Harnessing the Energy Potential of Cattle Dung in India: A Policy Memorandum to the Ministry for New and Renewable Energy

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Executive Summary: The Ministry of Power has created an ambitious framework that heavily relies on clean and renewable energy to meet India's growing energy demands. India, home to a third of the world's cattle, has access to large quantities of manure, which has high methane content and can easily be converted to biogas. The Ministry of New and Renewable Energy (MNRE) is currently running a National Biogas and Manure Management Programme (NBMMP) which has witnessed mixed results. We believe that a decentralized management approach with more funding allocated towards repair programs, the restructuring of payment plans for family-sized biogas plants, creation of more communal biogas plants, and financial incentives for the dairy industry will help India maximize its biogas potential at an individual, communal, and industrial level respectively. We urge the MNRE to act on these policy recommendations and work in conjunction with the Government of India to create policy conducive to the growth of biogas as an energy source.

I. Introduction:

The International Energy Agency predicts that India's energy demand will grow faster than that of any other nation from now through 2040. A growing number of industries and consumers will result in a 4.9% increase in demand for electricity per year. Yet as of 2015, energy consumption per capita is only a third of the global average, and roughly 240 million people had no access to electricity.[1] In 2016, India's Ministry of Power released a plan aiming for 57% of India's electricity capacity to come from non-fossil fuel sources by 2027. In an attempt to shift away from coal, which currently accounts for 61% of India's energy, India hopes to increase its renewable energy capacity from 42,489 MW to 175,000 MW by 2022, equivalent to 60% of India's total energy production capacity in 2015. As a part of this goal, India plans on nearly doubling its biogas capacity from 5446 MW to 10,000 MW.[2]

Biomass has long been used in developing countries as a fuel source because of the scarcity of cheaply available alternate fuels.[3] 85% of rural Indian households directly burn traditional biomass, such as firewood and agricultural residue, for cooking, which is

inefficient and polluting.[4] Because of India's large cattle and water buffalo population (upwards of 300 million as of 2016), manure represents a largely untapped potential fuel supply that could be utilized to create upwards of 18 billion cubic meters of biogas annually.[5,6] While the number of family type biogas plants in India has increased from 1.27 million in 1990 to 4.75 million in 2014, the country has the potential for nearly 8 million more.[7,8,9]

Cattle dung is ideal as a biogas source because highly efficient methanogenic bacteria in the stomachs of ruminants are ejected along with faeces, thereby reducing the need to introduce outside cultures for methanogenesis.[10] This allows for a theoretical 94% efficiency rate in anaerobic digestion, producing burnable methane during decomposition with an energy potential that surpasses the alternative of direct burning.[11] The conversion of 25 kg of fresh dung to biogas yields a 55% efficiency rate compared to just 10% efficiency by direct burning. Furthermore, conversion to biogas introduces fewer air pollutants and permits for the production of 10 kg of air dried manure for use as organic fertilizer.[12] This manure has been shown to increase the quantity of macroelements (chemical elements required as nutrients in large amounts) in select crops as compared to mineral fertilizers, notably producing higher quantities of nitrogen and phosphorous at 17.68% and 7.14% respectively.[13,14]

II. Current policy and challenges for biogas:

Policy history

The Ministry of New and Renewable Energy (MNRE) is currently running the National Biogas and Manure Management Programme (NBMMP), which has been in place since 1981.[15] The Programme's Central Sector Scheme is run by State Nodal Agencies including the Agriculture Department, District Rural Development Agencies, and Khadi and Village Industry Commission centers. Its main objectives are to provide clean bio-gaseous cooking fuel, reducing use of Liquid Petroleum Gas (LPG), and to provide bio-fertilizer to reduce the use of chemical fertilizer.[16] The scheme has targeted "rural and semi-urban" households, 68.84% of the population, by distributing family size anaerobic digesters for individual homes at a subsidized cost.[17,18] Biogas policy in India can be assessed on three levels: family, communal, and industrial.

Family biogas plants

The NBMPP saw its budget increased from 1.3 billion rupees in 2015-16 to 1.42 billion rupees (Rs) in the 2016-17 fiscal year with a target of 100,000 biogas plants.[19,20] Interested beneficiaries are required to contact state agencies in order to get anaerobic digesters. The program has seen mixed results thus far. In 2015-2016, India installed 47,490 biogas plants, representing only 42.7% of the annual targeted quantity.[21] Multiple inspections by state nodal agencies and district level agencies make the process of getting a biogas plant excessively long. Subsidies released by state nodal agencies must make their way through district and village offices before finally reaching the recipient. The average cost of a 2 cubic meter biogas plant is about Rs. 17,000, which often fall into the range of Rs. 10,000 following government subsidies under the NBMMP.[22] For the average Indian household with an annual income of Rs. 160,000, such a purchase would represent a relatively significant cost of around 6.25% of their income.[23] Delays in repair and maintenance for biogas plants have given them a reputation as a cumbersome technology.[24] This can largely be attributed to a lack of specific repair programs at the district level. Although regional training centers, called Biogas Development and Training Centers, offer training to develop repairmen and masons, these results do not trickle down to the district or village level.[25] The state departments and agencies work in conjunction with Khadi and Village Industries

Commission to monitor the biogas plants annually, but there is a shortage of on-demand repairmen.[26]

Communal biogas plants

The Indian government has paid greater attention to subsidizing individual biogas plants than to subsidizing communal plants. However, villages of up to 500 families have implemented communal plants.[27] Communal plants often function better than biogas plants for individual families because there is less likely to be a shortage of dung or water, which is the primary cause for malfunction. Monitoring and repairing one large plant is also less demanding for the state than paying attention to hundreds of family-sized plants in each village. Even though the fixed cost for communal plants is high because they are larger, the burden is spread across the entire village to ease the financial stress.

Dairy farm biogas plants

There are currently no financial incentives offered by the government for the implementation of biogas capture within the dairy industry, making it infeasible for farms to install transport pipelines to biogas compatible power plants due to the large fixed costs. Alternatively, biogas to compressed natural gas (CNG) conversion is more feasible because CNG is a more transportable fuel (high energy density) and can be used to power the over 3 million natural gas cars currently on Indian roads.[28] However, this would require biogas purification and compression at dairy farms, and small dairy farms are not currently able to incur the fixed cost of anaerobic digesters, H_2S and CO_2 scrubbers, and compressors. The economies of scale of larger dairy farms mean that they stand to benefit, however there are very few documented examples of dairy farms using biogas systems.

III. Policy recommendations

Extending payment timeframe

The Ministry of New and Renewable Energy needs to offer a more financially friendly payment structure in order to expand the NBMMP. Even after subsidies, family size biogas plants are too expensive to outweigh free alternatives such as firewood. We propose that a low-interest to no-interest payment option over three years should be offered to buyers. Paying less money up front will have a smaller annual financial impact on rural and semi-urban families, reducing economic deterrents. A scheme that requires a smaller initial payment is more marketable, and will be more likely to attract greater attention.

Local authorities

One of the factors leading to the difficulty of biogas plant installation is the bureaucracy involved in applying for installation through the state authorities. We believe that recipients should go through district/village authorities to get biogas plants installed instead of through state authorities. The reason for this is twofold: First, people tend to be more familiar with local authorities and are more likely to approach them as opposed to calling a state department. Second, state departments handle a wide variety of responsibilities that tend to delay implementation and contain multiple layers of bureaucracy that are difficult to navigate by the typical citizen. Coordination between the district/village, state, and central governments is necessary since the NBMMP is a national program, but customer interactions should be processed locally.

Technical expertise at grassroots level

The massive increase in the budget for the NBMMP gives the MNRE the opportunity to allocate more resources towards skill development. Regional training centers already exist, and expanding this program will address the shortage of skilled repairmen. Deploying repairmen at the district level will increase the speed at which technical issues are addressed. Biogas plants are used to fulfill daily energy needs like

cooking and lighting, so technical issues need to be addressed immediately. Having repairmen closer to the scene does this effectively.

Dialogue between MNRE and village/district leaders about communal biogas plants

The MNRE already holds summits and courses to educate state-level authorities about biogas plants, and it should take the initiative to institute similar outreach programs focusing on village/district leaders from areas with energy shortage issues. Getting local leaders on board with communal biogas plants is a crucial step towards creating more large-scale community plants. Moreover, formal pathways for communication between the MNRE and local officials already exist, and should be utilized for this purpose. These include the Information and Public Awareness Programme, the Special Area Demonstration Project Programme, and the Technology Information Forecasting Assessment and Databank.[29] Additionally, the MNRE provides seminars and symposia to promote discussion and awareness of their policy efforts.[30]

Tax breaks for dairy farms

Offering tax breaks to dairy farms that produce CNG is an effective method of spurring investment in anaerobic digesters and biogas-to-CNG technologies. Though large dairy farms have significant potential capacities to produce biogas, the costs associated with simultaneously installing industrial production facilities and transport networks makes it a difficult/uncertain investment decision. By subsidizing these kinds of sustainability initiatives, dairy farms will have lower fixed costs, setting them on paths towards profitability that can encourage further shifts within the industry. Produced CNG can be sold off as clean energy source for either electricity generation or vehicle fuel, creating additional economic incentives to pioneer developments. Moreover, processed manure can be sold as fertilizer, benefitting dairy farms by generating income using a material that would otherwise cost money to transport elsewhere.

IV. Health and environmental benefits

Air pollution has an outsized disease burden in India because of the prevalence of indoor, solid fuel-burning stoves. Household air pollution resulting from the burning of solid cooking fuels is a factor in 1.04 million deaths and 31.4 million disability-adjusted life years–6% of India's overall disease burden.[31] Additionally, over 600,000 premature deaths and 17.8 million disability-adjusted life years can be traced to ambient air pollution such as that given off by environmentally-unfriendly power sources.[32] This burden disproportionately affects low-income households, who are more reliant on solid fuel than their higher-income counterparts.[33] Replacing solid fuel-burning stoves with biogas plants would significantly reduce this disease burden. A single family biogas plant can substitute for 316L of kerosene, 5,535kg of firewood, and 4,400kg of solid cattle dung yearly.[34] The global warming mitigation potential of a family size biogas plant in India is estimated to be 9.7 tons of CO_2 equivalent, adding up to a potential reduction of approximately 120 million tons of CO_2 equivalent if India is able to install the targeted 12.34 million family size plants.[35] Establishing communal and large-scale biogas plants would increase these benefits even further. A transition from solid fuel-burning stoves and polluting, inefficient power sources would mean a reduction in exposure to carbon monoxide, air pollutants such as sulfur and nitrogen dioxide, and fine particulate matter which are responsible for health problems such as chronic obstructive pulmonary disease, lung cancer, and cardiovascular disease.[36]

Gender and socioeconomic benefits

Low-income households and women are disproportionately affected by biomass pollutants, and therefore would strongly

benefit from the introduction of biogas plants. 90% of those harmed by the health impacts of solid fuel-burning stoves are women, and women and children in the developing world can spend a significant portion of the day simply gathering cooking fuel.[37] Biogas policy reform can correct these imbalances. In Odisha, a state where the Indian government has promoted the use of biogas stoves, women using these stoves reported gathering cooking fuel for 1.4 hours per day versus 2.9 for those using traditional stoves.[38] When coupled with a decrease in pollution and respiratory health problems, those using biogas and other improved cooking stoves spent over 50% fewer days per month in the hospital.[39] Large-scale implementation of biogas policy would therefore result in important health and time-saving benefits for the women who use them.

IV. Conclusion

India has the potential to expand its biogas production but this will require a concerted policy effort from the MNRE. While the Modi government has demonstrated interest in renewable energy, specifically biogas, structural flaws and a lack of focus are preventing biogas from expanding as rapidly as it could. The involvement of district officials is a crucial component to successful biogas policy, given that it is inherently different from other more centralized energy sources. Biogas plants are ideal because they are clean and not very capital intensive. In fact, the Government of India could afford to reduce its LPG subsidy if biogas technology proliferated throughout the country. Solar energy and wind energy are at the forefront of the MNRE's efforts to expand India's renewable energy capacity and meet the Paris Agreement's goals, but biogas can also play a crucial role in helping India achieve its ambitious clean energy goals. If India is able to fully capitalize on manure, the country will be able to produce 8.75 billion cubic meters of biogas capable of generating 11.67 GWh, or nearly 7% of India's 2022 goal for renewable energy.[40]

While other forms of renewable energy have high infrastructure costs and take time to implement in rural and semi-urban areas, biogas plants are relatively cheap ways of powering these areas. They also reduce the reliance on direct burning of biomass for cooking, which is a large source of household air pollution. This is a niche that other renewable energy options cannot fill. Furthermore, the strong presence of CNG vehicles in India and a growing market for CNG suggests that the dairy industry can fill a specific role as CNG suppliers.[41] We propose that the MNRE consider the aforementioned policy recommendations to expand biogas at an individual, communal, and industrial level.

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