



Decoding and Simplifying Climate Change and Action through Adoption of Energy Swaraj

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1. Introduction – Climate is not changing; climate has been changed

The climate is not changing; it has already changed. Pakistan is already bearing the brunt of the climate crisis, with extensive flooding, despite having a very low carbon footprint. The same is the case with the Silicon Valley of India – Bengaluru. Typhoon Hinnamnor is expected to have life-threatening effects in South Korea and Japan. Europe is facing its worst drought in 500 years. Sixty-four districts in Uttar Pradesh have received less than normal rainfall this monsoon, with several of these districts prone to drought-like conditions. All these are consequences of climate change, which is primarily caused by human-induced activities. All the life-supporting elements of nature's ecosystem, like air, water, soil, rivers, ice caps, and forests, have been degraded to the point where restoration is seen as a distant dream.

Our energy basket comprises 80-85% of fossil fuels. Due to the burning of fossil fuels, heat-trapping gases like carbon dioxide are emitted into the atmosphere, thus making the planet unbearable to live on. Since the beginning of industrial times (in the 18th century), human activities were responsible for raising atmospheric Carbon dioxide by 50%. The current status of Carbon dioxide is 150% of its value in 1750 [1]. The planet has become hotter by 1.19 degrees centigrade, and the average global temperatures are rising. This global warming is leading

to repercussions such as rising sea levels, heat waves, cyclones, floods, droughts, and forest fires are ever-increasing, leading to negative implications for humans.

UN Secretary-General António Guterres says, *'this is code red for humanity. We must combine forces now to avert climate catastrophe.'* We have only 7-8 years before the global temperature touches the 1.5°C mark. With this paper, we bring to your climate action through the adoption of Energy Swaraj, to bring in energy independence and self-sufficiency. In this paper, the idea of Energy Swaraj and its feasibility & viability is discussed in detail.

2. Modern Humans without a Touch of Philosophy

The 21st-century human civilisations are scientifically, technologically, and economically far more advanced than their predecessors. Missions have been sent to Mars now. Medically, the advancement is such that heart replacement is now a reality. With increasing technological advancement, the world is becoming more powerful. However, one has to bring in a philosophical perspective to withhold this power. Otherwise, the world will lead to disastrous conditions. It is said by Plato, a Greek philosopher in his book *The Republic*, *"Every king should be a philosopher or only a philosopher should become a king"* [2]. A king should have the special quality of knowing his kingdom's people and being able to do justice without thinking about self-interest, and that could be done if a king thinks philosophically beyond his limits of power. History has witnessed many incidents of kingdoms leading to extinction, whose kings were greedy for power only.

However, it is unfortunate that for the urge of making life easier through technology, day by day many innovations are being done for finding the solution but this solution on other hand losing the touch with philosophy. The modern world is unaware of the aftereffects of these innovations.

For instance, everyone wants that our Gross domestic product (GDP) should grow, and our income should grow, but how much it should grow nobody knows. What could be the likely answer to the question of GDP growth? Should it grow by 5%,

7%, 9%, 10%, 15%, or 20%? No one knows the answer. Even our Prime Minister would not be able to answer it. The only answer is comparatively better GDP growth.

3. Few philosophical questions – everyone must know the answer

It's important to be philosophical. Let's have a simple question for everyone: what can be the goal of one's life, irrespective of their status in terms of education, income, and so on? It could be materialistic pleasures, individual achievements, self-actualisation, and so on.

Every individual in this world would probably like to lead a happy and contented life. This implies, on the other hand, that any development, whether the development of technology, innovations, or economic growth, should also lead to life contentment. However, if life contentment cannot be achieved through economic or technological growth then one should have to rethink the path chosen and probably change the direction of growth till one achieves the purpose of becoming happier.

In the modern world of the 21st century, to achieve better levels of economic growth, one has to pursue scientific and technological growth. But every year when the economy is growing, let's say at the rate of 5%, does it assure a similar increase in the happiness index of the country? Anecdotal evidence suggests that no, that is not happening [3].

As the GDP rises, the incidences of prosperity are found to align with a specific class and select spaces—mostly urban spaces. However, with growing prosperity, stress, tension, depression, violence, and suicide rates, which are increasing [4], are some of the vital manifestations that are on the rise, indicating ill societal mental health. The same indicates that there is something wrong in this world. This is what one must realize and understand before it is too late.

Let's have one more philosophical question: What is the most important thing in the life of a person? The typical answer one gets is that it is health, happiness,

independence, money, parents, children, job, satisfaction, position, love and so many other things. But if we return to the very basic questions of survival, a re-realisation can be experienced, for example, a simple experiment of not breathing for about a minute would help us to realize the most important thing in life! Readers may try this. It is the air or oxygen required for breathing. One cannot live without Oxygen even for a minute. But almost no one puts the air in the topmost thing, in the list of most important things in life. As our priorities are set materialistically, the importance of air and that too clean air is not set as precedence. The outcome is the ever-worsening air quality index (AQI) in many parts of the world [5]. Today, all elements on the planet that are essential for living beings are in poor condition compared to the past. For example, the air quality index is supposed to be less than 50 $\mu\text{g}/\text{m}^3$ for a good healthy life, but most Indian cities have an air quality index of 60 $\mu\text{g}/\text{m}^3$ and above [6]. During the winter season, many times Delhi's air quality index stands at 400 $\mu\text{g}/\text{m}^3$ and 500 $\mu\text{g}/\text{m}^3$. Last winter (2021), in part of the Delhi region, the air quality index reached its highest pollution level of 999 $\mu\text{g}/\text{m}^3$ [7].

According to the Air Quality Index (AQI), 92% of people live in places where air quality levels exceed World Health Organization (WHO) limits and, because of this, air pollution causes at least 4.5 million premature deaths every year [8].

Forests are considered the lungs of the planet, but around 33% of our forests have been cut down. The world lost 1.5 billion hectares of forest in 2020. This area is expected to be 1.5 times the size of the United States [9].

Soil is very important to us; one cannot produce food without it. Nature takes millions of years to obtain soil nutrients, but half of the soil has been washed away in the last hundred years, and of the remaining, 33% of it has been degraded to dust, where one cannot grow anything. According to a study, more than 90% of soils will degrade by 2050 [10].

Water is important for one's life, but two-thirds of the world's population (4 billion people) live in conditions of severe water scarcity for at least 1 month a year, and

500 million people worldwide face severe water shortages throughout the year [11].

An embarrassing thing for all of us is that we call ourselves modern humans, but we can't even guarantee clean drinking water for all human beings. According to the World Economic Forum, scientists in 2016 found that "4 billion people face water scarcity globally [12]."

A similar case can be observed with other vital natural elements like land, water, biodiversity, and so on. Nature that nurtures life, is degrading in totality.

On the one hand, there is remarkable progress in science, technology, and GDP; on the other hand, nature is deteriorating. Why should it not be considered a disaster of the present time? Or should we consider this reckless exploitation of natural resources as stupidity? There was a story from ancient India, where a person was sitting on a tree branch and cutting the very same branch. What is such a person called? A stupid, a fool.

4. Why has the world degraded? – Use of carbon-based energy

Energy is everything, and everything is energy. The entire world is a play of energy. Everything in this world happens due to energy. One can define two types of energy for humans: (a) Internal energy that drives the human body and (b) External energy that drives all the machines made for human comfort.

All the social and economic parameters of growth are related to energy. The United Nations has come up with 17 Sustainable Development Goals (SDGs) [13]. Each of the SDGs has a connection with the use of energy, be it related to health, education, inequity, sustainable consumption, industrialization, climate change, or even global peace and partnership, which has something to do with energy. In short, everything around us is affected by energy.

Energy is, therefore, a very important driver of our modern life, and it therefore, has to be used with proper care. Unfortunately, these drivers have been misused to lead to complex geopolitical situations and vulnerabilities with the complete reliance of the entire world economy on fossil fuel-based energy sources since the industrial revolution.

Before 1850, humanity survived entirely on renewable energy sources like wind, hydro, solar, and biomass. After 1850, the use of coal became predominant. In 1900, the use of crude oil started, and after 50 years, in 1950, natural gas got added to the fuel basket. And, beyond 1950, energy consumption has almost grown exponentially (Global energy consumption). Now in 2022, many sources of energy are being used. Human lives are fulfilling their energy needs from biomass, coal, oil, gas, solar, wind, hydro, and nuclear [14].

But most of the energy, despite the growth of renewable energy technologies, comes from fossil fuels. Even today, on average, 80–85% of the energy consumed in the world comes from carbon-based fuels, mainly coal, oil, and gas [16].

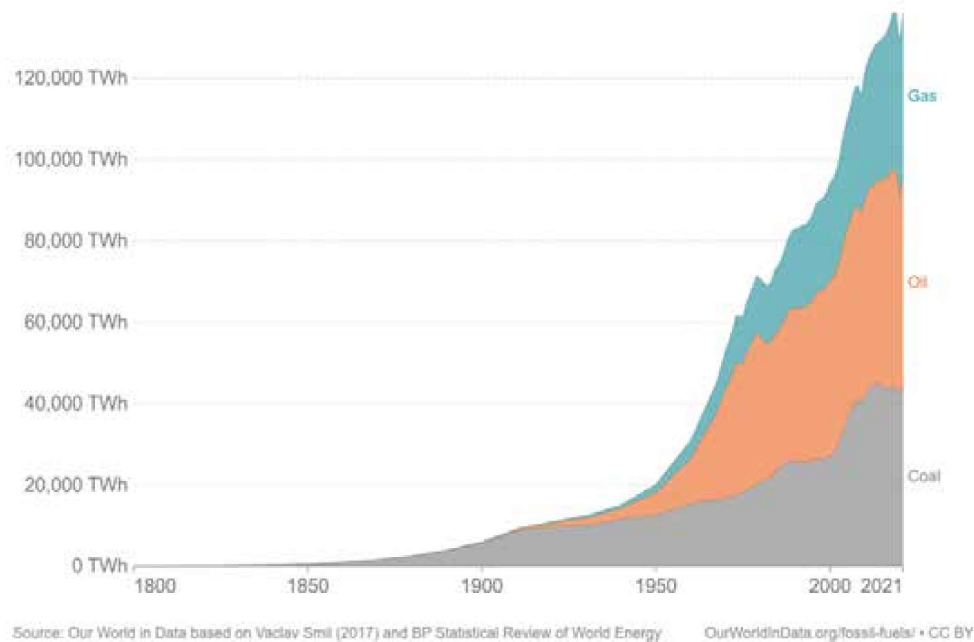


Fig.1 Global fossil fuel consumption (measured in TWh–terawatt-hours)

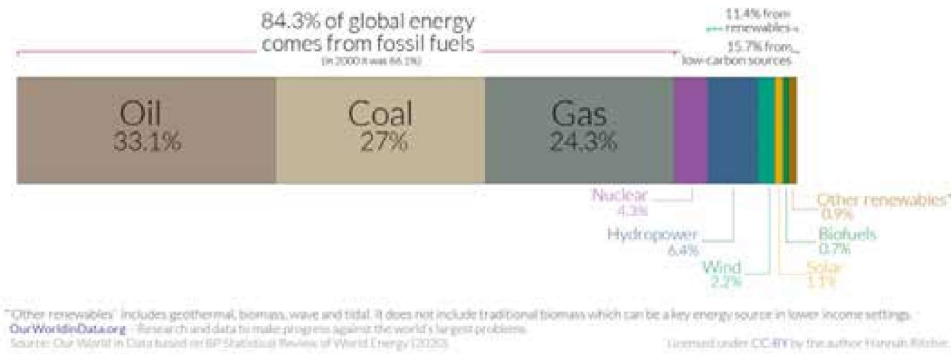


Fig.2 Global primary energy consumption by source 2019

There are many problems associated with the use of fossil fuels. Many countries do not have these resources and need to import them from other countries. Over 150 countries are dependent on the import of these carbon fuels [17]. The same complicates geopolitical conditions, significantly escalating various conflicts. For example, a populous country like India depends on energy imports from other countries. India just does not have enough of these fuels. India imports approximately 80–85% of its crude oil, 50–60% of its natural gas, and 20–30% of its coal. India also imports hydroelectricity. [18] The same is true for many other countries in the world. For importing fossil fuels, the countries need foreign exchange, and for that, they need to export, which requires the sale of services or goods, which in turn requires energy. This implies that the world is trapped in a self-created vicious cycle of energy.

The recent incident in Sri Lanka provides an example of such a vicious cycle. Sri Lanka ran short of foreign exchange and was not able to import sufficient fossil fuels. As a result, the whole supply chain, like the food supply, was disrupted. [20] People had money, but they did not have food due to disrupted food supply chains. Even Europe is feeling the heat of the war between Ukraine and Russia. European countries have been asking their citizens to cut down on energy consumption [21].

Any country that is dependent on other countries for the import of fuel can never become a strong country. In this modern world, where countries are armed with weapons of mass destruction, interdependence cannot lead to global peace

and partnership. Such a global arrangement is against the UN general assembly resolutions of 2015 (Doc. A/RES/70/1), titled “Transforming our world: the 2030 Agenda for Sustainable Development”, which clearly articulates a focus on People, Planet, Prosperity, Peace, and Partnerships [22].

The availability of carbon-based fuel is not the main problem. These three fuels, that is, coal, oil, and gas are made out of carbon. Whenever we use these fuels and burn them, it results in the following equation: CO₂.



The use of energy from carbon-based fossil fuels releases carbon dioxide (CO₂) into the atmosphere. Every human being, rich or poor, from developing countries or developed countries, uses carbon-based energy, and therefore each one is responsible for carbon dioxide emissions. Almost every second on this planet, carbon dioxide is released into the atmosphere.

Most people, as users of energy, have never realised that they are directly or indirectly responsible for carbon dioxide emissions. However, it is easy to understand that the use of fans, lights, cooking food, and vehicles all run on carbon-based fuels and therefore result in carbon dioxide emissions. But it is difficult to comprehend how indirectly, the use of materials is contributing to carbon dioxide emissions.

For example, brushing one's teeth is a simple activity. For this, one needs toothpaste, which has to be manufactured in some factory. Many electrical machines are used to manufacture toothpaste, which in turn needs energy. To pack Toothpaste in a nice package, one needs to manufacture the packing material, which also takes energy. Then, there is a need to transport the toothpaste from the manufacturing place to shops, which takes energy. The storing of toothpaste in the shops, before it is purchased, also requires some energy. Therefore, from manufacturing toothpaste to its final use, many steps that require energy.

For brushing teeth, one also needs toothbrushes. Again, one needs energy for manufacturing, packaging, transporting, and storing the toothbrush. Similarly, one needs water for brushing our teeth. That will in turn need pipes, motors, and overhead tanks. All these require energy, right from mining the raw materials to getting them into the finished shape. That's not enough, one also needs a wash basin and mirror. Again, these materials take energy from manufacturing and transportation to the final use. And, also, we need electricity to run the light and motor.

This is how a task as simple as brushing teeth, requires so much energy. One can imagine the amount of energy each individual is using throughout the day to perform day-to-day activities. In the modern world of the 21st century, each act results in the emission of carbon dioxide.

5. Carbon Dioxide – the Culprit

The atmosphere has finite limits for holding carbon dioxide. But so far humans have not set any limit for the emission of Carbon dioxide. As a result, the concentration of Carbon dioxide has increased by 50% as compared to the pre-industrial era.

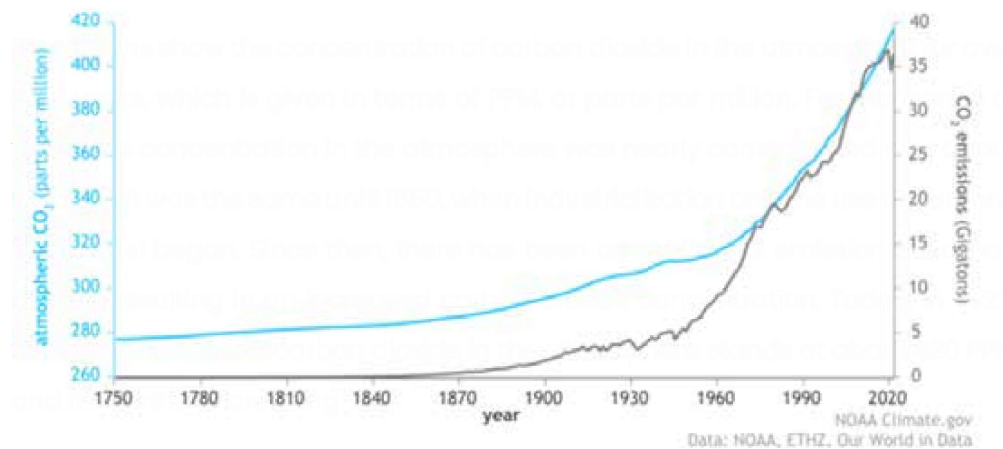


Fig. 3 Atmospheric carbon dioxide amounts and annual emission (1750–2021)

Carbon dioxide is a greenhouse gas. It is a colorless and odorless gas. It contributes to the greenhouse effect, trapping heat and keeping the planet warm.

Since Carbon dioxide concentration has increased by 50% in the atmosphere, substantially more heat-being trapped, which is warming up our planet. This phenomenon is referred to as global warming. It is not that carbon dioxide alone is causing global warming. Other gases like methane (CH₄), nitrous oxide (NO), and water vapor also contribute to the greenhouse effect. However, the amount of carbon dioxide emitted in the atmosphere is very high as compared to others and is hence considered a main greenhouse gas.

The more serious problem with carbon dioxide is that it has a very long life in the atmosphere before it gets reabsorbed.

Once emitted, carbon dioxide has an average lifespan of 300 years [24]. Some amount of carbon dioxide gets absorbed in a short span of 40 to 60 years, while other amounts take up to 1000 years to get absorbed, but on average, it has a lifetime of 300 years. It means that the act of using carbon-based energy and emitting carbon dioxide into the atmosphere today will have its effect for nearly 300 years. Today's use of energy for comfort will cause discomfort for nearly 300 years, as it is going to cause global warming for a long time.

6. Global warming and climate change

The climate is not changing, it has already changed. The temperature of the entire planet is rising. The rising temperature is resulting in a change in the climate. Modern human day-to-day activities have resulted in carbon dioxide emissions and have caused climate change for the entire planet. Today, the planet is, on average, warmer by 1.19 degrees Celsius, or about 2.14 degrees Fahrenheit, as compared to the pre-industrial era [25]. Such a small increase in temperature has changed the balance of climate in a significant manner.

Normally, the human body temperature remains between 97 and 98°F, and when it increases by 2°F, it becomes 100°F. At 100°F, the body gets into the condition of fever. When the temperature of the planet increases by 2.14 °F, can it be said that the planet has a fever?

When one gets a fever, medicine like paracetamol is taken to bring the temperature down. Is there any paracetamol that one can use on our planet?

When one gets a fever, they lose balance and cannot study properly or work, sleep or eat properly. When the planet has a fever, how can it work properly? As a result, there are all sorts of erratic weather patterns being observed all over the world. There are floods, but also draughts. There are heat waves but cold waves. There are forest fires, glacier melting, sea level rise, and so on.

In recent times there were floods in Pakistan, Australia, Western Europe, China, Japan, Brazil and, India [26]. There were forest fires in Amazon, USA, Australia, Greece, Italy, Turkey, the UK, and Russia [27].

Sea level is rising all over the world and is already responsible for the displacement of millions of people. The rate at which the sea level is rising is 3.3 millimeters per year [28].

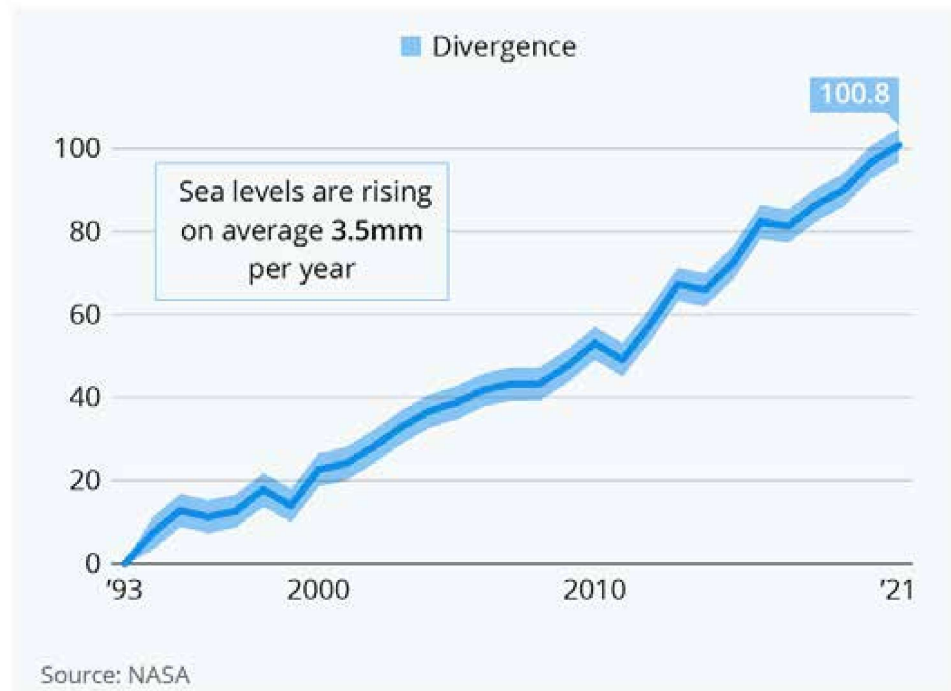


Figure 4: Rising sea levels (1993–2021)

Jakarta, Indonesia's capital, is considered the world's fastest-sinking city [29]. The Indonesian government is spending \$30 billion to shift the entire city somewhere else. If they spent half the amount on renewable energy, the intensity of the problem could be considerably less.

In India, four cities- Mumbai, Chennai, Cochin, and Visakhapatnam will be significantly submerged in water by 2050 [30].

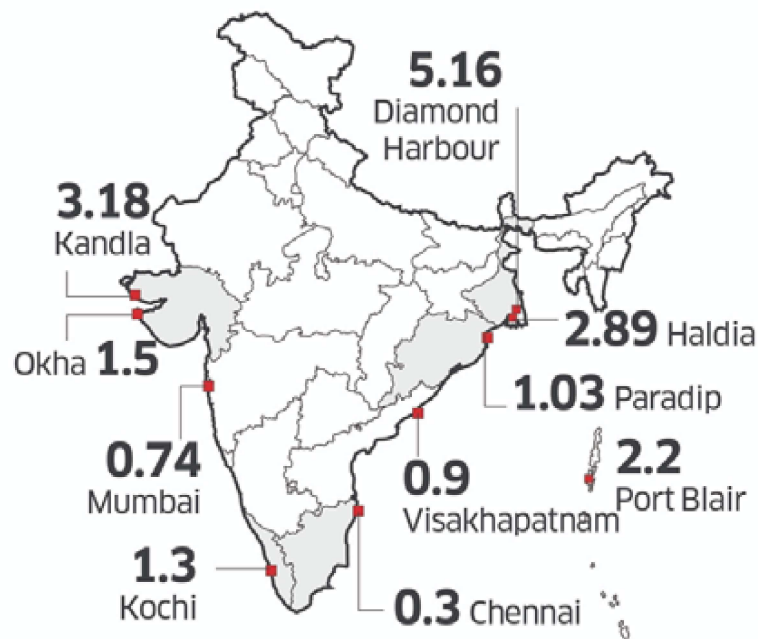


Fig.5 Annual sea-level rise at various Indian ports (mm/year)
Mumbai, Kolkata, Surat, Chennai are 4 cities in danger
Source: deccanherald.com

In Canada, the temperature in the city of Lytton was 49.60C. This is why more than 900 people died from the heat wave [31].

All these erratic activities are signs of an ill balance in the planetary system. Millions of people are affected by climate change. Already, the world is losing billions of dollars due to the impact of climate change. The question is: what comes next? What is going to happen 5 years down the line, 10 years down the line, or 20, 30, or 50 years down the line? Will humans be able to do something to mitigate climate change?

According to the report of the IPCC-2018 (Intergovernmental Panel on Climate Change), to save the climate one has to limit global warming to ideally 1.50C or a maximum of 20C [32].

Climate change would be irreversible if the 1.50C limit was exceeded. Therefore, corrective action should be taken to limit global warming to not more than 1.5 0C.

The second problem is that we have very limited time to limit climate change. It depends on the carbon budget. There is a central linear relationship between the amount of carbon dioxide in the atmosphere and the amount of global warming.

According to reports, the amount of Carbon dioxide that can be emitted is 270 billion tons (to reach 1.5oC) and 1050 billion tons (to reach 2oC) [33].

That's a very large number, but the rate at which carbon dioxide is emitted into the atmosphere is 1,332,000 kg per second. That's a huge number, and if one takes that number and divides it with the carbon budget, the time remaining is 7 years and 43 days from the 9th of June 2022 [34].

7. Drastic and immediate actions are required

The climate clock is ticking faster than ever and hence one needs to take stronger action for climate correction than ever. As per the IPCC (Intergovernmental Panel on Climate Change), one needs to make 'drastic' and 'immediate' changes in the energy use pattern. The words 'drastic' and 'immediate' characterize the nature of the action that one needs to take. These words are qualifying criteria for actions toward climate correction. One has to judge the actions that have been taken to solve the problem of climate change based on the above two criteria.

Does onetruly understand 'drastic' and 'immediate' changes in energy use patterns? Are humans taking enough action?

Starting with the Kyoto Protocol of 1998 and the Paris Agreement of 2015, COP meetings are conducted every year to make international agreements to act upon to reduce carbon emissions. As a part of the Paris Agreement, more than 180 countries have signed to reduce their carbon emissions to nearly 50 % by 2030. But is this really happening? The answer is: No. Rather than decreasing, carbon emissions are increasing every year at about a rate of 1.7% [35].

There are thousands of organizations and NGOs working and advocating for a solution to climate change. But the fact remains that, rather than slowing down, climate change is accelerating. Current disastrous events all across the world are examples of it.

The reason we are not making a radical and immediate change is that humanity at large is looking for growth, and the growth is fuelled by energy. Today about 80 to 85% of the world's energy requirements are being fulfilled using carbon-based fuels, which is resulting in Carbon dioxide emissions, further accelerating climate change.

What a contradiction! Modern life is full of contradictions, on the one hand, it is said that climate mitigation is our goal, and on the other, growth becomes the priority for everyone even though it would accelerate erratic climate conditions.

In short, climate change, a global rise in temperature, and changes in weather patterns show that the survivability of human life on this planet is becoming difficult. The Dalai Lama mentioned about a year and a half ago: "More and more people realize that the existence of humanity is at stake, simply doing prayer, pranayama and meditation will not be enough. One must have to take action." [36]

As a result, ensuring growth without negatively impacting the environment is a trillion-dollar challenge. And, anyone who finds a solution to this should get, not one but many Noble prizes.

8. Switching on 100% Solar Energy – not 99%

What could be the solution to climate change? To treat cancer, we need to remove the cancerous cells from our bodies. Similarly, to solve the problem of climate change, one needs to remove its root cause, which is the emission of carbon dioxide and other greenhouse gases. For doing so, one has to switch to some alternative form of energy from fossil fuels. It must be available in abundance, and its use must not cause environmental damage. For obvious reasons, solar energy solutions or in general renewable energy solutions fall into this category. Biomass, wind, and hydro energy are derived from solar energy and hence can be considered solar energy solutions. In the rest of this article, we will refer to clean energy solutions as solar energy solutions.

Not only is there a need to switch to solar energy, but it also needs to follow the two qualifying conditions 'drastic' and 'immediate' as per the IPCC recommendations for energy usage patterns. It can be explained like this: If most people switch to solar energy completely i.e., 100%, then it will be a drastic change and if all switch to solar energy right now, then it will be an immediate change.

Therefore, switching to 100% solar energy immediately could be the way out. Considering the severity of climate change, and its acceleration in recent times, and the paucity of time available for climate correction, there can be no other way to tackle this problem. Switching to solar energy at 100% is the need of the hour and the only way to mitigate, rethink, and redesign our energy generation, distribution, and consumption patterns.

9. Careful use of solar energy following fundamental laws

Nature puts limits on everything that it does. Every living being on the planet has a finite dimension, nothing is infinite. From the above argument, one can say that though one needs to switch to solar energy, blindly generating unlimited amounts of solar energy would be a violation of nature.

It is very important that before planning to use solar energy in a massive amount, one must be careful about energy harnessing. One must follow some fundamental laws to live on this planet. Based on our understanding of nature, people, and economics, two fundamental laws, called the Solanki's fundamental laws of human existence, have been induced.

These laws are as follows:

Solanki's fundamental Fundamental Law of Sustainability 1: "In an ecosystem of finite resources, there must be finite consumption."

Solanki's fundamental Fundamental Law of Sustainability 2: "In an ecosystem of finite resources, there must be distributed production."

These laws are fundamental and were conceived by the author himself. These laws are essential, like gravity or Newton's law, and fundamental laws apply to every human, irrespective of their understanding or desire to follow these laws.

10. Understanding the Solanki's fundamental laws of human existence or laws of sustainability

The first fundamental law of existence, in nutshell, can be written down as 'limiting our consumption'. Why should one limit energy consumption? Because the Earth is a biological ecosystem with finite resources, our consumption should also be finite. Mahatma Gandhi has put this in beautiful words. He said, "There is only enough in the world for everyone's need not for anyone's greed" (open citation). The concept of Earth Overshoot Day clearly explains this. Earth Overshoot Day is supposed to come on Dec. 31st of every year to be sustainable living on this planet. However, the Earth Overshoot Day in 2022 occurred on July 28 [37]. It means that all the resources humans are going to consume from 29th July till 31st December will be the ones that are being stolen from future generations.

The second Solanki's fundamental law of existence, in nutshell, can be written down as 'localizing our production'. Why should one localize the production?

Centralisation requires huge energy to distribute and redistribute. In this, Mahatma Gandhi said, “Not the mass-production, one needs production by masses.” (Open citation). Production by masses or localized production would result in localized wealth generation, and possibly more equal and just distribution of resources.

The two fundamental laws of ‘Limiting consumption’ and ‘Localizing production’ are essential for the survival of human beings. These regulations must be remembered and followed in all forms of consumption. The immense reliance on technological advancement cannot help humans to become sustainable unless one follows the two laws of limiting consumption and localising production.

11. Idea and benefits of Energy Swaraj

Limiting energy consumption in the first place by avoiding wasteful use of energy and then generating remaining energy needs locally is the core of energy independence. This is referred to as Energy Swaraj or energy self-rule. Locally generating and fulfilling energy needs refers to making use of local energy sources. Renewable energy sources are available everywhere. Therefore, Energy Swaraj means using local renewable energy resources. When humans entirely depend on local energy sources for fulfilling local energy needs then one is likely to have to depend on local people in the process of generation, supply, and maintenance of localised energy systems. In this way, one can also interpret Energy Swaraj as Energy by Locals for Locals using local energy resources.

Energy Swaraj can also be interpreted as energy independence. In the world, most countries have to depend on energy imports from a few countries. This also requires foreign exchange, the availability of which due to varying national and geo-political conditions may get affected. Such dependence makes the whole economy of a country very fragile and dependent on external factors, which are always fully not in control. Therefore, Energy Swaraj, or localized energy independence, will strengthen the energy independence of a country, a desirable and achievable feature in the modern world.

With the advancement of renewable energy technologies, particularly solar energy technologies, in the last decade, not only has the performance of these technologies improved but the cost per unit of generating electricity has also become competitive with fossil fuels. This makes the adoption of Energy Swaraj both technologically and economically viable.

The world, which is driven by about 80–85% carbon-based fuel and is controlled by only a handful of countries, causes geo-political stresses among the country. Having energy self-rule could be a powerful and desirable aspect for every country. The decision to adopt Energy Swaraj will be beyond economic considerations. In today's world, which is affected by catastrophic and accelerating climate change, the decision to adopt Energy Swaraj is practical, sustainable, and survival-oriented.

Other than fulfilling our energy needs locally, the adoption of Energy Swaraj could provide several other benefits, which include:

- Skill development in each area towards installation and maintenance of renewable energy or solar energy systems,
- Creation of jobs in the local area as installation and maintenance will be done most efficiently by local people,
- Local jobs will result in the circulation of money in local geographical regions which will strengthen the local economy,
- Adoption of Energy Swaraj locally will make people energy independent which will also help the country to become energy independent, or energy secure,
- A country having less dependency on energy imports will also save foreign exchange, enhancing its strength,
- Above all, energy independency also means saving on carbon emissions and contributing greatly to climate change mitigation.

12. Avoid–Minimize–Generate (AMG) approach to switch to 100% solar power

Considering the acceleration of climate change and the fact that the time left as per the climate clock is short, one needs to switch to solar energy drastically and immediately. But, generating and consuming as much energy as one wishes to, even with the help of solar energy or renewable energy, cannot be sustainable. One must follow certain norms. The two fundamental laws of existence clearly state that: to learn to 'limit consumption' and then 'localize production'.

Following the fundamental laws of existence, a three-step approach called Avoid–Minimize–Generate, or AMG approach, is proposed to switch to 100% solar power in the most sustainable way possible.

• Step-1: Avoid the use of energy by 1/3rd

Avoid the use of energy as much as possible, even if it is solar energy.

Why is there a need to avoid the use of energy, even if it is solar energy? For the simple reason that there is no manufacturing technology in the world, which does not have any side effects on the environment. Even the manufacturing of solar panels has an environmental impact, however, one that is less than coal-based energy, but not zero.

For instance, to make solar panels based on silicon, one has to make silicon crystal, then a silicon wafer, using which a solar cell is made. Manufacturing a solar module requires glass, an aluminium frame, and polymer sheets. Then to erect a structure to mount solar panels one requires galvanized iron. To process the power generated using solar panels or carry the power, one needs cables and power electronics. To store energy, one needs batteries. At the end of its useful life, recycling all the materials are required for which further energy is needed. This, in turn, causes further environmental damage.

Therefore, avoiding or not using any energy as much as possible, is the best option one can opt for the mitigation of climate change. Particularly, the wasteful

(using energy when not required) and overuse (using more energy e.g., lights than required) of energy can be avoided. As a personal observation during my travel across the country, I could see that there is tremendous wastage of energy.

Following are some examples of how one can avoid the use of energy when feasible:

- Not using the lights during the day time, using only natural sunlight
- Not ironing clothes
- Not taking bath in hot water
- Eating more fruits, sprouts, and uncooked food
- Not using the vehicle for short-distance travel
- Not using air-conditioning in favourable season
- Not buying new materials, clothes
- Consuming less of everything, any consumption requires energy
- etc.

People, institutions, and corporations can create their own lists of what they will avoid based on their own work environment, lifestyle, and comfort. A third of all energy consumption can be avoided.

One very powerful and simple reason why one should avoid the use of energy is to avoid the emission of carbon dioxide. In India, about 75% of electricity generated comes from coal.[38] One unit of electricity generated and consumed causes about 1kg of carbon dioxide emission and this carbon dioxide once emitted remains in the atmosphere for an **average of 300 years**, contributing to global warming for that many years.[39]

From this perspective, many avoidable things have become part of normal life in this modern world, like the use of refrigerators, geysers, air conditioners, etc. These are highly energy-consuming devices. One day of use of a refrigerator requires about 1 unit of electricity, taking one good bath with hot water requires about 1 unit of electricity, and using air conditioner for 1 hour requires 1 unit of electricity.

Our comfort or convenience of using a refrigerator for one day, taking one good bath with hot water, and sitting in an air-conditioned room for one hour is going to be uncomfortable for someone for 300 years. 300 years is approximately 10 generations of human life. It means that one's actions today will have an impact on future generations, including one's children, grandchildren, and great-grandchildren. Does it sound like a disaster or stupidity? The purpose of the 11-year-long **Energy Swaraj Yatra** is to bring this awareness to the masses so that they can make appropriate modifications to their lifestyles.

In my house at IIT Bombay, there is no refrigerator, no geyser, no air conditioning, and no microwave. Not to say that I am poor, I am a professor at IIT Bombay. I can pay for everything, but it's better to avoid the use of energy if it is avoidable. Except for some inconveniences here and there, mostly we live happily without these gadgets. Our monthly electricity consumption ranges between 60 and 100 units on average.

• **Step 2: Minimize the use of energy by 1/3rd**

Minimize the use of energy, as much as possible, using efficient appliances

Minimizing electricity use refers to reducing the use of electricity for a given operation using efficient appliances. Thus, in this step, to reduce electricity consumption one should replace less efficient appliances with more efficient appliances. For example, using an LED bulb or tube light reduces electricity consumption by almost 2.5 to 3 times compared to fluorescent lights. This requires the replacement of normal loads with efficient loads. For every gadget that uses electricity, there are efficient alternatives available in the market. With efficient appliances, electricity consumption can be reduced by 20 to even 50 percent.

The use of efficient lighting devices can help us reduce electricity consumption. LEDs are more efficient devices than fluorescent lights (tube lights and CFLs). A typical commercial CFL gives about 50–60 lumens per Watt, while a commercial LED bulb will provide about 110–120 lumens per Watt. It means that for the same light output, one needs only half the electricity while using LEDs. A 10 Watt LED would give light output equivalent to a 20 Watt CFL. Similarly, when replacing

ordinary tube lights with energy-efficient LED tube lights, one can save 50% of the electricity, which also means 50% carbon dioxide emissions.

The use of efficient motors in motor-based appliances can help us in saving electricity. The appliances which usually run on induction motors such as fans, water pumps, compressor pumps, etc., are available in more efficient alternatives, where the induction motor is replaced with a DC motor. For example, the induction motor-based fan (table fan or ceiling fan) can now be replaced with the energy-efficient BLDC (brushless DC) motor-based fans that have advanced speed control systems. Using energy-efficient BLDC fans, one can reduce electricity consumption by at least 50% for a ceiling fan. Typically, there are many fans on any academic campus, and replacing old fans with new, efficient fans can significantly help in the reduction of electricity consumption. A comparison of the electricity-saving potential of using BLDC fans instead of a normal AC fan is given in the table below.

Table-1 Comparison of electricity saving potential of using BLDC fans

Appliances	AC Ceiling Fan	BLDC Ceiling Fan
Power Wattage (Watts W)	75	28
Usage (hr)	10	10
Energy Consumption (Wh)	750	280

Nowadays, air coolers are also one of the popular appliances used in the summer as a low-cost alternative to air conditioners. It works on the principle of evaporative cooling of water, mainly consisting of a fan and a small water pump as energy-consuming equipment.

Similarly, in the case of refrigerators and air conditioners, one can prefer to use the appliances with higher star ratings, as defined by the BEE (Bureau of Energy Efficiency), Government of India. For example, the energy savings of a 5-star rated 190-liter refrigerator are 59% compared to a 1-star rated appliance. Similarly, a 1.5-ton, 5-star rated air conditioner saves about 23% of the electricity compared to a 1-star rated appliance. The new inverter AC technology helps reduce electricity consumption by about 30 to 35% compared to normal AC. Nowadays,

advanced energy-efficient DC compressor pumps are also available, thus one can use energy-efficient refrigerators or air conditioners that directly run-on DC power (i.e., solar) and save energy.

• **Step-3: Generate only 1/3rd**

Generate energy locally as little energy as possible after following avoid and minimize step

Once the energy consumption is avoided (hopefully, by 1/3) and minimized (hopefully by another 1/3rd), then the remaining electricity (the 1/3) can be easily generated using the solar system without needing significant investment.

The AMG, or 1/3rd-1/3rd-1/3rd approach, is just a guideline, and adoption of it depends on the climatic situation, building design, the sensitivity of building users, etc. In this way, the percentage number of each step 1 to step 3 can vary. It is obvious that the more steps one avoids and minimizes in step 2, the less steps one has to generate in step 3.

After following the 'Avoid' and 'Minimize' steps, the 'Generation' step can be taken, wherein one can design and install a solar system to fulfill remaining energy needs. Designing a solar system and figuring out panel size and battery size for fulfilling the energy requirements, 24x7 for 12 months a year is simple, and everyone can do it themselves.

In designing a solar PV system with battery backup for given electricity needs, the following questions are to be answered:

- How much area is required?
- What would be the capacity of PV modules?
- How is much battery backup required?
- How much would it cost?

Thumbs rules can be used to figure out the approximate answers to the above questions; however, exact design and costing may vary by 10 to 20% depending on the needs and constraints of a given institution.

The design starts with a requirement of estimated electricity to be generated per day after applying Avoid and Minimize steps. Let us take an example of an academic campus, which wants to run its full operation on solar energy. It is assumed that if the campus's electricity consumption were 10,000 units monthly at the start of the exercise, the electricity requirements would come down to only about 3500 units (the best case) to 5000 units (the good case) or 6000 units (the average case) monthly after applying the Avoid and Minimize steps.

Let's consider the best-case scenario of 3500 units requirement per month.

Area requirement: The rooftop area requirement in square feet is one-to-one with monthly electricity unit requirements. It means that if one has to generate 3500 units per month using a solar PV system, one will need 3500 square feet of area on the roof. If one has to generate 4000 units per month, then one will need 4000 square feet of area. Simple!

PV module requirement: The capacity of the PV module required to generate in Watts is one to ten times the number of monthly units required.. It means that for 3500 units of electricity per month, one has to install 35000 Watt of PV modules or 35 kW of PV modules. For 4000 units per month of electricity generation, one will need to install 40000 Watt or 40 kW, of PV modules.

Battery requirement: the capacity of the battery required for academic campuses that run mainly during day time is one is to one with daily electricity requirements considering the use of lead-acid batteries. It means that if 3500 units are the campus's monthly requirement, daily requirements would be about 120 units. Therefore, the battery needs to store 120 units of electricity. This is considering using lead-acid batteries (if we use Li-based batteries, we only need 60 units of storage). This battery backup would ensure that the campus can run on full loads for 4 hours when sunshine is not there (which is assumed to be

not the case for academic campuses running during the daytime). This battery backup would also take all night loads of street lights, security cameras, etc.

Cost estimation: the estimated cost of the entire solar system (in lakhs) with battery back-up for academic institutions is one is to 0.7 with solar power capacity in kW. When we need 3500 units per month, we need 35 kW of solar panels. Therefore, the entire system's cost, including everything, would be 0.7 of 35 in lakhs, that is 0.7×35 or 24.5 or approximately 25 lakhs.

In this way, by following the AMG approach people, institutions and countries can adapt to Energy Swaraj in a very cost-effective and sustainable manner. If one doesn't follow the AMG approach, one has to say OMG (Oh My God), solar energy is expensive, solar energy takes up a lot of space, and government policies and support are not enough.

Energy Swaraj is energy independence. In the modern world suffering from climate change and energy stress caused by the interdependence of nations on energy, the adoption of Energy Swaraj would be a powerful tool for making a sustainable world. It's not a powerful tool for a single individual, institution, state, or country but for the whole world, be it America, Japan, or Africa. It is in the interest of society and humanity to become energy independent.

13. Need for a public movement

We're running out of time and as IPCC suggests we need 'drastic' and 'immediate' actions. Be it the Kyoto protocol or Paris agreement or COP meetings, it is proven without any doubt that global efforts are not proving to be enough in mitigating climate change. Climate change is worsening with every passing year. The national governments are elected for a short 4 or 5-year term. Within this period, governments are occupied with many domestic issues and do not have enough bandwidth and time to properly estimate and take actions toward climate change mitigation. Even if governments wish to act, most governments, including the most powerful and economically prosperous, will lack the financial resources to

do so. Therefore, due to time and resource constraints, it is abundantly clear that government actions will not be enough to mitigate climate change. Therefore, relying on government policies, programs, projects or subsidies is not prudent.

In this context, every person must take part in climate corrective actions. Every person must abide by two fundamental laws of human existence. Every person must adopt the AMG approach sooner than later and switch and run their lives 100% on solar energy or renewable energy. This is possible only when climate corrective actions take the form of a public movement and everyone understands their responsibility and takes action towards climate change mitigation. The Energy Swaraj Yatra has been initiated with the objective of creating a public movement by bringing awareness among the masses and encouraging them to take action.

If action is not taken now, it is estimated that by the end of this century (IPCC report), that is to say in 78 years, the global temperature will reach a minimum of 30C and up to 60C. Currently, the global temperature rise is about 1.10C above compared to pre-industrial levels. The current level of global warming itself is causing tremendous damage. We are observing the ravages of nature's wrath and imagining what will happen if the temperature increases by 3 to 60C. There is a big question mark as to whether or not human life can survive on the planet, and for those who will survive, how many and in what form will they live on this planet.

Before it's too late, let's start taking action; if not, we say that once upon a time there were dinosaurs on the planet, they are no longer there, they have disappeared due to climate change. If we don't take appropriate actions, some three, four, or five thousand years later, a new species will appear on the planet, and they will say that once upon a time there were humans on the planet. It is not an exaggeration. Our experience, data, and facts suggest that we are heading in this direction. Therefore, before it's too late, let's start taking action.

Let us start a public movement to reduce our resource consumption, meet our needs with local resources, and run our lives entirely on clean, long-lasting energy sources.

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