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ENERGY FUTURE

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FEATURE

BINDER-LESS BRIQUETTES: AN ANSWER TO PADDY STRAW DISPOSAL

VIEWPOINT

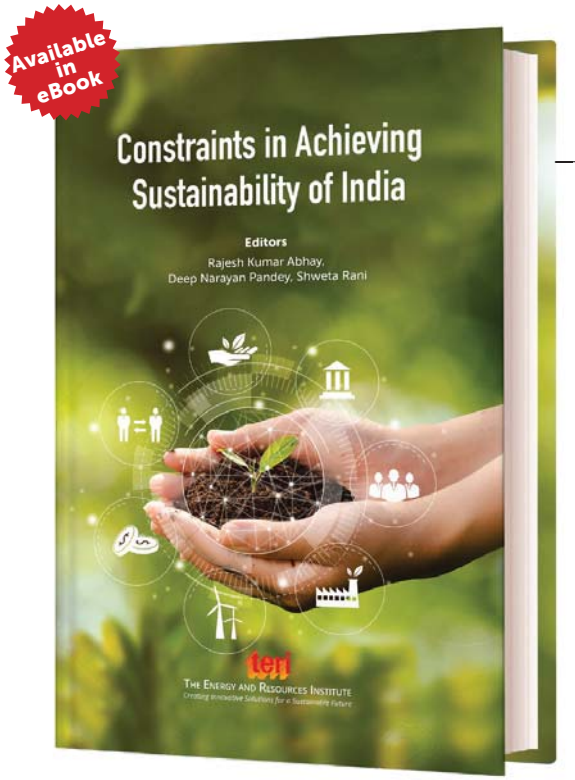
HCCB'S JOURNEY TOWARDS SUSTAINABILITY: ENERGY-EFFICIENT MANUFACTURING AND SHIFT TOWARDS RE

COVER STORY

SHIFTING ENERGY PATTERNS: A CASE STUDY OF PMUY AND LPG ADOPTION IN HILL DISTRICTS OF THE CENTRAL HIMALAYAN REGION

teri

Study of the challenges to sustainable development via scientific means



Major topics covered

- Sustainable Development: concept, components and history
- Environment, Culture, and Sustainable Development
- Sway of Indian Cinema in Diffusing Environmental Sentience
- Poverty Lines and Poor in India
- Sanitation Workers and Associated Problems for the Sustainability of Religious Events
- Assessment of Basic Infrastructure Development and Associated Issues in India

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Purpose of the book is to develop, contribute, and disseminate scientific knowledge pertaining to the issues related to sustainable development. The chapters are developed so that the contents can facilitate comprehension of the major constraints in achieving sustainability including but not limited to environmental, social, economic, and governance-related issues from local, regional, to national level. Resource management, climate change, agriculture, population, education, women, poverty, infrastructure, crime, corruption, governance, are the other relevant topics that have been both identified and suitably discussed. *Constraints in Achieving Sustainability of India* can be utilized as a guiding tool for realizing sustainability in development, especially, in the Indian context.

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Editorial

Pradhan Mantri Ujjwala Yojana (PMUY) has significantly impacted the adoption of LPG (liquefied petroleum gas) in India overall and Uttarakhand in particular, transforming the way households in the state access and use cooking fuel. Launched by the Indian government, the PMUY aims to provide clean cooking fuel to economically disadvantaged families, thereby reducing dependence on traditional biomass fuels and improving health outcomes. In Uttarakhand, the scheme has led to a notable increase in LPG coverage, with many rural and semi-urban households now benefiting from the convenience and safety of gas cooking. This shift has not only enhanced the quality of life by reducing the time and labour spent on collecting firewood but has also contributed to environmental sustainability by lowering carbon emissions. The adoption of LPG under PMUY in Uttarakhand underscores the state's commitment to advancing public health and environmental goals through improved energy access. The cover story, in this issue of Energy Future, largely focuses on shifting energy patterns, with a case study of PMUY and LPG adoption in hill districts of the Central Himalayan Region. PMUY and LPG adoption has contributed to shifting energy patterns, mainly cooking in villages of the Central Himalayan Region and reducing traditional dependence on firewood for energy requirements. The author analyses the factors responsible for adopting clean cooking fuels such as LPG in rural households in the hill districts of Uttarakhand.

India generates substantial organic liquid waste annually, which, when left untreated, contaminates drinking water, degrades soil quality, harms aquatic life, and produces unpleasant odours from open-air fermentation. This exposure also fosters pathogens and insects, leading to health issues such as diarrhoea, jaundice, dengue, and chikungunya. However, this waste has significant potential for clean energy production through fermentation, offering an efficient treatment solution. This month's feature article highlights that anaerobic digestion is the best method for efficient disposal of organic waste effluents as well as simultaneous production of energy. This technique is able to eliminate nearly 95% COD (chemical oxygen demand) present in the influent and allows for the effluent to be directly exposed to the environment after digestion. This method not only aids in maintaining a clean environment but can also generate additional revenue from bio-hydrogen, bio-methane, and other volatile fatty acids. Adopting the two-stage anaerobic dark fermentation method could also produce bio-hythane, a promising clean automotive fuel for the future, potentially benefiting the transportation sector and helping reduce the carbon footprint.

Another feature article in this issue informs us that the Department of Renewable Energy Engineering, Punjab Agricultural University (PAU), has developed a process of preparing binder-less briquettes from chopped paddy straw. Although waste management is the obvious outcome of this process, it also promotes environmentally friendly employment opportunities in rural India. Biomass briquettes are a one-stop solution that can create wealth from waste, generate employment, and contribute to combatting health and environmental hazards related to agri-residue disposal.

Girish Sethi
Senior Director – Energy Programme, TERI

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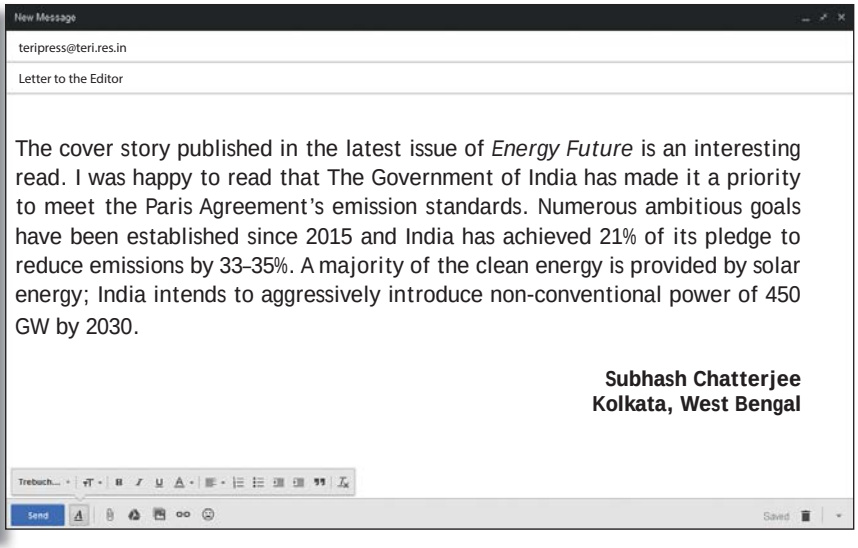


"The discussion on energy security goals and climate concerns in India presented in the feature article of this issue is very informative. India's energy security goals and climate concerns are closely intertwined, and both need to be addressed to achieve sustainable development. While India has made significant progress in increasing renewable energy capacity and promoting energy efficiency, there is a need for greater efforts to reduce the dependence on fossil fuels and address air pollution. India needs to focus on a low-carbon energy system that is environmentally sustainable and socially inclusive. Needless to say India is a rapidly developing economy, facing increasing energy demands due to its growing population and expanding industrial sector."

Mohan Iyer
Delhi

Thank you very much for your encouragement. The editorial team of Energy Future will ensure that the magazine caters to your information and knowledge needs. We welcome your suggestions and comments to further improve our content and presentation.

Email: teripress@teri.res.in

Editor
Energy Future

"I agree with the author of the article "Changing dynamics of blue and green conservation in global south in Kolkata" that blue and green conservation is essential for urban sustainability which is also modernization. The old process of recycling and reuse of water and the monotonous process for vegetation conservation in urban area needs reconstruction. The different new processes of blue and green conservations are established in the study and the objectives are fulfilled. In Kolkata, different organizations are taking effective actions for the blue and green conservation which may enhance the pathway of sustainability in future.

Ashish Mukhopadhyay
Ranchi, Jharkhand

"Renewable energy has emerged as a transformative force in shaping economies worldwide. In the context of India, the integration of renewable energy sources has ushered in a new era of sustainable development, fostering numerous positive impacts on various economic sectors and facets of growth. The remarkable strides made by India in harnessing renewable energy are evident through ambitious initiatives. These policies, coupled with a supportive regulatory environment, have encouraged investments and facilitated the deployment of clean energy infrastructure.

Shruti Sharma
Bengaluru, Karnataka

CONTENTS

PAT SCHEME SAVES 1.16 MTOE ENERGY IN STATE

As part of its efforts to enhance and promote energy efficiency in the industrial sector, AP energy conservation mission (APSECM) recently organized a workshop on the 'perform, achieve and trade' (PAT) scheme, which helps build the capacity of energy managers in industries, thereby enabling them to utilize energy effectively.

The PAT scheme workshop attracted 100 participants, including designated consumers (industries) from Andhra Pradesh, Telangana, and Odisha. High-profile attendees included Special Chief Secretary (energy) K Vijayanand; APSECM CEO BAVP Kumara Reddy; APCPDCL CMD K Santosha Rao; NDEDCAP VC&MD M Nanda Kishore Reddy; AP Solar Power MD M Kamalakar Babu; and Bureau of Energy Efficiency (BEE) Senior Sector Expert Naveen Kumar.

Vijayanand explained that the PAT scheme is a market-based mechanism designed to accelerate improvements in energy efficiency for energy-intensive industries across India. He stated that the scheme, introduced by the Union Ministry of Power-led Bureau Of Energy Efficiency (BEE), has yielded impressive results—achieving energy savings of 8.67 MTOE and avoiding around 31 million tonnes of CO_2 emissions in its first cycle (PAT Cycle-1). "These positive outcomes continued in PAT Cycle-II, with energy savings reaching 14.08 MTOE, translating to an avoidance of approximately 68 million tonnes of CO_2 emissions," said Vijayanand. EF

Source: https://timesofindia.indiatimes.com

ELECTRONIC MEDICAL RECORD SYSTEM THAT USES RENEWABLE ENERGY REDUCES CARBON FOOTPRINT: STUDY

Electronic medical records (EMR) systems in hospital settings emit significantly more greenhouse gases than the traditional paper-based system. But, if conventional energy systems were replaced by renewable energy, then the GHG emissions would be comparable to paper-based systems, say researchers.
A study to understand the benefits of EMR was recently done at the Aravind Eye Hospital in Puducherry. The article *The Environmental Impacts of Electronic Medical Records Versus Paper Records at a Large Eye Hospital in India: Life Cycle Assessment Study*, published in the recent edition of the *Journal of Medical Internal Research*, tried to understand the environmental emissions associated with medical record-keeping in the context of climate action and carbon footprint. They found that if the hospital sourced all electricity from renewable sources, such as solar or wind rather than the Indian electric grid, its EMR emissions would drop to 24,900 kg CO_2 e (0.046 kg CO_2 e per patient), a level comparable to the paper record-keeping system.

One of the researchers and the hospital's Chief Medical Officer R Venkatesh said decarbonizing electricity sources in healthcare facilities could mitigate environmental impact. The 650-bed tertiary care centre caters to over 21.2 million people in the neighbouring districts of Tamil Nadu besides Puducherry. EF

Source: https://www.thehindu.com/

GOVT. PLANS TO LEASE STRATEGIC OIL RESERVE SPACE TO PRIVATE COMPANIES

The government plans to lease out a fifth of its Strategic Petroleum Reserve capacity to oil companies after the budget scrapped an INR 5,000-crore-plan to purchase crude to fill it, an official said.

India has strategic crude storage at three places—Mangalore and Padur in Karnataka and Visakhapatnam in Andhra Pradesh—with a total capacity of 5 million metric tonnes (mmt). Rules allow part of these storages to be leased out to oil companies, while giving the government the right to access crude from these reserves in case of emergency. About 0.75 mmt of capacity in Mangalore and about 0.25 mmt in Visakhapatnam is currently vacant and needs to be filled, said L R Jain, the CEO of Indian Strategic Petroleum Reserves Limited (ISPRL).

ISPRL, which manages the country's Strategic Petroleum Reserve, will soon invite separate expressions of interest (EoIs) from energy players seeking to commercially use the unfilled storage space, Jain said. EF

Source: https://economictimes.indiatimes.com/

KARNATAKA POWER PANEL SLASHES TARIFFS

For the first time in more than a decade, the Karnataka Electricity Regulatory Commission (KERC) has announced "significant reduction" in energy charges for the 2024–25 financial year. Though Bescom and other electricity supply companies had sought to increase tariffs to bridge the revenue gap, the KERC—after considering power purchase charges, sales, and the current state of power production—has decided to reduce the rates. Energy charges for High Tension (HT) industrial consumers will come down by 50 paise per unit, and for HT commercial consumers, the tariff will come down by 125 paise per unit.

Power charges for Low Tension industrial installations will also come down by 100 paise. Moreover, the order has some good news for residential consumers who have been left out of 'Gruha Jyothi', the state government's free power scheme. Domestic consumers who use more than 100 units will see a reduction of 110 paise per unit in their power bills. Now, Bescom consumers who consume over 100 units are being charged INR 7 per unit. This will come down to INR 5.9 per unit.

To ensure better management of available energy during the peak hours, KERC has reintroduced Time of Day (ToD) charges for morning peak hours between 6 am and 9 am. EF

Source: https://www.deccanherald.com/

GOVT. ANNOUNCES NEW CENTRE FOR ENERGY TRANSITION IN COLLABORATION WITH TERI

Union Minister for Power and New and Renewable Energy, R K Singh announced the establishment of a Centre for Energy Transition in collaboration with The Energy and Resources Institute (TERI), at the 23rd World Sustainable Development Summit held in New Delhi in February 2024. This centre aims to lead the way in sustainable energy transition and innovation in renewable energy.

Addressing the summit delegates during a session on 'Energy Transitions for People, Peace, Prosperity, and our Planet', the Union Minister emphasized India's leadership in climate action and energy transition. He highlighted India's remarkable progress and said: "44% of our power generation capacity is from non-fossil-fuel sources. About 180-plus GW of total capacity of 427 GW is from non-fossil-fuel sources, most of which is renewable capacity. Our rate of energy transition is unmatched. We are the only country issuing bids for round-the-clock renewable energy."

Chairperson of TERI Governing Council, Nitin Desai, speaking on India's commitment to sustainability, announced the establishment of this Centre in Hyderabad, in partnership with the government. This centre aims to develop comprehensive energy transition pathways, not only for India, but also for other nations. EF

Source: https://economictimes.indiatimes.com/

TN GREENHOUSE GAS REPORT: 77% EMISSIONS FROM ENERGY SECTOR, LONG ROAD TO ACHIEVE NET ZERO

Tamil Nadu has emitted 184 $MTCO_2$ (million tonnes of carbon dioxide equivalent) in 2019 and has a long road ahead to achieve net zero, according to the greenhouse gas (GHG) inventory released by the state government.

Tamil Nadu is the first state to come-up with GHG inventory to draw pathways for net zero transition. With the help of partner institutes like Council on Energy, Environment and Water (CEEW), the government hopes to chalk-out a transition plan and decarbonize its economy without compromising on growth. According to the report, which was released by Sports Minister Udhayanidhi Stalin during TN Climate Summit 2.0, the state's energy sector alone accounted for 77% of the state's total emissions at 141 $MTCO_2$, out of total 184 $MTCO_2$, followed by the agriculture, forestry, and land use (AFOLU) sector at 22.5 $MTCO_2$ (12.3%), waste emissions at 12.2 $MtCO_2$ (5%) and industrial process emissions at 10.5 $MTCO_2$ (5.7%).

It is imperative for Tamil Nadu to reassess the state's solar and wind potential. Authorities say this is not impossible considering the state aims to attract investments worth ₹23 lakh crore, as per the vision documents presented during the recently concluded Global Investors Meet. In addition, to support the growth of the manufacturing sector, an investment of USD 236 billion is likely to flow in by 2030. EF

Source: https://economictimes.indiatimes.com/

SOLAR ROOFTOP SCHEME: POSTAL STAFF TO CARRY OUT DOOR-TO-DOOR SURVEYS

After Prime Minister Narendra Modi recently announced the launch of Pradhan Mantri Surya Ghar Yojana, which is aimed at providing up to 300 units of electricity through rooftop solar (RTS) every month to 1 crore households, the Postal Department has been roped in for the task and made the nodal agency for the scheme. The Postal Department, through its field staff postmen and Grameen Dak Sewaks, will conduct door-to-door surveys and do registration of people on the mobile application by explaining them about the benefits of the scheme.

Sharing details, Subhash Chandra Meena, Senior Superintendent of Post Offices, Jalandhar, said the staff would also explain about the scheme,

including its costs, benefits and subsidies, in rural areas. Registration of people who wish to install solar rooftop plants would also be done on the spot.

Meena said details such as photo of the rooftop, beneficiary's mobile number, Aadhaar card and electricity bill of the past six months would be uploaded on the app and the registration would be done by postal employees.

He said: "Under this campaign, consumers will get 300 units of free electricity every month. People can get information about this scheme by visiting the post offices. For average monthly power consumption of 0–150 units, the suitable rooftop solar plant capacity is 1–2 kW with subsidy ranging from INR 30,000 to INR 60,000. Similarly, for average monthly power consumption of 150–300 units, the suitable rooftop solar plant capacity is 2–3 kW and there will be a subsidy ranging from INR 60,000 to INR 78,000. The total subsidy for system larger than 3 kW is capped at INR 78,000." EF

Source: https://www.tribuneindia.com

COAL SECTOR AIMS TO RAMP UP RENEWABLE ENERGY CAPACITY TO OVER 9 GW BY 2030

With a keen focus on enhancing renewable energy capacity, the Ministry has set ambitious net-zero electricity consumption plan for Coal/ Lignite PSUs. Recognizing the pivotal role of renewables in mitigating environmental impact, the Ministry is actively promoting the deployment of both rooftop solar and ground-mounted solar projects across mining facilities. Furthermore, innovative plans are underway to develop solar parks within the reclaimed mining areas as well as other suitable lands, leveraging underutilized land resources for sustainable energy generation. This strategic initiative is aligned with the government's updated NDC target to achieve 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030.

In order to minimize the carbon footprints of mining, the Ministry of Coal has issued directives to coal companies to accelerate the adoption

of solar energy solutions. This includes the installation of rooftop solar panels on all government buildings and the establishment of solar projects in de-coaled areas and other suitable lands, effectively harnessing solar potential in previously utilized spaces. Presently, the combined solar capacity installed by leading coal companies, including Coal India Limited (CIL), NLC India Limited (NLCIL), and SCCL, stands at approximately 1700 MW, supplemented by an additional 51 MW from wind mills. Looking towards the future, the coal sector aims to ramp up renewable energy capacity to over 9 GW by the year 2030, signaling a profound commitment to sustainability and environmental stewardship. EF

Source: https://pib.gov.in

APPLE PARTNERS WITH CLEAN MAX TO INSTALL 14.4 MW OF ROOFTOP SOLAR IN INDIA

Apple, the iconic creator of iPhones and iPads, has invested in setting up more than 14 MW of rooftop solar capacities across its six industrial sites in India through Clean Max Enviro Energy Solutions.

The consumer electronics giant aims to become carbon neutral across its entire value chain by the end of this decade. More than 18 GW of clean electricity now powers Apple's global operations and manufacturing supply chain, which is more than triple the amount in 2020.

As part of the partnership in India, Clean Max has successfully installed 14.4 MW of rooftop solar installations, which is expected to mitigate around 207,000 tonnes of CO_2 emissions throughout their operational life, the renewable energy provider to

commercial and industrial (C&I) segment said.

The collaboration is grounded in an innovative business model, where the environmental benefits accruing from the financed projects will assist Apple in addressing the emissions associated with its corporate operations in India, it added.

In a statement, Apple said: "To address its growing corporate operations in India, Apple has also embarked on a joint venture with leading renewable developer CleanMax to invest in a portfolio of six rooftop solar projects with a total size of 14.4 MW."

The added capacity provides a local solution to power Apple's offices, its two retail stores in the country, and other operations in India. Apple first achieved 100% renewable energy for its global corporate operations in 2018, it added. EF

Source: https://www.thehindubusinessline.com

UAE BACKS INDIA'S SOLAR HUB GOALS WITH TECH AND INVESTMENT

The UAE can collaborate with India on aiding the former's endeavours to become a global hub for solar photovoltaic (PV) manufacturing with investments and technology partnerships, a report prepared jointly by UAE-India Business Council (UIBC) and Nangia Andersen said.

The report, *Modern Energy: India-UAE Collaboration for a Sustainable Future*, highlights the partnership between both countries in the renewable energy (RE) sector and its future potential. Suraj Nangia, Managing Partner, Nangia Andersen, noted that India and the UAE have emerged as strong advocates for a sustainable future, and the report delves into the essence of this partnership. Besides solar PV manufacturing, India and the UAE can merge synergies to create specialized research facilities to capitalize on their respective expertise in the concurrent development of state-of-the-art technologies for producing green hydrogen, wind, and solar energy. The UAE's financial strength and India's research prowess can propel clean energy innovation.

Another critical area, the report points out, is the green hydrogen domain. "Collaboration between India and the UAE could be instrumental in the development of a green hydrogen trade corridor. This would position India as a significant producer and exporter of this environmentally friendly fuel, while the UAE, leveraging its current energy infrastructure and strategic location, would function as a pivotal distribution hub," it emphasized. EF

Source: https://www.thehindubusinessline.com

SOLAR SUCCESS IS A CURSE FOR CHINA'S MANUFACTURERS

Ever since photovoltaic cells started popping up on pocket calculators and building roofs a few decades ago, solar power has faced a key drawback: it's a nice technology, but they're simply not enough of it to make a difference right now. It's facing the opposite difficulty.

The tidal wave of investment panels has swell through the point that it is threatening to overwhelm. The global industry of cheap Chinese-made modules, manufacturers have either world themselves off behind private barriers, (as in India and the US) or resigned themselves to extension, as in Europe. Now, even the Chinese companies blame to the current glut of panicking.

On the face of it, this sounds like a great problem to have from the perspective of manufacturing. The world will need to install about 650 gigawatts (GW) of solar a year in 2030 to avoid catastrophic climate change, according to the International Energy Agency. But major manufacturers have already built about 783 GW of annual production capacity, and we might hit the IEA's 2030 installation target this year, according to Bloomberg NEF.

The hitch in all this is that it's a lot harder to connect a solar panel, then it is to make one. Utilities and even households, face regulatory, political, and logistical roadblocks joining the grid. Module costs have already fallen by more than half over the past two years. The current access suggests price declines are to come, which is great news for consumers, but terrible for manufacturers. EF

Source: https://epaper.financialexpress.com/

WITH SOLAR INDUSTRY IN CRISIS, EUROPE IN A BIND OVER IMPORTS FROM CHINA

Europe just had a bumper year for green energy. European Union countries installed record levels of solar capacity, 40% more than in 2022. The vast majority of those panels and parts came from China—in some cases, 95%, International Energy Agency data show.

Yet, the green energy boom hasn't helped Europe's few local solar panel manufacturers, which have hit a crisis point, crushed by cheaper imports and oversupply. Announcements of production closures are piling up, and the sector has warned half of its capacity could shut within weeks unless governments step in.

Policymakers are scrambling to respond, but are split over how to do so. The industry itself is divided over the solution. Solar manufacturers have urged governments to step in to buy up excess inventories of solar modules to ease the oversupply; if this cannot be done fast, consider trade barriers. But the broader green energy industry is opposed to import curbs. EF

Source: https://www.thehindu.com/

RECORD US RENEWABLE ENERGY INVESTMENT NOT ENOUGH TO MEET CLIMATE GOALS: REPORT

The US must add 60 to 127 GW of capacity in 2024 to stay on track, the report said, adding that installations are likely to fall short of that range. US investment in wind and solar power plants hit record levels last year, but even that dramatic rate of expansion fell short of the level needed to meet the nation's climate change goals, according to an analysis.

A joint report by researchers from Princeton University, Massachusetts Institute of Technology, Rhodium Group, and the non-profit Energy Innovation analyzed US progress in making investments needed to achieve a 40% reduction in greenhouse gas emissions by 2030—an objective outlined in President Joe Biden's 2022 landmark climate change law, the Inflation Reduction Act (IRA).

The findings were mixed. Large clean energy installations for utilities are being stymied by permitting and grid interconnection delays and challenges sourcing equipment, the report said, while sales of electric vehicles are meeting researchers' forecasts. The IRA provides generous tax credits for EVs and clean energy technologies like wind and solar farms. EF

Source: https://www.deccanherald.com/

NEW SANCTIONS THREATEN RUSSIAN OIL SALES TO INDIA

Fresh US sanctions on Moscow threaten to dent Russian oil sales to India, the biggest buyer of Russian seaborne crude, and complicate efforts by Indian state refiners to secure annual supply deals, three industry sources familiar with the matter said.

Washington imposed sanctions to mark the second anniversary of Moscow's invasion of Ukraine and retaliate for the death of opposition leader Alexei Navalny. The sanctions target Russia's leading tanker group, Sovcomflot, which Washington accused of being involved in violating the G7's price cap on Russian oil, as well as 14 crude oil tankers tied to Sovcomflot.

Sources said Indian refiners are concerned the latest sanctions will create "challenges" in getting vessels for Russian oil and could drive up freight rates. That may narrow the discount for the oil, which is bought from traders and Russian companies on a delivered basis. In addition, Moscow may have to push even more volumes through traders to shield from further sanctions risk, adding to uncertainties, the industry sources said, declining to be named because of the sensitivity of the matter.

India rarely bought Russian oil before 2022 due to high freight costs, but refiners in the world's third-largest oil importing nation are now big buyers, benefitting from lower prices, after Europe banned Russian oil imports. EF

Source: https://www.reuters.com/

REPORT SAYS USD 2 TRILLION PER YEAR NEEDED TO TRIPLE GLOBAL RENEWABLES BY 2030

An investment of USD 12 trillion till 2030 is needed to deliver the goal of tripling renewables, as agreed at the UN climate conference in Dubai in December 2023, according to a report released by global think-tank Climate Analytics.

The report said Asia is the only region broadly on course to meet the goal of tripling global renewable energy capacity—driven mostly by policies in China and India. The region makes the biggest overall contribution, providing around half (47%) of the 8.1 terawatt of renewable capacity additions needed globally by 2030. However, the significant coal and gas pipelines in these countries risk stranded assets or slowing the transition. As renewables are set to grow strongly in the region, new fossil fuel plants are not needed and should be avoided, it said.

Neil Grant, climate analytics expert and the report's lead author, said, "USD 2 trillion a year sounds like a cost but it's really a choice. We are set to invest over USD 6 trillion in fossil fuels over this decade - more than enough to close the tripling investment gap. Faced with this choice, I would go with the safest, best-value option—renewables." EF

Source: https://indianexpress.com/

PFC TIES WITH ITALIAN EXPORT CREDIT AGENCY SACE TO BOOST INDIA–ITALY COOPERATION

पी एफ सी PFC

पावर फाइनेंस कॉर्पोरेशन लिमिटेड.

(भारत सरकार का उपक्रम)

एक आईएसओ **9001:2015** और आईएसओ **45001:2018** प्रमाणित कंपनी

State-owned Power Finance Corporation (PFC) said it has become the first government firm to collaborate with SACE, an Italian export credit agency, to boost the cooperation between the two countries.

PFC is partnering with SACE, the export credit agency of Italy, for an innovative ECA-backed financing facility under its 'Push Strategy' initiative, according to a statement. This proposed partnership will position PFC as the first government-owned entity in India to partner with SACE under this initiative. Through this structure, PFC will benefit from an 80% guarantee from SACE, with HSBC acting as a coordinating bank, lead arranger and facility agent for the financing of up to 200 million euros.

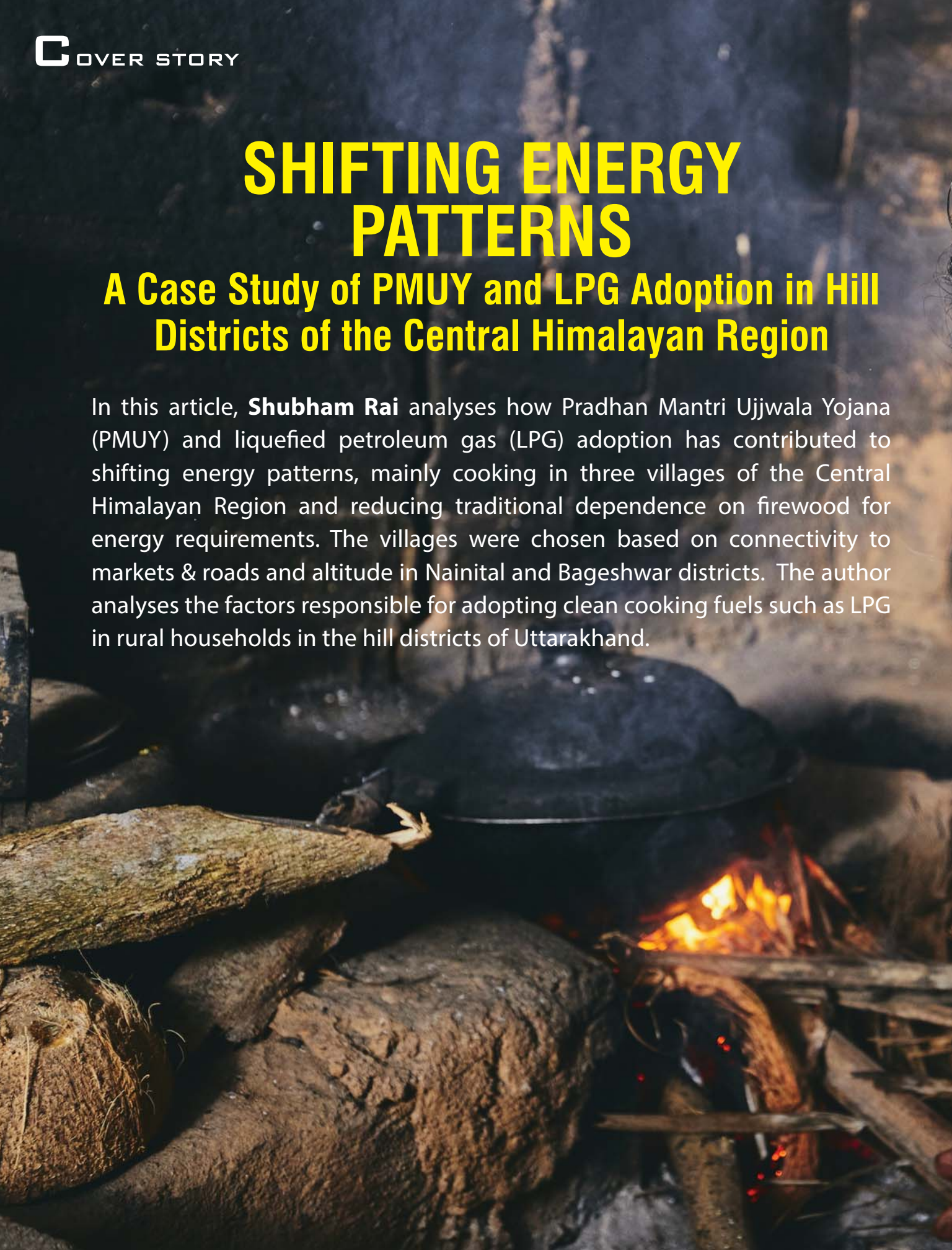
Further, the envisaged financing under the 'Push Strategy' will provide project owners across India an opportunity to access Italian technology and collaborate with Italian companies through business-matching activities. "PFC has always been at the forefront of exploring innovative foreign currency borrowing avenues," Parminder Chopra, Chairman and Managing Director of PFC, said in the statement. EF

Source: https://economictimes.indiatimes.com/

SHIFTING ENERGY PATTERNS

A Case Study of PMUY and LPG Adoption in Hill Districts of the Central Himalayan Region

In this article, **Shubham Rai** analyses how Pradhan Mantri Ujjwala Yojana (PMUY) and liquefied petroleum gas (LPG) adoption has contributed to shifting energy patterns, mainly cooking in three villages of the Central Himalayan Region and reducing traditional dependence on firewood for energy requirements. The villages were chosen based on connectivity to markets & roads and altitude in Nainital and Bageshwar districts. The author analyses the factors responsible for adopting clean cooking fuels such as LPG in rural households in the hill districts of Uttarakhand.



The usage of forests for biomass and meeting energy requirements has remained prominent in the Central Himalayan region. It has been argued that over the past decades, the complete reliance upon forests for energy requirements has resulted in forest degradation. Although firewood consumption is cost-free, the firewood collection process has various risks and challenges, particularly for women. For instance, households' reliance on fuelwood has burdened women and exposed them to several health hazards, as women generally collect firewood and fodder from the forest.[1] Pradhan Mantri Ujjwala Yojana (PMUY), accredited as a major clean energy policy of the Government of India, claims to accelerate LPG usage in poor and deprived households by shifting the cooking patterns of households, particularly women, and reducing traditional dependence on forests.

In India, several initiatives have been taken to reduce reliance on firewood, cow dung, and coal for cooking purposes. A national programme on improved chulha was implemented in the 1980s, and 35 million improved cookstoves were distributed.[2] The policy's major objective was to improve women's health conditions, address concerns about greenhouse gas emissions and climate change and solve the issue of a fuel shortage caused due to mass deforestation in the 1970s. Non-governmental organizations (NGOs) actively participated in the distribution of cookstoves to rural households. However, the policy failed because it was not designed to meet user requirements. In many cases, the cookstoves were difficult to light, undercooked food, took a long time to cook, were easily damaged, and could only hold small amounts of wood.

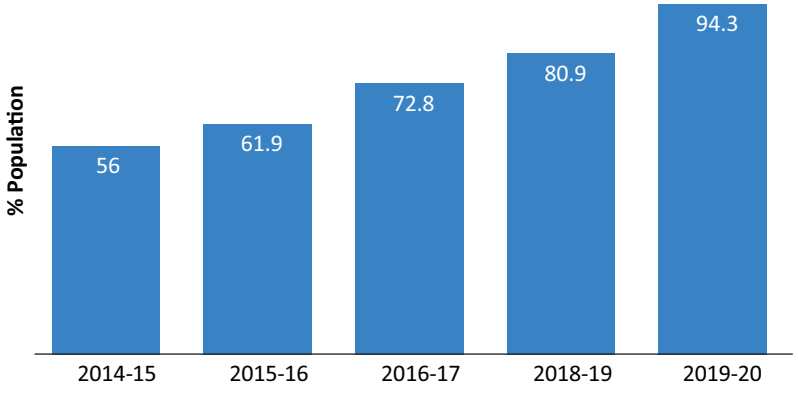


Figure 1: LPG coverage in India

Source: OGD Platform, Government of India

LPG has been considered an essential and reliable clean cooking fuel in rural India.[3] The Government of India (GoI) has taken several initiatives to increase LPG usage in India. According to the 2011 Census, only 28.5% of households used LPG as their primary cooking fuel. However, as per the study by the Council on Energy, Environment and Water (CEEW), 71% of households were using LPG as the primary cooking source by 2020.[4] The increase in LPG usage and shifting energy mix can be attributed to several policies of the GoI. The increasing LPG coverage in India is illustrated in Figure 1.

One major initiative the GoI took was implementing the Rajiv Gandhi Gramin LPG Vitran (RGGLV) scheme in 2009 to enhance LPG coverage in India's remote and rural areas by establishing small LPG distributing agencies.[5] Initially, the scheme was launched in 8 states occupying around 1200 locations with

the lowest number of LPG connections in India.[6] The scheme was part of 'Vision-2015', which aimed to increase LPG coverage to 75% population of India.[7] Four thousand new LPG distributors were set up after the scheme's launch.[8] Indian Oil Corporation set up the most number of distributors. Also, the cost of security deposits was compensated by the oil marketing company for people belonging to the BPL category.

The new policy, Direct Benefit Transfer of LPG subsidy (DBTL), was

1 S.S. Swain, P. Mishra. Determinants of adoption of cleaner cooking energy: Experience of the Pradhan Mantri Ujjwala Yojana in rural Odisha, India Journal of Cleaner Production 248 (2020) 119223

2 Meena Khandelwal, Matthew E. Hill, Paul Greenough, Jerry Anthony, Misha Quill, Marc Linderman, H.S. Udaykumar, Why Have Improved Cookstove Initiatives in India Failed?, World Development, Volume 92,2017

3 C.F. Gould, J. Urpelainen LPG as a clean cooking fuel: Adoption, use, and impact in rural India. Energy Policy 122 (2018) 395–408

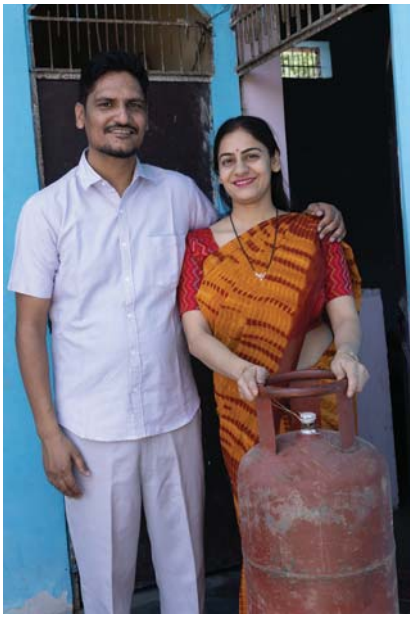
4 (2021) State of Clean Cooking Energy Access in India : Insights from the India Residential Energy Survey (IRES) 2020. rep. CEEW.

5 Press Release. 'Shri Deora launches Rajiv Gandhi Gramin LPG Vitrak Scheme' (16 October, 2009). Ministry of Petroleum and Natural Gas.

6 ibid

7 ibid

8 Saikia, S. (2015) 'Narendra Modi govt halts Rajiv Gandhi Gramin LPG Vitaran scheme', Financial Express.



launched in 2013 and initiated the subsidy for LPG gas cylinders of 14.2 and 5 kg.[9] The facility of directly transferring subsidies into beneficiaries' bank accounts linked with Aadhaar was introduced. However, there were difficulties in linking the bank account with Aadhaar, and the selection criteria of beneficiaries were unclear. Hence, by 2015, the policy was modified and renamed 'Pratyaksh Hastantrit Labh' (PAHAL).[10] The new policy stated that the number of subsidized cylinders remains fixed, and necessary changes were made to address the issue of linking Aadhaar with bank accounts. Hence, customers without Aadhaar could also avail of the facility. The oil marketing companies were transferring the subsidy into beneficiaries' accounts and claiming the amount from the government via petroleum analysis and planning cells. The scheme also received a Guinness World record globally for the highest cash transfer benefit.[11] Moreover, PAHAL provided the platform to launch PMUY and played a crucial role in its formulation.

[9] (2014) Review of Direct Benefit Transfer for LPG Scheme. rep. Ministry of Petroleum and Natural Gas.

[10] (2015) Pratyaksh Hastantrit Labh (PAHAL). rep. Ministry of Petroleum and Natural Gas.

[11] Ibid

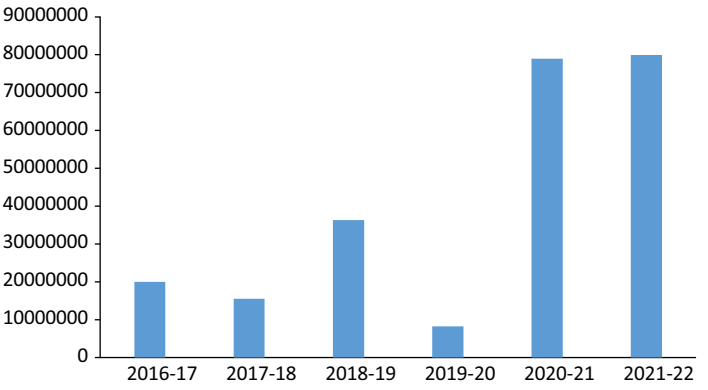


Figure 2: Number of refills sold to PMUY beneficiaries

Source: OGD Platform, Government of India

PMUY was launched in 2016 with the ostensible purpose of safeguarding the health conditions of deprived rural households, particularly women, by providing clean cooking fuel. The scheme is touted to be a stepping stone in India's journey to clean energy transitions. The policy emphasizes the shift from traditional cooking fuels such as firewood and cow dung to improve health conditions and conserve the environment. The scheme's first phase was launched to provide 5 crore gas cylinders in 3 years with the financial assistance of INR 1600 for 14.2 kg cylinders and INR 1150 for 5 kg cylinders to each customer during the installation.[12] A budgetary allocation of INR 8000 was made for the scheme.[13] The scheme also provided loan facilities for setting up stoves and the first refill. According to the PMUY portal, 78% of households availed of loan facilities in the first phase.[14] The beneficiaries were women above 18 years in the BPL category, Antodaya Anna Yojana, and those from deprived communities. Also, they must not have any installed LPG connection in their home. A bank account was a must for availing of the facility. They could avail of cylinders in their households by filling out the Know Your Customer (KYC) form and submitting documents such as Aadhaar card, ration card, and bank details. The scheme was part of the 'Give it Up campaign' by the Prime Minister in 2015 to expand LPG coverage in India.[15] The targets of the first phase were revised to provide 8 crore LPG cylinders by 2021 with an additional budgetary allocation of INR 4850 crore.[16] Oil market companies were tasked with distributing LPG cylinders and appointing a district nodal officer to monitor the scheme's progress and implementation.

In 2021, the scheme's targets were revised to provide 9 crore cylinders and were renamed as 'PMUY 2.0'. By the end of 2022, the scheme completed its target of giving 9 crore cylinders to women belonging to deprived and poor communities in rural India (Figure 2). As a result of the supposed efficient response for PMUY, 60 lakh more connections were added under PMUY 2.0. According to the GoI, LPG coverage has increased from about 62% in 2016 to almost every household at present.[17] PMUY claims to generate employment opportunities for 1 lakh people since its inception in 2016. Uttar Pradesh, West Bengal, Bihar, Madhya Pradesh, and Rajasthan were India's largest PMUY beneficiary states. About 35.1%

[12] (2022) Pradhan Mantri Ujjawala Yojana. rep. Press Information Bureau, Ministry of Petroleum and Natural Gas.

[13] Ibid

[14] Ibid

[15] Ibid

[16] Ibid

[17] (2022) Pradhan Mantri Ujjawala Yojana. rep. Ministry of Petroleum and Natural Gas.

of women availing connections under PMUY belonged to SC&ST categories.[18] The International Energy Agency (IEA) and World Health Organization (WHO) have acknowledged PMUY as a significant achievement in improving women's health conditions and conserving the environment. WHO (2018) cited it as a major step in reducing particulate matter and air pollution.[19] LPG panchayats were organized to raise awareness regarding the scheme, acquaint customers with the advantages of using clean cooking fuel compared to traditional fuels such as firewood and cow dung, and the safety precautions taken while using the cylinder. A safety card is issued to each customer, which includes a list of do's and don'ts.

One of the major initiatives PMUY took was increasing accessibility by augmenting the number of LPG distributors. About 6000 LPG distributors were commissioned in the scheme all across the country. During COVID-19, the central government provided free refill options through Pradhan Mantri Garib Kalyan Yojana (PMGKY). More than 14 crore free refills were provided during the global pandemic.[20] In some cases, NGOs and Self-Help Groups were constituted to raise mass awareness of LPG usage in rural households.Overall, PMUY's vision was to increase the affordability, accessibility, and adaptability of LPG connections in rural areas.

Challenges in Implementing PMUY

One of the major challenges PMUY faces is identifying beneficiaries through the Socio-Economic Caste Census (SECC) under the Census of India, 2011. The discrepancy in the census data resulted in various affluent households acquiring PMUY connections and many deserving households being left out of the beneficiary list.[21] The non-availability of documents and bank account numbers is also a major hurdle, as many deserving candidates are left out of the scheme.[22] There are accessibility concerns as well. In a few areas, new LPG distributors could not be commissioned.[23] As a result, many people were deprived of the scheme's benefits. There have been cases where LPG distributors neglected validation checks while distributing the cylinders.[24] For instance, LPG cylinders were issued to men and minors, more than one cylinder was issued to one woman in the same household, delays in the verification and installation of cylinders, and registered accounts were not about beneficiaries. Hence, several cases were highlighted where the PMUY guidelines were not followed by Oil Marketing Companies' distributors while issuing the gas connections. Sometimes, the customers did not avail loan facility to refill the cylinders. Also, due to the high cost, beneficiaries lowered their frequency of refills, putting a financial burden on Oil Marketing Companies.

It is evident that LPG is a desirable fuel, with rural households finding it convenient to use.[25] Nonetheless, the most crucial challenge of the policy is that the higher cost of refilling cylinders is a major barrier to the continued usage of LPG. The refill cost was hiked after 2020 due to logistics disruption due to the Russia–Ukraine war and India's higher reliance on imports from Gulf states.[26] Thus, the GoI scrapped the transfer of subsidy amount in 2020 to beneficiaries for refills, resulting in the same refill price for every consumer. Twenty million of the total beneficiaries have taken only refills.[27] Around 56.5% of households refilled in 4 months or fewer in the 2021–22 financial year.[28] As a result, PMUY could not become highly successful as the policy shifted the energy use of rural communities for just a short time. The long-term transition requires households to continue using LPG. However, the higher refill cost will cause impediments in people's behaviour to continue using LPG when a cost-free alternative is already present. Therefore, the government needs to act on the refill cost to extract positive gains in the long term.

18 Ibid
19 Ibid
20 Ibid

21 (2019) Report of the Comptroller and Auditor General of India on Pradhan Mantri Ujjwala Yojana. rep. Ministry of Petroleum and Natural Gas.
22 Ibid
23 Ibid
24 Ibid

25 C.F. Gould, J. Urpelainen LPG as a clean cooking fuel: Adoption, use, and impact in rural India. Energy Policy 122 (2018) 395–408
26 Aggrawal, R. (2022) 'Why Cooking Gas Is Getting Costlier? | Explained', India.com, 25 March.
27 THE WIRE (2020) 'Over Half of PMUY Beneficiaries Took 4 or Fewer Refills in 2021-22; National Average 6-7', 25 March.
28 Ibid

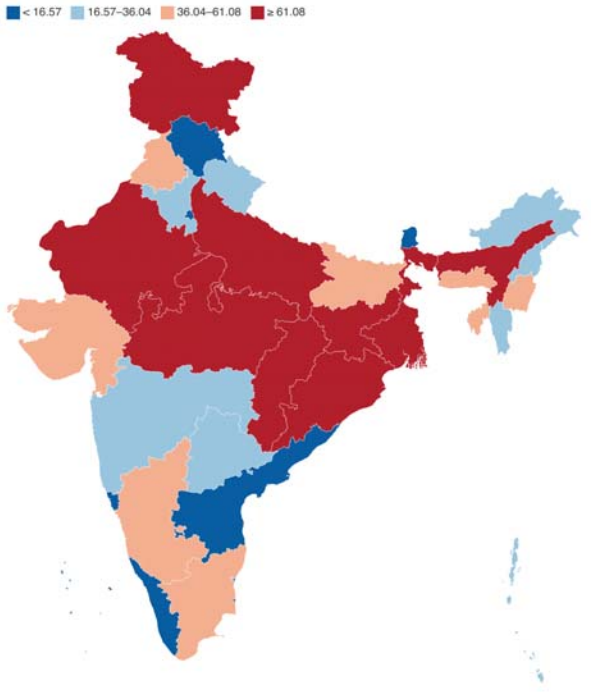


Image 1: State-wise percentage of households availing PMUY connections

Source: Author's own analysis based on SECC, 2011 & PMUY data on OGD Platform, Govt. of India

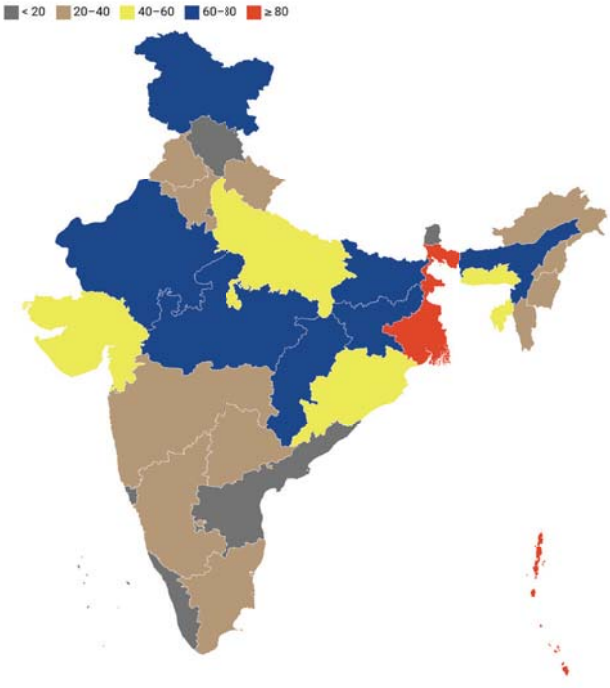


Image 2: State-wise percentage of total ration card holders availing PMUY connections

Source: Author's own analysis using data from National Food Security Portal & OGD Platform, Govt. of India

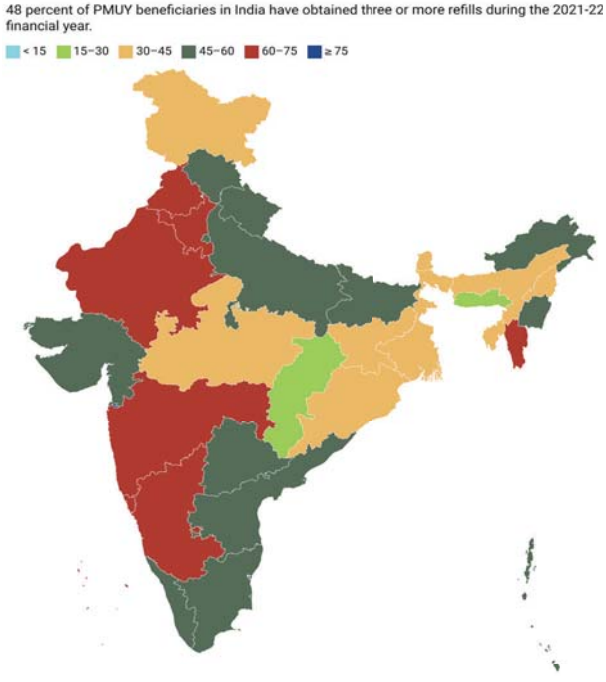


Image 3: State-wise percentage of PMUY beneficiaries obtaining three or more refills in 2021–22

Source: Author's own analysis using data from National Food Security Portal & OGD Platform, Govt. of India

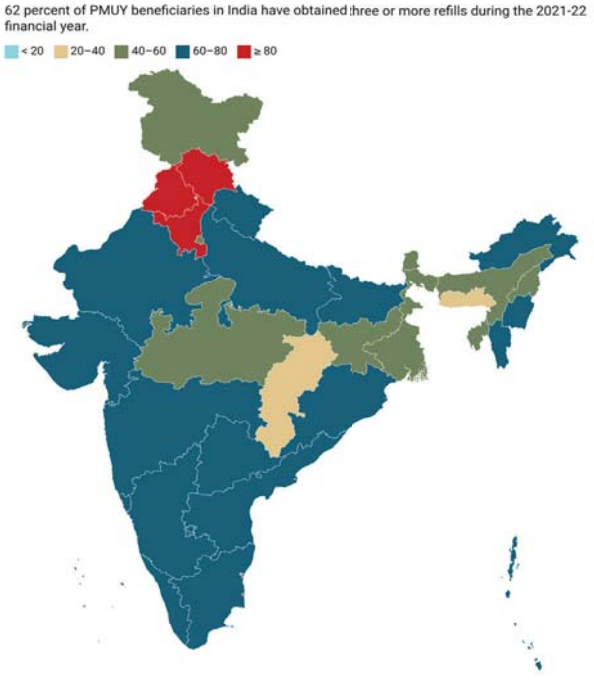


Image 4: State-wise percentage of PMUY beneficiaries obtaining three or more refills in 2020–21

Source: Author's own analysis using data from National Food Security Portal & OGD Platform, Govt. of India

PMUY and Shifting Cooking Patterns by Sample Households

It has been pointed out that the continued reliance of people upon forests for their energy requirements has impacted the sustainability of forests causing large-scale forest degradation in the central Himalayan region.[29] Historically, the incidence of degradation was higher as people relied entirely upon community forests for their biomass needs. However, in the past decade, the clean energy discourse gained widespread popularity, and several initiatives were taken to reduce the community's dependence on forests. PMUY, as specified above, is one of the significant policy apparatuses implemented nationwide to facilitate the shift in the energy mix of rural households. Hence, examining how much the policy has impacted forest dependence in the central Himalayan region is imperative. Thus, this study draws its inferences from household surveys in the central Himalayan region to measure the role of PMUY in shifting energy mix and declining forest dependence of the rural community.

Three villages were selected based on their location from urban centres, household profile, altitude, and roadway connectivity. The energy usage data, mainly cooking patterns, was collected. Two chosen villages, Simayal and Harinagar, are from Nainital District, which is more developed, and one village, Okhalisirod, from Bageshwar District, is considered remote and comparatively less developed than Nainital District. Fifty households were selected using a stratified random sampling method from the villages. Twenty households from Simayal and Okhalisirod and ten from Harinagar were selected. The inferences from the three villages have been given in the form of case studies below.

The case of shifting energy mix in Simayal, Nainital

Simayal, a village located in the Nainital district, comprises 113 households. Raikwals mainly dominate it, occupying around 90% of the total population (Figure 3). There are very few households of Chilwals and Aryas (Scheduled Caste). Simayal is a developed village compared to other villages in the district, with good connectivity to roads and markets. It has attracted attention in the past decade by becoming a prominent tourist spot due to a clear view of the Himalayan view. The primary reason for the development is attributed to intervention by NGOs like the Central Himalayan Rural Action Group (CHIRAG). Twenty households were interviewed from different socio-economic and caste categories to attain a representative sample for the whole village. The households were randomly selected from the two hamlets of the village (Odakhan and Reetha). Three scheduled caste households, 2 BPL households, 2 Antyodaya Anna Yojana and 13 APL households were interviewed from the two hamlets (Figure 4). The rest households were from the upper and unreserved caste categories. Hence, the survey included around 15% of the total village population.

The primary occupation in the village is farming and planting orchards (Figure 5). A few people have also opened local shops and supplied milk to dairies in the village. Also, few people are employed in NGOs like CHIRAG, CEDAR & Gene Campaign. As per asset ownership, most households have televisions, refrigerators, mobile phones, and motorbikes in their homes. The asset ownership of households has increased in the past decade. Grid electricity is available for an average of 22–23 hours daily. There is no problem with the electricity connection during the summer and rainy seasons. However, during winters, the electricity

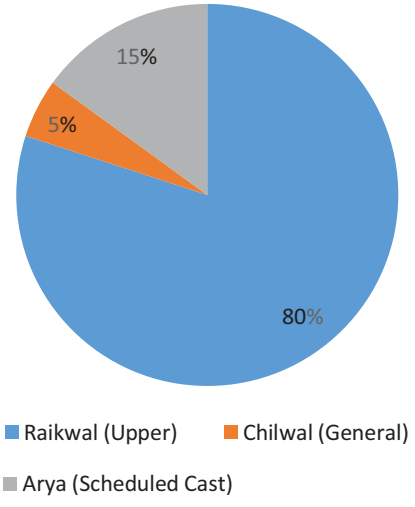


Figure 3: Caste composition in Simayal

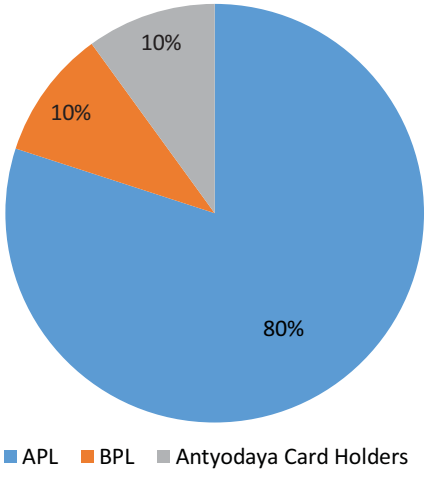


Figure 4: Socio-economic composition in Simayal

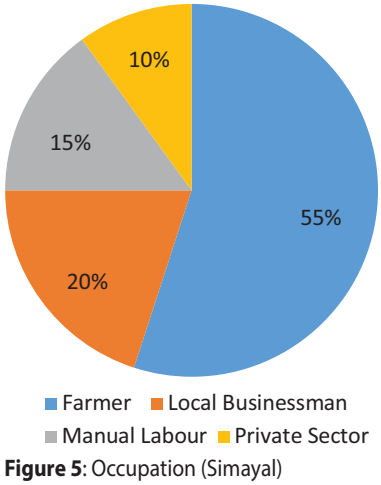


Figure 5: Occupation (Simayal)

[29] Ram Ranjan, What drives forest degradation in the central Himalayas? Understanding the feedback dynamics between participatory forest management institutions and the species composition of forests, Forest Policy and Economics,Volume 95,2018,Pages 85-101,

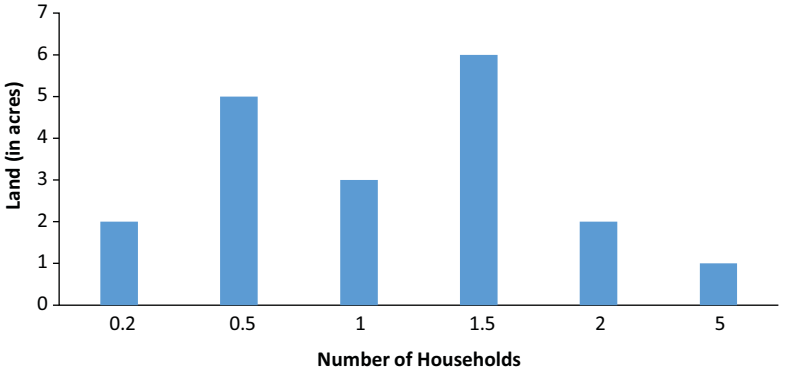


Figure 6: Land holding by households in Simayal

connection is disrupted in case of snowfalls and takes 3–4 days to repair. Many households have availed the benefits of Krishi Vikas Yojana by making self-help groups and getting equipment at an 80% subsidy. Hence, the incidence of mini tractors has increased rapidly in the village in the past 3–4 years. People do not use solar home systems, diesel generators, and tubewells in the village. There are few solar street lights (3–4 in the village). The electricity consumption has increased in the village, as depicted in Figure 7.

In Simayal, firewood consumption has declined over the past decade, as illustrated in Figure 8. According to the survey findings, only 10% of households used LPG as a primary cooking source a decade ago. However, 60% of households use LPG as their primary cooking fuel. Hence, there has been a shift in energy usage patterns in the past decade. The frequency of refill of LPG cylinders has increased in the village. A comparative image of the frequency of refills currently and a decade ago is illustrated in Figure 9. Ten years ago, only 60% of households had LPG connections, and many households among them used to refill their LPG cylinder on a four or six-monthly basis. However, every household has availed LPG connection, and 60% of households fill their cylinders in 1.5 months. Hence, there has been a clear shift in the frequency of refill of households since the past decade. Also, Simayal's per capita refill consumption is 2.05, comparatively much lower than other villages and the national average, as illustrated in Figure 10. The primary reason for this pattern could be the opening of an LPG gas depot nearby. Hence, the supply of gas cylinders became convenient, and awareness among people increased. Moreover, the frequency of trucks carrying cylinders increased after the Nathuakhan gas depot opened. Earlier, there was only

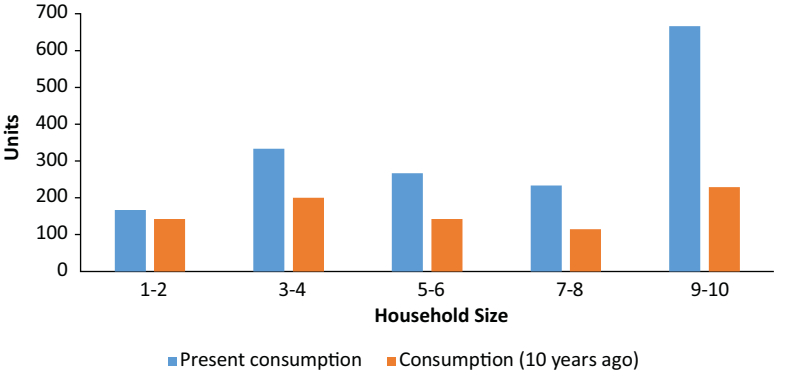


Figure 7: Comparison of electricity consumption in Simayal

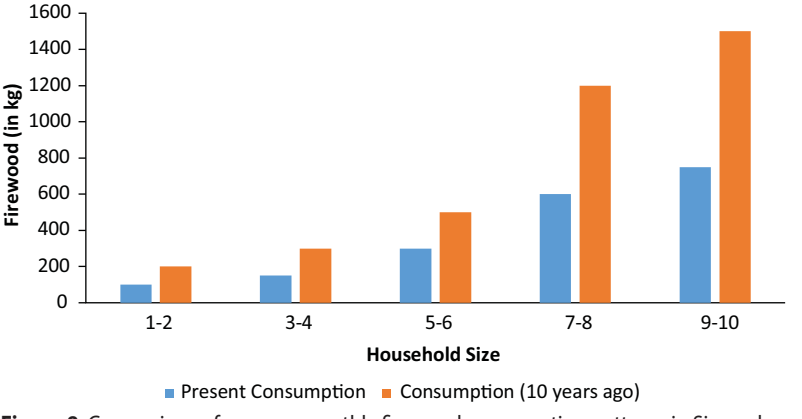


Figure 8: Comparison of average monthly firewood consumption patterns in Simayal

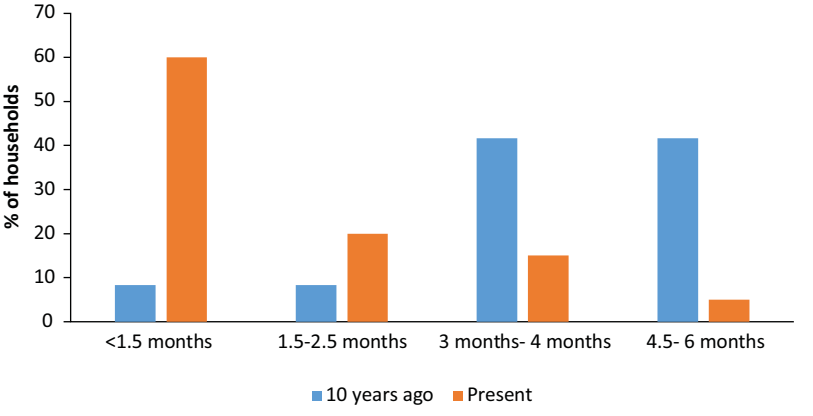


Figure 9: Frequency of refill of LPG cylinder in Simayal

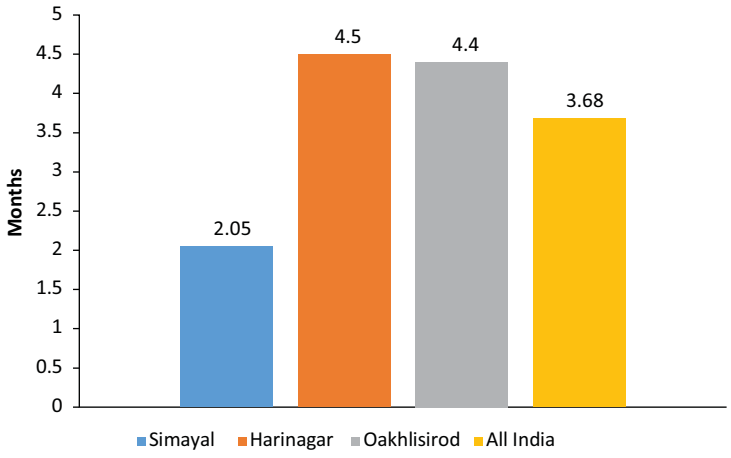


Figure 10: Comparison of per-capita refill consumption of PMUY connections

one gas godown at Bhawali (36 km away from Simayal), and the truck carrying cylinders used to visit once a month. The users pay the delivery charge of INR 20 every month for Nathuakhan.

The increased usage of LPG cylinders can also be due to various socioeconomic factors. For instance, educated females have stopped going to forests for firewood needs. Awareness programmes by NGOs, the forest department, and Van panchayats to reduce deforestation could be attributed to the shift in the energy mix and reducing forest dependence. The results can be seen as a declining frequency of visits to Van Panchayat forests over the past decade. Furthermore, one hamlet (Reetha) is located three kilometres from the Van Panchayat forest. As a result, villagers residing in the hamlet prefer to avoid visiting Van Panchayat forests as it is far. Many households gather and collect wood from their orchards by lopping the fruit trees. Although LPG connections have increased and many households are using it as their primary cooking fuel, and firewood usage has consequently reduced, fuelwood use continues. During winter, firewood consumption is significant. Also, taste preferences and household size are essential factors in the continued reliance on firewood. Currently, 40% of households use firewood as their primary cooking fuel. One of the major reasons is the large household size, and another could be (as reported by many respondents) that the taste of food cooked on firewood is comparatively better than that of an LPG cylinder.

One of the significant findings is that firewood consumption is dependent upon the household size rather than the socio-economic status of the households. Some poor households are using LPG cylinders as their primary cooking source. Also, small size households mainly use LPG as their primary cooking fuel. In many households, women cook food for their children on LPG cylinders to prepare the food in time for school, as cooking on chulha consumes much time.

Only 10% of households are beneficiaries of the PMUY scheme in Simayal. According to the Indane gas godown located at Nathuakhan, PMUY beneficiaries comprise 12.5% of the total LPG connections in their zone. The number is low because few villages like Simayal have availed LPG connections before the coming of the Ujjwala Yojana. However, neighbouring villages like Chatola and Harinagar contain many beneficiaries of the Ujjwala Yojana. According to the gas godown, setting up LPG panchayats to create awareness regarding PMUY has increased LPG coverage in the region. However, the gas agency reported they could not profit more than gas godowns in plains because of people's continued reliance on firewood.

Case Study: CHIRAG's Intervention in Simayal

Central Himalayan Rural Action Group (CHIRAG), formed in 1986, mainly works towards capacity-building programmes that empowered the local community and addressing the incumbent challenges in Simayal and neighbouring villages in the central Himalayan region. The objective of CHIRAG is to reduce forest dependence of the rural community. The majority of people employed at CHIRAG are from nearby villages. CHIRAG has also set up a primary school for educating children of adjacent villages. CHIRAG raised a campaign to reduce deforestation in 2000 by supplying subsidized LPG connections to people. As a result, many households availed of LPG connections due to the intervention of CHIRAG in 2000. Similarly, CHIRAG has worked on different projects like installing cookstoves in 2004–05 and assisting in setting up biogas in the 1990s to reduce the community's dependence on forests. However, after 4–5 years, people stopped using biogas and cookstoves. According to villagers, forest degradation has reduced in the past two decades, and a major credit is attributed to CHIRAG's intervention in empowering the local community. Currently, CHIRAG is working on a spring shed management project to increase the water source for the community, which has been facing water shortage problems constantly and has historically troubled the rural community.

The Case of Firewood Dependence in Okhalisirod, Bageshwar

Okhalisirod, a village located at an altitude of 1200 metres in the Bageshwar District, comprises 157 households. The village is situated near the Binsar Wildlife Sanctuary. The primary occupation in the village is manual labour. Okhalisirod is remote compared to Simayal, as it is far from the market and has minimal NGO intervention. Consequently, there are lower employment opportunities. The village includes around 70% scheduled caste population (Figure 11). Most households have BPL cards. The average land holding in the village is 0.2 acres (Figures 12 and 13). Many households lack assets such as televisions (TVs) and bikes. A total of 20 households were interviewed, representing around 12% of the village population. Due to the large scheduled caste population in the village, 12 SC and eight upper caste households were randomly chosen, and one-on-one interviews were conducted with them. Furthermore, a focused group discussion with an SHG was undertaken to get acquainted with the process of functioning of the SHG. The SHG's primary role is to provide financial loans to people during the marriage or any other occasion, repaid at a 1% interest rate. The households deposit INR 180 every month in the SHG account, which is managed by the president, whom the people elect.

The village lacks employment opportunities, which creates a problem for most residents as their primary source of income is manual labour. Few households are also employed in Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) but are dissatisfied because they receive low wages at the end of the month. The manual labourers receive INR 500–600

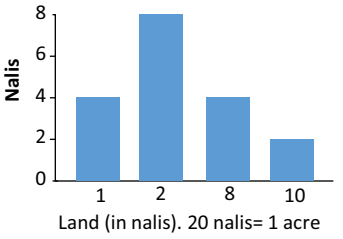


Figure 12: Land holding by households in Okhalisirod

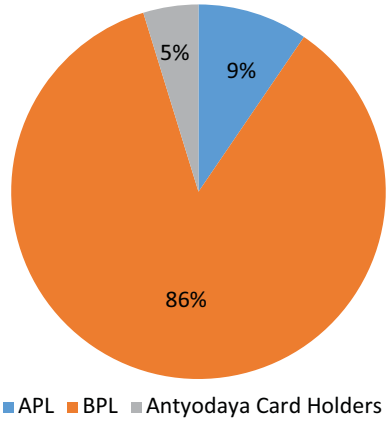


Figure 13: Socio-economic composition in Okhalisirod

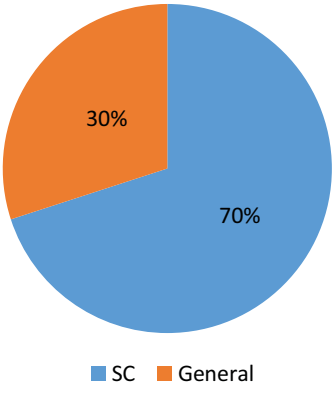
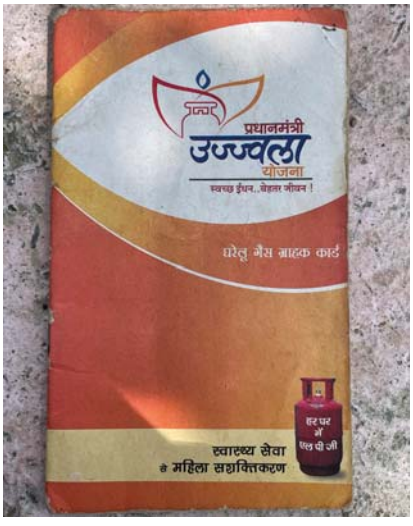


Figure 11: Caste composition in Okhalisirod



for working one day, and MNREGA employees receive just INR 200–250 per day. Also, manual labourers receive money at the end of the day, while MNREGA employees must wait until the end of the month to receive the income in their bank accounts. Farming is dangerous in the village because of the persistent attacks by wild animals like wild pigs and monkeys as they destroy the crops at night. Hence, most of the agricultural land is left vacant.

Most of the households availed of electricity connection in 2013. Some people received grid connections in 2000, 2015, and 2018. Currently, electricity is supplied in the village for around 20 hours. Ten years ago, the electricity duration was about 12 hours, and 27% of households did not have grid connections then. Sixty per cent of the households do not own TVs, and

none own refrigerators or washing machines.

People rely heavily upon firewood as their primary cooking source. Although the magnitude of firewood consumption has declined over the past decade, every household uses firewood as its primary cooking source. People mainly go to Binsar Wildlife Sanctuary to collect firewood and meet their energy requirements. Van Panchayat of the village does not have enough trees to meet the energy requirements of the people. It has been found that the consumption of firewood is higher as per the household size. However, there has been increasing usage and coverage of LPG cylinders over the past decade. A decade ago, only 10% of households had LPG connections, and their refill frequency was 6–8 months. However, during the time of this study, every household has availed of LPG connections at present. Most households are getting refilled in 3–4 months, as illustrated in Figure 15. The advancement could be attributed to the Ujjwala scheme, which increased the number of connections in December 2021.

Eighty-five per cent of households are beneficiaries of PMUY. Most households availed Ujjwala connections

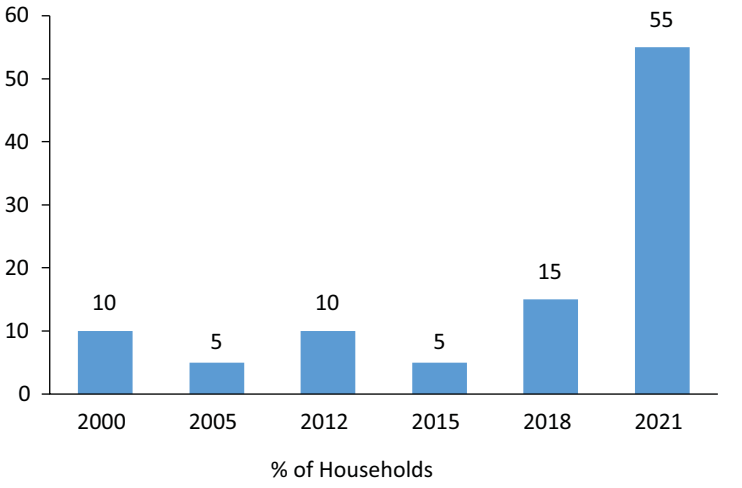


Figure 14: Year-wise installation of LPG connections (Okhalisirod)

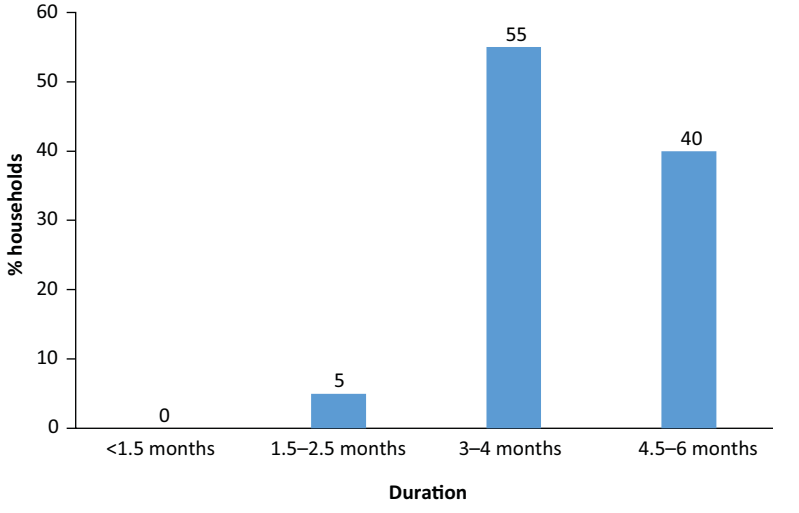


Figure 15: Frequency of refill of cylinder of households in Okhalisirod

Case Study: Harinagar, Nainital

Harinagar, a village located in Nainital district comprises around 100 households with entire scheduled caste population. The village is situated near Nathuakhan market and has higher number of PMUY beneficiaries. The primary occupation in the village is manual labour. The average land holding in the village is 1 acre. Ten households were randomly selected for the study. Most of the households have refrigerators, TVs, motorbikes, and smartphones in their homes. The average electricity duration in the village is around 20 hours. Seventy per cent of households have BPL cards. A decade ago, only 20 per cent households had LPG connections. However, after the opening of Nathuakhan gas depot there has been increasing of LPG connections. At present, every household has connection. Eighty per cent households have availed PMUY connections after 2019 from the new gas godown at Nathuakhan market. The frequency of refill of cylinders is between four to six months. However, only 20% of households are currently using LPG as their primary cooking fuel. Firewood remains an integral part of energy mix in Harinagar as most of the households avoid spending money in refilling the cylinders when a cost-free alternative is already present.

in December 2021 at a camp organized at Kathpuria (6 km away from the village) by Bharat gas depot, Bageshwar. Opening a new gas godown in 2021 at Takula (12 km from the village) has also played an important role in increasing access to LPG connections, as illustrated in Figure 14. Some people availed Ujjwala connection in 2017 from the LPG panchayat camp organized at Takula. Even though Ujjwala connections are freely installed, they had to pay transport charges of INR 300 for carrying the cylinder to their homes. The frequency of trucks carrying LPG cylinders increased after the gas godown opened at Takula. However, people pay transport charges of INR 70 to truck drivers every month for having the cylinders to the village. However, some households are far from the roads, making it difficult to take the cylinder to their homes in hilly terrain. They usually carry the cylinders on their heads. Furthermore, the increasing refill cost is a barrier to the complete transition to LPG, especially for people belonging to the SC population. Also, low employment opportunities in the village create a major obstacle to refilling the cylinders. Furthermore, one of the major observations is that households in the upper caste population have more cylinders than the lower caste households. Many families of the upper

caste population have two cylinders in their homes compared to just one in the lower caste households.

Conclusion

It has been found that PMUY has increased the LPG coverage in remote hilly districts like Bageshwar. For more developed villages like Simayal, LPG adoption started in the 2000s due to the intervention of a local NGO, CHIRAG. Hence, there is not much variation in LPG coverage after implementing PMUY in Simayal because most people already had connections before the scheme's launch. Due to the expanding LPG coverage, firewood consumption has declined over the past decade. However, it remains a prominent part of the energy mix in hilly terrains. The frequency of refilling the LPG cylinders has also increased over the past decade. The increasing LPG usage is mainly due to the opening of new gas godowns in the past two years and the transition to a cash economy. The change is evident in Simayal, as 60% of households use LPG as their primary cooking fuel. Nonetheless, the cost of refilling cylinders is a major barrier to changing household behaviour in adopting LPG as a primary cooking fuel. It is much more evident in Okhalisirod and Harinagar than in Simayal because of a higher proportion of the scheduled caste population with low income and fewer employment opportunities. Thus, adopting LPG as a primary cooking fuel in hilly terrains depends on the location, socio-economic status, and connectivity of the villages, apart from governmental interventions. As a result, PMUY could not become highly successful as the policy is gaining results on a short-term basis. The long-term transition requires households to continue using LPG. However, the higher refill cost hinders the sustained use of LPG connections. Therefore, the government needs to act on the refill cost to extract positive gains in the long term.

Furthermore, the firewood collection process is primarily influenced by the strength of the workforce in the households, especially the number of females and their educational status.[30] The educational status of women is an essential factor in the adoption of LPG, as educated females are unwilling to visit community forest to gather firewood and fodder. In addition, firewood collection has various risks and challenges, particularly for women. For instance, households' reliance on

30 S.S. Swain, P. Mishra . Determinants of adoption of cleaner cooking energy: Experience of the Pradhan Mantri Ujjwala Yojana in rural Odisha, India Journal of Cleaner Production 248 (2020) 119223

fuelwood has burdened women and exposed them to several health hazards, as women generally collect firewood and fodder from the forest. In Simayal, the shift to LPG reduces women's time collecting firewood and fodder. As a result, they watch TV in the afternoon, engage in other occupations like farming, or are employed as Anganwadi Workers. Hence, there have been changes in women's lifestyles due to LPG adoption over the past decade. However, due to low household earnings and low economic opportunities, the difference in visits to forests for biomass is minimal in the other two villages. It is much evident in the scheduled caste population in all three villages.

Household size is essential in shifting energy patterns as the larger household size makes people continue using firewood as their primary cooking source. Also, in the case of Simayal, it is observed that many poor households with lower income sources and small household sizes are using LPG as their primary cooking fuel. However, it is not the case in Harinagar and Okhalisirod. Furthermore, the forest dependence of the community has a direct relationship with LPG usage. The expanding LPG coverage in hilly terrains is reducing forest dependence of the rural community as their frequency of visits to Van Panchayat forests for firewood and fodder has decreased significantly over the past decade. The change is observed in all the villages but is much higher in Simayal than in other villages. However, households stack LPG with firewood and use multiple sources of energy rather than sustained use of one particular energy source. It has been found that many households are using LPG for small tasks like preparing tea and preparing lunchboxes for their children. This is highly evident in large size households in Simayal. Hence, the government needs to promote and provide subsidies in more than one refill so that people's usage of LPG increases. The affordability, socio-economic composition, and accessibility are imperative in LPG adoption in the central Himalayan region. EF

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HYDROPOWER ENERGY ALONG WITH CASE STUDIES

Practical aspects of harnessing renewable energy

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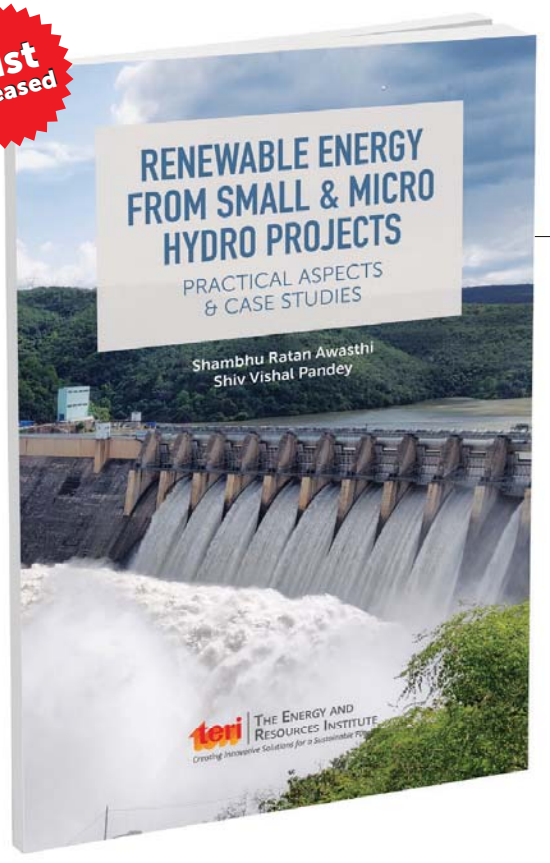

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BINDER-LESS BRIQUETTES
An Answer to Paddy Straw Disposal

The Department of Renewable Energy Engineering, Punjab Agricultural University (PAU), has developed a process of preparing binder-less briquettes from chopped paddy straw. Although waste management is the obvious outcome of this process, it also promotes environmentally friendly employment opportunities in rural India. Members from Team PAU—**Ritu Dogra**, **Manpreet Singh**, **Rajan Aggarwal**, and **Sahilpreet Singh**—showcase the efficiency of their process in this article.

Paddy is cultivated in 3.1 m ha area in Punjab, which is about 75% of the total cultivable land and more than 60% of the geographical area. This results in the generation of about 20 million tonnes of paddy straw, the utilization or disposal of which is a major challenge for the stakeholders. Except for Basmati rice which is generally harvested manually and the straw thereof is used as cattle feed—other varieties of paddy are harvested mechanically, leaving considerable stubble in the field. Thirty to forty per cent of this stubble is utilized for incorporation in the field itself; the remaining is burnt by farmers to prepare their farms for sowing of next Rabi crop. Burning of paddy straw leads to heat generation that penetrates the soil, leading to loss of moisture and useful microbes; thus, adversely affecting soil properties. High cost of collection and lack of economically viable options to utilize this valuable bio-resource are identified as major factors, compelling the farmers to burn it. So, there is urgent need of ex-situ management, along with more vigorous in-situ management.

The Department of Renewable Energy Engineering, Punjab Agricultural University (PAU), has developed a process to manage this problem: preparing binder-less briquettes from chopped paddy straw. Briquetting is a process of densification of biomass to form energy-dense fuel briquettes. Briquetting of paddy straw can be done for preparation of fuel briquettes, which can be used for various thermal applications such as cooking, heating, steam generation, etc. It occupies space up to 1/30th of loose paddy straw and 1/6th of baled paddy straw, helping in efficient handling, storage, and transportation of biomass. PAU's modified process has been standardized and recommended by University Research Evaluation Committee for manufacturing the briquettes from chopped paddy straw.

At present, a small proportion of paddy straw is used in power plants. Briquetting of paddy straw will reduce both the required storage space and transportation cost. If the existing briquetting system is modified and refined for low-cost production of chopped paddy straw briquettes, then a large proportion of paddy straw would be utilized for various industrial applications in which low temperature furnaces are used. This will prove to be economically beneficial to farmers and will simultaneously reduce environmental pollution and retain soil health.

The briquetting system is a combination of the briquetting

Figure 1: Biomass shredder

machine and the biomass shredder. Briquetting machines are commercially available which use various dried and ground crop residues for briquette manufacturing.

The PAU modified technology involves drying straw under open sun. Then, a biomass shredder (Figure 1) is used for size reduction (up to 10–12 mm) of dried paddy straw. After shredding, the chopped material is conveyed to the feeding hopper of a briquetting machine using an inclined screw conveyor. A briquetting machine (Figure 2) consists of a feeding hopper, cylinder, piston, and die which is attached to the cooling line for prepared briquettes.

The material is fed to the briquetting machine from this feed hopper at a uniform feed rate.

Figure 2: Briquetting machine

Figure 3: Binder-less briquettes of chopped paddy straw

Next, the briquettes coming out of the die are conveyed to a distance within the cooling line. Binder-less briquettes—exclusively from chopped paddy straw (Figure 3)—are obtained that can further be stored loose or in bags, as per requirement.

An energy efficient briquetting system has been successfully implemented which is very useful for effective utilization of paddy straw in rural areas. This is because abundant raw material is available in these areas and its disposal is challenge for them. An added benefit is that this system will create employment opportunities for rural youth.

Energy Consumption Comparison

A briquetting plant (biomass shredder and briquetting machine) was used for the formation of chopped paddy straw briquettes—including chopping, grinding, and briquetting. The energy comparison of PAU's process with the conventional process of briquettes formation was done. Table 1 shows the specific energy consumption values for different unit operations individually, as well as for chopping and briquetting together.

Table 1: Comparison of specific energy consumption in different unit operations of briquetting

A. Formation of briquettes by chopping, grinding, and briquetting					
Process	Mechanical Energy		Manual Energy		
	Specific energy consumption*		No.	Equivalent energy[$]	Specific energy consumption
	(kWh/t)	(MJ/t)		(MJ/h)	(MJ/t)
Chopping	22.2	79.9	2	0.54	1.08
Grinding[#]	32.5	117.0	2	0.54	1.08
Briquetting	62.0	223.2	2 + 1 = 3	0.81	1.62
Total	116.7	420.1		5.67	3.78
Total Specific Energy Consumption (MJ/t)	423.9				
B. Formation of chopped paddy straw briquettes by chopping and briquetting					
Chopping + Briquetting	78.0	280.8	2+1=3	0.81	1.62
Total	78.0	280.8		0.81	1.62
Total Specific Energy Consumption (MJ/t)	282.42				
* Assuming production capacity of 500 kg/h					
[#] Information on grinding of paddy straw from review					
[$] Equivalent energy for a man taken as 0.27 MJ/h					

It was observed that for production of one tonne of briquettes 423.9 MJ of energy was utilized, if all three operations were adopted. In comparison to this, if we go for chopping and briquetting without grinding the material then 282.42 MJ of energy is utilized. This technology saves 141.48 MJ of energy in the production of one tonne of briquettes. So, the process developed by PAU is 33% more energy efficient than the conventional method of producing briquettes—which includes chopping, grinding, and briquetting of paddy straw (Table 1). The PAU technology requires lesser power and is, therefore, cost effective as compared to the conventional technology. So, one can earn better margins and more profit.

Cost economics of the briquetting process

If the cost of storage shed is considered, the total input cost for manufacturing briquettes is INR 3.22 (without bags) and INR 3.47 (with bags). Total input cost for manufacturing briquettes, if the cost of storage shed is not considered, is INR 3.16 (without bags) and INR 3.41 (with bags). In operational costs, the cost of raw material is a significant component followed by electricity cost, labour cost, packaging cost, and repair and maintenance cost.

Total cost of the project is INR 25 lakh—excluding the cost of land. One machine can produce 500 kg of briquettes per hour and the entire system requires three people for all operations, along with 500 m^2 space. One briquetting machine can cover 1 hectare of paddy straw in 10 days.

Conclusion

There is immense scope for employment of rural youth, along with environmentally friendly wealth creation and waste management. Briquettes prepared by this technique were as good as wood, but considerably cheaper than it. These briquettes can be used in low temperature boilers/ furnaces for co-firing with wood, or by themselves, as the heating value is same as that of wood. Availability of wood is a question mark in the near future. Biomass briquettes are a one-stop solution that can create wealth from waste, generate employment, and contribute to combatting health and environmental hazards related to agri-residue disposal. EF

Dr Ritu Dogra, Professor, Dr Manpreet Singh, Scientist, Dr Rajan Aggarwal, Head, Er Sahilpreet Singh, Young Professional, Department of Renewable Energy Engineering, PAU, Ludhiana, Punjab, India.

POTENTIAL OF LIQUID WASTE FOR CLEAN ENERGY PRODUCTION

Organic liquid waste, usually relegated to the category of a 'problem', actually carries the potential to contribute to India's renewables. In this article, **Dr Rupal Jain** provides a case for producing hydrogen, among other clean energy products using wastewater—effectively killing two birds with one stone.

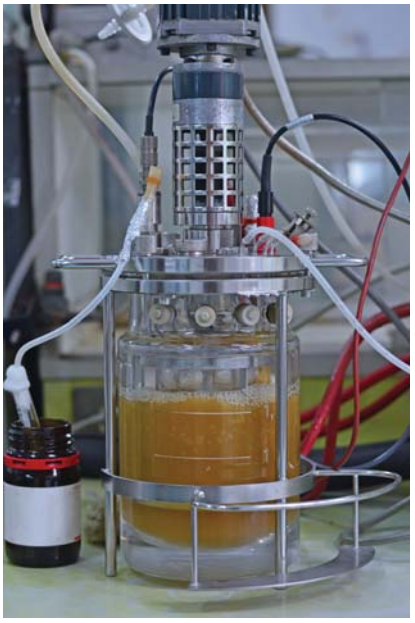
A huge amount of organic liquid waste is generated every year in India, which is exposed to the environment without any pretreatment. These effluents, which play a crucial role in contaminating the environment, are generally domestic waste (rice, vegetables cooking/cleaning water, etc.), dairy waste (spoiled milk, cheese whey, vessel cleaning water, etc.), agro industrial waste (fruits or pulp waste, oil refinery waste, sugarcane molasses, etc.), and beverages or distillery waste. These effluents contain large amounts of organic solid particles, dissolved carbohydrates, protein, starch, and fat, among other such elements. Only a few large industries are required to have their own wastewater treatment plant, according to government rules and regulations, while most other small or moderate industries release/discharge these effluents into open environments or nearby water bodies like rivers. This causes contamination of drinking water, deterioration of soil quality, loss of aquatic life, and foul smell due to their fermentation in open air. It also leads to the production of various pathogens or insects in open air, which can create numerous health diseases like diarrhoea, jaundice, dengue, and chikungunya due to consuming contaminated water/food or an increase in mosquitoes. However, these organic effluents have huge potential for clean energy production through the fermentation mechanism, which also allows their efficient treatment.

Possible Waste Effluents Utilization

As shown in Figure 1, organic waste effluents can be harnessed for clean energy production either through anaerobic digestion or ethanol fermentation. However, the production of ethanol through fermentation can only be done by using sugar-rich substances like sugarcane molasses, sugar beet pulp, cassava, or maize starch. These products generally do not come under waste materials and have their own value in the market. Therefore, the anaerobic digestion of effluents is the only solution to convert them into valuable products, along with ensuring their efficient treatment for disposal into the surroundings.

Anaerobic Digestion

It is a biochemical process, carried out in an enclosed vessel in the absence of air. In anaerobic digestion, organic materials are broken down into simple molecules by the interaction with micro-organisms. These simple/smaller molecules are consumed by various microbes, releasing a gaseous mixture which is known as 'Biogas'. Biogas



generally contains 50–70% methane (CH_4), 30–40% carbon dioxide (CO_2), 5–10% hydrogen (H_2), 1–2% nitrogen (N_2), and 0.3% water vapour (H_2O). It has calorific value in the range of 4500–4800 kcal/m^3 and can be used for the cooking, lighting, heating, and steam generation among other uses.

How it works

Anaerobic digestion mainly involves three stages, namely: hydrolysis, acidogenesis, and methanogenesis. In the first stage (i.e., hydrolysis) complex organic molecules like fat, proteins,

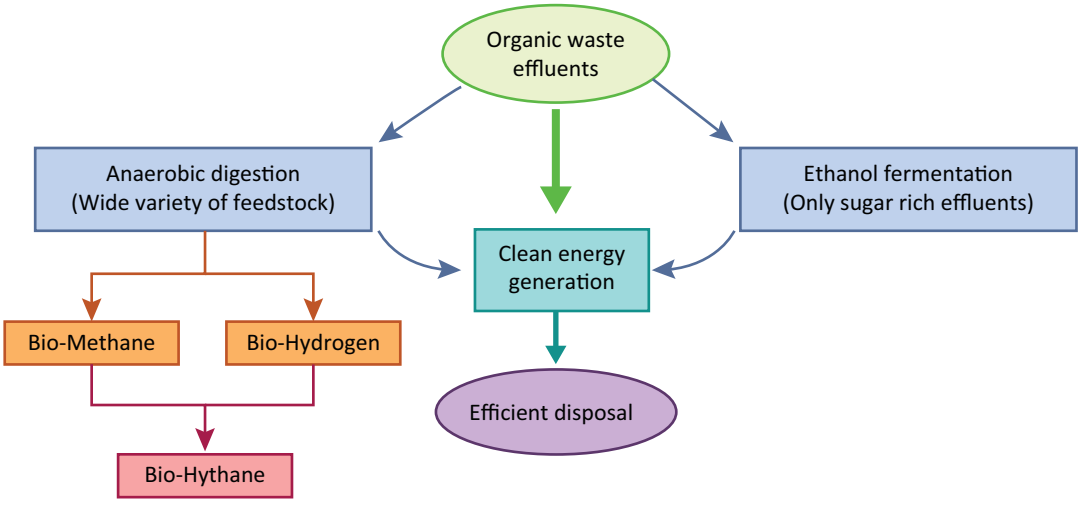


Figure 1: Possible uses of waste

and starch (present in the feedstock) which are water insoluble and remain in effluents are broken down into simpler substances with the help of enzymes released by the microorganism. In the end of this stage, glucose is produced in the form of simple or small molecules. Hence, this stage is also recognized as the polymer breakdown stage. In the second stage, the obtained product (glucose) from the previous stage works as an input for the acidogenesis bacteria. Acedogens present in this stage ferment this monomer into various organic acids leading to the production of major end products—ethanol, acetic acid, butyric acid, and propionic acid—along with the production of hydrogen, carbon dioxide, and traces of other gases. In the last stage, methanogenesis, the present methanogens convert intermediate products of the previous stage finally into methane, carbon dioxide, and some other gases, which is known as biogas. Methanogens are very sensitive bacteria to both low and high pH and sustain between 6.5–8 pH.

Dark Fermentation

The production of hydrogen in anaerobic digestion can be separated through dark fermentation technology, which is an intermediate stage of this digestion. Since hydrogen is a clean energy fuel, having higher energy density 142 MJ/kg (nearly 2.75 folds of petroleum fuels) with only water molecules as a byproduct instead of greenhouse gases, the production of hydrogen from organic wastes has drawn increasing attention nowadays. If we efficiently controlled acidogenesis's products from further fermentation, hydrogen can be obtained.

Various operating parameters are required to be controlled for restricting the proliferation of methanogens in the fermentation process; mainly pH and hydraulic retention time (HRT). Along with these operating parameters, hydrogen producing strains are required for initiation of the dark fermentation technology. In place of pure strains, pretreated mixed culture can also be utilized as a hydrogen producing bacteria It has high flexibility to digest any types of complex organic effluents. Potential of some organic effluents for hydrogen production is shown in Table 1.

Table 1: Potential of some organic waste effluents for bio-hydrogen production

S. No.	Waste effluents	Hydrogen production potential
1.	Cheese whey	2.49 L H_2/L Cheese whey
2.	Sugarcane molasses	1.65 L H_2/L molasses
3.	Sugar beet pulp	17-37 ml H_2/g Vs
4.	Starch factory wastewater	182 ml H_2/g COD
5.	Sucrose water	320 ml H_2/g Vs
6.	Potato wastewater	150 ml H_2/g Vs
7.	Bean wastewater	80 ml H_2/g Vs

Only 30–40% of the feedstock is used to produce hydrogen using this mechanism, while the rest 60–70% is transformed to a variety of different metabolites. Some commercially valuable byproducts of hydrogen generation include ethanol, butyric acid, and 1, 3-propanediol. Other metabolites that build up during hydrogen fermentation include acetic acid, succinic acid, lactic acid, and propionic acid. These valuable metabolites can be separated through various biorefinery approaches. In the absence of their recovery, the liquid waste from hydrogen generation can be transformed into various value-added products—such as polyhydroxyalkanoates (bio-plastic), biobutanol, lipid, methane, and even hydrogen. Furthermore, these organic acid rich effluents can be a viable replacement for phosphate-solubilizing biofertilizer. Therefore, the idea of producing hydrogen from organic waste effluents can be expanded to a hydrogen biorefinery, where several additional products of commercial relevance could be generated simultaneously.

Bio-methane production from the remaining volatile fatty acid rich effluents, through the two-stage anaerobic digestion technique, has become the most viable approach in recent times. This is because the mixture of hydrogen (10–25%) and methane (75–90%) has been recognized as a most probable transportation fuel for the future, which is known by the name 'bio-hythane'. In this technique, hydrogen is produced in the first stage by utilizing fresh effluents, while methane is produced in the second stage by harnessing volatile fatty acids rich effluents obtained from the previous stage. However, correct proportions of these gases are needed to be maintained for the formation of bio-hythane by using this technology. The production of bio-hythane from waste effluents can generate revenue through sale, carbon credits, as well as the cost-saving associated with organic waste management. The market of bio-hythane is growing and its use is encouraged by government policies and incentives, making it a promising source of revenue for producers.

One of the main problems with the production of dark fermentative hydrogen has been inadequate substrate exploitation. By offering the greatest possible feedstock utilization, the recommended approach will assist in eliminating this disadvantage. On the same note, it might produce more revenue to promote the generation of biological hydrogen and increase its competitive industrial production scale.

Conclusion

Anaerobic digestion is the best method for efficient disposal of organic waste effluents as well as simultaneous production of energy. This technique is able to eliminate nearly 95% COD (chemical oxygen demand) present in the influent and allows for the effluent to be directly exposed to the environment after digestion. This will promisingly help to keep our environment clean and green, along with providing a healthy environment. Furthermore, additional revenue can also be generated by harnessing these effluents for energy production in the form of bio-hydrogen, bio-methane, and other volatile fatty acids.

By the adaptation of the two-stage anaerobic dark fermentation method, bio-hythane can be produced which carries the potential to be a clean automotive fuel in the future. It will prove to be a boon in the transportation sector in the upcoming years and help mitigate the carbon footprint for the synthesis of a clean environment. EF

Dr Rupal Jain is Senior Research Fellow at Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh.

MANAGEMENT OF RICE STRAW THROUGH PARALI CHAR

An Easy-To-Adopt and Sustainable Technology

There is an urgent need to sustainably manage crop residue for practicing climate-smart agriculture. Of the many technologies recommended by the Punjab Agricultural University, parali char is an easy-to-adopt and sustainable technology that returns nutrients to the soil, improves soil health, and mitigates the adverse effects of global warming. The present article, by **Iqbal Singh**, **R K Gupta**, and **Rajan Bhatt**, highlights this concept and the methodological approach for its wide adoption at the national level.