPORT ON OPTIMAL GENERATION CAPACITY MIX FOR 2029-30, https://cea.nic.in/old/reports/others/planning/roptimal_mix_report_2029-30_FINAL.pdf



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Way forward in Energy Demands

Promoting Renewable - Moving towards net zero carbon

- In order minimize the carbon footprints of mining and to progress towards the goal of net zero carbon emission, coal/lignite companies are keen on promoting renewable energy.
- Coal companies are going for both roof top solar and ground mounted solar projects. It has also been envisaged to develop solar parks in some of the reclaimed mining areas.



Source: <https://coal.gov.in/en/sustainable-development-cell/promoting-renewable>



Way forward in Energy Demands: Notable renewable projects



Neyveli Lignite Corporation India Limited (NLCL): Solar Power Panel in Ramanathapuram District, Tamil Nadu



NLCL : Wind Mill in Kazhuneerkulam, Tirunelveli District, Tamil Nadu



400 KWp Rooftop Solar Installation in Central Coalfields Limited (CCL), Ranchi, Jharkhand



60 kWp installed on rooftop in Ballarpur Area Office, Western Coalfields Limited (WCL), Maharashtra



Singareni Collieries Company Limited (SCCL): Solar Power Plant at Manuguru (30 MW), Telangana



Source: <https://coal.gov.in/en/sustainable-development-cell/promoting-renewable>



Then energy demands related challenges are also there and a lot of policies are coming like solar related or some other electric power generation from renewable resources. So, a lot of focus is there basically, in meeting those energy demands. We can say this net zero carbon related the policies there after certain decades we want to go for net zero carbon emissions.

So, that way huge shift is demand or huge shift is needed from fossil fuel based energy products into renewable resources based energy production. Example is there like notable renewable projects have been with large scale projects have been implemented in India like in Tamil Nadu this solar power panel, big plant is there in again Tamil Nadu at another place, windmill has been there in Rajasthan in Jaisalmer a lot of windmills have come then this 400 kilo watt power rooftop solar installation in central coalfields limited in Jharkhand has been implemented. Similarly, in Telangana, Maharashtra, huge plants are coming to generate energy from the solar power plants.

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Emerging innovative technologies to curb air pollution

- As a global movement to tackle air pollution gathers pace, innovators are rising to the challenge, unveiling products and technologies.
- Here are **four** innovative technologies to beat air pollution:
 1. Mexico City – Special Mural painting
 2. London City – Biosolar Leaf
 3. Germany – City Tree
 4. United States – Special roofing granules

Continued..



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1. Mexico city (1/2)

Special paint gives Mexican murals super powers

- Mexico City may be infamous for its smog but it's also renowned for its **murals**, and now the two have come together in a startlingly innovative way.
- The **Absolut Street Trees** initiative involves artists painting giant murals in the city using **Airlite** paint, which purifies polluted air in a process similar to photosynthesis.



■ The "**Absolut Street Trees**" murals can be found on buildings in the neighborhoods of Cuauhtémoc, Juarez and Roma in Mexico.



Source: <https://www.unep.org/news-and-stories/story/business-unusual-four-innovations-clear-air> Image: <https://www.telesurenglish.net>



1. Mexico city (2/2)

Special paint gives Mexican murals super powers

- Airlite copies nature to break down pollutants the paint acting as a catalyst, rather than absorbing or filtering them out.
 - ✓ Actively breaks down NO_2 to purify the air by reducing pollution and toxins.
 - ✓ Contains no VOCs (respirable irritants).
 - ✓ Prohibits mould growth, thereby reducing airborne spores and allergens.
 - ✓ The paint lasts about 10 years.



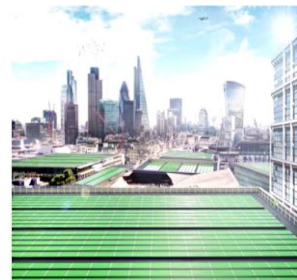
Source: <https://www.bouygues-es.co.uk/buildings/airlite-paint-purifies-air> Image: <https://www.republicworld.com>



2. London city

BioSolar Leaf

- Scientists at **Imperial College, London** are collaborating with start-up **Arborea** on the world's first **BioSolar Leaf**—large panels covered with **tiny plants that wash up carbon dioxide and release oxygen** at a rate equivalent to 100 trees from the surface area of a single tree.



BioSolar leaf. Photo by Arborea



Source: <https://www.unep.org/news-and-stories/story/business-unusual-four-innovations-clear-air>





Then new innovative technologies are also coming to curb their pollution around the world. Like in Mexico City special mural painting has been promoted which absorbs pollution, Biosolar leaf, City tree or special roofing granules you can see these murals which are using certain paint which can absorb the air pollutants. So, antipollution, gravity's popular nowadays in Mexico City. Biosolar leaf is also one technology large panels which are like they are producing energy with this new kind of solar panels.

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3. Germany

CityTree

- German start-up Green City Solutions' mossy living walls, built over wooden benches, are the world's first intelligent biotech air filter—and a welcome space to sit after hours of walking around the city.
- The ability of certain moss cultures to filter pollutants such as particulate matter and nitrogen oxides from the air make them ideal natural air purifiers.

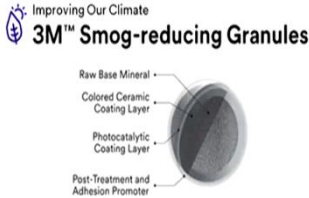

Source: <https://www.unep.org/news-and-stories/story/business-unusual-four-innovations-clear-air>

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4. United States

Houses to reduce smog with special roofing granules

- In the United States, manufacturing conglomerate 3M has designed smog-reducing granules that turn roofing gravels into a pollution-fighting surface.
- 3M designed its new granules with a photocatalytic coating which is activated by the sun's UV rays, generating radicals that bind with the chemicals in smoggy air and transform them into water-soluble ions that eventually wash away.

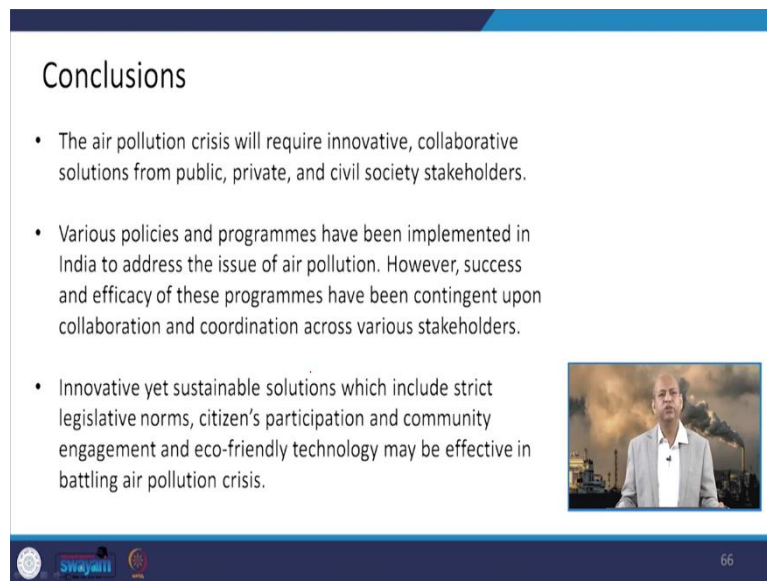



Source: <https://www.unep.org/news-and-stories/story/business-unusual-four-innovations-clear-air>

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Then in Germany City tree is one technology, where they are using these kind of moss cultures, which can absorb a lot of particulate matter and nitrogen oxides basically. So, that way improvement in air quality can be achieved. In United States again, the smog reducing granules are promoted by a company which can reduce the smog formation kind of pollutants.

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Conclusions

- The air pollution crisis will require innovative, collaborative solutions from public, private, and civil society stakeholders.
- Various policies and programmes have been implemented in India to address the issue of air pollution. However, success and efficacy of these programmes have been contingent upon collaboration and coordination across various stakeholders.
- Innovative yet sustainable solutions which include strict legislative norms, citizen's participation and community engagement and eco-friendly technology may be effective in battling air pollution crisis.

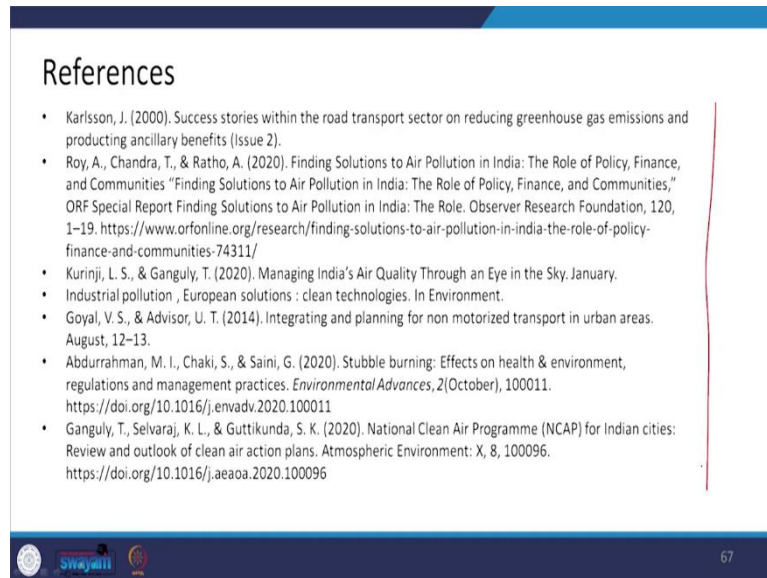
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So, in conclusion, we can say that of course there are a lot of challenges still to reduce the air pollution emissions. But new innovative technologies are coming, new innovative programs are implemented by several countries. And in India, basically we are shifting from fossil fuel based economy to renewable energy based economy that is a big program and like E mobility and there are other ways which are coming up in a big way to reduce the air pollution emissions.

So, that way we can say that awareness of public is also needed. So, that they can shift from quickly from those polluting kind of technologies to non-polluting kind of technologies and also like sifting from fossil fuel based transportation to non-motorized transportation (NMT). All these need infrastructure facilities as well as public awareness. So, so many innovations are coming and that way we can deal with the challenges.

So, in conclusion, we can say that challenges are there but innovative solutions are also there. And you can also think means everybody has a creativity and innovative attitude if they can apply they can come up with new solutions. So, this is all for today. So, to deal with the challenges let us come with the innovative solutions to put forward the new ways of dealing with the air pollution emissions and to improve the air quality.

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So, this is all for today, these are the references where we have taken information you can go through at leisure to these references to have more information on a particular topic. So, thank you for your kind attention. See you in the next lecture. Thanks again.