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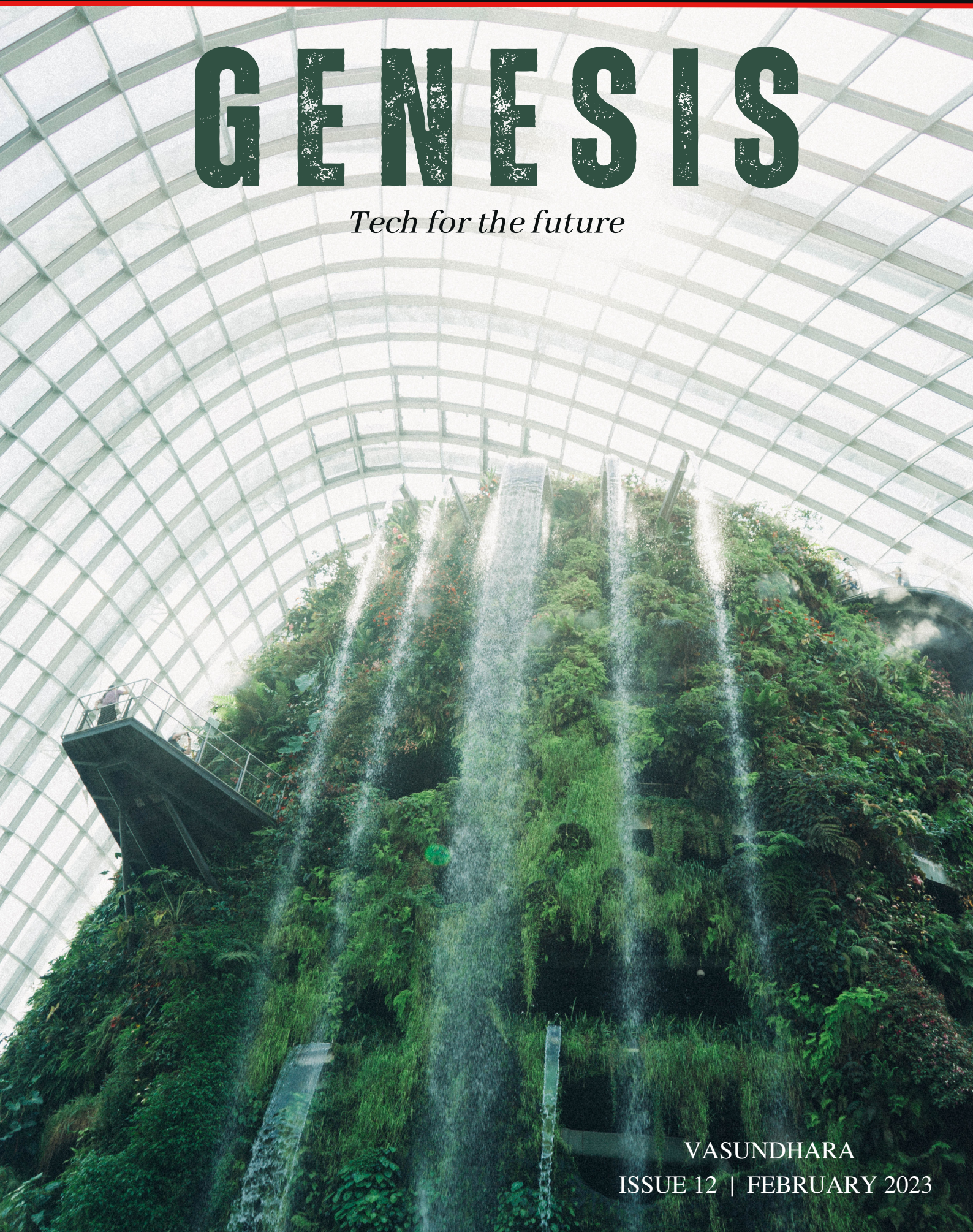
GENESIS

Tech for the future



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Eco Club, TERI SAS brings to you "Genesis- Tech for the Future", the twelfth edition of Vasundhara magazine, curated to comprehend the development of Sustainable Technologies, the different types, their uses and implementation in multiple fields, and the need for a green transition in the economy. The information in the magazine is for general use only and has been compiled from various research papers, articles, and government databases. Some personal experiences and anecdotes have also been shared for which we extend our sincere gratitude to the contributors. The content is accurate to the best of our knowledge as of February 2023. We apologize for any inadvertent errors that may exist.

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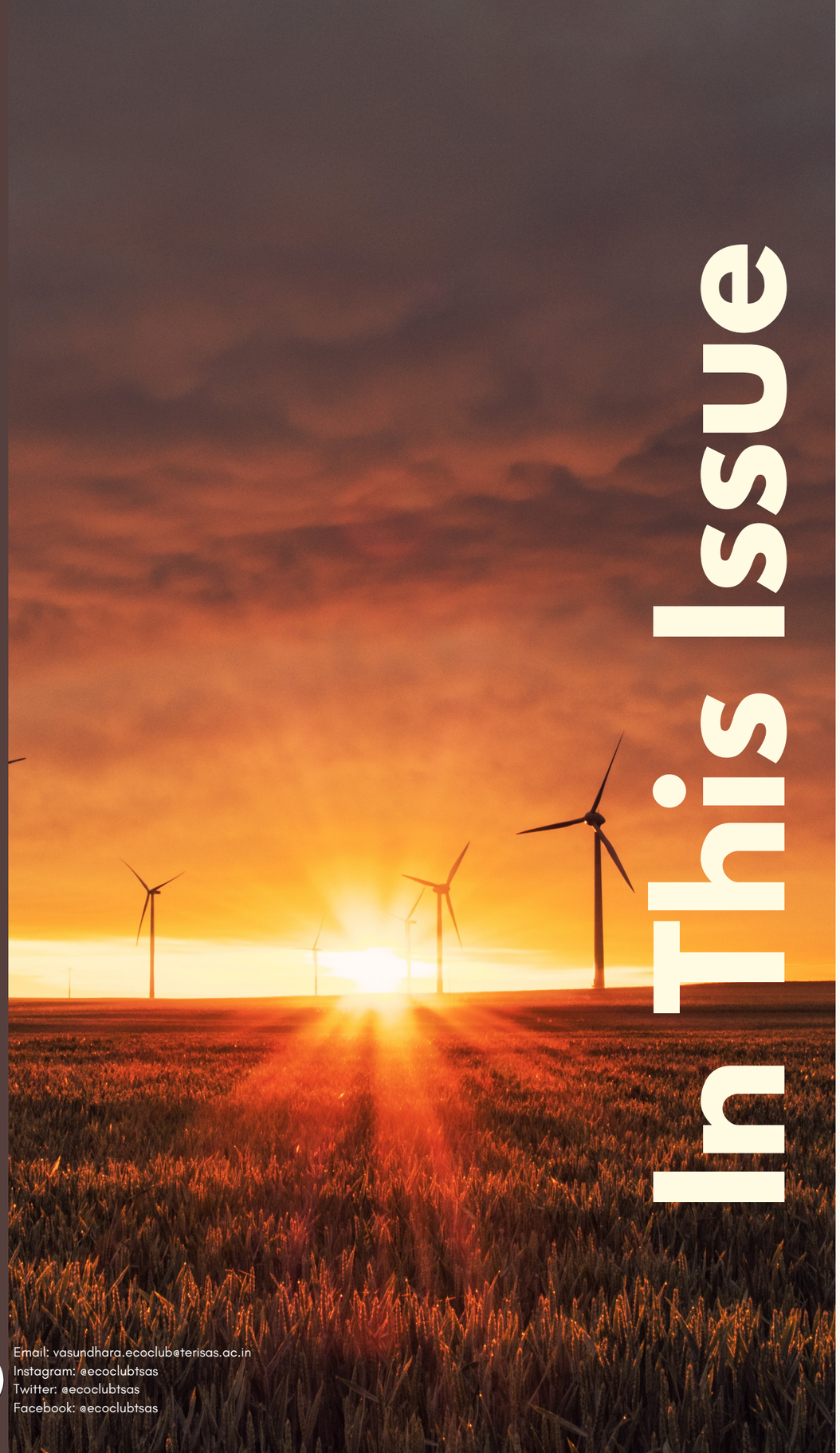

In this Issue

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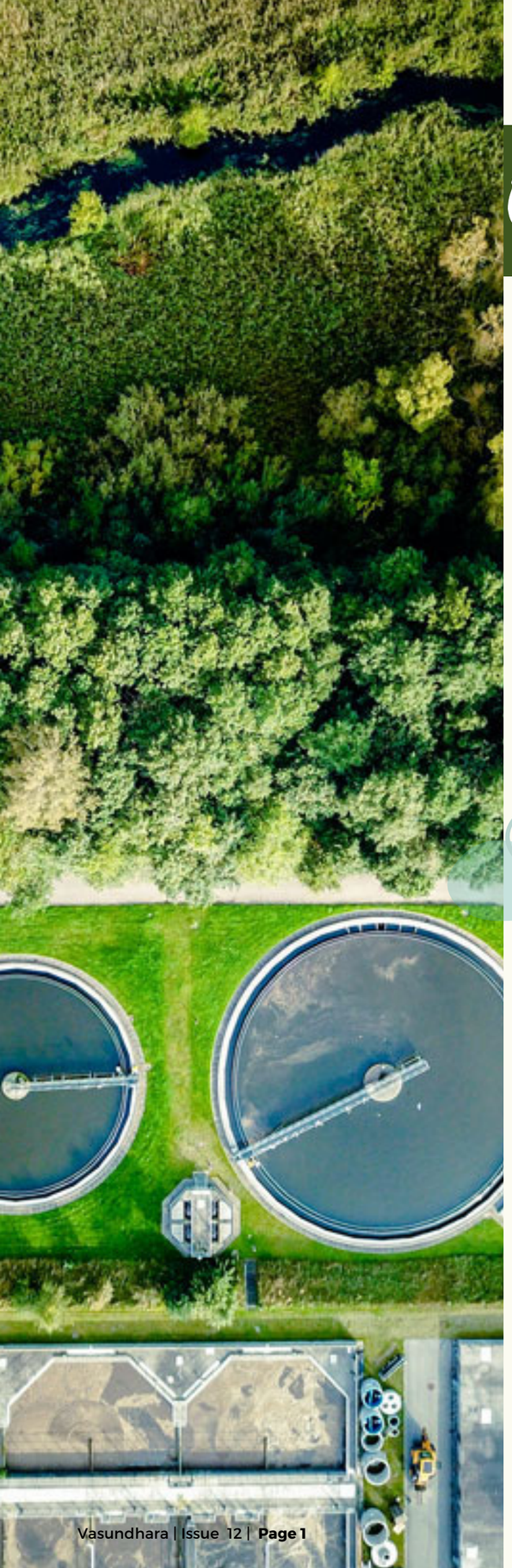
Vasundhara

Editor's note	**1**
Sustainable Technology: A new dawn of development	**2**
Tackling Global Climate Change: A technological approach	**3**
Daylight Harvesting- Optimising Energy savings in India	**4**
Decoding the budget	**5**
Technologies in Green Architecture	**7**
Cool cities becoming hot-headed	**10**
In conversation with Anson Sando	**11**
Achieving good health and well being	**13**
Green hydrogen for decarbonizing India	**14**
Green jobs	**15**
Greener pastures	**15**
Debugging the glitch in the matrix	**17**
Green Mobility for Greener Tomorrow	**19**
Engineering the Oceans for a safer world	**21**
Expert Tech by Dr. Debajit Palit	**23**
Knowledge Upgrade	**27**
References	**29**



Editor's Note

Rapid expansion of human population and advancement of global economies, have put pressure on nature's resources. Most of these resources have become extinct, thus exposing us to an existential crisis. To ensure continued survival of mankind, the concept of 'Sustainability' has gained prominence over the years, with recent focus being centred on sustainable development. In simple words, sustainable development is an idea, as to how we can meet our present needs, while making certain that the future needs would be met adequately.

For creating sustainable ecosystems, while promoting social and economic development for all, innovations that embrace sustainability are the need of the hour. In the 21st century, technology, has become an integral part of our lives. Looking around, we can see that we are surrounded by some from of technology at every instance of time. The rapid industrialization that we have witnessed over the last few decades, is proof of the fact that technology can provide solutions to tackle environmental problems. Technologies such as those that can contribute towards controlling global warming; keeping the concentration of greenhouse gases in check and reducing them; preserving natural resources, etc. can play a major role in ensuring development, that is sustainable. 'Sustainable' or 'Green' technologies, are those that are considered to be environment-friendly, through production or supply-side processes.

The current edition, 'Genesis: Tech for the Future', proposes an amalgamation of Sustainability and Technology. From understanding the need for it, to identifying its evolution and uses in areas such as agriculture, health, construction, etc. this edition aims to highlight the need to transition towards cleaner and greener technologies.

- **Amulya Varma**
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Sustainable Technology:
A New Dawn of Development

Sustainability has evolved from being a mere concept to a lifestyle and state of mind. Be it on the global, national, or personal level, there is greater recognition and action toward becoming more sustainable. Starting from the early environmental movement in the 60s up till the present, there has been a lot of flak towards technology being a key contributor to the broad environmental challenges.

Technology and sustainability are two words that rarely resonate as complimentary in most environmental literature. While blaming technology as a whole, underpins its merits, the reckless use of certain technologies in the pursuit of profits has taken its toll on the environment. The amount of strain that the industrial revolution and the capitalist economy have put on the planet is rather substantial.

Global climate change issues have moved to a point of urgency, driving global action on sustainability. The fault lies in the way the technology has been used. However, as policy and actions point in the direction of sustainability, a reimagination of technological powers being channeled effectively is also underway. The Sustainable Development Goals (SDGs) that form the heart of the global sustainability movement also recognize the vitality of technology in this mission. In particular, SDG 9 focuses on ensuring equitable access to technology for all, giving it value as a resource to be utilized. Simultaneously, it highlights the need to incubate technological innovation as a catalyst for a more sustainable society.

This innovation and shift of the narrative of technology from being a foe to a friend are evident in both the industrial and social outlooks. Most countries, including India, are experiencing the big pledge era where there is a call for action and commitments about climate action. Responding to the need to act with a long-term objective in mind, innovation, and research has brought forth a new prospect in the form of 'sustainable technology'. It helps to achieve social and economic developmental goals in a way that is more considerate and conscious.

Three key branches of sustainable technology mitigate ecological risks while creating a way forward. The first branch pertains to prevention. Preventative technology focuses on mitigating environmental harm by negating the negative implications. Carbon capture plants are a great example of preventative sustainable technology, wherein the units are set up to capture, store, and isolate CO_2 emissions to prevent environmental harm. The second branch of substitution focuses on developing alternatives and facilitating the transition to cleaner and greener methodologies. For instance, the substitution of fossil fuel-generated energy with renewable energy sources to regulate emissions and environmental impact is a good demonstration of how the substitution part of technological innovation works. The final branch of efficient sustainable technology focuses on paving the way forward with more efficient technology and improvising and utilizing the available tech for the greater sustainability objective, for example- natural gas heat pumps use ultra-low emissions combustion burners for insulation and heating purposes.

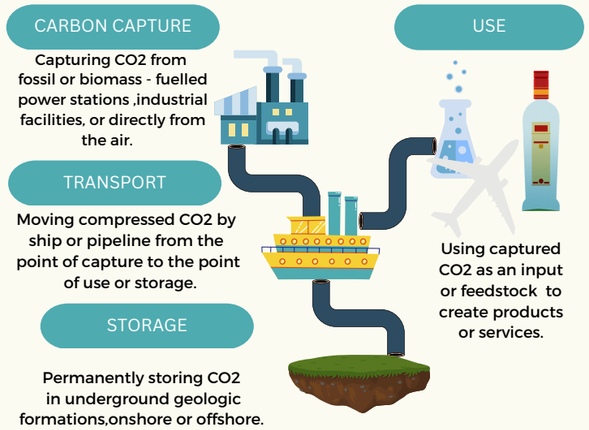
While there is a long way to go, businesses and innovators have responded to the call for more sustainable technologies to create a greener future. Concluding, valuing technology as a boon rather than a bane for sustainability is a key imperative for the greater good, both for the planet and human life.

Authored by Deergha Nagpal

TACKLING GLOBAL CLIMATE CHANGE:
A TECHNOLOGICAL APPROACH

Despite employing alternative energy sources and energy-efficient systems to minimize CO2 emissions, total CO2 in the atmosphere is still increasing and must be reduced to prevent the detrimental effects of climate change.

Carbon Capture, Utilization, and Storage (CCUS) is the umbrella name for techniques and technologies that capture CO2 from flue gas and the environment, then recycle it for use before establishing safe and permanent storage options. The initial step of CCUS entails the capture of CO2 from large point sources, such as power plants or industrial facilities that consume either fossil fuels or biomass as fuel. Additionally, CO2 may be extracted from the atmosphere directly. The most progressive and widely used capture technologies are chemical absorption and physical separation; other approaches include membranes and looping cycles such as chemical or calcium looping. Infrastructure that can transport CO2 safely and reliably is critical for the adoption of CCUS. The two primary methods for transporting CO2 on a large scale are pipelines and ships, whereas carrying CO2 over short distances and in small quantities by truck or rail costs higher per tonne of CO2. The transported CO2 may be utilized as an input in various products and services. Potential uses for CO2 include direct usage (non-conversion), in which the gas is not chemically transformed, and there is conversion of CO2 to a utilitarian substance through chemical and biological processes (conversion).Conversion of CO2 leads to new routes for the use of CO2 by using the carbon to transform hydrogen into synthetic hydrocarbon fuel, as an alternative to fossil fuels in the synthesis of certain chemicals, and by using CO2 in the production of building materials to replace the water in concrete or as a raw material in its constituents. The storage of CO2 involves injecting collected CO2 into a deep underground geological reservoir of porous rocks, topped by an impermeable layer of rocks, which seals the reservoir and prevents CO2 from migrating upwards or leaking into the atmosphere. It is possible to store CO2 in varied reservoir types, although deep saline formations and depleted oil and gas reservoirs have the highest storage capacities.



Source: *International Energy Agency*

CCUS technologies also lay the groundwork for carbon removal or 'negative emissions' when CO2 is produced by bio-based processes or straight from the atmosphere. There are already over 35 commercial plants using CCUS for industrial operations, fuel conversion, and power production, with a combined yearly capture capacity of roughly 45 Mt CO2. CCUS reduces the carbon intensity of industrial activities and is vital in meeting the Paris Agreement's worldwide net-zero targets. Indeed, the Intergovernmental Panel on Climate Change warns in its Global Warming of 1.5˚C reports that attaining net-zero emissions by 2050 is not conceivable without substantial mitigation measures, such as the large-scale deployment of carbon dioxide removal technology like CCUS.

Authored by Aditi Kumari

DAYLIGHT HARVESTING
OPTIMISING ENERGY SAVINGS IN INDIA

India's total consumption of electric energy amounts to 1.137 trillion kWh per year, which is 816 kWh per capita on average. Several reports show that this consumption has only seen an upward trend over the years. An interesting sustainable technology that is gaining momentum to lower energy consumption in buildings is daylight harvesting. Daylight as a resource is available in ample amounts globally and is considered to be a clean as well as a cost-efficient form of energy. Harvesting daylight holds a lot of potential for a developing country like India and can also contribute significantly towards achieving overall reduction in emissions in the long-run, through continuous Research and Development.

It is expected to save 60% of India's energy if used properly, assisting in meeting its net-zero emissions goal. In March 2022, the Ministry of Science & Technology decided to promote India's first startup that uses daylight harvesting technology as its USP and simultaneously aims to reduce carbon footprints significantly.

However, there are a few constraints related to daylight harvesting in India. The first concern is the issue of uniform illuminance. Considering urban infrastructures, every household receives different amounts of daylight at different times of the day. Some households receive a lot of daylight, while others receive negligible amounts during the day. The second issue is that of the weather. India experiences all four seasons at the same time in different places. So, for example, the states experiencing monsoons will not be able to contribute much to daylight harvesting.

Although many systems may improve daylight penetration, they are somewhat expensive to install and have high maintenance costs as well. Thus, daylight harvesting technologies come to the rescue to provide solutions to these constraints, cost-effectively. The two major forms of technologies included in the daylight harvesting system are mentioned below.

1) **Daylight Sensors:** Aims at distinguishing natural light from artificial light. It has a simple design and is economically viable as well. Once installed in a daylit space, it will help control the artificial light and use natural light at the most, thereby reducing energy consumption by a significant amount This will prove to be helpful in households as well as office buildings and help save energy.

2) **Automatic Blinds**: Here, the blinds will be opened once a day (when the daylight exposure is at its highest) and absorb the maximum amount of daylight, proving helpful to houses receiving variable sunlight.

If daylight harvesting systems are implemented in rural settings, they can prove to be effective in the longer run. The daylight of rural lands can be stored and used to illuminate the areas (in both lands) where daylight exposure is low.

The architecture of the upcoming houses and buildings can be modified according to the daylight harvesting systems, which will prove to attain the objective of reducing energy consumption. Like the norm for installing chargers for electric vehicles in new construction, the government can propose norms for installing daylight harvesting systems as well.

The journey of India's technological progress can be made rapid and efficient with the use of such simple and economically viable methods and technologies. Even though there might be infrastructure constraints, new modes of technology are being included in the DHS from time to time. Therefore, daylight harvesting is key to a sustainable future.

Authored by Sunaina Saxena

DECODING THE BUDGET

Green Energy, Green mobility, Green agriculture and plans to transition towards a net zero economy, were some of the major highlights of the Green Growth strategy, that has been advocated for, in the Union Budget 2023. The focus is on reinforcing India's commitment to long-term sustainability. To tackle climate change and reduce emissions at a national level, a comprehensive plan of action has been developed, with significant resource allocation, to achieve the proposed targets.

GREEN POWER

3000 Crore rupee increase Ministry of New and Renewable Energy (MNRE) budget, currently standing at a total of 10,222 crore rupees

95% Increase in solar energy sector schemes allocation, from Rs. 185 crores to Rs. 361 crores

RENEWABLE ENERGY EVACUATION

20700 Crore rupees of investment outlay allotted to the inter-state transmission system for the evacuation and grid integration of 13GW of renewable energy, from **Ladakh**

8300 Crore rupees support from the Center

सत्यमेव जयते
Ministry of New and Renewable Energy
Government of India

सत्यमेव जयते
Ministry of Power
Government of India

ENERGY TRANSITIONS

35000 Crore rupees has been allocated to ensure India's energy security

Focuses on priority capital investments, to drive India's energy transition and to achieve our Net zero targets, by the year 2070

सत्यमेव जयते
Ministry of Petroleum and Natural Gas
Government of India

NATIONAL GREEN HYDROGEN MISSION

19,700 Crore rupee investment to reduce the country's dependence on fossil fuels, thereby, pushing for a low carbon future.

Green hydrogen is to be included in the country's energy mix, due to it's advantages regarding energy density, ease of long-term storage and the potential to be produced carbon-free.

ENERGY STORAGE

4000 MWH capacity of battery energy storage systems to be developed and supported.

The Viability Gap Funding (VGF) will be a crucial step in this direction.

THRUST AREAS FOR GREEN GROWTH IN THE BUDGET 2023

पेयजल एवं स्वच्छता विभाग
जल शक्ति मंत्रालय
भारत सरकार
DEPARTMENT OF DRINKING WATER AND SANITATION
MINISTRY OF JAL SHAKTI
GOVERNMENT OF INDIA
सत्यमेव जयते

भारी उद्योग मंत्रालय
MINISTRY OF
HEAVY INDUSTRIES
सत्यमेव जयते

Ministry of Environment, Forest and Climate Change
Government of India

रसायन एवं
उर्वरक मंत्रालय
MINISTRY OF
CHEMICALS
AND FERTILIZERS
सत्यमेव जयते

GOBARDHAN

Galvanising Organic Bio-Agro Resources dhan under Swacch Bharat Mission - Gramin

10000 Crore rupees investment outlay

500 'waste to wealth plants' under the GOBARdhan scheme, exemption of excise duty on GST-paid compressed biogas (CBG) and a 5% CBG mandate for all organizations marketing natural and biogas, will be core pillars in India's decarbonizing initiatives

FAME

Faster Adoption and Manufacturing of (hybrid and) Electric vehicles in India, launched in 2015

70% Increase in FAME allocation

Custom duty exemptions have also been provided on import of capital goods for manufacture of lithium-ion cells for EVs, for cost-reduction.

GREEN CREDIT PROGRAMME

Will work in favour of providing incentives to companies, individuals and local bodies, to take environmentally conscious actions.

It will be notified under the Environment (Protection) Act, to help mobilize additional resources for these activities.

PM-PRANAM

Promote the adoption of alternative fertilizers and natural farming

10000 Bio-input resource centers

459 Crore rupees have also been allocated for the National Mission on Natural Farming for the scheme that will also contribute towards reduction of Greenhouse Gas emissions.

Designed by Riddhi Mukherjee (MSc Economics)

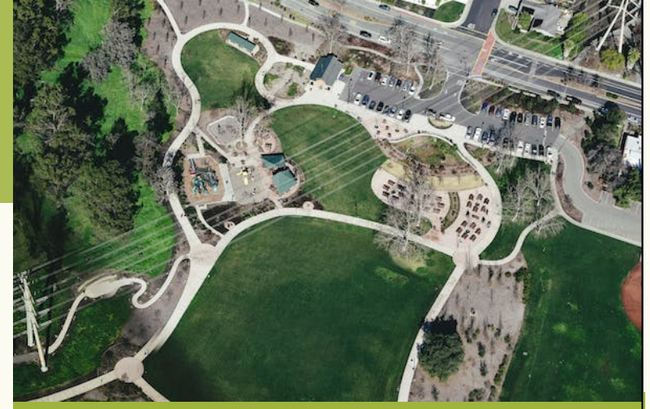
Technologies in Green Architecture

The global temperature is increasing and as per the IPCC 2018 Special Report on Global Warming of 1.5˚C, it is threatened that it can be far more than 1.5˚C if the world is not carbon neutral by 2050. To do so we need to attain net zero carbon emissions by 2050 and reduce emissions in the 2020s.

The construction industry is one of the major contributors to CO2 emissions. Hence there is a dire need to focus on reducing the emissions in construction through green architecture.
Green building design is a philosophy that advocates design more sustainably. A few of its characteristics include energy efficiency, water saving, recycling of construction and demolition waste , indoor environment quality and efficient use of space. This approach of architecture tries to reduce the detrimental effects on human health and the environment.

Apart from designing the infrastructure, the material composition also plays a major role in green architecture so let's take a look into that. The carbon emissions from the cement industry are about 7% of the total carbon emissions. Cement industry is considered to be one of the most severe pollutants in the world, as cement factories emit extraordinarily high levels of particulate matter (PM) into the atmosphere. Both consumption and output of cement in India are high due to government housing programs, urbanization, and efforts to maintain and upgrade roads and other infrastructure. An extensive amount had been set aside for infrastructure in the Union Budget 2021–22.

There is constant research going on for "greener" alternatives in the construction industry. GreenJams, a startup company in Visakhapatnam, claims to be the first Indian startup to report an environmental product declaration (EPD) for its carbon-negative building blocks. Agrocrete is a carbon-negative building material made using crop residues such as paddy straw, cotton stalks, bagasse, etc., and non-toxic by-products of steel and power plants. Products formed from agrocrete are vegetal concrete and carbon-negative bricks. The vegetal concrete comprises vegetal matter which is chemically bonded with the mineral binder before it is decomposed, causing the fixated carbon to be locked away in a mineral matrix that the binder creates.



The carbon negative bricks are a better alternative to conventional bricks as it reduces building costs by up to 50 percent and operating expenses by 30 percent. This not only deals with capturing carbon dioxide but also reduces the emissions which could be caused by the burning of the waste crop residue.
There is also an attempt of producing self-healing concrete. Researchers from the University of Bath are investigating how certain species of Bacillus bacteria could be used to make such concrete. The Bacillus species used by the researchers naturally produce crystals of calcite (a form of calcium carbonate that makes up limestone) when exposed to calcium and CO2. The concept of bacteria in concrete is that they will survive on the small amount of soil mixed in concrete and will replicate themselves when there are empty spaces. Adding these species to concrete would allow them to seal up cracks, and hence prevent structural degradation. Repairing concrete structures currently requires a lot of time and money, and also has a significant impact on the environment. Increasing the lifespan of structures by using self-healing concrete could dramatically reduce their carbon footprint. The researchers are currently looking for ways to seal bacterial spores in capsules that will protect them inside the concrete. Whenever there is a crack, the capsules will be dissolved, providing food and calcium to the bacteria, and allowing them to fill the gaps with calcite. Increasing the lifespan of structures by using self-healing concrete could dramatically reduce their carbon footprint.

The development of new technologies in green building design would also help in mitigating emissions and thereby, facilitate bringing down the expenses of infrastructure formation.

Authored by Anshika Shah

COOL CITIES BECOMING HOT-HEADED!

As more people migrate to cities and their surrounding areas, it is unsurprising that the effects of rapid urbanization are causing concern. Surface and ambient temperatures rise due to higher absorption of insolation. Major changes caused by urbanization are classified into two categories: changes in the physical and chemical properties of the atmosphere caused by pollution and land-use changes caused primarily by altering the natural surface cover.

The temperature differences between an urbanized area and its less urbanized counterpart are mostly felt during calm and clear evenings, leading to the formation of an urban heat island (UHI). The maximum heat island effect is often felt three to four hours after sunset. This happens because urban areas cool off way slower than their rural surroundings since much of the heat stored in urban structures during the day is retained.

Causes of Urban Heat Island Effect (UHI)

- Reduced natural landscapes in cities and towns lead to the formation of "urban deserts" with more impervious surfaces. Less vegetation, fewer water bodies,a lack of evapotranspiration and increased sensible heat, result in lower air cooling and a higher increase in temperature.
- Urban geometry, with its tall buildings, obstructs winds and reduces their speed; these tall urban canyons formed by such structures trap radiant energy in between their walls.
- Most cities' urban haze, like smog, acts as a miniature greenhouse layer, preventing outgoing thermal radiation from leaving.
- Anthropogenic releases of heat from the consumption of fossil fuels or other forms of energy by humans also get trapped and contribute to the heating effect.

A cumulative impact, thus brings about a distinct "warm island" effect in an urbanized area among the "cool sea" effect of the surrounding areas. Due to the varied presence of greenery and natural land cover, certain portions of a city with a higher share of heat-absorbing structures end up being relatively hotter and forming intra-urban heat islands. In a UHI, green urban parks, ponds, and well-planned residential areas are cooler.

Impacts of Urban Heat Island

Elevated temperatures from such UHIs end up affecting the quality of life as well. The increased levels of emitted air pollutants and greenhouse gases spiral up the pollution, thus leading to increased energy consumption, e.g., from air conditioners. Human health and comfort get compromised, especially for older adults, young children, people in poor health, people with more outdoor work, and those with low income who have inadequate resources to find comfort.
The intense loop of urban heat islands, combined with overall warming caused by global climate change, will have a compound effect on the estimated 70% urban population by 2050. UHI is a direct consequence of urbanization. But ignorance of the non-inclusion of nature in planning results in avoidable high heat intensities.

Tech Solutions to Mitigate UHI

Developed cities have started adopting strategies and technologies to mitigate UHIs, such as nature-based solutions like increased green cover. Growing a vegetative layer on roofs, reduces the temperature of the roof surface and the surrounding air. It improves stormwater management and lowers energy demand. China is promoting "sponge cities," and Zhuhai is part of a pilot project where hard surfaces, such as transforming pavements into permeable ones, which lowers their surface temperature. Singapore adopted the "Cooling Singapore Initiative" in 2017, which included efficient physical infrastructure, to replace individual air conditioning and inclusive planning with various stakeholders for protecting vulnerable populations. Further, carbon cured cement will help solve the double burden of UHI and carbon capture.

Authored by Meghma Mitra

IN CONVERSATION
with
ANSON SANDO

Mr. Sando is currently heading the Energy program at IIT Madras Research Park (IITMRP). As part of the 10x initiative of IITMRP the energy program works on two primary domains- identifying technologies to be commercialized in short, medium and long term for India's clean energy transition and technologies that will help India reach net zero by 2047. He is also collaborating with various stakeholders in facilitating India's journey towards 100% renewable energy and become a market leader by 2047.

Q. We want to understand what we mean when we talk about sustainable technologies. What is its ultimate goal and purpose?

A: Currently, India is the third largest emitter of greenhouse gas emissions but on a per capita basis we are placed at just 103rd in the GHG (Green House Gas) emissions ranking list. So, there's a clear dichotomy of sorts. Simply because we're a developing nation, a lot of our cities and states are yet to be built, so it's noticeably clear that our emissions are only going to be on the incline. As per IEA projections India is estimated to add the highest energy demand among any other country. So, the problem is clear, that India is going to continue emitting a large chunk.
And to address this issue, the only way is to move towards sustainable energy systems. The level of sustainability across agricultural activities, our transportation habits, our energy usage habits become fundamental. I don't want to call the 1.5 degrees celsius a magic number, but that's sort of a ceiling at this point that we have. Failing which, irreversible effects across the planet such as floods, harsh winters, heat stroke, severe heat waves across the world and country will occur. This multiple fold problem has started taking shape in various parts of the world.

IIT Madras Research Park (IITMRP) team aims at becoming one of the leaders in these technologies that mitigate climate change. We believe a large chunk of these problems can be addressed through technology. There's one aspect of technology: adoption and awareness. We also want to work towards bringing about the awareness and the adoption mechanisms where we can essentially bridge the gap and move towards a sustainable way of life.

Q. How soon do you think India can reach net zero and what are the different kinds of sustainable technologies and energy systems that are needed for India to ensure a clean energy transition?

A: In a recent conference, "Envision" we brought in experts from the industry, academia, government, stakeholders as well as startups and students to talk about the technology transformation towards net zero. Our goal is that India can celebrate its 100th Independence Day by moving towards net zero. So, by 2047 we should at least aspire to move towards net zero. Whether we actually hit net zero or not might be a question of how fast we can adopt and move, We intend to keep an optimistic view of 2047 as our target. Most of us must act in the next decade or two, beyond which it is certain that there will be irreversible damage.

In terms of our target for technologies and the specifics, there are three distinct categories. **One** is just energy generation, as primarily about 65% of today's energy in India comes from coal or is fossil based. Solar and wind cost cheaper than coal-based electricity, and in terms of today's technology costs, they are as competitive as fossil-based energy generation sources. We must move towards renewable energy sources where solar and wind have the primary contribution somewhere between 70 to 80% of all our energy generation. We will slowly start seeing the projects coming up in offshore wind, Tamil Nadu and Gujarat are taking the lead in that side. Other generation sources such as ocean wave, tidal energy today are not as cost competitive as compared to the existing technologies, but with innovation and R&D there certainly is a promise as India has a big coastline which can be tapped into. Energy sources like nuclear power, green hydrogen, exhibit potential and may need extensive R&D and innovation. The **second** thing that we need to look at, are energy storage systems. Solar, wind or any renewable energy source are very variable and not controllable in nature. The only way we can make it flexible or control is through storage systems. There will always be an imbalance between demand and supply. The only way to manage the mismatch is to have some kind of storage systems that are essentially going to play an integral role in moving towards sustainable or fully renewable energy-based systems. The **last** thing that warrants our attention, is the use of technologies such as carbon capture systems.

> *The only thing to do with carbon emissions is to capture it, utilize it and sequence it.*

But again the costs are prohibitively expensive and we need to do significant R&D to make it economically viable.

Q. How does the role of DISCOMs change in the Energy Transition and what are the policy support needed to make them an active participant in the energy transition?

A: DISCOMs need to be a lot more efficient in operations. Average transmission distribution loss in India is around 23 % which is 4 times that of developed nations. This loss needs to be minimized due to the dependency of electricity transmission on distribution channels across the country. Loosing 23 % means that we need to generate 23 % more to meet the same demand. The role of DISCOMs is changing from managing energy generation to ensuring that transmission from point of generation to consumption happens in a seamless, effective and efficient manner. The distribution of renewable energy is dependent on the same transmission channel. Policy support for the implementation of open access is essential. Anyone with a connection will have an open access to distribution and transmission channel at a standard cost per unit rate. The delay in the application process before they get a clearance is challenge. Therefore, there is a need of a single window clearance for open access- which ensures that clearance happens within a stipulated time frame.

Q. What are the strategies needed to commercialize RE tech like energy storage and enable their mass adoption?

A: Any technology needs to go through 4 stages, before commercialization:
a. Proving the science-and checking its applicability in laboratories.
b. Pilot demonstration stage- testing it at one or two locations.
c. Early implementation- proving readiness to scale and economic viability. E.g., Google, Amazon, etc., are early adopters of sustainable tech. But they still require financial incentives and policy support.
d. Large scale implementation.

Therefore, there are multiple rounds to be undertaken, starting from labs, to full scale commercialization. These rounds can be followed either through established companies which do R&D jointly with labs or through startups. The path through startups consist of incubating a company and letting it move from 2nd and 3rd to the 4th stage. The question of whether this needs to be done through established companies or startups depends on the developers of technology, who take the final call.

Q. What is the role played by Energy Management System (EMS) in correcting the mismatch between supply and demand?

A: Energy consumption and generation profile will vary- day to day and, from month to month. There is a need to build a comprehensive system that will assist in effectively managing energy generation- as to where energy is going, and if it is being used directly or it is being directed to a storage system. If it is being used directly- then is it being consumed efficiently?

> *Energy Management System (EMS) needs to track and monitor real time data of all devices- in terms of how much energy is being consumed and for what appliances.*

Suppose there is an excess of solar energy- then EMS needs to take a decision whether it should be sent to a storage system and which storage should it use. This will involve technology like Machine Learning and data analysis. Only after we understand patterns and see several cycles, can we decide on the best mode of operations. So, managing and ensuring that storage system is effectively utilized is very important. The focus should be on collecting, monitoring and analyzing Real Time Data, such that the software learns from the data, thereby contributing to efficient functioning of EMS.

ACHIEVING GOOD HEALTH AND WELL-BEING

The health care system currently accounts for approximately 5.5% share in the national carbon footprints of the OECD (Organization for Economic Co-operation and Development) countries. USA leads in this aspect with almost 10% of its contribution coming from the health care system.

There are various ways in which the health sector is contributing to carbon footprint. The use of high-power medical equipment such as MRI and CT scanners contributed to 0.77% of global carbon emissions till 2016. Another factor observed is the extensive resource usage throughout the supply chain of medical health care, which alone contributes to 60% of the total emissions of the health care systems. This includes the production of drugs, vaccines, and appliances, added to their transportation chains. Medical waste is one of the easily neglected factors, but with a majority of the approximate 16 billion injections being administered worldwide every year ending up in landfills.

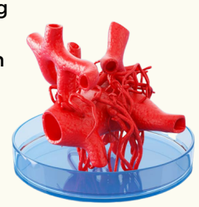
The ongoing international effort for achieving sustainability in health care is engineered through advances in technology. Under SDG 3 (Ensure healthy lives and promote well-being for all at all ages) and SDG 9 (Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation), there is a global shift in the ideology towards health care systems.

Sustainability needs to be achieved across all five steps of health care, to have a complete impact. The steps include prevention, diagnostics, treatment, monitoring, and caregiving. Prevention of a disease can be achieved through early and precise diagnostic evaluation, using modern technologies. If the disease cannot be prevented then there should be precise treatment strategies, with effective monitoring. Post-treatment, there should be a healthy, sustainable caregiving period for the patient to recover fully.

A FEW RECENT BREAKTHROUGHS

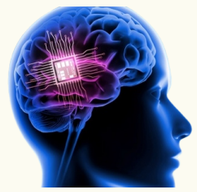
1.CRISPR: Clustered Regulatory Interspaced Short Palindromic Repeats is a tool developed by Emmanuelle Charpentier and Jennifer A. Doudna, which fetched them the Noble Prize in Chemistry in 2020. The technology can be used to alter the DNA sequences of organisms, i.e., change the gene code. Current studies focus on providing immunotherapies for cancer and repair genes in large organs such as the brain and muscles. The most important application of CRISPR lies in the usage to cure inherited diseases like, sickle cell anaemia, beta thalassemia and inherited eye diseases which were previously considered to be incurable.

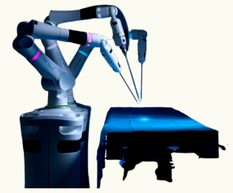
2. 3D bioprinting of tissues/organs: Currently, the replacement of organs/tissues largely relies on obtaining tissues from the same individual or a donor, who has a match to donate. With three-dimensional (3D) bioprinting we seek to achieve the fabrication of biological constructs with the same hierarchal structure as their native counterparts. The process involves the printing and patterning of cells, tissues, or other biological entities, directly done on a substrate or tissue culture dish, via an automated dispensing system. 3D bioprinting eliminates the need for a donor, thereby increasing the chances of being cured.



Authored by Aviral Srivastava

3. **Brain Sensors and implants**: We have observed a rise in various brain conditions like dementia, epilepsy, post-traumatic stress disorders, etc. These ailments are largely viewed as untreatable in the medical field because there is no way to record the malfunction in the brain and then provide treatment. The recent development of brain sensors and implants has become essential in this regard. These implants record the electrical signals in the brain, and thus help us to not only record the activities of the brain, but also communicate with the organ. Another major advancement observed in this field is the development of Neuralink (founded in 2016 by Elon Musk and a group of engineers), which focuses on allowing people with paralysis to control devices from their brain. One major drawback of electronic sensors for brain was the fact that these sensors were not resorbable and acted as a nidus for infection. But with the advancement of technology, bioresorbable brain sensors have been created, which do not have to be removed post-surgery.





4. **Robotic surgeries**: This refers to the robots acting as an assistant to the surgeon, majorly. Even if the robot is performing, it has been programmed to do so via machine learning. Machine learning as a concept means that we make any artificial intelligence learn things by providing it with data. One very common example of machine learning is the captcha that we solve, which is being used to make artificial intelligence smarter. But we cannot be dependent on AI for complex surgeries as it might not be programmed for that particular case. This is why the human hand remains the most reliable. But robotic arms can be of much help to doctors as they can function to do ultrasounds while performing the surgery, greatly assist the surgeon, or even provide higher accuracy by gearing the movement of the surgeon. If the surgeon moves his hand by 1 cm, there is a movement of 1 mm. Robot arms also help by reducing the possibility of tremors being felt by the surgeons or assist in holding things which cannot be held or manipulated by human hands.

A primary barrier in delivering these sustainable technologies is their high manufacturing cost. The lack of finance hinders capital poor nations from having access to these technologies. We can hope that the future advancements in technology would be a driving factor in bridging this gap.

GREEN HYDROGEN FOR DECARBONIZING INDIA

Hydrogen which is extracted from the electrolysis process powered by renewable energy is known as green hydrogen (GH2). Today, 95% of hydrogen produced is grey hydrogen which is produced through steam methane reforming (SMR). Production of hydrogen through the SMR process contributes to about 56 to 66 million metric tonnes (MMT) of CO2 for the year 2021.The demand for hydrogen is approximately expected to increase to 11 MMT by 2030 and 28 MMT by 2050. India can cut down these emissions by using green hydrogen.

Strategic interventions for green hydrogen transition (SIGHT)
Under the National Green Hydrogen Mission, the government has launched the SIGHT programme, through which India aims to move toward increasing the adoption of green sources of energy. A budget of Rs.19,744 crore has been allotted, which includes Rs.17,490 crore for the green hydrogen transition programme, Rs. 1,466 crores for Pilot Projects, Rs.400 crore for Research & Development, and Rs. 388 crores towards other Mission components. The mission aims to add at least 5 MMT of green hydrogen production capacity per annum by 2030.Additionally, this will also add renewable energy capacity of 125 GW and an electrolyser capacity of 60-100 GW. This will help India to cut down its emissions by 50 MMT CO2 by 2030.

The way forward
Cost of operation and electrolyser cost are one of the early barriers for green hydrogen. The recent release of the green hydrogen mission does provide adequate policy support and the introduction of the carbon markets creates a positive sentiment for investors to invest in green hydrogen. But policymakers need to be careful in carrying out this energy transition. A continuous modelling of optimistic, conservative, and worst-case scenario of India's way to net zero is essential, so that policies for green hydrogen can be made accordingly, keeping in mind the 2070 net zero goals.

Authored by Pranayak Sharma

GREEN JOBS

Sustainable technologies are designed to minimize the negative impacts and promote sustainable practices while meeting the needs of today. New developments often have many socio - economic impacts that come to surface while in use. The use of these sustainable technologies has led to creation of “green jobs”, in particular in the fields of renewable energy, circular economy and waste reduction techniques. Green jobs are those, that lead to positive environmental impacts, and at the same time contribute to overall environmental welfare. Traditional sectors such as manufacturing and construction have the potential to provide green jobs, in manufacturing of solar panel modules, inverters, converters, energy-efficient pumps, etc. Rise in adoption and use of EVs, have further led to increased demand for workers in design and production sectors as well. Green jobs in different sectors of the economy can help in addressing the employment crisis, lead to cost savings in business operations and therefore increase the awareness regarding green processes and technologies.

GREENER PASTURES

A real measure of development is when technology reaches into rural India's backbone and pivotal occupations such as agriculture. With a growing pool of Agri-tech companies and start-ups in our country, newer sustainable technologies are reaching farmers. These solutions are also attracting a greater number of people from urban areas to look at farming as a profitable profession. For everything ranging from e-retail to policy making, data driven decisions are made, thus making data, the new gold and oil. The future of agriculture also depends upon data driven farm decisions. Fasal and CropIn are among the top Indian Agri- tech start-up players that facilitate this type of precision in farming by driving decisions on optimum moisture for irrigation, temperature and humidity control of greenhouse using Internet of Things (IOT) solutions.

Innovative technologies: case study

With mobile phones and internet connections reaching every nook and corner, most of the farmers in rural India could benefit with the right marketing of their produce. eNAM, an online integrated national market releases prices of agricultural commodities in majority mandis of India, which helps farmers to have better price discovery. Software’s also provide information on warehouses, storage and tracking services for the commodity which helps farmers to decide on the best option for their produce by getting direct wholesale buyers from all over the country. Many researchers working in Centre for Excellence, IIT-Kanpur and similar institutes, have put in continuous efforts to promote these digital mandi solutions, but such software’s and apps can be successful only with integration with KVKs and Agriculture Departments. To support technologies in farming, the GOI has launched Digital Agriculture Mission (2021-2025) which aims to divert more funds into technology driven agriculture with robotics, ML, and Artificial Intelligence. Through this mission, the government plans to disseminate more information on warehousing, cold storage, soil testing and crop prices through similar software and applications. With the wave of farming reaching the urban ground, technological solutions like vertical farming, hydroponics and aquaponics have taken off. By using <80% water than traditional farming, hydroponic and aquaponic agriculture is a way forward. These work on precision agriculture and use smart tech like IoT, Big data and AI to maximize efficiency and production. However, a continuous supply of electricity, from renewable sources is a must to keep the water recycling in the set-up. Due to the technological attraction, a new community of urban, educated farmers have risen who use smart solutions to ensure food security for growing urban population. These techie farmers use precision farming and cloud-based software solutions, such as the ones provided by CropIn to maximise their yield with minimum inputs. By growing off-season and exotic vegetables under fully controlled greenhouses, they earn a considerably high margin by exporting and marketing to elite urban markets.

Uttam Fasal Uttam Enaam

These images are from TERI-SAS Hydroponics setup integrated with Solar Photovoltaics. This setup was developed by TERI SAS students Mr. Souryadeep Basak and Lavkesh Balchandani.

This unit can grow rich, nutritious green fodder with very little water and soil-less farming technique, capable of increasing crop yields by sixfold compared to traditional approaches

These cutting-edge technological solutions not only come from big data driven start-ups, but also from local innovative farmers. One such story is that of Cold Space Agro-Tech, a post-harvest management service for fruits and vegetables with pre-cooling and storage integrated Ethylene-based pressurised ripening chambers. This has helped farmers in saving their produce which otherwise would have gone over-ripened. Similarly, an important technological tool is cold storage in the supply lines around the farmlands. These storage facilities are good only near the Tier 1 and Tier 2 cities where the consumers are situated. Snowman logistics and Coleman are some cold storage players in the Indian agriculture supply chain. The costs can further be cut down and the whole supply chain can be made more time and space efficient by integrating warehousing with cold storage and manufacturing trucks or EVs with an in-built cooling facility.
Drone mapping is an up-and-coming technology that has reached the farmers of our country. This has helped large corporations who hire these farmers on contract to monitor the crops, nutrition requirements and pest infestation. Optimum application of fertilizers and pesticides instead of rampant spraying helps shifting toward a step into sustainable agriculture.

Challenges to be addressed in Agri-tech

With more than 86% farmers in our country being marginal and small-scale farmers, with landholdings less than 2 hectares, the on-field technologies like precision and cloud-based solutions seem like a farfetched dream. These technologies need to be sponsored or enforced under a contractual offer with a large corporation or organisation as these farmers survive only on subsistence levels. They neither have the skill nor the financial resources to adopt these technologies. Technological skills need to be developed and integrated into the practices of these marginal farmers to bring about massive revolution in the Agri-tech space.

In conclusion, there is a need to integrate high-tech solutions into the Indian Agriculture scenario, immaterial of the economic roadblock of small farmers or inefficiencies with the supply chain. These can be solved only by better penetrative solutions that can be adopted with ease.

Authored by Arundhati Varma

DEBUGGING THE GLITCH IN THE MATRIX

"You cannot get through a single day without having an impact on the world around you. What you do makes a difference and you have to decide what kind of a difference you want to make."
— Jane Goodall

With the future of the planet inside the cage of global warming and pollution, sustainability through the lens of technology has emerged as our saviour. From shaping the path of the future to fixing the past, people have started adopting sustainable practices to advance towards a green economy. With this composition taking an insightful turn, let's dig into the successful journeys of Nexus Power, Phool.Co., Graviky Labs, and Newlight Technologies that describe the perfect amalgamation of Sustainability X Technology and what the future beholds for this sector.

Nexus Power: Biodegradable Powerhouse

An IEA report reveals that in 2022, the global sales of electric cars skyrocketed rapidly, with approximately 2 million sales in the first quarter, which was 75% more than the sales from the same period in 2021. It is well known that for the ultimate goal of Net Zero Emissions by 2050, the revolution of electric vehicles holds a spotlight. But with the exponential rise in electric vehicle usage, the graph of concerns surrounding the efficiency of their batteries has also taken an upsurge. Amidst the fog of these concerns, emerged an idea to manufacture biodegradable batteries.

Nexus Power is an Indian sustainable startup founded by Nikita and Nishita Baliarsingh, whose flagship technology utilizes fully bio-degradable materials for manufacturing eco-friendly batteries to power electric vehicles. Unlike lithium-ion batteries, this innovative battery technology uses crop residue to produce rechargeable energy-depositing cells. The composition of the batteries consisting of the nanomaterials from crop residue makes them fully recyclable and allows the charge to work for a longer time. Serving the dual purpose of manufacturing biodegradable batteries and curbing air pollution by stopping the crop residue from getting burnt away, Nexus Power is well committed to leaving its impact on the future of power.

Graviky Labs: Creativity of Pollution

"Harvesting pollution into art" might seem dubious, but this has been made viable by Graviky Labs, a startup led by Mr. Anirudh Sharma and Mr. Nikhil Kaushik, operating towards an imperishable future. In its creative journey to conserve the planet, the company has developed a novel solution by converting carbon emissions and pollution into a spin-off called AIR-INK.

AIR-INK is the world's first ink made from upcycled carbon emissions and is black, carbon negative, and directly usable in inks, paints, coatings, etc. The company utilizes carbon sequestration to store the carbon from the atmosphere, including factories, cars, etc., and then the emissions are processed into usable carbon. In its mission to eradicate the deliberate burning of fossil fuels to produce carbon, this sustainable ink is trying to recast pollution into an opportunity for innovation. The company's planet-friendly affiliations have made it possible for brands like Doconomy-MasterCard, Johnnie Walker, and Pangaia to use AIR-INK on their products, such as PANGAIA x AIR-INK® capsule, Johnnie Walker's limited edition bottles with Black Label series using AIR-INK, and Doconomy and Mastercard's first carbon limit debit card using AIR-INK.

Phool. Co. : Recycling temple waste

Eight million tonnes of flowers are reportedly thrown into rivers yearly for religious purposes in South Asia alone. As a result, this is contributing to the pollution of the river Ganges, which provides drinking water to approximately 400 million people. Phool (2017) developed the concept of "flower cycling" to address India's enormous temple trash problem to lessen the pollution, preventing 97 kg of harmful chemicals and 7,600 kg of waste flowers from entering the river each day, supporting 1200 rural families, and employs 73 women as 'flower cyclers.'

It gradually advanced to making vermicompost, organic gulaal, 'Flora foam' (used by companies like Bajaj and Havells to package their goods) - a compostable alternative to Styrofoam (non-biodegradable plastic), and most recently, a kind of eco-friendly, tensile, and breathable leather called 'Fleather'(adopted by Anita Dongre). Phool was chosen for this innovation with nine startup entrepreneurs from the second round of the South Asia Innovation Program, which was organized by a global initiative- Fashion for Good.

With a focus on raw material technologies, wet processing, packaging, and digital acceleration, the pioneers provided solutions that were essential to South Asian supply chains and industries.

It appears that unsustainable and harsh products like (animal) leather will soon be a thing of the past with such developments happening in the fashion business!

Newlight Technologies: Sustainable Plastic and Leather

According to a report by UNEP, globally, 46 percent of plastic waste is landfilled, 22 percent is mismanaged and becomes litter, 17 percent is incinerated, and 15 percent is collected for recycling, with less than 9 percent recycled after losses. With plastic harbouring such a crucial standing in our everyday routine, recycling alone cannot end plastic pollution. This led Mark Herrema and Kenton Kimmel's Newlight Technologies to introduce a more sustainable and naturally recurring solution- AirCarbon. In the pursuit to work in this direction, they found that nature consists of microorganisms that feed upon greenhouse gases like methane and carbon dioxide. Through biological carbon capturing, the isolation of these microorganisms in a replicated ocean condition on land led to the growth of a muscle-like material called AirCarbon in their cells. AirCarbon is a biomaterial called PhB, a naturally occurring substance in almost all known life on Earth. After its extraction and purification, the material can be melted and moulded into anything ranging from fibre to sheets, which makes it a replacement for synthetic plastic and animal leather.

It is degradable and is used to create products for the food, fashion, and automotive industries. Currently, the company makes reusable, plastic-free, regenerative food wear, starting with drinking straws and cutlery, and Covalent-brand regenerative, carbon-negative fashion, starting with eyewear and leather replacements.

GREEN MOBILITY FOR GREENER TOMORROW

As per a report by the World Bank, passenger traffic will exceed 80,000 billion passenger kilometers, an increase of 50 percent, and freight volume will grow by 70 percent globally by 2030. The addition of road traffic will increase fossil fuel usage in the years to come, therefore posing one of the most extreme environmental and social challenges of our time. Although transportation serves as an infinite network to uphold our society and economy, it has also left an indelible footprint on the environment in the form of pollution. According to a report by UNEP, transport is responsible for nearly a quarter of global energy-related CO2, which has put into question the role of urban mobility in developed and developing countries. With the global vehicle fleet set to multiply in the coming years, there is a growing consensus for more sustainable patterns of transportation with technological improvements such as fuel efficiency and smart mobility.

Sustainable mobility refers to the provision of infrastructure and services for the mobility of people and goods by advancing economic and social development to benefit future generations in a manner that is affordable, accessible, safe, efficient, and resilient while minimizing environmental impact. The 17 SDGs (Sustainable Development Goals) or the Global Goals indirectly incorporate the role of sustainable mobility, which provides a critical enabling environment to realize other SDGs. For instance, sustainable mobility is requisite to achieve SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), and SDG 9 (Industry Innovation and Infrastructure). Even SDG 12 (Responsible consumption and production) and SDG 13 (Climate Action) are reliably dependent on the role of sustainable mobility. Sustainable mobility includes a wide range of innovative mobility trends, like shared mobility, public transport, smart mobility options, bicycle and pedestrian lanes, electric vehicles, and synthetic fuels.

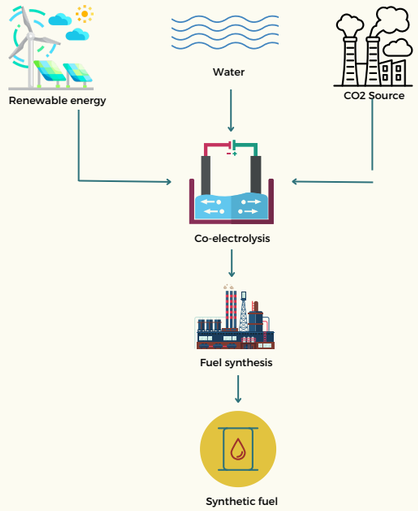
- Shared mobility is a system where the public shares a vehicle as a group over a personal rental, which eliminates the need for each user in the group to purchase it separately. Shared mobility has introduced us to new services like peer-to-peer car sharing, pooled ridesharing, e-hailing services, etc. This reduces the carbon footprint of transport and moves people from carbon-intensive modes to more sustainable forms of travel.

- With the power of cloud-enhanced sustainable mobility, smart mobility has emerged as another solution to promote flexible and sustainable forms of transportation. Intelligent systems in the vehicles serve as route optimizers by helping customers avail parking spaces, warning them of traffic congestion, and facilitating automatic payments along the route, thus enabling less fossil fuel combustion and providing flexible and sustainable mobility solutions. Besides that, IoT sensors also help reduce energy consumption by generating maintenance alerts concerning faulty parts, controlling the temperature, and switching off lights in empty areas. Moreover, real-time tracking features in these systems can also deliver real-time data on the state of shipments, which provides a solution to large-scale inventory wastage in the supply chain that has severely contributed to carbon footprints in previous decades.

- Walking and cycling short distances are other ways to promote sustainable mobility while also contributing to the health of the population and the ecosystem. Pedestrian and bicycle-oriented lanes, which can be a path, walking street, sidewalk, bike lane, bike path, etc., are designed especially for the mobility of pedestrians and bicycles.

Considering all cars will be electrified one day, what about the emissions generated by airplanes, ships, and trucks? The answer to their heavy reliance on liquid fuels is synthetic fuels. Synthetic fuels constitute one of the most promising routes for fuels in the future. Synthetic fuels use carbon dioxide and renewable sources of energy to produce gasoline and diesel and substitute natural gas. If the greenhouse gas or carbon dioxide is collected directly from the atmosphere, an eco-friendly, carbon-neutral internal combustion engine is possible. Its combination with conventional fuels can help reduce the emissions of existing vehicles.

Despite a surge in technological advancement in sustainable mobility, the leadership vacuum remains a critical problem in this sector. Unified and strict action by global authorities such as the UN agencies are required to avoid fragmented approaches with no reliable outcome. A clear definition of objectives needs to be defined by the SDGs to reach net zero by 2050.



Source: MDPI

Electrifying the vehicles!

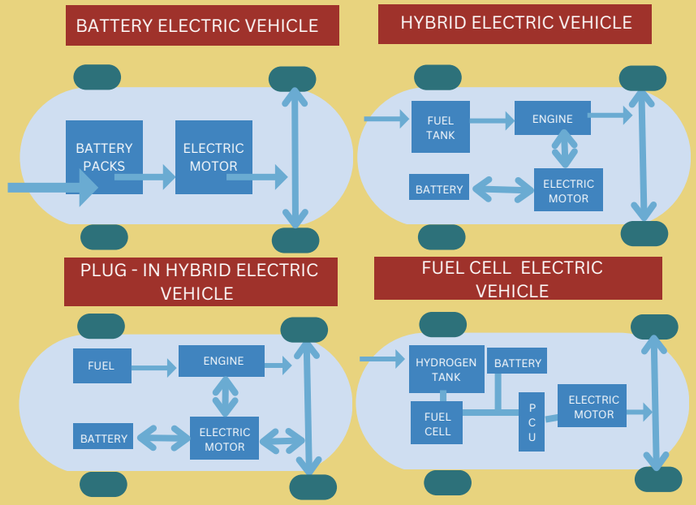
One of the biggest revolutions in sustainable mobility is an EV (or electric vehicle). In recent years, EVs have seen exponential growth, helping to decarbonize road transport and achieve net zero emissions by 2050. EV sales nearly doubled from 2020 bringing the total number of electric vehicles on the road to 16.5 million in 2021. EVs run on electric motors that require a large traction battery pack to power the motor. This helps to reduce fuel consumption while also lowering emissions. Electric vehicles are heavily dependent on advances in technologies, such as comprehensive charging services, electric drive solutions, and lightweight components that determine the efficiency and quality of an electric vehicle. There are four types of electric vehicles:

1. BEVs or Battery Electric Vehicles run on a battery-powered electric drivetrain. They use the electricity from large battery packs that use electricity grids for charging purposes.

2.HEVs or Hybrid Electric Vehicles run on both engines and electric motors, in which the transmission is rotated simultaneously by both the engine and the electric motor.

3.PHEVs or Plug-in Hybrid Electric Vehicles have both an engine and a motor. These vehicles let you choose among the fuels—alternative fuel (such as biodiesel) or conventional fuel (such as petrol)—and are powered by a rechargeable battery pack.

4. FCEV or Fuel Cell Electric Vehicles run on fuel cell technology. They convert the chemical energy of the fuel into electric energy that generates electricity, enabling the vehicle to run.

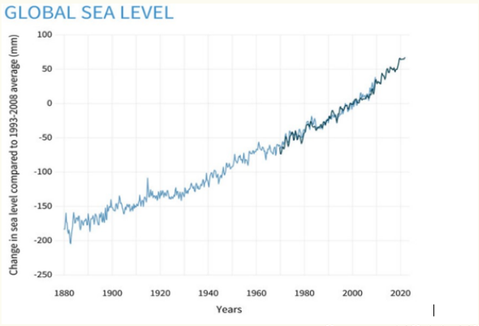


Source: NITI Ayog

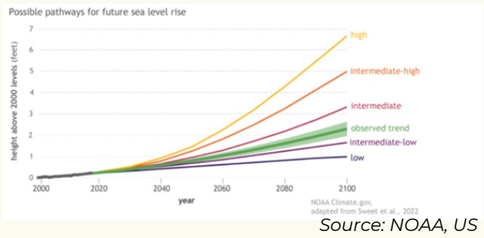
Authored by Aakriti Arora

ENGINEERING THE OCEANS FOR A SAFER WORLD

Climate change is real, and there is ample evidence to prove it, the most significant being sea level rise. According to the latest report by Inter-Governmental Panel on Climate Change (IPCC), global mean sea level is expected to rise between 0.29 m to 1.1 m. The latest report titled "Special Report on the Ocean and Cryosphere in a changing climate" (SROCC) has identified ocean warming, acidification, and sea level rise as prime factors for a changing climate. The evidence suggests a sea level rise of a record 97 mm above 1993 levels and it is further expected to increase only.



Source: NOAA, US

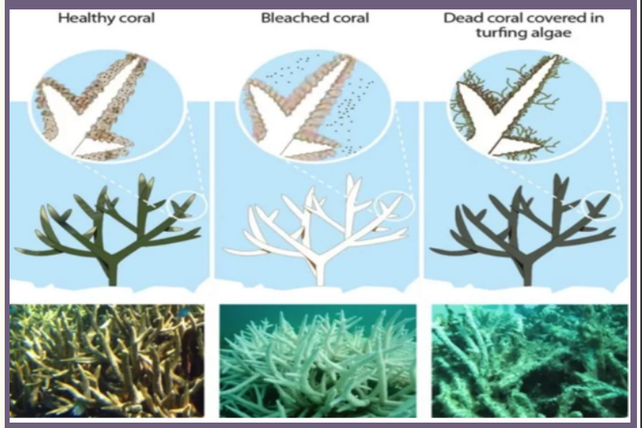


Source: NOAA, US

UN estimates suggest that close to 50% of the world's population will be living near the coast by 2050. These communities will bear the brunt of extreme disasters like coastal flooding, cyclones, storm surges, tsunamis, and coastal erosion. To mitigate the impact of climate hazards and achieve SDGs 11,13 and 14, adaptation measures must be taken. Scientists and engineers have developed sustainable technologies that help in engineering the ocean to make the world a better place. In this article two such efforts are talked about, namely Coral reef restoration using Biorock technology and the Netherlands mastering the ocean to prevent flooding and erosion.

Coral Reef Restoration using Biorock Technology

Coral reefs are termed "rainforests of the sea" and are one of the oldest and most diverse species on Earth. They serve as a habitat for almost 25% of marine species such as fishes, turtles, and other aquatic organisms thus terming them as "Cradle of fishes". Hard corals build reefs that help in preventing coastal erosion, and climate hazards and act as breakwaters during storm surges. With climate change, ocean acidification and warming seas, a lot of these reefs experience stress and thus coral bleaching occurs which leads to their death.



Source: Great Barrier Reef Marine Park Authority

Scientists have come up with a technology called 'Biorock' or 'Mineral Accretion' technology which helps in restoring dead reefs and help them grow back stronger and faster. Biorock technology was invented by the late architect Prof. Wolf Hilbertz to support the natural regrowth of corals using various materials in the sea. These materials grow and get stronger with age and are self-repairing.

Electrically conductive materials like steel are used for reef building, and a low-voltage electrical current is applied to it. It is like electrolysis; thus, calcium ions combine with carbonate ions and adhere to the structure.

Authored by Bharat Ramachandran

Delving Deeper: How Netherlands prevents coastal flooding?

The Netherlands is a low-lying country that is frequently prone to flooding and coastal inundation. The North Sea flood of 1953 submerged almost half of the areas which are below the Mean Sea Level (MSL), which led to the commissioning of the Delta works project for flood protection. The project comprised laying 13 dams, including barriers, sluices, locks, dikes, and levees, to reduce the Dutch coastline's size and protect the areas within and around the Rhine-Meuse-Scheldt delta from North Sea floods.

The project involved building dykes and storm surge barriers that are open during normal conditions. When a storm surge or coastal hazard occurs the gates of these barriers are closed so that the low-lying areas can be prevented. The most important barrier is the Maeslantkering barrier as it protects the port city of Rotterdam.

The technology was made sustainable and considerate of the ecology of the region by changing the design. The initial design was proposed to be a fully closed permanent structure, but this would impact the saltwater ecosystem and biodiversity of that region. So, a more sustainable design where the gates open and close was constructed.

A more sustainable long-term design that prevents coastal flooding and also conserves biodiversity and aquatic species of the region is the hallmark of this Dutch engineering marvel. In the coming years, the majority of coastal cities are predicted to be sunk by rising sea levels. There also exists a looming threat of more frequent climate hazards like cyclones, tsunamis, storm surges, etc. These cities can adapt to a changing climate by commissioning such sustainable structures.

Location of Maeslantkering barrier

Closed gate

Open gate

EXPERT TECH

DEBAJIT PALIT

Dr. Debajit Palit, listed in the Top 2% World's Scientists (for 2019 & 2020) by Stanford University and Elsevier BV, has more than 25 years of experience in the fields of- renewable energy, clean energy access, electricity policy and regulation, rural electrification, decentralized electricity solutions, energy-gender-poverty nexus, and water-energy-food nexus. While at TERI, Dr. Palit completed nearly 200 analytical and implementation projects, in areas ranging from clean energy technology, energy planning to impact assessment and capacity building. He is currently a Professor at the NTPC School of Business.

Q1. With the Indian government taking significant steps towards sustainability, what is your take on the allocated budget for facilitating green growth?

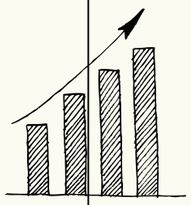
The budget for the current financial year has allocated Rs 35,000 crore for clean energy transition. The finance minister also said that green growth is one of the seven priorities or saptarishi to guide India into Amrit Kaal. The budget for the Ministry of New and Renewable Energy has also been increased this year. In the energy storage sector, the budget has provisioned viability gap funding support for 4,000 MWH of battery energy storage systems and a policy for pumped storage projects is expected soon. Plans are also on the cards for 500 new 'waste to wealth' plants under the GOBARdhan scheme to promote a circular economy.

In January 2023, the National Green Hydrogen Mission with an initial outlay of Rs 19,700 crore was launched. The prime minister's vision of Lifestyle for Environment is also expected to move the country toward an environmentally conscious lifestyle and reduce demand for energy. We can say that India is moving forward firmly for the panchamrit and the target of net-zero carbon emissions by 2070, as committed in the Glasgow COP to usher in a green transition. The above are all welcome steps taken by the central government and it is expected that the respective state governments will also provide thrust towards green development in their budget. Several Indian corporate houses have also set decarbonization targets internally to become carbon neutral by 2050 or before. Indian Railways has set the target to achieve net zero carbon emission by 2030.
The budgetary amount and other allocation though are not small, the capital requirement to transition to a green economy is huge and thus access of low cost long term or patient capital will be key to achieve net zero. To reach net zero emissions by 2070, the International Energy Agency estimates that $160 billion per year is needed, on average, across India's energy economy between now and 2030, which is 3-4 times of current investment levels. Other agencies like McKinsey, CEEW and TERI estimates suggest roughly $7 trillion to $12 trillion of green investments until 2050, which translates to around 3.5% to 6% of India's GDP. Furthermore, if we specifically consider the power sector, the investments will also hinge on the discom's ability to pay to the renewable energy project developers against electricity procured. Given the current situation of the electricity sector, it may be difficult to generate enough revenue unless sectoral reforms are undertaken to depoliticise & professionally corporatize the electric utilities with proper disclosure norms in place. I would say, beyond the financial requirement, a robust policy and regulatory architecture, including for 'just transition', also have to be worked out for the sector to get the desired outcome.

Q2. During your vast experience of working on rural electrification projects, what according to you have been the biggest challenges in history? And where does India stand now on overcoming the hurdles in the past, or do we still have a long way to go?

There are four facets to electricity access. The first is extending connectivity to all villages. The second is to connect each household in the village. The third is to provide reliable, round-the-clock electricity along these connections, and the fourth is to make sure there is a responsive service network that takes care of metering, billing, collection, problems, and maintenance.
We have done very well on the first since the passage of the Electricity Act in 2003 and launch of national rural electrification scheme in 2005. At that time roughly 80% villages in India had connectivity but less than 50% of households had connections. The passage of the Electricity Act made the central government also responsible for expanding electricity access along with the state governments. Earlier, central government used to provide concessional loans to the states. Because of high capital cost coupled with losses in the sector, states were not able to spend or take loans to expand the infrastructure. After the National Rural Electrification Programme was launched in 2005, the country made rapid progress, with around 108,000 completely un-electrified villages connected in less than a decade.

By the year 2014 all except around 20,000 villages in remote areas were covered, and this was done quickly. This sometimes-required decentralised solutions, like solar microgrids or solar home systems. In 2017 the Saubhagya Scheme was launched, and in less than 2 years roughly 30 million households were connected, aiming at the second aspect. This was a huge achievement and has been globally recognised.



> *The next step is to provide 24X7 power supply to all connected homes and public institutions in a reliable and affordable manner.*

The task for providing electricity supply round-the-clock primarily falls on the mostly state-run Discoms. Discoms not only have to ensure that they produce/buy and supply electricity to rural areas but do it in the most efficient manner possible and recover revenues for their long-term sustainability. This is easier said than done, considering the operational inefficiencies and poor financial condition of most state electric utilities. My research shows that one of the key problems is what happens between the 11 kV feeder and the household. This is where the link breaks down from the government-built high-tension wires to the local village. What is thus required is to considerably improve the operational efficiency of the Discoms by undertaking change management capacity building programs as well as strengthening the electricity sub-stations and sub-transmission network. Discoms need to move from purely 'administration' to a mode of 'enterprisation' in decision making and management and from providing 'public service' to a 'customer-centric service' model. At the same time, electricity delivered to the rural areas must be priced rationally so Discoms find it profitable to serve.

Q3. How do the country's energy policies address the challenge of meeting increasing energy demands while reducing the number of people living in energy poverty?

India is the world's third-largest energy consuming country, thanks to rising incomes and improving standards of living. India has seen tremendous successes in its recent energy development. However, there also exists many challenges. On a per capita basis, India's energy use is less than half the world average. Despite achieving the distinction of near universal electrification as discussed earlier, the key question that continues to be relevant is, 'are the households being reliably served and serviced?'. Many researchers have shown that the near universal electrification has not translated into 24 × 7-electricity supply for most rural households and businesses. Furthermore, because of unreliability of electricity supply in many states and supply of single phase electricity, it is difficult for rural microenterprises to use electricity for productive applications. They have to go for alternative coping strategies spending additional resources, which otherwise could have helped them to save income.

In the cooking energy sector, while the government has facilitated LPG connection to almost all the underprivilege households, the adoption rate continues to be low and publicly available data shows many such households have not taken a LPG refill and continue to use firewood for meeting their cooking energy needs. The recently announced National Family Health Survey shows that every second household in Meghalaya, Bihar, West Bengal, Assam, Nagaland, Tripura and Himachal Pradesh has no access to clean fuels. Even Kerala, despite its high living standards, reported every third or fourth household not using clean fuel for cooking. One of the major barriers identified is the ability of most homes to afford a cylinder refill.

Furthermore, the socio-economic, cultural and behavioural issues in the transition to LPG have not been adequately addressed. With 80 crore people covered under Pradhan Mantri Garib Kalyan Anna Yojana and nearly three-quarters of

all rural households earning 5,000 or less, spending anything above 10 per cent of their total income on fuel will make them energy-poor. Though LPG connection has been provided freely, the refill cost is high for them. While there is no denying that all households have to be provided with cleaner fuels to reduce household air pollution, what is equally important is that government policy should be such designed that it ensures a substantial increase in rural income so that part of the added income is used to meet clean energy needs.

Q4. How will focusing on gender-energy nexus help achieve just transition towards renewable energy?

Though it is a well-established fact that electricity empowers women, what is not fully understood is the depth and level of empowerment. Based on a review of the current energy sector policies & programmes in India, my former colleagues in TERI and I found, while policies are gender-neutral and provide equal opportunities to men and women, it does not always result in equal outcomes for both men and women because of the inherent differences in baseline. Thus, most of the policies can be termed as 'gender-blind' since they do not explicitly acknowledge the differentiated need of men and women for equal outcome. One of the reasons could be that the energy policies and programmes, which form the basis for the expansion of centralised grid systems, have assumed that the benefits will trickle down and be of equal use to women and men. This is aggravated further by the absence of documented evidence on the merit of including gender elements in energy policies and programmes.

Over the last few years, we have largely only been adding renewable energy to the grid. There have been few, if any, new coal plants. The one main challenge is storage price, and by late 2020s this should also be cost effective. Renewable energy just makes good financial sense at this point of time. However, the transition to RE should have to be just and fair and gender inclusive. However, studies indicate that in India, women account for less than 10 % of the workforce in the overall energy sector and most of these jobs are non-technical. In case of renewable energy sector, as per IEA analysis, roughly 11% of the workforce are women. This is significantly less than the global average of women in the renewables sector at 32%.

Factors governing the low participation include a lack of access to opportunities for women due to safety and security concerns at different project sites, insufficient human resource policies beyond legally mandated requirements, societal norms and practices, among others. On the positive side, off-grid programmes, which also derive from the same 'gender-blind' policies, offer better anecdotal evidence of gendered outcomes and empowerment. As off-grid projects are usually designed through 'bottom-up' approaches, this enabled better participation of women and socially marginalised groups.

Considering the importance of gender equality and equity, we have to ensure that more women are increasingly engaged in the sector through sensitization and targeted training and affirmative policies.

Q5. What should be the role of government in reskilling the workers based on fossil fuel economy?

Roughly 20 million people are currently employed - formally and otherwise - in the fossil fuel and allied sectors in India and will need to be provided decent employment to prevent social and economic distress. The country thus needs a strong action plan to reskill fossil fuel sector, especially coal mine workers, in order to protect their interests while making a transition from conventional fuel to renewable energy usage. With a shift towards an ambitious decarbonised power sector in India, some studies indicate that coal-sector-based employment is expected to decline by around 50% between 2020 and 2050.

On the other hand, more than 3.2 million people can be employed in the renewable energy sector by 2050 and 1 million by 2030.

> *Reports indicate that the RE sector could employ five times more people by 2050 than what the entire Indian fossil-fuel sector employs today.*

Distributed renewables, such as mini and micro hydro, rooftop solar and biomass has the potential to create maximum employment for every MW of installed capacity.

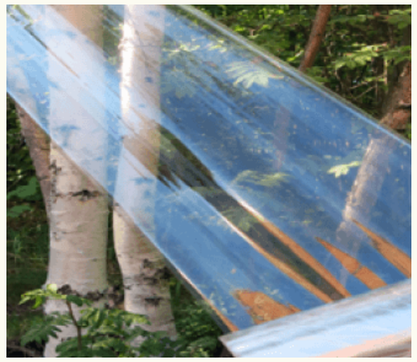
The lack of alternative economic activities to replace fossil fuel industry jobs should not be a reason for slowing down India's efforts at decarbonisation. Thus, utmost importance should be provided towards reskilling and fresh skilling to cater to the needs of the RE industry. Additionally, organizations, businesses and governments also have a social and ethical responsibility to look at how technology will impact each and every role in the workforce and identify a path to a future-proofed role.

The National Institute of Solar Energy under the Ministry of New and Renewable Energy and Skill Council for Green Jobs have been developed as training centres for RE sector. The government can consider skilling and female employment a mandatory part of new RE projects. Second, improvement in data availability concerning employment in the RE sector. More granular data on employment would help researchers and policymakers to track total employment in the sector. Policymakers could then design policies in ways that maximise job creation. Third, promoting distributed renewable energy to get the maximum benefit from the point of job prospects.

Furthermore, a more inclusive coverage of RE projects across different states in India with more support to the laggard states will also be helpful. Coal regions are mostly located in the eastern region whereas the RE projects are primarily located in the western and southern region. It is thus important to pro-actively assess the RE potential in the coal regions as deploying renewables in the coal regions can generate re-employment and ancillary economic activities in those regions. Re-skilling of the existing workforce would ensure their employability in emerging RE technologies.

Source: CEEW

KNOWLEDGE UPGRADE



Using Wood to Make Plastic?

The VTT Technical Research Centre of Finland has created an alternative that mimics the utility of plastics – a compostable multi-layer material from agricultural and forestry by-products. It can be used for making stand-up food pouches such as rice, cereal, nuts. etc. This benign alternative of wood by-products contains cellulose – a renewable polymer considered as most abundant. Fibre and plastic are at times, layered alternately. VTT's regenerated or recrystallised transparent cellulose film can be an environmentally friendly alternative as it is biobased and biodegradable. When a certain threshold of dampness is crossed, the cellulose film completely disappears in nature, just like a sheet of paper.

3D Printed Houses with Local Soil

What is currently gaining momentum for construction of housings is the use of additive manufacturing, more commonly known as 3D printing. This system has the advantage of allowing local materials like soil, clay, sand, or plant fibres to be used as raw materials. This eliminates the need for cement and can cut down by 95% on the number of materials that need to be transported, which is often one of the biggest barriers to construction particularly in developing countries and also generates greenhouse gas emissions.

Oatly debuts carbon footprint labeling in U.S.

Oatly, an oat drink company introduced carbon footprint in their products. Four of Oatly's Oatgurt products now come with climate footprint labelling in North America. The label shows the greenhouse gas emissions in kilogrammes of carbon dioxide equivalents (also known as CO2e) for each kilogramme of packaged food products. The emissions are computed using CarbonCloud, a third-party company, which combines the emissions into a numerical unit based on the quantity of greenhouse gases released and their potential to cause global warming over a 100-year period. Climate footprint labelling is one way that food and beverage brands are aiming to inform their consumers about their carbon emissions reduction goals.

CarbonCloud

India's Largest Floating Solar Power Project

The largest floating Solar Power Project of India has been fully operational at Ramagundam in Telangana since July 1, 2022.The total commercial operation of floating solar capacity in southern India increased to 217 MW as a result of the operationalization of the 100 MW solar PV project at Ramagundam with the previously existingcommercial operation of 25 MW of floating solar at Simhadri in Andhra Pradesh and 92 MW of floating solar at Kayamkulam in Kerala.

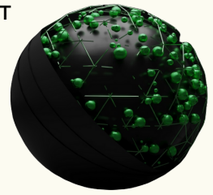
The Ramagundam Floating Solar project is equipped with cutting-edge technology and environmentally friendly features. The project covers five-hundred acres of reservoir and is divided into 40 blocks with 2.5 MW each. An array of 11,200 solar modules and one floating platform make up each block. A HT breaker, a transformer, and a single inverter make up the floating platform. On floaters made of HDPE (High Density Polyethylene), the solar modules are mounted. Special HMPE (High Modulus Polyethylene) rope is securing the entire floating system to the dead weight concrete blocks in the balancing reservoir bed.

From an environmental standpoint, the most obvious benefit is that less land is needed, particularly for associated evacuation plans. Additionally, the presence of floating solar panels reduces the rate of evaporation from water bodies, which aids in water conservation.

World's largest floating solar project is to begin in 2023 at Omkareshwar dam in the Khandwa district of Madhya Pradesh on the Narmada River with a capacity of 600 MW. In partnership with the World Bank, the project's primary feasibility study has been completed.

Company receives grants from IISc to sustainably degrade plastic

Quantumzyme, a Bangalore based biotech company that focuses on clean and green chemistry has received a grant from Indian Institute of Science, Bengaluru to produce an affordable solution in order to sustainably degrade plastic. Qzyme workbench TM is a proprietary technology that create ways to degrade plastic in a more sustainable manner. It works by creating an enzyme that 'greens' the chemical reactions for PET plastics and other industries including textiles, pharmaceuticals, flavours amx fragrances and fine chemicals and more.



Waste made from plastic have a huge impact on human health and causes severe environmental problems. Traditionally used chemical processes use high purity recovered PET that is more expensive, less readily available and have complicated procedures. Using the technology Qzyme Workbench TM aims to prepare their first prototype by the end of this year. Naveen Kulkarni, the CEO if Quantumzyme said that they would seek additional funding if required from the agency. The approximate cost of the project will be around 3.2 crores.

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