Kirit Shelat
Odemari Mbuya
Suresh Acharya *Editors*

ATMANIRBHAR BHARAT - Energy Security

Roadmap 2022-47

Published by

National Council for Climate Change,
Sustainable Development and Public Leadership
(NCCSD)
Ahmedabad

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Dedicated to

Shri Kantisen Shroff

Veteran NGO

3rd January, 1923 – 13th May, 2021

An inspiring visonary and missionary for makng our country Atmanirbhar in all walks of life through participative endeavors.

डॉ. पी. के. मिश्र
प्रधान मंत्री के प्रधान सचिव
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Principal Secretary to Prime Minister

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FOREWORD

Energy is the back-bone of our economy since it powers the day-to-day life of each one of us. Energy is required for cooking, for mobility and at workplace. Farmers require energy and so do industries. India consumed 929 Mtoe (Million Tonnes of Oil Equivalent) of energy in 2019 and was the 3rd largest energy consumer in the world. Our energy demand is increasing rapidly. With per capita energy consumption at one-third the world average, our energy consumption will only increase with the pace of development.

India is at the cusp of accelerated economic growth. Affordable energy will play a key role. If energy becomes unaffordable due to adverse geo-political situation and other factors, economic growth of the country gets impacted. No country is immune to the pressure of energy prices. The European countries (EU) are presently battling a price increase. In July 2022, the high energy prices prevailing in Europe (on account of the Russia-Ukraine war) have forced EU to reduce the EU growth forecast for 2022 by 1.3 percentage points to 2.7 per cent. The importance of affordable energy for economic growth cannot therefore be overemphasized.

Our Prime Minister's vision for making India a developed country pivots around the three pillars of self-reliance in energy, energy equity and a decisive move towards green sources of energy. I am happy to see that the present volume has contributions on each of these aspects.

India imports a significant part of its energy requirement. Prime Minister emphasizes on reducing energy imports. We have achieved 10 per cent ethanol blending in petrol, five months ahead of the November 2022 target, enhancing India's energy security and reducing crude oil import of more than 5.5 billion dollars. Initiation of gas marketing reforms, deregulating the sale of domestically produced crude oil and change in contracting regimes aim at a lighter touch in regulation. Blending of ethanol (produced from a variety of feedstocks) in petrol is also a step in that direction.

Energy equity is being furthered by focusing on access to energy and finding greener derivatives from coal. The PM Ujjwala Yojana, SAUBHAGYA, and City Gas Distribution have expanded the access through widening the scope of energy availability with reducing India's carbon footprint by moving to relatively cleaner sources of energy. Budget 2022-23 has announced measures for coal-gasification as well. The development of clean coal technologies is an appropriate means to greening coal-driven energy production. The challenge for policy-makers and energy specialists is to tap diverse sources of energy, balancing the concerns of both climate change and equity.

A clear policy goal has been set at CoP-26 in November 2021. It targets achieving a Net Zero Economy by 2070. Our aim is to achieve 50 per cent of installed electricity capacity from non-fossil fuel sources, and reduce the emission intensity of the GDP by 45 per cent of its 2005 levels by 2030. We are firmly on this path. Our commitment to reach 40 per cent of installed electricity generation capacity from non-fossil-fuel based sources has been achieved, nine years ahead of schedule. About 370 million LED bulbs have been distributed in the last few years. This has contributed to energy saving of about 50 billion units of electricity per year.

To complement the above supply-side interventions, PM introduced Lifestyle for Environment (LiFE) in CoP-26. The LiFE Campaign is being transformed into a 5-year mission-mode programme. Mission LIFE is an India-led global mass movement (janandolan) that will nudge individual and collective action to protect and preserve the environment. It builds on values of moderation, mindful and optimal consumption, and harmonious coexistence with nature.

This book tries to weave in these multiple facets of India's energy scene has contributions from energy sector scholars and practitioners and is very timely considering the present global context. Practitioners, such asVK Saraswat, Anil Kakodkar, Kirit N. Shelat, Kirit Parikh, Ranjan Mathai and academics such as Prof. Mukul Asher, Odemari S. Mbuya have made contributions. I am confident that the book would prove useful to students, researchers and policy analysts.

I congratulate NCCSD - India, for orgranizing series of Inter-action meets and also to the editors – Sarvsri Dr. Kirit Shelat, Prof. Odemari Mbuya and Dr. Suresh Acharya for editing this very useful book.

PERFACE

India has become the fifth largest economy of the world from eleventh rank a decade ago. It has been becoming a hub of world class manufacturing imputed to "Make in India, Make for the World" initiative as evident from the latest global demand for Tejas Mark 1 fighter aircraft. Though per capita energy consumption in India is lower, yet it is the third largest energy consumer of energy. Its energy demand has been increasing over time due to improvements of life style and population increase. The apace economic and social developments simply indicate that demand for different purposes and types, quantum and quality of energy has been expanding. On the supply side, accessibility of energy has improved, though its disruption, irregularity and availability still rankle consumers. Therefore, Āatmnirbharta in energy entailing accessibility of safe, clean, affordable, regular, undisruptive supply of energy as a resource for national economic growth and for ease of doing daily chores needs no underscoring.

In pursuant to basic principle of science that energy can neither be created nor it can be destroyed, the energy doesn't produce on its own but requires sources like coal, gas, sun, wind, water, etc. The major source of energy in India is still coal and would remain so in the near future. Further, energy production is highly polluting as right now about three fourth of greenhouse gases (GHGs) are from energy sector. India has huge coal reserves and need to develop technologies to get an idea of how much coal can be used efficiently. Further, transformation to green energy has become the bounden need of the day. In this backdrop, India has not only done exceptionally well but has also assumed international leadership by holding out, "The One Sun One Earth One Grid" initiative to the world. During the last few years, achievements of India in renewal energy sector have been exemplary, However institutional and social challenges still need redressals to remove systemic inefficiencies and promote responsible consumers centric policies to achieve "Net Zero Target" by 2070.

The Indian energy sector is inordinately dependent upon imported energy. The energy import would become more intense owing to current trends of fall in production andincrease in energy demand. The current geopolitical disruptions have made it amply clear that energy has become a potent weapon for arm twisting diplomacy. Therefore, creative energy diplomacy to enhance capabilities; investing in renewable energy supply chain; and pursuing greater fossil fuel efficiency in both production and consumption have become the new imperatives. Further, the pragmatic solution to reduce burden of imports lies in increasing domestic production of crude oil and finding substitutes for petroleum products. The increase in production has not been possible, though replacements in the form of renewable energy has been quite successful. India's commitments to achieve 40 per cent of its installed electricity capacity from renewable energy sources has been accomplished.

The Govt of India has many laudable feathers in energy sector to its cap like cent per cent electrification of its villages, distribution of LPG gas stove to BPLs, Suryashakti Kisan Yojana, Pradhan Mantri Ujjwala Yojana, Kusum Yojna, etc to make the energy sector efficient. Even some responsible consumers have also become the bellwethers to catapult their nagging problems to awesome solutions. The burning of crop residues is a humungous roblem. The farmer burns it due to paucity of time and resources. There is also an issue of the costs of collecting agricultural biomass and transporting it to factories for making cellulosic ethanol. However, some entrepreneurial interventions like one in Gujarat to collect the agricultural waste after making attractive payments to the farmer has been very encouraging. An App has also been developed to digitally locate the crop residues. The entrepreneurs in Gujarat have set an example by on spot purchasing the crop residues from the farmers, transporting it to their facilities for converting it to energy dense briquettes. The participatory installment of solar operated water pumps to efficiently manage the water at village in central Gujarat is another bellwether example as to how operating the solar based irrigation at day time inculcates better water management, obviates risks of snake bites, etc and above all ensures additional income by selling the extra energy saved after using in irrigation. Such bellwether examples can be replicated elsewhere to achieve Āatmnirbharta in pollution-free energy.

Huge resources of energy are available. It is a question of appropriately employing and using them with appropriate innovation-based technologies for efficient production, storage, transmission, distribution and efficient use. Coal as a source of energy is likely to stay as reality in India. Obviously, more R&D is desired to make it efficient and pollution free source of energy. The nuclear energy assures clean power without any GHG emissions, yet time and cost have remained nagging issues in its execution. Solar and wind are the two renewable options. However, their availability again depends upon only when the sun is shining or the wind is blowing. Blending different renewal resources energy and employing technologies for their efficient transmission, storage and use are desired. A number of options like off river pumped storage, cheaper storage in batteries, developing cellulosic ethanol based on cellulosic by-products of agriculture can be exploited.

"*Atmanirbhar Bharat* – Energy Security" is second book in *Atmanirbhar* series by NCCSD. The first book "*Atmanirbhar* Self Reliant and Climate Smart Farmers – Roadmap for Agriculture – 2020-30 – India" was published in October, 2020. The current book "*Atmanirbhar Bharat* – Energy Security" comprises 23 chapters has fathomed some of these aspects to achieve *Āatmnirbharta* in energy. These chapters have been contributed by eminent experts in their fields that varied from energy security in relation to different stakeholders, sources of energy for clean energy transition and their impact on sustainable development, climate resilience and explorations in relation to achieving Āatmnirbharta in energy. We are taking this opportunity to thank Dr. P.K. Mishra, IAS, Principal Secretary to Hon'ble Prime Minister of India, for writing foreword for the publication.

This book focuses on energy, sustainable economic development and self-reliance for a nation, India. The national security of any country squarely depends on secure energy in its many forms. Since the industrial revolution in the 1750's the world has largely depended on fossil energy for economic development with unintended and unforeseen consequences like global warming and climate changes. Dependence on fossil energy is unsustainable at a global scale, Thus all nations must review and revise their energy policies. Unwise use of the wrong source of energy can threaten the very existence of life on this plant. India has realized the importance of energy security for all sectors of the economy, and some of the initiatives for sustainable development and self-reliance are discussed in this book. In different chapters, energy and energy security are associated with national security, economic development, food security, climate change, environmental sustainability, healthy and geopolitics. India is under rapid transformation under the Leadership of Hon'ble Prime Minister Shri Narendra Modi. The Government and NITI Aayog – are open to suggestions – we are sure – the way forward recommended in the book by scholars, researchers, practitioners will find place in the changing policy framework for Atmanirbhar Bharat.

Dr. Kirit Shelat

Dr. Odemary Mbuya

Dr. Suresh Acharya

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Our thanks are due to many persons who have made this book possible.

- Hon'ble Prime Minister Shri Narendra Modi - who initiated *"Atmanirbhar Bharat"*.
- The contributors - the eminent scholars who had shared their visions. Some of the Papers are Presentation made in our Think Tank meets.
- Dr. P.K. Mishra, Principal Secretary to Hon'ble Prime Minister for sparing his time to write 'Foreword' of book.
- President of NCCSD, Justice B.P. Singh - formerly Judge - Supreme Court of India.
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- Shri Hasmykh Upadhyay, Shri Mohandas Kallingal, Deepak Rana, Bhavini Aiya and Ms Nisha Shah - CEO.

We are grateful to *Param Adarniy* Mahant Swami Maharaj whose blessings encouraged us for this venture.

Contents

About the Editors

Dr. Kirit Shelat

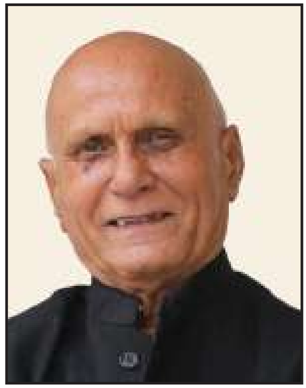
Dr. Kirit Shelat is Doctorate in Philosophy with Public Administration. He was awarded a degree of D.Litt. – Doctorate of Science by Junagadh Agricultural University – India for his outstanding contribution in promoting Climate Smart Agriculture and Building Climate Smart Farmers. He had long spell of his carrier in Indian Administrative Service. He has hand into introduction in "New Extension Management – *Krishi Mahotsav*" approach in Gujarat as Principal Secretary – Agriculture – which doubled the income of farmers. He has designed and implemented large-scale projects for poor families, farmers and micro entrepreneurs and remote rural areas. He has authored more than 20 books related to agricultural and rural development and related to impact of climate change and ways to meet that challenge at local level – village level. He is Executive Chairman of National Council for Climate Change, Sustainable Development and Public Leadership (NCCSD).

Dr. Kirit Shelat has written biography of Pujya Pramukh Swami Maharaj - "YUG PURUSH, PUJYA MAHANT SWAMI MAHARAJ - a life dedicated to thers". This is published in six languages with ninve editions. he has also written biography of Pujya Mahant Swami Maharaj - "Mahan Rushi Mahant Swami Maharaj" - June, 2019.

He was member of sub-committee set up by Planning Commission of India on Enhancing preparedness for Climate Change and has his hand in introduction of NICRA - National Initiative for Climate Resilient Agriculture. He was member of Expert Committee of Government of Gujarat on Economic Revival in Arena Covid Pandemic". Along with Prof. Mbuya of FAMU USA - he introduced concept of Building Climate Smart Farmers. His latest publication includes "Atmanirbhai Bharat – "Self Reliant and Climate Smart Farmers - Roadmap for Agriculture 2020-30 India" and "Atmanirbhar Farmers – Gujarat – Roadmap 2030".

Dr. Odemari Mbuya

Dr. Odemari Stephen Mbuya is a professor of Agricultural Sciences, Director of the Center for Water Resources, Program leader of Plant, Soil and Water Sciences at Florida Agricultural and Mechanical University (FAMU), and a Courtesy Professor of Agronomy at the University of Florida/Institute of Food and Agricultural Sciences, where he teaches Statistical Research Methods, Plant and Soil Sciences. With broad and extensive knowledge in agriculture, life sciences and sustainable ecosystems for the past thirty years, Dr. Mbuya leads the faculty effort in integrating all concepts of sustainability in innovative research and teaching at FAMU. With his extensive education and research career he has trained undergraduate and graduate students as well as postdoctoral researchers. He has worked as a research scientist in Tanzania, a visiting researcher at the Centro Internacional de Agricultura Tropical (CIAT) in Colombia, a consultant and volunteer representing the United States Department of Agriculture (USDA) and FAMU in South Africa and India, and a delegate of Institutions of Higher Learning from the United States to the Netherlands. Dr. Mbuya holds a M.Sc. and Ph.D. from the University of Florida (USA), and a Bachelor of Science in Crop Science from Sokoine University of Agriculture (Tanzania).



Dr. Suresh Acharya

Dr. Suresh Acharya is an expert in Crop Improvement and multi-disciplinary Research Management. After serving in five different SAUs of the country, he hung his boots in 2017 as Director of Research, SDAU, SK Nagar, Gujarat. At present he is working in AGROCEL Industries Pvt. Ltd., Koday, Mandvi, Kachchh, Gujarat.

He has bred 19 versatile varieties (wheat, cotton and pulses), 81 R lines and 110 A lines in pigeonpea. He guided 12 Msc and 09 PhD students. He handled 15 diversified projects as Principle Investigator; and organized 16 National Level Workshops / Training Courses / Seminars as Organizing Secretary / Nodal Officer / Course Coordinator. He has been a member of 17 important committees that also included Extant Varietal Identification Committee, PPV&FRA, New Delhi. He was in the editorial panel of different National Journals and was Editor-in-Chief of GAU J Research.

Consequent upon his expertise, he was conferred ICAR Team Award (1994-96); Sardar Patel Award (2000); Cotton Growers' Award (2002); Hari Om Ashram Award (2006); Bharat Jyoti Award (2006); Best Pigeonpea Team National Award (2008); Best Coordinated Project Arid Legume Team (2009).

Introduction

A Low Carbon Energy Transition Strategy for Making India Āatmnirbhar

Dr. V. K. Saraswat
Member (S&T), NITI Aayog • Email : vk.saraswat@gov.in

Introduction

One of the biggest and the most significant challenges facing humanity in the twenty-first century is the decarbonization of the world's energy systems. Since the energy sector produces nearly two-thirds of the world's carbon dioxide, it is essential to combat climate change. Energy sustainability or the provision of energy for sustainable development, is a problem that both industrialized and developing nations must grapple with.

Pursuant to economic expansion, population, urbanization, and industrialization, India has become the world's third-largest energy-consuming country. Over the next 25 years, there will be an annual increase in energy usage of 4.5 %. Since 2000, energy consumption has doubled, with coal, oil and solid biomass still meeting 80% of the need. From 82.9 % (2017–18) to 85.5% (2020-21), the country is now more dependent on oil imports. However, India uses less energy per person than the global average, as do other important metrics like the production of steel and cement and the ownership of automobiles.

With a strong emphasis on renewable energy sources like solar and wind, India is striving towards a diverse energy mix. One of the primary indicators of the energy transition is expected to be electricity demand. In fast-growing nations like India, where consumption growth has not slowed down as it has in other mature economies, electricity is still a crucial factor in economic development.

India has Made Outstanding Progress Against its Energy Goals

India stands at fourth position in the world in terms of installed renewable energy capacity and the GoI has set a target of installing 175 GW of renewable energy capacity by the year 2022. In order to provide appropriate power to agricultural customers in accordance with State policy, the Ministry of Power launched a cooperative initiative with all States and UTs from 2014 to 2017 and created State/UT-specific action plan documents. This effort aimed to gradually connect all unconnected users to electricity by 2019 and ensure an uninterrupted supply of high-quality power to current consumers.

Through its several programmes, such as the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) and the Integrated Power Development Scheme (IPDS), the Government of India has been assisting the states in achieving the goal of supplying stable power to all families. The State Power Distribution Utilities are given financial support under the recently implemented Revamped Distribution Sector Scheme (RDSS) to strengthen the distribution infrastructure. Fund releases under the scheme are linked to the start of reforms and the achievement of results, which include trajectories for increasing the number of hours that electricity is available to consumers in urban and rural areas.

Similarly, the Pradhan Mantri Ujjwala Yojana (PMUY), a flagship programme of the Ministry of Petroleum and Natural Gas (MOPNG), was launched in May 2016. Its goal is to make clean cooking fuel, such as LPG, accessible to rural and underprivileged households that would otherwise use traditional cooking fuels like firewood, coal, cow-dung cakes, etc. Traditional cooking fuels have a negative effect on both the environment and the health of rural women. Provision has also been made in the Union Budget for FY 21–22 for the release of an additional 1 crore LPG connections under the PMUY scheme. Special accommodations have been made for immigrant families in this phase. As of June 1, 2022, 92,714,083 connections have already been released under the Pradhan Mantri Ujjwala Yojana.

Balancing the 'Energy Trilemma'

A national energy system's balance can be seen in the 'Energy Trilemma Balance Triangle', where Energy Security, Energy Equity, and Environmental Sustainability act as the three main pillars. The 'Trilemma' of balancing these three objectives makes balanced systems necessary for national growth and competitiveness.

i. Energy Security: The effective management of primary energy supply from domestic and external sources, the reliability of energy infrastructure and the ability of energy providers to meet current and future demand.

ii. Energy Equity: Accessibility and affordability of energy supply across the population.

iii. Environmental Sustainability: Encompasses the achievement of supply and demand-side energy efficiencies and the development of energy supply from renewable and low-carbon sources.

Clean Coal Technology: Coal to Supplement Hydrocarbon

India is the world's second-largest user of coal and has the fifth-largest coal reserves in the world. By 2040, coal will make up around 45% of all primary energy consumption. Coal is anticipated to be India's most popular fuel by 2030, with demand ranging between 1192 and 1326 million tonnes. Imports have been rising for the past two decades to meet rising coal demand amid supply limitations. To reduce imports, it is necessary to choose coal technologies that are suitable for Indian coal.

Despite having the greatest carbon emission coefficient of any energy source at the moment, coal is still an essential part of the world's electricity production. The development of clean coal technologies (CCTs) has been pushed as an appropriate means to achieve both coal-driven energy production and environmental protection due to the significance of coal in the global energy framework and the difficulties in phasing out its usage, at least in the near future.

Some of the coal combustion methodologies (for efficiency improvement) include Coal Gasification which bypasses the conventional coal burning process altogether by converting coal into a gas. Coal gasification is more efficient than traditional coal combustion. This method is approximately 17 to 20 % more efficient than traditional coal-fired energy generation. Coal gasification can be used to generate electricity, liquid fuel chemicals and hydrogen.

Similarly, when compared to hydrogen produced through electrolysis and natural gas, the cost of hydrogen produced from coal can be less expensive and less susceptible to imports. Indian coal reserves could become a source of tremendous hydrogen supply if the carbon monoxide and carbon dioxide produced during the 'coal to hydrogen' process are captured and used in an environmentally sustainable manner.

Another potential CCT is converting coal to methanol. Converting coal to methanol entails converting coal to synthesis (syngas) gas, cleaning and conditioning of syngas, conversion of syngas to methanol and methanol purification. In most countries, low-ash coals are used in coal-to-methanol plants. In the case of Indian coal, which has a high ash content, handling high ash and the heat required to melt this large amount of ash is a challenge. BHEL (R&D), Hyderabad, and IIT Delhi & Thermax Ltd., Pune have developed pilot plants to convert high-ash coal to methanol, which might speed up the country's transition to clean technology.

Methanol as a liquid fuel for transportation and cooking is seen as a viable option in India. The NITI Aayog is now promoting a 'Methanol Economy,' with the goal of lowering India's oil import bill and greenhouse gas emissions by converting coal reserves and municipal solid waste into methanol. Methanol is the most cost-effective alternative fuel with obvious benefits. It produces fewer SOx, NOx, and particulates. Methanol also has a high-octane number, which ensures it ignites with less 'knock.' Dimethyl ether (DME), a derivative of it, has the ability to meet a number of energy needs, including household fuel.

M15 (15 percent Methanol mix in gasoline) has been approved as an automotive fuel by the Indian government, which has also granted a Central Excise exemption on Methanol blended Petrol and set standards for methanol blended fuel. The Indian Oil Corporation has already rolled out M15 petrol on a pilot basis in Assam's Tinsukia district on May 01, 2022.

Hydrogen: A Key Part of Future Energy Systems

Hydrogen is a fuel with the highest specific energy (33.3 kWh/kg as against 11.8 kWh/kg of diesel). If produced from renewable resources or coal with carbon capture, it is a carbon-neutral fuel that has the potential to replace traditional fossil fuels. Additionally, MSW and biomass can also be used to make hydrogen, which has numerous benefits in addition to reducing pollution. BP Energy outlook estimated that hydrogen production in 2035 will be 37% (Grey), 31% (Blue) & 32% (Green). By the year 2050, hydrogen production will be47% (Blue) and53% (Green).

Clean hydrogen could cut up to 34% of global GHG emissions from fossil fuels and industry – at a manageable cost if policies are put in place to help scale up the technology and drive down costs. Renewable hydrogen could be produced for $0.8 to $1.6/kg in most parts of the world before 2050. This is equivalent to gas priced at $6-12/MMBtu, competitive with current natural gas prices in Brazil, China, India, Germany and Scandinavia.

Methanol as Hydrogen Carrier

Methanol is tomorrow's hydrogen. It is an extremely efficient hydrogen carrier, packing more hydrogen in one simple alcohol molecule than can be found in hydrogen. Being a liquid under ambient conditions, methanol can be handled, stored, and transported with ease by leveraging the existing infrastructure that supports the global trade of methanol. Methanol reformers are able to generate on-demand hydrogen at the point of use to avoid the complexity and high cost associated with the logistics of hydrogen as a fuel. Methanol can also be produced from sustainable and green pathways to allow it to be a carrier of low carbon, and potentially carbon-neutral hydrogen.

Sectoral Transformation of the Energy System

The energy transition is a pathway toward the transformation of the global energy sector from fossil-based to zero-carbon by the second half of the century. Enabling policy and regulatory frameworks need to be adjusted to mobilize the acceleration of renewables growth that is needed in the area listed below:

i. **Power Sector**

   a) Accelerate renewable capacity additions to generate adequate power with low-carbon technologies

   b) Update grid planning to accommodate rising shares of variable renewable (solar and wind) energy

   c) Support distributed energy resource deployment

ii. Transport Sector

a) Reduce transport volume and congestion

b) Accelerate the shift to electric mobility

c) Prioritize biofuels in road freight, aviation and shipping

iii. Industrial Sector

a) Reduce energy consumption industries and enable corporate sourcing of renewables.

b) Accelerate low-carbon technology deployment (having improved energy efficiency) for industrial process heating.

c) Integrate CCUS

d) Use cleaner fuels like methanol

iv. Building Sector

a) Design green buildings and avoid the addition (and potential lock-in) of inefficient and carbon-intensive technologies in all new construction

b) Enable deployment of high-efficiency, low-carbon technologies such as electric heat pumps and solar thermal units

c) Promote the use of advanced controls and integration of renewables and integrated storage in fossil fuel heating systems.

Roadmap to Three Key Sectors for Carbon Free Future

In light of India's crucial contribution to the future of global decarbonization, balancing is needed in domestic interests like economic growth, job creation, and self-reliance. The rising industries that support our expanding economies, such as cement, steel, infrastructure and energy, require ongoing investments. To meet our expanding home and commercial energy needs, domestic energy generation, transmission, and distribution infrastructure will need to expand.

Energy Sector

- Develop renewable energy sources quickly while gradually retiring coal assets, all while balancing the two with labour reforms, skill development and job growth.
- Utilize the fundamental connections between all of the energy sectors - renewables, power, oil, and gas - to enable sector coupling and boost the proportion of renewable energy in the energy mix to over 50% while reducing reliance on foreign oil and gas.
- To enhance sector coupling and move towards energy security, increase

energy infrastructure with a focus on transmission infrastructure and a drop in average AT&C losses from the current 18% to 5%.

Industry and Manufacturing

- Encourage the use of clean technology and alternative fuels in the industry to fully realize their potential and minimize emissions without impeding the sector's expansion.
- Encourage industrial energy efficiency to lower energy use while making investments in waste management for effective waste disposal and energy recovery.
- As envisioned by the *"Āatmnirbhar Bharat"* plan, offer incentives to draw investments in the indigenize manufacturing of new low-carbon technologies such as carbon capture and water electrolysis in order to meet domestic demand.

Transport and Infrastructure

- Create a clear role for CNG, EVs and biofuels; evaluate LNG and Green Hydrogen in specialized transport use-cases, and implement a comprehensive mobility transition programme to promote important clean fuels throughout transport sectors.
- Increase the effectiveness of the logistics infrastructure through infrastructure improvements including designated freight corridors and a strong rail network to move freight from the road to the rail.

Conclusion

A transition to a low-carbon energy system necessitates the creation of effective policies that encourage the use of biomass resources, boost the use of renewable energy sources and dissuade the use of fossil fuels and unsustainable use of natural resources. There are various strategies, measures and technologies that can be used to promote low carbon energy transition and improve sustainability which include energy efficiency, increasing the contribution of renewable energy in electricity generation, use of CCS in fossil/biomass power plants, use of hydrogen in the transportation sector and reductions in the demand for energy and electrification as well as the use of biofuels in transport services.

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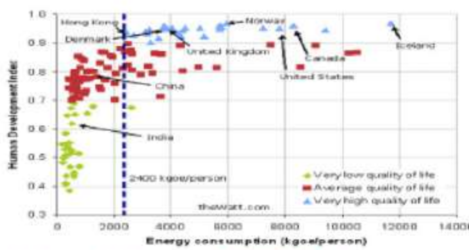
Clean Energy Transition in India
A Macro View

Anil Kakodkar
Chancellor, Homi Bhabha National Institute,
Chairman, Rajiv Gandhi Science & Technology Comnnission
Former Chairman, Atomic Energy Commission of India • Email : kakodkaranil@gmail.com

Green energy transition needs a major rethink!

- India has committed to reach net zero emission by 2070 at Glasgow.



- By that time, India can be expected to surpass annual per capita energy consumption level necessary to be on par with the best in world in terms of quality of life. Even after accounting for a reduction in threshold to reach that level to around 1400 Kgoe as a result of improvement in efficiency the total energy requirement in India would be around **28000 TWhr/yr**. (up from present level of ~6580 TWhr/yr).

- Total assessed renewable energy potential in India is @ **5855 TWhr/yr*** (*Sukhatme, Current Science, Vol. 103, No. 10, 25 November 2012 - includes Solar, Wind, small and large Hydro, Biomass and Tidal). While there may be additional renewable energy potential (particularly the potential of bio-energy @ 2500 TWh/yr as against 60 TWh/yr factored in above assessment), the gap is too large to bridge. The only other available non-emitting energy source is nuclear. **Nuclear playing a major role is thus inevitable.**

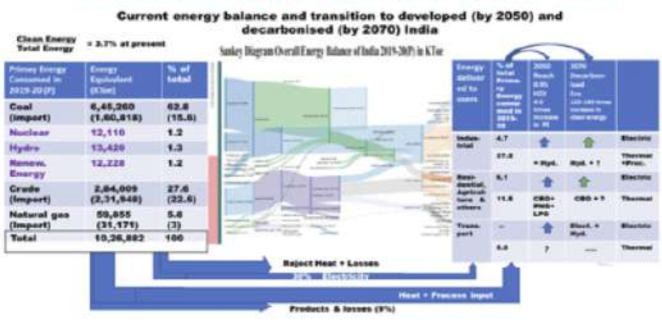
Surplus Biomass useable as energy

Sr. No.	Biomass type	Quantity	Calorific value	Energy	Remarks
1	Firewood (sustainable production)	~100 MT*	17,000- 22,000 KJ/Kg	~ 550 TWh	*S.N. Rai, S.K. Chakrabarti 'Demand and supply of fuelwood and timber in India' March 2001Indian Forester 127(3):263-279
2	Animal-dung	2600 MT of wet dung or 150-250 b Cu. M of biogas+	6-8 MJ/ Kg(dried) 20-25 MJ/Cu. M	~ 1400 TWh ~ 1100 TWh	+*Energies* **2017**, *10*(7), 847; https://doi.org/10.3390/en10070847
3	Surplus agri. residue	178 MT 51.3 b Lt ethanol	~10 MJ / Kg ~ 26.8 MJ/Kg for ethanol	~ 500 TWh ~ 278 TWh	http://krishi.icar.gov.in/jspui/handle/123456789/34455
5	MSW	~ 60 MT	~7 MJ/Kg	~118 TWh	More then energy resource useful to reduce public health management burden
6	Total			~ 2000 – 2500 TWh	Comparable to current petroleum product consumption in the country

Challenge – to use this energy resource in a manner that does not impact air quality and enables a healthy ecosystem.

Clean energy transition --Share of clean energy supply (Nuclear, hydro and renewable energy to grow from 3.7% to 100%

Emphasise Gas economy in the transition period
- **. Sustainability**
- **. VRE penetration**
- **. Bridging fuel**



Key forms of energy delivery post transition
- **. Electricity**
- **. Hydrogen**
  - **Electrolysis**
  - **Thermo-chemical splitting**
- **. Bio-energy**
  - **Cooking gas**
  - **Agri. machinery**
- **. Fossil + CCUS**

➢ **Except Biomass, all other clean energy sources first produce electricity (Solar thermal and High temperature nuclear reactors, both yet to be commercially developed, can however directly produce Hydrogen by thermochemical splitting/radiation dissociation of water.)**

➢ **Share of electricity would thus need to go up from ~18% to ~35% (If hydrogen is produced by thermochemical splitting/radiation dissociation of water - potentially a cheaper option) or ~80% (If Hydrogen is produced through steam electrolysis) in a net zero emission scenario**

Potential mega trends:

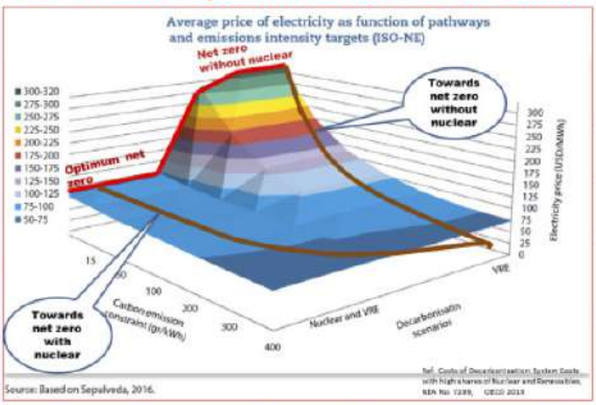
- While total energy consumption would increase ~ 4 to 5 times (at a rate consistent with economic growth), clean energy consumption would need to increase ~ 80 - 100 times (at a rate consistent with reaching net zero target). The increase has to come primarily through Renewable (including Bio-energy) and Nuclear

- The energy mix that we need to adopt in different demand segments:
  - Residential & Agricultural ⟶ Electricity* + Bioenergy*
    * Decentralised generation, boost to rural economy, to be dealt with in a technology agnostic way
  - Industrial ⟶ Electricity + Hydrogen + Hydrocarbons** + Coal**
    ** Needing CCU/CCUS
  - Transport ⟶ Electricity + Hydrogen

- We need an optimum mix of electricity generating systems to ensure diversity of energy sources, optimum peak capacity investments and stability of grids

Studies show that as one approaches net zero, a 'mix relying primarily on nuclear energy is the most cost-effective option to achieve the de-carbonisation target'.

Renewable energy integration costs rise as the share of variable renewables in the grid increases. Systems costs (profile costs, connection costs, balancing costs and grid costs) rise as the growing share of variable renewables imposes greater costs on the grid for stability and flexibility.



- Min. average generation cost at low emissions without nuclear
  - ~ twice in New England USA and
  - ~ four times in TBT region China
- Nuclear Capacity as % of peak demand
  - ~60% in New England USA and
  - ~80% in T-B-T region China

Nuclear energy development needs greater attention since it positively impacts price of electricity whose share in the total energy system would now be much higher

Key elements of suggested sustainable clean energy policy

- Electricity, Hydrogen and bio-energy – key feeders for meeting energy demand
- Reserve CBG for cooking energy, Bio-CNG for running agricultural machinery (strengthen rural economy) --- ~2500 TWh/Yr
- Emphasise decentralised renewables for rural and remote areas through microgrids interconnected to main grid
- Develop and deploy solar thermal and high temperature small modular nuclear reactors for hydrogen production through thermo-chemical splitting of water --- ~15,000 TWh/Yr. (Captive hydrogen plants for industries)
- Augment electricity generation based on optimum mix of renewables, hydro and nuclear --- ~10,000 TWh/Yr or more to bridge shortfall in hydrogen production through high temperature electrolysis
- Balance through fossil energy use backed up by Carbon Capture & Utilisation

Other critical technologies to be deployed

- **Steam electrolysis (and also SOFC)**
- **Thermo-chemical splitting of water (Radiolysis of water could also be explored)**
- **Energy storage**
- **Technologies for greening industrial production** (particularly for steel, cement, fertilisers, petrochemicals, ...)
- **Production of hydro-carbon substitutes using hydrogen and bio-mass**
- **CCU&S to meet energy needs, meet emission targets and produce value**

To Sum up:

1. **India can become energy independent as result of clean energy transition**
2. **Large share of nuclear energy is necessary both for sufficiency of energy supply as well as for economic viability**
3. **Share of electricity in the overall energy supply would go up substantially depending on mode of green hydrogen production**
4. **Bio-energy should be preferably leveraged for cooking energy as well as for agricultural machinery**
5. **New technologies would be needed both at supply end as well as demand end**

Energy Security in India
Āatmnirbhar Bharat

Dr. Kirit N. Shelat[1], Dr. Odemari Mbuya[2], Nisha Shah
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Energy Security in general means uninterrupted availability and accessibility of energy sources at an affordable price to all citizens in all areas. But in context of overall national interest, a nation should have "Guaranteed" supply of sufficient energy sources and related inputs for all it needs at all the times.

India should not be at the mercy of other nations for its energy requirements, as in long term it can find itself held hostage. India did experience an energy shortage in the Indo-Pak conflict in 1971. Currently, India is dangerously dependent on imported oil and gas which provide 80% of its needs and as per one projection by 2030 dependency on imported energy could increase upto 90%. Therefore, there is a need to develop a multi-faceted Āatmnirbhar Plan. Under the leadership of Hon'ble Prime Minister, Shri Narendra Modi, India has already taken lead on Āatmnirbhar Plan. India has taken major steps on alternative and renewable energy sources.

Despite the dependency on imported petroleum oil and natural gas, today the country has connected all its villages with electricity and rural house wives are using gas for cooking. India is making subsidized electrical power to its farmers, solar roof tops and solar pumps in rural and urban areas and promoting the use of Bio-Energy and that country is meeting its energy needs of all sectors.

Impact of Climate Change

The new report on impact on climate change is alarming, not that it was not so earlier, but now the world has started suffering severely due to recurring extreme weather events. India has a serious challenge ahead in confronting severe extreme weather events (heat waves, cyclones, floods, droughts, etc.). We have been looking into adverse impacts of climate change on rural areas, agriculture and farmers and the role of agriculture - vegetation -as a mitigating force (due to its photosynthesis process which absorbs CO_2. India has now successfully developed sustainable agriculture despite the adverse impacts. The major challenges are mainly on energy and water security. Energy and water insecurity are major threats for economic growth in India. Energy and water affect rural and urban livelihood and economic growth. Therefore, there are issues which need attention, deliberation, strategy, plan and execution.

Gujarat had a severe cyclone, 'TAUKTAE', in May 2021 which made severe impacts in villages. For example, in the district of Amreli more than 100 villages had lack of energy, as electrical poles were grounded. Repairs and replacement of poles took months.

Talking to engineers we realized that over years wind velocity is increasing and capacity of poles to withstand it is deteriorating – due to regular on slaught. Hence with cyclone – they fell down. While major transmission lines were not affected – but there are increased transmission losses and there is need to assess its capacity to withstand cyclonic events.

Similarly, in the United States, electricity and gas supplies were disrupted in Louisiana due to recent extreme weather events, and it is taking time to restore power and people have been advised to stay away until normal power is restored.

Dependence on Imports

Another example is related to new technologies of electric car / auto motors and wind energy. Electric vehicles need more mineral inputs – like copper, aluminum, lithium, cobalt etc. more than a regular vehicle. On shore Wind Infrastructure uses nine times more mineral inputs than a gas-fired power plant. Both need increased mining – or dependence of imports at high cost. All these minerals like copper, zinc or aluminum are in abundance – but current policies are conservative. As a result, there is high cost of imports of copper and like.

Same is true – about oil and gas – despite available ground resources – our exploitation and exploration are not enough. Hence high import cost. But in the changed context of international threats – both business and political – we need to look this closely for urgent action. Foreign powers – through oil companies – can destabilize our economy by increasing oil / gas prices – as that results hike in petrol – diesel prices and over inflation and people's resentment and agitations. Further, an unlikely, event of war can paralyze our defense preparedness as supply chain could be disrupted.

Recent Initiatives

- Nuclear energy: India has few nuclear plants which are operational. An agreement was signed between India and USA for transfer of critical technology about a decade ago, but no major headway have been seen.
- Green hydrogen: Hydrogen energy is derived from water. Already there is progress on use of hydrogen energy has been made in Delhi where 18% of CNG run on hydrogen. Major public and private sector companies are taking

the Green hydrogen initiative for its development. NTPC is running 10 buses using hydrogen. Countries like Poland and Germany have trains fueled by hydrogen.

- Biofuel: New Incentive Policy for blending ethanol in petrol has started. Target is 20% by 2030. Current production capacity is 426 crore liters, target is 760 crore liters.
- Renewable energy: Currently estimated solar and wind energy production is 146 GW. Target production by 2030 is 450 GW.
- Hydro energy: India has taken initiative to build new dams for hydroelectricity.
- Petroleum and natural gas: Currently these are the major sources of energy production and will continue to remain so with rapidly growing urbanization, transport, infrastructure, and industries. India imports 80% of its total needs. Local production is on decline.
- Coal: India has large coal deposits, and its exploitation is very good. It meets 80% of national needs, balance is imported.
- India is world third largest consumer of electricity
- India is also 3rd largest producer of renewable energy

The major users of energy are railways, aviation, heavy vehicle transportation, light vehicles, ships, industries, commercial buildings, residential, agriculture, infrastructure and civil amenities. There is tremendous need for efficient use of energy.

Barriers

- Inefficient – transportation – evacuation losses.
- Inefficient oil and gas exploration and lack of policy to attract investment.
- Inefficient coal exploitation.
- Evacuation problem related to solar and wind energy from rural and remote areas.
- Solar and wind energy – storage not yet feasible and efficacy of photo-voltaic panel is low.
- Impact of adverse extreme weather events. For example, cyclones affecting electric poles and high-tension lines.
- Biofuel crops like jatropha have not been successful.
- Hydro-power generation has problem related to environmental clearances.

NCCSD - Initiative

It is in this background with cooperation of the Department of Energy & Petrochemical, Government of Gujarat and NCCSD organized a brainstorming meets on "Energy Security". These were on-air webinars. Distinguished Economist Dr. Kirit Parikh, Prof. Odemari Mbuya, Dr. Mukul Asher, Dr Anil Kakodkar, Dr. Govind Hariharan, Prof. Anil Gupta, Dr. Rajendra Shende, Dr. Mamta Verma, IAS Principal Secretary, Energy & Petrochemical Department, Govt. of Gujarat, Prof. P. M. V. Subbarao,Head of Department, Centre for Rural Development and Technology, Indian Institute of Technology Delhi, Dr. Alagusundaram Dy, Director General – ICAR, New Delhi, Shri Pravinbhai Parmar –Secretary- Dhundi Solar Energy Producers' Cooperative Society-Anand, Gujarat, Shri Kamlendhu Bhakat –VRTI, Mandvi, Kutch Gujarat, Shri Bhartiben-President Vaghai Dang District –Gujarat, Shri Ashwinbhai Shroff, Chairman – Excel Group of Industries, Shri Shekhar Bhadsavle, Saguna Rice Technique (SRT) and Saguna Rural Foundation (SRF), Maharashtra, K S Randhawa, IFS Managing Director, Uttar Gujarat Vij Company Limited, Mahesana –Gujarat, Dr. Abhinav Trivedi, Consultant (S&T) NITI Aayog, New Delhi, Dr. A R Pathak - Former Vice chancellor, Junagadh Agricultural University, Director – Gujarat Energy Development Agency - GEDA Gujarat and Dr. Suresh Acharya, Former Director – Research, Sardarkrushinagar Dantiwada Agricultural University – SDAU. Dr. Vikas Sharma, Ms Roshni Choudhary Dr. Sudhir Sharma and Ms.Payal Chauhan – CAIRN – Vedanta participated and Dr. Sharma – Ex-ONGC and Managing Director – GSPC & Managing Director – Gujarat Gas also joined.

There were in all seven Seminars and more than 600 Stakeholders participated.

Initiative of NCCSD-Seminar series on "ENERGY SECURITY"

- Seminar on "Energy Security - Āatmnirbhar Bharat" - keynote address was given by Dr V K Saraswat on 7th of October, 2021 and 8th January 2022
- "Energy Security in Rural Areas" –keynote address was given by Dr. Kirit Parikh - Former Member, Planning Commission on 15th November, 2021.
- "Energy Security – Oil and Gas" keynote address was given by Anil Kakodkar, Chancellor, Homi Bhabha National Institute, Chairman, Former Chairman, Atomic Energy Commission, on 17th December, 2021.
- "Āatmnirbhar Bharat: Energy Security – Bioenergy- keynote address was given by Prof. Anil K. Gupta, Founder, Honey Bee Network, SRISTI, GIAN & NIF on 21st December 2021.
- The outcome of Seminar was presented to Hon'ble Member Niti Aayog Dr V K Saraswat on 8th January 2022.

The brief summary of deliberations is narrated below :

Oil and Gas

India is emerging as country with rapid economic growth. It has growing urban areas, massive infrastructural and industrial development and growing modernized

Dr. V.K.Saraswat,Hon'ble Member, NITI Aayog,Government of India

Dr.Mamta Verma, IAS Principal Secretary, Energy & Petrochemical Department, Govt. of Gujarat

Shri G S Vaidyanath, Assistant General Manager, FSDD, NABARD

agriculture and rural development. The livelihood both quality and quantity is improving with decline in families below poverty line. Key to this is nexus of food, water and energy security. The country is trying to meet growing energy needs for urban, rural and manufacturing, agriculture and service sector, with wide range of initiatives for both conventional and non-conventional renewable sources.

As per one estimate, energy consumption will grow 4.5% every year for next 25 years. The dependence is on Oil & Gas and Coal. While Oil & Gas constitute 80 per cent of energy sources. Oil import dependence is rising from 83% - 2017-18 to 84% 2020-21.

Domestic production is on decline.

India is vulnerable to oil and gas imports. The volatility in crude oil prices – disturbs the economy – results into inflation and discontent among people. Even exporter countries/organizations can manipulate externally to disturb Indian economy and defense preparedness. Country can lend itself in a precarious position in unlikely event of happening of war. Hence key to Energy Security – to free oil & gas from imports and reduce dependence on imports.

India needs new roadmap for oil and gas production.

The current efforts of expanding production areas are noteworthy and so are efforts of doing ease of business, both for public and private players in oil and gas production.

But oil and gas sector needs changing of course. This is critical. The current policies need in-depth review to realize that "Security of Nation" is more important than realizing revenue. Hon'ble Prime Minister has called for "Energy Security" as need of time in his Independence Day speech on 15th August, 2021. While Ministry has taken measures for sustainable future – but unless overall framework is redesigned to attract 'Investment' earnings to producers, 'New Technology' removal of market barriers and incentivized investment strategy – without these getting energy security will not be easy. We will have to move away from Conventional Policies related to use of natural resources.

New vision for the oil and gas sector need to be investment oriented – with use of advanced technology and financial incentives both to enhance current production and production in new areas. In fact, incentives are needed for both – probably more for current production areas – as that will yield quick results. If we reduce imports – automatically more savings will be generated which will offset current levies, access, profit sharing etc.

Energy Security –Rural Areas

Rural Energy Security is key to sustainable livelihood, poverty reduction and rapid economic growth. Energy Water Food nexus is vital for Sustainable Agricultural and Rural Development.

Rural India has widespread momentum on economic activity. Over 60% of people live in villages. There is growth of the villages with constructed houses, well-planned streets, and piped water supply. The government is trying to make electricity available to all villages. A massive programme of rural electrification is under implementation, while natural gas is made available for domestic cooking.

Local Needs

Currently Rural Energy needs are as follows:

• Domestic Household Use-Collecting Fuel	• Cooking • TV • Lights within and outside house • Transportation • Students – internet study
• Community Needs	• Streetlights • Pumping water supply • Public and private transport
• Agriculture	• Ploughing • Seed planting • Irrigation • Harvest and post-harvest • Storage

• Local Level Processing-Pallets • Micro Enterprises • Service Centres • Shops & Est.	And similar needs

Sources of Energy

- Electricity supply by Discom-including nuclear power supply.
- Diesel, petrol and kerosene
- Solar – rooftop and farm-based systems
- Wind energy – hydro power(almost non-existent)
- Gas cylinders (natural gas and propane)
- Cow dung briquettes – mixed with agro-waste
- Local wood
- Biogas
- Coal
- Animals (bullock, donkeys, horse, camel)

Major requirement of rural energy is for domestic, agricultural, and occupational uses. It has issues like quality of energy, distribution losses, multiple of sources, energy auditing of agricultural and domestic tools and appliances including water pumps. Further, the pricing of rural energy particularly for agriculture need to be revisited. The dedicated separate lines with information as to when the energy will be available is good. However, it has prompted the farmers to install high-capacity pumps to withdraw water to make up for time and faulty distribution.

The Atmnirbharta in rural energy is feasible. With harvesting solar energy both for domestic and entrepreneurial purposes including agriculture. In fact, today rural areas have multiple sources-they get electrical power, gas, kerosene solar, Bio energy, bio gas but their dependence and liking are for power supply as it easy to access and subsidized; Hence other resources-are not fully used.

Solar Energy

India is committed to reach to use renewable sources 450 GW by 2030. We have already reached 156 GW, out of this solar and wind account for 106 MW.

There is multiple level action points-big with huge solar farms, small players and individual who has as roof top at farm level.

Bhadla Solar Park is the largest solar park in the world as of 2021, and is spread over a total area of 5,700 hectares (14,000 acres) in Bhadla, Phalodi tehsil, Jodhpur district, Rajasthan, India.

The park has a total capacity of 2245 MW. The park had witnessed the lowest bid for solar power in India as of December 2020 at ₹2.44 (3.1¢ US) per kilowatt-hour. In September 2018, Acme Solar announced that it had commissioned India's cheapest solar power: 200 MW at Bhadla.

- There has been a visible impact of solar energy in the Indian energy scenario during the last few years.
- Solar energy has benefited people in Indian villages by meeting their cooking, lighting and other energy needs in an environment friendly manner. The social and economic benefits include reduction in drudgery among rural women in the collection of fuel wood and cooking in smoky kitchens, minimization of the risks of contracting lung and eye ailments, employment generation at village level, and ultimately, the improvement in the standard of living and creation of opportunity for economic activities at village level.
- Further, the solar energy sector in India has emerged as a significant player in the grid connected power generation capacity over the years.

But Issues Relate –

a) Storage – technological

b) Design for rural huts – technological

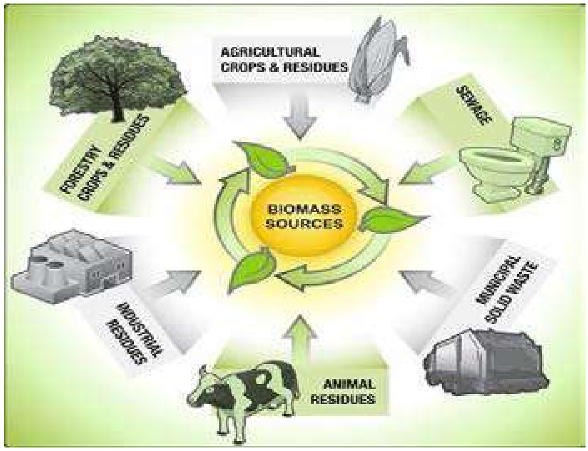
c) Linking farm – rural house-roof top to grid.

d) Financing both solar energy equipment producer-and users who are small farmers / poor householders.

- Recently, India achieved 3rd global position in solar power deployment. Solar power capacity has increased by more than 11 times in the last five years.Presently, solar tariff in India is very competitive and has achieved grid parity.

Bioenergy

- Biomass has always been an important energy source for the country considering the benefits it offers. It is renewable, widely available, carbon-neutral and has the potential to provide significant employment in rural areas. Biomass



also capable of providing firm energy. About 32% of the total primary energy use in the country is still derived from biomass and more than 70% of the country's population depends upon it for its energy needs.

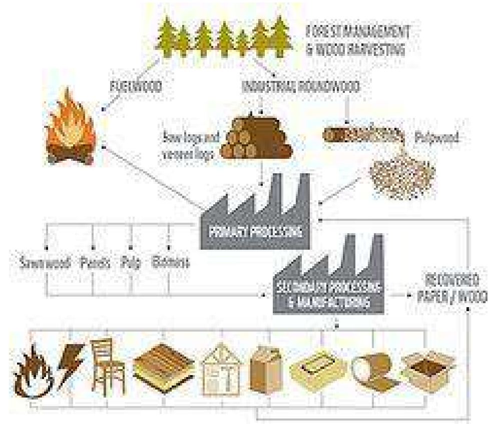
- As per recent study sponsored by MNRE the current availability of biomass in India is estimated at about 750 million metric tonnes per year. The study indicated estimated surplus biomass availability at about 230 million metric tonnes per annum covering agricultural residues corresponding to a potential of about 28 GW. This apart, about 14 GW additional power could be generated through bagasse-based cogeneration in the country's 550 sugar mills.
- On the other hand, crop residue is being burnt on farm causing serious pollution problem. In fact crop residue generates bioenergy which is available on farm – at local level and can be fruitfully used by farmers – as it is many are traditionally using it.

Who Uses Bioenergy?

- Bioenergy is a diverse and accessible form of energy. Home owners can begin generating energy just by creating a compost heap. However, on a grand scale, large energy suppliers are now creating bioenergy power plants. As they search for new sustainable energy sources, they now invest more money in bio-energy technology and research.
- When we use biomass to create energy, the raw material is known as a feedstock. These consist of waste products. There are dry feedstocks and wet feedstocks. Dry feedstock mainly consists of wood pellets that we burn.
- Wet feedstocks include food waste. These are stored in sealed tanks where they rot and produce methane. The gas can then be burnt in order to generate electricity.

- Bioenergy is a source of energy that is extremely flexible. We have the ability to turn it up and down in order to meet demand.

We have already Good PracticesBioenergy :– 'Bamboo'



- Bamboo grows in forest – but can grow anywhere. Bamboo can also grow in coastal areas – working as a wind barrier and can restrict ingress of seawater both over-ground and under-ground. It also absorbs CO2. Grows very well on wasteland / degraded lands and once planted – expands its own.
- Bamboo is conventionally used for handicrafts, rural housing in forest areas, furniture – kite sticks and fuel etc.
- It can however be better used as an energy source.
- Calorific value of Bamboo is 4000 kcal/kg and content LI%, Grows throughout the year – can be harvested round the year – multiplies on its own. It grows within 3 years. Bamboo poles can be harvested every year. It can be used as a fuel by making Briquettes from Bamboo. Captive energy plantation – 1 MW Power plant needs 200 acre of land of bamboo. Bamboo can be used for ethanol production also.

Fuel Briquettes from Agro Waste

- Gujarat has more than 200 units making fuel briquettes from crop residues. This needs to be popularized – by developing Bankable Plan and promoting rural youth to undertake it. Even FPO can be promoted. Groundnut oil industries and castor oil mills are using residues as fuel. In Ludhiana recently 40 units modified their Boilers to use Agro waste.
- In Kutch, Gujarat – coal from Baval-Propsopisjuliflora–is produced and well marketed.Baval grows and expands on its own in the margin area of desert – on wasteland local people are making 'coal' from it and it is an income generating

activity. This needs to be expanded for entire Rann of Kutch – where they can be grown and coal can be produced and it can be self-sustaining income generating activity. It will also reduce salinity ingress and advancement of desert.

- **Village Level Hydro Power - Maharashtra**


- Hydel Energy by using gravity of natural water spring – Village Songao – Lotte – Maharashtra.
- Village has a natural water stream having gradient height of more than 100 meters.
- Village constructed check dam in up-stream on top of hill to maintain flow.
- Villagers have set up a project of 2 kW power generations for community services, such as streetlight, lights in Panchayat office and primary school.
- Tail water after power generation is used for agriculture and cattle.
- Mechanism is simple. It comprises of cylindrical caste iron easing housing an alternator which is connected to turbine through the shaft. Water is used to turn turbine to generate energy.

Pilot Project on Solar Farming: Crop Production with 1MW Solar Power

- 1 MW Solar PV Pilot Project undertaken by AAU in collaboration with Gujarat Industries Power Company Limited (GoG) at Village Amrol, Anand District.
- 1.5 ha cultivatable area
- Solar panel size 2x1 m, 310Wp capacity
- Number of Rows = 17; Total solar panels = 3240
- Distance between two rows = 10 m
- Spacings between two panels = 25,150 and 250 mm
- Crops grown (Kharif, rabi and summer seasons) – Groundnut, Soybean, Pearl millet, Pigeonpea, Wheat, Mustard, Okra, Green gram, Maize, Cotton, Amaranthus, etc.
- Power generation of 4320 to 4560 kWh / day. The power generated is sold to Madhya Gujarat Vij Company Limited
- The farmer could get the benefit of power generation along with crop production as an additional income.
- State and Central governments gave 60 per cent subsidy on the cost of the project. The farmer is required to bear 5 per cent cost, while 35 per cent will be provided to him as an affordable loan with interest rates of 4.5-6 %
- For the first 7 years, farmers will get INR 7 per kWh and remaining period will get INR 3.5 per kWh sold.
- This is now under scheme Surya Kisan Yogna. In Gujarat, 4520 farmers are benefiting by selling excess electricity generated and have an extra source of Income.

Solar Energy

- Sardarkrushinagar Dantiwada Agricultural University undertook project.
- Farmers adopted use of 5 HP photo voltaic water system coupled with micro-irrigation system and used it around the year. The system was appropriate in the total head range of 5-85 M. Life cycle cost – LCC of photo voltaic, system

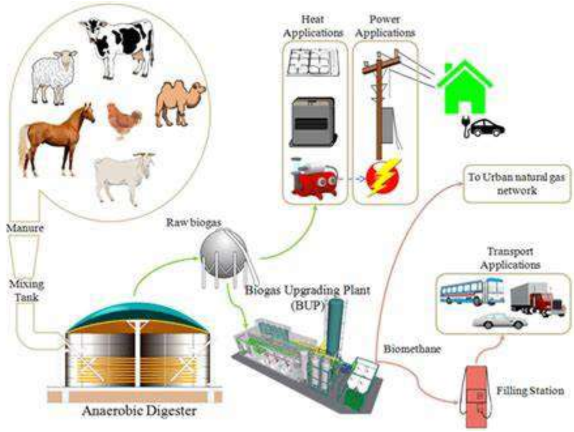
was Rs.5,50,000/- against that of diesel engine Rs.13,37,000/-. The average payback of solar system was four years.

Banas Dairy, Palanpur, Gujarat: CNG Plant

- Application of Biogas to CNG vehicles
- Bio-CNG: Bio-CNG contains 92 – 98% methane. The calorific value is 13000 Kcal kg – which is 2.7 times higher than raw biogas.
- Banas Dairy, the largest milk producing cooperative with more than 10,000 milk producers as members.
- It set up 3,500 cubic meter biogas reactor.
- Plant uses cattle dung and agricultural waste as feedback. Dairy collects 40-45 metric ton of cow dung from 250 farms along with milk collection. Biogas is compressed and stored in cascade. Cascade is delivered to Bio-CNG filling station to fill CNG vehicles. On average 1,000 vehicles are using biogas.
- Dairy distributes dry and liquid organic fertilizer. Dry organic fertilizer is packaged in 50 kg bags.

Organic Waste

- As per one estimate, India has a potential to produce 5.4 million tons of compost from Urban Organic Waste.
- As per Ministry of Housing and Urban Development (Annual Report 2020-21), there are only 1,311 operational wastes to compost plants. These plants are underutilized.
- One way is to use organic waste is to produce "Biomethanation" – it can provide cleaner fuel as biogas and slurry can be used as organic manure.
- Total production – in India, biogas production is reported to be 2.07 billion M/year while potential estimated is 29-48 billion M/year.
- It may be possible to make it compulsory for all Urban Authorities, Corporations and Municipalities to use organic waste as biogas and for organic manure. If they do not comply, no government grant may be released.



Energy Security

Āatmnirbhar Bharat

Issue Wise Action Recommendation

Reducing inefficiency and enhancing quality of energy supply	Use of innovation-based snag-free technologies for energy auditing of supply chain entailing production, processing, storage and distribution and demand side for increasing generation efficiency, reducing transmission and distribution losses and effective use of energy.
Adverse weather events and increased wind velocity brings heavy losses like falling of poles, snapped lines, etc. Last year in Amreli District 100 villages were affected for more than 3 months and remained without electricity	Laying underground lines for rural area need to be done. Big high voltage transmission lines – structure could be strengthened /enforced – but important is detailed survey of all over-ground poles / transmission structures to verify their stability and capacity to face cyclonic thrust and increased wind velocity due to climate change.
Thefts and losses	Vigilance and demand-supply auditing – this has to be done at sub-station level. Theft points need to be located and quick FIR lodged against oflenders/of lenders. Separate dedicated Grid for Agriculture and Domestic purposes with different tariffs structure. Gujarat has already done this. This can be replicated all over country.
Disreptted of DISCOMS and SEB/management	Participation of multi-players in DISCOMS to improve efficiency and give choice to consumers for quality, reliability, and affordability of energy.

Silo approach of DISCOMS and SEB/ management	Reliable rural grid to handle energy from different sources
Price: Low, highly subsidized & Consumption-based	Instead of lower prices and consumption-based subsidy, consumers need to be incentivized for saving the energy. Further, the subsidy may be continued only to BPL consumers. The subsidy / incentive should be deducted from energy bill or it may be transferred directly to consumers' bank account. The awareness creation is desired for responsible use and accountability for energy among the consumers.
Old system with local wood collection that is pollution and labor-intensive job	Adopt Biomass Cooking Stove that has zero maintenance with high end performance and saves 40-50% wood that otherwise would take 4-5 hrs for collection. Similarly, Portable Solar Cooker and induction cooker can be used for cooking and ensuring rural energy security.
Irresponsible and inefficient use of energy, like use high powered tractors, over-sized water pumps, old tools, etc.	The awareness programme should focus on and inculcate responsible, informed, and efficient use of toolsand equipment, depending on actual need. For example, high powered tractors have no use in light soils or for that matter oversized pumps in shallow wells. Information on best management practices (BMPs) needs to be precisely communicated to the farmers through extensive awareness programme, advising farmers what tools and equipment they need to use and not guided by market / sale campaigns.
Management of conflict at grass-root level which need attention and resolution by policy makers. Concept Smart Energy use and plugging inefficient use needs attention at implementation level.	• Use of Petroleum Gas vis-à-vis Biogas. • Use of agro-waste briquettes vis-à-vis coal. • Use of Solar Energy vis-à-vis DISCOM Electric Power Supply. • Inefficient use / waste of energy due to cheap and subsidized power supply. • Production of renewable solar and wind vis-à-vis storage, transmission and integration between electric power and non-renewable power. • Farmer can produce more but lack of evacuation from farms to electrical transmission line.

	• Multiple sources but lack of unified information network to guide rural and urban residents from installation, maintenance, and repairs. • Civil Society members are interested but not involved in entire programme. • Research –education and dissemination of it. • Higher investment in research and development institution. Encourage private sector for same.
Access to finance for roof top to small and medium projected Roof top solar system is not Bankable finance	• Bankable Project have to develop with easy system for process individual or institutional proposal with clearance in time bound.
Climate Change India is warning faster than global average and is already hit by heat waves.	• Action for mitigation and adaptation-at all levels at a base for agriculture or manufacturing. The way of lifestyle will have adaptive and mass education and awareness of the need to use energy efficient and stop wastage.

Conclusion

- In the new millennium – particularly in the last five years India has been able to provide access to energy to all its households – both rural and urban.
- In rural areas, however, there remain problems of disruption, irregularity, and availability (time limit, poor quality and quantity) of power supply by Discom – but it has adequate renewable natural resources. These are biogas, solar energy and local bio-energy like fuel wood, briquettes and dung cakes prepared from cow-dung with agro-waste. Perhaps, if properly harnessed – can supply surplus to urban areas.
- However, what is needed is responsible use by community and families. Local administration has multiple agencies, for programme implementation some at local level others operated from regional or State level. The local self government bodies are not involved.
- There is need to involve Panchayat Raj Institutions to ensure that at village level – Gram Sabha level, families are made aware of need to use renewable sources – and not remain solely dependent of Electric Power Supply – both at farm level and in house and become Self-reliant – Atmanirbhar.
- There is need to develop ENERGY PLAN at district-level - block level and village level - and get it implemented through local level self government bodies of Panchayati Raj institutions in rural areas and Municipal bodies in

urban areas. The country has capable Development Administration. Together the elected and the non-elected members of public administration can make this happen.

- There is need to introduce Capacity Building Programme at multi-level. Educate – up-skill farmers and rural women on how to use solar energy and briquettes. Educate urbanites to reduce wastage and use energy efficiently. Rural youth could be skilled for installation and maintenance of solar appliances and solar systems and bio-gas plants. Government official also up-skilled about how to make solar roof-top accessible to every villager and to ensure that every house has it and provide farmer – solar system which can be integrated with power-grid – so that farmers get income of surplus power generation.
- Amend Building-bylaws-of building plan approvals to include solar roof panels compulsory both rural and urban household and for all existing and future public premises including commercial and non commercial high rise building..
- All these need a comprehensive "RURAL ENERGY POLICY" integrating all that is available and ways to use it with micro-level plan, its execution and monitoring and make Collector of District accountable for its successful implementation. At national level there is thrust on reduction on dependence on oil – gas and coal – by overall energy policy and programmes of Renewable Energy – which are doing extremely well and this has also reduced dependence on oil, gas and coal to certain extent. But despite that dependence on oil, gas and coal will continue for several decades. There is currently no problem related to supply and demand – however, dependence on imports is growing. Local production is on decline. Dependence on imports is dangerous to economy and national security – as recent international events reveal. Current fiscal policies related to oil, gas and coal are working against getting new investment. Even existing projects are not viable and hence decline in production. In fact we have enough coal resources, but we are importing. In case of oil and gas there are existing areas where production can be enhanced – but currently they have become non-viable. In both major players are government companies like ONGC & Coal India. There is potential for enhancing domestic oil & gas. But it needs review of current policies.

Country has taken significant steps in a wide range of areas to make it self-reliant – Atmanirbhar for Energy Security –We end this the vision of Hon'ble Prime Minister Shri Narendra Modi as mentioned in his speech in India Energy Forum oct 26th, 2020. He laid down India's Energy Map comprising seven key drivers. Says Prime Minister Modi "Like the seven horses driving the Sun God's chariot, India's Energy map will have seven key drivers:

- Accelerating efforts to more towards gas based economy.

- Cleaner use of fossil fuels.
- Greater reliance on domestic sources.
- Achieving the renewable targets of 450 GW by 2030.
- Increasing contribution of electricity to decarbonizes mobility.
- Moving emerging fuels like hydrogen.
- Digital innovation across energy system.

He further said "Our Energy Sector will be growth – centric, investor friendly and environment conscious. India's reform journey has been on high speed in the last five years – he added."

Late Shri Kantisen Shroff, Veteran NGO said "the country has prepared it self to meet challenges on Energy Front and provide access to all villages. In fact, it has Energy Security but there are challenges ahead and dependence on imports. The Leadership is already seized of these challenges and multi-pronged programmes are already under progress. Citizens have to also become responsible for efficient use of Energy and reduce wastage". We need each one of us learn to become 'Atmanirbhar' that is the call of our beloved Hon'ble Prime Minister Sri Narendrabhai Modi.

Progressing Towards Āatmnirbharta in Oil and Gas Sector by India

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Introduction

Reducing India's current high dependence in a prudent and sustainable manner on fossil fuels for its overall energy needs, and thereby progressing towards Āatmnirbharta in this sector, is among the priorities of the Indian government. Some observers argue that India needs energy Āatmnirbharta in not just oil and gas, but also in nuclear, coal, solar, and wind.

It should be noted that Āatmnirbharta does not necessarily require India to fully meet its demand for energy from domestic production, but to create strategic alliances for long term availability of the energy sources from global partners, even as domestic production is encouraged.

Saudi Aramco's CEO Amin Nasser has rightly stressed that fossil fuels will continue to play a key role in energy mix for a much longer time, and he has, therefore, urged the world leaders to continue investing in fossil fuels. This observation is supported by other observers.

https://swarajyamag.com/news-brief/aramco-ceo-warns-of-social-discord-and-rampant-inflation-if-fossil-fuels-are-ditched-too-quickly-bats-for-continued-investments-in-oil-and-gas

Accessed on 7 December 2021

The rest of the paper is organized as follows. Section II sets the global and Indian contest for the oil and gas sector and alternatives to reduce relative dependence on them. This is followed by a brief statement of India's renewable energy goals at UN climate change conferences. Section IV discusses avenues which India is pursuing to bring about greater Āatmnirbharta in the oil and gas sector. The final section provides concluding remarks.

The Context

Figure 1 presents oil demand dynamics of the world and of selected groupings and countries, including India. In 2019, India accounted for only 5.2 percent of global oil demand; though between 2000 and 2019, its contribution to world oil demand growth was 13.5 percent, as compared to 45.5 percent for China, and negative 0.8 percent for the United States.

Figure 1 Oil Demand Dynamics

Oil Demand Dynamics	World	OECD	US	Europe	China	India
Crude Oil Demand (2019, MBPD)	97.7	46.1	19.4	14.8	14.3	5.1
World Oil Demand Increase Between 2000 to 2019	21.2	-2.5	-0.2	-1.3	9.7	2.9
CAGR (2000 to 2019)	1.2%	-0.3%	0.0%	-0.4%	5.8%	4.1%
Contribution to World Oil Demand Growth		-11.6%	-0.8%	-6.4%	45.5%	13.5%
Avg GDP Growth (2000 to 2019)	3.1%	2.0%	2.1%	1.6%	9.0%	6.5%
GDP Growth - Oil Demand Growth	1.9%	2.2%	2.1%	2.0%	3.2%	2.3%

MBPD: Million Barrels Per Day

DSP Source: BP Energy Outlook, IMF, Bloomberg Data As on June 2022

Figure 2 shows carbon emission/ capita by country. While India's per capita carbon emission at 1.7 is relatively low, (corresponding figures for the United States and China are 14.4 and 7.1, respectively). This figure will increase as India progresses from USD 3 trillion plus economy in 2022 to USD 10 trillion plus economy by mid 2030s. It is in this context that India's policy goal to minimize increase in per capita emission per trillion USD GDP added acquires significance.

Two of the key reasons for the continuing role of fossil fuels are the projections that supply of key metals is likely to exceed demand. (Figure 3)

The second reason is that supply of these metals is concentrated in only a handful of countries, potentially reducing India's leverage and resilience (Figure 4).

India is, however, engaging in creative diplomacy with several of the countries, such as Russia, Australia, Brazil, USA, and South Africa, which have metal reserves to manage the metal supply chain. Another critical area is metal and minerals refining capacity. China has a large share of global refining capacity and global diversification at a measured pace is a necessity.

Āatmnirbharta requires India to creatively manage and counter this global reality. This is among India's key geo-economic geo-strategic goals.

Figure 2 Carbon Emission Per-Capita by Country

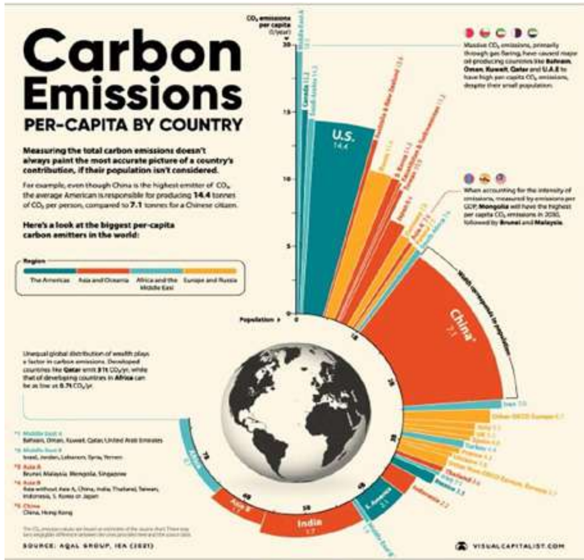
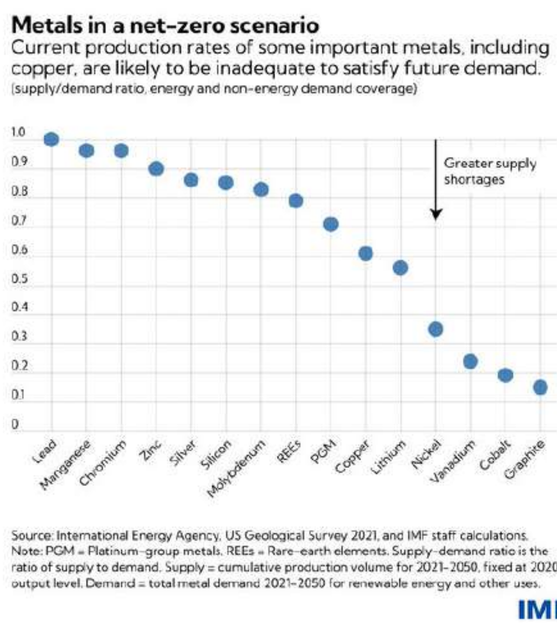
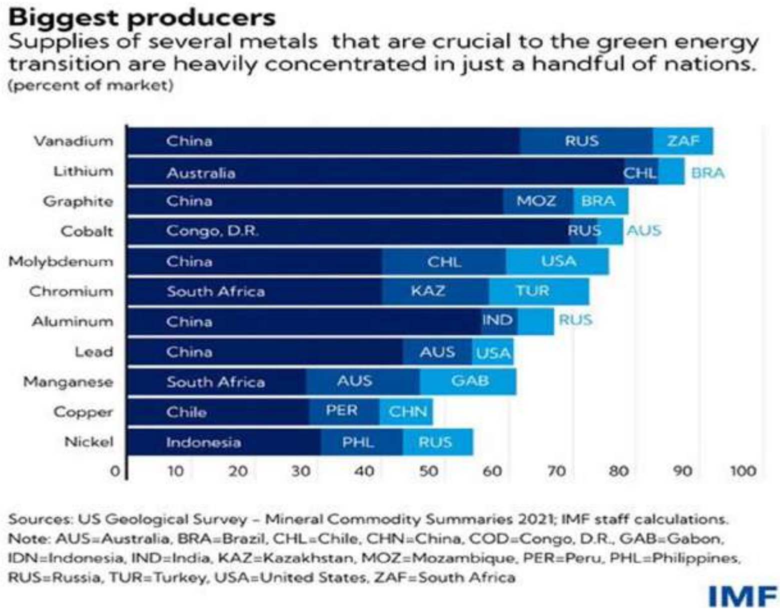


Figure 3 Demand and Supply of Key Metals



Source :Nico Valckx, Martin Stuermer, Dulani Seneviratne and Ananthakrishnan Prasad, IMF Blog, Accessed on 8 December 2021

Figure 4 Major Producers of Key Metals



Source :Nico Valckx, Martin Stuermer, Dulani Seneviratne and Ananthakrishnan Prasad, IMF Blog, Accessed on 8 December 2021

Figure5 shows 20 top producers of oil globally. From India's perspective, US, Saudi Arabia, UK (Shell is now UK company); Russia, and France could be key partners for India in this sector. Absence of any Indian company in the top 20 is noticeable.

Figure 5 Top 20 Oil Producers Globally

India and UN Climate Change Conference Renewable Goals

At COP 21(United Nations Climate Change Conference) in Paris in 2015, as part of its Nationally Determined Contributions (NDCs), India committed to achieving 40 per cent of its installed electricity capacity from renewable energy sources. It achieved this in November 2021 itself, according to the Ministry of New and Renewable Energy

https://energy.economictimes.indiatimes.com/news/renewable/india-achieves-target-of-40-power-generation-capacity-based-on-non-fossil-sources/88062440

Accessed on 3 December 2021

India's installed renewable energy (RE) capacity around 2020 stands at 150.05 GW, a sharp increase from just 30 GW in 2015. India aims over next eight years to add 35 GW of capacity addition per year to achieve 500 GW by 2030.

In 2021nuclear power capacity of India was 6,780 MW, and the plans are to increase it to 22,480 MW by the year 2031 on progressive completion of projects under construction and accorded sanction.

At the COP26 meeting in Glasgow in 2021, PM Modi announced that by 2030, India would increase its non-fossil energy capacity to 500 gigawatts (GW), fulfil 50 per cent of its energy requirements from renewable sources; reduce its carbon intensity of economy by 45 per cent; and reduce total projected carbon emissions by 1 billion tonnes. These are indeed ambitious goals for which Atmanirbharta in various energy sources would be needed.

The Indian government has launched the National Hydrogen Mission to prepare stakeholders to progress towards developing a hydrogen-based economy. This Mission aims to meet the climate target and make India a Green Hydrogen Hub. A key challenge will be to produce it at affordable costs. Green hydrogen produced by renewables is far from competitive compared to other fuels, costing nearly double the price using coal, India's main source of electricity.

Avenues for Greater Āatmnirbharta in Oil and Gas Sector

As the nature of globalization undergoes a shift toward "common-interest country shoring' rather than globalized shoring, economic and strategic diplomacy has acquired greater prominence. For security and for national prosperity and resilience. India is pursuing three broad avenues for greater Āatmnirbharta in the oil and gas sector.

Moreover, if India lacks critical capabilities and technologies, these cannot just be acquired by trade. So, policies need to be consistent with developing needed capabilities and technologies if India is to acquire greater resilience.

The first avenue is creative strategic diplomacy with key global players who can help advance India's goals in the oil and gas sector. The second avenue is investing in renewable energy supply chain with global participation and financing. The third avenue is exploring opportunities to reduce fossil fuel consumption

(1) Creative Diplomacy: Illustrative examples of such diplomacy are as follows.

(i) India's CEPA (Comprehensive Economic Partnership Agreement) with UAE (United Arab Emirates), a key strategic partner who has large oil and gas reserves for greater longer-term reliability of supplies as well as knowhow and investments, host to significant number of Indian workers and professionals, and home to Dubai, a strategic global hub and port, as well as a financial center, came into force on 1 May 2022.

https://pib.gov.in/PressReleasePage.aspx?PRID=1821785

Accessed on 1 May 2022

India is expected benefit from preferential market access provided by the UAE on over 97 %of its tariff lines which account for 99% of Indian exports to the UAE in value terms particularly from labour-intensive sectors such as gems and jewellery, textiles, leather, footwear, sports goods, plastics, furniture, agricultural and wood products, engineering products, pharmaceuticals, medical devices, and Automobiles. As regards trade in services, Indian service providers will have enhanced access to around 111 sub-sectors from the 11 broad service sectors.

The government projects that CEPA is expected to increase the total value of bilateral trade in goods to over US$100 billion and trade in services to over US$ 15 billion within five years.

https://pib.gov.in/PressReleasePage.aspx?PRID=1821785

Accessed on 1 May 2022

CEPA encourages mutual investments through establishing the UAE-India Technical Council on Investment with the objective of promoting, facilitating and monitoring the investment activities, as well as identifying new opportunities for investment. UAE is a large investor abroad, and the agreement should facilitate greater UAE investments within India and with Indian companies abroad.

There are other signs of increased density of India-UAE relations. Thus, Reliance Industries initiated first oil cargo from the UAE trade arm in December 2021. Being present in the UAE will help in searching for new economic opportunities for Reliance Industries in the oil and gas sector.

(ii) Deepening Strategic Partnership with Russia, a Major Producer of Energy, Metals, and Minerals and of Nuclear Technology

India and Russia are pursing creative economic and strategic diplomacy to give impetus to their partnership relevant for the twenty-first century.

India's economic and strategic diplomacy during the NATO (North Atlantic Treaty Organization)-Russia war, involving Ukraine, has been consistent with its national interests, balancing its relations with Russia, NATO, Ukraine, and other key countries.

At the 2021 Annual Summit between India and Russia, India's Prime Minister urged Russia and India need to guide their business communities to reach the target of USD30 billion in trade and USD 50 billion investment between the two nations by 2025.

https://www.republicworld.com/india-news/general-news/india-russia-need-to-guide-business-communities-to-reach-30-dollars-bn-trade-target-pm-modi.html

Accessed on 7 December 2021

Speaking at the same Summit, India's Foreign Secretary noted,

"On the trade and investment side, there are some specific plans which include long-term cooperation in the areas of inland water ways, fertilizers, coking coals, steel, skilled manpower. We have expressed interest in further investments in the oil and gas sector, as well as in the area of petrochemicals."

https://www.india-briefing.com/news/modi-putin-meeting-22-dialogue-expected-to-strengthen-india-russia-ties-23775.html/

Accessed on 8 December 2021

Russia has reportedly agreed to supply state-of-the-art technology to India's Kudankulam nuclear Plant. Nuclear energy is increasingly accepted as among the cleaner energy sources available.

https://economictimes.indiatimes.com/news/india/russia-signs-pact-to-supply-state-of-the-art-tech-for-kudankulam-nuclear-power-plant/articleshow/92683155.cms?utm_source=twitter_pwa&utm_medium=social&utm_campaign=socialsharebuttons&from=mdr

Accessed on 5 July 2022

It is noteworthy that the European Union Parliament in July 2022 declared nuclear, and LNG as "green" sources of energy.

Russia has welcomed India's participation as a reliable partner in the development of the Russian Far-East, identifying sectors such as energy, transport and logistics, maritime connectivity, diamond processing, forestry, pharmaceuticals and healthcare, tourism, and humanitarian fields.

Many Indian businesses have expressed interest to explore these sectors in the Russian Far-East.

The two countries are exploring a shorter sea route between Chennai in India and Vladivostok in Russia's far east, which will replace sea route between Mumbai and St. Petersburg. (Figure 6).

This shipping link would enable to transfer cargo between Chennai and Vladivostok in 24 days in comparison to over 40 days currently taken to transport goods from India to Far East Russia via Europe. Passing through the Sea of Japan, South China Sea and Strait of Malacca, the maritime corridor is designed to protect India's strategic interests, especially in engaging with other major maritime powers, including China.

https://nickledanddimed.com/2021/03/03/power-play-vladivostok-chennai-maritime-corridor/

Accessed on 3 March 2021

Figure 6: A shorter Sea Route between India and Vladivostok in Russia's Far East

Source: https://nickledanddimed.com/2021/03/03/power-play-vladivostok-chennai-maritime-corridor/

Accessed on 3 March 2021

(iii) India-Australia Economic Cooperation and Trade Agreement (AI ECTA)

Both India and Australia are members of QUAD, an informal strategic group comprising United States, Japan, India, and Australia. Its main aim is to keep the strategic sea routes in the Indo-Pacific free of any military or political influence. The QUAD group has gradually expanded its scope of activities in line with multi-dimensional risks to national and international security and prosperity.

Thus, the leaders of the Quad nations met on May 24, 2022 in Tokyo for the fourth time and the second time in person. The Quad summit witnessed the launch of a new initiative for continuous collaboration in the maritime domain, space, climate change, health, and cyber security.

India and Australia have decided to deepen and widen their economic and other engagements beyond Quad. Thus, they signed AI ECTA on 2 April 2022.It is aninterimagreement, with comprehensive agreement to follow by end of 2022 or first half of 2023. Under it, Tariffs will be eliminated on more than 85 per cent of Australian goods exports to India (valued at USD12.6 billion a year), rising to almost 91 per cent (valued at $13.4 billion) over 10 years. Australian households and businesses will also benefit, with 96 per cent of Indian goods imports entering Australia duty-free on entry into force.

https://www.trademinister.gov.au/minister/dan-tehan/media-release/historic-trade-deal-india

Accessed on 2 April 2022.

According to the above source, AI ECTA will also facilitate the recognition of professional qualifications, licensing, and registration procedures between professional services bodies in both countries. Australia and India have also agreed to undertake cooperation to promote agricultural trade as part of the agreement and will now work toward concluding an enhanced agricultural Memorandum of Understanding (MoU).

Australia is a major producer and refiner of critical metals and minerals (Figure 4), and has an ageing population which complements India's relatively young population. A trade agreement with Australia would facilitate better access to supply of important metals and materials necessary to achieve mass-scale transport electrification. As Australia has rich supplies of these minerals and commodities and India has vast demand both could reap significant benefits.

Australia and India have agreed to a partnership to strengthen their co-operation in developing critical metal projects and supply chains. India's

Coal and Mines Minister is visiting Australia to explore joint investment possibilities in Lithium and Cobalt Projects in Australia, which is critical for India's transition towards clean energy ambitions.

https://newsonair.gov.in/Main-News-Details.aspx?id=443572#:~:text=Coal%20and%20Mines%20Minister%20Pralhad,ambitions%20in%20a%20sustainable%20manner.

Accessed on 3 July 2022

(iv) Engagement with Iran, Central Asia and Mongolia

India is also engaging energy and minerals and metals rich countries of Iran, Central Asia, and Mongolia/ Access to them also facilitates greater security space globally.

India and Iran continue their cooperation on the development of the Chabahar Port in Iran as a transit hub for the region, including Central Asia. Delegates from the two counties will meet soon to address operational aspects of the key port. This port is a more economical and stable route for landlocked countries of the region to reach India and the global market.

https://www.business-standard.com/article/current-affairs india-iran-reaffirm-cooperation-on-chabahar-port-a-key-transit-hub-122060900149_1.html#:~:text=Chabahar%20port-,India%20and%20Iran%20on%20Tuesday%20reaffirmed%20their%2 commitment%20to%20continue,aspects%20of%20the%20key%20port.

Accessed on 9 June 2022

India is also developing intense diplomatic engagement with the Central Asian countries. Central Asia is rich with diverse energy resources. In the downstream countries of Kazakhstan, Uzbekistan, and Turkmenistan there are significant reserves of oil, gas, and coal. The upstream countries, Tajikistan and Kyrgyz Republic, are rich in undeveloped hydropower potential.

India is also involved in an oil refinery project in Mongolia, contributing to its energy security.

(2) Investing in Renewable Energy Supply Chain with Global Financing

U.S. International Development Finance Corporation (DFC), the country's development bank, announced on 7 December 2021 that it approved up to $500 million of debt financing for First Solar Inc., the largest American solar manufacturing company to build a solar-panel factory in Tamil Nadu, India.

The DFC financing will support the First Solar's previously announced vertically integrated photovoltaic (PV) solar module manufacturing facility in Tamil Nadu, India, with a projected annual capacity of 3.3 gigawatts (GW). The USD 684 million facility will commence operations in the second half of 2023.

(3) Finding New Opportunities to Reduce Fossil Fuel Consumption

There are a large number of such opportunities in transport, infrastructure and other sectors as well as in changing consumption patterns. Illustrative examples are given below.

Reforming Electricity Distribution Companies for more reliable and efficient supply could significantly reduce the use of economically costly use of generators in residences, businesses, and industrial units.

India can reduce its carbon foot print by partly replacing chemical fertilizer and coal fired electricity with natural manure and gobar gas. It is reported that in the United States, states such as California has developed significant gobar gas industry.

Another major opportunity is reducing reliance of around 400,000 telecom towers in India on fossil fuels.

Telecom tower operators currently use diesel generators, batteries, and a variety of power management equipment to address the demand-supply gap. The resulting energy costs alone account for 25 percent of the total network operating costs, affecting the profitability of the operators.

This could help in reducing demand for fossil fuels.

India is developing on its eastern coast the LNG terminals at Kakinada, Andhra Pradesh, and in Dhamra, Odisha, with global partners. These are designed to meet India's growing demand for LNG, a cleaner fuel. The existing LNG import terminal at Ennore, Chennai, will also play an important role in LNG-related import and distribution.

India is also investing heavily in modernizing and expanding its existing oil refineries to make them more efficient, as it approaches Āatmnirbharta in the oil and gas sector in a nuanced manner.

There are also possibilities to reduce fossil fuel consumption in agriculture by measured moderate shift towards crops which are less water and energy intensive; and by a shift to economically more rational pricing policies towards water, fuel, and other resources. Change in consumption habits could support such a production shift.

Concluding Remarks

Progressing towards the goal of greater Āatmnirbharta represents major challenges for India. This reduction should however be undertaken in a sustainable manner, particularly not reducing fossil fuel usage and investments pre-maturely.

Three avenues which could help in progressing towards the goal are creative diplomacy with key global players to enhance capabilities; investing in renewable energy supply chain within India, including in hydrogen technology; and pursuing greater fossil fuel efficiency in both production and consumption.

Āatmnirbhar Energy Strategy Needs Long-Term Vision

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Our energy strategy needs a relook because of the number of changes that have taken place in the international environment. The most important one here is the concern for climate change and our promise to make India a net zero emitter of Greenhouse gases (GHGs) by 2070. Why self-reliance or Āatmnirbharta is important for India is evident from the large dependence of India at present on imported energy and energy technology. Some 80% of our consumption of petroleum products depends on imported crude oil. Even for coal for which we have large reserves, we import some 20% of our consumption. 25% of the gas consumption is also based on imported LNG. Clearly reaching net zero and being self-reliant pose important challenges for India.

First of all, our coal reserves are estimated to be around 110 billion tonnes and our consumption is 0.9 billion, it is likely to increase to 1.3 or 1.4 billion tonnes in the coming years. However, from the reserves of 110 billion tonnes, extractable coal is much less. In our conventional mines only around 40% of the reserves are extracted. The extraction ratio can be increased by using different technologies and can be as high as 60% and in some cases even 85%. If you take an average, somewhat optimistic, extraction rate of 60 % our total extractable coal reserves may be around 66 billion tonnes. Thus, even with these large reserves of coal we may run out of coal within 45 to 50 years depending on how fast our coal consumption increases, how much it is based on domestic coal or how rapidly the technology of mining improves.

Coal is our major energy resource and our need to use coal would be there even when we go for a net zero target. The solution here is that we need to develop climate sensitive technologies such as CCS, carbon capture and storage, or CCU, carbon capture and use. CCS involves an energy penalty of around 20% but the more important problem is we do not know what is the country's potential of storing carbon dioxide. There are also concerns about the safety of such storage sites and whether they can pollute groundwater or escape in a sudden burst into the atmosphere. In any case what India needs to do is to assess the potential of carbon storage in the country. Then we can have some idea of how much coal we can safely use using the CCS Technology. Similar problems are also associated with carbon capture and use. There are industries in which captured carbon can be used effectively in the manufacturing process itself but here again we need to assess the total potential of such CCU.

Concerning our large dependence on imported crude oil two possible options one can consider. One is to increase domestic production of crude oil. The sad reality is that for nearly 20 years our domestic crude production has not increased. This is not to underestimate the efforts of our public sector units involved in maintaining the same level of production for many years. Explorations by the domestic firms have not particularly been successful, nor have we been successful to attract large multinational corporations to invest in explorations in India. Either the terms that we offer are unattractive or the multinationals assess our potential oil reserves to be not sufficiently large to attract them in the country. The second option to reduce our dependence on imported crude oil is to find a substitute for areas in which petroleum products are used by an energy source that we can domestically produce and generate. Cellulosic ethanol produced from agricultural wastes can replace some fuels in the transport sector. Replacement of internal combustion engine based conventional motor vehicles gradually by electric vehicles can reduce our need for petroleum products. That however requires that electricity generation should be as clean as possible so that the emissions get really reduced from the transport sector.

What are our options for having power sector that is emitting as little as possible? We can replace present coal plants with coal with CCUS, nuclear power, solar or wind as well as by hydrogen and cellulosic ethanol.

While nuclear energy provides clean power without any GHG emissions there are certain problems that we need to be aware of. Most of our nuclear power plants have taken much longer than scheduled and have not been built within the original estimated cost. Nuclear power has not met its targets over the last 50 years since the first nuclear power plant was built at Tarapur in the late sixties. There is however a silver lining. I am told the last two units at Tarapur, TAPS -3 and TAPS-4 were built on time and within cost.

Our nuclear power strategy is based on a three-stage development. Since we are short of Uranium, the whole idea was to build uranium plants in Phase 1. These reactors produce along with generating electricity, plutonium and depleted uranium as by-products. Once enough plutonium has been accumulated, we can build in phase 2, fast breeder reactors (FBR) which use the plutonium and the depleted uranium. The fast breeder reactor generates power and produces more plutonium than what was put in. Once we have a number of fast breeder reactors in Phase 2 we would have the opportunity to put a Thorium blanket around the reactor of a fast breeder to convert Thorium into fissile material. We have an abundance of Thorium and it was felt that in the 3rd phase we would have unlimited nuclear power based on Thorium. Thorium by itself is a fertile material but not a fissile one and that is why it was necessary to convert it into fissile material using fast breeder reactors.

India has been building the first large-scale commercial fast breeder reactor in the world for many years. For the last 10 years I have heard that the FBR will go critical next year. Unfortunately, this has not yet happened. So, our rapid move into the third phase of abundant nuclear power based on Thorium, is stalled. It is true that with the fuel supply agreement signed during the UPA government we are now able to import first generation uranium-based power plants and the required fuel from abroad. However, such reliance on imported Uranium is not consistent with our idea of Āatmnirbharta.

Apart from nuclear, solar and wind are two renewable options which hold high promise. The costs of these have been coming down, particularly that of solar power plants, and now at least when it is available solar power is competitive to coal power. The problem with solar and wind power is that they are available only when the sun is shining or the wind is blowing. There is a requirement for some other forms of power to balance the load. A number of options are available. One could have pumped storage and recent analysis has shown that India has substantial potential for off river pumped storage schemes. These can be small and can be constructed quickly without involving much displacement and resettlement. These need to be explored and their costs need to be estimated. Another option would be electricity storage in batteries. India can have power trade with Bhutan and Nepal and import hydro power and supply them base load power. Studies at IRADe have shown that large amount of renewable power can be used in India with balancing power coming from Bhutan and Nepal. Battery prices have been coming down and it is expected that maybe within 20 or 30 years solar with battery storage may compete with coal-based power plants. The problem with batteries is that these are mainly lithium ion batteries and China is the major source of lithium in the world. So, if we go for large use of lithium ion batteries, which will be also required for electric vehicles also, then we become again dependent on imports from China. Thus, we might reduce our dependence on import of oil from Middle East but increase our dependence on imports from China.

Even when cheap battery storage is available expansion of renewable energy Will face another problem. The electricity distribution companies, Discoms, are not able to fulfil even the modest renewable portfolio obligation set for them that requires them to have a certain portion of electricity they distribute from renewable power. When the share of renewables increases substantially Discoms' ability to absorb them will have to be taken care of. The financial status of Discoms has been precarious for many decades and despite many programmes and support measures announced by the central government there has been no substantial improvement in their financial situation. Many states are reluctant to reform the Discoms for a variety of political reasons. In fact, just before elections in most states political parties announce significant giveaways and one of the important ones here has always been subsidy on power. Given the experience recently of farm laws, which were retracted due to strong opposition by farmers in just one state even though farmers in many other states might have welcomed the reforms, political parties are likely to be reluctant in facing opposition that they might get by reforming power tariffs. While privatization of Discoms may appear to be an attractive option it is unlikely that many state governments would want to embrace that. Of course, there have been some states like Gujarat where state owned Discoms' performance have significantly improved due to the strong support given to the Discoms by the then chief Minister Shri Narendra Modi. Such support does not seem to be likely in other states.

Another option would be to develop green hydrogen, that is hydrogen manufactured using renewable electricity. Hydrogen would be needed in any case for a number of hard to replace fossil fuel industries and also for long distance truck transport. Hydrogen can also be used in hydrogen powered fuel cells to provide electricity to vehicles. The versatility of hydrogen, therefore, is quite attractive though the costs are not as yet competitive. There are many countries such as the USA, and even Reliance in India, have a target to produce hydrogen at the cost of one US dollar per kilogram of hydrogen within a decade. The government of India has also mounted a hydrogen mission but its contours are yet to be finalized.

To substitute fossil fuels in industries and transport we need to develop cellulosic ethanol based on cellulosic by-products of agriculture such as rice straws, wheat straws etc. Here again the technology needs to be developed so that the costs are comparable to petroleum products which are being substituted. There is also an issue of the costs of collecting agricultural biomass and transporting it to factories which make cellulosic ethanol. The price to be paid to farmers should be attractive enough for them to sell straws rather than burn them.

We can now summarize the main conclusions that emerged from the discussion so far.

- In order to use our coal reserves, we need to develop CCS and CCU technologies as well as assess the potential of these technologies in the country so that an idea of how much coal can be used.
- To expand nuclear power to its large potential in an Āatmnirbhart away, the FBR must work. An expert body should assess the reasons why it has been delayed and find ways to overcome the problems.
- Assess the potential for solar and wind, both onshore and offshore, in the country. The available potentials are based on old estimates and vastly inadequate for a Net Zero India.

- Promote electricity trade among Bhutan, Nepal and India.
- For solar power focused research should be done to improve efficiency of solar photovoltaic cells as it will reduce the area needed.
- Even more important is to develop battery technology that relies on widely available materials.
- The potential for off river pumped storage schemes should be assessed so that an effective system of balancing renewable power can be set up containing our need for importing batteries.
- For replacing fossil fuels in transport electric mobility is important. However, to hasten its adoption, cheap, efficient and lightweight batteries are critical. Thus, R&D in batteries is of vital importance.
- Hydrogen seems to offer the best option for many industries, heavy vehicles and even airplanes to replace fossil fuels. The national mission launched for hydrogen should also focus on reducing its cost. A public-private partnership may provide a good opportunity for this.
- Development of biofuels based on cellulosic agricultural by-products to replace petroleum products to reduce costs is needed.

We see that in almost all areas for a self-reliant energy strategy, we need to do research to develop technologies. We need to keep a long-term perspective and aim to produce state of the art, not as of today, but state of the art when the R&D is completed. R&D should aim to fight tomorrow's battles and not today's battles. This is equally, if not more, relevant for defense R&D. If China can become a global technology leader in thirty years, surely India with its human resources can do it in twenty years provided sustained support is provided by the government.

Impact of Energy Security on Sustainable Development

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Introduction

Energy security is not only crucial but an imperative issue for each and every country. In this world energy is around us in different forms (solar, wind, water, fossil, nuclear, thermal and biofuels). However, the knowledge, technology, and processes of harnessing the different forms of energy into useable and safe energy remain to be a challenge. Energy can also be categorized as renewable or non-renewable resources of a country. Each of the two categories of energy has its challenges. Despite the abundancy of potential energy sources, to date billions of people continue to be without basic modern energy services. This situation is expected to change only a little by 2030 unless more vigorous action is taken (International Energy Agency on Energy Access). We use energy to cook our food, heat or cool our homes and offices, charge our electronic equipment, light our streets, drive our cars, cultivate our farms and so many other uses. Those who do not have access to reliable and affordable energy sources are said to be "energy poor". "Energy poverty" impacts one billion people worldwide, as their well-being is negatively affected by a low energy consumption, use of dirty or polluting fuels, and excessive time spent collecting fuel to meet basic needs. According to the International Energy Agency, for people in developing countries, having access to energy is fundamental to reducing poverty and improving health, increasing productivity, enhancing competitiveness, and promoting economic growth. Because access to reliable and affordable energy is essential in the struggle against poverty, former UN Secretary-General, Ban Ki-moon, called on governments, businesses, and civil society to achieve universal access to modern energy services by 2030 through their "Sustainable Energy for All" program.

Energy security is a complex issue attained when a nation can deliver energy economically, reliably, environmentally sound and safely, and in quantities sufficient to support a growing economy and defence needs (Miller, 2011). The United Nations defined energy security as "the continuous availability of energy in varied forms, in sufficient quantities and at affordable prices" (World Coal Institute, 2005). The

International Energy Agency (IEA) defined energy security as the "uninterrupted availability of energy sources at an affordable price" (IEA, 2018). Another aspect of energy security is the need for system reliability such as the continuous supply of energy, particularly electricity, to meet consumer demand at any given time (i.e., short-term security). There are many drivers governing secure supply of energy (World Coal Institute, 2008):

This will require policies that support expansion of the energy supply and delivery infrastructure (with sufficient storage and generating reserves), diversity of fuels, and redundancy of infrastructure to meet the demands of economic growth. Energy security is a prerequisite for economic and social development of any nation. Energy can be produced from different sources, mainly fossil fuel (coal, petroleum, and natural gas), solar (photovoltaic), wind, hydro, nuclear, and renewable bioenergy (plants, algae). The major form of energy delivery is electricity and petroleum (hydrocarbon). Energy security is the continuous availability of energy in its various forms, in sufficient quantities and at affordable prices (World Coal Institute, 2005). Continuous and uninterrupted availability of energy to a specific country or region is the essence of energy security (Speight, 2017). However, energy security is a complex term with a wide range of implications on society in terms of national and international policy, politics, economic, environmental, social, and technical dimensions (Jakstas, 2020; Sovacoolet al., 2012; Miller, 2011). In order to attain energy security, we must; i) encourage energy conservation and efficiency, ii) maintain diverse sources and supplies of energy while enhancing domestic production; iii) accelerate research and development (R&D) to create and deploy advanced energy technologies, and iv) develop and implement effective energy contingencies and emergency plans (Miller, 2011). Energy system of a nation (infrastructure, delivery, and services) must have low exposure to risks (low vulnerability) and resilient to external factors, natural (e.g., climate change) and manmade (e.g., sabotage).

Energy security has been defined by the United Nations as "the continuous availability of energy in varied forms, in sufficient quantities and at affordable prices" (World Coal Institute, 2005). In terms of energy security, a key issue is resources availability, which is the actual physical amount of the resource available around the world (i.e., long-term security). Another aspect of energy security is the need for system reliability such as the continuous supply of energy, particularly electricity, to meet consumer demand at any given time (i.e., short-term security). There are many drivers governing the secure supply of energy (World Coal Institute, 2008), including; i)diversification of generation capacity—to allow prices to remain reasonably stable, ii) prices—energy must be affordable, iii) levels of investment required—a significant investment is needed to meet the forecast growth in energy demand and the availability of that investment can be problematic in developing countries, iv) ease of transport—energy must be readily available, v) concentration of suppliers—the reliance on imported fuels from a limited number of suppliers increases the risk of adverse market influence, vi) availability of infrastructure expertise—countries must have access to different energy sources to achieve a diverse energy mix vii) interconnection of energy systems—the interconnection of energy systems, particularly electricity, must be considered, viii) fuel substitution—diversification in the uses of fuels may also be important for energy security, and ix) political threats—the energy supply system can be vulnerable to disruptions caused by political interests and terrorist attacks (Miller, 2017).

Nowadays energy security studies have shifted from the classic approach and become an interdisciplinary field. Climate change, globalization, and uncertain future of fossil fuels have added new dimensions, such as sustainability, energy efficiency, mitigation of greenhouse gas emissions, accessibility of energy services (energy poverty), etc. Thus, the concept of energy security became interconnected with other environmental, social, political, and security issues. One of the aims at capturing multidimensional essence of energy security is international research about differing perceptions of energy security (Sovacool et al., 2012). The term energy security has been broadened to include dimensions such as i) energy education and ii) transparency in energy projects. To go further, Sovacool adds the concept of "cultures" within the energy sector. He argues that different perceptions could be explained by a culture to which a person belongs (Sovacool, 2016). In addition, Sovacool (2016) note that at least five different cultures, such as national, economic, political, professional, and epistemic could exist. The author shows the multidimensional essence of energy security, but also adds to the discussion how this matter is differently perceived by different subjects based on their own preferences.

Another effort to conceptualize the term is a study by Cherp and Jewell (2014). They focus on the concept of security *per se* by emphasizing that when talking about energy security we need to ask "what to protect?" They describe energy security in a broad term as "low vulnerability of vital energy systems." Vulnerability rises from exposure to the risks, be it natural or from other social actors, and resilience. The authors trace vulnerabilities within different energy systems, including energy infrastructure, energy services, and renewable, among others. This term helps to define energy security in a universal way, but as authors themselves note, it is still very abstract and is dependent on the actor using it (Cherp and Jewell, 2014). Therefore, energy security is a complex and ambiguous concept.

For the purpose of this chapter, energy security has two meanings, i) diversification of primary energy supplies and ii) reliability of the power system. A diversified energy generation system (supply) includes renewable (solar, wind, biofuels) and non-renewable (fossil fuels and nuclear) sources. In order to enhance energy security, we must do the following; i) encourage conservation and energy efficiency, ii) maintain diverse energy supplies while enhancing domestic production and delivery, iii) maximize economic efficiency, iv) accelerate research and development (R&D) to create and deploy advanced energy technologies, v) develop and implement effective contingency and emergency plans, and vi) develop policies based on sound science and realistic economic, national security, and environmental needs to make decisions that are timely, consistent, and coordinated with energy security, economic, and environmental objectives (Miller, 2011).

Energy Security and Economic Growth

Energy is the backbone of our economies and an essential element for both economic growth and poverty reduction (Lee and Nguyen, 2019). Ensuring and securing the energy needed by a country is a fundamental requirement for sustainable economic growth and social welfare of that country (Bompardet al., 2017). Almost all sectors of a vibrant economy (industry, agriculture, service, military defence) require and use energy in one form or another. For example, efficient production on motor vehicles, agricultural produce, services (health, education, tourism, hospitality) and military defence require energy. Energy security is a national security imperative for sustainable development in all fronts. Depending on one form of energy is counter intuitive and irresponsible. Nations must develop their energy policies based on sound science to address their economic, social, environmental, and national security needs.

Too often energy for economic development, energy security, and climate change mitigation have been pursued as separate themes, each attracting its own constituencies. Several studies have shown the linkages among the three themes, implying that each can be strengthened through cross referencing the others (Feinstein, 2002; Lu et al., 2006; Cherpet al., 2016; Prado et al., 2016). A study by Le and Nguyen (2019) suggested that at a global level, economic development, energy security, and climate change mitigation should be pursued as integrated themes since there are linkages among these three agendas. Any national policy for economic growth and development that does not address energy security is nothing short of fantasy, as energy security is a driver for economic growth.

Evaluation of energy security needs to consider different dimensions and is of the utmost importance as a benchmark to conceive and implement different policies. Assessment of the level of security should rely on science-based models that are able to track the rapidly evolving geopolitical scenarios, and to provide detailed information and quantitative indexes to policy decision makers. The importance of national energy policy for economic growth cannot be emphasized enough.

Energy Security and Food Security

The first World Food Summit, held in 1996, stated that food security "exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs (FAO, 1996). Energy is involved in food production, processing, storage, retail distribution, preparation, and cooking. Therefore, energy security affects food security both directly and indirectly. On the other hand, food security has a key role in alleviating energy poverty (the lack of access to sustainable modern energy services and products) by being a source of energy (biofuels). The nexus between energy and food could not be more obvious. Sustainable food systems require adequate, reliable, continuous, and affordable source and form of energy. A food system includes production, processing, distribution, marketing, acquisition and consumption. All these activities (or processes) require reliable and affordable energy. The cost of energy has been shown to increase the cost of food.

Improving access to energy across the developing world is key for improving the lives of people in poor communities. For example, there is an estimated 2.7 billion people relying on traditional biomass (charcoal and firewood) for cooking and about 1.4 billion without access to grid electricity. Majority of people in Africa and South Asia are energy poor (Kerekezi and Kimani, 2004; Kerekezi et al., 2005; Kerekezi et al., 2012). Energy plays a crucial role in enhancing food security through technologies that can be used for water pumping and irrigation. Energy is required for mechanical power tillage, planting, harvesting, storage and transportation of produce from the farm to markets. Without access to electricity and sustainable energy sources, communities have little chance to achieve food security and will have no opportunities to secure productive livelihoods as well as alleviate poverty.

Energy Security and Climate Change

Energy security and climate change are some of the major obstacles to the socio-economic development in the world. Greenhouse gases (GHGs) are major human influenced climate drivers. Use of certain sources of energy (e.g. coal and petroleum) produce large amount of CO_2, a greenhouse gas. Increase of CO_2 in the atmosphere due to energy generation and use cause global warming. Climate change mitigation intends to reduce greenhouse gas emissions and concentrations in the atmosphere. Climate change adaptation means taking appropriate action to prevent and minimize damages and to take advantage of opportunities created by such change. The strategies employed by major US cities (and other countries) to promote energy security include: i) retrofitting existing commercial and multifamily buildings to improve their energy efficiency and reduce their reliance on fossil fuels for heating and cooling, ii) implementing net-zero energy building code for new construction, iii) improving energy efficiency and reducing overall consumption, iv) increasing electricity generation and optimize energy distribution system, v) increasing the share of renewable energy in energy supply, vi) developing renewable portfolio standards to steadily increase the use of renewable energy, vii) reducing dependence on private vehicles and increasing the use of public transit, viii) increasing biking and walking, and ix) deploying zero-emission electric vehicles (Zhang et al., 2011).

The strategies adopted by major US cities are as follows: i) deploying cool roofs, green roofs, reflective pavements and other new technologies to mitigate the urban heat island effect, ii) improving transportation and utility infrastructure to maintain variability during extreme weather events (e.g., heat waves, severe storm, flooding), iii) upgrading existing buildings and designing new buildings and development projects to withstand climate change impacts, and iv) strengthening community, social, and economic resilience to make neighbourhoods and communities safer and more prepared.

Mitigation of climate change can be attained by harnessing new technologies, promoting renewable energies, improving efficiency of older energy systems, or changing management practices or consumer behavior. According to the Intergovernmental Panel on Climate Change (IPCC, 2014a, 2014b), mitigation is the effort to control the human sources of climate change and their cumulative impacts, notably the emission of GHGs and other pollutants, such as black carbon particles, that also impact the planet's energy balance. Mitigation also includes efforts to enhance the processes that remove GHGs from the atmosphere, known as sinks. Mitigation of climate change is delineated as "a human intervention to reduce the sources or enhance the sinks of GHGs.

Energy Security and Geo-politics

A combination of energy and geopolitics can disrupt regional stability and have major effects on global energy markets. By monitoring challenges and opportunities at this intersection, emerging risks can be identified, and trends can be highlighted to provide a clearer picture of the global energy landscape. The current war between Russia and Ukraine is a good example of energy and geopolitics. Russia is a major source of energy (petroleum) to Europe while Ukraine is a major source of cereal (wheat) to many countries, including the continent of Africa. The evidence of rising of energy cost and shortage of food can be linked to geopolitical posture by Russia. Russia's war with Ukraine is making energy a new battlefield. The geopolitics of the Middle East dictate the price of energy around the world, with far reaching ramifications, including wars (e.g. the Gulf war). Traditional geopolitical considerations have become even more complex with global climate change.

Since the industrial revolution, the geopolitics of energy, including who supplies it and securing access to those supplies, have been a driving factor in global security and prosperity. Over the coming decades, energy politics will continue to become more complex (CSIS, 2019).Confronting challenges of energy security in the context of geopolitics requires an understanding of the fragility of international oil and gas markets, but also of the nexus among national security, economic growth, food security and climate change.

Energy Security and National Security

The concept of national security remains ambiguous and it is evolving as it means different things to different people. The narrow sense of national security emphasized the ability of a nation to protect itself from military threat and attack from another country (military strength). To date the concept of national security encompasses non-military concerns such as economic security, energy security, environmental security, health security, food security, climate change, terrorism, religious and political extremism. Unlike national security, national defence specifically refers to the ability of the armed forces to defend the sovereignty of a nation and the lives of its people.

A nation that lacks secure energy cannot defend itself. We strongly believe that a nation's ability to feed its people is paramount to national security. Simply put, national security heavily relies on energy security. Any national policy on national security must put priority on energy security to address the complexities of national needs.

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Transforming the Policy Intent of Climate Resilient Economy into a Reality: The Indian Case

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Six important strands of public policy are evident in India's preparedness to tackle impacts posed by climate change. A synthetic approach is, therefore, evident in her case even as she strives to meet the developmental aspirations of her citizens through climate resilient pathways. These include a value-based acknowledgement of the issue at the global level, policies that address the entire value chain, a groundswell of stakeholder response as part of locally relevant concerted action and an open – ended systemic perspective through missions to sustain actions and outcomes. This landscape of inter – twined thrusts as part of country's preparedness is a case in point. India SDG index and dashboard reveal the fact that SDG 7 in particular implies universal access to energy services and high orders of energy efficiency driven by a robust energy mix. Importantly India is awake to the implications of phase down and just-transitions for livelihood of millions of people employed in energy intensive end use sectors.

The first of the six strands is about the fact India always made her intentions clear about energy security. This reflects resolute leadership even in inclement geo-political contexts. This was evident recently and consistently so at the G7 summit[1]. India's policies are designed to serve the developmental aspirations of its citizens through an integrated economic and holistic development perspective. India's bilateral agreement for instance with Germany[2] on clean energy and with the USA[3] for instance optimize on technology and policy cooperation. The latter includes the annual U.S.–India Energy Dialogue; and in addition, India's inputs in the multilateral Clean Energy Ministerial forum. The UK – India initiative covers the climate and clean energy imperative including a much-needed focus on resilient infrastructure[4].

The second is about an enabling milieu for action beyond rhetoric. India, reportedly met her NDC target through non-fossil based installed energy capacity, supported with market and institutional mechanisms across sectors to sustain transitions[5]. Bold business strategies by several industries in India[6] provide the impetus for alternatives. Energy sector companies across production, storage and delivery of energy as a service adapt across value chains and commit to de-carbonize. These also help mainstream SDGs right at the local level, as stated, for instance by the Global Observatory on Local Democracy and Decentralization and the five prongs of the High-level Dialogue on Energy.

India's systemic approach to meeting the net zero commitment is best exemplified by the energy sector. This signifies the third strand. India's energy transition policies and plans recognize its interface with agriculture, health, water, sanitation, industrial production and consumption, transport and the buildings sectors. They address capacity gaps to forecast impacts, the interplay of tariffs, quotas and subsidies and imperatives of expanded grids, reducing transmission, distribution and aggregate technical and commercial losses to enhance the financial viability of the sector.

Heuristics and innovations, customer service standards, efficient energy markets, accountability and institutional capacities are central to the envisaged success. The Electric Mobility Mission and the National Hydrogen Mission are cases in point. Importantly coal can be expected to, however, be the mainstay for a significant while.

The third strand is signified by local action. India's power sector for instance takes note of the groundswell created by such initiatives as Climate Investment Funds, the Green Hydrogen Alliance, Climate Action100 and Climate Group's EP100 involving energy - smart companies. Several Indian public sector enterprises partner, and signify the spirit of SDG 17. Climate related disclosures, efficiency improvements and alignment with Task Force on Climate-Related Financial Disclosures (TCFD) are part of this coming together. India's Business Responsibility and Sustainability Report framework calls for internationally accepted ESG reporting. India's Cooling Action Plan will help her fulfil her commitments for integrated protection of climate and ozone layer systems. India has simultaneously established cross-border trade and regional network integration for more efficient and secure systems of power supply. Importantly, domestically, cycles of the Perform Achieve Trade (PAT) practices reduced specific energy consumption in energy intensive industries enabled through an integrated market-based mechanism. Thermal power plants and distribution entities joined the initiative. NITI Aayog's National Strategy to Artificial Intelligence addressed issues of cyber security, data privacy and the need for system specific models to forecast energy generation especially through micro grids in remote areas.

The fourth strand is about related externalities. The frequency and intensity of cyclones and floods have increased significantly. Loss and damages, they inflict cost India billions of USD. These influence the disaster-energy consumption nexus and paths to recovery. It is, therefore, essential to insulate investments based on a deeper understanding of vulnerabilities to chronic and acute risks. Interestingly multilateral development banks enable and rationalize climate – action through robust tracking of outcomes of various instruments of financing. This will help banks and financial institutions in our country screen better for climate resilience and incentivize project developers to incorporate mitigation and adaptation strategies.

Learning from emerging frameworks is the fifth and overarching strand. The IEA's de–carbonization scenario and the Transitions Pathway Initiative provide useful lessons for the electric utility companies in particular. The Institutional Investors Group on Climate Change's strategy outlines priority actions for the sector recognizing that its own de – carbonization will influence climate efficiency plans of other sectors. Power sector leaders also take note of the2-Degree and Beyond 2 - Degree Scenarios, the Paris Agreement Capital Transition Assessment, World Energy Model framework and others with special reference to the policies interface. Technology leapfrogs and pole-vaults are an integral part of the emerging ethos of sustainability

The sixth strand is about acknowledging the reality that India is at a unique space / time coordinate. She is poised to pole vault into pathways that address the energy trilemma through strategically important evidence-based governance. It is, however, essential to secure deeper understanding of the limits and limitations of technologies and ecosystems services of nature's sinks to plan for integrated mitigation and adaptation gains. Human knowledge and skill capital that imbibes insights from emerging frontiers of science, technology and practice are central to transitions. This was rightly articulated by Fankhauser et al[7] as credible net – zero transition. These are related to often highlighted implications of policy preparedness to reduce externalities[8, 9]. That industry across several sectors of the economy and the government are also poised to lead such transitions[10 - 13] createing hope to ameliorate. The long arm of law too will ensure compliance[14].

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Energy Security-Natural Calamities

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Recent global events such as the COVID- 19 pandemic, extreme weather events and the Russia- Ukraine war have brought to the forefront, the need for countries and their citizenry to become more resilient. Such crisis events are not new and happen with regular frequency in various parts of the world whether it is in health, weather, economy, or politics. Common amongst all these crises is often the pure unpredictability of its occurrence, location, severity, and duration. Despite developments in technical fields of forecasting, monsoons can only be predicted as a likelihood or probability distribution with forecast errors and pinches of salt (and hope). Despite major advances in biotechnology and immunology, even after its advent, uncertainty prevails as to the preventive steps to take, the short and long-term impacts of the virus has continued. Business and industry as well must make decisions now despite uncertainty about the future. The key to resilience in all these circumstances is often to not veer from the long-term goals/purpose set for the person, the company or the nation due to these unexpected challenges but incorporate short term resilience solutions while moving toward the long-term purpose.

Extreme and Unexpected Weather Events could Push Critical Infrastructure to its Limits

A core element to the wellbeing of modern life is the need for energy to fuel our economic production, transportation, medical care, and comfortable living. In February 2021, the State of Texas in the United States was pushed to its limits to cope when three severe winter storms with temperatures well below freezing unexpectedly hit within 10 days of each other. The energy infrastructure broke down as equipment froze shutting down production and distribution at a time when need/demand would have been high. Over 4.5 million homes and businesses had no power for days if not weeks and the entire state was within minutes of the electricity grid shutting down. Over a hundred people died and millions were freezing in the bitter cold and estimated economic damages were in the hundreds of billions of dollars as it became the Costliest Disaster in Texan history. Texas is the largest energy producer in the US and was brought to its knees by this unexpected convergence of multiple factors. Weather proofing the production and distribution infrastructure for every unlikely extreme weather is prohibitively costly and the lack of such investments has been argued to be one of the factors that caused this breakdown. Resilience is not building a permanent infrastructure that could withstand every unlikely event and is not needed unless the extreme event happens, spending enormous resources that could be spent toward other critical services. Resilience perhaps is looking for smart solution such as short-term (and far less costly) fixes such as cooperative agreements with neighboring regions to ensure temporary crisis delivery while continuing to build long term smart grids to efficiently provide electricity to all.

Complex Challenge of Balancing Climate Change Goals with Economic Growth Requires Smart Energy Solutions

As countries around the world address measures to reduce their carbon footprint, the challenges of balancing climate goals with immediate needs to provide for the present-day economic wellbeing of their citizenry is a daily decision. Resilience requires governments to follow the compass on the road to their long-term goals while looking for short-term solutions to short term problems. In September 2021, the Northeast Province and Guangdong in China, faced an unexpected crisis. The rapid increase in Post COVID manufacturing caused a surge in demand for energy. As part of its efforts to cut down on coal, China had been cutting back on coal production and other coal exporting countries were facing shortages of their own. This unexpected shortage of coal to produce electricity at a time of an unexpected surge in demand for electricity caused major rolling blackouts and shutdowns. Similarly, a severe shortage of coal brought a dramatic cut in electricity production in India in 2021. Like China, over 70% of India's electricity generation is coal powered. Faced with a shortage of electricity to power industries, the economy, and homes, pressure on governments mounted in both countries to focus more on short term challenges. China and India are both back to strong and growing economic production. Texas was back to normal in a few months. The next monsoon may be a good one. Smart and resilient energy solutions require innovative approaches to handling unexpected short-term crisis without swaying away from the long-term goals.

Some of These Events Around the World are Production based, Some Distribution based, and Some Demand based. Need Smart Resilience Solutions to All.

Unexpected shocks can arise at any stage of the electricity chain. In production, unexpected poor monsoons (or cold weather in Texas), shortages of coal and other critical inputs, labour strife can all cause power shortages. Distribution of power often faces unexpected shocks from extreme weather, equipment failure and fires, theft of electricity as well as wires to name just a few. Consumption/demand can unexpectedly surge due again to extreme weather, surge in industrial activity etc. Climate related shocks are a common and central causal element at all three stages as shown in Figure 1.

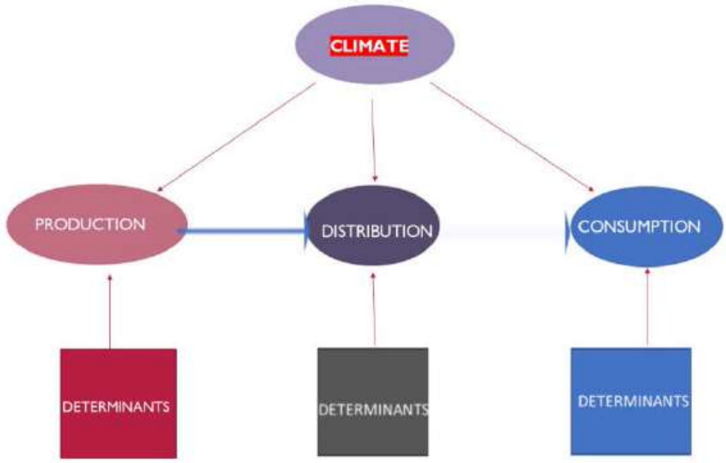

Figure 1: Climate related shocks are a major source of unexpected disruptions at every stage of electricity

Complex Problems- Complex Questions

Alternative sources of energy, regulations and micro grids are all solutions that have been offered to the complex problem of dealing with unexpected shocks in energy. Uncertainty abounds in every aspect of energy and climate. Should we plan for the worst-case scenarios in energy as is proposed for climate preparedness (Precautionary principle of regulation)? That however is a very costly proposition that can cause enormous damage to present day economic wellbeing of the citizenry. Will challenges to achieving climate change goals get reduced or exacerbated with the energy crisis? It need not, if innovative smart solutions for unexpected short-term shocks are developed without losing sight of long-term goals.

Āatmnirbhar Bharat- Rural Energy

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Energy is the key to sustainable livelihood and in agriculture it is more important. In rural areas the domestic sector accounts for nearly 80 percent of the total energy consumption. About two third of the population i.e., 1 billion people live in rural area. India is having energy crisis and currently importing 100 million tons of crude oil. Foreign exchange out-flow of Rs 1.5 trillion per year and by 2030 it will rise to 300 million tons of crude oil.

- Rural area needs energy for fuel for cooking, water for drinking, light for studying and convenience, television and telephone for entertainment. Household sector is the largest consumer of energy accounting 40 to 50% of total energy consumption. Therefore, there is a need to have energy policy guidelines. Rural energy systems are strained by the inability of the people to shift to commercial fuel like electricity, LPG and kerosene due to low purchasing power of the people and limited availability of these fuel. Several efforts have been made by both Government and NGO to address the issues. Energy security means availability of an uninterrupted energy supply at affordable cost. Agriculture needs energy for land preparation, irrigation, inter culturing, harvesting, organic manure, fertilizer, pesticide production, etc can be considered as an indirect energy input since require a substantial amount of commercial energy. Increased use of energy has been the incidence of droughts, consumption of electricity in agriculture, oil and diesel consumption. Tractors are used for all agriculture operations. Other form of machinery requires diesel as well as electricity. Utilization of proper HP tractor for cultivation and other purposes can save the oil consumption. Only few agriculture operations like ploughing requires high HP tractors. Normal agriculture operations like cultivation, sowing needs 25 to 30 HP tractors. Similarly, threshing, winnowing operations need machinery with low HP. Irrigating the field with open canal, needs more water, energy and time to irrigate required area. Instead of this use of drip and sprinkler requires less energy irrigating same area. Agro processing at rural area needs machinery and energy. Farmers can save energy with proper machinery for the purpose. For household also, the use of improved chulha can save fuel energy. Now the government is providing good subsidy for solar panels, for installing solar power for running the pump as well as for household consumption. Harvesting solar energy for household use not only save the money but will also be helpful to farmer by providing extra power to grid. Research conducted at JAU suggested that growing vegetables, flower crops under solar panels gave better yield along with income through power generation. Electric pump operated through solar system at KVKs Amreli found more remunerative.

Energy is a crucial for all day to day requirements in agriculture too. With proper policy and utilization, the problem can be solved to greater extent.

Rural Energy Security

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Introduction

India is the second most populous country and the third-largest economy in the world. It has set an ambitious target growth rate of 9%, a trajectory towards becoming a US$ 5 trillion economy by 2024-25, thereby making it the fastest growing large economy in the world. The global economic growth has never been so energy driven as it is now. Around two third of the Indian population live in villages. Rural economy constitutes 46% of the economy. This was rightly summed up in a seminal observation of Mahatma Gandhi that India lives in villages and that nothing much can be expected without addressing issues of rural areas. There hardly needs any underscoring on significance of energy in sustainable livelihood, poverty alleviation and rapid economic growth. In pursuant to concerted efforts of the Government of India, Rural India has been witnessing a watershed growth with mechanism of constructed houses, well planned streets; good quality piped drinking water to each house. At the same time, nexus between energy, food, health and social order have been getting dicer day by day. India being the third largest energy consumer and the third-largest oil importer cannot afford ignore in rural energy security with dogged needs for attaining high efficiencies in the energy operation systems. The results of these efforts are evident in massive programme of electrification, augmenting accessibility of domestic cooking gas cylinders and above all spurred up action for adequate energy security in rural areas.

Energy Vital for Development

The generic meaning of the energy security entails availability of safe, clean, affordable, regular, undisruptive continuous supply round the clock in consonance with the current and future energy demand. Rural development *per se* had never been an agenda or for that matter figured in the energy policy. In olden days, rural energy mainly comprises electrification to meet the irrigation needs of agriculture as part of the overall food security policy. Household electrification came as a collateral issue. For achieving sustainability in rural development with emphasis on livelihoods and economic wellbeing of the rural, the affordable and dependable access to energy is vital. Therefore, use of energy as an integral tool to trigger inclusive development of different sectors including food, health, education, nutrition and economic activities of the rural areas have become a bounden obligation rather than choice.

Rural Energy Scenario

India's economic growth engine has placed an enormous emphasis on energy resources, energy systems and infrastructure for rural areas. Despite lesser opportunities in rural areas, two-thirds of the population still lives in villages. Agriculture, which is the overarching occupation of the people in rural India, can generally be regarded as pooling of tried and tested practices gathered over tens of thousands of years relying predominantly on animated sources of energy like bullocks. However, the green revolution has altered this situation by replacing bullocks with tractors and other such energy intensive farm-machineries. Energy consumption in agriculture mainly hinges and is driven by the state of farm mechanization, such as tractors, power tillers, irrigation pump sets, threshers, etc. The key drivers of energy use comprise activity drivers (total population growth, increasing food demand, crop production pattern, irrigation, and farm mechanization), economic drivers (agricultural GDP, market status, income, and price elasticity) and social drivers (villagers' unity, cooperative sector, FPOs, etc). The transformations of energy in agriculture have been helpful in transmuting India's status from scarce to surplus in food grains. The larger credit of these incredible transformations can be given to ameliorations in energy scenario in rural areas. Today India has to its credit wiring its remotest of the remote village to the energy. However, the problem of irregular and constrained supply vis-à-vis yawning gap between demand-supply with lot of disruptions still exists in rural areas. The awareness, accountability, responsibilities and consequently the informed use of energy use are abysmally lacking in rural areas. At the same time the rural areas have massive potentials of multiple sources of energy that can be tapped adequately to ensure Āatmnirbharta in good quality uninterrupted cheaper energy.

The Covid-19 introduced enormous reverse migration of people from urban to rural areas; necessitating livelihood security for them. The small-scale industry in rural areas on the tenets of make in India and vocal for local has lot of potentials in addressing both economic and employment woes of rural areas. Therefore, rural energy sector deserves diversification and effective use of available multiple resources. The schemes for using unconventional energy sources like solar energy are already in place both for domestic and agriculture purpose. However, there are not many takers as per expectation of these schemes from rural areas; though the things are changing gradually. However, access to gas cylinders has evinced punctuated adoption for cooking and has facilitated the rural woman in ease of doing the things reducing her burden, pollution and collateral health issues related to burning biomass.

Diverse Needs of Rural Energy

The requirement of the energy in the rural sector for households, agriculture, cottage, industries and agro- processing fall in the broad categories of subsistence and productive needs. Energy needs of rural areas are different than the urban needs. The economic disparities further hobble the rural consumers to use energy the way urban consumers avail.

The potential needs of the rural poor are characterized by a high demand for energy for purposes such as lighting, cooking, space heating in the domestic sector; water lifting and transportation in agriculture; and small and medium enterprises. Lack of access to affordable energy is an important factor contributing to the relatively poor quality of life in rural areas. With the increasing use of commercial sources of energy, there has recently been a substantial shift towards commercial sources. The distribution of gas cylinders has improved the quality of life. The availability of energy despite poor quality has facilitated time saving and ease of doing the things in local movement, field operations, marketing both way for buying or selling at better price in urban centers.

The agriculture sector is the second largest energy-consuming sector in rural India. In the agricultural sector, animated energy (human and draught power) accounts for more than one-third of the total energy consumed. In animate energy inputs are mainly in irrigation through diesel and electrical pump sets. Diesel for tractors is used in tilling, harvesting, etc. is the other important energy source.

Rural energy needs vary across sectors for domestic house hold use, agriculture (land preparation, seeding, etc), village community needs like pumping water supply, micro level processing, micro enterprises, service centres, shops and other establishments. The current emphasis on development of Farmers Producers Organisations, digital agriculture including marketing, logistics, etc. has further underscored that rural energy needs are transforming and are going to be very diversified lot in the coming days. Similarly, rural energy needs mean different to different people like unlike farmers need of energy for agricultural operations or transport; women need energy for lighting, cooking, cooling, heating, sewing, etc. The other group comprising students, blacksmith, etc the energy need is diametrically different from reading to repairing farm implements. The Covid-19 afflicted reverse migration to villages has further diversified needs for rural energy. However, they all have one commonality in requirements for dependable, safe, clean, affordable, regular, undisruptive continuous supply round the clock.

The diversified demand of rural energy for subsistence or otherwise has been addressed by wide arrays of schemes of both central and state governments. Yet the status of rural energy has never been very impressive and has been plagued with its own infrastructural, quality of energy and distribution problems. Despite exceptional government schemes ranging from distribution of kerosene through

PDS to promotion of solar energy through schemes like household solar panels and PM-KUSUM ; people still use biomass energy as energy source in rural areas. This not only causes health and environmental issues but also triggers gender issues as women are normally engaged in collection of wood and become victims of smoke-filled kitchens. The Government initiated enormous endeavors in 1980s to provide fuel switch of alternative renewable sources through programmes like National Project on Biogas, National Programme on Improved smokeless Chullah followed by establishment of Department of Nonconventional Energy Sources and Indian Renewable Development Agency for R&D, demonstration and dissemination of renewable and rural energy technologies. Later in 1992 it was upgraded to a fully-fledged Ministry for Nonconventional Energy Sources. Appreciating the area specific nature of rural energy problems coupled with remote locations and psycho-socio-economic variations, attempts have been made at block level (Integrated Rural Energy Programme) and at village level planning (Urjagram). All the villages have been energized by extension of rural grid; attempts have been made for increasing efficiency through distribution of subsidized LED lights and LPG connections. The solar power scheme, "Suryashakti Kisan Yojana" (SKY) facilitates the farmers with solar panels based on load requirements on their existing electricity connection. It is a revolutionary step to empower farmers to generate their own electricity using solar energy and help doubling their income.

Diverse Sources of Rural Energy

Rural areas are replete with energy-dense materials varying from conservative (animals and their waste, fuel wood, crop residues, etc), conventional (coal, electricity, gas cylinders, diesel, petrol and kerosene, etc) to unconventional sources (solar roof top and farm-based systems, wind energy, bio-gas, etc).

Biomass energy is the most common no-cost local energy available in rural areas to tend minimum needs particularly for cooking. Sixty-five per cent of the biomass energy in the rural areas is apportioned to fuel wood, 20% to agricultural waste and 15% to cow dung. The per capita or per family consumption of fuel wood varies considerably across different regions and agro-climatic zones depending on the resource endowments and accessibility. Most of the fuel wood consumed in the rural areas is collected in the form of twigs and branches, mainly by women and children, and not purchased.

Animal waste in the form of dung cakes is important in the agriculturally prosperous regions where the fuel wood supply is poor. However, the number of farm animals has decreased and most of the available dung is used as manure in the fields. As a spinoff of this, diversion of dung as fuel has mammoth opportunity cost in enriching soil.

Being loose and having high rate of combustion with difficulties in controlling combustion, crop residue is the least preferred of the biomass fuels. Despite inefficient fuel, this is used as a back-up fuel wherever fuel wood is scarce.

Huge and diverse types of crop residue are available; timely removal of which from the field is a big problem for the farmers. The instant removal of the crop residues after harvest is necessary to ensure timely sowing of the crops in the ensuing season. This works as a double edge sword like it happens in some northern states; where burning of crop residues not only damage soil biota but add massively to carbon footprints aiding environment pollution. The adversity can be converted to advantage if these crop residues are used to make briquettes, biochar & other uses like mushroom raising, organic manure, etc.

Coal is an overarching source used for generating electricity, though it pollutes air. In order to reduce carbon footprint, emphasis is on reducing coal for electricity generation. The rural areas have enormous potentials for energy generation like roof top, agrivoltaic (growing crops under solar panel), crop residues, energy crops, etc for alternate renewal sources of energy like gasification, biofuel, biogas, or even for hybrid technologies. The hybrid technologies like solar + wind or solar + biogas has lot of scopes for enhancing availability and reducing cost of production of energy.

Energy Access

Among the four facets to energy access viz; (i) extending connectivity to all villages; (ii) connect each household in the village; (iii) provide reliable, round-the-clock electricity along these connections, and (iv) responsive service network that takes care of metering, billing, collection, problems, and maintenance; only the first one has been attended very well. In 2017 the Saubhagya Scheme was launched for accomplishing the second aspect. Achieving near universal electrification was a huge achievement, and was globally recognized. However, the questions of centralized or decentralized power generation in rural areas become irrelevant if local service mechanisms do not work. The blatant energy loss between the 11 kV feeders and the household is the teething problem. This is where the link breaks down from the government built high-tension wires to the local village.

Energy equity is the other aspect that encompasses ability to ensure universal accessibility, affordability and reliability of energy for domestic as well as commercial use. Environmental sustainability has assumed added significance in the climate change afflicted era and captures efficiency of the energy system to mitigate and avoid potential harm to the environment. The energy could comprise finite resources such as coal, oil and gas or renewable such as hydroelectric, wind, solar and biomass energy.

India adopted short, medium and long-term energy planning processes in the country. In the short-term, the effort is to maximize returns from the assets already created in the energy sector, improving efficiency in production, transmission and end use; reducing energy intensity of different consuming sectors and initiating steps for meeting fully the basic energy needs of the rural households. In the medium term, progressive substitution of petroleum products by coal, natural gas and electricity, accelerated development of renewable and promotion of R&D efforts on decentralized energy technologies based on renewable resources have been suggested. In the long-term, promotion of energy supply systems based largely on renewable and promotion of technologies of production, transportation and end use of energy, that are environmentally benign and cost effective, have been suggested. India is concentrating long-term energy planning processes in rural areas involving solar and other renewal sources.

India's endeavors to haul up different parameters of energy system viz; energy as a component to support economic growth and development, universal access to a secure and reliable energy supply and environmental sustainability across the energy value chain has been admired world over. However, other emphasis on parameters of the energy transition like regulatory structure, consumer awareness, incentives to promote investments and innovation, adoption of new technologies, etc is desired. However, given the current political commitments for enabling energy sector particularly the renewal one and easing business ecosystem the needed thrust to improve downstream delivery to improve transmission, distribution infrastructure and financial position of distribution companies; access to clean cooking fuel through efficient and affordable fuel and ensure regular supply of electricity is quite evident in rural areas.

Renewable Energy

India has always been connecting with nature. With an aim to combat climate change, it has announced that by 2030, it would strive to achieve 500 GW of installed electricity capacity from non-fossil fuel sources, reduce the total projected carbon emission by additional one billion tons, reduce the carbon intensity of the economy by less than 45% and lastly, the country would achieve net-zero emissions by 2070. The intent to provide energy security in rural areas will have far-reaching impact on India's energy portfolio as is embraces clean energy pathways. The per capita energy consumption of India is one-third of the world average. The disparity for energy accessibility and consumption between the rural and urban areas needs no underscoring. More efforts are required to improve this per capita energy consumption for the inclusive development of the rural areas.

The energy sector contributes to about 75% of the total greenhouse gas emissions of the country. The paradigm shift in the clean energy transition has two-fold objectives of ensuring affordable and reliable energy to all with lesser dependence on fossil-based energy by accelerating the clean energy transition. The government has opted inclusive participation of the people by incentivizing them to be part of the solution, like selling electricity to the grid like it has been done in PM KUSUM scheme, which supplies solar panels to farmers for the use of water pumps and other essentials. There is the option of selling the power to the grid if they have excess electricity. It has belied the misconception that the people and organizations, who can afford to set up solar panels and potentially sell power back, are the creamy consumers. Suryashakti Kisan Yojana (SKY) that was first started in Gujarat facilitated the farmers with solar panels and enabled them to generate electricity for their captive consumption as well as sell the surplus power to the grid and earn an extra buck. Similarly, there are bellwether projects like Songaon-Ghaghadi, a village in Maharashtra used Hydro-water power from natural water spring through a cylindrical cast iron housing to turn the turbine to generate energy; known as HydroGen. The energy is used for street lighting and also for lighting Panchayat Ghar and village school.

The rural energy is missing a focus on change management, especially in distribution companies to make the consumers understand that the changes were to their benefit. As such one of the major problems of rural energy sector lies in centralization of delivery and services, and an appalling lack of engagement with the people both in distribution companies and the consumers.

Current Issues and Solutions

Rural areas have access to energy but have problems of disruption, irregularity and availability (poor quality, constrained quantity and duration). Sector needs diversification and effective use of available multiple sources available in rural areas besides mandated supply by DISCOMs. Priority can be given to solar energy that is abundantly available due to long sunny hours across the year. Alternate sources are crop residues, energy crops, gasification, biofuel, biogas, or even hybrid technologies can also be used to ensure good quality uninterrupted energy.

“Responsible Use and Integrated Approach” is missing both among consumers; and local administration who have multiple agencies at helm without any accountability. Thefts and losses are the other aspects that needed adequate consideration by increasing vigilance and demand-supply auditing.

Rural energy sector is loaded with awful inefficiencies all through the supply chain of production, storage, distribution and consumption. The innovation-based snag free technologies can be adopted for energy auditing of supply (production, processing, storage and distribution) and demand side chain for increasing generation efficiency, reducing transmission and distribution losses and effective use of available energy.

The nexus of energy with Water-Agriculture-Livelihood security has grown from complex to intricate. The aquifer has gone deeper requiring more energy for withdrawing water and WUE getting lower with deteriorated soil quality particularly the organic matter. The WUE right now hovers around 0.38. consequently, agriculture has become obvious for irresponsible and inefficient use of energy. The stench of the problem can be had from sprinklers system adopted largely in Banaskantha district of Gujarat. However, energy being very cheap supplied on flat rates, farmers seldom operate them as per recommendation but let it operate till energy supply is available. This makes even innovation-based technology sprinklers system look like flood irrigation with water overflowing on roads. This is a double waste of precious water and energy. The engagement of over-sized water pumps, energy inefficient tools high powered tractors, etc is considered normal in agriculture. The awareness programme should focus and inculcate responsible, informed and efficient use of energy. This needs to be precisely communicated to the farmers through extensive awareness programme advising them what tools / equipment they need to use in consonance to local factors and technological recommendations rather than guided by market / sale campaigns. Separate dedicated grid for agriculture and domestic purposes with different tariffs structure is reemphasized for scaling out at national level like it has been done excellently in Gujarat.

The price of energy is low and highly subsidized on consumption of energy; directly proportional to energy consumed. Instead, the consumers need to be disciplined for responsible use and incentivized for saving the energy. Further, the subsidy may be continued only to needy layer like BPL consumers. The subsidy / incentive should be deducted from energy bill or it may be transferred directly to consumers' bank account. The awareness creation for responsible use and saving of energy among the consumers is the need of the hour.

The rural energy right now has silo approach of DISCOMS and SEB/ management. Poor energy security and efficiency can be countered by facilitating participation of multi-players in DISCOMS to give choice to the consumers for quality, reliability, and affordability of energy. Similarly, energy from multiple sources need appropriate mixing like solar + wind or solar + biogas by developing effective grid connectivity for enhancing availability and reducing losses / cost of production of energy.

Old system of local wood collection for cooking is still in vogue, which is pollution and labour intensive besides a known health hazard to women. "Biomass Cooking Stove" has zero maintenance with high end performance and saves 40-50% wood that otherwise would take 4-5 hrs for collection. Similarly, Portable Solar Cooker and Induction Cooker can be used for cooking and saving energy.

The climate change triggered adverse weather events have become a new normal causing heavy lost infrastructures like uprooted poles, snapped lines, etc. The inaccessibility of such areas becomes a common feature after such events. As such, those areas have to remain bereft of energy for quite some time. It becomes significant that detailed survey of all over ground poles / transmission infrastructures be done in rural areas to verify their stability and capacity to face such events. One of the solutions lies in laying underground lines and strengthening /enforcing big high voltage transmission lines/ structures in rural areas.

Way Forward

The current spurt of development in energy sector in India has been extolled world over. It is already meeting the energy needs of the rural areas. Rural areas have access to energy but it is disrupted, irregular and availability in intent, content, space, time and quality are the major issues. In recent years, with the introduction of targeted schemes by the Government, the coverage of village and household electrification and residential LPG fuel has increased substantially. However, energy is still dealt in silo as a specific need of people for irrigating fields or lighting houses or fuelling their cooking stove rather than integral component of the inclusive and integrated development process across sectors like health, education, nutrition and economic activities.

Meeting the needs of energy for rural masses still remains an unfinished task. The sectoral development of ensuing schemes / programmes has led to many biases among which urban rural divide, gender biases and inequitable developments issues are the few to mention. Covid-19 pandemic has added another dimension to it due to reverse migration to villages. The volume of the migrated labour is too big to be absorbed adequately in agriculture alone in rural areas. Obviously new opportunities have to be found for engaging such people. This also fits in government policies of "Make in India" and Vocal for Local for promoting micro-entrepreneurship. It is good to note that internet penetrations in rural India have improved impressively. "Digital India" offers enormous opportunities for starting mini / micro entrepreneurship in villages.

Rural energy sector has been constrained by both availability of energy and poor purchasing power of the consumers. Consequently, they find it difficult to shift to commercial fuel switches. This problem has been tried to be resolved by providing subsidies. However, currently the huge subsidies on energy for agriculture and kerosene have also been a teething concern for energy planners. Several efforts have been made to counter these problems by designing national programmes for promoting both conventional and unconventional technologies like biogas, improved cookstoves and solar cookers, etc. However, the impact of these programmes on improving the rural energy scenario has not been felt to a desired scale.

Traditionally, India has been an agricultural economy. This sector has forward and backward linkages with the other economic sectors. Therefore, changes in the agricultural sector have a multiplier effect on the entire economy. Mechanization of various agricultural operations like threshing, harvesting, land preparation, irrigation, etc. account for the energy demand in the agricultural sector. Energy demand in the agricultural sector in India is mainly attributed to two major agricultural operations: land preparation and operating irrigation pump sets. The energy demand for land preparation and irrigation is a function of land under tractors and tillers and area under irrigation, respectively. The demand also depends on the technological parameters of the associated machines.

The problems of connectivity, quality and reliability are different in different areas. Therefore, appropriate village and block level energy sufficiency and efficiency development plan need to be worked-out after ascertaining precise customized needs, status, potentials, analysis of demand-supply conundrum and ways to abridge gaps between them. Grid supply has lot of disruptions that need improvement to check losses. Possibilities of developing decentralized sources of renewable energy at village level is an incredible proposition. However, it needs bracing up of centralized backup to ensure uninterrupted supply.

Precise and specific transformative package is needed for countering physical losses and damage due to extreme events of climate change. The plan should specifically focus on creating awareness through mass communication for responsible, informed and efficient use of energy.

Lot of improvements has been done in GENCOMS including participation of another players / private sector. Considering that monopoly breeds inefficiency, the DISCOMS also need improvement on GENCOMS pattern for participation of multi-players so that consumers can choose among distributors on the basis of the quality, reliability, and affordability of energy. At present rural energy DISCOMS are managed on silo approach, "SEB / my way or no way". The rural energy policy needs to be developed on holistic basis.

The fossil fuel-based energy needs to be phased out and integrated concept may be used to develop independence and self-reliance in rural energy. Some of the concepts like Pico Hydel Power Units, Hydro Turbine Pumps cum Generators, redesigned empowered Vertical Axis Water Wheel, etc work efficiently with lesser watershed and can be used for achieving Āatmnirbharta in rural energy. This can be further braced up with endeavours like harvesting solar energy both for domestic and micro-entrepreneurial purposes including agriculture. Both solar energy and biomass including agriculture waste is available in plenty and can be used for conversion to efficient bioenergy products like briquettes, charged charcoal, biofuel, etc. The niche cultivation of energy crops like sugar beet can also be thought of. Solar energy can be also harvested in tandem with agricultural production by putting solar panels in agriculture fields.

There exists a vicious nexus of Water-Energy-Agriculture-Livelihood Security. Gujarat has established separate dedicated grid for agriculture and domestic purposes with different tariffs structure. Gujarat SSKY scheme (Surya Shakti Kisan Yojana) has been adopted in many villages for installation of solar pumps for withdrawal of water from the aquifer. This needs to be scaled up and out at the country level. The awareness creation is desired for responsible use and accountability for energy among the consumers. There is quite an irresponsible and inefficient use of energy like employing high powered tractors, over-sized water pumps, old tools etc. For this awareness programme should focus on and inculcate responsible, informed and efficient use of tools and equipment depending on actual need. High powered tractors have no use in soft soil or for that matter oversized pumps in shallow wells. This needs to be precisely communicated to the farmers through extensive awareness programme advising farmers on what tools /equipment they need to use and not guided by market / sale campaigns.

Crop residue management is pivotal for both rural energy security and checking environmental pollution. Despite availability of huge quantity of crop residue as raw materials, benevolent government subsidy programmes and high-end technologies for residues management, it has not been adopted for enhancing rural energy security due to lack of awareness among the farmers. At present, crop residues are burnt to save time and avoid investment for their disposal. Transporting crop residues to industrial site is also an arduous, time, energy and capital-intensive proposition. It can be converted to clean fuel but requires models that can be executed and operated at on-field actual site. Different Commercial Scale Biogas Units are available that can process over 10 tons rice straw per day to generate 3500 cubic meters biogas along with silica rich fertilizer and methane gas that can be used as BioCNG. These models can be game-changers for achieving self-sufficiency in energy and that too in a decentralized manner. Alternatively, crop residues can be converted into energy packed briquettes; while microbes consortia can be used to convert them to composts for enhancing soil health. This way it not only reduces carbon-footprints but also lowers requirements of next crop fertilizer by 25%.

Innovation-based technologies including software can be used for locating availability of different types of biomasses over different villages and linking them to high energy ends like anaerobic digestion and thermo-chemical gasification. Improved technologies like "Biodiesel Reactor" which has been designed to convert different types of oils (linseed, jatropha, karanj, etc) can be used for production of biodiesel. Gujarat has 300 odd companies that buy and manufacture briquettes out of crop residues. It not only facilitates the farmers and pays them for the crop residue but also augment the judicious use of energy resources.

The Cooperative Sector or Farmers Associations at village level can be used for assuring energy security and phasing out the fossil fuel-based energy for water withdrawal from the aquifer like it has been done in village Dhundi, Thasra, Middle Gujarat. This has inculcated responsible use of water for agricultural purposes at cooperative level culminating in energy saving, water saving and above all opening an additional avenue of income varying from 1.0 – 1.5 lakh / year / farmer by selling extra energy after meeting irrigation demands. The said cooperative endeavour of the village has other collateral advantages like solar can be used only during day; which enable the farmers to manage water practices in a better way with least danger of life-threatening issues like snake bites, etc during the night.

Vermiwash, a nutrient and microbes' rich concoction is a low temperature composting with earthworms using cow dung and agro-waste saves use of chemical fertilizer, makes soil nutritious and hold water better. Thus, it saves energy in lesser use of fossil fuel based chemical fertilizers. It also triggers soil biota and increase nutrient use efficiency, thereby economising fossil fuel in terms of nutrient saving.

Very less attention has been given to appropriately use energy for primary processing at village level. Some zero energy technologies like SunFridge/solar based cooling have been developed using solar energy and water circulation, and can be used for cold processing / storage and thereby enhancing shelf-life and market value of fruits and vegetables by about two days.

There are many simple village level high-end interventions that can reverse positive association between energy and production and excel Āatmnirbharta in rural energy. For this, mechanisms like custom hiring models can be used eg direct seeding of rice of Tamil Nadu. This saves lot of energy and labour that otherwise would have been spent in tillage, water required for puddling and fertilizers application. The self-sufficiency in rural energy and water security can also be aimed by constructing Bhandaras (Water Reservoirs) and using gravity-based reaction types high volume lesser watershed turbines to light streets in remote villages and assuring water supply to households. Shaguna Rice Technology is another regenerative method of farming without tillage. It is quite effective in saving energy that otherwise had been used for tillage. It also saves energy indirectly by reducing use of fertilizers and irrigation. All it requires is a SRT Frame and a spray pump. Thus, it is a cost and energy effective practice and can be used for improving ecological recycling making the soil and the farmer happy. Similar other technologies be used to save energy in farming. Even adopting MIS can save energy in comparison to flood irrigation. Further, agriculture has become immensely energy intensive; be it be tractor, agrochemicals or for that matter logistics everything is energy intensive. Collective logistics, fuel efficient tractors, use of microbes to reduce use of agrochemicals etc can be thought as mitigating measures for use of rural energy.

Agrivoltaic is a method of growing crops under solar panel and has been very successful in cultivating some crops under it with high yield, energy harvesting with enormous water saving by checking direct evaporation, saving from extreme weather conditions like heavy rain and high temperature. The efficiency of solar panels also increases due to lower temperature. It is also important from ecological point of view like increased bee activities. However, only few crops have been raised under agrivoltaic. As every crop requires customized height of panels and crop husbandry, R&D is desired on these aspects in different crops.

Key sources for energy like solar energy (both roof-top and farm pump), and bio-energy, like briquettes of agro-waste need to be exploited. They need to be properly implemented with massive drive like solar panel for energy roof-top, irrigation pump sets or on the line of Swachh Bharat Abhiyan. The Panchayat administration can be made responsible for village level execution.

It needs no underscoring that rural poverty impacts urban poverty through rural-urban migration. Thus, any attempts to alleviate poverty should begin with rural areas. The elimination of poverty in rural areas has not received the desired impetus, except for subsidies and free distribution of resources. This cannot be sustainable on long terms. Energy is critical both as a resource and a necessary input for creating state of wellbeing in the rural areas. The major challenge is how to promote and provide a "Fuel Switch" for effective transition from traditional source of energy to cleaner technologies and fuels in the rural areas. The energy sector has not been adequately linked to generate livelihoods or enhance income through energy related interventions particularly in sectors like education, health and other social sectors. They need to be complemented / supplemented with other developmental initiatives for overall development of rural areas. There are innumerable schemes for poverty alleviation. The success of all those schemes primarily hinges on uninterrupted supply and quality of energy. Thus, linkages of different sectors with rural energy are desired.

There is need to introduce Capacity Building Programme at multi-level. Farmers and rural women may be trained on aspects like how to use the energy responsibly and not waste it like it is happening right now. Rural youth could be skilled for installation and maintenance; while Government official may be empowered as to how to make the energy accessible to every villager and to ensure that every house has it. The use of energy efficient equipment and tools assume special significance for achieving this as a unit saved of energy is equivalent to two units; one that was not wasted and the other that it became accessible to another consumer.

There is need to create responsible administrative unit, Panchayat Raj Organization to integrate & inculcate responsible use from diversified multiple sources, electricity, petrol, diesel, kerosene, bio-energy, solar energy, etc in highly integrated precise manner. For this an "Energy Plan" can be developed and executed at micro-level, block level & village level. This needs a comprehensive "Rural Energy Policy" integrating all that is available and ways to use it with precise micro-level plan for its execution and monitoring. The responsibility of executing and monitoring the plan can be assigned to either District Development Officer or Collector who can monitor and review work of multiple agencies like DISCOMs, Electric Supply and Solar, GEDA, Guj. Agro (For Bio-gas).

There is a need to create livelihood opportunities with focus on developing programmes that build the capacity of the poor, thus ensuring sustainability rural energy security. The focus should be on specifically target enrolment of women in local training programmes with embedded poverty impact assessments, climate change, multi-stakeholder engagement with linking data collection, action and sharing between line ministries and energy agencies.

Conclusion

Access to energy has improved a lot in rural areas. However, it still has problems of disruption, irregularity and availability. The rural energy sector needs diversification and effective use of the diverse multiple sources available in rural areas. The energy from multiple sources needs appropriate mixing like solar + wind or solar + biogas by developing effective grid connectivity to enhance availability and reducing losses / cost of energy. The innovation-based snag-free technologies are desired for energy auditing of supply and demand side so as to improve generation, distribution, storage and consumption efficiencies. Responsible, integrated and inclusive approach of energy across different developmental sectors like health, education, nutrition, etc and discipline both among consumers and local administration is desired for assuring consummated growth of rural areas. Some of the successful bellwether programmes executed successfully at village level like cooperative solar pumping to meet the village need and selling extra energy to DISCOMs can be effectively scaled out for spurring rural energy security at the national level.

SUN : Solar University Network
A Tool for Short Term and Long Term Energy Security

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Context

It does not take a war to tell us that Energy Security is indelibly linked to National Security. Tale of two wars-one of Yom Kippur in 1973 and other fire-fresh war of Russia-Ukraine proves the point.

Apart from bombs and missiles, pipe-lines carrying fossil gas and ship-routes carrying coal and oil are the powerful weapons to win the wars. Wars in the past have been won by those who own the new weapon-system that enemy does not possess. In the world that is on the threshold of Industry 4.0 today tries to win the war by closing the valves on gas pipe-lines and blocking the marine-routes that carry oil and coal.

The situation is changing fast. Thanks to the climate change! Climate Change is a war against whole humanity that is not only waiting in the wings but already open on the stage. Humanity can win it by discarding the old weaponry of fossil fuel and adopting the latest system of renewable energy and Net Zero.

Aatmanirbhar (Self-reliant) India

India in 2021 made a waves at COP-26 in Glasgow when PM Modi made new and Big Five pledges. With 17 % of global population, India is responsible for just 5 per cent of emissions. But the country's commitment to climate change mitigation has far outstripped its role in global emissions. In that context the five pledges by PM Modi were like a 'gift' from India to the world in crisis.

In fact in the Indian language he described it as "Panch amrit ki Saugat" (Gift of Five Syrups of Regeneration)

PM Modi stated that:

- India will take its non-fossil energy capacity to 500 GW by 2030
- Meet 50 per cent of its energy requirements from renewable energy by 2030

- Reduce the total projected carbon emissions by one billion tonnes by 2030
- Reduce the carbon intensity of its economy to less than 45 per cent by 2030
- Achieve the target of net-zero emissions by 2070.

Walking the talk has become Indian government's strikingly unique character. India pledged that by 2030, 40 per cent of the capacity will be non-fossil fuel-based. India achieved this target 9 years in advance in November 2021 as per Ministry of Power. Today, established renewable capacity is 158 GW and another 54 GW is under construction. Added to that 6GW of nuclear capacity, the total renewable capacity comes to 165 GW which is 41 per cent of established capacity

This walking the talk and reaching the destination ahead of schedule is nothing but 'leading from the front' India is the world's third-largest energy consuming country, after China and USA, thanks to rising incomes and improving standards of living. Energy use in India has doubled since 2000, and stands at around 210 GW while installed capacity is nearly 400 GW. Indeed, India is self-sufficient in its energy needs but not in input needed for producing energy. India still depends on coal, oil and gas. In recent years, coal needs for power plant has reduced and use of solid biomass like bagasse has increased, but herculean task is needed to be 'Āatmnirbhar' (self-reliant)

On a per capita basis, India's energy use and emissions are less than half the world average. As India recovers from a pandemic slump, it is re-entering a very decisive, disruptive and dynamic phase of period in its energy-transition.

On one side millions of Indian households are set to buy new appliances, air conditioning units and vehicles in coming years. To meet growth in electricity demand over the next three decades, India will need to urgently to make long range plans by identifying the strength weakness opportunities and threats in deploying renewable energy.

More than that of any other major economy, India's energy future depends on buildings and factories yet to be built, and vehicles and appliances yet to be bought. Hence, forward thinking on the challenges with renewable energy in its production, distribution and deployment would need just declaration of short-term targets but devising out-of-box long term plans for research and innovation. There comes entry of youth in universities, wherein lies the vast potential of creativity.

That necessity of innovation and creativity and going beyond the present knowledge of renewable energy and energy efficiency is being addressed by the flagship project of TERRE Policy Centre called as "Smart Campus Cloud Network' (sccnhub.com). This worldwide Network of universities now has nearly 400 Universities and HEIs (15 from abroad) registered to kick off practical projects in their campus that make use of digital technology and contribute to United Nations Sustainable Development

Goals (SDGs).

Learning by doing and accelerating by sharing is the seminal approach of SCCN. It assumed campus as laboratory for SDGs. It encourages piloting and mainstreaming SDGs in partnership with various departments. By piloting the projects students and faculty engage in skill-building to make them SDGs-ready for their future career. Creating an inspiring model and leading from the front for implementation of SDGs is the seminal objective of SCCN.

UNESCO-Paris is main partner with the project. TERRE also works closely with ECOSOC, UNEP, IUCN and UNFCCC. TERRE is accredited with them in some cases as consultative status. We have working MOU with AICTE, EESL (Ministry of Power), ASSOCHAM and GORD (Qatar). In 2019, national competition in India for 'Smart and Clean Campus' was initiated which was jointly designed and implemented by SCCN and AICTE. TERRE is member of the expert committee of UGC to develop and update the guidelines for Universities on SDGs in their campuses.

The overall approach of SCCN is imparting the wholistic and integrated training to prioritize SDGs in the education system of HEIs by localizing SDGs in the campus.

The climate disasters like rising temperature, collapsing glaciers, flash floods, rise in sea-level and expanding desertification are creating existential crisis for the life on the planet. The root cause for the climate change is the human induced carbon-emissions. Natural carbon-cycle established by the ecosystem of our planet allows the natural carbon-emission as well as the natural sink (absorption). That keeps the Earth in balance. In order to rebalance the Earth, we need 'net zero' emissions.

In order to limit the temperature, rise of our planet to not more than 20^{o} C above pre-industrial times, as per IPCC, the world's carbon emission must be net-zero by mid-21st century, i.e., by 2040-2075.

The recent project that is aligned with India's pledge under Paris Climate Agreement is 'Not-Zero Net-Zero', for which 250+ universities (and number is growing) have initiated the work on carbon neutrality. Recognising that the students in HEIs are of 18-24 age, the project leverages their potential not only to innovate on the SDGs related projects like energy efficiency, clean energy, water conservation, waste management. climate action, sustainable transport, carbon neutrality, health and well-being but goes beyond it. AICTE (All India Council for higher Technical Education) has recommended all HEIs to be part of SCCN and take pledge for 'Not Zero-Net Zero'.

For registering your university or education institutes with SCCN: login at https://sccnhub.com/sign-in and register, preferably with your name as head/VC. The Pledge for carbon neutral campus is available @ https://sccnhub.com/not-zero-net-zero-pledge that can be taken after registration is complete). Once registered (no fees for registration) we would approach you to jump-start the action with specific guidelines

Side Benefits, Speed and Scale

SCCN creates awareness on co-benefits of taking early action on Climate Change through data analysis and surveys. Reduction in air pollution, health benefits, cost-saving, accelerating the innovations are some of the co-benefits whose identification would enhance the speed of transition.

Early actions may result in creating side-challenges, sometimes unintended. However, educational institutes are the centres where youth exudes the ideas for a change towards the better future. They are the breeding grounds to address the climate challenge through early actions, but more than that they are also incubators to ensure that unintended challenges are also addressed. Having piloted the actions related to SDGs in some of the institutes, TERRE is now encouraging all the institutes and universities to set up research and innovation programmes to 'disrupt' the technology trends.

Solar Energy: Is It Ultimate Solution for India's Energy Security?

Indeed, solar energy has helped India in reducing the dependence on fossil fuel to certain level. However, is it the panacea for energy security? Sun has the dark spots and hence energy coming from Sun also has darker dimensions. SCCN has set up Solar University Network (SUN) for effective utilization of Solar Energy in short term and to innovate through research so that Solar Energy becomes the long-term solution for India's energy security.

1. **Initial Capital Cost of Solar Energy is High. Is that a Barrier?**

   The capital cost of the solar energy/electricity is falling rapidly mainly due to scale of economy and incentives provided by the government. In any case the initial cost now can be opportunity to develop new investment models like CAPEX and OPEX. Investors can provide all the capital cost and then recover the investment through the savings that are accrued to the buyer. It is indeed not a barrier, but opportunity for the investors.

2. **Deploying the Solar Energy to Meet the Needs of Campus in Lighting, Fans, ACs, Kitchen and EV Transport**

   As described in the beginning of this article, India has made great strides in solar energy, by meeting the GW targets.

3. **Enhancing the Efficiency of Solar Panels**

   Today's solar panels have operating efficiency at commercial level limited to 20 per cent max. How that could be improved to 40 per cent and then 60 per cent.

4. **Safe and Environment Friendly Disposal of End of Life Solar Panels and EV Batteries that would Work on Solar Energy**

With rapid rise in manufacture of solar panels and electrical vehicles there is scanty attention of the manufacturers towards end of life disposal. There is also tendency to think about 'crossing the bridge when we come to it. While solving one challenge we seem to be creating another challenge.

5. Do the Solar Panels Provide Only Energy?

Solar panels can be used to create shadow underneath by lifting them. The farm animals seem to enjoy the shadow for resting. Their wellbeing can also be ensured.

The shadow underneath also helps to improve the productivity of the horticulture because if left exposed to sun their growth could be stunted.

Solar Panels can also be used to collect the water from dews that form on cold panels in the morning.

6. How Blue, Green and Grey Hydrogen Energy could be Integrated in Cost-Effective Manner for Energy Production through Fuel Cells and for Electrical Vehicles

In conclusion, SUN allows us to move rapidly in deploying the solar energy and allows to leverage the potential of youth and network of university campuses to kick start the key projects for "Not Zero Net Zero" that are likely to meet the targets pledged to United Nations Framework Convention on Climate Change. More than that there are long-term research and innovations that are badly needed to enhance the effectiveness of the projects. Short term and long-term solutions can effectively meet the energy security and hence national Security.

Energy Security for Rural Areas

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One of the pioneers of power distribution utilities in the Indian power industry Uttar Gujarat Vij Company Limited (UGVCL), is continuing its journey to provide a sustainable, affordable, safe and reliable quality power supply to its consumers. The brief @ UGVCL is as under.

- 146 sub divisions under 22 division offices of 4 (four) Circle office.
- 4502 villages and 38 towns with @ 50000 Sq.Km area covering 7 full and 3 partial districts of North Gujarat.
- Has 10000 employees and 39 lakh consumers entailing 545 - 66-KV sub stations and 6060 11-KV feeders

The green energy revolution is unfolding on global scale with utilities, industries and even commercial establishments opting to switch from conventional to renewable energy.

There are several reasons for this transition to green power. First, renewable power, especially solar or wind power, is quite cheap than power sourced from DISCOM. By utilizing solar power, power bills and operating cost is decreased. Second, power reliability and quality against the use of diesel generator, which is both costly and polluting. Due to awareness and benefits of renewable power, now it is not restricted to residential only, solar panels are mounted on the premises of metro stations, railways, airports and where the space is available everyone thinks for energy security.

❖ **What is Energy Security**

- IEA (International Energy Agency) defines it as the uninterrupted availability of energy sources at an affordable price.
- It can be defined as the maintenance of safe, economic energy services for social well-being and economic development without excessive environmental degradation.

- ❖ **Why?**
  - To Ensure economic function/s without interruption.
  - Can reduce reliance on imports of oil, gas and coal.
  - Play crucial role in GDP [Gross Domestic Product].
- ❖ **Key Factors – Four "A"s**
  - Availability
  - Affordability
  - Accessibility
  - Acceptability
  - Above four aspects are must for Energy Security. An increase in the cost of energy can put people into energy poverty and leave them choosing between paying for energy or other essentials such as food.
- ❖ **Key Factors**
  - All forms of energy supply (renewable, fossil, nuclear) are having some form of insecurity.
  - The various energy supply sources and technologies pose different kinds of insecurity
  - Most renewable sources are up to some extent; variable and/or unpredictable
  - Fossil and nuclear fuels suffer volatile increases in prices and ultimate unavailability
- ❖ **Rural Regime [Necessity of Energy]**
  - Energy for cooking
  - Common fuel - animal dung, agricultural waste and firewood – to be reduced
  - New fuel – Biogas, LPG, PNG, Solar – to be increased
  - Household lighting – 100 % electrification
  - Village Service – 100 % electrification of school, dairy, panchayat, police station etc.
  - Enterprises - 24 hrs supply
  - Agricultural – irrigation, electrification, solar
- ❖ **How to Achieve ?**
  - **Economic Supply – Lower Cost**
    - – Demand management reduces the costs of supply.

- The reduced variations in demand bring reduced peak demands needs and, therefore, lower capacity costs and utilization of the marginal high cost supplies

- **Stability**
  - Effective distribution
  - Proper mix of energy – renewable – electricity
  - The greater the fraction of renewable supply, the lesser is the impact of finite fuel price rise
  - Load management can contribute to the matching of demand with variable supply with storage, control and interruptible demand.
- **Accessibility**
  - Effective implementation of all schemes by identifying gaps in existing schemes and problems.
  - Ensuring access to energy for each family by proper planning and monitoring.
  - Plan for future to meet rapidly growing demand for energy.
  - Proper control for energy waste – reduction in theft, energy conservation, redesign, innovative solution etc.
- **Acceptability**
  - Mass awareness by use of social and local media.
  - Periodical survey.
  - Encouragement for adopting technology.
  - Mass one to one communication.

❖ **How Achieved by UGVCL**

- Segregations of AG (Pumps) &Non-AG load – AG DOM feeders
- 24 hrs – 3 Phase supply to villages – JGY feeders
- Off line solar pump for household- farmers
- Solar Rooftop - Residential – Rural areas.
- SKY - 100 % for farmers

❖ PM KUSUM [Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan]

Public Awareness

- Mass awareness by use of social and local media

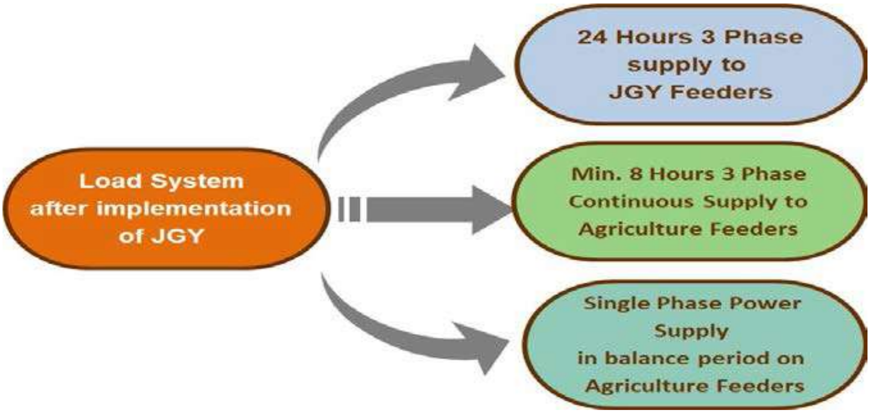
- Periodical survey
- Encouragement for adopting technology
- Mass one to one communication

❖ Jyoti Gram Yojana (JGY) – A Game Changer in Supply Management

- Benefits to the Utility
  - Flexible load management
  - Better quality and reliability of power supply
  - Reduction in transformer failure
  - Speedy restoration at the time of calamity
- Benefits to the Consumers
  - No Power cuts, hence increase in activity levels
  - Employment opportunities socio-economic upliftment – health, education, safety, entertainment & information, support to cottage industries, SSI, farming and dairy development, etc.

❖ **Before JGY**

- 8-14 Hours of 3-Phase Power Supply
- 10-12 Hours of Single-Phase Power supply
- 3-4 Hours of no Power Supply



- Higher transformer failure rate, T&D losses & interruption

❖ **After JGY**

- Implemented from 2005
- 24 Hours 3-Phase supply to JGY Feeders
- Minimum 8 hours 3-Phase continuous supply to AG Domestic Feeders
- 1 Phase Power Supply in the remaining hours on AG Domestic Feeders
- Reduction in transformer failure rate, T&D losses & interruption

❖ **Benefits of JGY Scheme**

- Enabled flexible load management
- Better quality and reliability of power supply
- Reduction in transformer/ system failure
- Speedy restoration of power supply at the time of calamity
- No load shedding - 24x7, 3-phase power supply available to villages
- Students encouraged to use computers for education
- Provision of better health services & infrastructure
- Reduction in migration from rural to urban areas

24×7 Power helps villagers to avail easy Repair & Maintenance of their machineries / vehicles through facilities of welding/lathe in the village.

24×7 Power enables the villagers to setup local dairy and in house milk testing.

24×7 Power has made it possible for the villagers to have the facilities of Copier machines making it easy for their important documents to be processed further.

24×7 Power Availability promotes Entertainment through television

24×7 Power makes it possible to use Modern Medical Equipment in villages

24×7 Power empowers the villagers with Mobile Communication thereby making their life easy and more manageable

Development of Small Scale & Cottage Industries in rural areas

Āatmnirbhar Bharat: Various Achievements by UGVCL

Various Schemes

- **SKY Scheme (Surya Shakti Kisan Yojna Agriculture Pump Solarisation)**
    - Scheme is for the farmers having agriculture Connection
    - Farmers are provided grid connected SPV System (1.25 time of contracted load in HP) with 7-year warrantee.
    - Day time power supply to SKY consumers for 12 hrs.
    - Purchase of surplus energy by DISCOM at the rate of Rs. 3.50 /Kwh for 25 years along with Rs. 3.50 /Kwh EBI up to 7 years (loan period) restricted to 1000 units /1 KW system annually
- **SKY Scheme (Salient Features)**
    - 5 % Contribution from farmer
    - 30% Capital subsidy from MNRE, GOI
    - 30 % Subsidy from GOG in the form of EBI (Evacuation-based Incentive) Rs. 3.50 per Kwh on exported energy after deducting feeder losses in excess of 5% (Up to 1000 unit /Kw/Year) for 7 years
    - 35 % Loan by GOG on behalf of the farmer, for which installment will be paid within 7 years from amount to be paid to farmer against purchase of surplus energy

- Reduce the subsidy burden on GoG
- Incentivize farmers for surplus power exported to the grid
- Secondary source of income
- Encourage farmers to efficiently utilize power and water.
- Help the DISCOM to promote renewable energy
- Reduce cross subsidy burden on other consumers
- Reduction in distribution loss
- Emphasis to distributed solar generation
- Farmer will get ownership of PV system after payment of loan

❖ **SKY Scheme Achievements**

- Total 18 Agriculture Feeders
- 621 Nos. of agriculture consumers having 19,540 MW solar installations.
- Cumulative generation by agriculture consumers- 72.52 Mus
- Average CUF (capacity utilization factor) > 18.3
- 285 Nos. of agriculture consumers (out of 441 nos.) have received Rs.2.41 crore against surplus energy injected in to grid during year 2019-20
- 424 Nos. of agriculture consumers have received Rs.3.87 crore against surplus energy injected in to grid during year 2020-21.

❖ **PM KUSUM– "B" / "C" (OFF Grid / ON Grid)**

- 30% CFA from GOI-MNRE (up to 7.5 HP)
- 30% Subsidy from GoGand 40% farmer's contribution
- Achievement: - KUSUM – B - Off grid
  - Total 238 applications of 1.798 MW received out of which 65 applications of 441.45 KW paid and commissioned.
- Scheme PM- KUSUM – C (Grid Connected) under implementation
  - Solar capacity (KW)= Max 1.75 times pump capacity in KW
  - Rate at Rs. 2.83/ Unit up to 25 Years.

❖ **Surya Urja Rooftop Yojana (SURYA-Gujarat)**

- Gujarat stands at 1st position in installation of solar rooftop in the country
- SURYA-Gujarat: - Scheme is for residential category connection

- MNRE CFA / state subsidy, 40 % up to 3 kW capacity
- 20 % subsidy for the above 3 kW and up to 10 KW
- Group Housing /RHA for common amenities 20 % subsidy
- Achievement UGVCL: Total 36,147 Residential Solar Rooftops installed having capacity of 137.625 MW up to 15.02.2022 Surya Gujarat scheme). Residential category – total installed 41,428 Nos. of 159.59 MW.
- Achievement Gujarat State: Total 2,73,805 residential solar rooftops installed having capacity of 1063.38 MW up to 15.02.2022

❖ Other Achievement of Solar Schemes

- Captive Use by Industries: At present total 17 f plants were commissioned by industries/individuals having installed capacity of 23.66 MW for their own use.
- Under SSDSP Scheme out of 438 (360MW) applications, 6 (10.04MW) were commissioned.
- Solar Water Pump off Grid (For farmers)
  - Total 934 AG Connections were released with off grid solar water pump having capacity of 5.263 MW.
  - Total generation 40.60 MWH.
- Solar Home Light Scheme (For Residential Remote Places).
  - New lighting connection in scattered residential area with stand-alone off-grid with 400-watt PV system.
  - Total 10200 solar home light systems have been installed in UGVCL area.

UGVCL has kept continuous pace for achieving energy security at higher level with renewable sources and assured to cooperate to achieve the dream target of Hon,ble Prime minister of 175 GW -2022 and 500 GW up to 2030.

Contextualizing Energy Security

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Energy is a vital component for all living organisms. The sun, directly or indirectly, is the prime source of all the energy available on the Earth (Other geothermal or Tidal energy). We should choose our energy sources very carefully, as our choices and decisions have impacts on the Earth's natural systems in ways we are yet to understand. Our bad choices of energy sources have resulted in climate change, increased ambient temperatures, and increased frequency of extreme climate events including frequent heat waves, deluges and draughts. These result in rise of sea level, livelihood losses and depletion of flora and fauna. There are several economic, political and social consequences that need to be considered while suggesting alternate sources of energy security.

The economic factors of an institution or organization or country or region or an individual move around the factors like levelized cost of energy, availability of the fuel, annual bills and network costs. All these factors when combined comprise the affordability of the technology. However, while planning the long-term source of energy, the fuel diversity, internal political / social disruptions, external disruptions and supply diversity are considered for analysing the availability of the energy source. The factors like reduction on dependence on imports or rejection of technology due to social unacceptance are pivotal for analysing the long-term availability of the source of the energy.

Consequent upon increased awareness about environment and climate change, stakeholders consider carbon emission and water intensity while choosing source of energy along with the availability of material and fuel while doing the investment. These factors can be categorized under the sustainability category, where as in the reliability category factors like response and reserve, shock resilience, de-rated capacity margin and system adequacy play a huge role. Each of these factors decides the fate of the technology and is important for policy makers and researchers to understand them. While the technologies are improving and people are adapting to the new sources of sources of energy, the relevance of above factors for energy security for generating electricity can be summarized as below.

	Parameter	Technology										
		Coal	Lignite	Gas	Diesel	Hydro	Solar PV	Wind	Bio-mass	Waste to Energy	Small Hydro	Nucle-ar
Affordability	Network Cost	4	4	4	4	4	2	3	3	4	4	4
	LCOE	2	2	2	2	2	2	2	2	2	2	2
	Fuel Poverty	2	2	2	2	2	1	1	2	2	4	3
	Annual Bills	2	2	2	4	2	2	2	2	3	2	4
Availability	Fuel Diversity	4	4	4	2	2	4	4	3	3	2	1
	Internal Disruption	2	2	3	2	4	1	1	3	3	4	5
	External Disruption	2	2	2	4	2	3	3	2	2	2	4
	Supply Diversity	4	4	4	4	4	2	2	4	4	2	4
Sustainability	Materials Depletion	2	2	2	3	1	2	2	3	3	1	2
	Fuel Scarcity	2	2	2	2	1	1	1	3	2	1	4
	Water Intensity	5	5	4	2	1	3	1	4	4	1	4
	Carbon Emissions	4	4	4	5	2	1	1	2	2	1	2
Reliability	Response and Reserve	4	4	4	4	4	2	2	3	3	4	4
	Shock Resilience	4	4	2	1	4	1	2	3	3	2	5
	De-rated Capacity Margin	4	4	5	5	4	1	1	3	3	4	2
	System Adequacy	4	4	4	2	4	1	2	3	4	3	5

Some sources of energy are infinite, while others are finite, so is the case with the technologies, some are at very mature stage while others are at native stages. It is very important to understand the energy requirement to analyse the concept of energy security; rightly said as per the famous saying by Mahatma Gandhi "The world has enough for everyone's needs, but not everyone's greed,".

We should also do investments in the technologies, policies and practices which are efficient, flexible and sustainable. The electricity sector has started moving towards energy efficiency, demand side management, availability-based tariffs, prepaid meeting and innovative technologies. The integrations of blockchain, internet of things, machine learning, artificial intelligence, virtual and augmented reality related applications to strengthen the energy security scenario.

The technology solution providers are finding innovative ways to energize different process, below is a picture of a Multi grain processing unit which is fully run by females in Jharkhand, the unit is in very remote locations and never had electricity before. The unit is serving as 8 to 10 nearby villages, which brings revenue and new business opportunities to the village.

FIGURE 1: MULTI GRAIN PROCESSING UNIT IN REMOTE VILLAGE OF JHARKHAND

This also gives us a lesson, when a less privileged areas can benefit by adopting modern technologies, why don't we also adopt sustainable technologies for community or self-utilization for betterment of us and our future.

Role of Solar Energy In Agriculture

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Introduction

In order to keep pace with the development, there is rise in energy consumption with significant impact on climate resulting from the use of diminishing fossil fuels. This opens opportunity to harness non-conventional energy sources and particularly much available solar energy. In many places, energy harvesting from wind and biomass have proved to be an impressive alternative. Solar based devices may also work in an integrated manner with small wind turbines as hybrid devices.

India, with a target of achieving 175 Giga Watts of installed capacity from non-conventional energy sources by the end of 2022, different initiatives have been made through different policies for achieving this target. In the recent past, a significant progress has been made to install solar PV plants, wind turbine, hydropower, biogas e.g. renewable installed cumulative capacity has been increased from 14.4 GW at the beginning of 2009 to 71.5 GW by the end of July 2018. In India, wind energy continues to dominate India's renewable energy industry, accounting for over 48.1% of installed capacity (34.4 GW), followed by solar power (23.2 GW), biomass power (9.4 GW) and small hydro power (4.5 GW). Rajasthan and Gujarat share 21% of the total solar power installed capacity in the country, whereas these two states share 43% of total wind turbine installation capacity. Tamil Nadu and Maharashtra dominate the total wind installation in our country sharing 39% of total installed capacity. By the end of 2017, a total of 38,687 off grid solar pumps have been installed in India. In agricultural sector, energy is directly used for pumping irrigation water, operating different mechanized farm implements/tools and processing of foods. Currently in agriculture, its average usage of energy is around 2.2kW per hectare and is of seven to eight percent of total energy consumption across all sectors [1].

Energy Scenario in India

A sustained 8% GDP growth of India requires an annual increase of commercial energy supply from 3.7 to 6.1%. Limited supply of coal, coupled with its poor quality, low level of technologies advancements and high environmental hazards. Fossil fuels are the major source of power generation worldwide. About 87% of the world's energy supply comes mainly from fossil fuels. Its share in India is more than 90%. The demand of energy is increasing by leaps and bound due to rapid industrialization and population growth, the conventional sources of energy will not be sufficient to meet the growing demand. Consumption of fossil fuel causes to emit large amount of pollutants such as carbon dioxide, sulphur oxides, bottom ash, fly ash, etc. which are hazardous for both environment and human survival on the earth planet. Conventional sources are non-renewable and bound to finish one day. Due to these reasons, it has become important to explore and develop non-conventional energy resources to reduce too much dependence on conventional sources and development of alternative sources of energy which are renewable and environment friendly.

Power generation from renewable energy sources like solar energy, wind and water power, other forms of biomass (plant material), and biogas (gas produced from fermentation of manure and crop residues) can be utilized in various applications in agricultural operations like water pumping, lighting and other processing operations [2].

Energy Use in Agriculture

Energy in agriculture is important in terms of crop production and agro-processing required for adding value. Human, animal and mechanical energy is extensively used for crop production in agriculture. Energy requirements in agriculture are divided into two groups, direct and indirect. Direct energy is required to perform various tasks related to crop production processes such as land preparation, irrigation, intercultural, threshing, harvesting, and transportation of agricultural inputs and farm produce. Direct energy is directly used on farms and on fields. Indirect energy, on the other hand, consists of the energy used in the manufacture, packing and transport of fertilizers, pesticides, seeds and farm machinery. As the name implies, indirect energy is not directly used on the farm. Calculating energy inputs in agricultural production is more difficult in comparison with the industry sector due to the high number of factors affecting agricultural production. However, a considerable number of studies have been conducted in different countries on energy use in agriculture.

Future Prospects of Renewable Energy in Agriculture

(i) Solar PV Operated Water Lifting / Pumping System

Lifting or pumping of water for irrigation purposes is the primary operation in agriculture. Energy demand for this purpose is ever increasing. Generation of the required energy demand on farm itself aids in the sustainable growth[1]. Pressurized irrigation systems e.g. drippers, sprinklers etc are of great importance in 'crop per drop' mission. However, ensured power supply is essential to operate these systems. In applications like pressurized irrigation and lifting of water devices from irrigation canals and where distribution of water required even, solar PV pumping systems play crucial role[3]. At present, about 16 million electric pumps and 7 million diesel pumps are in operations in the country for irrigation purpose. However, they are highly energy intensive and, therefore, if replaced with solar pumps may greatly contribute to country's energy security.

Till December 2020, 2,72,700 pumps have been installed in the country, which are mostly of 2 or 3 HP pumping system, which has been recently appended with 5 HP pumping system. These solar pumps have the capacity to withdraw water from a depth of about 75 m and therefore, may be beneficial in areas where groundwater is deeper. Moreover, solar pumps are directly operated by solar irradiance and therefore, diurnal and seasonal variations play a key role in implementation of solar PV pumps. In arid and semi-arid regions of the country, clear sky condition with average irradiance of 5-6 kWh/m^2/day is available for 300 days in a year and thus, solar pumps can be operated for about 6 hours a day for most of the period in a year (Anonymous, 2019).

Figure : Picture of Solar Pumping Systems on Field

(ii) Agri-voltaic or Solar Farming

Integrating solar PV systems with agriculture is called as Agri-voltaics (Zainol et al. 2021). Unlike solar farms, solar panels in the agrivoltaics installed with higher ground clearance leaving enough space for the agricultural operations and allowing the crop to grow[4]. Agrivoltaic land utilization system or solar farming is proposed to either ascertain a portion of land for erection of PV modules in a farmer's field or introduce crop cultivation in the same piece of land where PV panels are erected for electricity generation purposes. By adopting such system, the risk of loss due to crop failure during aberrant weather events may be marginalized in farm scale and may prove to be an effective drought proofing strategy. PV panels are placed in a solar power plant for electricity generation conventionally in long rows with sizeable areas left blank by default to avoid shading. These inter- panel areas and below -panel areas can be effectively utilized for growing such crops that can tolerate certain amount of shade for different durations of the day.

Solar PV plants installed in agrivoltaics can be on grid or off grid and is of fixed or single axis or double axis sun tracking system enabled to ensure harnessing of maximum energy[5].

In arid zone, a small amount of shading actually serves as a boon by reducing evaporation and transpiration losses. Secondly, all solar PV plants in arid zone have a problem of deposition of a fine film of wind born sand on panels requiring a water spray to clean it. This water washes down the panel into the soil. Thus, there is an availability of partially shaded space and recurrently available washout water, which can both be harnessed for growing crops. Ideally, crops for these sites should be such that it is not taller than 50-70 cm, preferably perennial, spreading, and do not interfere in any way with the functional efficiency of solar power plant.

1 MW Agri Voltaic Solar Power Generation Plant, was installed in Village: Amrol, Ta. Anklav, Dist. Anand, Gujarat by Anand Agricultural University in collaboration with Gujarat Industries Power Company Limited

(iii) Solar Based Processing of Agricultural Produces

Processing of agricultural produces like drying, cleaning, grading, winnowing etc. is important for value addition. There are already well established solar thermal and PV based devices available commercially and many specific technologies have been developed by different institutes for farmers and villagers. For example, inclined solar driers have been found quite useful to dry different agricultural produces along with maintenance of quality of the produce. Animal feed solar cooker have also been found to augment the milk production from cattle by providing them quality boiled feed. Solar water heater also has great potential in different processing stages.

Crop Drying Operations

Use of solar energy can also be seen in crop and/or grain drying[6]. Farmers have been using the sun to dry crops for centuries. Though allowing crops to dry under the sun naturally by spreading evenly is not only the least expensive technique yet the chances of the crop damage by environmental effects, birds etc are more[7].

However, solar dryers are designed to provide protection from insects, rodents and birds, as well as weather. Advanced solar based dryers offer uniform and fast drying with a better-quality output compared to open sun drying.

Perforated drying trays, glazed box and solar collector are the basic constituents of the solar dryer[7]. The design of a solar crop drying system is quite simple. The heated air is then moved through the crop material either by natural convection or with a fan. In hot and arid climates, the solar collector may not even be necessary for the solar dryer. The southern side of the enclosure itself can be glazed to allow sunlight to dry the material.

Designing of the collector size and airflow rate depends on the quantity and nature of the product, amount of moisture to be removed and presence of humidity in the air, and the amount of insolation available[6].

Solar collector amounts to be the major portion of the solar dryer cost and hence found very less on fields. This led to the multipurpose use of solar collectors of the dryers when they are not in the drying operations[6]. Natural convection solar drying has advantages over forced convection solar drying because it requires lower investment, but it is difficult to control the drying temperature and the drying rate in natural convection. Due to low cost and simple operation and maintenance, natural convection seems to be more popular[8].

Solar drying has the following advantages:

- (i) Facilitates early harvest;
- (ii) Permits planning the harvest season;
- (iii) Helps in long-term storage;
- (iv) Helps farmers to fetch better returns;
- (v) Helps farmers to sell a better-quality product;
- (vi) Reduces the requirement of storage space;

(vii) Helps in handling, transport and distribution of crops;

(viii) Permits maintaining viability of seeds.

Different modes of solar drying[9] are discussed below.

Direct Mode Solar Drying

In this mode of drying, the product to be dried is exposed to the solar insolation through a transparent glass. Most of the solar radiation is converted into heat, thus raising the temperature of the crop and its surroundings.

Indirect Mode Solar Drying

In this mode of drying operation, the product to be dried is not exposed to insolation.

The air which removes moisture from the product is passed through a solar collector where heat generated is absorbed by the absorber plate where heat exchange from absorber plate to air takes place. The hot air, when allowed to flow through the product removes the moisture from the product. Drying temperatures can be controlled in these types of dyers.

Mixed Mode Solar Dryer

Mixed mode solar dryers offer advantages of both direct and indirect mode solar dryers, but the adaptability rate of these dryers is less because of not economically viable.

Figure :Mixed Mode Solar Drier

Dairy Operations

Hygiene is the top priority in the dairy farms and for cleaning dairy equipment's hot water is required. Heating operations itself accounting to 40 percent of the total energy consumption. Hence, solar water heating systems are beneficial for meeting the hot water requirements[7].

Solar Roof: Greenhouse

By appropriately positioning solar panels on greenhouse roofs, it is possible to obtain multiple advantages:

- Using the solar energy makes the agricultural production independent of traditional energy sources
- Reduces the environmental impact and production costs;
- Judicious use of land as both agriculture and photovoltaic panels need sunlight and available land
- The shading produced by passive cooling system of panels works as an alternative to special shading systems such as nets and reflective coatings.

Figure : Indicative Picture of Green House with Solar Panels Roof

iv) Solar Wind Hybrid Systems

Wind and solar energy can be used to power the greenhouse to produce fresh water without the support of energy sources from fossil fuels (Bermudez-2008). Nowadays, most of the water desalination uses fossil fuels, and therefore, it contributes to greenhouse gases (GHGs). Developing an idea of using solar energy, PV and wind energy to power a seawater greenhouse equipped with systems for humidification and dehumidification that create the right climate to grow at the same time and to produce fresh water from the saltwater. A greenhouse with a dimension of 16 m wide and 60 m long, produces 297 L/day of fresh water. In just 8 h (between 9:00 and 17:00 h) the greenhouse produces up to 98% of the total fresh water; this interval corresponds to the duration of solar insolation. The solutions for managing renewable energy sources should be developed involving local people.

Due to the complementary intermittent nature of wind and solar, power production can be levelled out throughout the day with a Solar-Wind Hybrid models. With a hybrid, reliability of the grid is improved by ensuring power during peak requirements. The introduction of the National Wind-Solar Hybrid Policy has been instrumental in encouraging the hybridization of existing wind and solar plants thereby promoting Hybrid models in India (https://economictimes.indiatimes.com/small-biz/productline/power-generation/decoding-the-national-wind-sol?from=mdr).

The primary aspect of the hybrid plant is the configuration - AC or DC integration and the use of technology.

Another aspect is sizing of the hybrid plants. Huge benefits of hybrid plants can be achieved by reducing transmission losses and with better grid stability. To ensure, better grid stability, identification of wind power dense locations is important and integrating the same with a small size solar pv plants as a hybrid component[10]. Small wind aero-generators in hybrid mode with solar panels are useful for off grid renewable energy-based electricity generation. These devices are quite useful considering their 24-hour generation potential. Solar PV panel enables generating electricity during day time and clear sky conditions, whereas small wind turbine of Savonious design at low heights is capable of harnessing wind energy during both day and night including cloudy days. In agricultural farms, installation of such hybrid devices along farm boundary not only will protect crops but also will generate electrical energy that can be used in different farm operations.

Figure : 5kW Hybrid Solar Wind Power System at College of Agricultural Engineering and Technology, Anand Agricultural University, Godhra

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Āatmnirbhar Bharat : Energy Security-Bioenergy

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General

With a population of 1.4 billion and one of the world's fastest-growing major economies, India will be vital for the future of the global energy markets. Biomass has always been an important source of renewable energy for the country considering the benefits it offers. Looking ahead, the government has laid out an ambitious vision to bring secure, affordable and sustainable bio-energy to all its citizens. Bioenergy is the third-largest primary energy source in India, estimated to provide 21.2 % (186.8 Mtoe) of total primary energy supply (TPES), 44.6 TWh (2.9% of electricity generation) in 2017. India, the second largest agro-based economy after china with year-round crop cultivation, generates a large amount of agricultural waste, including crop residues. The crop residue is termed as potential source of bio-energy. Crop residues, in general, are parts of the plants left in the field after crops have been harvested and thrashed. The harvest waste, which is more popularly termed as crop residue can contain both the field residues that are left in an agricultural field or orchard after the crop has been harvested and the process residues that are left after the crop is processed into a usable resource. Stalks and stubble (stems), leaves, and seed pods are some common examples for field residues. Sugarcane bagasse and molasses are some good examples for process residue. More than 70% of the country's population still depends upon biomass for its energy needs. The government is discouraging the direct combustion of biomass energy owing to health and environmental issues. Bio-methanation, gasification, pyrolysis, bio liquefaction and briquetting are the key technologies for biomass to energy conversion. As per a recent study by MNRE, the current availability of biomass in India is estimated at about 750 million metric tonnes per year, surplus biomass availability is about 230 million metric tonnes with a power installation potential of about 28 GW. Till November 2021, an installed capacity of 10.374 GW has been achieved for biomass energy. (MNRE, GoI).

The College of Renewable Energy and Environmental Engineering (CREEE)

Fig.1: The SDAU and CREEE

This is only and first of its kind college established in 2009-10, at Sardarkrushinagar Dantiwada Agricultural University (SDAU). The then CM Shri Narendra Modi was instrumental behind the establishment of the college. This four year under graduate degree programme is a revolutionary approach in combining the disciplines of Renewable Energy and Environmental Engineering Undergraduate, post graduate and Ph.D. level degree programmes are being offered by the college.

Use of Satellite-Based Remote Sensing Technologies

To monitor crop residue management, the National Remote Sensing Agency (NRSA) and Central Pollution Control Board (CPCB) initiated the process of mapping volume of crop residues and locate the exact crop burning locations, the Punjab Pollution control Board (PPCB) and the Environmental Prevention and Control Authority (EPCA) (National Agency) used remote sensing techniques and aerial surveillance. The burning areas were identified as red dots in the imagery.

Farm Machineries for Crop Residue Management

1. Straw Reaper

Fig.2: Straw Reaper with Netted Trolley

Straw Reaper is a chopper machine which cuts, threshes & clean the straw in one operation. The wheat stalks left after combine harvest are cut by an oscillating blades while revolving reel pushes them back toward and auger. The stalks are conveyed into the machine by the auger and guide drum, which reaches the threshing cylinder which cut the stalks into small pieces against concave. Double blower operating just behind rushes the straw to netted trolley attached and separate the dust particles.

2. Paddy Straw Chopper

Fig. 3: Paddy Straw Chopper in Operation

It is used for chopping of paddy straw and residues of crops such as wheat, maize, sorghum, sunflower etc. The machine consists of a rotary shaft mounted with blades known as flails to cut the straw and knives for chopping.

The chopped and spreaded stubbles are easily buried in the soil by the use of single operation of rotavator or disc harrow. Subsequently, wheat sowing is done as usual by the use of no-till drill or traditional drill/other equipment

3. Baler

It is used to compress raked residues of rice, wheat, fodders, sugarcane, legumes etc. into compact bales that are easy to handle, transport, and store.

Two different type of bale–rectangular or cylindrical, of various sizes, bound with twine, strapping, netting or wire have been developed and readily available.

Fig. 4: Baler Machine and Prepared Bales

The bales being compact are easy to handling and transport. It is used for animal feeding, biofuels and power generation. The technology creates ecofriendly livelihood to the farmers.

Technologies for Biomass to Energy Conversion

1. Gasifier

Gasification is a flexible, commercially proven and efficient technology. In gasification process, wood, charcoal and other biomass materials are gasified to generate so called ´producer gas´ for power or electricity generation. Theoretically, almost all kinds of biomass with moisture content of 5-30 % can be gasified.

Fig.5: Gasifier and its Schematic View

Biomass gasifier technology is a mature technology and gasifiers are available in several designs and capacities to suit different requirements. The technology is suitable and economical for small, decentralized applications, typically with capacities smaller than a megawatt.

2. Biomass Briquettes

Biomass briquetting technology is used to make energy fuel briquettes from biomass waste.

Briquetting machine is an energy saving machine and renewable source of energy.

Fig.6: Biomass Briquetting Machine and Briquettes

Biomass briquette are produced from agriculture and forestry waste without adding any chemical in biomass. Biomass Briquettes are widely used for any type of Thermal Application like steam generation in boilers, heating purpose, drying process & gasification plant to replace existing conventional fuel like coal, wood & costly liquid fuel like FO, diesel, LDO, kerosene etc. It is environment friendly technology.

The Government of India recently directed the National Thermal Power Corporation (NTPC) to mix crop residue pellets (nearly 10%) with coal for power generation. This helped the farmers with a monetary return of approximately Rs. 5500 (77 USD) per ton of crop residue. These lucrative measures are yet to be in action and it can be profitably exploited by the farmers.

3. Biogas Plant

The biogas technologies have been in vogue since the 1970s and several programs are run by the National Biogas and Manure Management Program-off grid biogas power generation program to provide renewable energy for electricity generation, cooking and lighting purpose.

These programs were implemented by the Government under the "waste to energy mission". This is also a part of India's action plan on climate change. Government of

Fig.7: Floating Dome Biogas Plant and Its Schematic View

India has recently launched a GOBARDHAN scheme to promote the technology at rural level. Anaerobic digesters can turn biomass into biogas, a renewable energy source, containing approximately 60% methane, and a final solid residue usable as a fertilizer rich in nutrients. Anaerobic digestion is a promising technology due to its ability to convert almost all sources of biomass, including different types of organic waste, slurry and manure into highly energetic biogas.

4. Biochar

Biochar is a fine-grained carbon rich porous product obtained from the thermo-chemical conversion of crop residue called the pyrolysis at low temperatures in an oxygen free environment.

Fig.8: Biochar Production System and Its Use in Soil Conditioning

It is a mix of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), sulphur (S) and ash in different proportions. When added to soil, highly porous nature of the biochar helps in improved water retention and increased soil surface area. It mainly interacts with the soil matrix, soil microbes, and plant roots, helps in nutrient retention and sets off a wide range of biogeochemical processes. Many researchers have reported an increase in pH, increase in earthworm population and decreased fertilizer usage.

A Success Story of Bio-CNG cum Organic Fertilizer Production Unit

It is estimated that annually 1200 million tons of cattle dung is available in India, of which about 600 million tons surplus can be used as feedstock for biogas generation (https://dahd.nic.in/related-links/chapter-v-part-2). It means there is potential to generate 2,40,00000 cubic meters of raw biogas every day. Application of biogas is not just confined to domestic use but with its purification, we can run CNG vehicles. The pure form of raw biogas is known as bio-CNG. Purification means removal of CO_2, water vapour, H_2S etc. Bio-CNG contains about 92-98 % of methane and only 2-8 % carbon dioxide. The calorific value of Bio-CNG is about 13,000 kCal per kg, which is 2.7 times higher than that of raw biogas. The low emission levels of Bio-CNG also make it a more environment-friendly than fossil CNG.

Banas Bio-CNG Unit

Fig.9: Bio-CNG plant of Banas Dairy

The Banas, Asia's largest milk processing cooperative located at Palanpur in the state of Gujarat, India developed a 3500 cubic meter Biogas reactor exclusively for the production of Bio-CNG and organic manure production. The plant uses cattle dung and agricultural waste as a feedstock. The project was commissioned under "Swachh Bharat Mission", the vision of Shri Narendra Modi, Prime Minister of India. Shri Shankarbhai Chaudhary, Chairman of the dairy was instrumental behind the world-class development.

Dung Collection and Feeding

The Banas dairy regularly collects 40-45 metric tons of cow dung from 250 farms of twelve nearby villages by fleets of tractors. Apart from milk, now the cooperative members also earn extra income from dung.

Fig.10: Dung Loading, Unloading and Mixing with Water

Digester

The homogenized mixture (fresh slurry) is pumped to the digester at the flow rate of 30 m3/hr. The digester is a fixed dome type, it is that component where the fresh slurry gets digested anaerobically to produce raw biogas. Digester can hold up to 3000 m3 of liquid slurry.

Fig.11: Fixed Dome type Biogas Digester and Gas Holder

Gasholder

Raw biogas is stored in to double membrane gas holder. The outside cover of the balloon is made of flexible PVC and neoprene with special ingredients to withstand ultraviolet radiation and precipitation load. The balloon dome gets stretched with the increase of biogas pressure. Gasholder capacity of the plant is 500 m^3.

Fig.12: Gas Holder System

Purification System

1) Water Scrubbing

The scrubbing is a simple process, where raw biogas and water flow in a countercurrent pattern at 0.5 to 1.0 bar pressure. The gas stream flows upward, while water is sprinkled downward, the CO_2 present in the gas gets dissolved in the water, Slighly acidic water is found suitable for agriculture, where soil is little alkaline in nature. Efficiency of the scrubbing system is about 85-90 percent.

2.) Vacuum Pressure Swing Adsorption (VPSA)

Fig.13: VPSA Purification System

The VPSA is a secondary or fine purification of biogas. The relatively pure biogas is fed in the reactor (vessel) to a pressure of 5-10 kg/cm^2 where it is adsorbed by porous solid adsorbents like activated carbons, zeolites, and other materials (titanosilicates). Adsorbent gets saturated with CO_2 needs to be renewed periodically by creating vacuum (reverse flow).

Biogas Compression and Bottling

The bio-CNG is then compressed and stored into cascade. Compression is carried out into four stages, first stage 0 to 4 bar, second 4 to 16 bar, third 16 to 70 bar, fourth stage 70 to 200 bar. The bio-CNG is stored in cascades with total capacity of 1600 kg, which equals two reserve days.

Fig.14: Biogas Compression and Bottling Unit

From cascades the gas is delivered to Bio-CNG filling station established on roadside to refill CNG vehicles.

Bio-CNG Filling Station

Fig.15: Bio-CNG Filling Station

Everyday 100 CNG vehicles are being served by 800 kg of bio-CNG per day.

Solid and Liquid Fertilizer Production Unit

Digested slurry recovered from biogas plant is further processed to produce dry and liquid bio fertilizer. The Banas dairy distributes the dry fertilizer in a bag of 50 kg. Spray of liquid fertilizer is provided by the dairy through specially designed tanker services. Every day the unit produces about 8 tons of solid fertilizer and 70,000 Liter of liquid fertilizer.

Project Financials (Rs.)

Total Project Cost (Without Land Cost Rs.)	Operational Expense/Year (Rs.)	Gross Revenue/ Year (Rs.)	Profit/Year (Rs.)
8,04,00,000 Subsidy: 66,00000	4,68,11,000	6,04,07,500	1,35,96,500

Fig.16: Solid and Liquid Fertilizer Production Unit

Conclusion

Agricultural growth is a top priority agenda of the Indian government. The sustainable management of agricultural waste has become a great challenge, especially for developing countries such as India. Appropriate farm machineries play important role in timely and cost effective management of crop residues. If managed properly the biomass resources could be turned into prosperity of farmers. Effective and efficient management of untapped biomass energy through technological breakthrough is need of the hour for eco-friendly development of agriculture. Decentralized units for bio-energy conversion, not only will help reduce reliance on fossil fuels but will pave a way for building "Self Reliant Nation". The Banas Dairy has an ambitious plan to set up at least 50 such biogas plants in the district.

Rural Energy Security Focusing Farmers

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Rice being staple food for more than 50% of the population, its sustainable production is of utmost importance. The two essential resources, the excess water and the skilled labour are both becoming limited. Not requiring the transplanting and the puddling; SRT gives relief to the tune of 50% reduction in both the input requirements.

Today's trend in R&D for agriculture is to come up with bigger and powerful machines for soil tillage. They not only guzzle huge amounts of fossil fuel but also destroy the organic carbon fixed into the soil triggering a chain of multiple problems towards global warming and creating subsoil hardpan which prevents water infiltration into aquifers.

SRT being a zero energy for tillage and 50% less water requiring technique has huge direct impact on saving of foreign currency.

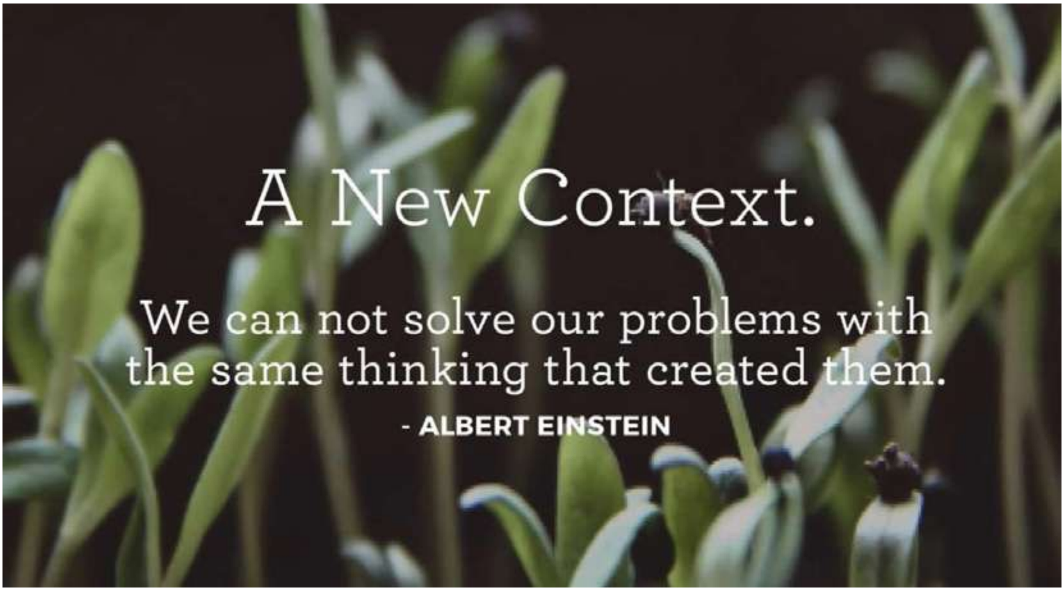
Gigantic national objectives like "Aatmanirbhar Bharat" have no relevance unless the smallest concerned individual accepts the idea aggressively and wholeheartedly. SRT is a unique such example. It has proved that the smallholder (84%) farmers are once again becoming happy and confident soon after adopting SRT.

Even a one-acre farmer suddenly becomes a three-acre farmer by adopting SRT and becomes financially a well-off farmer in the picture following rotation of fragrant Indrayani rice - lettuce - broccoli getting an income of Rs. 3 lakh per year per acre, the family became happy and content.

Only a few farmers becoming happy by adopting a technique is not the need of the hour. An extensive movement of happiness by farming is possible by adopting SRT.

Mechanization for tillage operations is still a top priority for farmers' upliftment by the governments and the institutions. This is like digging our grave for soil erosion, a big global concern.

Soil Erosion will demand more energy in the form of fertilizer, tillage, irrigation & chemicals.



Degenerative agriculture is where tillage like ploughing is performed which is burning away huge energy whereas using agro-chemicals like herbicides will turn off tillage, will improve soil health and biodiversity and bring down energy consumption to zero in agriculture.

Carbon sequestration by no till method is the key to saving energy.

Happy & Confident Farmer, Happy Soil & Happy Environment should be the primary goal in front of the authorities and the ones with the power.

It is a misunderstanding that healthy soil and a happy environment can be understood and resolved only by those in the chair. SRT, a technique by a group of innovative farmers, is proving to be sustainable in solving many problems of global agriculture including energy conservation, yet disapproved and not acceptable by the authoritative agricultural institutions.

Technology for Enhance Water Productivity

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Enhancing Water Productivity   Waste Water Treatment & Reuse

Exploring Climate Adaptation and Mitigation in Drylands towards Achieving the SDGs

The government of India has introduced Jal Jivan Mission (2019) which provides for minimum 55 litres per capita per day (LPCD) supply of water through tap. Half of the States are providing 70 litres or 100 litres LPCD. Considering 65% of water is generated as a waste, the grey water (including blackwater) would be in the range of 40 to 60 LPCD. Thus, 1000 population would generate an average 50 KLD (Kilo liters /day) (taking into account for next 5 years).

Treatment of wastewater is a big challenge. The big central treatment plants have proved to be ineffective because of the high operational cost, load of pollutants, inadequate technology, and very high capital costs.

Bio-filters technology is a decentralised effective, efficient and cost-effective system for addressing the issues. The treated water is acceptable for Agriculture, as per CPCB norms of 2017. The water can fetch Rs.2.00 per thousand litres. The treated water supply can be used to support summer crops. This also accrues saving in the extraction / distribution of Agriculture Water (Rs.5/- to Rs. 10/- per thousand litres depending on source and distance of transport). Waste Water Treatment is crucial for reducing pollution load in ground water and streams & rivers. Bio-Filter technology also obviates the generation of sludge and hence ease in handling black water (septic tanks).

As per study conducted by Shroff Foundation Trust in of around 0.5 MLD of waste water is available for reuse purpose that otherwise end up of in nearby nallah. SFT use technology to manage waste water.

Decentralize Waste Water Treatment Plants for Villages – Khanderaopura, Taluka-Padra

Case Study - "Zero Waste Village" by Solid and Liquid Waste Management"

Genesis :

- Khanderaopura village (Padra block of Vadodara District, Gujarat) is a village having population of 1500 having 185 households.
- In 2016 this village had an outbreak of Cholera and it earned a bad name. It remained focus of media for a long period. Shroff Foundation Trust was requested to look into the problems of sanitation & hygiene of this village.

Thus it was decided by the village community that this village would need to be qualified for ODF and the drainage line would be repaired to make it functional.

Re-use of Treated Waste Water

- Khaderaopura Village generates 100 to 120 KLD domestic waste water @ 70 lts.per person per day.
- Proper mapping was done to collect the entire quantity of waste water generated for further treatment.
- Biofilter plant was installed of 120 KLD capacity, which is solar based and the total treated water is used by villagers for agriculture.
- Even the operation of the plant is done by villagers after providing proper training and today they are able to take 3-4 crops per year.

Collector of Vadodara received Award for the Project

RESOURCE GENERATION PER ANNUM FOR 120 KLD PLANT

Sr. No	Particular	Basis	Quantity In Kgs/KL	Rate/Kg in Rs.	Amount in Rs. Per Annum
1.	Water for Irrigation	Cost of device & use of energy to lift water.	120	10 /KL	396000.00
2.	Nutirtive Water for Agri/ horticulture	Available Nutrient contents -			
		a. Av. Nitrogen(NO3)-Urea	4560	5.5	25080.00
		b. Av. Phosphorus- DAP	636	22	13992.00
		c. Av.Potassium- MOP	1740	11	19140.00
3.	Vermi-Compost generation	a. organic Media consumed 3 MT/year b. out of which 1/4th is converted into Vermi compost	3000	3	9000.00

4.	Earthworm Biomass	a. Fully matured Biofilter bed harbors 4-5 kgs earth per cum	250 Kgs	200	5000.00
5.	Resource Generation / Year				468212.00
6.	Resource /day				1418.00
7.	Resource / KL				11.82

Note: The cost of water includes nutrients value, vermin-compost & earthworm biomass

Challenges of Drylands

To resolve the challenges of drylands in terms of water scarcity, SFT made an attempt at 3-4 different locations viz (KVK-Jalna, Villages - Khanderaopura, Chikodra & Kukma) using recycled waste water and observed encouraging results. This could provide adequate water for irrigation through the year to take 3-4 agriculture crops.

Capital and Operating Cost

- Recycled Water available throughout the year.
- The Capital Cost for 50000 LPCD Plant would be Rs. 10 lakhs including Solar Plant
- The operating cost (including maintenance) is around Rs. 10 per thousand litres i.e.1 paise per litre.
- Grey & Black Water including sludge can be managed.

Experience sharing - use of technology - City Sewage Treated and Recycled for Agriculture

Jalna is a city located in Marathwada and receives very less rainfall and is drought prone area. Having population of around 3.0 lakhs, availability of domestic sewage is sufficient including in summers. Farmers of Jalna here facing shortage of water for agriculture and therefore it was decided to treat the city sewage (from nearby nallah) through Bioflter Technology and reuse for agriculture. Since then the farmer are able to take 3-4 crops per year and their problem of water shortage was completely resolved.

Advantages of Biofilter Technology

- Green technology – no use of chemicals
- Use of all material from natural origin
- Low energy & maintenance required (no mechanical equipment.)
- No sludge generation
- Aerobic with no odour
- Resource generation in form of “Bio-nutritional” products like:

- Nutrient rich water,
- Vermi-compost &
- Earthworm biomass

- Can be implemented at De-centralized level.

Average Results

Parameters	Before Treatment	After Biofilter Treatment
pH	8.7	8.0
TDS (ppm)	1200	1200
Turbidity (NTU)	95	14
COD (ppm)	400	90
BOD (ppm)	150	20
DO (ppm)	Nil	2.9
Colour	Dark Grey	Pale Yellow
Odour	Strong	Odourless
Fecal Coliforms (MPN/100ml)	$> 10^6$	$< 10^3$

Note: The treated water quality is as per the CPCB norms of 2017 for land irrigation

Benefits derived

1. Total 30 acres of land is cultivated using Biofilter treated water.
2. 7 types of fruits like Mango, Tamarind, Sweet orange, custard apple, Guava, Kagzi Lime and Grapes are cultivated with Biofilter water.
3. Vegetables like Tomato, Chilli, Brinjal, Lady finger, Bitter Guard and Bottle Guard are cultivated in an year.
4. Fodder crops with substantial growth is grown in 1 acres of area getting 5-6 cuts of fodder in a year.
5. Vigorous growth is observed in all plants, No scorhching of leaves and the crop yield doubled by usage of Biofilter treated water.
6. 10 quintals of compost is harvested and used in KVK farm.

Innovative Model for Safe Drinking Water

The consumption and need of diverse energy sources are increasing rapidly day by day. It has increased burden on energy production processes and strategies. In spite of serious efforts put in by the government the situation is going out of control. Hence the policy makers have emphasized on developing alternative sources in form of renewable energy to achieve, "Aatmanirbhar Bharat in energy". Over the years the visionaries of Shroffs Foundation Trust had started thinking and experimented few models, which are important to ease the day to day activities of the rural people. Renewable energy provides reliable power supply and fuel diversification, which increases energy security and reduces the risk of fuel spills by reducing the need for imported fuel. Renewable energy also helps in the conservation of the country's natural resources. In addition to increasing energy supply, renewable resources will help India mitigate climate change. India is heavily dependent on fossil fuels for its energy needs. Most of the electricity is generated by coal and oil-based power plants which are major contributors to greenhouse gas emissions. The primary purpose of using renewable energy in India is to promote economic growth, improve energy security, improve access to energy and mitigate climate change. Energy and safe drinking water are the essential needs of every human being. Though availability of water is universal in nature; its quality and quantity are major constraint. Drinking water need of human is small in quantity and hence can be managed locally, but many villages still face acute shortage of drinking water due to various reasons of its management.

The water distribution system in the tribal villages of Chhotaudepur district was badly affected despite having availability of water sources. Mini water supply schemes are developed as a part of decentralized planning. The water is supplied through a deep bore well by pumping and distribution network. The major difficulty faced is timely availability of power supply for water pumping and lifting. As a result, though many villages have water in the bore wells, the villagers do not have access to drinking water regularly.

About Village Bilvant

The village Bilvant is a typical tribal village within forest area located about 42 Km from Chhotaudepur town. The village is divided in to four hamlets with a population of 910 having 146 households and 584 animals. There were total 31 drinking water supply sources including hand pumps and mini water supply schemes; of which only 16 were functional.

The depth of the bore wells ranges between 75 to 125m and hence in absence of electricity supply the villagers are dependent on open wells made for irrigation. These wells also dry up from month of March till the monsoon. The water available in the open wells was highly contaminated both physically and biologically; despite the villagers would use it. Out of four clusters of houses in the village, the cluster having 48 households covering 288 people and 192 animals was found most water scarce. The power supply is not regular in these villages, the women would spend average 4 to 5 hours a day collecting the water for domestic use. The situation was an opportunity to explore use of solar energy for addressing the irregular power supply impacting access to water.

Solar Pumping-Based Distribution System

A well-known corporate manufacturing the pumping machineries for domestic and irrigation purposes came forward to own up this social cause to develop a water distribution system which is based on solar energy pumping system. Project components based on technical assessment following interventions were finalized.

- Creating water source by drilling of 116m bore well.
- Construction of pump house and overhead tank.
- Laying water distribution pipe line with stand posts and cattle trough.
- Installation of solar power-based water lifting mechanism.

Community Participation

The project was innovative and highly technology driven in nature; the dialogue was initiated with the Village Water & Sanitation Committee (VWSC). The project concept and its possible benefits were discussed and explained to the members of the VWSC. Need-based project was launched in the village with the following conditions. The criteria for village selection were

- The beneficiaries must be ready for providing their beneficiary contribution
- The beneficiary group should be ready to maintain the system

Impact

The success of the pilot led to the technical solution of huge numbers of such mini water supply schemes which are incomplete due to lack of availability of power connection. The salient impacts are as follows :

- 50 families are enjoying 100 litres of safe drinking water daily.
- Easy access to drinking water at hamlet level has helped in reducing dependency of women.
- The water is available to the families on demand which was not possible earlier.
- Led to reduce the habit of water storage, use and reduced wastage of water.
- This is a decentralized model of water management catering need of small numbers of families and hence its management is easier due to participation of all beneficiary families.
- The system has saved recurring expenditure in maintenance and electricity; which is one of the major constraints in management of water supply in rural area.
- The replacement of electric power with solar energy which is a clean energy will help in reducing greenhouse gases (GHG) emissions occurring in production of electricity in thermal power station.

Operation and Maintenance

The pumping of water by solar energy-based pump set is new and innovative technology first time introduced in the area; the day to day operation needed lots of technical skills, the technical team of the donor companies intensively trained the members of VWSC and demonstrated various operations. Also, the team of SFT sensitized on justified distribution of water, documentation system and water tariff. At present per family Rs.50/- per annum is fixed as water tariff. SFT team helped in starting and establishing the documentation system, the registers for documents like meeting minutes, contribution, maintenance and receipt books were started.

Recommendations

The regular supply of electricity is still out of reach to the remote villages of Gujarat. It impacts the daily life style of the people. Not only supply of safe drinking water but lightening of streets and houses also are equally important in these remote areas; The solar based electricity supply system can be a long-lasting dependable solution, Hence it can be replicated in such areas. on priority basis the miniwater supply schemes waiting for power connection can be equipped with the solar pumping system to minimize the hardship of the people and get water on demand.

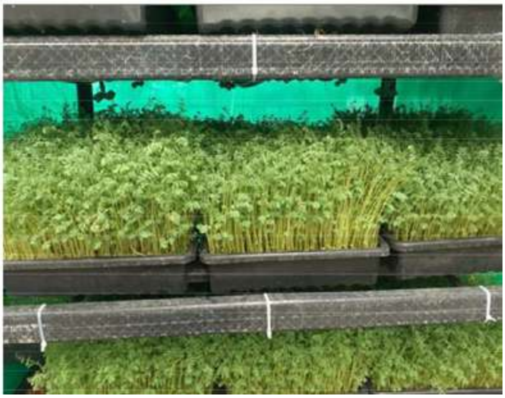
Hydroponic system for green fodder
"A smart and innovative farming "

1

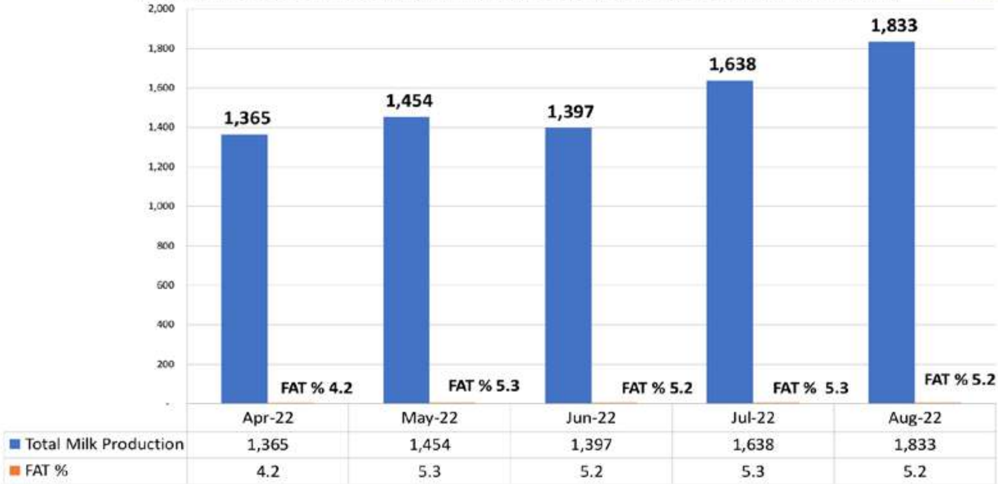
TRANSCHEM AGRITECH Pvt. Ltd.

Hydroponic system capacities

20 Kg per Day	For 2 cattle's
50 Kg per Day	For 4 Cattle's
100 Kg per Day	For 8 Cattle's



TOTAL MILK PRODUCTION & FAT % AFTER USE OF HYDROPHONIC SYSTEM SINCE APRIL22



COMPARISON OF CONVENTIONAL METHOD OF GROWING GREEN GRASS VIS-À-VIS HYDROPONIC METHOD

CONVENTIONAL METHOD OF GROWING GRASS		HYDROPONIC METHOD OF GROWING GRASS	
1.	Area required 4500 sq. meter of land.	1.	3 sq. meter space required
2.	Production quantity 10000 Kgs per season.	2.	50 kgs per day.
3.	It consumes around 16 lacs liters water per season.	3.	50 liters water required per day.
4.	Soil required to grow grass.	4.	Soil not required.
5.	Soil borne decease problem occur.	5.	No soil borne decease.
6.	You don't get fodder every day.	6.	You get fodder every day in equal quantity.
7.	Land cost not considered.	7.	The hydroponic grass growing unit cost approx. Rs.50,000/- per unit + tax.
8.	Electricity required to pump water.	8.	Being it works on Solar, no electricity required.
9.	Protein content – 2 – 5%	9.	More than 17%. Improve health of cattle, increase in milk production and fat percentage.

COST BENEFIT RATIO BEFORE AND AFTER USING HYDROPHONIC UNIT FOR FIVE MONTHS							
Before using Hydroponic unit	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22		TOTAL
TOTAL DHAAN	83,020	83,670	82,980	84,250	85,930		4,19,850
TOTAL DRY GRASS	43,000	-	59,160	72,545	54,625		2,29,330
Total	1,26,020	83,670	1,42,140	1,56,795	1,40,555		6,49,180
After using Hydroponic unit	Apr-22	May-22	Jun-22	Jul-22	Aug-22		
TOTAL DHAAN	52,390	36,100	50,390	51,950	50,490		2,41,320
TOTAL DRY GRASS	-	-	38,650	-	-		38,650
Seeds used for Hydroponic unit	14,590	16,210	19,018	18,445	12,434		80,697
Total	66,980	52,310	1,08,058	70,395	62,924		3,60,667
Reduction in cost after starting of Hydroponic System							2,88,513
AVERAGE COST REDUCTION PER MONTH							57,703
NOTE : ONE TIME INVESTMENT FOR TWO HYDROPONIC UNITS RS. 1,60,000/- APPROX. SAVINGS RS. 57,000/- PER MONTH.							

Energy Security: Oil and Gas

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1) The Council in its introduction has briefly, and aptly, defined energy security as uninterrupted availability of energy sources at affordable prices; security requires that India should not be at the mercy of others for energy supply. The theme of the webinar is oil and gas; and hence the focus is on what security means in practice, with specific reference to Oil and Gas, and suggestions for achieving it. The Council's introduction referred to historical experience of difficulties during the 1971 war; documentation of the uncertainties over adequate oil supplies from foreign multinational companies is relatively limited. I will illustrate the critical difficulties of foreign dependence with a personal memoir from August- September 1990, when I held charge of the Indian Embassy in Tehran, Iran. After Saddam Hussain annexed Kuwait there was a build up to the first Gulf War, and shipping lanes in the Gulf were becoming danger zones. As war loomed, the price of crude doubled from 17$ per barrel in July 1990 to 36$ by October of that year, adding to India's foreign exchange woes. The real fear in India, however, was physical shortage of oil. I recall getting frantic phone calls from the concerned Ministries and senior executives of oil PSUs asking me to request Iran to ensure that oil shipments to our refineries kept moving. This was at a time when oil imports met less than 50% of our requirements; but India had no strategic reserves, and our refineries did not maintain large feedstocks. A supply squeeze would have led to serious crisis, if not chaos. We were lucky that the conflict did not spread into Gulf waters so the disruption of oil supplies was temporary. But it is often forgotten just how much the oil crisis of 1990-91 contributed to India's financial crisis of 1991 which was a turning point in our history. (As a footnote I may add that the Iranian officials I met during those crisis months, said that Iran could guarantee flow of oil supplies to India – but it could not offer any guarantees on pricing!)

2) Why is the subject of energy security generally associated above all with Oil and Gas? This is because of the specific role of oil in the economy and the critical role of oil in national security. In India the use of oil sector-wise is, broadly 50-60% for transport; 20-25% for petrochemicals; about 12% for LPG

used commercially and domestically; and small amounts for power production and other uses. (Actually, the role of oil in the power sector has been wrongly calculated for official data. According to national statistics less than 1000 MW of India's power generation of 350,000 MW is from oil-diesel. However, this data does not show that for back-up supply, the diesel gensets used in India have 90,000 MW capacity!). Transport is the key to all the supply chains of our national economy, and lack of adequate fuel can cripple it. The overall dependence of the transport sector on oil is unlikely to change substantially till 2040 despite rapid sales of EVs. The armed forces will similarly require oil for weapon platforms and mobility for decades; and the need for adequate supplies available immediately, and locally, will continue. Fuel shortages can have serious military implications as shown by history.

Energy sources are changing, but attempts to switch to new sources too quickly will cause-and have caused-economic disruption world wide as demonstrated by Europe's current desperate spot market purchases of LNG for electricity and heating (to make up for shortages in solar/wind energy in winter). India's energy consumption per capita is still extremely low and we will need every available source of energy to overcome poverty. We will require oil and gas for decades and we must plan for greater self-reliance in oil. In future when reliable and affordable alternate energy sources are put in place, the same need for domestic supply will apply to critical minerals used for new energy.

3) The NCCSD document has suggested examining the subject in four areas; (i) Gaps, (ii) Barriers, (iii) Positive areas of pushing production, and (iv) Strategy for framing new policy framework. This paper will follow this template.

4) Gaps and Barriers:

(i) There is serious dependency on imports of oil and gas which is a drain on our foreign exchange as well as a security hazard. Made worse by the fact that dependency is growing each year; from about 80% in 2015 (when the plan for greater self-reliance was announced by PM) to over 85% today. Indications are that it will exceed 90% in the next decade, if not earlier.

Some statistical data will reflect the scale of the problem: -

a) Production of Crude Oil: In 2015 about 740,000 barrels per day (bpd), totalling 37 million metric tonnes (mmt) for the year. In 2019, it was about 615,000 bpd totaling 32 mmt pa.

b) Imports of Crude Oil : 2015:- 202 mmt costing just over Rs 4 lakh crores; while in 2019:- 220mmt costing Rs 7 lakh crores !

(ii) There has clearly been a lack of seriousness in the Govt of India about reaching the target of 33% self- sufficiency ever since 2015 when it was projected. Loud pronouncements were made about Discovered Small Fields, Hydrocarbon Exploration and Licensing Policy (HELP), Enhanced Oil Recovery (EOR) incentives etc. But all of this was for future actions and there was no relief or incentives for the fields where the bulk of India's oil is produced, and where production could be ramped up in the 5-7-year time frame envisaged by PM. An increase of 400,000 bpd-which would have been required for meeting PM's target- cannot be achieved from new discoveries or small fields -as is well known to anyone with any experience of petroleum production. And HELP has not helped to bring a single new global major into Exploration and Production (E&P) in India since it was launched. Domestic oil production in 2020 was the lowest ever in this century and the 2021 data' when available, may show lowest production since 1993! Changing this trajectory for oil in India would require overcoming systemic preference for imports which has both internal and external dimensions.

(iii) Experience of last 30 years may have reduced the intensity of energy security concerns, with focus largely on economic cost, i.e. the massive import bill. We have had severe difficulties with oil price as in 2013-14 but no supply crises, despite occasional issues over US sanctions on Iran and Venezuela. But our dependence on the Gulf region for 60% of oil makes us vulnerable to recurrent problems in this volatile region. Our Strategic Petroleum Reserve (SPR) is still not enough for more than a few weeks of disruption

(iv) We also have to take note of new and difficult global circumstances which are emerging for India's oil security in future; reduced global availability and options because of climate change issues. India's oil requirement may double from 4 million bpd to 8mbpd by 2040; but global production of oil is set to decline if the world transitions away- as planned- from hydrocarbons to renewables, hydrogen etc. Remaining oil exporters will be mainly from low cost producing basins in the Gulf region and Russia. As competition for these resources will persist, the geopolitical risk of dependence on volatile Eurasia and West Asia (and chokepoints like the Straits of Hormuz) will increase substantially.

(v) There are persisting internal constraints on oil E&P in India. The Association of Oil and Gas Operators of India (AOGO) has every year petitioned the government for tax and regulatory relief, but without success. Tax and Cess on oil production in India are among the highest in the world; even Royalty paid to the Govt attracts service tax! The oil sector is viewed mostly as a source of income for governments rather than a national security partner, and Govt takes 65% of revenues earned from oil production. Then there are delays in clearances of Production Sharing Contracts and Field Development Plans, which have slowed down work programmes; and costly litigation coming in the way of smooth partnership between Govt and private oil producers. The harsh treatment of Cairn Energy, after it had made India's biggest oil discovery in 40 years. made all foreign investors cautious. To add to the worries of producers there are many challenging environmental clearances which take disproportionate time and effort to be achieved. As a result, there is very little E&P in India and 70% of India's believed potential is yet to be discovered. The Category 2 (contingent resource identified but no production) and Category 3(with geological potential, but not explored) sedimentary basins have remained static for decades. (vi) ONGC which was set up to find oil in India has not been empowered to prioritize exploration. Its financial reserves have been frittered away in acquisitions of HPCL and GSPC assets, and payments of dividends to Govt.

5) Positive opportunities and possibilities for increasing oil and gas production

Despite the dismal history of E&P in India and the complex global scenario for the oil industry there are opportunities which can be tapped. Constraints on the E&P sector can be overcome by viewing oil through the prism of national security, concern for which has been increased because of the two-front threat on our borders. Investors can be assured that growth in demand in India is likely to continue for 20 years which means an assured market for any oil produced in the country; increased domestic production canalso enhance policy choices and options for India.

6) Suggested strategy for policy framework

(i) Treat oil and gas as a stand-alone sector for national security; and establish a dedicated Cabinet Committee for overseeing oil production, and ensuring availability. This will help overcome some of the tax and regulatory obstacles (and import lobbies) that disincentivize production. China today, and USA in the past, provide examples of how oil security is prioritized. Chinese oil PSUs stepped up investment in upstream by 30% in 2018 and 20% in 2019, in response to calls from the Govt to reverse the decline in production and reduce import dependency of 70%. The Chinese national security concern is that oil import lanes could be curtailed in case of a maritime clash with US or other adversaries. Regulations were eased and FDI allowed in E&P. The Chinese companies Sinopec, CNPC and CNOOC increased technological investment to raise production from mature fields with remaining large reserves, as well as new discoveries; they have already successfully stopped the earlier production decline. China has successfully increased production of natural gas by 30% in 2017 and managed over 50% self-sufficiency so far.

(ii) Further liberalize terms and conditions for E&P in India with added incentives for Category 3 basins and provisions for international arbitration of disputes. It should be understood that entry of foreign oil companies in E&P will help kickstart an investment cycle, during an investment drought in the country; and they will require support services from Indian companies. Wherever potential is proven in initial exploration, create inter-ministerial teams (from central and concerned state governments) to facilitate converting potential into actual production.

(iii) Ensure policy continuity through appropriate regulation and building consensus in Parliament on policy frameworks. Provide guarantees that ill-treatment of investors (a la Cairn Energy) is not repeated. If that means tax departments are legally barred from targeting windfall profits in case of a discovery- so be it.

(iv) Plan for cooperation with Bangladesh and Myanmar to expand the possibilities for evacuation by pipeline if Northeast potential generates more 1P Reserves. Many petroleum geologists believe the North eastern States of India hold very good potential for oil and gas. There is need for political accommodation of State Govts and local communities in the North eastern region to make sure exploration can be carried out effectively. If, as is believed possible, there are major new discoveries, we would need to find ways of evacuating the production, after catering to local needs; this will call for cooperation with neighbouring countries.

(v) Keep a lookout for buying new technologies particularly in countries which are discouraging oil production in their own jurisdictions; provide incentives for their companies with real track record to invest in or shift base to India, with tax and other incentives. This applies particularly to expertise in Enhanced Oil Recovery (EOR) where new technologies could substantially increase the amount of oil which can be extracted from our ageing and mature fields in a relatively short time-frame. EOR can double our reserves at a fraction of the cost of developing completely new fields. There are many PIOs who are at the leading edge of companies in western countries with specialized expertise in oil and gas development; and an effort should be made to develop a database to see if any are interested to work in India. We should also encourage Startups in India to collaborate with such expertise from abroad.

(vi) Leverage India's role as major importer to get foreign suppliers to support expansion of India's Strategic Petroleum Reserve. This should be done by increasing storage along both coasts and even inland in geologically suitable caverns.

(vii) Enable ONGC to focus on E&P for which purpose it was set up by the founders of our nation. ONGC already has a backlog of licenses won in earlier bidding rounds which remain undeveloped. If required, ONGC should sell of its other business ventures and focus on finding new oil deposits in our sedimentary basins and developing them. This will require giving greater autonomy to the PSU which still has many world class professionals in the organization.

(viii) Oil and gas must be produced and used in accordance with national goals of Sustainable Development and environmental responsibility. E&P operations, production facilities, and pipelines must be subject to the highest standards of health and safety regulations. There is need to develop, or import, technology/expertise for best in class practices for reduction of methane leakage during gas production; use of CO_2 for EOR; as well as Carbon Capture and Storage in old oil wells. We can ensure that communities near Oil and Gas facilities are made financial and social stakeholders of projects near them. It should be feasible to start SMEs/social welfare programmes with funds from a District Oil Fund on the lines of District Mineral Funds. This can provide sustainability to enhanced oil exploration, production and transportation in the country; and help people support the government's aim of greater self-reliance in oil and gas for energy security.

Energy Security for Āatmnirbhar Bharat : Need to Increase Oil & Gas Domestic Output

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Background & Context Setting

India's energy demand has doubled in the last 2 decades with India emerging as the 3rd largest energy consumer in the world, consuming around 806.1 million tonnes of oil equivalent[1] (MToE) in 2019. Oil and gas will continue to remain important elements for India's energy security with its primary energy demand expected to grow at a CAGR of 4.2% during 2017-2040. Share of Hydrocarbons has increased to 28%[2] of our total energy basket and is estimated to remain around this level for the next two decades. India's oil consumption is expected to rise from 4.8 million barrels per day (mbd) in 2019 to 7.2 mbd in 2030 and 9.2 mbd in 2050 as per the (IEA's key scenario based on stated policies)[3]. The projection shows the centrality of oil in the Indian economy over the next three decades. India's oil demand will rise 50% by 2030 as against a global expansion of 7%. India's natural gas demand is projected to double to 133 billion cubic meters in 2030 from 64 BCM in 2019 as against a 12% rise in global gas demand[4].

This makes a compelling case for India to work towards increasing its domestic oil & gas production s to reduce import dependence. As on date India imports more than 85% of its crude oil requirement and 50% of its gas requirement at an import bill of > USD 100 Billion[5]. Thus, India is vulnerable to the volatility in crude oil prices which frequently impacts its import bill leading to trade deficits and inflation. This problem is further exacerbated by the fact that our domestic production has been declining for the last 8 years[6].

India is not self-sufficient in key resources (like lithium, vanadium, nickel, silicon, & other rare earth elements etc.) to completely transition from fossil fuels to

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1. MoPNG Annual Report 2020-21
2. India Hydrocarbon Outlook 2020-21
3. IEA Indi Energy Outlook 2021
4. India Hydrocarbon Outlook 2020-21
5. PPAC Ready Reckoner February 2022
6. Annexure 1

other sources of energy like EV or solar. Supply of these elements is concentrated in a handful of countries reducing India's leverage and resilience& leaving India susceptible to global prices & currency fluctuations.

As India moves towards a 5 trillion-dollar economy, with commensurate energy needs, the criticality of hydrocarbons in meeting this growing energy requirement hardly needs emphasis. Govt. has ushered in a series of reforms along the Upstream, Midstream & Downstream operations of the Oil & Gas sector to address priorities like Energy Access, Energy Efficiency, Energy Sustainability & Energy Security. These are also expected to remove systemic inefficiencies to infrastructure investments in oil & gas sector, provide ease of doing business, minimum government maximum governance and promote "Make in India". While these are steps in right direction, many aspects still need to be streamlined for robust implementation of these policies and provide their intended benefits to the beneficiaries.

Energy Security Envelope cannot be considered inclusive and complete without climate change concerns. With the growing environmental concerns, there's a need to decarbonize the Oil & Gas Industry value chain.

Management of Supply Side Imperatives Include:

- Import substitution by increasing domestic crude & gas production
- Exploration & augmentation of alternate energy sources – nuclear, natural gas, unconventional hydrocarbon (shale and CBM) and gas hydrates
- Harnessing renewables
- Research &development and technological innovations

To address the concerns over the falling domestic production, GoI has made major policy reforms in the form of HELP and added more than 150 blocks through OALP and DSF auction rounds during the last 5 years. However, production from HELP will come only after 3-5 years. Hence major reforms in the overall E&P sector are required to boost domestic production, bring more investments & provide "Ease of Doing Business" to simplify procedures and streamline clearances & approval mechanisms. Extending the learnings incorporated for attracting investments in the HELP regime to previous fiscal regimes will provide a level playing fields to Operators working on nomination, pre NELP and NELP Blocks.

Upstream Oil & Gas Industry in India

As of April 2020, the country had balance recoverable reserves of about 493.3 million metric tonnes of crude oil and about 1,080.4 billion cubic meters of natural gas[7]. In 2020–2021, crude oil production was about 30.5 million metric tonnes[8],

7. MoPNG Annual Report 2020-21
8. PPAC production Data – Petroleum

and the natural gas production of the country was about 27,784 million metric standard cubic meters[9].

The Indian government, from time to time, has adopted various licensing regimes with a view to enhance domestic production. With each iteration, a number of dispensations have been provided to the operators in order to attract more investments & global best practices & technologies in subsequent rounds. However, the same liberalized policies/dispensations are not extended to earlier regimes. As a general principle, an acreage awarded under a licensing regime continues to be regulated under such a regime, and any subsequently amended regime is applicable to acreages awarded under such regime. Therefore, at present different blocks are governed by different licensing regimes (depending on when they were awarded).

The Nomination Regime

This regime was applicable for blocks awarded till late 1970s & the Petroleum Exploration Licenses (PEL) were granted to the 2 National Oil Companies (NOCs) - Oil India Limited (OIL) and Oil and Natural Gas Corporation Limited (ONGC) on a nomination basis.

Pre-NELP Regime

Under this regime, the blocks were awarded to private companies with participation interest of NOCs between 1980 & 1995. Under Pre-NELP Exploration Rounds, 28 exploration blocks were awarded to private companies. OIL and ONGC were given the right to participate in the blocks after discovery. At the end of 2019–20, 11 pre-NELP production sharing contracts (PSCs) were active[10]. Regarding pre-NELP discovered field or development rounds, for the small, medium-sized and discovered fields (proven reserves as discovered by ONGC and OIL), petroleum mining lease (PML) was granted to private parties for these fields. The Indian government has signed 28 contracts for 29 discovered fields. At the end of 2019–20, 21 contracts were active[11].

New Exploration & Licensing Policy (NELP)

NELP was introduced to inculcate healthy competition for exploration & production of oil & gas & to bring state of the art technology and efficiency of operations/ management in the country. Blocks were awarded under NELP from 1999 to companies – both private & foreign companies- through international competitive bidding process. The NELP regime was based on the 'production sharing model' i.e., the Indian government is paid a part of the profits, after deducting the costs incurred by the contractor. The percentage of profit proposed to be paid by the contract was

9. PPAC production Data – Natural Gas
10. India Hydrocarbon Outlook, DGH Report 2020-21
11.

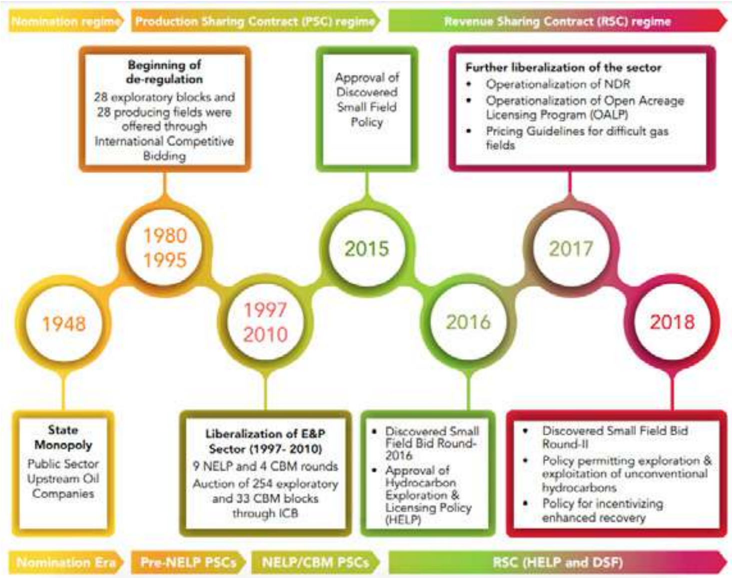
a biddable criterion. Some 254 production sharing contracts were signed under nine licensing rounds. At the end of 2019–20, 45 contracts were active[12].

Discovered Small Fields (DSF)

GoI launched the DSF Policy in 2015 with an aim to develop & monetize discovered hydrocarbon resources under revenue sharing mechanism wherein the terms are liberalized for providing maximum autonomy to contractor with minimum Government oversight. This policy offers improved fiscal terms viz. no oil cess applicable on crude oil production, moderate royalty rates, no upfront signature bonus, pricing and marketing freedom for oil and gas and no carried interest by NOCs. Two DSF bidding rounds have been conducted till date in which 54 Contract Areas have been awarded, resulting in entry of over 20 new players in Indian E&P sector.

Hydrocarbon Exploration & Licensing Policy (HELP)

HELP regime was launched in 2016 to attract investment & new technologies in the India E&P sector. This regime substantially liberalized the fiscal & policy terms for investors including a uniform license for all forms of hydrocarbons, a revenue sharing model, an open acreage licensing policy (OALP) under which prospective bidders have the option to carve out exploration blocks, marketing & pricing freedom, reduced royalties, etc.



CHRONOLOGY OF E&P REGIMES IN INDIA

Source: Ministry of Petroleum & Natural Gas

12. India Hydrocarbon Outlook, DGH Report 2020-21

Exploration & Investments

The conventional hydrocarbon resources in India are currently estimated at approx. 42 billion metric tonnes of Oil &Oil Equivalent of Gas (O+OEG)[13]. However, India's hydrocarbon resources still remain highly underdeveloped as only 28%[14] of the prognosticated resources could be converted to In-place volumes through discoveries in the last 7 decades. Progressive Govt. policies & interventions are required to promote exploration & appraisal activities & bring more under active exploration.

While the need for increasing domestic crude production has been stressed upon at various forums for many years, there hasn't been much discussion on how to intensify Exploration & Appraisal of Indian Sedimentary Basins. Govt. has taken some steps like the National Seismic Programme, the National Data Repository, but regulatory hurdles, lack of far-reaching policies and the need to decarbonize the E&P value-chain has weighed heavily on the exploration sector.

Indian policy needs to focus on exploration intensification and production maximization but in all the regimes, pre-NELP, NELP, HELP and OALP with their production sharing (PSC) or revenue sharing (RSC), revenue maximization has been the main criterion. Instead of spending hard earned foreign exchange on oil and gas imports, the focus should be to promote Rupee-Oil (the domestic oil) which may be cost-intensive in the initial stages due to deployment of best-in-class technology and envisaged effective incentivisation but in the long run, it would turn out to be a win-win situation for the Operators and the Government, with substantial conversion of resources to producible reserves.

Solving the Production Conundrum

95-99% of India's crude & gas production comes from Nomination/Pre-NELP fields[15] which are mature & ageing fields, often requiring capital intensive technologies to increase (or in some cases maintain) production. With a view to increase the domestic production in the interim, Govt. should provide commensurate fiscal incentives to these blocks.

Fiscal Incentives

The Pre-NELP & Nomination blocks are subject to one of the world's most arduous fiscal structure. The central& state levies in the form of OIDB Cess, Royalty, Govt. share of Profit Petroleum and other corporate taxes results in as much as 70% of Operator's revenues flowing to the exchequer leaving very less investible surplus, thereby hampering continued investments to increase production. The investments are important to increase production from mature Pre-NELP & Nomination fields and need capital intensive technologies to increase, or to even sustain the baseline

13. India Hydrocarbon Outlook 2020-21, DGH
14. India Hydrocarbon Outlook 2020-21, DGH
15. India Hydrocarbon Outlook 2020-21, DGH

production. Apart from inherent geology of a field & technical know-how, capital resources are most crucial for increasing domestic production.

There is also a disparity in fiscal levies across regimes. The relatively newer regimes of NELP& HELP were introduced with a view to attract investments and have forward-looking policies. While the Govt. considerably reduced the fiscal levies on the newer regimes, the same was not extended to the older Pre-NELP & Nomination regimes which continue to face higher levies.

Comparison of Fiscal Regimes				
Regime	**Nomination**	**Pre- NELP**	**NELP**	**HELP**
Period	1960-1990	1990-1999	1999-2017	2017 onwards
Royalty	20%	20%	12.5%	12.5%
Cess	20%	20%	NA	NA
GoI Share	NA	60%	30%	30%
Sales Tax	5%	5%	5%	5%

Rationalisation of Central & State Levies

The fiscal structure for Pre-NELP blocks, coupled with other state levies, GST on input items & corporate taxes results in up to 70% of the revenues flowing to the Govt[16]. This leaves Operators with very less investible surplus, thereby hampering continued investments to increase production. Hence, in order to support the mature producing fields, the Govt. may look at rationalizing the levies structure for Pre-NELP fields & bring it at par with NELP, HELP & DSF regimes (One sector, One regime).

Incentivise Enhanced/Improved Recovery and Unconventional Hydrocarbons

India's Oil & Gas production has been declining for the last 8 years leading to an inflated crude oil import bill of more than USD 100 billion annually despite our Hon'ble Prime Minister's vision to reduce import dependence by 10% by 2022. Ageing & mature fields go into a decline phase unless capital intensive technologies such as Enhanced Oil recovery (EOR) or Improved Oil Recovery (IOR) techniques are deployed. Providing incentives like sliding scale of royalty, weighted tax deduction on expenditure for EOR pilot, etc. would help in increasing domestic production.

Bring Oil & Gas under GST Ambit

GST is levied on inputs for upstream sector but input tax credit is not available on outputs. This non-fungibility of taxes increases the cost of production for the sector. The Oil and Gas Sector is not covered under GST. However, the entire procurement bears the GST impact. The Operators also pays GST on few of the ancillary services

16. Annexure 2

along with the inter-state stock transfers of the inventory which are taxable under GST Govt. should look towards bringing Oil & Gas sector, at least the Upstream Value Chain under the GST ambit.

Import Parity in E&P Value Chain

Domestic crude sales to refineries are subject to CST/VAT while the same is not applicable on imported crude. This makes domestic crude costlier by 3%. But since import parity is not there, this extra cost can't be passed on to the customers. Hence the domestic producers bear this cost, adding to the cost of sales.

Also, in the Union Budget announced in Feb 2021, the CST act was amended to remove the benefit of 2% concessional rate of CST against C-form. This further increases the cost borne by the producers as cost of sales.

Income Tax Benefit under Section 42

Unlike all preceding E&P licensing contracts, Section 42 under Article 16 of RSC does not identify the tax benefits of Exploration and Production. Required changes in existing RSCs have not been carried out as yet and if the amendments (plus placing of amended RSCs in the Parliament) are not carried out before the filing of Income Tax returns, existing operators of RSC blocks would be deprived of substantial tax benefits. In order to boost the oil production by the awardees of OALP, who are investing millions for the extraction of oil, weighted deduction for Exploration and Development expenditure is recommended for the new blocks awarded under OALP.

Policy Levers

Accelerate Exploration & Appraisal

India has prognosticated conventional hydrocarbon resources of approx. 42 billion metric tonnes of Oil & Oil Equivalent of Gas (O+OEG) out of which 73% is in yet to find category. Hence Govt. should promote exploration & appraisal activities while not hindering or ring fencing of cost recovery aspect.

Marketing & Pricing Freedom

Pre-NELP oil producing fields are assigned refineries and allocated volumes are to be sold to the said refineries during a year. This restriction on marketing freedom in effect curtails the pricing freedom as selling to a pre-determined set of buyers hinders effective price realizations, reducing sales realization of producers & in-effect reduces the GoI revenues. Full marketing and pricing freedom conditional upon arms-length prices through competitive bidding can ensure effective realization for producers and maximize GoI revenues.

1. Ease of Doing Business & Faster Clearances

Major hassles for E&P operators arise in procuring necessary approvals from various government agencies like Ministry of Environment & Forest, Department of Defence, etc. For instance, the average timeline for approval of a Field Development Plan (FDP), from the Technical & Cost Alignments, Operating Committee (OC) & Management Committee (MC) reviews, takes between 12-14 months. The entire chain of approvals must be repeated in case of any revisions. This prolongs the time between project conception to project execution.

Government's recent efforts to address this problem through fixing approval time-limits and Self-Certification for certain matters are aimed in the right direction, however, it substantially increases the burden of reporting on the Operators in its present form and doesn't provide Ease of Doing Business in the actual sense of the term. Also, the said notification is valid only for blocks in Pre-NELP & NELP regime and any such measure is yet to come out for OALP & DSF blocks. Self-Certification facility for DGH &MoPNG related processes addresses only part of the problem. Major hurdles occur while obtaining Technical Alignment & OC approval in case of JVs. Hence a similar exercise needs to be undertaken by Govt. Nominees (ONGC/OIL) to fast-track approval process.

Assurance of policy congruity & continuity would provide a stable business environment & boosting investor confidence.

Technology & Data-Driven Reforms
Technologies for Recovery from Mature Fields

Ageing & mature fields go into a decline phase unless employed with Enhanced Oil recovery (EOR) or Improved Oil Recovery (IOR) techniques which may increase recovery factor by 20-30%. Given the fact that major producing fields in India are in a decline phase, Govt. should encourage & incentivise operators to use EOR techniques such as ASP to improving oil recovery. Providing incentives as per ER policy is a step in the right direction, however, other benefits like sliding scale of royalty, weighted tax deduction on expenditure for EOR pilot, etc. would help in increasing domestic production.

Full Tensor Gravity Gradiometry (FTG)

FTG is a technology that's been utilised world-wide as an air borne regional reconnaissance tool to analyse/evaluate the perspectivity of large geographical areas quickly and at 5-10% of the cost of conventional 2D seismic data. The areas identified under FTG analysis can then be earmarked for further 2D & 3D seismic evaluations. This technology helps in reducing exploration cycle time & capex cost and time in acquisition of 2D and 3D seismic data over larger than necessary areas. Such a technology is also less environmentally invasive, thus minimizing the environmental impact of exploration activities.

This technology provides a cost-effective & environmentally non-invasive technique to evaluate large geographic areas in both a reconnaissance and exploration analysis. Its importance is greatly enhanced in post-Covid scenario when labour & other resources are in short supply. Exploration efforts can be significantly enhanced with this technology and this needs to be recognised as a substitute for committed work programme wherever so required.

Data Swapping on NDR

Govt. has allowed operators to purchase and process the legacy data from the National Data Repository (NDR). Data purchased is reprocessed by the Operators for certain improvements to facilitate better and precise interpretations. This reprocessing is carried out at a cost which varies as per the state of the data and improvement required there upon, and the reprocessed data is submitted back to NDR. Such data adds value to the interpretation work and often saves the requirement of new data acquisition. It becomes logical that the amount spent should be allowed to be set-off against Operator's commitments.

Natural Gas as an Alternative Cleaner Fuel

There is an increasing global movement towards replacing carbon-emitting fossil fuels by clean energy such as natural gas and renewable energy. To facilitate a substantial transition from polluting fuels, carbon tax has been devised to make these fuels costlier for production and sale to customers.

However, coal dominates India's energy mix at a total proportion of 44%. This is in sharp contrast to the energy mix of developed markets where oil, gas and coal consumption is more balanced. The share of coal in India's energy mix is the third highest among G20 countries[17].

Globally, Natural Gas has been gaining traction as a key alternative fuel to support the energy shift in favour of cleaner and greener energy sources. India too is on its path to become a sustainable economy and has set a vision to become a gas-based economy. Two overarching targets set by the Government of India testify to the vision:

(i) Under the 2015 Paris agreement, India has committed to reducing the greenhouse gas (GHG) emissions intensity of its Gross Domestic Product (GDP) by 33-35% by 2030 relative to 2005, for which it must quit burning coal that causes global heating. Using natural gas reduces GHG emissions as the combustion of natural gas emits about half as much carbon as coal.[18] India is committed to net zero by 2070.

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17. India Energy Outlook 2021, International Energy Agency
18. https://www.business-standard.com/article/current-affairs/how-natural-gas-could-thwart-or-support-india-s-renewables-progress-121101900140_1.html

(ii) In 2017, the Indian government announced that it would increase the share of natural gas in its energy mix to 15% by 2030.[19]

The Government has laid down three broad areas for policy intervention:[20]

(i) Development of gas sources either through domestic gas exploration & production activities or through building up facilities to import natural gas in the form of LNG,

(ii) Development of gas pipeline infrastructure and secondary distribution networks, and

(iii) Development of gas consuming markets like fertilizer, power, transport and industries etc. in the domestic sector.

However, currently, Gas plays a peripheral role in India's energy mix. In practice, Gas currently accounts for only 6%[21] of the country's energy mix compared to a world average of 23%[22]. Growth in India's gas demand has outpaced domestic production, leading to a steep rising dependence on imported LNG from 20% of India's total gas demand in 2010 to over 50% as of date.[23] Natural Gas production during the year 2020-21 as per provisional estimates is 28,672 MMSCM, which is 10% lower than the production levels during 2016-17 which was 31,897 MMSMM[24].

The GoI has been taking a range of policy measures to expand domestic production. Provision of marketing and pricing freedom in new policy regimes namely Hydrocarbon Exploration Licensing Policy (HELP) and Discovered Small Fields Policy (DSF) is a progressive measure to augment the natural gas production in the country. In 2020 the government also launched the Indian Gas Exchange (IGX), a trading platform for natural gas.

Further, the Gas pipeline grid determines the structure of the gas market and its development. 19,998 km of Natural Gas pipeline (including sub-transmission pipeline & tie in connectivity pipeline) are operational and 15,369 km are under various stages of construction.[25] An interconnected National Gas Grid has been envisaged to ensure adequate availability and equitable distribution of natural gas in all parts of the country.

However, the relatively low level of gas prices over the past few years has acted as a disincentive for domestic production. Considering the Gas Vision 2030, India needs greater domestic natural gas production to meet the rising demand. Most

19. https://pib.gov.in/newsite/PrintRelease.aspx?relid=173167
20. https://pib.gov.in/newsite/PrintRelease.aspx?relid=153957
21. India Energy Outlook 2021, International Energy Agency
22. https://www.iea.org/fuels-and-technologies/gas
23. India Energy Outlook 2021, International Energy Agency
24. Petroleum Planning & Analysis Cell (PPAC)
25. https://pib.gov.in/PressReleasePage.aspx?PRID=1739017
26. Wood Mackenzie Issue June 2019

of India's indigenous gas production comes from the fields under Nomination and Pre-New Exploration Licensing Policy (NELP) regimes. For a successful shift to a gas-based economy, it is important to allow the market to mature, for which existing price distortions need to be corrected. To promote investments in exploration, a market driven pricing mechanism is envisaged. All gas-producing fields should be brought under a uniform taxation regime, and incentives offered to acreages under the HELP and DSF regimes should be extended to all other licensees to ensure investment flows into tapping reserves in older and mature fields, which may need enhanced recovery techniques.

Unconventional Hydrocarbon (UHC)| Ushering the Next Phase of Growth

India has several basins with potential Shale Oil and Gas resources such as Barmer, Assam, Krishna Godavari, Cambay, Cauvery, Ganga and Gondwana. As per Energy Information Administration (EIA), 2013 the shale resource potential is close to 584 TCF of shale gas and 87 billion barrels of shale oil in 4 basins (Cambay Onland, Damodar, Krishna Godavari Onland & Cauvery Onland). Additionally, the Barmer Basin is estimated to have nearly 15 billion Barrel oil equivalent potential of shale in place. Govt. has from time to time brought out forward-looking policies to increase the exploration & exploitation of Unconventional Hydrocarbons in India. However, domestic production of unconventional hydrocarbons has not yet become mainstream.

Shale oil and gas is a difficult play, needs special considerations. A major component of the technical know-how and global best practices need to be acquired from overseas. These resources are distributed over larger areas and are technically more complex. This increased technical complexity makes unconventional exploration and development more expensive than conventional onshore wells. Increased complexity and cost necessitate a policy which balances the risk – reward ratio and incentivizes players to invest in these projects despite the real possibility of commercial failure. In a country like ours where the Shale Gas/Oil exploration is still in its nascent stage, wide-scale pilot projects would enable the operators to understand the nitty-gritties and the challenges of field-scale implementation of exploration and subsequent exploitation particularly for aspects such as project planning and execution, infrastructure, etc.

The shale revolution acted as a major boost for the energy sector of the United States and is credited with reducing its dependence on the Middle East, creating large-scale employment and turning it from a historically importing country into a net exporter. China has also been focusing on developing its shale resources, driven by efforts to boost energy security. The Chinese government has directed state oil and gas majors, including the biggest companies such as PetroChina and Sinopec, to work towards significantly boosting their production from shale formations. To further boost production, China is looking to attract investments in shale developments by easing restrictions on foreign entities and subsidizing costs[26].

The global norm for commercialization of shale takes the form of providing incentives - entailing lower royalties, lower profit tax, or rates varying with well productivity/ cost, longer terms of contracts, infrastructure credits, and direct price subsidy. Policy enablers particularly with supportive fiscal parameters should be brought about for ensuring long-term viability and sustainability of discoveries. Provision of incentives at least for initial few years may provide an impetus to the shale industry in India during the nascent stages. Considering the large expanse of shale deposits in the country, with the right kind of enabling factors, the international success in Shale Oil and Gas technology can be replicated in India.

Another unconventional natural gas resource is the Coal Bed Methane (CBM). The estimated CBM resources are of the order of 91.8 Trillion Cubic Feet (TCF) spread over 11 States in the country.

Conclusion

More focus of the Govt. needs to be on production enhancement rather than revenue enhancement. Because if India is able to arrest the constant decline in hydrocarbon production & actually increase it, the revenues enhancement would be a by-product of that.

ANNEXURE 1 – India's Annual Production of Hydrocarbons

Year	Total Oil Production (MMT)	Total Gas Production (BCM)
2013-14	37.68	35.40
2014-15	37.34	33.64
2015-16	36.95	32.249
2016-17	36.01	31.90
2017-18	35.68	32.65
2018-19	34.20	32.87
2019-20	32.17	31.18
2020-21	30.49	28.67

Source: DGH Hydrocarbon Outlook, 2020-21

ANNEXURE 2 – Flow of Revenues to Govt. (for illustration only)

	UOM	% to Revenue	Pre-NELP
Base Production	KBOEPD		164
Oil Price	$/BBL		70
Gross Revenue	**USD MM**		**4190**
CST Discount @ 5%	USD MM	5%	210
Net Realised	**USD MM**		**3981**
Royalty @ 20%	USD MM	14%	597
Cess & NCCD @ 20%	USD MM	16%	663
Production Cost	USD MM		539
Development Cost	USD MM		539
Total Cost	**USD MM**		**2338**
Profit Petroleum	USD MM		1643
GoI Share @ 60%	USD MM	24%	986
JV Partner @ 30%	USD MM	5%	197
Company Share	USD MM		460
Income Tax @ 36%	USD MM	4%	166
GST on Cost @ 5/12/18	USD MM	3%	108
Total GOI Take	USD MM		2926
% GOI Take		70%	70%
Net to Company	**USD MM**		**294**
% to Company	%	7%	7%
Cost before GST	**USD MM**		**970**
% Cost	%	23%	23%

Efficacy of Oil and Gas Exploration in Energy Security of India

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At the World Energy Policy Summit 2022, the Hon'ble Minister of Petroleum and Natural Gas, Shri Hardeep Singh Puri stated that India will continue to rely on hydrocarbons to meet its growing energy needs in the foreseeable future. The government is envisaging to doubling the area under Exploration and Production of Oil and Gas to 0.5 million square kilometres by 2025 and to 1 million square kilometres by 2030 to raise domestic output and cut import dependence.

India is the world's third largest energy consumer, with the energy demand estimated to grow by 3%[1] per annum till 2040, compared to the global rate of 1%. The share of hydrocarbons in India's energy mix is about 28%[2] and is estimated to remain around this level for the next two decades. India's energy security is critically hinged on Oil and Gas which cannot be displaced in the near future since alternate energy solutions will take several years to become mainstream. Crude Oil is particularly important in view of its crucial role in transportation by road, sea, and air. Natural gas is increasingly being utilised for industries such as power, fertilizers and petrochemicals. With Government's (GoI) vision to progress India into a gas-based economy, the natural gas which occupies a 6% share in the current domestic energy mix is projected to reach a level of 15% by the end of this decade.

Though India seems to have the potential to meet its oil and gas energy requirements, the Nation is yet to attain energy security of significant scale and is overly dependent on imports. Hon'ble Prime Minister Shri Narendra Modi had set a target in 2015 to reduce import dependency by at least 10% by 2022. However, the country's dependence on oil imports has been continuously increasing from 78.5%[3] in 2014-15, to 85%[4] in 2020-21. Further, India also imports 55%[5] of its natural gas consumption.

1. India's Hydrocarbon Outlook 2020-21, Directorate General of Hydrocarbons (DGH)
2. India's Hydrocarbon Outlook 2020-21, Directorate General of Hydrocarbons (DGH)
3. Ready Reckoner Snapshot of India's Oil & Gas data; Petroleum Planning & Analysis Cell; Ministry of Petroleum & Natural Gas; October 2016
4. India's Hydrocarbon Outlook 2020-21, Directorate General of Hydrocarbons (DGH)
5. India's Hydrocarbon Outlook 2020-21, Directorate General of Hydrocarbons (DGH)

The exploration of Oil & Gas can broadly be categorized under two heads – Exploration for Conventional hydrocarbon resource and for Unconventional hydrocarbon resource. Under the Conventional resource category, exploration is carried out for yet-to-find potential i.e. New Exploration, as well as, Exploration in contiguous areas or mining lease (ML) are a Steward finding additional Oil and Gas in old fields with new ideas and technologies. Exploration of Unconventional resources by and large pertains to Shale Oil & Gas and Coal Bed Methane (CBM). The oil/gas Industry is a demand driven and technology dependent Industry. The guiding principles for exploration of conventional resources whether for yet-to-find potential or for additional oil in ML areas are same but significantly different, costlier and riskier for exploration of unconventional resources.

New Exploration for yet-to-find potential is key to reducing the huge reliance on imports. Idle, unmonetized resources, need to be monetized. India's prognosticated conventional hydrocarbon resource potential is estimated at ~42B Toe (unrisked) of which nearly 28% (12 BToe) is converted to Inplace volume through discoveries during the past seven decades. Through this effort eight of the total twenty-six sedimentary basins proved to be proliferous- Assam-Arakan, Tripura-Cachar, Cambay, Jaisalmer, Mumbai Offshore, Krishna-Godavari, Cauvery and MBA basins. The remaining potential falls in the yet-to-find category which requires aggressive but focused exploration efforts. Converting even 15% of the Undiscovered Hydrocarbon resource into discovered in-place volume can reduce import dependency, substantially. Under the OALP, such areas which are either unexplored or less explored are identified and carved out by the Operators from the open acreage and auctioned through OALP bid rounds by the regulator DGH from time to time.

Operators have an option to carve out the new blocks either from the earlier relinquished acreage from proven proliferous basins- mostly category-I basins and partly category-II basins or go for new frontier areas in category-II and III basins. Exploration business is cost-intensive with high economic risk with an average commercial success rate of around 1:3. With several decades of exploration in India, of the 26 sedimentary basins, eight could be proven as proliferous basins where so called 'easy-to-find' oil/gas has been discovered. The task is challenging since the easy oil is largely discovered and what's awaiting discovery is largely new and innovative technology dependent and thus cost intensive.

Exploration in contiguous areas or mining lease are ascetains to finding new/additional Oil and Gas in and around old fields with new ideas and technologies. Several new discoveries happen around existing producing areas globally as a direct result of improved understanding of the subsurface from drilled well and production data, new data viz. improved seismic imaging, interpretation and new geological models. There are numerous worldwide examples of exploration successes in and around established producing acreage as a result of exploration promotional policies. To name a few: deeper subsalt plays of Brazil, Angola and Gulf of Mexico, North Sea, New

Zealand, etc. There are countries which allow cost recovery of exploration expenses, for example New Zealand allows cent percent deduction for exploration expenditure in the year in which it is incurred, development expenditure over seven years for offshore wells and any losses are not ring fenced either to permits, fields or even the trade- these can be offset against any New Zealand income of the Company. (Reference: World Bank Working Paper No. 123- Fiscal Systems for Hydrocarbons: Design Issues, SylvanaTordo). Indonesia and Vietnam are other examples.

When a commercial discovery is made in such areas, it is developed and brought on production within a short time frame by tying back to existing production facilities and infrastructure along with ready market availability. This in turn leads to early monetization and instant increase in revenue stream. In the current challenging times when our Nation is in dire need of this commodity, it becomes all the more important to do away with the concept of ring fencing around producing fields/ML areas which the GoI has implemented by way of Office Memorandum-2019(OM 2019).

The policy on exploration in ML areas vide GoI Office Memorandum-2013 (OM2013) was unambiguous. It allowed cost recovery upon establishing Declaration of Commerciality (DOC) and Final Development Plan (FDP) approval for the discoveries. However, the OM 2019 mentions that the recovery of past exploration, development or production costs will not exceed the cash inflow/revenue generated from new discovery(ies) in the block in accordance with PSC provisions. It further says that GoI share of Profit Petroleum from existing monetised discoveries are not adversely impacted, existing cash inflows/revenue arising out of already monetised discoveries will not be used for recovery of past exploration, development or production costs. The revenue from existing monetised discoveries in ML areas shall not be adversely impacted.'

It has thus very emphatically ring-fenced the discoveries and disallowed exploration cost recoveries from contiguous areas. The guidelines are quite restrictive as it is stated that exploration can be undertaken by the Contractor at its sole risk and any cost recovery will be allowed only in case such exploration leads to a commercial discovery. This prevents unconstrained exploration in the block and leads to manifold increase in the Operators' risk. Operators now consider attempting only those additional explorations where costs and risks are substantially low. Unfortunately, consequent to OM-2019 many potential oil and gas resources that might otherwise be discovered and subsequently produced will remain unexplored. Any unsuccessful additional exploration is revenue negative to the operator and cannot be undertaken routinely. It is to be understood that in the event of successful discoveries, Government too would be earning revenue through statutory levies like royalty, cess tax, profit petroleum, etc. which adds up to almost 70% of the revenue stream in the nomination, pre-NELP and NELP regimes.

Hon'ble Prime Minister Shri Modi on the last Independence Day called for

"Environmental Security" and while saying that India is not energy independent, expressed concern on country's spend of over Rs 12 lakh crores every year for energy requirements. He also asserted that we must resolve to make India energy independent.

The relaxation of ring fencing can provide a strong financial incentive to Operators, especially those who have existing production or are in tax paying position. The existence of a cost recovery limit may enhance the importance of this type of incentive. This stride might not meet the short run gratification of revenue generation that is anticipated by the Government, but it will open up more reserves which in the future can generate even greater revenue for the Government. (Reference: Ring fencing of investment spending and its implications on profitability of E&P projects, AwoniyiBabtola, SPE-172439-MS)

The GoI has had a vision to open up more acreage for exploration to help boost India's Oil and Gas production, however, despite permitting 100% FDI in the sector, the interest from international players has been rather passive. In 2016, GoI brought in a new reform through OALP and shifted from a Production Sharing Contract (PSC) to a Revenue Sharing Contract (RSC) regime. Notably, except for the first-round wherein Cairn-Vedanta secured a number of blocks, private sector participation has been scanty with limited presence of players such as Reliance- British Petroleum. Blocks under other rounds have been secured primarily by state-owned firms such as ONGC and Oil India Ltd.

Since most of the blocks under OALP are either re-carved out from earlier mandatorily relinquished portions of exploration blocks or from rank exploratory areas, require deployment of world class technology including artificial intelligence, digitalization, big data analysis, etc which happens to be cost-intensive. Globally, many IOCs have significantly reduced spending on exploration under pressure from environmentalists but net importers like India which also have hydrocarbon resources cannot afford to ignore exploration for the sake of energy security. Rather a focused and aggressive approach towards Exploration is the need of the hour. Facilitation from the GoI in providing dispensations for new technology-intensive Exploration would enable the desired investments which will also lead to growth in revenues in the long run including those of GoI. Further, the facilitation needs to have flexibility to adopt new, progressive and/or more appropriate technologies in place of those committed under contracts through a swapping formula.

It is noteworthy that Exploration under the more progressive OALP regime will start delivering results in course of next few years only. The current production comes primarily from pre-NELP, NELP and nomination acreage. The mature and ageing fields of these regimes are under natural decline over the long production years and require improved and enhanced recovery techniques which again are cost intensive. Further, various legacy issues impacting these regimes exist, which adversely affect the investment plans of the Operators. Ease of Doing Business initiatives and other relaxations under the Hydrocarbon Exploration & Licensing Policy (HELP) should ideallybe extended to fields under the older regimes also so as to make these regimes investment friendly and help ramp up production.

Additionally, the taxation, pricing and marketing mechanism needs to be streamlined and the Oil & Gas commodity brought under purview of the GST regime. There are other issues which await redressal like lack of import parity in the Oil & Gas value chain despite high import dependency. Domestic producers are rendered at a disadvantage due to the imposition of CST/VAT on domestic crude sales to refineries, whereas no such duty is applicable on imported crude. More so, additional layers of complexity and the uncertainty due to delays in environmental and other statutory clearances/ approvals by regulatory and other State/ Central authorities are causing time and cost over-runs.

Exploration of Unconventional resource encompasses CBM and Shale in our Country. The shale revolution acted as a major boost for the energy sector of the United States and is credited with reducing its dependence on the Middle East, creating large scale-employment, and turning it from a historically importing country into a net exporter. Another example is China where focussed efforts are on towards exploring and developing domestic resources including the unconventional shale to boost energy security.

India has several basins with potential Shale Oil and Gas resources such as Barmer, Assam, Krishna Godavari, Cambay, Cauvery, Ganga and Gondwana. Currently, the extraction of Shale oil and gas in India is at the research phase. As per Energy Information Administration (EIA), 2013 the shale resource potential is close to 584 TCF of shale gas and 87 billion Barrels of shale oil in 4 basins (Cambay Onland, Damodar, Krishna Godavari Onland & Cauvery Onland). Another substantial resource base of nearly 15 billion Barrels of oil plus oil equivalent is estimated in the Barmer Basin. Coal Bed Methane resources are estimated at 2599 BCM of which Inplace volume of 295 BCM is already established in 3 states- Jharkhand, WB and MP.

In 2018, the Central government approved a far-reaching policy that allows private and public players to explore and exploit unconventional hydrocarbons in contract areas that were primarily allocated for extracting conventional hydrocarbons under existing Production Sharing Contracts (PSCs), Coal Bed Methane (CBM) contracts &Nomination fields. In addition, in October 2018, a policy framework to promote and incentivize Enhanced Recovery Methods was also notified. However, domestic production of unconventional hydrocarbons has not yet become mainstream.

It is felt that considering the large expanse of shale deposits in our country, with the right kind of enabling factors and state-of-the-art technology, the successes met overseas can be replicated in India. Increased complexity and cost necessitate a policy which balances the risk–reward ratio and incentivizes players to invest in these projects despite the possibility of commercial failure. In a country like ours where the Shale Gas/Oil exploration is still in its nascent stage, wide-scale pilot projects would enable the Operators to understand the nitty-gritties and the challenges of field-scale implementation of exploration and subsequent exploitation particularly for aspects such as project planning and execution, infrastructure, etc.

Enabling factors can include supportive fiscal parameters to subsidize significantly high cost and technical complexity vis-à-vis conventional hydrocarbons; supportive interventions for land acquisition due to higher land requirements, formulation of a sector-specific Environment Impact Assessment manual for sustainable shale exploration, permitting Operators to undertake wide-scale cost recoverable pilot projects (the Argentinean model), development of a robust midstream system via pipelines once the pilots are successful. The global norm for commercialization of shale takes the form of providing incentives; entailing lower royalties, lower profit tax, or rates varying with well productivity/ cost, longer terms of contracts, infrastructure credits, and direct price subsidy. Policy enablers particularly with supportive fiscal parameters should be brought about for ensuring long term viability and sustainability of discoveries. Provision of incentives at least for initial few years may provide an impetus to the shale industry in India during the nascent stages.

Notably, oil prices have been on the rise globally. Oil is the only commodity where among other factors, production cuts have become a tool to push up the prices by the major exporting nations. While India has been demanding 'responsible pricing' by oil producing nations, the country's energy security will remain vulnerable to geopolitical developments and exposed to volatility in the crude prices.

The aggressive purchase of foreign currency for import for crude oil and natural gas is also one of the reasons for steady devaluation of the Indian Rupee leading to rise of commodity prices. While short-term measures to give relief to consumers and to abate concerns of inflation may be met through reduction in taxation on retail fuel, in the medium-to-long term, efforts need to be made to encourage domestic exploration and production through a more enabling investment climate as discussed above. Under-investing in Oil and Gas before renewable are ready to scale up could create recurrent energy crises and result in adverse economic consequences.

A 10% rise in oil prices leads to an increase of nearly USD 15 billion in India's current account deficit, or 0.4% of its GDP. For every 10% increase in crude oil prices, the wholesale price index in India increases by 0.9% - 1 % and the consumer price index by 0.4% - 0.6%.[6] While short-term measures to give relief to consumers and

6. S&P Global Platts; https://www.livemint.com/industry/energy/crude-prices-continue-to-surge-amid-russia-ukraine-conflict-11645773412663.html; https://www.fipi.org.in/Policy_Economic_Report/February2022/mobile/index.html

to abate concerns of inflation may be met through reduction in taxation on retail fuel, in the medium-to-long term, efforts need to be made to mitigate 'imported inflation'[7] and encourage domestic exploration and production.

In the backdrop of the Russia-Ukraine conflict, self-sufficiency in domestic production of oil and gas assumes even more importance for India. This year's Economic Survey expects crude petroleum prices to be in the range of $70-75 per barrel over the course of FY'23.[8] The announcement by the Russian Government of a military operation in Ukraine, has sent oil and gas prices soaring, and is an example of how sensitive and volatile the commodity is. Oil prices soared past $100 for the first time in more than seven years. The latest report by the State Bank of India's (SBI) economic wing says the government is likely to lose up to INR 1 trillion amid rising oil prices in FY23.[8]

Tesla chief executive officer Elon Musk has called for an urgent increase in oil and gas output from United States. Musk, co-founder of an electric vehicle and clean energy company, said that the move would "negatively affect" Tesla but underscored that the production and adoption of sustainable energy solutions cannot be accelerated instantaneously to make up for Russian oil and gas exports.[9]

US President Biden's 'turn around' on fossil fuels production has been remarkable. He had warned against depending on foreign oil and has committed not to ban hydraulic fracturing[10]. China's national energy security strategy is focused on domestic resources and reduction in the dependency of imported Oil and Gas. Likewise, boosting domestic Oil and Gas exploration and production with the objective of self-sufficiency needs to be an integral aspect for the long-term success of the Indian Government's Āatmnirbhar Bharat initiative.

7. https://www.moneycontrol.com/news/business/economic-survey-2022-crude-oil-pegged-at-70-75-a-barrel-caution-over-inflation-due-to-energy-imports-8009121.html
8. https://www.outlookindia.com/business/crude-oil-price-russia-ukraine-crisis-how-government-stands-to-lose-up-to-rs-1-trillion-amid-russia-ukraine-conflict-news-184003; https://www.business-standard.com/article/economy-policy/rising-oil-can-burn-rs-1-trillion-hole-in-govt-coffers-in-fy23-sbi-report-122022500575_1.html
9. https://www.hindustantimes.com/world-news/hate-to-say-this-elon-musk-ceo-of-clean-energy-firm-calls-for-increase-in-oil-and-gas-output-101646446376662.html
10. https://www.naturalgasintel.com/latin-americas-importance-in-energy-transition-expected-to-grow-says-yergin/

Transformative Potential of Unconventional Hydrocarbons

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The shale revolution has been the focus of interest of the petroleum industry for several years. The shale revolution witnessed in USA wherein there has been a rapid and steep increase in crude oil and natural gas production due to technological developments in hydraulic fracturing and horizontal drilling, has brought long-lasting changes to the world energy market. U.S. oil production, which had been declining since 1970, has risen to 11.19 million barrels per day in 2021, more than doubling during the period from 2008 to 2021.[1] 65% of total U.S. crude oil production in 2021 were produced directly from shale resources.[2] The United States has surpassed Russia as the largest natural gas producer in 2011 and Saudi Arabia for oil in 2018.[3] Gas production in the US has surged during the past few years to such an extent that companies that had created gas import re-gasification facilities have now applied to convert them into gas liquefaction export plants.[4]

Previously, popular discourse was dominated by the narrative of the peak oil theory, wherein it was predicted that U.S. crude oil production would peak sometime between 1965 and 1970. While this is partially correct as U.S. production had reached 9.6 million barrels per day in 1970[5] before decreasing through 2008, however, production began to rise steadily in 2009 as new oil and gas technologies began to open up previously inaccessible resources, ushering in the U.S. Shale Revolution.[6] The shale revolution has opened up an entirely new frontier of hydrocarbon resources and acted as a major boost for the energy sector of the United States and is credited

1. https://www.eia.gov/outlooks/steo/pdf/steo_full.pdf; https://www.eia.gov/outlooks/steo/archives/may09.pdf
2. https://www.eia.gov/tools/faqs/faq.php?id=847&t=6
3. https://hir.harvard.edu/a-crude-restructuring-how-the-american-shale-revolution-is-changing-the-geopolitical-calculus-in-the-middle-east/
4. https://indianexpress.com/article/opinion/columns/from-rocks-to-riches/
5. https://www.cnbc.com/2017/06/06/us-oil-output-to-hit-record-10-million-barrels-a-day-next-year-eia.html
6. https://www.strausscenter.org/energy-and-security-project/peak-oil/#:~:text=Using%20the%20peak%20oil%20theory,1970%20before%20decreasing%20through%202008.

with reducing its dependence on the Middle East, creating large scale-employment and turning it from a historically importing country into a net exporter that can now impact global prices and be energy independent. U.S. has regained the position it lost in the 1970s as the world's largest oil producer, which it will likely hold through at least till the 2040s.

While the United States still continues to import some quantum of crude for the sake of efficiency, it has also managed to diversify the source of such imports to protect its energy supply. Today, the USA imports 62% of crude oil imports from Canada, while only about 9% of U.S. crude oil imports were from Persian Gulf countries in 2021. Saudi Arabia, the largest OPEC petroleum exporter to the United States, was the source of only 6% of U.S. crude oil imports in 2021.[7]

Shale Gas and Shale Oil are hydrocarbon molecules trapped in layers of rock (shale). The permeability of shale layers can be 1,000 to 10,000 times less than that of conventional hydrocarbon reservoirs. Consequently, until recently, extracting unconventional resources was generally a significant challenge.[8] Historically, the process for extracting and refining oil from shale has been difficult and extremely expensive. For most of the 20th century, the technology necessary to extract the oil from the shale rock simply didn't exist, and even when massive shale rock formations were discovered in the 1980s, it was too costly to make it profitable for oil companies. As such, the United States continued to depend on cheap domestic energy resources, such as coal and the import of heavy crude oil from countries in the Persian Gulf, namely Saudi Arabia. However, through a combination of government restructuring and technological developments, the United States was finally able to tap its enormous energy resources.[9]

These extraordinary results have catalysed worldwide interest in shale gas and tight oil (liquids from shale). Many hydrocarbon-producing countries are now looking to replicate the U.S. success. Many governments have asked their technocrats essentially three questions. Does the country have shale rock? If so, what might be the unconventional hydrocarbon potential? And what must be done to develop and monetize this potential?

The response to the first two questions has so far been almost uniformly positive. Most countries have established that they do have shale and those non-US reserves are potentially huge. China has also been focusing on developing its shale resources, driven by efforts to boost energy security. The Chinese government has directed state oil and gas majors, including the biggest companies such as Petro China

7. https://www.eia.gov/energyexplained/oil-and-petroleum-products/imports-and-exports.php
8. https://www.bcg.com/publications/2013/energy-environment-great-global-shale-gas-development-race
9. https://hir.harvard.edu/a-crude-restructuring-how-the-american-shale-revolution-is-changing-the-geopolitical-calculus-in-the-middle-east/

and Sinopec, to work towards significantly boosting their production from shale formations. To further boost production, China is looking to attract investments in shale developments by easing restrictions on foreign entities and subsidizing costs.

Initial studies are encouraging for India. India has several basins with potential Shale Oil and Gas resources such as Barmer, Assam, Krishna Godavari, Cambay, Cauvery, Ganga and Gondwana. Currently, the extraction of Shale oil and gas in India is at the research phase. As per Energy Information Administration (EIA), 2013 the shale resource potential is close to 584 TCF of shale gas and 87 billion Barrels of shale oil in 4 basins (Cambay Onland, Damodar, Krishna Godavari Onland& Cauvery Onland).[10]

The answer to the third question pertaining to above the ground impediments, however, has been more cautious. India has tremendous potential to meet its energy requirements. However, the nation is yet to attain full-fledged energy security and is becoming overly dependent on imports due to various institutional constraints. Hon'ble Prime Minister Narendra Modi had set a target in 2015 to reduce import dependency by at least 10 percent by 2022. However, the country's dependence on oil imports has been on a continuous rise, from 78.5%[11] in 2014-15, to 85%[12] in 2020-21. Further, India also imports 54.3%[13] of its natural gas consumption. Thus, the country's energy security will remain vulnerable to geopolitical developments and exposed to volatility in crude prices, which also has adverse economic consequences including current account deficit and inflation. This issue is further exacerbated by the fact that our domestic production has been declining for the last 8 years.[14] Most of our existing fields are mature and ageing and have become less productive over time, due to which producers would now have to invest in extracting oil and gas using enhanced recovery techniques. Finding newer reserves through exploration rounds is key to reducing the huge reliance on imports, wherein unconventional hydrocarbons have a possible transformative potential.

In 2018, the Central government approved a far-reaching policy that allows private and government players to explore and exploit unconventional hydrocarbons in contract areas that were primarily allocated for extracting conventional hydrocarbons under existing Production sharing Contracts (PSCs), Coal Bed Methane (CBM) contracts &Nomination fields. Further, the Hydrocarbon Exploration Licensing Policy (HELP)of 2016 allows the contractor complete freedom to explore unconventional hydrocarbons along with conventional hydrocarbons. In addition, in October 2018, a policy framework to promote and incentivize Enhanced Recovery Methods was also

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10. https://dghindia.gov.in/index.php/page?pageId=37
11. Ready Reckoner Snapshot of India's Oil & Gas data; Petroleum Planning & Analysis Cell(MoPNG); October 2016
12. India's Hydrocarbon Outlook 2020-21, Directorate General of Hydrocarbons (DGH)
13. Petroleum Planning & Analysis Cell (PPAC's) Snapshot of India's Oil & Gas data; Abridged Ready Reckoner; January, 2022
14. DGH Hydrocarbon Outlook; 2020-21

notified. However, while these policies are directionally right, domestic production of unconventional hydrocarbons has not yet taken off.

Shale Oil and Gas was not at the forefront for a long time due to the significantly high cost and technical complexity vis-à-vis conventional hydrocarbons. Shale oil and gas is a difficult play, needs special considerations. Some of the factors that led to the success of shale hydrocarbons in the USA can be attributed to favourable geology, large resources play, and intensive Research & Development efforts supported by the Department of Energy to aid improved recovery techniques. Other factors were deregulated natural gas prices, well developed pipeline infrastructure, private land and mineral rights ownership, easy leasing framework, water availability, and tax credits.[15] The American companies have had little or no difficulty in negotiating rights to expansive and contiguous acreage because the average size of landholdings is large and the landlords have an incentive to encourage drilling because they own the sub-surface minerals. The oil service sector is well developed and capable of supporting an intensive assembly line drilling programme. The approval process is streamlined and time-bound.[16]

The development of shale hydrocarbons is fundamentally different from the development of conventional oil and gas resources. Conventional wells observe a slow decline over their roughly decade-long lifetimes, but Shale wells' output also tails off rapidly, with 50 percent of a typical shale well's production often occurring in the well's first year. It takes many more wells to develop a shale field than a conventional one. Shale fields are also much less predictable than conventional fields for operators. With conventional fields, the long-term rate of development and positioning of wells can be gauged fairly early on, but with shale plays, the learning is constant and the model may need to be refined after every new well.

These realities should factor into the design of licensing policies. Shale plays, being continuous and low permeable reservoirs, typically require thousands of development wells leading to the need for a huge amount of land. To encourage and facilitate exploration, governments should grant operators access to large amounts of land vis-à-vis the allotments typical for the development of conventional resources, factoring in the highest number of wells to develop shale fields efficiently. Policy interventions to streamline and support land acquisition need to be undertaken.

Operators should also be granted extended exploration periods, where the main criterion for approval should be the commitment to execute large seismic surveys and to drill and fracture a large number of wells. The evaluation of field development plans for the granting of production licenses should allow for the alteration of those

15. https://lupinepublishers.com/ocean-journal/fulltext/shale-oil-gas-as-an-alternative-source-of-energy-management-strategy-in-modern-industrial-development.ID.000118.php
16. https://indianexpress.com/article/opinion/columns/from-rocks-to-riches/

plans down the line, given that the first batch of development wells will influence the rest of the development concept.

Shale hydrocarbon operations require a complex logistic setup, one that has to be repeated by operators a multitude of times for potentially thousands of wells. Hence, a well-resourced mechanism should be devised for granting permits. The fiscal framework should impose a relatively light tax burden during the exploration phase.[17] Given that shale investments are capital-intensive, enabling contractual provisions for recouping the exploration cost should be provided for Operators.

A well-established midstream system is one of the driving factors behind the North American shale boom. The GoI policy should focus on planning new pipelines or diverting currently planned/proposed pipelines towards basins having unconventional potential.

The shale revolution is not only an energy revolution; it is a technology revolution, enabled by advanced methods for oil prospecting and extraction. For one, horizontal drilling, as opposed to the traditional vertical wells, have allowed for access to a much larger area of underground rock formations. Another is hydraulic fracturing, commonly known as fracking, which is a new process that uses water, sand, and chemicals are pumped into wells to expose cracks in rocks to release the oil hidden inside.[19]

Outside of the USA, one of the main hurdles that governments and operators face in formulating long-term strategies for shale hydrocarbons development is simply the lack of available relevant geographical, geophysical and environmental data. To address this shortcoming, governments must encourage data acquisition and promote data sharing. These efforts can be supplemented by fiscal policy – for instance, operators can be granted special tax treatment for exploration wells and seismic surveys.[20]

A major component of the technical know-how and global best practices need to be acquired from overseas, principally the USA. Technology partnerships with international companies can be a good start for indigenous development backed by international collaboration.

Shale resources are distributed over larger areas and are technically more complex. This increased technical complexity makes unconventional exploration and development more expensive than conventional onshore wells. Increased complexity and cost

17. https://www.bcg.com/publications/2014/energy_environment_shale_gas_ten_levers_ensure_safe_effective_development
18. https://www.wsj.com/articles/how-american-fracking-changes-the-world-1543276935
19. https://hir.harvard.edu/a-crude-restructuring-how-the-american-shale-revolution-is-changing-the-geo political-calculus-in-the-middle-east/
20. https://www.bcg.com/publications/2014/energy_environment_shale_gas_ten_levers_ensure_safe_effective_development

necessitate a policy which balances the risk – reward ratio and incentivizes players to invest in these projects despite the real possibility of commercial failure. In a country like ours where the Shale Gas/Oil exploration is still in its nascent stage, wide-scale pilot projects would enable the operators to understand the nitty-gritties and the challenges of field-scale implementation of exploration and subsequent exploitation particularly for aspects such as project planning and execution, infrastructure, etc.

The potential magnitude of the impact of shale oil and gas makes it a profound force for change in energy markets and the wider global economy. The potential availability and accessibility of significant reserves of shale oil around the globe; and the potential effect of increased shale oil production in limiting growth in global oil prices - has implications that stretch far beyond the oil industry. The effects of a lower oil price resonate along the entire energy value chain. Shale oil has the potential to reshape the global economy, increasing energy security, and affordability in the long term.[21] Likewise, large volumes of cheap gas made available through shale exploration can facilitate switching to a gas-based economy, aligned with the vision of the Indian Government to increase the share in the energy mix to 15% by 2030.

The global norm for commercialization of shale takes the form of providing incentives - entailing lower royalties, lower profit tax, or rates varying with well productivity/cost, longer terms of contracts, infrastructure credits, and direct price subsidy. Policy enablers particularly with supportive fiscal parameters should be brought about for ensuring long term viability and sustainability of discoveries. Provision of incentives at least for initial few years may provide an impetus to the shale industry in India during the nascent stages. Considering the large expanse of shale deposits in the country, with the right kind of enabling factors, the international success in Shale Oil and Gas technology can be replicated in India. In order to attract prospective international investors to come into the fray, existing Operators who have the acreages available to them and the infrastructure in place, should be actively encouraged to explore for the shale potential in an unencumbered manner without being mired by legacy issues. It is, therefore, critical for policymakers to consider the strategic implications of these changes now.

21. https://www.pwc.in/assets/pdfs/publications/2013/shale-oil-report.pdf

Opportunities and Challenges of Energy Security

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Looking into the Future : From Supply Chain Disruptions to Energy Blackouts

A recent news on a TV channel has made us anxious to say the least. According to this report the earth is completing its revolution in less than 24 hours. This means that the earth is rotating faster than usual and there is a significant drop in its orbital rotation. Scientists have attributed this to climate changes that have affected the poles which have become less in weight due to snow melting. Only someone as foolish as one can be would like to discard such incidents. The wise will however look for corrections and solutions at the earliest. Unfortunately we the living beings on Earth are so tied to the notion of Insurance that we think that everything is protected. However, nature does not have any such agreement with us and can do what it wants to do and when it wants to do. Therefore, to playing with nature will be the biggest folly that mankind can ever have.

But it seems that we humans are drifting in our own ways unaware of all such issues. The Ukraine-Russia crisis has almost brought the world to its knees which was only walking lamely after covid. The world is experiencing the first truly global energy crisis in history. And as the International Energy Agency has been warning for many months, the situation is especially perilous in Europe, which is at the epicentre of the energy market turmoil. I'm particularly concerned about the months ahead.

The natural gas prices along with Brent crude topped prices and broke previous records over the year. The present Brent crude price around 99 dollars is said to be bottomed out. The Biden administration in the US faced tough times as citizens felt the pinch of high gasoline prices and inflation pressures. India was lucky to get its energy needs fulfilled from discounted Russian sources.

Countries like Sri Lanka succumbed to this energy pressure while Pakistan as usual is begging all around the world for survival.

The last nail in the coffin could be the visit of US Congress Speaker Nancy Pelosi to Taiwan which China considers as part of the mainland.

Opportunities from an Uncertain Future

With such an uncertain future that can have existential crises for many countries, it is imperative to look into the energy resources and solutions comprehensively. Further, there are challenges arising from climate change and on other side geopolitics.

The fallout from the Covid-19 pandemic and Russia's invasion of Ukraine has put global energy supply chains under enormous pressure, leading to soaring prices of oil, gas and coal, as well as shortages of semiconductors and the critical minerals needed to manufacture clean energy technologies. While the current energy crisis poses a threat to near-term economic prospects, it also provides an opportunity to accelerate the shift away from fossil fuels through a massive surge in investment in renewables, energy efficiency and other clean energy technologies. (Ref: IEA)

Clean energy supply chains largely depend on minerals, not fossil fuels. As a result, the related energy security considerations will be about access to the critical minerals, materials and components needed to manufacture clean energy technologies rather than the supply of fuels alone. Establishing secure, resilient and sustainable supply chains for these technologies will be essential. Important lessons can be drawn from established markets and technologies such as solar photovoltaics (PV) – where China has secured a dominant position at each step of the global supply chain – to shape emerging markets for batteries, low-emissions hydrogen and other technologies vital to the clean energy transition.

The Supply Chain Challenge:

The deployment of clean energy technologies needs to be scaled up rapidly around the world to avert the worst effects of climate change. The IEA's Net Zero Emissions by 2050 Scenario, described in detail in the Net Zero by 2050: A Roadmap for the Global Energy Sector report prepared in 2021 for the Conference of the Parties in Glasgow, sets out an energy pathway consistent with limiting global temperature increase to around 1.5 degrees Celsius. The huge increase in the deployment of solar PV, EVs and low-carbon hydrogen in that scenario calls for rapid growth in the manufacturing of these technologies, as well as the production of essential material and mineral input.

The generation of electricity using solar PV technology is a central pillar of the clean energy transition. Annual average capacity additions in the Net Zero Emissions by 2050 Scenario quadruple over 2020-2030, with solar accounting for roughly one-third of total generation by mid-century – up from just 3% today.

Solar PV panel production already accounted for 10% of global demand for silver and over 40% of global tellurium use in 2021. Rising global solar PV needs will boost opportunities for expanding manufacturing capacity in the Indo-Pacific region. Almost all of today's global manufacturing capacity for solar PV is in the Indo-Pacific region, most notably in China. The region also hosts the majority of material processing capacity to sustain such manufacturing capacity. Although there are plans to scale up module manufacturing capabilities in North America and Europe, the region is well placed to remain a major supplier of components and a key manufacturer of panels.

Accelerating the uptake of EVs will require a massive expansion in the supply of batteries, which will drive up demand for several critical minerals. Like solar PV, global sales of electric cars have soared over the last few years, doubling in 2021 alone to a record 6.6 million. Just 120 000 were sold in 2012. Sales of electric buses (up 40%) and medium- and heavy-duty trucks (up 100%) have likewise seen large increases in the last year. In the Net Zero Emissions by 2050 Scenario, the global fleet of EVs reaches 350 million (excluding two/three-wheelers) and their share of the total vehicle fleet around 20% in 2030. By then, EV sales reach over 65 million per year – almost 60% of total vehicle sales. This contributes to an average increase of 30% per year over 2021-2030 in global demand for lithium (compared with 6% over the last five years), 11% annual demand growth for nickel (5%) and 9% annual demand growth for cobalt (8%).

Australia is the largest producer of lithium, producing over half of global mined production in 2021, and is home to two of the top five global producers – Pilbara Minerals and Allkem. For nickel, laterite deposits are mainly found in Indonesia, the Philippines and New Caledonia. There are plans to launch or expand battery manufacturing in several countries. Indonesia recently created a government-owned battery corporation that aims to build 140 GWh of battery capacity by 2030, of which 50 GWh will be for export. Today's global battery manufacturing production capacity is about 871 GWh.

Compared with solar PV and EVs, low- emissions hydrogen1 – produced by electrolysis or steam reforming of natural gas with carbon capture, utilisation and storage (CCUS) – is still in its infancy, with production of around 30 kt via electrolysis and 0.7 Mt via CCUS in 2021 (less than 0.8% of total hydrogen output). In the Net Zero Emissions by 2050 Scenario, low- emissions production takes off quickly, reaching around 150 Mt in 2030 and 520 Mt by 2050. This requires a massive increase in electrolysis capacity, from 0.3 GW today to close to 850 GW by 2030 and almost 3,600 GW by 2050.

The clean energy transition is fundamentally changing the nature of energy security. The IEA defines energy security broadly as the uninterrupted availability of energy sources at an affordable price. There are several aspects to this. Long-term security hinges on the timeliness of investments to supply energy in line with demand, while short-term security is linked to the ability of the energy system to react promptly to sudden changes in the supply-demand balance. Until recently, discussions about energy security were largely focused on the supply of fossil fuels, notably oil. Fossil fuels are again at the heart of the current global energy crisis: oil, gas and coal still account for 80% of the global energy mix. This is a stark reminder of the need to always ensure supply security of traditional fuels during the clean energy transition, but it should not divert our attention from the security of clean energy transitions.

The supply of critical minerals such as copper, lithium, nickel, cobalt and rare earth elements will be of particular importance. These critical minerals are essential for many clean energy technologies. The world's resources of these minerals are undoubtedly big enough to meet this increase, but production and processing operations for many of them are highly concentrated in a small number of countries at present, making supplies vulnerable to political instability, geopolitical risks and possible export restrictions

India's Initiatives

India has committed to reach net zero emission by 2070 at Glasgow. Much before that India can be expected to reach annual per capita energy consumption of 2400 kgoe (28000 KWh), minimum consumption level necessary to achieve a very high quality of life. The total energy consumption would then be 44800 TWhr/yr. (up from present level of 6830 TWhr/yr).

While there may be additional renewable energy potential (particularly the potential of bio-energy @ 2500 TWh/yr as against 60 TWh/yr factored in above assessment), the gap is too large to bridge. The only other non-emitting energy source is nuclear. It can meet our needs and is also inevitable for optimum & stable grids.

While total energy consumption would increase ~ 4 to 5 times (at a rate consistent with economic growth), Clean energy consumption would need to increase ~ 70 times (at a rate consistent with reaching net zero target). The increase has to come primarily through Renewable (including Bio-energy) and Nuclear

Except Biomass, Solar thermal* and High temperature nuclear reactors*, all other clean energy sources first produce electricity (*both yet to be developed, even bio-energy calls for major development thrust)

Share of electricity would thus need to go up from ~20% to ~35% (If hydrogen is produced by thermo chemical splitting/radiation dissociation of water - potentially a cheaper option) or ~80% (If Hydrogen is produced through steam electrolysis) in a net zero emission scenario.

We need an optimum mix of electricity generating systems to assure diversity of supply, optimum peak capacity investments and stability of grids.

Other Critical Technologies to be Deployed

1. Steam electrolysis (and also SOFC)
2. Thermo-chemical splitting of water (Radiolysis of water could also be explored)
3. Energy storage

4. Production of hydro-carbon substitutes using hydrogen and biomass

5. CCU&S to meet energy needs, meet emission targets and produce value.

Conclusion

A comprehensive and coordinated approach is required to develop and expand global clean energy technology supply chains that are secure, resilient and sustainable. This means supply chains that can meet the needs of a net zero pathway and that can absorb, accommodate and recover from both short-term shocks and long-term changes, including material shortages, climate change, natural disasters and other potential supply disruptions. The goal should be to enhance the security and resilience of supply chains while maintaining a commitment to principles of open and transparent markets and avoiding barriers to trade. Self- sufficiency is not always an option – particularly for critical minerals that are geographically concentrated – nor an economically optimal approach: a combination of open markets, strategic partnerships and diversity of supply sources can deliver security, resilience and sustainablity it.

India has taken some tiny steps in the right direction. But clearly there is a lot that needs to be done . An uncertain world will bring new challenges that may cripple the whole economy in no time. The present EV and semiconductor crisis is a good example of the same. India has to focus on indigenous methods (Atmanirbharta) in a big and focused manner.

Developing a Gas-Based Economy

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India made an ambitious but prudent announcement at COP-26, held late last year, to achieve net-zero emissions by 2070. For a country of 1.32b and growing, with large urban centres situated on the coastline, taking cognizance of the perils of climate change is essential. To this end, India has taken many rapid strides.

This is not just with India, but globally too, there is an increasing movement to replace high carbon-emitting fossil fuels with cleaner energy sources. In many economies, a carbon tax too has been devised to make these fuels costlier and disincentivize their use. While India has shied away from embracing the carbon tax, and rightly so, given the depth of our economy and continued reliance on fossil fuels– its intentions to diversify sources of energy are compelling.

Under our publicly declared Nationally Determined Contributions (NDCs) under the 2015 Paris Agreement, India has committed to reducing the greenhouse gas (GHG) emissions intensity of its GDP by 33-35% by 2030, relative to 2005. However, coal dominates India's energy mix at a proportion of 44%, which is the third highest among G20 countries.[1] There are many reasons that back this continued dependence; nonetheless, our search for cleaner cost-efficient sources is gaining swift pace.

A Case for Natural Gas

Globally, natural gas has been gaining acceptance as a key alternative fuel to support the energy shift in favour of cleaner and greener energy sources. Renewable energy production, such as wind and solar sources, is intermittent and critically dependent on weather conditions. To ensure continuous supply through these sources while maintaining grid stability and avoiding intermittency, gas is a promising option. The combustion of natural gas emits about half as much carbon as coal.[2] Globally, one of the most significant growth drivers for natural gas rests in its increasing use as a transport fuel.

1. India Energy Outlook 2021, International Energy Agency
2. https://www.business-standard.com/article/current-affairs/how-natural-gas-could-thwart-or-support-india-s-renewables-progress-121101900140_1.html

India too recognizes the potential in gas and has set a vision to increase its share in the energy mix to 15% by 2030. Currently, the country is promoting natural gas as a 'transition' or 'bridge fuel' in its journey towards using renewable energy as its main power source. The role of natural gas as a relatively low polluting transition fuel will become even more significant in the coming decades given the target of achieving net-zero carbon emissions economy by 2070, for which India would also need sufficient capacity for power storage. However, grid scale battery storage is an evolving technology and currently entails high levels of cost – this makes natural gas even more attractive.

Now, as we aim to increase the share of natural gas in our energy mix to 15% by 2030[3], newer policies are being announced that cover supply-side aspects, distribution related interventions, as well as demand-side initiatives for the development of gas consuming markets. However, in practice, gas currently plays a peripheral role in India, accounting for only 6.7%[4] of the country's energy mix compared to a world average of 23%[5]. While the share of gas remains relatively low, niche sectors are driving a steady increase in demand. For instance, gas has a role to play in providing stable power, particularly for providing backups and grid integration vis-à-vis diesel generators. The use of gas-based power is preferred over coal-based power as it can be ramped up more quickly. Further, gas will also provide baseline power to complement the growing capacity of renewables.

Matching Demand with Supply

India has also been increasing its pipeline and distribution network through policy changes pertaining to City Gas Distribution (CGD) with an envisaged coverage of 96% of the population within the next few years.[6] Demand is especially rising in sectors where gas can substitute liquid fuels. Policy interventions are also under consideration for LNG in long-distance freight transport.

Another potential area of growth lies in the Micro, Small & Medium Enterprises (MSMEs) sector which relies heavily on coal, and firewood. Constituting the bulk of India's manufacturing and export prowess, stricter emission norms are likely to drive these industries towards natural gas. Further, integrated power heating and cooling can offer attractive environment-friendly energy solutions for many missions such as the Smart Cities Mission. Here, CNG/LNG in vehicles would go a long way in addressing the challenges of urban pollution.

3. https://pib.gov.in/newsite/PrintRelease.aspx?relid=173167
4. India's Hydrocarbon Outlook 2020-21, Directorate General of Hydrocarbons (DGH)
5. https://www.iea.org/fuels-and-technologies/gas
6. India's Hydrocarbon Outlook 2020-21, Directorate General of Hydrocarbons (DGH)

Growth in India's gas demand has outpaced domestic production, leading to a steep rising dependence on imported gas from 20%[7] of India's total gas demand in 2010 to 54.3%[8] as of date.The Government of India has adopted a range of policy measures to expand domestic production. For instance, the provision of marketing and pricing freedom in new policy regimes namely Hydrocarbon Exploration Licensing Policy (HELP) is a progressive measure to augment natural gas production in the country. In 2020, the government also supported the launch of IGX; a trading platform for natural gas.

An interconnected National Gas Grid has been envisaged to ensure adequate availability and equitable distribution of natural gas across the country. Today, 19,998 km of natural gas pipeline (including sub-transmission pipeline & tie-in connectivity pipeline) is operational, and another 15,369 km is under various stages of construction.[9] Open access to pipeline infrastructure is a key tenet of the competitive markets ensuring that market-driven fair price discovery is enabled by way of equitable and open access to all prospective buyers. The government is also in the process of setting up a Transmission System Operator (TSO) to allow transparent access to gas pipeline capacity to all prospective buyers. Moving ahead it is important to recognise that if gas fails to account for 15% of India's energy mix within the next few years, India might have to fall back on coal. The infrastructure being created now might then turn into under-utilized assets.

Policy First

The shift to increasing the share of gas will also require a combination of policy changes on taxation, carbon pricing, and environmental norms. Currently, natural gas is not a part of the GST regime and input tax credit cannot be availed by producers – though coal enjoys benefits under the GST regime. Further, most of India's indigenous gas production comes from the fields under Nomination, Pre-New Exploration Licensing Policy (NELP), and NELP regimes. To transition towards a future of gas, all gas-producing fields should be brought under the uniform taxation regime. Additionally, incentives offered to acreages under the HELP regime should be extended to all other licensees to ensure investment flows into tapping reserves in older and mature fields, which may need application of enhanced recovery techniques. A fully market-driven price discovery mechanism will expedite the development of domestic gas.

Further, India continues to control gas pricing for these older regimes by way of the allocation mechanism, wherein the government pre-determines the volumes to be sold by gas producers to buyers. In one way, this arrangement could have

7. India Energy Outlook 2021, International Energy Agency
8. Petroleum Planning & Analysis Cell (PPAC's) Snapshot of India's Oil & Gas data; Abridged Ready Reckoner; February, 2022
9. https://pib.gov.in/PressReleasePage.aspx?PRID=1739017

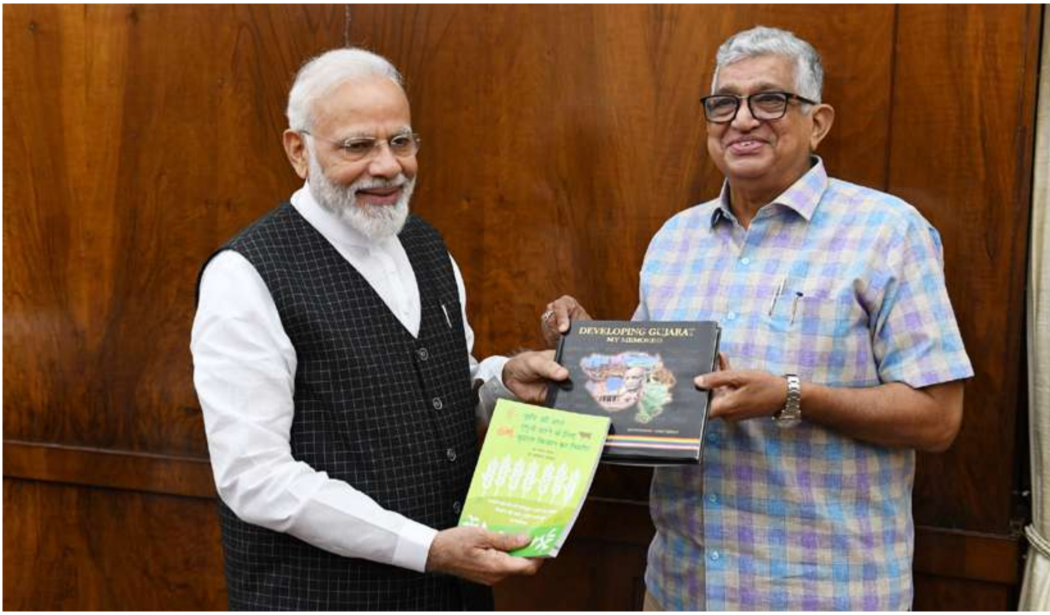
kept energy prices low, and could have helped sectors such as manufacturing gain competitiveness. In practice, however, it has created skewed conditions as it creates an outcome where a company's viability depends on the price at which it gets gas. Ensuring complete marketing and pricing freedom with deregulation will create a more level-playing field and attract investment in exploration and production.

Given India's development priorities, it is unlikely the country will be able to make a complete exit from fossil fuels in the near to medium term. However, that should not be a hindrance to the journey towards net-zero emissions. We can begin tracing that goal by using the least-polluting fossil fuels to complement the shift to renewables. Streamlining the taxation, pricing and marketing mechanism for natural gas will enable a reduction in import dependency and self-sustained domestic production, aligned with the country's vision of establishing anAtmanirbhar India. The initial benefits of this ambitious target can be experienced by first, increasing the share of gas in the energy mix while ramping up renewables in the energy mix. In India's energy transition journey, gas, thus, brings the greatest promise and possibility.

National Council for Climate Change Sustainable Development and Public Leadership (NCCSD) India

In new millennium the world is facing the challenge of climate change with increasingly unpredictable weather events and its intense adverse impact on habitat. The cause of climate change is global warming – increased green house gasses. Although global warming in an international phenomena – its adverse impacts are at the local level. The severely affected are the villages – the farm lands and the farmers. The increased floods, cyclones, delayed rains, droughts, heavy rains on one day, un-seasonal hot and cold waves, frost – all these lead to crop – failures – low productivity and mortality. This also causes challenge of food security.

It was in this context that Dr.Kirit Shelat initiated a dialogue by organizing an International Conference on "Global Warming, Agriculture, Sustainable Development and Public Leadership" at Gujarat Vidhyapith – Ahmedabad in March 2010. The outcome of conference was twofold. The Planning Commission of India set up of a special sub group in on " Enhancing Preparedness for Climate Change" headed by Dr. Kirit Shelat and simultaneously, it was decided to set up a special purpose – NGO with focus on Agriculture and National Council for Climate Change, Sustainable Development and Public Leadership – NCCSD come in to existence at Ahmedabad. Dr. M.S. Swaminathan the veteran agriculture scientist the leader of Green Revolution, Shri Purshottam



Rupala, Dr. Y.S. Rajan and Shri Kantisen Shroff gave their blessing and support. The organization was rolled in September 2010 with Dr. Kirit Shelat as Executive Chairman and Justice B. P. Singh as its President.

The mission of NCCSD is to prepare Public governance system, farmers and rural youth to meet challenges of climate change. This is with series of initiatives.

The focus of NCCSD is on Agriculture sector, farmers, rural youth, agriculture university students and faculties, extension team of Government and volunteers of NGO's. The objective is to promote sustainable livelihood in area of Climate Change - so that farmers continue to increase their income.

This is through new modals of training for adaptation and mitigation and climate resilient agriculture And includes weather related information, followed by agro – advisory, contingency plans by farmers and market related information.

NCCSD, based on feedback received from farmers and stakeholders, developes policy and programming related suggestions and takes up that with State Government and Central government.

NCCSD conducts leadership building programme which includes entrepreneurship training for students of agriculture universities.

NCCSD participates in 'Conference of Parties"- meet of countries organized by UNFCCC to meet the challenges of climate change. It was realized that agriculture and farmers do not figure in COP discussion. The role of agriculture as nature's tool for mitigation- was not recognize. NCCSD organizes every year, side events and exhibitions. NCCSD successfully prioritized agriculture in COP. The Paris Agreement accepted importance of food security, food productivity, technology transfer and capacity building.

FAO also liked idea it created a special purpose organization Called GACSA- 'Global Alliance for Climate Smart Agriculture'.

NCCSD organizes international Conferences. The first was on 'Climate Change and its impact on Agriculture and farmers 2012 -New Delhi, Followed on -at Morroco-2012, in 2014-Ahemadabad on Climate Justice,2016-at anand on Food, Water and Energy Nexus.

In 2014 NCCSD is collaborated with Florida Agriculture and Mechanical University 'FAMU', USA for building climate smart farmers. USAID helped FAMU to send 30 US- scientists to train our farmers and faculty members of States Agriculture Universities.

NCCSD brought out a Guide Book for farmers "Building Climate Smart Farmers-A Guide Book for Doubling Income of Farmers in Arena of Climate Change" This book is authored by Dr.Kirit N. Shelat and Dr. Odemari Mbuiya. This is part of regular activity to make available learning material to farmers.

During COVID pandemic, NCCSD organized web-on-air meets and continued district to national and international meets. The important inter-action meets included deliberations on Atmanirbhar Bharat in response to the call given by Hon'ble Prime Minister Shri Narendra Modi. It organized series of experts and stakeholders meet to develop Atmanirbhar Agriculture Gujarat Roadmap 2022- 2030 and Atmanirbhar, Self Reliant and Climate Smart Farmers Roadmap for Agriculture 2020-2030 India. Both were published during pandemic.

The current book on "Atmanirbhar Bharat Energy Security" is similarly based on series of experts and stakeholder's interaction meets.

The contact person of NCCSD is Ms Nisha Shah – CEO.

Web-link – http// www.nccsdindia.org

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Atharvaveda Hymn LXVII

१. पश्येम शरदः शतम् ॥

1. May we see for hundred years. (4960)

२. जीवेम शरदः शतम् ॥

2. May we live for hundred years. (4961)

३. बुध्येम शरदः शतम् ॥

3. May we acquire knowledge for hundred years. (4962)

४. रोहेम शरदः शतम् ॥

4. May we go on prospering and progressing for hundred years. (4963)

५. पूषेम शरदः शतम् ॥

5. May we go on being nourished for hundred years. (4964)

६. भवेम शरदः शतम् ॥

6. May we remain strong and sturdy for hundred years. (4965)

७. भयेम शरदः शतम् ॥

7. May we retain our prestige and influence for hundred years. (4966)

८. भूयसीः शरदः शतात् ॥

8. May we retain all these powers of sight etc., for greater numbers of years than hundred. (4967)

– Dr. R. S. Rajan
Distinguished Scientist - ISRO
Council Member of NCCSD

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#AatmaNirbharBharatAbhiyan

Message from Hon'ble Prime Minister

- Move with confidence towards self-reliance
- Time to become vocal about local products & make them global
- Economy, Infrastructure, Technology Driven Systems, Vibrant Demography & Demand are 5 Pillars of AtmaNirbharBharat
- Bold Reforms across sectors
- Comprehensive package of Rs 20 lakh crores equivalent to 10% of India's GDP for cottage industry, MSMEs, labourers, middle class, industries