Reinventing India : PIC Policy Paper #20

PUNE INTERNATIONAL CENTRE

Towards Promoting Green Economic Recovery For Maharashtra

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OCTOBER 2020

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Acknowledgements

We, the EECC Team, thank all Pune International Centre (PIC) Members who contributed to the Energy, Environment and Climate Change (EECC) project since its initiation. We sincerely thank all Climate Collective Pune (CCP) members for their help and suggestions in improving this document. We are grateful to PIC President, Dr Raghunath Mashelkar and Vice-President, Dr Vijay Kelkar for their valuable guidance, advice and constant support. We thank Mr Abhay Vaidya, Associate Director, PIC for the valuable inputs and suggestions. We thank Director, PIC, CAO, PIC and all the staff for their ready cooperation and help.

- Prof Amitav Mallik
and Team EECC

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Executive Summary

TOWARDS PROMOTING GREEN ECONOMIC RECOVERY FOR MAHARASHTRA

The bright side of the Covid-19 pandemic disruption has been a demonstration of how a change in lifestyles by mankind can significantly improve earth environment quality. This can help to usher a **'New Normal'** for remaining healthy and progressive despite future disruptions. The present economic model must now change to preserve a decent life for the young generations who would otherwise face a very hostile earth environment. Essentially, global warming must slow-down very quickly and our planet earth must become '**Net-Carbon-Neutral' by 2050** to remain within the 20C warming threshold to avoid catastrophic climate impacts within the next few decades. While the problem is indeed global, fortunately the solutions are mostly local and technologically possible.

Awareness of this urgency for change is growing rapidly as we witness extreme weather events like: floods, droughts, bush-fires and ice-melting across the earth. Every nation, state or human habitat in the world must strive for systemic changes to reduce global emissions while striving to be economically progressive. Mankind is already in a **'Climate Challenged World'** with just a 10-year window to avert serious environmental catastrophe and economic collapse with dire consequences to human survival. It is time to realise that priorities for economic development and preserving the earth-ecosystem are now intrinsically linked. Hence the real solution is a 'Green Economic Recovery' as a major 'course-correction' for the future of Maharashtra, and indeed the Nation.

The challenge therefore is to re-design the economic development model in such a manner that the real cost of development, including the cost to the environment, is reduced with technological innovations and life-style changes. This can then meet the real-world economic aspirations of modern human society without causing debilitating climate impacts on the economy. Reducing per-capita carbon emission to below 2 ton/year can be an important target for all cities. Enhancing carbon sequestration capacity will be very critical for absorbing as much emissions as possible for a carbon-neutral economy. This kind of synergistic development policy is indeed possible if we can change mind-sets and create effective economic policy drivers for the change required.

The Economic Recovery post-2020 must therefore be used by a progressive state like Maharashtra to make it a **'Green Economic Recovery'** for the future. Major challenges as explained in the policy document will be: (1) Moving away from Fossil-Fuel power by rapidly increasing the

indigenous Renewable Energy (RE) electricity including charging of all Electric vehicles. (2) Changing the present economic model and the modern urban life-styles for a transition to 'Low-Carbon Economy' for sustained progress, and (3) Increasing Carbon Sequestration capacity of the State to absorb all the excess CO_2 emissions and improve Climate Resilience. **All of this is very much doable if one can find synergy with environment to remain economically progressive with green jobs and healthy lifestyles, with due care for earth ecosystem.** The additional bonus will be a huge improvement in Energy Security.

This report highlights several **'Actionable Recommendations' (AR)** for Maharashtra that can yield immediate co-benefits both for the economy and the environment. Some of these clear win-win solutions discussed in detail in the paper are summarised here:

1. Rapid Transition to Renewable Energy (RE) with Solar, Wind and Bioenergy for effectively reducing the fossil-fuel use from present 65% to less than 30% by 2030.

2. Aggressively promote Solar Rooftop with efficient Net-Metering for all electric power users and mandatory use of RE Back-up Units for replacing all diesel gen-sets.

3. Increase overall Energy Efficiency of the State by 3% every year to reduce the overall energy demand of the State by about 30% in the next 10 years.

4. Actively expand Electric Mobility and build RE charging infrastructure for reducing Transport sector GHG emissions and air pollution, availing economic benefits.

5. Maharashtra must expand existing 5.2 Million hectare Forest Cover by 200% till 2030 by adding 10% area each year for next 10 years to double the CO2 Sequestration capacity.

6. Establishing Eco Industrial Parks to facilitate better material management and energy efficiency performance while creating thousands of local green Jobs in the process.

7. Mandate a unified 'State Green Building Code' for all new construction and incentivise Green performance with 'RE Star-Rating' for boosting RE use.

8. Formalise the Water and Waste Management sector with monitoring, segregation and for optimising the life-cycle processes, for 'Circular Economic' integration.

9. Invest in innovation for (a) Energy Storage Battery technologies for 24x7 RE power supply and (b) Technologies for removal of CO2 from Air for Net-Carbon-Neutrality.

10. Establish a Maharashtra Climate Action and Adaptation (MCAA-TF) **Task-Force** to ensure strong Administrative and Governance support to accelerate the transition to a Low-Carbon Sustainable Economic model for optimising the green growth.

Mumbai, the financial capital of the country, is one of the most vulnerable cities to 'Sea Level Rise' which will threaten its coastal areas within the next 10-15 years. It can and must adapt to Climate Change by implementing the major recommendations listed in the report. The specially empowered MCAA Task-Force with adequate representation of environmental, social and economic experts is an absolute must, for effective transition to a green economy.

Maharashtra can certainly take up this transformational task in a drive to take the leadership role in this challenging green transition on the path towards **'Making Maharashtra State Net Carbon Neutral'** with well-planned calibrated steps within the next 10-15 years. This can be achieved without compromising any real economic priority for a sustained progress. **That should be the final objective of the proposed Green Economic Recovery.**

Chapter 1

Case For A Green Economic Recovery Of Maharashtra

Case For A Green Economic Recovery Of Maharashtra

The Covid crisis has exposed humans not just to a health risk but also to the inadequacy of our systems to deal with a global disaster. The 2018 UN Special Report has indicated that Global GHG emissions must fall by 7.6% every year from 2020 to 2030, to keep the global average temperature increase below 1.5°C compared to pre-industrial level. If atmospheric Greenhouse Gas (GHG) concentrations continue to increase steadily, it will trigger irreversible changes like 'climate tipping points' which will cause irreversible damage to the environment and human livelihood. Once these tipping points are breached, human intervention would no longer help in restoring the Earth ecosystem.

According to the Global Climate Risk Index 2020, India's rank in the global climate vulnerability ladder worsened to 5th in 2018 from 14th in 2015. India suffered an economic loss of $37 billion in 2018 alone due to climate change impacts[1] and is the third largest emitter of GHGs globally. The 'Climate Action Tracker' website marked India as the only major economy on track to achieve its '2° Celsius Compatible' Paris commitments, provided, no further coal capacity is added to its Energy mix. India ranked as low as 168 out of 180 countries in the environmental performance index 2020.

India thus has a three-fold challenge of building eonomic resilience while reducing carbon emissions and, focusing on restoring the environmental balance and stability for continued progress despite many impending climate disruptions. Clearly, any economic recovery now in 2020-21 without building robust Resilience will be very short lived. The new state economic policy must factor in reducing health risks, wastages and system inefficiencies; while maintaining and improving native biodiversity, resource availability and human life quality. Even though India ranks in top 5 clean renewable energy producers due to Renewable Energy (RE) generation capacity, it is much lower in terms of percent of Clean Energy in Energy-mix, as the electricity sector is still dominated by coal-powered thermal energy. This is where a progressive State like Maharashtra must take up the leadership role. As the IMF and World Economic Forum have clearly emphasised; **the 2020 to 2030 decade must cast a focus on green economic growth.**

1.1 Synergy between Environmental and Economic Priorities

It is now globally accepted that bold and urgent policy changes are required to slow down the Anthropogenic global warming and restore the eprogress and well-being. Every 1 US$ invested in climate action today would result in over 6 US$ saving of expenditure on disaster management within the next 10 years.[2] Figure 1 shows that there has been a

Every 1 US$ invested in climate action today would result in 6 US$ saving of expenditure on damage response within the next 10 years.

drastic rise in atmospheric Carbon dioxide (CO2) concentration from 275 ppm to 412 ppm in the last century due to human activities, causing Global Warming and Climate Change.

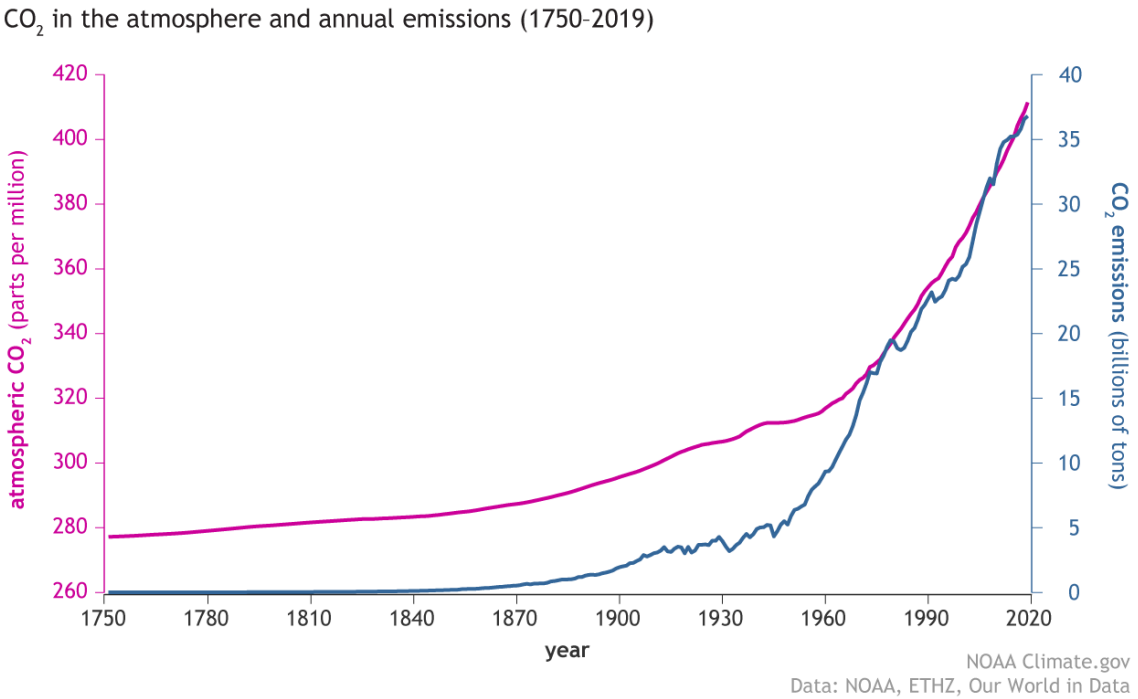


Figure 1: Sharp rise in atmospheric CO_2 concentration since 19th century

Reopening national coal mines presumably to create jobs post Covid-19 slow-down is not advisable as coal is already the most economically in-efficient and polluting option for energy production. In contrast, Solar Energy creates more employment per unit of energy generation with much lesser environmental damage. Further expansion of coal, will not only lead to increasing the GHG emissions but also increase energy production costs and expenditure in pollution impacts. It is misleading to assume that the loss of environmental and human well-being can be acceptable as long as it is creating jobs and wealth for the nation. In contrast, a green economic growth provides immense investment opportunities for building economic and environmental synergies and generate more national wealth while adding value to the quality of life for all its people.

Only an integrated effort by all levels of governance can achieve the scale of transformation needed to transition to a low-carbon, equitable and sustainable economy. The paper attempts to bring out how Maharashtra State can thrive both in economy and environment for a progressive future and the betterment of the current and next generations. The challenges may seem daunting but these can be overcome by foresighted planning. The paper draws on the knowledge collated in preparing the PIC Policy Roadmap for 'Making Pune Metropolitan Region (PMR) Carbon Neutral by 2030' that was released by the State's Environment Minister in January 2020. Similar goals are even more doable at the state level to ensure a low-carbon sustainable development.

1.2 Need for Adopting a New Economic Model for Maharashtra

In the post-pandemic economic recovery, there is a natural tendency to want to get back to the old status. But the economy was not faring well even on economic terms before the pandemic, given the deteriorating social or environmental performance parameters. Hence, it is important to realise that this 2020 disruption must be used as a 'Major Reboot' opportunity to adopt a new resilient and sustainable economic framework. Maharashtra, with a maximum GDP[3], is also one of the top 5 GHG emitting states in India. Unfortunately, it is also one of the worst Covid-19 hit state with maximum cases and 15.6% fall in GDP. Thus, Maharashtra has a better capacity and a greater need to adopt a 'Green Recovery' plan. This will improve the State performance in the following parameters –

Index/ Parameter	Value	State Rank
Human Development Index (UNDP) 2018	0.696	15
SDG National Indicator (NITI Aayog)	64	10
GSDP 2019 (lakh crore)	₹28.78	1
Renewable Energy (CEA) (MW)	1,311	8
Total Emissions MTCO2eq	233	6
Forest Cover Change since 2015 (MOEFCC)	-0.01%	Negative

Table 1: Performance of Maharashtra on various fronts

Another important issue which deserves attention when planning green recovery is that, the lower income section of the society suffers the most due to high vulnerability to climate and environmental impacts. This can be corrected by appropriate policy interventions to make the actual polluters pay for their emission loads. As social cohesion and harmony will become increasingly critical when facing multiple simultaneous disruptions due to climate change, the green recovery strategy must stay focused on inclusive development.

Cities, responsible for around 70% of both GHG emissions and economic activities, need to rapidly become more socially and environmentally responsible.[4] Cities especially in Maharashtra are highly vulnerable to Climate impacts due to their unsustainable growth. Thus, reducing per capita urban emissions to below 2 TCO2eq/year is an important target for the State (currently at business as usual scenario is expected to reach 3.2 TCO2eq/year by 2030)[5] Like the 'C40 Cities or the '100 Resilient Cities, Climate Resilience should become the basis for all planning for Smart Cities Mission or City Development plans.

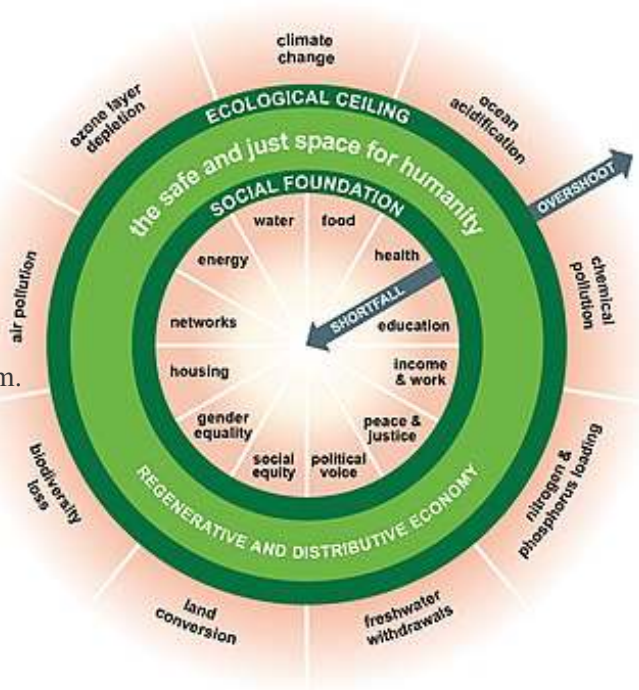
Recently announced changes by GOI in the Draft Environmental Impact Assessment 2020 (EIA),

could have a negative impact on many priorities for moving to a greener economy. Even Multi-National Corporations (MNC) now have a strong regard for sustainability and green growth in their company policies. Hence, green economic growth offers an attractive option for Business and Industries to build their reputation as a progressive green Company. Resources mined from the urban mines (recycling) instead of natural mines too can be extremely valuable to be truly 'Atmanirbhar' to maintain resource security for the nation without compromising the natural biodiversity richness.

1.3 Pathway to Low Carbon Sustainable Development of Maharashtra

A very suitable model to achieve green growth today is Dr. Kate Raworth's 'Doughnut Economy' model as it recognizes coherence between economic, environmental and social issues and assumes all actions are interconnected.[6] If one looks at the doughnut diagram, there are two circles – a small circle representing the minimal social foundations (UN-SDGs) in the middle and a large outer circle representing the the ecological ceilings (planetary boundaries). A society is considered prosperous if no one is left in the hole in the middle of the Doughnut and simultaneously all activities are within self-sustainable capacity of the planet. With careful planning and redesign, GDP can continue to grow while staying within planetary boundaries and thus creating robust social foundations.

Social Foundations (UN SDGs)
1.Health
2. Education
3. Energy
4. Food
5. Water
6. Housing
7. Network and Comm.
8. Income and work
9. Social equity
10. Political Voice
11. Gender Equality
12. Peace and Justice



Ecological ceilings (Planetary Boundaries)
1.Biodiversity Loss
2. Climate Change
3. Air pollution
4. Ocean Acidification
5. Chemical pollution
6. Nitrogen and phosphorous loading
7. Freshwater withdrawals
8. Land conversion
9. Ozone layer depletion

Figure 2: The Doughnut Economics Framework

Maharashtra being the leading business state in India, should be the first to achieve 'Low-Carbon Sustainable Development' as a Business success. This synergistic development policy is indeed possible if we can develop the right kind of mind-sets and create economic policy drivers for the change to happen. What is required is a clear focus on the following:

- Rapid transition to Renewable Energy-Economy within the State in next 10 years
- Low-Carbon Industrial Ecosystems for better Energy and Resource Efficiency
- Builiding Climate Change Resilience in the state for disaster preparedness

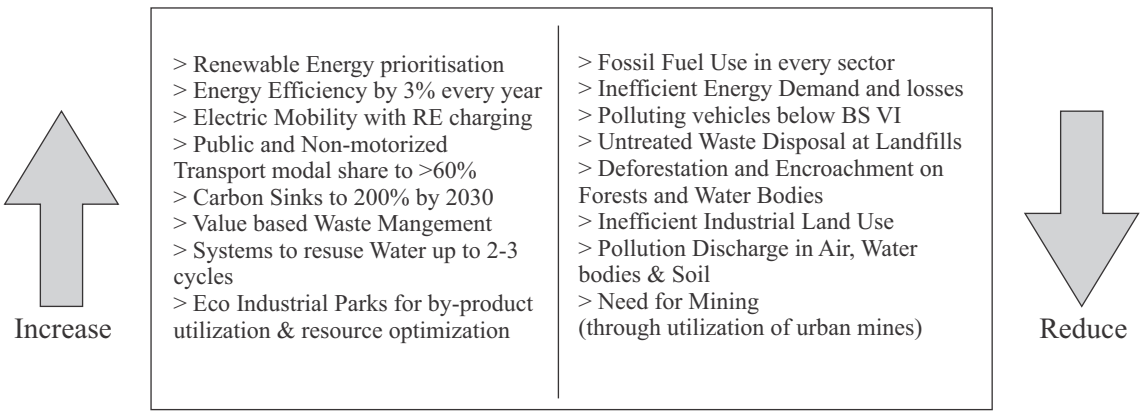


Figure 3: Pathway to Low Carbon Economic Development of Maharashtra

Chapter 2

Current Climate-Economic Scenario in Maharashtra

Current Climate-Economic Scenario in Maharashtra

There are reports available on current economic activities which provide information about Climate Change and Sustainability in the State. This chapter analyses the data to understand which sectors will be most rewarding in terms of Climate mitigation, resilience and adaptation, while also supporting economic progress for Maharashtra.

2.1 Vulnerability to Climate Change and Economic Disruptions

Maharashtra's Geography has played a crucial role in boosting its economic growth due to its contrasting climatic zones from the Konkan to the Vidarbha region. These regions are affected in various ways due to local climatic conditions.[7] MSAAPC report provides insight into climate crisis scenarios that will see increase in average temperatures, changing rainfall patterns and drought conditions. It reports that currently Maharashtra's districts have a poor Climate Resilience with Nandurbar being the most vulnerable, followed by Dhule, Buldhana, Jalgaon, Hingoli, Nashik, Jalna, Gondia, Washim and Gadchiroli.

The state sees approx. 86.9 deaths/1,00,000 people due to air pollution-related causes each year, ranking 15th in the average deaths in the country.[8] The average life expectancy would have been 1.5 years higher if air pollution levels were less. Such negative effects will continue to rise until strict action is taken to shift to a green economic model. Many negative trends in crop yields are estimated just at 2°C rise and can have profound and sometimes irreversible effects on economy as well as environment. The report however, misses out on some crucial weather events like thunderstorms and lightning, as well as health risks linked to temperature rise and associated increase in air pollution hazards.[9]

Soil erosion reduces agricultural productivity through the loss of nutrients and topsoil loss as observed in Dhule district where almost 64% land is degraded and under desertification. Ahmednagar and Sangli have also reported nearly 50% degrading lands.[10] This leads to excessive use of chemical fertilisers to compensate for the loss of nutrients or for cheaper mass production of crops. However, such short-term quick solutions lead to loss of soil quality and decrease the quality and nutrient value of crops. This has also given rise to another problem as excess fertilisers are carried by streams and rivers (and ultimately, the sea) where they lead to Eutrophication (excessive richness of nutrients in water bodies).

A warmer atmosphere holds more water vapour and will lead to intense rainfall events with longer

dry spells. The MSAAPC report highlighted that extreme rainfall is projected to increase in all regions of the state with greater increase in the northern parts, like Aurangabad and regions around Nashik. By the 2030s, Amravati will have 17.5-30% more rainfall, which will further increase to 22.5-32.5% by the 2050s. Meanwhile, parts of south-central Maharashtra (Ahmednagar, Solapur, Beed, Latur, Osmanabad, etc.) are projected to experience more dry days in the 2030s. These districts of Marathwada are already prone to recurring droughts and high rates of farmers' suicides. Current projections by NASA and IPCC show a doubling of average temperature increase to 4.1 – 4.8°C by late this century. This temperature rise will cause heat stress and also affect the work force because of heat cramps, heat exhaustion and heat stroke. As the immune system weakens with heat, susceptibility to diseases will also increase.[11]

2.2 Cost of Climate Inaction and Bridging the GHG Emission Gap

The table below shows 2 scenarios that could occur: business-as-usual (BAU) and rapid climate action (RCA) if we reduce emissions by 70% by 2030. Current emissions have been extrapolated from 2015 data[12] and CO2 sequestration area is taken from ISFR report.[13] The BAU assumes same carbon emission intensity and forest cover whereas RCA assumes low-carbon economic growth and doubling of present forest cover.

Scenario	Maharashtra GHG Emission	CO_2 Sequestration Capacity	Emission Gap
Current (2020) (Baseline)	302,579,947	42,952,000	259,627,947 (85.8%)
Business-As-Usual (2030)	484,014,867	42,909,908	441,104,959 (91.1%)
Rapid Climate Action (2030)	90,773,984	85,904,000	4,869,984 (5.3%)

Table 2: Maharashtra Emission Gap Estimates (TCO2eq)

Currently, Maharashtra's forest cover sequesters only about 15% of the state emissions. The table clearly shows that emission control is not achieved within this decade, the cumulative emissions will keep rising and the emission gap following the business-as-usual scenario will make it nearly impossible to reach Carbon Neutrality by 2030. Whereas, prompt Climate Action for 70% reduction in GHG emissions and doubling of our forest cover to 33% state area by 2030, will leave a manageable emission gap of 4.8 million TCO2eq. Hence, each decision about energy and environment will have a large impact within this decade. Any further destruction of green cover or increase in CO2 emissions will lead to a grave scenario where our future generation will be left with the impossible task of paying for our emissions and dealing with Climate Change Impacts.

In the context of Maharashtra, various sectors contribute differentially to the total GHG emissions, and it is essential to know their respective contributions to introduce sector-specific actions. Electricity accounted for around 139.7 MTCO2eq (46.2%) of total state GHG emissions with next important sector being transportation at 50.69 MTCO2eq (16.7%) in 2019-20. Hence a focus on electricity and transportation sector can significantly help in addressing about 60% of the State Climate Mitigation efforts and provide major economic savings. Figure 4 shows that Energy sector contributes the most to total GHG emissions and will keep on rising due to the growing energy demands of the housing and industry under BAU scenario. But 70% emission reduction by RCA (Rapid Climate Action) will lead to almost 75% reduction in the Energy sector emissions compared to the BAU scenario. The high contribution of AFOLU (Agriculture, Forestry and Other Land Use) in both cases can be compensated by adding carbon sinks.

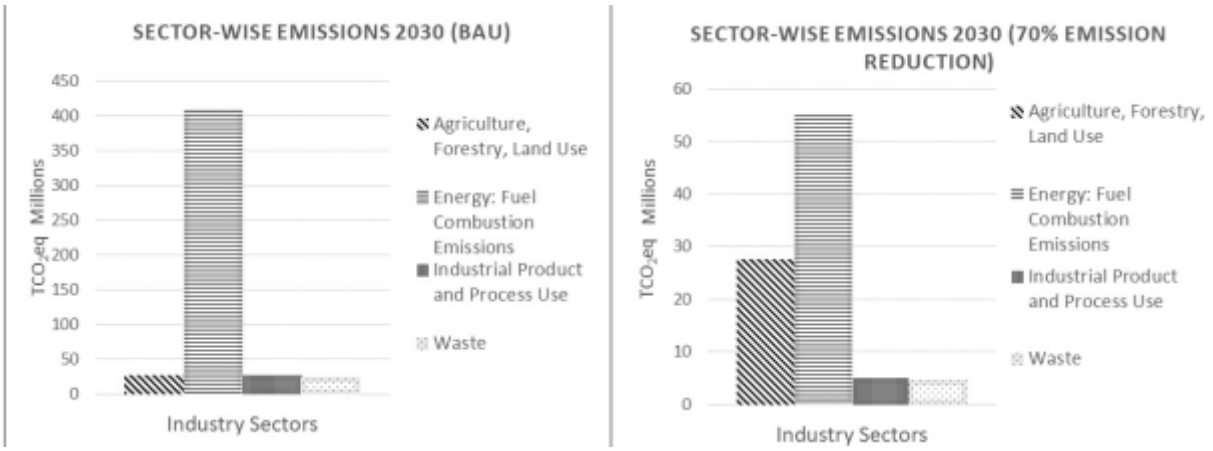


Figure 4: Sector-wise contribution to GHG emissions in 2030 in BAU and RCA scenarios

The LCOE (Levelized Cost of Electricity) for RE is far lower than that of Coal which makes it a cheaper option to produce electricity. In the long run, as the cost of producing electricity from coal remains mostly stagnant, the cost of RE produced electricity will continue to drop due to growing demand and mass market production of its technology. According to our estimates, the 2.4 TCO2eq Per capita emission of 2020 of the state is already above the globally agreed goal of 2 TCO2eq and this could rise to 3.3 TCO2eq by 2030 if transition to RE does not happen rapidly. Of the 36.81 GW electricity generation capacity in 2019, Maharashtra used 65% thermal energy at about 24.29 GW and 34% RE including Hydro (big and small) as well as just over 1% from nuclear sources.

2.3 Strategy for Green Recovery to Build a New Resilient Economy

The social cost of carbon is a measure of the economic harm expressed as the dollar value of the total damages from emitting 1 TCO2 into the atmosphere. The Social Cost of Carbon for the Indian economy is up to $210 billion every year and estimated to be about $85.4/TCO2eq. As per the 2020 estimates, Maharashtra may be already experiencing social costs of emissions up to 8.9% of the GSDP (Gross State Domestic Product). The rising absolute value of these losses means witnessing GSDP levels less than the potential of the State. India's Human Development Index (HDI) still ranks low at 129 out of 180 countries! If the economic, social and environmental aspects are tackled together, we can perhaps handle their interactions better and reduce the social costs.

The state forest area needs to increase to 33% to improve sequestration capacity and reduce the emission gap.

Agriculture, Forestry and Other Land Use (AFOLU) also contributes significantly to GHG emissions of Maharashtra. The forested area now stands at approx. 17% of the total state area, whereas Forest Policy of 1952 says 33% state area should ideally be under forests. Every 1 ha deforestation releases 100-200 TCO2eq[16] permanently into the atmosphere. Maharahtra, with 161,000 ha (1,610 sq. km) forests cleared in past 30 years, emitted at least 24 million TCO2eq and this may have incured a Social Cost of Carbon too. An addition of 1,000 trees to non-forest areas will annually save 84,000 US$ of alternative or artificial sequestration costs and also produce Oxygen worth 84 million US$.

This decade from 2020 to 2030, must emerge as the transformational decade for Green Economic Transition. Notable scientists and academics have been highlighting the lack of disease resilience and mitigation measures for years to come, until 2020 finally proved them right. The conventional economic approach assumes that, development and growth can only be achieved at the cost of the environment. Such assumptions for economic growth result in weakening economic and health conditions as given above. A rich economy in the future will be defined not by wealth in GDP but with natural resource management and human wellbeing index of a country. A Green Economic Model will have to be the 'New Normal' for the future.

Going back to polluting and unplanned development will lead to repetitive economic slumps that will not just affect Maharashtra but rest of the country. The following chapters give Actionable Recommendations (AR) that can bring immediate co-benefits to the economy and the environment.

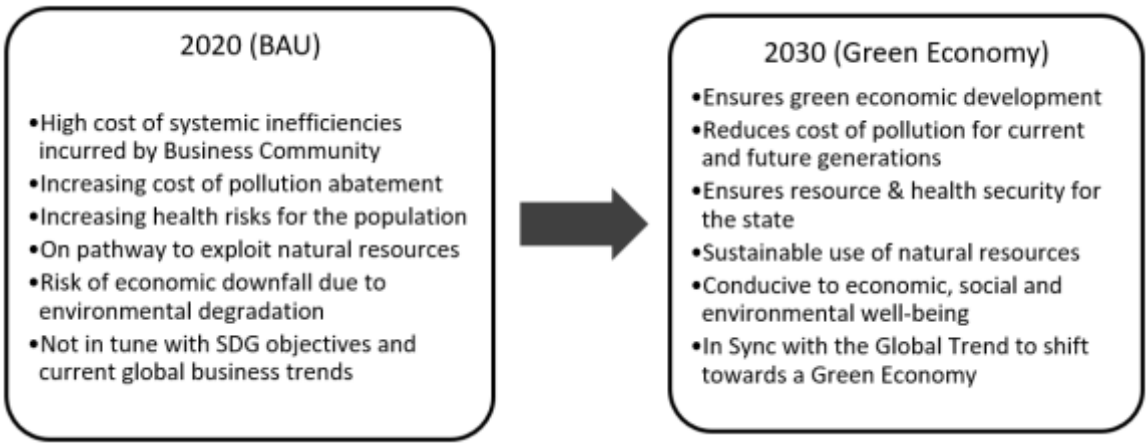


Figure 5: A summary of Green Transformation Decade from 2020 to 2030

Chapter 3

Transforming the Energy Dynamics of Maharashtra

Transforming the Energy Dynamics of Maharashtra

Recent technological advances in Solar Photo-Voltaic and Wind Power have made the Coal-fired electricity non-competitive despite long history of major infrastructure investments and Government subsidy support[17].Trends indicate that major fossil-fuel industry leaders are already reading the writing on the wall and have started investing more in RE sources like Solar and Wind. Majority of developed nations have already shifted to less polluting Natural Gas in place of coal and global energy experts are advising strongly against continued dependence on Coal for electric power generation.

While Solar and Wind power are already more cost competitive to Coal-fired power, given advances in Battery storage technology and rapid reduction in costs, Solar PV with Battery storage is set to soon become 24x7 cost competitive even to Natural Gas, which is the top choice currently due to its lower CO2 emission with high 'Base Load' capacity. It therefore makes it immensely wise not to invest too much in import-dependent Natural Gas power, but to give maximum boost for indigenous generation of RE power. This is also a clear choice for maximising the Energy Security of our nation.

A rapid transition to RE power in Maharashtra can transform the dynamics of the energy-economy equations to make the State more competitive, highly eco-friendly, as well as offering maximum energy independence. Promoting solar, wind, bioenergy, biofuels along with small hydro and wave-energy where feasible, will thus ensure a holistically green and resilient energy transition for the state. Given the governance structure, such a transition will be easier to achieve for a state like Maharashtra, much before it can be achieved for the entire country. Maharashtra can thus become the leader in this once-in-a-lifetime transformation to a new Energy-Economic model.

3.1 Rapid Shift to RE Power Dominance

Energy sector contributes the highest GHG emissions and it also presents the biggest opportunity for reducing emissions and the related costs. Hence RE dominating the energy sector without any penalty to the environment is a must for the future. With Battery storage technology advances, Maharashtra can easily aim for 24x7 RE abundance by 2030 to pioneer the successful transformation to Low-Carbon Economic Development.

However, moving away from Fossil-Fuels after decades of established energy-economic practices may not be easy. Given the economic and environmental compulsions, regions that are shifting to

low-cost and low-carbon solar power, wind turbines, electric vehicles etc. are already attracting international businesses and investments. A recent study brings out a less known fact that the social and environmental co-benefits of phasing out Coal power far outweigh the costs of staying with it in countries like India and China[18]. Considering discounted co-benefit considerations of coal-exit scenarios before 2050, it reports India to be much above the break-even line between cost and benefits.

A rapid transition away from coal can be made easy with an intermediate phase of Natural Gas replacing coal in the thermal energy basket, before 'RE + Battery' option can grow to the scales required. Natural Gas has lower CO2 emission than coal and it has better flexibility for spot changes in demand as well as 3 times higher base load factor than RE. However, it cannot be a permanent solution as Natural Gas too is a fossil fuel and based on high costs imports, since India does not have adequate indigenous Gas resources. It is important to note the cost-to-customer of 'Solar PV+ Battery' system is already at Rs 4 per kWh (Unit) as against earlier Rs 6 per Unit, but the scale-up for wide availability could perhaps take until the year 2025 depending on many factors.

Another major reason for shifting to a green growth model is about stabilizing the earth's atmosphere. Every year earth emits and absorbs about 750 Gt in its natural carbon cycle and human activities are now adding additional over 40 Gt of cumulative CO2 emissions each year. This is creating an imbalance in the natural carbon cycle and causing unprecedented Global Warming and Climate Change. Most of these emissions come from fossil-fuel burning and can now be easily replaced by indigenous RE power generation that is more efficient, cost competitive and environment-friendly.

Hydrogen fuel-cells is another promising RE power source particularly for E-Vehicles to avoid Petrol/Diesel burning IC engines. Such new green and sustainable technologies provide an exciting market in the transport sector – as proved by the 'Tesla' company in the US. Most of its success comes from using sustainable technology that is not only green but also easily scalable for attractive cost benefits.

These new Energy-Economic choices offer an exciting high-performance matrix with huge market potential for large profitable investments for better and sustained economic growth. Thanks to technological innovations that provide new options to economic performance without the cost to environment, our world is on the cusp of a major green business transformation in which the state of Maharashtra must take leadership role.

Assuming that the energy demand for Maharashtra will double by the year 2030 from the current 36.7 GW to about 72 GW; we can foresee the RE generation increase scenario for a robust green economic growth. Until the year 2022, a BAU scenario may continue, given that the initial RE boosting policy implementation may need time. The tendency to continue using fossil-fuels for the time-being, also may remain mostly unchanged. But after 2021, things must change very rapidly to boost RE in every manner.

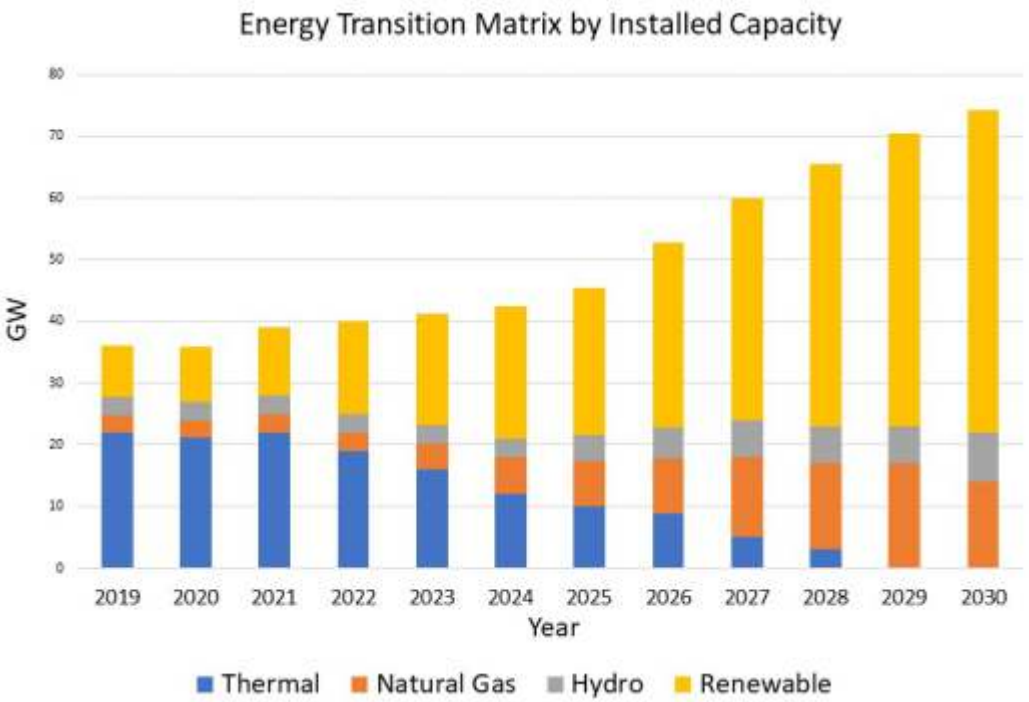


Figure 6: Transition needed in Maharashtra Electricity Mix (from 2020 to 2030)

From the year 2023 to 2025 an increase in RE capacity is expected as it becomes more cost effective and Thermal coal power will get phased out slowly due to growing concerns of air pollution and increasing cost of coal power generation. Simultaneously Natural Gas capacity is expected to increase from 2022 to 2028 due to base load requirements. But battery technology is rapidly getting cheaper for RE storage and it will be the major source in the electricity mix from 2025 onwards with a rapid growth expected by 2030.

3.2 Making Maharashtra the Maximum Solar State

Total electrical energy requirement for Maharashtra in 2019-20 was at 162,706 MUs and it will likely double to about 325,400 MU by 2030. Given that, each kWh (Unit) of Coal energy causes about 1 kg of CO2 emission. Hence, 325,400 MU replaced by solar electricity will save 325 M TCO2eq/year GHG emissions or 8,125 M TCO2eq over the 25-year life cycle. Maharashtra can thus take leadership to earn the title of "Maximum Solar State of India" by 2030 - to steer Maharashtra to spectacular economic and environmental well-being.

Maharashtra RE potential is at least 113.925 GW (3X times more than 2020 total electricity use) and it will have to reach over 22 GW to meet the NDCs. But the installed renewable capacity in the State was only 12.52 GW in 2019. Hence, ambitious goals and timeframes are necessary for rapid transition to RE systems for enabling the development activities without adding to carbon emissions.

The present time is an excellent opportunity for a progressive State like Maharashtra to build a greener, clean economy for a decisive shift to low carbon economic development for the immediate future. This can be the real 'Green Economic Deal' for Maharashtra. The technological advances in Solar and Wind power generation have now made such a transition very profitable. Going green will also help in reducing global warming to limit future impacts of climate changes. The transition to RE can help Maharashtra demonstrate that Economy and Environment can thrive together synergistically for a progressive green future. Some estimations are presented below to support this multi-dimensional strategic shift to 'Low-Carbon- Economy', which now must become the 'New Oil'. RE is not only clean with minimum carbon footprint but also more efficient, costs competitive and easily deployable. Solar is particularly better suited for 'Distributed Generation' on site. New innovations are emerging fast to make this indigenous un-limited energy source the bedrock for future Energy-Economic dynamics. This will signal a new era of real clean energy abundance with maximum energy independence - ideal for the energy security of the Nation.

Every 4 acres of non-agricultural land can easily accommodate a 1 MWp of solar generation which can give 1.6 MU of Renewable Energy (RE) per Year. Hence the estimated 325,400 MU energy needs by 2030 may require 813,500 acre land (assuming all energy requirements are to be met by solar). For the state of Maharashtra with total 76 Million acre area, 813,500 acre area should not be very difficult to identify for Solar farms, but the high cost of land often makes Solar farms almost prohibitive. That is the reason why Govt of India has the 60+40 model where 40% of the RE capacity can come from Roof-Top or distributed Solar power with zero land costs. Ground mounted Solar farms for 60% of 325,000 MU =195,000 MU/year, may thus require only 487,500 acres of suitable land.

The Balance 40% RE from rooftop solar power of 130,160 MU will require Rooftop area of about 863 Sq-Km by 2030. (At 150 MU/Sq-Km). For this, 30-40% of the state solar rooftop capacity can be utilized for Solar PV installation in all new constructions with right policy incentives including schemes for retro-fits for old constructions. MERC and MSEDCL should establish the mechanism to facilitate citizens and organizations to install Rooftop Solar (RTS) along with strong Net-Metering integration to achieve the RE targets by 2030.Several Indian states like Karnataka or Gujarat have succeeded in making profits by changing the business models of their DISCOMs and

Maharashtra must do the same. (Detailed policy amendments in MERC regulations 2019 to achieve this target are given in the Annexure: Net-Metering for Rooftop Solar.)

This is entirely doable for Maharashtra if majority of the Institutional, commercial and residential rooftops are used for RTS in increasing steps up to 2030. But such distributed generation will require efficient Net-Metering to be integrated with the grid, or Battery back-up capacity for non-sunny days. Inverter and Battery technologies have progressed very well (e.g. Lithium-Ion battery for Millions of Cell Phones) and stand-alone Solar power units like the 'Tesla-Wall' systems in US are already promising 24x7 clean power capability at affordable and competitive costs. Hence, it is only the matter of judicious and correct policy decisions that are awaited.

Given the planned rapid expansion of Electric-Vehicles, further increasing the RE capacity to charge all EVs will be an additional requirement but that should not be a problem. Additional Grid-connected Wind power generation can rapidly enhance the RE content in the conventional grid to dramatically reduce the use of fossil-fuels and thus further reduce the CO2 emissions. The main rationale for Electric Vehicle is to reduce air-pollution as well as CO2 emissions due to the Transport sector. This objective will be well-served if RE based charging is made available in real time in synchronisation with expansion of EVs through to 2030 and beyond.

As is well known, every kWh of thermal energy causes 1 kg of CO2 emission. Hence a solar generation plant of 1 TWh capacity can save 1 Million Tons of CO2 per year, or 25 Million Tons emission saving over the 25-year life cycle. This is equivalent to the sequestration capacity of 1 Million trees doing the same job. Thus, RE power will also hugely improve the Air Quality Index (AQI) that harms the health of millions of urban citizens world-wide every year. In fact, given the spectacular advances in technology and cost savings, one can easily foresee a situation of 24x7 abundance of RE power to energize the economy with thousands of well-paid green jobs without any penalty to the environment. This will be the true Green Revolution-II for India in which **Maharashtra can soon earn the distinction of becoming the first "Maximum Solar State of India."**

Hybrid Solar-Wind System - An innovation that can provide reliable RE power to nearby localities, if mounted along major road medians and metro-routes, is a Vertical Axis Wind Turbines system developed by University students - (VAWTs). Such a promising hybrid initiative deserves immediate policy and financing support for ushering a new era of clean energy access as it will also serve towards increasing awareness about RE infrastructure amongst localities and commuting citizens in an industrious state like Maharashtra.

This 6-foot vertical Wind Generator on a highway median rotates with passing Vehicles and is aided with Solar panel. Placed at 33-meter gap, 300 units can give 3-5 kW every 1 Km of road. Deployed on 3 highways in Denmark these are already powering 3000 households.

Key recommendations for immediate actions for Maharashtra must include:

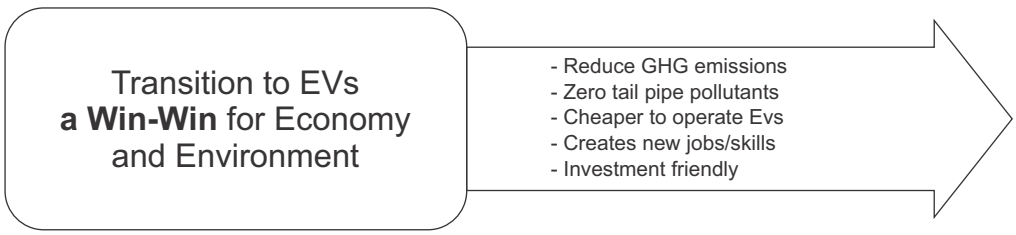
1. Establish an empowered policy advisory body to set the 2030 actionable targets.
2. Use of State Energy Ministry proposals for enhancing Grid-integrated RE capacity to 200,000 MUs by 2030 by encouraging MSEDCL to adopt max RE.
3. Establish the mechanism to facilitate citizens and Corporates to install Rooftop Solar with efficient Net-Metering to achieve collective 130,000 MUs by 2030.
4. Mandate all EVs in the State to use only RE for recharging through Mini-grids or stand-alone charging stations to meet all the demands in real-time.
5. Establish suitable financing for all innovations and RE deployment in the state
6.Establish Skill-Training Centres for thousands of new RE jobs opportunities and create a reward/penalty mechanism for effective implementation of Policies.

3.3 Expanding E-Mobility and Sustainable Transport Systems

As on 31st December 2019, the total 371.22 lakh vehicles registered in Maharashtra had only 2.71% LPG/CNG vehicles and 0.07% EVs. India has taken bold steps for rapid introduction of Electric Vehicles (EVs) with Flame 1 and 2 initiatives replacing >50% fossil-fuel driven vehicles by 2025 and 100% by 2030. But if this is not backed by RE charging, nearly 75% of the transport GHG emissions will not get reduced due to heavy reliance on thermal electricity-based Grid-power. In fact, this will sharply increase the demand for fossil fuel power generation. Hence, this transformation to EV will not be complete without parallel development of RE-charging infrastructure. RE charging will enable about 6.29 lakh TCO2eq/day or 229.5 million/year TCO2eq emission reduction!

While Maharashtra is the first State to launch a 'Maharashtra Electric Vehicle Policy', investments to set up RE charging stations to promote the use of EVs beyond the 5-lakh target is equally necessary. Incentives for EV parking including prime slots, subsidies for shared and public EVs and building RE charging and battery swapping stations in a planned manner, will make the E-mobility transition easier and robust. State Transport should increasingly add E-buses to the fleet and completely shift to E-buses by 2030. BEST and PMPML E-buses are already showing profits and eventually all public transport should shift to E-mobility with RE-charging. State Government should completely shift to e-vehicles by 2030 and also promote EVs by choosing right brand ambassadors.

The main rationale of EVs is to reduce air-pollution as well as GHG emissions. This will get defeated substantially unless RE-based charging is made available in real time along with EV expansion by 2030.



For Maharashtra, Replacing Thermal electricity with RE charging for 1 Lakh vehicles will need about 100,000 X 32 = 32,00,000 Units/day and save 2374 TCO2eq/day GHG emissions. All parking spots should have E-charging slot, preferably with RE charging and tenants should be allowed to install EV charging stations. Reduction of local taxes for EV ownership and loans, including road tax, registration tax, no toll fees, free parking for EVs in public spaces with RE charging facilities etc. will act as incentives for shifting to EVs. The main rationale of EVs to reduce air-pollution as well as GHG emissions will get defeated substantially unless RE based charging is made available in real time along with EV expansion by 2030.

3.4 Enhancing Local Options for RE Power Generation

Maharashtra being predominantly an agrarian state with more than 50% of its population residing in rural areas needs to pay special attention on developing and enhancing all local RE generation options. Today the demand for 24x7 electricity is not yet met in the rural areas, this gap can be easily bridged by opting for locally produced RE. These local options will not only be a boon for the rural economy and agriculture, but also help them become 'Energy Independent'.

Biomass energy has huge potential as it is produced from locally available organic material. It may not be 100% clean, but available at any time throughout the year unlike solar and wind. With the advancement in technology like the 'two stage gasifiers', use of bio-energy will become more

efficient at a lower cost. Throughout the year farmers produce a variety of crops but often cannot process them locally due to lack of electricity, thus have to sell them as raw material and sacrifice profit. By use of bio-energy the farmers can be liberated from such shackles, thereby strengthening the rural economy. Germany has been proactive in shifting to bio-energy and has invested around 2 billion £ in it.

Bio-Gas: Bio-gas is often neglected and overlooked, but bio-gas is necessary in order to achieve sustainability in agriculture-based economies. Bio-gas is storable, efficient and a profitable source. Today treated bio-gas has been found to be a direct replacement to CNG and LPG fuels. The raw material needed for the use of bio-gas is already in abundance and not using it would mean losing out on potential. It has proven to be useful in rural as well as urban areas. A good example can be Pune's Model Colony biogas plant, which is one of the several functioning bio-gas plants in Pune. The plant locally utilised 10,000 tons of wet-waste to generate 1.2 Lakh kWh of electricity and 700 tons of manure in one year.

Waste-to-Energy: Waste-to-energy plants offer two important co-benefits of environmentally safe waste management as well as the generation of clean and renewable electric power. Its growing use has greatly reduced environmental impacts of municipal solid waste management, including emissions of GHG. Electricity generated also reduces the requirement of grid electricity and the GHG emissions are significantly reduced by preventing methane emissions from landfills. Moreover, waste-to-energy plants are highly efficient in harnessing the untapped sources of energy from a variety of wastes. Indore's model of waste to energy can be kept as a role model for cities in Maharashtra.

Hydrogen Fuel-Cells: Hydrogen fuel-cell technology transportation has recently emerged as a highly viable option that can complement EV transition in Maharashtra. The application scope of fuel-cells is expansive. Fuel-cells have myriad advantages over combustion-based devices, with over 60 percent efficiency in the conversion of the fuel's chemical energy to electrical energy. To put that in perspective, 1 gal of gasoline has about the same amount of energy as 1 kg of hydrogen. Most fuel-cell cars carry about 5 kg to 6 kg of hydrogen but go twice the distance of a modern internal combustion engine car with equivalent gas in the tank, which works out to a gasoline-per gallon equivalent between Rs.350 and Rs.420. Hydrogen fuel-cell cars now average between 502 km and 612 km in range. The state of California has invested over 900 million dollars to jumpstart the use of fuel-cells, Maharashtra can follow the same pattern.

Scenarios	2022 (Capacity 42 GW)	2024 (Capacity 50 GW)	2026 (Capacity 54 GW)	2028 (Capacity 64 GW)	2030 (Capacity 70 GW)	Total benefits for given 5 years
Base refrence: BAU – 10% RE	1.71 trillion	2.04 trillion	2.45 trillion	2.90 trillion	3.47 trillion	No major Benefits
Savings by transition to 70% RE sources	-73 billion (total cost- 1.79 trillion)	+62 billion (total cost- 1.98 trillion)	+282 billion (total cost- 2.17 trillion)	+660 billion (total cost- 2.24 trillion	+1.007 trillion (total cost- 2.46 Trillion)	1.9 trillion savings
Savings by transition to 100% RE sources	+ 245 billion (total cost- 1.47 trillion)	+344 billion (total cost- 1.69 trillion)	+793 billion (total cost- 1.65 trillion)	+1.09 trillion (total cost- 1.88 trillion)	+1.72 trillion (total cost- 1.74 trillion)	4.1 trillion Savings

Table 4: Cost effectivity of RE over Thermal Energy and Benefits of Transition (in INR)

The table is based on the following Logic and Assumptions:

- Calculations are based on forecasted Levelized Cost of Electricity of different sources
- The demand for energy is assumed to double as we reach 2030.
- The base reference has been taken w.r.t current energy mix of 2020.
- Savings are calculated by comparing baseline scenario with 2 scenarios which show benefits of RE transition (70% and 100%)
- The composition of RE in the energy mix has been shown to increase gradually and finally reach its targeted composition by 2030.
- The table aims to show how RE transition is hugely beneficial economically.

Major potential of RE for job creation:

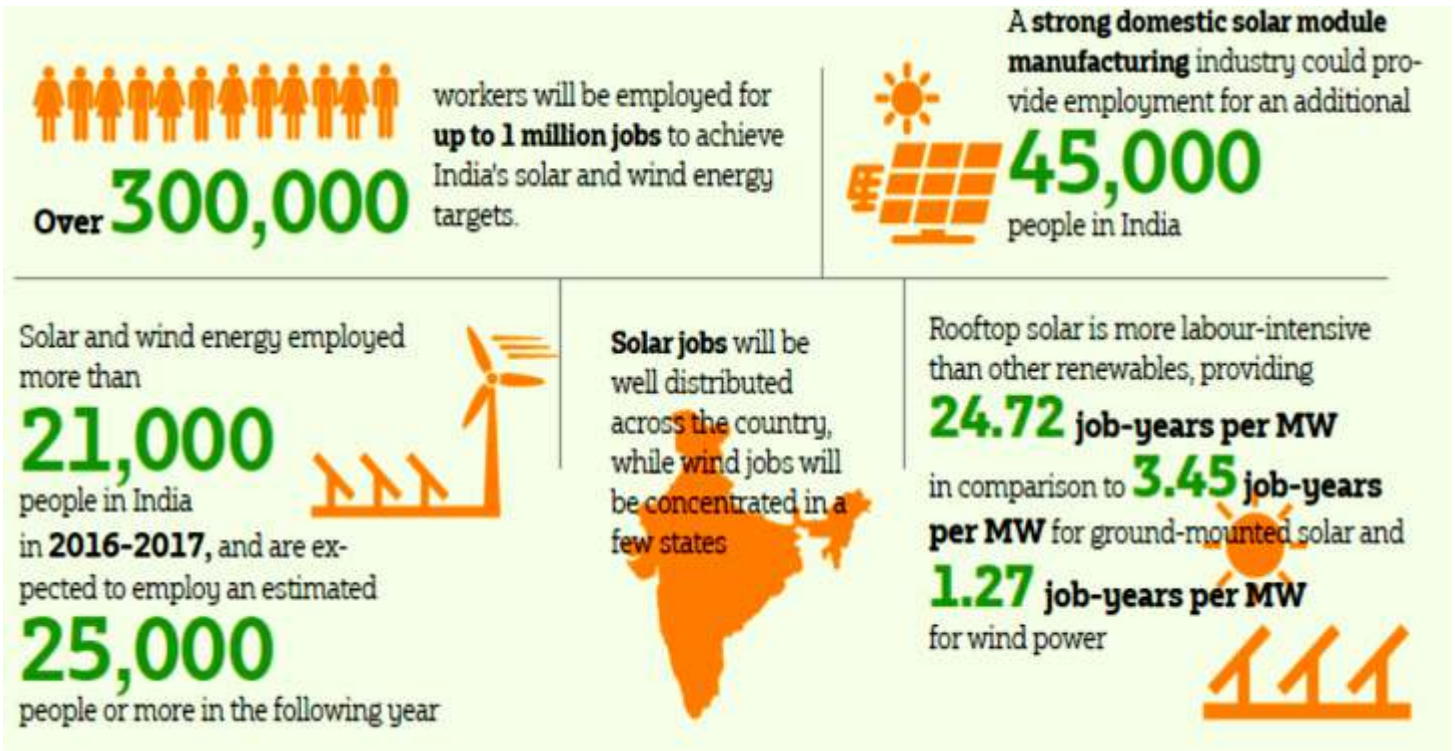


Figure 7: National Employment potential from meeting RE-related NDC22

Chapter 4

Developing Low Carbon Business Ecosystems

Developing Low Carbon Business Ecosystems

When companies conduct an efficiency analysis of their businesses it helps to identify inefficiencies due to excessive by-product discharge or poor use of materials within a value chain. This highlights the need to minimise these inefficiencies through careful by-product management or improving material value chains which directly translates into reduced costs. A healthy environment can lead to; and is necessary for a healthy economy. In this chapter we will discuss methods to reduce costs for a green economy which include improving efficiency, design of Eco Industrial Parks, taking a Circular Economic approach and planning priorities to be given for Sustainable Infrastructure.

Recent reports have suggested that the economic growth in India for the next decade to 2030 will be boosted by the digital markets for which access to a digital infrastructure will need to be provided to the poorer sections of the society as well. India's growth can then be further spurred by introduction of faster connectivity and AI systems that require a strong climate resilient technology infrastructure. Frequent weather disruptions, increasing temperatures and polluted air can shake the jar of our current economic strongholds and could lead to an economic decay. India's ~26 million micro-small and medium-sized enterprises are also especially vulnerable to Climate Change impact and its consequent economic slumps. Thus, it is imperative that we move towards a green economic recovery that can lead India to lasting economic progress with a strong resilient economy and an environmentally responsible new paradigm.

A major misconception in India is that eco-friendly projects tend to offer lower returns than less eco-friendly ones. United Nations estimates that bold climate action taken today will trigger at least US$26 trillion in global economic benefits by 2030[19]. A decisive shift to a 'Low-Carbon-Economy' can support all economic aspirations without violating planetary boundaries. Developing a framework for a Sustainable Green Economy can be done using the following key frameworks:

4.1 Enhancing Energy and Resource Efficiency

Measures taken now to improve energy efficiency will reduce specific demand and avoid unnecessary energy wastage. Today, India's energy and resource efficiency are deemed to be very low and improved efficiency is crucial for improved financial gains and true resource independence. Increase in energy efficiency will play a significant role in optimization of our energy use patterns and will also help with adoption of clean energy. Increase in resource use efficiency of our natural resources like, soil, forests, water and air will also ensure sustainable use of

our natural resource which are highly perishable.

4.1.1. Rapidly reduce overall Energy demand by 3% every year in next 10 years

According to the Ministry of Power annual report on energy generation, Maharashtra today is able to provide electricity to all its villages[20]. Hence electrification in the state; since it has reached all nooks and corners must now focus on increasing efficiency. Energy efficiency is highly essential for sustainability as it not only saves money, but also prevents and reduces the load on the environment. A State Green Building Code if adopted, can help reaching this target of 3% reduction/year, with specific codes for increasing energy efficiency in buildings which contribute to 33% of total energy demand and hence have potential for large-scale reduction. Maharashtra's booming industries are highly dependent on the use of the state's natural resources such as land for agriculture and construction, water for household and industries and forests for their commodity/ eco-system services. Hence, going ahead, it is highly recommended to adopt sustainability standards (such as ISO or GRI) for improving the efficiency of resource use to ensure sustainable supply of resources for the present and future generations.

4.1.2. Utilize water efficient irrigation systems for agriculture and set up area-specific water recycling and reuse stations for industrial processes

According to data by the Maharashtra Water Regulatory Authority and the Irrigation Department, it is well established that water resources are depleting to near impossible levels for extraction and since the cost of electricity increases every year, it is imperative to reduce water and energy demand by using efficient irrigation systems such as Drip Irrigation and combining them with solar pumping initiatives.

4.1.3. Focus on Sustainable Agriculture for organic Soil Carbon Sequestration

Soil use has also become a massive issue in Maharashtra as most agricultural land is used for growing only a few cash crops. This model of farming, however cost effective or cash flow intensive it might be, is causing serious irreversible damage to soil quality. The Department of Agriculture must ensure soil security for the State by exercising crop rotation patterns, using organic and natural methods of farming and limiting use of chemicals and fertilizers as it leads to nutrient drainage, GHG emissions[21] and is known to cause serious long-term health risks for the consumers. If these measures are not taken immediately, it can turn into a mere fight for survival to save agricultural soils for current and future generations.

4.2 Adopting Circular Economy Solutions for Businesses

Industries and Businesses need to manage the environmental challenges they are currently facing by planning, financing and stream-lining environmentally responsible technologies, actions and initiatives. Using renewable energy, optimizing waste end-of-life strategies, water conservation and going beyond these to achieve true sustainability and resilience may prove to be a challenge

without proper guidance from the State Government, NGOs and Civil organizations. Hence, initiating low carbon and circular economic models today, will help industries to simultaneously achieve social, environmental and economic goals.

A **Circular Economy** is a regenerative system in which raw material input, emissions output and energy wastage are minimized by closing and narrowing energy and material loops. It can lead to an efficient and regenerative solution that aims to keep products, components, and materials flowing within the economy at all times. Like energy, the way we deal with materials also significantly determines the level of GHG emissions. Reducing, reusing, recycling and up-cycling of resources in addition to waste-to-energy projects, can decrease immediate fossil fuel demand and increase Green Jobs as well. Hence, industries adopting circular economic practices should be given due incentives.

This model of an economy that supports green growth, will not only be in line with the country's 'ATMANIRBHAR' growth policy but will also make our economy resilient to future economic or climate related damages. It will also improve working productivity of material and human capital as it reduces climate change related stress. Cities that have in the past, grown in an unsustainable manner cannot be termed 'true development' as they have led to decreasing productivity due to long transit times between work and homes, breathing of polluted air, increase of heat stress every year due to rising temperatures and increase in climate intensity of rainfall and thunderstorms. Such unsustainable growth can only lead to impacting the productivity of India's human capital and could deter the said economic growth we strive to achieve.

In the year 2018-19 only 42.2% of Municipal Solid Waste (MSW) was treated in Maharashtra before being sent to the landfill and a staggering 45.5% of MSW was dumped untreated onto the landfills leading to GHG emissions, contamination of ground water and loss of opportunity cost by segregating and extracting resources from the waste end-of-life streams. In order to manage our waste problem more efficiently unified laws need to be passed taking into account the value addition of recycling and upcycling of waste rather than just disposing it in Landfills.

4.2.1. Formalising the Sustainable Waste Management Sector

Maharashtra is home to many Solid Waste recycling industries ranging from metal, plastic, paper to clothes. However, these recycling industries urgently need help to streamline segregation of MSW into plastics, metals, paper and E-waste; and formalize the MSW collection system. The organic waste on the other hand is currently being collected separately in some cities but such policies need to be implemented state wide. Biogas plants have increasingly become relevant in generating electricity and producing manure both in urban as well as rural areas from organic waste. Among the plants installed in Pune City, a good example is the centrally-located Model Colony Biogas Plant which locally collected more than 10,000 tons of wet waste to generate 1.2 Lakh kWh of electricity and 700 tons of manure for farmers[22].

Policy guidelines and standards are required for upcycling and recycling of Solid Waste. There is a dire need for regulated and simplified waste collection and processing systems. As currently, these activities are conducted in slum areas without any health and security concerns or proper monitoring.

In 2019, the Biogas plant at Model Colony in Pune locally collected more than 10,000 tonnes of wet waste to generate 1.2 Lakh kWh of electricity and 700 tonnes of manure.

District authorities should make comprehensive Waste Management plans for separate collection and recycling of waste resources and preventing their untreated disposal. This will ensure reduction of waste going to landfills or Nalas and provide financial and regulatory stimulus to our Recycling Industry which has tremendous potential for development and growth.

4.2.2. Adopt Green Dot System to make recycling obligatory for manufacturers

The "Grüne Punkt" i. e. "Green Dot" system was developed by a not-for-profit organisation Duales System Deutschland (DSD) for Germany in the wake of its 1990 packaging ordinance - a law obliging manufacturers, fillers and distributors to take back their used packaging waste and send it for recycling. Under the legislation, producers are exempt from the obligations if they take part in a collective recycling scheme, such as the "duales (dual) system" provided by DSD. If they do not partner with DSD then they must ensure recycling of their packaging waste. Such a law focuses on collectively recycling MSW and ensures that companies not only take responsibility for disposing their own products, but are not burdened to doing so themselves. The State Ministry of Environment and Climate Change can take up the responsibility to gather funds from companies that are using packaging materials for products in the form of a single pool of funds to be used for streamlining local waste segregation, collection and recycling.

4.2.3. Strategically establishing Eco-Industrial Parks to boost industry profit margins and create thousands of local Green Jobs in the process

Identifying Industrial Synergies within industries in a location can lead to exchange of energy or material flows to increase efficiency and boost profit margins. Identification and implementation of these synergies with regards to planning and infrastructure development can lead to development in green jobs. These new green jobs would require new training regimes for creating not just officers or consultants but entrepreneurs and leaders that have the right set of tools to balance both the economy and the environment. This will also help prevent future unemployment rates when we shift to a green economy.

The concepts of Eco-Industrial Parks (EIPs) can be used for cross-industry utility linkages (see Annex 4). According to the World Bank, Eco-industrial parks offer the business advantages of traditional industrial parks while also using resources more efficiently, improving productivity, supporting the achievement of the firms' social responsibility goals, and lowering the exposure to climate change risk.

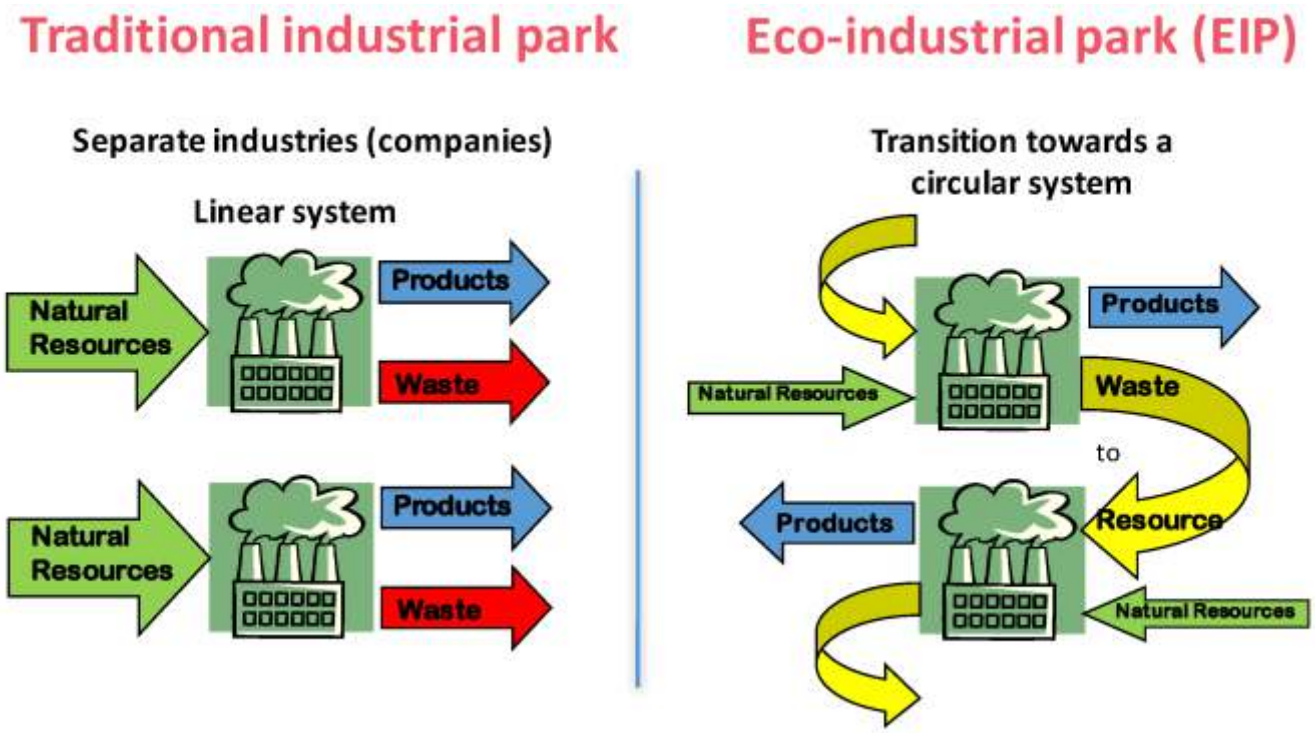


Figure 8: Comparison of traditional and eco industrial park

In India, very few EIPs exist like; at Nandesari and Dahej (Gujarat) where a database of material inputs and outputs for industrial synergies was provided by the Gujarat Cleaner Production Centre. A few private companies such as Mahindra World City in Chennai have also adopted material synergisms within industrial parks.

An EIP collaboration could help its members achieve greater economic efficiency than their stand-alone counterparts. Companies could also use EIPs as a solid foundation for green marketing campaigns. For the local governing body where the EIP is located, it entails increase in tax revenues, worker wages, increasing job opportunities and lower expenditure on sewage, sanitation, disaster management and environmental clean-up[23].

Maharashtra must incorporate Eco-Industrial Parks while planning the Delhi Mumbai Industrial Corridor (DMIC) and new MIDCs; to utilize by-products from one industry as raw material for the other. In order to regulate and guide the transition to adopting Eco-Industrial-Parks, MPCB and MIDC must keep a database of the inputs and outputs within cluster industries to identify local synergies and possible exchange of utilities. EIPs can also be combined with Maharashtra's current Industrial Policy of 2018 that provides beneficial funds to environmentally sustainable companies. Hence, Environmental Accounting serves to increase the profit margins and they do not derail development, if done correctly.

4.3 Planning Priorities for Sustainable Infrastructure

The building sector consumes almost 33% of India's total energy. Buildings have a relatively long lifespan of several decades and will continue to affect their GHG emissions over the long-term hence, it is imperative to take action today to reduce their GHG emissions. These actions will signal a new era of clean energy abundance with maximum energy independence ideal for energy security for the State and the Nation.

4.3.1. Design and mandate a unified State Green Building Code with annual reporting

MHDCL, and Ministries of Environment and Climate Change, Rural and Urban Development should design and mandate a unified combination of ECBC codes, Green Building Codes for Maximum RE capacity, green practices and climate-friendly design, as a unified 'State Green Building Code' for all new constructions; on the lines of Sustainable Certification scheme in Copenhagen, Denmark. This will also reduce maintenance and energy costs for the users and reduce the environmental pressures during the lifetime of the building. Improved working environment due to emission reduction and increase in energy efficiency makes the workforce up to 16% more productive with lower rates of illness as opposed to energy-guzzling buildings. Reduction in electricity use can yield up to US$46 health benefits for each tonne of CO2 saved in India. It is also estimated that every 1 million US$ invested in urban green buildings generates 14 job-years of employment.16 This is a clear win-win for all.

Reputation builds a better market status and inspires constructive clientele action, rather than compulsion. All Residential, Industrial and Commercial Buildings should have 25% or more RE and get a RE Star Rating. 90% or more - 5 Stars; 75-89% – 4 Stars, 60-74% – 3 Stars; 40-60% – 2 Star and 25-29% 1 star. If a building invests twice the deficit in external Clean energy sources like solar-wind grid connected farms, it can also improve its Star rating. Tax rebates can be designed proportional to Star rating and annual electricity generation details submitted to the local governing body.

4.3.2. All Urban expansion should be in the form of planned Green Townships

Rapid urbanization being a key challenge for Indian cities, planning and infrastructure practices which support low GHG emissions and prepare the city for climate adaption are the need of the hour. Big Complexes and Townships should aim to be Carbon Neutral and Sustainable and plan all systems likewise, the solutions for which already exist. Urban expansion should happen only in a planned manner with 'Green Townships' that are self-sufficient settlements supporting basic requirements of up to maximum 1,00,000 people. Low Carbon and Decentralized practices should be mandated and regulated for all upcoming residential and industrial premises and complexes. Governance policies to incentivize Green Infrastructure and penalize insensitive construction will accelerate this process.

Green townships should prioritize the following:

- Energy-efficient planning to reduce energy demand and losses
- Maximum electricity independence by distributed generation with RE
- Rainwater harvesting in recharge zones; recycling and reuse of water
- Sewage Treatment at source using low carbon technologies
- Suitably treated wastewater used to irrigate and/or fertilize nearby farms
- Educational and vocational training centres including soft-skills centres
- Easy access to internet and green technologies
- Transit-oriented transport to encourage walking, cycling and public transport
- Not disturbing native ecosystems and environmental water flows
- Developing open and recreational spaces and greening campuses
- Diligent monitoring and assessment of change in land use, risk factors, resource use and quality of environmental assets and strict action against non-conformance

4.3.3. Widely Shifting to Environmentally sound Public Transport to reduce emissions and decongestion, especially in Cities

Public transport can reduce up to 80% transport-related injuries, create direct and indirect employment and also improve public health and environmental conditions. Rapid improvement in Bus Transport by shifting to E-buses and improving service benchmarks, increasing frequency and number of rides, starting BRT routes and strategizing route maps for ease of access and better connectivity are also very necessary. Cycle sharing and public E-taxi/rickshaw stations should be placed near public transport systems to provide last-mile connectivity. It is also crucial to include adequate space for non-motorized transport like cycling and walking in all Road Design. Every million people switching to cycling or walking of 5 km (one way) can get health benefits worth about 1,450 million US$/year from physical activity and 33 million US$/year associated air pollution reduction in large cities. Adding metros, underground, trains, buses and encouraging cycling and carpooling wherever possible will increase use of public transport.

Currently, the biggest challenge for citizens to shift from private motorized transport is the time, cost, physical exertion and last-mile connectivity. Cities and towns should have intermodal hubs where multiple forms of transportation such as airports, trains, metros and buses are inter-linked. Developing a common mobile app or chip card to help citizens choose best public conveyance and pay online or in advance for all public transport within the state will make it easier for citizens to travel and also generate data to manage and plan these systems better. Public transport is a safe and affordable way to commute and can facilitate economy through innovative systems like the PPP model.

Shortfalls of Current Economic Practices

- For the mission to rapidly enhance RE in the Maharashtra, the current State Electricity Distribution Company Ltd. (MSEDCL) business model does not favour integration of RE into the grid mix through 2-way 'Net-Metering'. Hence a change in MSEB business model is needed for an economically viable transition to RE.
- Treatment of Municipal Solid Waste (MSW) has been an age-old problem not just for Maharashtra but in India. In 2018-19 only 42.2% of MSW was treated before being sent to the landfill and a staggering 45.5% of MSW was dumped untreated leading to contamination of ground water and opportunity loss in segregating and extracting resources from the waste streams[25]. Waste should not be disposed, but managed.
- Globally, the Linear Economic Model fails to address or optimize use of materials and resources that go into and come out of the economy. In the current economic model, Business-As-Usual scenario assumes that the earth has infinite resources for use and infinite regenerative capacity of resources after we dispose them. Shift to 'Circular Economic Model' is needed to incorporate Energy Efficiency and Waste Recycling to reduce energy demand and increase material reuse.

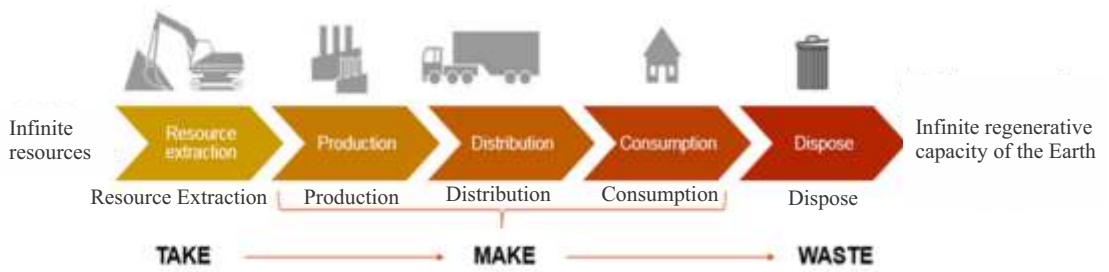


Figure 9: The flawed Linear Economic Model that we currently use[26]

Chapter 5

Making Maharashtra a Climate Resilient State

Making Maharashtra a Climate Resilient State

Environmental stability has always been the bedrock of human economic progress. Tropical Forests are one of the most cost-effective Climate Mitigation measure but their deforestation/disturbance contributes to 8% of the total global GHG emissions[27]. Natural ecosystems reduce soil erosion, impacts of natural disasters and pollution, and human-animal conflicts and provide flood control; groundwater recharge and crop pollination. Intact ecosystems; as opposed to gardening and plantations; harbour more diversity and native species, are resistant to climatic changes, and require low maintenance costs. With 2/3rd of the global mammal, fish and bird populations already lost in last 50 years, **Biodiversity Loss is currently one of the biggest global challenges.** Environmental stability can only be achieved by accepting the fact that development at the cost of environment will adversely affect livelihoods and security of a region now.

5.1 Improving CO_2 Sequestration and Biodiversity for Climate Resilience

Maharashtra, a tropical region, hosts diverse land and water ecosystems including the Western Ghats, a Biodiversity Hotspot (these areas support large percentage of the world's plant and animal diversity with high share of endemics, but have already lost >75% of the original forest cover). Tropical forests provide ecosystem services which amount to $2,007/hectare/year including offsetting GHG emissions. The existing 5.2 million ha State forest cover may be providing Ecosystem Services worth up to 780 billion Rs/year. The heavy ecosystem degradation costs, and the related ecological imbalances, are experienced by local people already. Public and Private Funding in restoration and expansion of ecosystems for CO2 sequestration and Climate Resilience will also generate green incomes and support knowledgeable people. Municipal bodies, in collaboration with organizations, can run donation schemes to adopt wilderness patches with due reporting.

5.1.1. Maharashtra should expand existing forest cover of 5,201,000 ha by 10% each year for next 10 years – to increase it by 200% by 2030

Achieving the NDC of 300% Carbon (CO2) Sequestration within the state implies 50% area and can hinder development. But like the national target, Maharashtra should incrementally increase existing forest cover to 200% (33% State area). It is also equivalent to the forest area the State lost in the last 50 years. The following table shows that protecting existing forests and doubling it strategically will be economically beneficial within a decade (20,300 $ US/ha is the maximum agricultural land price in India).

Forest Cover	Area In '1000 hectares	Percent Area %	Sequestration MTCO2eq/yr	Ecosystem Services (10 yrs) Million$ US	Initial Land Cost Million$US
100%	5,201	16.91	43.89644	104,384	0
200%	10,402	33.82	87.79288	208,768	105,580
300%	15,603	50.73	131.68932	313,152	211,160

Table 5: Benefits of increasing Carbon Sequestration Capacity

The State Environment Ministry should use a model like Bio Diversity Park (BDP) reservation to duly compensate land owners, for expanding the forest cover in non-forest areas. Local bodies should give appropriate tax-cuts for maintaining green cover. Compensatory Afforestation Funds must be used only for consolidation of remaining forest blocks and corridors and not for plantations. Prioritizing vulnerable but strategic habitats like mountain slopes, plateaus, mangroves, beaches, wetlands, savannahs, animal corridors, sacred groves, etc. as protected areas will strengthen the state's natural resource availability and security for the future. Environmental water flows should be conserved by protecting stream networks, river bed and banks, wetlands and marshes with least or no construction of artificial structures. This is already reflected in some recent State government decisions and should be continued to avoid degradation of existing forests at all costs.

5.1.2. Strict Demarcation, Protection and Restoration of all types of Forests and Water Bodies, as Carbon Sinks, to protect natural resources

Forest Department, MPCB, State Environment Ministry and local governments should take strict action and impose monetary fines on encroachment and pollution.

Agriculture, Forestry and Other Land Use (AFOLU) also contributes highly to GHG emissions of Maharashtra. Demarcation of forests and water bodies should be done by concerned departments like Irrigation, Forest, Planning and Land use, on priority. State should not initiate forest clearance for non-forest use, strictly following the Forest Conservation Act (1980). Forest Department, MPCB, State Environment Ministry, other State Regulators, and local governance bodies should take strict action and impose heavy fines against encroachment and pollution and direct those funds towards restoring ecosystems. As environmental issues need immediate jurisdiction, the National Green Tribunal with expert members should ensure effective and speedy adjudication of cases.

Development need not slow down but environment should not be compromised when planning infrastructure. Ongoing urban development frameworks like Smart City Mission, 100 Resilient

Cities, etc. must include Climate Resilience in planning and budgeting. Industry performance should include high compliance with environmental norms and laws, and not just turnover. Planners, architects, engineers and city management should be trained in ecological resilience and climate adaptation. Artificial restoration and plantation are both energy and water intensive, so Forest Department should invest only in increasing the quality of existing forest and wildlife with less invasive techniques. Tree-plantation drives should be allowed only in non-forest areas.
allowed only in non-forest areas.

5.1.3. Developing and maintaining Urban Forests

Miyawaki forests with native plants can grow 10X faster than natural forests and need maintenance only up to 3 years.

Cities being highly vulnerable to climate change, Urban Forests reduce the local urban heat island, noise, energy costs for buildings, air pollution and GHG emissions[28]. They act as environmental corridors which, like hallways enhancing the operation of a building, increase the value of natural resources by providing biodiversity refuge and linkages between surrounding ecosystems[29]. Economic benefits of urban forests include increasing the value of nearby residential areas, clean air, flood control, lower risks of building in areas with soils poor for development and preventing clean-up costs of water bodies[30].

One of the efficient techniques to engage citizens and increase local environment quality in urban settlements is the Miyawaki method. In this system, dozens of native species from four categories: main trees, other trees, shrubs, and herbs are planted densely together in treeless lands (20 sq.ft. to 2 acres), to better represent layers in the indigenous forests. These forests can grow 10X faster than natural forests and need maintenance only up to three years. This also helps in changing people's attitude towards commonly perceived 'bad' lands and reducing resource-depletion[31]. A new State Environment Ministry project aims for 65 Miyawaki plots with over 4,00,000 plants in Mumbai, such ventures can especially succeed if surrounding natural ecosystems are protected and restored[32]. The currently trending Butterfly Gardens provides a sanctuary for pollinators like butterflies, moths, bees, flies, and beetles and recreational activity for humans to appreciate plant-animal interactions. Typically, around 90% of all flowering plants and 35% crops may depend on animal pollination[33]. Butterfly gardening should be encouraged in schools and colleges with student engagement to boost their curiosity and interest in nature.

5.2 Developing a State Climate Action Plan for Economic Prosperity

India is a country with a large population dependent on climate-sensitive sectors. The costs of not taking Climate action may be uncertain, but welfare consequences of Climate action are enormous. Even after reducing emissions and building climate resilience, some negative Climate Change impacts are unavoidable now. The MSAAPCC report needs to be updated and executed with strict targets and timelines for a resilient green economy[34].

5.2.1. Formation of a State Climate Action and Adaptation TASK-FORCE

A specially empowered Task-force of environmental, social and economic experts to accelerate green inclusive economy and energy infrastructure will help in achieving Climate Mitigation, Resilience and Adaptation objectives simultaneously. It should oversee and prioritize the utilization of investments and funds towards required actions in all sectors. The Task-Force should also monitor development or re-development projects in residential, commercial and public infrastructure in Maharashtra to factor in the project impact on Climate Action and suggest changes accordingly.

International Banks like World Bank or European Investment Bank have dedicated green infrastructure funds for which Mumbai and coastal cities make a compelling case. It must ensure allocating State Funds and schemes for Disaster Mangement and relief operations using modern technologies and Artificial Intelligence systems to deal better with emergencies, especially in Coastal areas. Training programmes in vulnerable areas will help to improve disaster response in the state. Environmental topics like – Local and Global impacts of Biodiversity Conservation and Restoration, Climate Change and Global Warming; Sustainable Waste/Waste/Energy/Agriculture Systems and Consumption should be included as marked (and not graded) subjects in education.

5.2.2. Create Employment while executing Climate resilience and adaptation measures

Climate Action and Sustainability can create green jobs in rural and remote areas. Joint Forest Management systems can reward rural and tribal citizens with limited forest produce harvesting or give financial assistance in a phased manner for aiding forest department in conservation. The success story of Hivre Bazar, Maharashtra, the village with the highest GDP in the country, can serve as model to achieve this. National Rural Employment Guarantee Act, 2005 funds can be used for ecological restoration and climate adaptation interventions to create local employment. About 60% State Land Use in the state is agriculutre, hence, encouraging sustainable (mainly organic) agriculture and strengthening local supply chains will contribute to carbon sequestration and also emission reduction due to lesser transport. A study found that organic farms have soil organic carbon stocks 3.5 tonnes higher per hectare than non-organic farms. With market support, organic farming can be 22-35% more profitable than conventional farming.

Tourism accounts for around 10% global GDP as well as jobs; in India it is a booming industry and already accounts for 6.7% GDP and supports >37 million jobs. Ecotourism is a sustainable profit-making option; especially in biodiversity-rich Mountain and Coastal regions, to generate income for local communities. The State Environment and Tourism ministries should evolve a 'Maharashtra Ecotourism Policy' with rules, guidelines, training centres and web platform to monitor and support sustainable tourism. Botswana and Bhutan have successfully improved tourism revenue with sustainable tourism policies.

5.2.3. Invest in technology innovation for atmospheric removal of excess CO2 to ultimately achieve Net-Carbon-Neutrality for the State

Natural sequestration alone will not be able to bridge the state emission gap totally, hence investments and policies for Carbon Capture and Storage (CCS) technologies and Artificial Carbon Removal (ACR) are direly needed. Relevant technologies are proven but need to be made affordable. Government, institutes and industries should collaborate to artificially sequester carbon as some emissions from Industry processes and change in land use are inevitable. Simultaneously, going green as the new normal in business, industries, businesses and Govt practices must be encouraged with attractive incentives.

5.3 Focusing on Making Cities ‘Climate Smart' in Maharashtra

Climate Change Impacts are closely inter-related with sustainability, economics, health and security. Indian cities are highly vulnerable to these impacts due to high population density and low adaptive capacity. It is imperative to bend the ever-rising emissions curve downwards and adopt low-carbon economy to develop cities without compromising the basic human and environmental goals. Climate change is likely to exacerbate the degradation of resources and increase socio-economic pressures if rapid action is not taken. Thus, it is important to set up a Climate Smart City Framework to support, encourage and establish Climate-friendly choices for individuals, households, residential societies, mohallas, wards, industries, businesses, governments, in fact, everyone. Primarily, building a culture of being conscious about one's Carbon Footprint is necessary.

5.3.1. Follow the Climate Smart City Framework in all Major Cities

Climate Smart City Framework (CSCF) is a set of goals that can drive decision-making towards Low Carbon Sustainable Development. Cities which comply with this framework should be given more financial support to encourage green economy. These measures will also directly help in reducing natural resource costs due to optimization. Strict action against non-compliance of CSCF can also help to generate green funds within the state. The CSCF includes guidelines and targets rather than limiting to specific actions:

- City should make a GHG emission reduction and control plan

- Incentivize rapid transition to Renewable and Clean energy
- Reduce energy demand and increase energy efficiency in all processes and systems
- Strict Land-use and Environmental laws for protecting natural resources
- Shift to E- Mobility with RE Charging
- Increase area and restore Urban Forests
- Develop competent infrastructure for non-motorized and public transport
- Market incentives for Low Carbon Products and Services
- Waste management at local level with maximum 'Circular Economy' practices
- Minimum set of 'Best Practices' compulsory for all institutions with annual awards
- Set up Disaster risk reduction and response centres
- Establish multiple stakeholder platforms for adopting Green Economy

5.3.2. Integrating policy interventions for Air Pollution and Climate Change

Being a highly urbanized and industrialized state, Maharashtra faces the problem of air quality with air pollution levels in 17 cities not meeting the set standards (non-attainment cities)[35]. Air pollution causes many severe respiratory disorders and affects the health of human beings which costs trillions of dollars, and climate change may intensify this by increasing concentration of allergenic air pollutants like mold and pollen. The MPCB report 2018-19 shows that many cities in the state have Respirable Suspended Particulate Matter (RSPM) beyond the permissible limit set by CPCB and WHO. Air pollution costs due to personal burden, governmental expenditure and societal cost, on just Mumbai was estimated to be Rs 452.3 Crores/m3 for PM 10, and Rs 872.6 Crores for NO2 per 50 μg/m3 increase in 2010. They are likely to be much higher now[36]. Fossil fuel air pollution may be costing around Rs 10.7 lakh Crores annually which is 5.4 % of India's GDP[37].

Climate change impacts local air quality in complex ways. Short-lived climate pollutants (SLCP) like methane, hydrofluorocarbons and black carbon are powerful climate drivers with relatively short atmospheric lifetime. Black carbon emitted from incomplete burning of fossil fuels directly warms the atmosphere by absorbing incoming solar radiation and indirectly accelerates ice-melting by reducing the ice reflectivity[38]. Similarly, ground-level ozone is a serious pollutant affecting all vegetation and human health. The goal to reduce hydrofluorocarbons is already set by countries under the Kigali Amendment (2016) to the Montreal Protocol. SLCPs can be reduced economically with technologies and policies to reduce health risks, air pollution and local climate impacts simultaneously. A study found that fossil-fuel-related emissions also contribute to climate cooling by aerosols, which influence local weather and precipitation. Hence, reducing other non-fossil-fuel GHG sources also becomes important for an integrated climate change and air pollution policy[39].

The current consumption patterns and energy sources contribute significantly to both climate change and air pollution. Overall, the air quality scenario indicates that the action plans in many

cities in the state are not very effective in controlling air pollution and need reforms. Instead of tackling these problems separately, there are technological solutions that address both concerns at the same time. Rapid shift to RE, decentralization with RE, and making Maharashtra maximum solar state will help in reducing dependency on fossil fuel, and hence, air pollution by their utilization too. Expansion of E-mobility and sustainable transportation systems like shifting to E-buses, cycling and car-pooling will decrease the use of private vehicles and traffic problems. As mentioned in chapter 5 maintaining urban forests helps in reducing air pollution impacts.

MPCB should make coordinated efforts with municipal corporations specifically for air pollution-related problems, data, surveying and all the related functions. Some studies indicate that climate change and more intense extremes are likely to increase the risk of severe pollution events. Permissible limits of the State can be set lower and stricter than the national standards, so that overall air quality can be easily maintained even with changing climatic conditions.

5.3.3. Making Mumbai India's 1st Climate Smart Capital City: A Special Case Study

According to NASA, global average temperature increased by 2°C in the last century and by 2.3°C in Mumbai during the same period[40]. Erratic weather patterns like rainfall extremes such as the heavy 944 mm of rainfall in 24-hours on 26th July 2005 (which caused direct economic damage of 2 billion USD -Rs 15,000 Crores) could become more frequent in Mumbai due to climate change.(Ranger et al.2011)

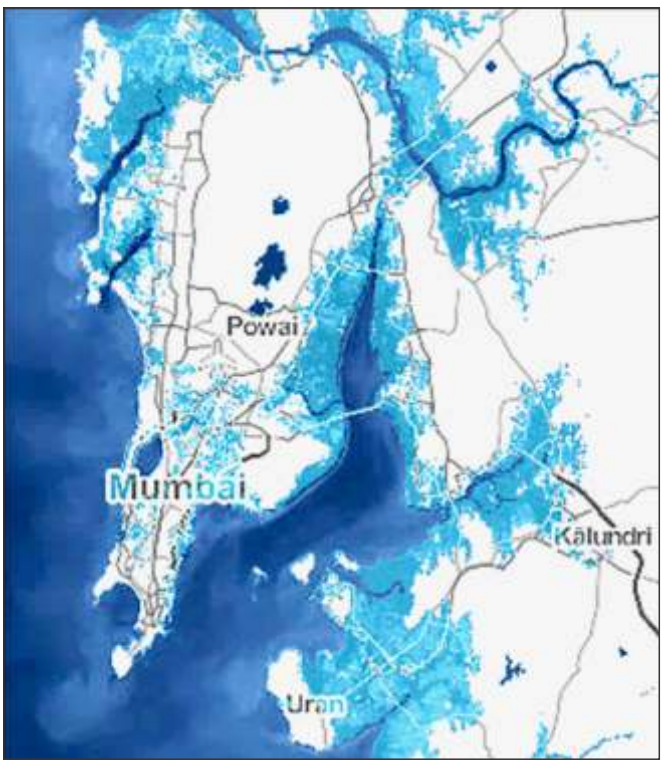


Figure 10: The Map shows the ocean in dark blue, Mumbai in white and its areas vulnerable due to Sea Level Rise in light blue

A NEERI study predicts the total economic loss for the city could be around 35,00,000 Crores. Climate Changes have increased irregular rainfall and flooding and also weather intensity as seen during cyclone Nisarga which impacted the entire coastline of Maharashtra. Coastal cities face multiple challenges like sea level rise, salination of fresh water, corrosion of materials and loss of biodiversity due to global warming. A clear indication of communities that may need resettlement are seen in the adjoining figure. Mumbai, being a coastal city and the financial capital of India, must adapt to Climate Change or it will face severe damages to infrastructure, vulnerable communities and socio-economic conditions. Given below are the main planning priorities which will help Greater Mumbai adapt better to Climate Change in the next decade. In addition to state level recommendations made in this paper, the following actions will specifically help Mumbai become more resilient.

- **Limit Coastal Activities and Construction of Natural Sea Barriers**

A complete ban on all new construction activities within 500 meters of the coastline is necessary to limit future damage to the coastline and complications arising due to irregular flooding patterns. The Maharashtra Coastal Zone Management Authority (MCZMA) had planned for 4 initial Dykes (sea walls) with further plans to build 22 kms of Dyke in various parts of Mumbai. Adopting bio-fences i.e. plantation of Mangroves instead of making artificial sea barriers is highly recommended as it preserves natural habitat and provides protection from flooding.

- **Rethink the Waste and Water Management Systems to integrate Circular Economy**

Decentralization of waste water treatment is required at all levels to reduce load on BMC operated STPs. This will also help reduce discharge in open water bodies within the city.
Simultaneously, redesigning Mumbai's drainage systems to account for increase in rainfall volume, intensity and also preventing clogging of drainage discharge and sea water infiltration is crucial. Extracting valuable minerals from waste and water treatment plants like phosphorous and nitrogen which utilizes the organic waste for producing electricity/CNG from biogas is important. Identifying areas for recharge of ground water to ensure reduction of annual floods and rise in sea levels is needed for better planning.

- **Reduce Pollution and create Carbon Sinks for Pollution Abatement**

Over 33% of the total pollution levels in Mumbai come from the city's outskirts[41]. Air pollution filtration and CCS technologies for industries are highly advisable for limiting pollution sources in the city. Designating more green areas in Mumbai in addition to the current ones can absorb and filter air pollution. Due to space constraints, architectural design should ensure increase in the vertical green urban landscape. Mangroves are excellent for bio-remediation (natural plant-based water pollution cleansing) and can be planted in NDZ's for cleaning waste water discharge as it eliminates polluting gases, and they require far less maintenance and energy. Native trees planted on roads can reduce heat, provide shade and aid pollution absorption too.

- **Establish Eco Areas in Mumbai as Role Models for Sustainability**

Identify and establish 'Eco Areas' in environmentally sensitive areas that can act as a role model for 'sustainable cities design'. These green zones will initially limit and later ban polluting activities by Industrial complexes and use of conventional fuel-based transport; ensure Rain Water Harvesting, Ground Water Recharge and Sustainable Waste Management and maximum green cover or Mangroves near coastline. Such green zones have also been created in other cities like London, Copenhagen, Chicago, Rotterdam etc.

5.3.4. Encourage Lifestyle Changes to create a citizen's movement in Climate Action

Individuals and communities will play an important role in the low-carbon transformation and changing development priorities to achieve meaningful Climate Action. Some lifestyle changes that encourage green economy are: Reduce avoidable energy demands and Change Lifestyle to consume less so as to not compromise the environment for comfort, Invest only in low-carbon goods and services and in companies supporting them, All individuals and organizations must plan and use Refuse, Reduce, Reuse and Recycle strategies to avoid wastage and emissions, Reduce wastage by buying less and giving away all consumables some time before expiry, Explore Reused Goods Sellers and Stores to reduce the production of goods, Buy only the properties that assure Green Infrastructure such as Solar Water Heating, Organic Waste composting mechanism, Common lighting on Solar PV, Green on ground, insulation for the roof if buying the topmost flat etc. The local and state governments should create appropriate incentives or award individuals and communities who adopt such climate-friendly lifestyles. This can be especially promoted by choosing ambassadors to spread the message.

Blended Finance Approach for Green Economy

Financing the Green Economy Recovery will be no easy task if we only depend on central or state funds. A Blended Finance strategy needs to be adopted combining state and corporate funds for transforming Maharashtra and provide the suitable financing for Low Carbon Sustainable Development. Global funds are shifting their focus from High-tech High investment infrastructure to more natural solutions for building infrastructure to adapt to Climate Change. A more robust financial structure will be created where social and environmental well-being will also be given priority over purely economic gains. Investing in cost-competitive Renewable Energy infrastructure would provide great dividends to its investors. As the global effort in providing financing to adapting to Climate Change has reached an all-time high, Maharashtra should focus on Green Economy over conventional GDP biased model.

Summary for Policy Makers

Climate Change is bound to cause disastrous impacts on the stability and survival of our ecosystems, economies and societies. We must rethink development, planning and management in light of our economic aspirations and its relationship with the Earth environment. The post Covid-19 economic recovery and progress must also focus on eco-system stability with a new 'Low-Carbon' economic model. It can do well without over-exploiting the Earth's environment and without polluting the air that we all breathe.

Maharashtra must create new green opportunities for all cities and settlements where people have better chance for being economically and environmentally responsible. The overall energy demand needs to be significantly reduced with energy and resource efficiency improvements within this decade. The 2020 stimulus packages must therefore set the pace for maximising Energy Efficiency, Renewable Energy (RE) use, Electric-Mobility and ensuring good Air Quality in the state. A mere return to GDP increase chase will be very short-lived. Simultaneously, restoring bio-diversity, forests, water bodies etc. can rebuild Carbon Sinks and keep focus on the health of our environment and people.

The means and technologies to achieve optimum synergy between economic progress and climate change concerns already exist. But it is important to urgently make bold policy decisions to fund and energise the transformation in the **'energy-economics-climate change'** dynamics. De-centralization will also play a key role in achieving the ambitious targets in challenging timeframes. Without that eventual and permanent decline of the quality of life for mankind will be unavoidable.

The resource-intensive growth in India is indeed polluting and the 'Social Cost of Carbon' for India is very high although it remains invisible under present policies. The goals and aspirations of economic progress and peaceful coexistence with minimal social tensions are now inseparable from the health and stability of our earth environment. This Policy paper presents a cogent discussion of the major problems and issues to bring out optimised solutions for a new approach to the Economic Recovery. This must be acted upon with foresight and determination for the betterment of the next generation.

As is brought-out in the Executive Summary, every decision made about Energy, Environment and Climate Change henceforth, will have a large impact within this decade. Assertive policy shifts, partnerships and collaboration, proper environmental pricing, strong public investment and mindful regulation will help the state of Maharashtra to become a leader in the new paradigm of 'Low-Carbon Sustainable Development'.

Our analysis shows that for Maharashtra the GHG emission gap between total State emissions and sequestration capacity is high and rising. Achieving Carbon Neutrality with business-as-Usual before 2050 will be nearly impossible. However, prompt Climate Action to reduce 70% GHG emissions and doubling of our forests to 33% State area by 2030 will make a huge difference. **The present time is ideal to kick-start the transformation to a 'Novel Green Maharashtra' that values both the economy and the environment. Sector wise 'Policy Improvements' desired urgently, are presented on the next page.**

Table: Sector-wise Policy Implications and Desired Policy Improvements

Sector	Current Policy Implications	Needed Policy Improvements	Agency
Energy Generation and Use	Current RE is 33% of the total - with 67% dependence on largely imported fossil-fuels	By 2030, State RE generation must be 70% of the total capacity. This is 5 times increase in the next 10 years. This is cost competitive, indigenous and very doable	MAHAGenco, MSEDCL, MEDA, MERC, MNRE
Renewable Energy – Solar and Wind	State target- 200 MW through solar rooftop PV by 2021. Current share of total solar energy is 12% of RE	40% of RE generation from Solar Rooftop PV by 2030. To achieve this the capacity must reach 20 GW, which is roughly 100 times increase	MSEDCL, MEDA, MERC MNRE
Rooftop Solar	No compulsion in the present policy for installation of solar PV in new constructions.	Making rooftop Solar PV generation and Solar Thermal water heating compulsory for new constructions	MAHA-RERA, MSEDCL, MEDA, MERC
Net – Metering	The MERC policy proposes to switch from net-metering method to gross metering (net billing method)	Profitable Net Metering business model for DISCOMS, Karnataka and Gujarat have successfully achieved this. Promote and increase the need for cleaner and cheaper renewable energy	MSEDCL, MERC, MEDA
Investments in Battery Technology	Nothing specifically mentioned by Maharashtra govt about battery technology	Investing in storage technology will increase profitability of RE generation for 24x7 use and will make it cost competitive for distributed energy generation in rural areas.	MNRE, M of Energy MSME

Electric Vehicle Transport with RE Charging	Central policies support installation of EV charging but no direction for use of RE. At current policy norm, 100% EV fleet cannot be accomplished by 2030	Simultaneous increase in EV fleet and RE generation will be necessary to reduce GHG emissions.Establish parking areas with RE charging. Including EV charging at Fuel Pumps.	Department of industries, M of Environment, transport, energy
Forest Area	National forest policy entails 33% of state area must be forest cover but with no clear timeline associated with it. With Forest areas concentrated only in Vidarbha	To create a strategy and pathway to achieve 33% of State land and increase existing forest cover incrementally by 10% per year to reach 200% by 2030, with provision for CSR funding guidelines and carbon credit benefits.	Forest Department, M of Environment, M of Forest, Irrigation Department
Climate Resilient Infrastructure	Currently our cities are not climate resilient, Mumbai faces problems every monsoon, although few decisions like water pumps were taken in this direction, they are not enough.ECBC codes not enforced	All further constructions must be planned in the form of green townships with rules that enforce climate resilient infrastructure designs. Design and mandate a unified 'State Green Building Code'	MAHA-RERA, MSEDCL, MEDA, MERC
Waste Management	Currently only some municipalities ensure collection of dry and wet waste	Shift away from Disposing, ensuring segregation, collection and management. Promote upcycling and recycling. Use waste to generate energy.	Local Municipal Corporations, MPCB, MIDCs
Eco-tourism	Maharashtra currently does not have an eco-tourism policy. Current tourism policy has no commitments for waste management and RE	Design a new Ecotourism policy with rules, supporting infrastructure, web platform. Protect and facilitate local communities to generate income. Bhutan improved tourism revenue without exploiting natural resources by making sustainable tourism policies. Make Religious and Cultural places and towns and transport facilities fully RE powered.	M of tourism, M of Environment, MTDC
Agriculture	State aimed to bring 8 to 10 lakh hectares of land under organic farming by 2021. Capital subsidy of 25% provided by central government 11	Ensure soil security. Assign certain agricultural land area for natural and organic farming practices. Incentivise and provide subsidy to organic produce. Establish efficient irrigation systems for responsible use of water combined with solar pumps	Agriculture Dept, Ms of Environment, Soil and Water Conservation, Rural Development

Annexure: Net-Metering for Rooftop Solar

Major reforms for seriously enhancing Renewable Energy (RE) including expansion of Roof-Top Solar (RTS) is a clear urgent requirement of India's National Energy Policy. The MNRE initiative of National Solar Mission promotes 40% RE generation from Rooftop-type installation with zero land-cost to Govt, but in Maharashtra the DISCOM (MSEDCL) has been very slow in providing easy Net-Metering facilities to its customers due to a mistaken perception that it would take away its paying customer base. Such apprehensions have been common at the initial stage of introducing Net-Metering to promote RTS all across the world, but most DISCOMS have quickly modified their business model to adopt the new realities of growing Renewable Energy (RE) dominance in the future. In India too, progressive states like Gujrat and Karnataka have successfully changed their business models by involving all stake-holders in aggressively promoting RTS as the most efficient and cost-effective option for energy supply.

MSEDCL should not view RTS as a loss making burden, but rather as a new business opportunity and a chance to be at the leading edge of what utilities must be in the future as seen from their success in New Delhi, Gujarat and Karnataka. An August 2019 regressive proposal by MERC/MSEDCL to discourage RTS with restrictive pricing and policy changes, deserves to be rejected due to following observations and the suggested solutions should be adopted as a much better progressive alternative:

1. Disincentivizing Regulation: A limit of only first 300 units (11.4) of Electricity generation/month for net-metering benefits can heavily discourage households with higher energy requirements. These potential customers are also usually the residents who have the financial wherewithal to pay for the high upfront cost that comes with solar power. MERC must focus on creating regulations that drive consumers to shift to RTS based on financial considerations while benefiting the utility as well.

2. Unfair Energy Valuation: With regulations (11.4 and 12.5) intending to change the mechanism under which power consumers are charged, the shift from net-metering system to net-billing system can be an unfair system for any individual RTS customer. A net billing system unfairly differentiates the energy value based on who produces it. This means that a unit of electricity produced from rooftop solar will be of lesser value than the unit of energy produced from the grid based on thermal generation. Such a system is anti-RTS and discourages new consumers from shifting to solar rooftop. What is desired is improving the net-metering system so that it ensures a direct energy barter system to ensure a level playing field between any consumer or producer.

3. Infeasibility of Generic Tariff: The new net billing system, if enforced, would ensure that every

MSEDCL customer will enter into a Power Purchase Agreement at the Generic Tariff approved for the respective period by the Commission. Such a tariff is economically impractical for small scale solar electricity generation as the current rate of generic tariff (₹3.29 per unit) is economically viable only for large multi-megawatts scale projects which have supply levels at or above MWh. At the same time, unlike large scale solar projects, solar rooftop users also buy electricity from the grid which must be taken into consideration. Therefore, what is recommended is parity between buying and purchasing of electricity when it comes to rooftop solar. Without this, rooftop solar will never be popular with the common man.

4. Operation and Management costs: MSEDCL argues that Solar rooftop customers, unlike regular grid users, use grid infrastructure only when required. So not only are solar customers using grid rooftop at their own convenience, they are also not paying for the operation and maintenance of the same. However, such an argument can be considered invalid as every grid user, whether regular or solar rooftop customer, already pays fixed charges as well as wheeling charges for units consumed from the utility grid every month as a payment for the O and M of the grid. Provision of charging the consumers for BTM systems is completely in violation of the basic principle of Electricity Act 2003 that has provided every consumer the right to produce and utilize the electricity for their own needs.

5. Violation of Objectives of National Solar Mission: As per the National Solar Mission, the present rooftop capacity installed in Maharashtra is only 266 megawatt (MWp) and the 2022 target is 4,700 MWp, which means the state has reached up to only 5.66% of its target in four years. The new regulations will only further deter the state of Maharashtra as well as the MNRE from achieving the vital 2022 targets.

6. Violation of Objectives of International Solar Alliance: As a founding member of the "The International Solar Alliance (ISA), the framework established includes accelerating the development and deployment of over 1,000GW of solar generation capacity in member countries to meet energy demands and to bring prosperity, energy security and sustainable development through solar. While the Govt of India has already contributed US$16 million to the establishment of the ISA along with funds contributed from other public sector Indian companies, it is surprising that a regressive MERC policy is proposed which is in contradiction to the vision of the ISA.

In conclusion, net-metering has been the cornerstone of the rooftop solar market in India and around the world. Any effort to dilute or weaken net-metering rules will certainly have a negative impact on growth in this sector as well as the industry. Any effort to restrict or to water down net metering regulations would also be inconsistent with India's stated goals of increasing solar generation capacity, and rooftop solar capacity in particular. Rooftop solar projects have clear benefits over other forms of power generation, in terms of air pollution, land use, and transmission

losses. Further, we request GOM must strengthen the existing Net Metering regulation 2015 by improving upon the following:

- Increase limit on distribution transformer to 80% from the current 40%
- Compel the distribution licensees in the state to implement the regulation in good spirit and efficiently – not charge the consumers for both the meters and also for testing and certifying the same – it is their practice for the last 4 years.
- Make it mandatory for distribution licensees in the state to publish up-to-date data of vacant capacity on each DT – they have never done that in the last 4 years.
- Make the distribution licensees in the state to abide by the timelines provided in the regulation they have not been following these in most of the cases.

Glossary

Biofuels - are a renewable energy source, made from organic matter or wastes that can play a valuable role in reducing carbon dioxide emissions

BS VI - are the unit emission norms that set the maximum permissible level for pollutant that an automotive or two wheeler exhaust can emit

Carbon Footprint - amount of carbon dioxide emission associated with all the activities of a person or the entity (e.g. building, corporation etc)

Carbon Neutrality - means having a balance between emitting carbon and absorbing carbon from the atmosphere in carbon sinks

Climate Adaptation - means anticipating the adverse effects of climate change and taking appropriate action to prevent or minimise the damage they can cause

Climate Mitigation - tackling the causes and minimising the impacts of climate change

Climate Resilience - ability to anticipate, prepare, and respond to hazardous events, trends, or disturbances related to climate

Circular Economy - A circular economy is an economic system aimed at eliminating waste and ensuring continual use of resources. It involves reuse, sharing, repair, refurbishment, remanufacturing and recycling to create a closed-loop system; and minimising the resource inputs and creation of waste, pollution and carbon emissions

DISCOMs - The power distribution sector consists of Power Distribution Companies (Discoms) responsible for the supply and distribution of energy to the consumers

Drip Irrigation - is a type of micro-irrigation system that has the potential to save water and nutrients by allowing water to drip slowly to the roots of plants, either from above the soil surface or buried below the surface

ECBC Codes - Energy Conservation and Building Codes. Their main objective is to establish minimum requirements for energy efficient design and construction of buildings

Ecological Resilience - The ability of an ecosystem to maintain its normal patterns of nutrient

cycling and biomass production after being subjected to damage or disturbance

Ecotourism - refers to responsible travel that conserves the environment and improves the well-being of local people.

Ecosystem Services - Ecosystem Services are the direct and indirect contributions of ecosystems to human well-being, quality of life and even survival

Emission - is something that's been released or emitted into the world

End-of-Life Solutions - mainly include reduce, reuse and recycle policies

Energy Efficiency - refers to a method of reducing energy consumption by using less energy to attain the same amount of useful output.

Environmental Impact Assessment - process of evaluating the likely environmental impacts of a proposed project or development, taking into account inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse

FTE - Full-time equivalent is a unit that indicates the workload of an employed person in a way that makes workloads or class loads comparable across various contexts

Global Warming - is the long-term heating of Earth's climate system due to human activities, primarily fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere

Greenhouse Gas (GHG) - is a gas that absorbs and emits radiant energy within the thermal infrared range and can cause greenhouse effect

GHG Emissions - the emission into the earth's atmosphere of any of greenhouse gases, especially carbon dioxide that contributes to the greenhouse effect

Grid Electricity - an intricate system designed to provide electricity all the way from its generation to the customers that use it for their daily needs

Human Development Index - HDI is a statistic composite index of life expectancy, education, and per capita income indicators used to rank countries into four tiers of human development

INDC - Intended Nationally Determined Contributions (INDC) are (intended) reductions in

greenhouse gas emissions under the United Nations Framework Convention on Climate Change (UNFCCC)

Industrial Corridor - is a package of infrastructure spending allocated to a specific geographical area, with the intent to stimulate industrial development

Intergovernmental Panel on Climate Change - IPCC is the United Nations body for assessing the science related to climate change

Joint Forest Management - focuses on relationships between local people and forest department on the basis of mutual trust and jointly defined roles and responsibilities for forest protection and development

MEDA - Maharashtra Energy Development Agency is a Maharashtra government institute, run with Government of India, to regulate energy conservation and to promote the development of renewable energy in Maharashtra State

MNRE - Ministry of New and Renewable Energy is the nodal Ministry of the Government of India for all matters relating to new and renewable energy

MOEFCC - Ministry of Environment, Forest and Climate Change

MPCB - the Maharashtra Pollution Control Board implements a range of environmental legislation in the State of Maharashtra

MSEDCL - Maharashtra State Electricity Distribution Company Limited

NASA - National Aeronautics and Space Administration in USA

Net Metering - is an electricity billing system that allows consumers to generate some or all of their own electricity, to use that electricity anytime through grid connection

PMPML - Pune Mahanagar Parivahan Mahamandal Limited

Solar Farms - are the large-scale application of Solar Photovoltaic (PV) installations used to generate electricity

Solar Rooftops (RTS) - solar panels placed on open surfaces or roofs of commercial, institutional or residential buildings, also known as solar rooftop photo-voltaic system

Sustainable Development - is the organizing principle for meeting human development goals while simultaneously sustaining the ability of natural systems to provide natural resources and ecosystem services on which economy and society depend

Sustainable Development Goals (SDGs) - also known as the Global Goals, were adopted by all United Nations Member States in 2015 as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030

TCO2eq - all GHG emissions are measured in equivalence to carbon dioxide and expressed as tonne carbon dioxide equivalent e.g. TCO2eq

Tropical Forests - are closed canopy forests growing within 28 degrees north or south of the equator which are very important as biodiversity reserves and carbon sinks

Vertical-Axis Wind Turbines - VAWT have the main rotor shaft set transverse to the wind (not necessarily vertically), and need limited space with less challenges to maintain

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