India Bioenergy Market Report

Outlook for liquid and gaseous biofuels to 2030

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Abstract

As demand for renewable energy grows in India, liquid and gaseous biofuels are expected to be one of the fastest-growing markets, driven by significant feedstock potential and supportive policies. These fuels can provide low-emission energy in heat, electricity and transport. They can also be produced domestically reducing reliance on imported fossil fuels, improve energy security, and create economic development and employment opportunities.

This report examines the current supply and demand of liquid and gaseous biofuels in India and their forecasted growth to 2030. It provides a detailed assessment of existing policy and regulatory frameworks, feedstocks, production capacity, and identifies key considerations that may influence future development. It also outlines a set of policy priorities, drawing on international best practices, that India could consider to accelerate the deployment of liquid and gaseous biofuels in India.

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Executive summary

Bioenergy is particularly important for India's rapidly growing energy market. It can strengthen energy security, reduce reliance on imported fossil fuels, create economic development and employment opportunities - especially in rural communities - and contribute to lowering greenhouse gas emissions. These benefits align closely with national energy and climate objectives, enabling India to leverage its domestic resources to support cleaner energy growth. India's abundant agricultural residues and organic waste provide a strong resource base for modern bioenergy production.

India's ethanol industry has emerged as one of the country's most successful policy-driven energy stories. Backed by a suite of supply, demand, innovation and financing policies, India's ethanol consumption has grown fourfold from less than 2 billion litres per year (BLPY) at the start of India's National Policy of Biofuels in 2018 to more than 11 BLPY by 2025.

Biogas has a long history in India, with the compressed biogas (CBG) sector undergoing a promising growth spurt. The new eleven major national policies put in place since 2018 have been successful to attract significant investment interest, with around 170 functional plants by 2025 and a pipeline of almost 300 new ones under construction.

Interest is also growing in sustainable aviation fuels and innovative fuel pathways. As demand for low-emissions fuels in aviation is expected to grow, so too is demand for biojet. However, rapid deployment of new projects, as well as scaling up new fuel technology pathways, will be required to meet forthcoming demand driven by India's sustainable aviation fuel mandate.

Liquid and gaseous biofuels are forecast to more than double in India if the right measures are implemented. In the main case forecast, which reflects current policies, projects, feedstock availability and market conditions, these fuels are expected to grow by more than 50%, from 293 petajoules (PJ) in 2025 to 429 PJ by 2030, with ethanol and CBG accounting for the majority of this growth. In an accelerated case, which assumes all announced targets are met, there is sufficient supply of feedstocks for fuel producers, and infrastructure, supply chains, and project development continue to expand, supported by enhanced policies, these fuels are forecast to more than double, from 293 PJ in 2025 to 609 PJ by 2030. More than three-quarters of this growth is driven by biodiesel, if feedstock supply and production capacity rapidly scales up. This would correspond to a sixfold increase in liquid and gaseous biofuels over a decade since 2020.

There are challenges ahead, but they can be addressed with right policy support. In the accelerated case, ethanol is expected to continue expanding backed by a suite of strong policies while biodiesel accelerates growth if feedstock challenges are addressed and production capacity are supported. Biojet is expected to scale-up but will continue to require support across the entire value chain. CBG's fast development pace needs to be accompanied by a comparable scale-up of the feedstock supply chain and the development of new markets for fermented organic manure produced in CBG plants.

Drawing on international best-practices, the IEA recommends four priority actions that can help accelerate liquid and gaseous biofuel in India use by 2030:

1- **Establish roadmaps, targets and policies and implement them robustly to support long-term demand.** While India has made strong progress on ethanol and CBG, a comprehensive sustainable fuel roadmap, which includes all liquid and gaseous biofuels and leverages strategic policy experience gained from developing the *Roadmap for Ethanol Blending in India*, could provide long-term investment signals for other fuels, support scale-up and improve alignment across central and state governments on policy mechanisms for deployment.

2- **Develop integrated supply chains and enabling infrastructure.** India could strengthen coordination to build integrated supply chains that leverage shared feedstocks and existing infrastructure and create new markets for co-products. This includes strategic planning tools such as a national biomass inventory to guide feedstock availability and avoid competition, alongside forward-looking investments in feedstock aggregation, transport networks, and storage facilities.

3- **Support innovation to close cost gaps for emerging fuels.** While ethanol, biodiesel, and CBG are commercially mature, fuels such as SAF require further technology development. Targeted support—such as grants, concessional finance for pilot and demonstration projects, innovation challenges, and public-private and international partnerships—can accelerate scale-up, reduce costs, and tailor solutions to India's specific needs.

4- **Develop carbon accounting and sustainability frameworks.** A robust and transparent framework for liquid and gaseous biofuels would enable easier certification, participation in voluntary green credit markets, and access to export opportunities. It would also help the government guide and reward best practices, ensuring fuels are produced sustainably, aligning with best practice in leading markets such as Brazil.

Chapter 1. Introduction

Bioenergy is the largest source of renewable energy globally today, accounting for more than half of the total renewable energy supply and over 6% of the overall energy supply. Modern bioenergy use is growing fast, with consumption projected to nearly double from about 21 EJ in 2023 to around 39 EJ by 2030. Bioenergy can provide low-emissions fuels, making it valuable for heating, electricity and especially hard-to-electrify sectors like aviation, heavy transport and high-temperature industrial processes. As the organic-derived resources used for bioenergy are geographically well spread, bioenergy is key for diversifying energy systems, bolstering energy security and reducing reliance on fossil fuels in those countries that need to import them.

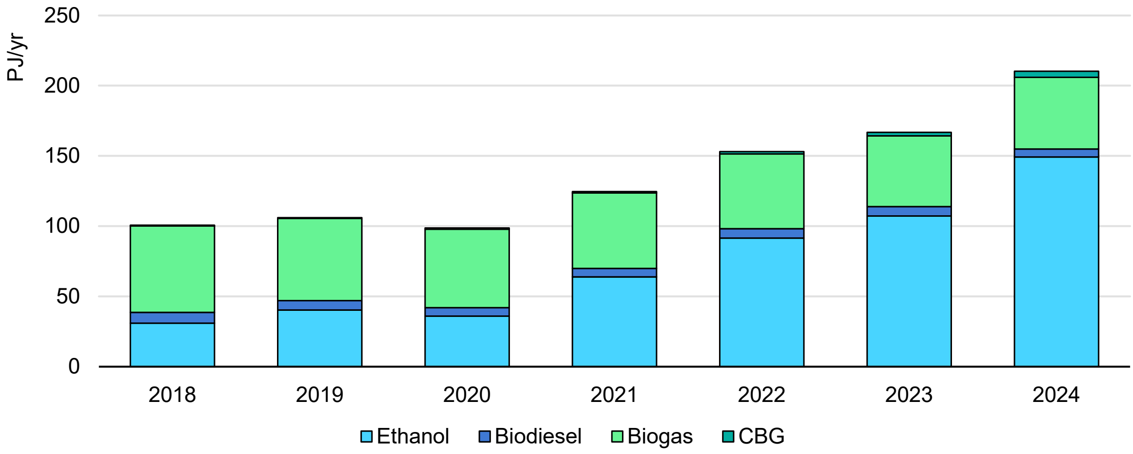
Bioenergy is particularly important for India's rapidly growing energy market, as the country has abundant biomass resources. India is projected to be one of the fastest-growing bioenergy markets globally, supported by policies that promote ethanol and biodiesel blending and expanded use of compressed biogas (CBG). India's abundant agricultural residues and organic waste provide a strong resource base for modern bioenergy production. This can help to improve energy security, reduce reliance on imported fossil fuels, create economic development and employment opportunities especially in rural areas, and reduce GHG emissions. Such developments align with national energy goals and help India leverage its domestic resources for cleaner energy growth.

Demand for liquid and gaseous biofuels has been growing steadily in India. It more than doubled from 101 PJ in 2018 to 210 PJ in 2024. Increasing demand and strong supportive policies, primarily for ethanol and CBG, have driven growth. Demand for ethanol has grown almost fivefold over the same period, and demand for CBG, while nascent, has grown almost eightfold.

As demand for energy in India continues to grow over the next 5 years, so too will demand for liquid and gaseous biofuels. Liquid biofuels (e.g. ethanol and biodiesel) are expected to increase in road transport, while demand for biojet[1] is expected to grow in the aviation sector. Similarly, gaseous biofuels such as biogas and CBG are expected to grow in road transport, as well as in buildings and industrial heating to displace natural gas.

[1] Biojet is a sustainable aviation fuel (SAF) produced primarily from biomass feedstocks. SAF can also be produced from low-emissions hydrogen and carbon dioxide (e.g. synthetic fuels). This report only includes SAF produced from biomass (e.g. biojet).

Figure 1.1 Liquid and gaseous biofuel demand in India, 2018-2024



Source: IEA analysis based on data from IEA (2025), Renewables 2025, GOBARdhan Unified Registration Portal, December 2025, and Ministry of New and Renewable Energy (MNRE) Annual Reports 2017-18 to 2024-25.

Liquid and gaseous biofuels are currently the most developed and cost-effective alternative to fossil fuels. However, substantial efforts are needed to expand and diversify biomass feedstock supplies, expand and adapt infrastructure, commercialise new processing technologies and scale up existing technologies.

This report covers current supply and demand for liquid and gaseous biofuels in India and the forecasted growth to 2030. It also provides analysis of existing policies and regulations, and identifies key issues for consideration to help develop the liquid and gaseous biofuels sector in India. In addition, it lays out policy priorities for action, supported with examples of good practices internationally, that India could consider to accelerate the deployment of these fuels.

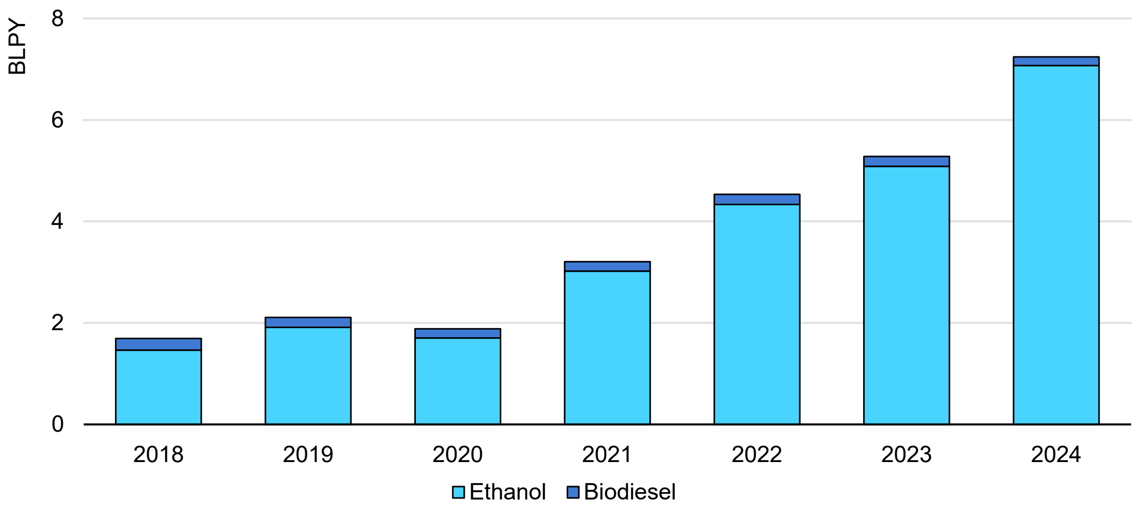
The direct use of modern solid biomass (e.g. wood pellets, wood chips and agricultural residues) for heat and power production is excluded from the scope of this report. Other emerging low-emissions fuels – such as low-emissions hydrogen, methanol, ammonia or synthetic fuels – are also not covered here, as their production is still nascent, and market volumes are expected to become significant after 2030.

Chapter 2. Liquid biofuels

Overview

To reduce crude oil imports, improve energy security and cut emissions in the transport sector, India has rapidly scaled up the domestic deployment of liquid biofuels. Since the implementation of its National Policy on Biofuels (NPB) in 2018, liquid biofuels have grown fourfold, driven almost entirely by increasing ethanol blending targets under amendments to the NPB in 2022. In 2024 alone, India was the world's fourth-largest consumer of liquid biofuels. Blending targets, support for feedstock supply, simplified procurement processes, and financial incentives to accelerate innovation and infrastructure development have driven rapid growth.

Figure 2.1 Liquid biofuel demand in India, 2018-2024



Note: BLPY = billion litres per year.

Demand is expected to grow as India looks to continue to reduce crude oil imports and emissions, while developing new economic opportunities, especially in the agricultural sector, and the broader bioeconomy.

Incentives and regulations

India has been supporting the growth of liquid biofuels domestically with a range of supply-, demand-, innovation- and infrastructure-oriented policies. These include blending targets, government-backed financing, preferential tax rates, fixed feedstock prices, supply expansion initiatives and market development.

Several states (e.g. Bihar, Haryana, Madhya Pradesh, Maharashtra, Uttar Pradesh) have developed their own bioenergy policies in addition to the incentives offered by the central government. These range from capital support for new ethanol and biodiesel plants to indirect tax exemptions and feedstock supply support.

Table 2.1 Selected liquid biofuel policies in India

Policy	Year	Main ministry	Key information
Administered Price Mechanism for Ethanol	2014 (subsumed under the Ethanol Blended Petrol (EBP) Programme in 2019)	Ministry of Petroleum and Natural Gas (MoPNG)	Initiative to fix prices for ethanol produced from feedstocks based on sugar cane to support ethanol production and cost-competitiveness.
National Policy on Biofuels (NPB)	2018 (amended in 2022)	MoPNG	To reduce crude oil imports and increase domestic production of renewable energy, the policy sets an indicative target of blending 20% ethanol in gasoline by 2025/26, and 5% blending of biodiesel in diesel by 2030.
Tax Breaks on Ethanol	2018	MoPNG	India has lowered the goods and services tax rate from 18% to 5% on ethanol meant for blending under the EBP Programme.
Scheme to Enhance Ethanol Distillation Capacity	2018	Ministry of Consumer Affairs, Food and Public Distribution	A 5-year interest subvention to enhance ethanol production capacity by building new plants or upgrading existing plants for feedstock diversification. The subvention is set at 6% per annum or 50% of the rate of interest charged by banks, whichever is lower.
Diversification of Feedstocks for Ethanol Production	2018-20	MoPNG	The government allowed ethanol production from B-heavy molasses, sugar cane juice/syrup/sugar, damaged food grains in 2018 followed by maize and surplus stocks of Food Corporation of India rice in 2020.
Ethanol Blended Petrol (EBP) Programme	2019	MoPNG	The government sets guaranteed pricing for ethanol based on feedstock costs that oil marketing companies (OMCs) pay to purchase ethanol. The values are updated several times a year to maintain cost-competitiveness of ethanol.

Policy	Year	Main ministry	Key information
Pradhan Mantri JI-VAN Yojana	2019 (amended in 2024)	MoPNG	Provides funding to support development of 10 demonstration-scale projects and 12 commercial-scale projects for new ethanol production pathways.
Roadmap for Ethanol Blending in India 2020-25	2021	MoPNG	An annual plan to increase domestic ethanol production in line with blending targets under the NPB and the EBP Programme to reach 20% ethanol blending in gasoline by 2025/26.
Extension of the EBP Programme to all of India	2021	MoPNG	OMCs directed to sell ethanol blended petrol with a percentage of ethanol up to 20%.
Setting up Dedicated Ethanol Plants	2021-23	MoPNG	Guidelines for signing of long-term offtake agreements (for 10 years) issued in 2021 and 2023. Public OMCs signed long-term offtake agreements with 233 project proponents for a designed capacity of about 795 crore litres per annum.
Sustainable Aviation Fuel Blending Target	2023	MoPNG/ Ministry of Civil Aviation	For international flights, the government has approved a SAF blending target of 1% by 2027, increasing to 5% by 2030.
Scheme for Cooperative Sugar Mills	2025	Ministry of Consumer Affairs, Food and Public Distribution	The government notified a scheme for co-operative sugar mills under the modified Ethanol Interest Subvention Scheme for converting existing sugar-cane-based feedstock ethanol plants into multifeedstock-based plants to use grains like maize and damaged food grains. The subvention is set at 6% per annum or 50% of the rate of interest charged by banks, whichever is lower.
Export of Second-Generation Ethanol	2025	MoPNG	The government notified an export policy for second-generation ethanol in September 2025.

Note: A crore is equal to ten million.

Ethanol

Policy support for ethanol in India gained momentum in 2014 with the introduction of a revised ethanol pricing mechanism which provided stable and fixed prices for ethanol produced from sugar cane to improve cost-competitiveness and support scaling up of production. Building on this policy, India launched its NPB in 2018 to expand its domestic liquid biofuel industry and reduce reliance on crude oil imports for gasoline production. The NPB originally set a target of blending 20% ethanol in gasoline by 2030, which was later amended in 2022 to achieve this blending rate by 2025/26.

India developed several other policies in 2018 to support development of the ethanol supply chain and the targets set out under the NPB. These measures included financial support for new projects through the Scheme to Enhance Ethanol Distillation Capacity, which subsidises interest on loans used to retrofit existing facilities or develop new ethanol plants, as well as an expansion of eligible feedstocks to include heavy molasses, sugarcane juice and sugar, damaged food grains, maize, and surplus rice. In addition, India reduced the tax rate on ethanol used for blending from 18% to 5% to improve the cost-competitiveness.

In 2019, India launched the EBP Programme, originally a pilot and demonstration programme from 2001, to provide additional financial incentives to support mandated ethanol blending targets under the NPB while supporting feedstock suppliers. Under this programme, the government sets remunerative pricing for ethanol produced from feedstock based on sugar cane to support cost-competitiveness for ethanol producers. The OMCs provide long-term demand for ethanol by entering offtake agreements, of up to 10 years, with project developers and lenders.

India developed the Pradhan Mantri JI-VAN Yohana programme in the same year, later amended in 2024, to increase production of ethanol from a greater diversity of feedstocks. The programme provides USD 230 million (1 969.50 crore Indian rupees (INR)) of funding for the expansion of existing, or development of new, integrated ethanol projects using lignocellulosic biomass, non-edible food crops and waste-based feedstock. The programme has set a target to develop 10 demonstration-scale and 12 commercial-scale projects by 2028/29. The programme has so far provided over USD 100 million (INR 908.25 crore) for six commercial and four demonstration plants.

In 2021, India created the Roadmap for Ethanol Blending in India 2020-25. The roadmap outlines annual measures to increase domestic ethanol supply and demand, setting intermediate targets in line with the NPB and the EBP Programme. These included a phased-in blending target of 10% for ethanol in 2022, as well as phased-in blending of 20% for ethanol by 2025. It also sought to double domestic ethanol production capacity from 2020 to 2025, to 15 billion litres (1 500 crore litres). The extension of the EBP, directing OMCs to sell gasoline blended with 20% ethanol, and the development of guidelines for signing long-term offtake agreements for ethanol for OMCs in 2021, complemented the roadmap and the NPB.

Several Indian states have also developed policies to support deployment of ethanol. In 2018, Haryana launched its Bioenergy Policy, which provides exemptions on stamp and electricity duties for ethanol producers. Similarly, in 2022, Uttar Pradesh launched its Bioenergy Policy, and in 2023, Bihar launched its Biofuel Promotion Policy, which both provide similar duty exemptions for ethanol production facilities. In 2024, Maharashtra introduced its Integrated Bioenergy Policy, again providing similar exemptions to duties, as well as capital subsidies ranging from 40% to 100% for new ethanol projects. In 2025, Madhya Pradesh launched its Biofuels Scheme, providing similar duty exemptions as the other states as well as a 40% capital subsidy up to USD 22.2 million (INR 200 crore) for new cellulosic-ethanol projects.

India has broadened support for ethanol development by providing financial support for the interest on loans used to retrofit existing, or develop new, ethanol production facilities under the Scheme for Cooperative Sugar Mills. Similarly to the Scheme to Enhance Ethanol Distillation Capacity implemented in 2018, it provides financial support for converting ethanol production facilities using sugar cane to ones that can use a range of feedstocks such as maize and damaged rice. As demand for sustainable fuels continues to grow globally, India's recent announcement to allow export of cellulosic ethanol has complemented providing support to increase production capacity for ethanol.

Biodiesel

Policy support for biodiesel also gained momentum in India in 2018 under the NPB, which also set a blending target of blending 5% biodiesel with diesel by 2030. To support the targets set out under the NPB, the Food Safety and Standards Authority of India launched the repurposed used cooking oil initiative the same year, to improve access to used cooking oil (UCO) for biodiesel producers.

In addition, India allows OMCs to develop offtake agreements through periodic procurement tenders, with guaranteed prices for biodiesel from UCO to support demand. In 2019, this was expanded to private biodiesel producers, allowing them to sell 100% biodiesel directly to consumers for blending, to support further demand.

At the state level, Uttar Pradesh developed production linked incentives of USD 3.3 per litre (INR 3 lakh[2] per kilolitre) up to USD 2.2 million (INR 20 crore) per facility for biodiesel plants under its 2022 Bioenergy Policy. In 2024, Maharashtra's Integrated Bioenergy Policy began providing capital subsidies of 70% for plant and machinery costs at biodiesel production facilities, while Madhya Pradesh's 2025 Biofuels Scheme provides a 40% capital subsidy for new biodiesel production facilities.

[2] An Indian lakh is unit in the Indian number system. One lakh equals 100,000.

Sustainable aviation fuel

India plans to support the development of domestic Sustainable Aviation Fuel (SAF) production and has set short-term blending targets, applicable to international flights, of 1% starting in 2027, 2% in 2028 and 5% by 2030.

Support for SAF production is also growing at the state level. Madhya Pradesh's 2025 Biofuels Scheme provides 40% capital subsidies for new biojet production facilities, while Uttar Pradesh is drafting its SAF Manufacturing Promotion Policy to generate new income streams for farmers while leveraging agricultural residues as feedstock for biojet production.

Feedstock

Support for the development of feedstock supply for liquid biofuels began in 2018 under the NPB. This policy regulates feedstock eligibility and allows adjustments during periods of surplus, or when damaged food crops and other feedstocks cannot be used for higher-value purposes.

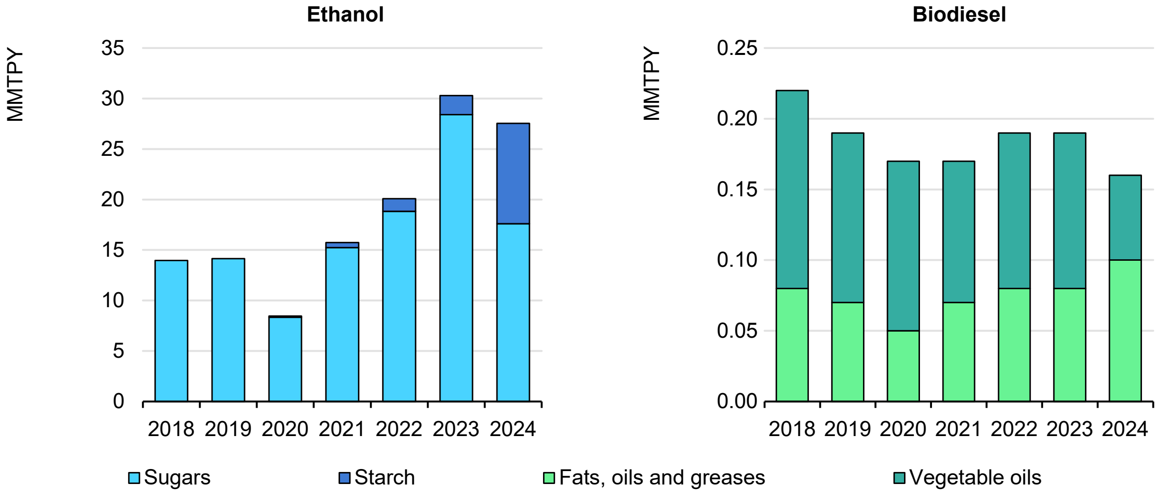
Several states have also been supporting access to feedstock supply for liquid biofuel production. Haryana's 2018 Bioenergy Policy provides subsidies for feedstock collection equipment and transportation of feedstock, while Maharashtra's 2024 Integrated Bioenergy Policy expands feedstock eligibility for ethanol to maize and rice when sugar cane is unavailable during the off season. Madhya Pradesh's 2025 Biofuels Scheme also provides support for feedstock supply by appointing biomass aggregators to ensure adequate accessibility to necessary feedstocks for liquid biofuel production.

Feedstock demand

Demand for feedstock has grown steadily alongside the increasing demand for liquid biofuels. Since 2018, demand has nearly doubled, driven primarily by increasing demand for ethanol. Starches, primarily surplus and damaged grains, made up 75% of this growth, with the remaining 25% coming from sugars such as sugar cane and molasses.

Demand for vegetable oils and other fats, oils and greases for biodiesel production remained small but relatively stable. This is primarily due to supply chain and logistic challenges experienced over the last few years. Collecting and distributing oil-based feedstocks (e.g. UCO for biodiesel) has remained a challenge. These feedstocks are usually dispersed across regions and feedstock suppliers, such as restaurants and industrial facilities, and can make collection challenging. In addition, unlike farmers, or farmer co-operatives, these feedstocks can be supplied in varying quantities, thus making the supply chain further disaggregated and difficult to piece together.

Figure 2.2 Liquid biofuel feedstock demand in India, 2018-2024



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Notes: MMTPY = million metric tonnes per year. For ethanol production, starches yield a higher volume of ethanol per tonne of feedstock than sugars (particularly sugar cane); therefore, as the proportion of starches increases, the total feedstock quantity decreases, on a per metric tonne basis as seen in 2024, yet the volume of ethanol produced increases.

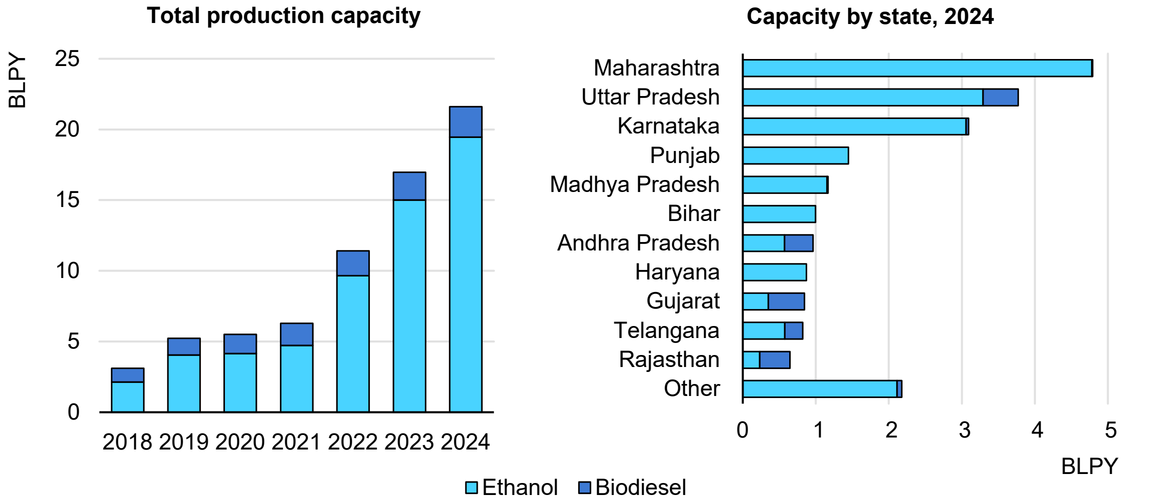
In 2024, India used over 25 million metric tonnes (MMT) of feedstock for liquid biofuel production. Sugars, primarily sugar cane and molasses, made up over 60% of all feedstocks, while starches, from surplus and damaged grains, made up just over 35% of all feedstocks. Oils, fats and greases made up the remaining amount.

Current status

Production capacity in India has been scaling up to meet domestic demand for liquid biofuels. Since 2018, liquid biofuel production capacity has grown nearly sevenfold – from just over 3 billion litres per year (BLPY) to more than 20 BLPY. Ethanol has driven this growth, with production capacity expanding from just over 2 BLPY to more than 19 BLPY. Strong support from India through blending mandates, price guarantees and financial support for scaling up facilities has resulted in rapid growth in ethanol production capacity.

Biodiesel production capacity in India has increased from just under 1 BLPY to more than 2 BLPY since 2018. This is partly due to feedstock supply, and accessibility to that supply, as well as a smaller suite of policies supporting scale-up for biodiesel in comparison to ethanol.

Figure 2.3 Liquid biofuel production capacity in India, 2018-2024 (left) and production capacity by state, 2024 (right)



Regionally, more than half of all liquid biofuel production capacity is concentrated in three states: Maharashtra, Uttar Pradesh and Karnataka. This concentration reflects strong policy support, particularly in Maharashtra and Uttar Pradesh. As discussed above, Maharashtra's Integrated Bioenergy Policy offers capital subsidies for new production facilities and equipment and broadens feedstock eligibility for producers. Uttar Pradesh's Bioenergy Policy provides production incentives for biodiesel and tax exemptions for ethanol producers. Given strong policy support, these three states also make up nearly 60% of all ethanol production.

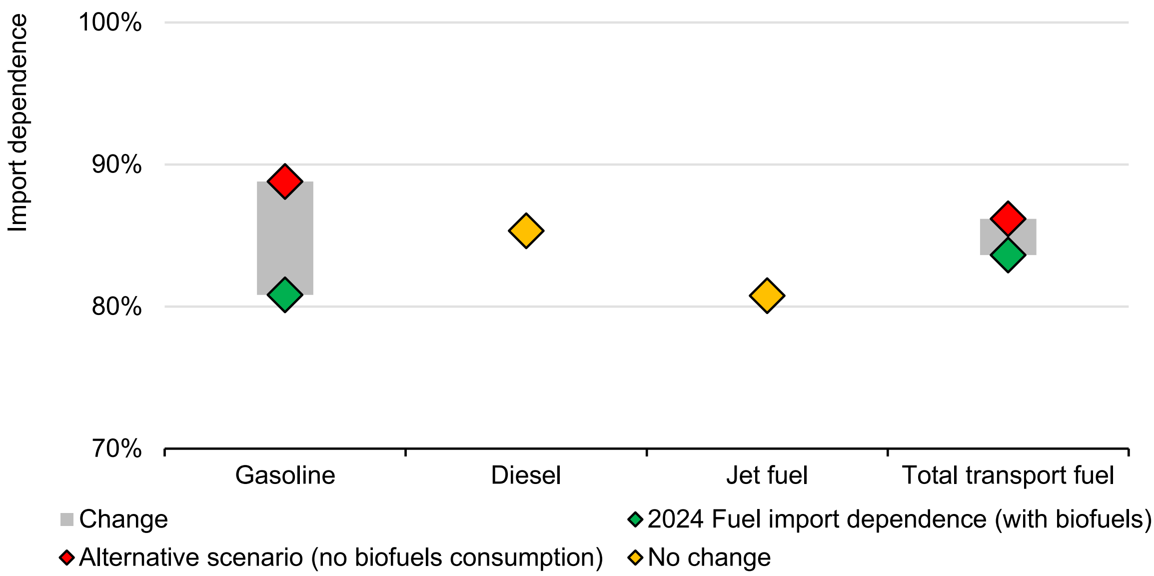
Similarly, biodiesel production is also heavily concentrated in India. Gujarat, Uttar Pradesh, Rajasthan and Andhra Pradesh make up more than 80% of India's biodiesel production capacity and are located on both coasts of the country. Again, regional concentration is partly due to strong policy support from Uttar Pradesh through biodiesel production incentives.

Demand

Road transport

The number of vehicles in India is expected to expand to more than 450 million by 2030. Therefore, fuel demand in road transport will increase. While electrification of road transport is a key pillar of India's energy transition, with electric vehicles projected to account for nearly 35% of vehicle sales by 2030 under policies such as the Faster Adoption and Manufacturing of Electric Vehicles scheme, overall fuel demand in the road sector is still expected to grow. As a result, demand for ethanol and biodiesel will also increase, underpinned by blending mandates under the NPB, to reduce crude oil imports and enhance energy security. For example, in 2024, the NPB, together with other supportive policies, helped displace 8% of crude oil imports for gasoline with ethanol.

Figure 2.4 Indian dependence on crude oil imports by fuel pool, with and without liquid biofuels, 2024



Notes: "Fuel import dependence" refers to the share of domestic fuel demand that is produced from imported crude. As most fuels in India are produced with imported crude, while being a net exporter of refined oil products (e.g. gasoline, diesel and jet fuel), the figure illustrates India's import dependence on crude oil if biofuel consumption was instead met with fossil fuels produced from imported crude oil.

In addition, India has also announced a Production Linked Incentive of USD 2.9 million (INR 25 938 crore) to accelerate introducing flexible-fuel vehicles, including engines capable of running up to 85% ethanol blends, and production of other ethanol compliant parts for engines to continue to support the ethanol industry.

Aviation transport

Air travel is expected to increase domestically and internationally in India. In 2024, there were more than 228 million domestic travellers and 64.5 million international travellers. By 2030, there are expected to be 300 million domestic passengers alone.

With growing air-travel demand and the introduction of India's SAF targets, the need for SAF is projected to increase sharply as the sector works to curb emissions and India looks to continue to reduce dependence on imported fuels. Global demand for biojet alone is also expected to rise to over 9 BLPY by 2030 as multiple countries implement blending mandates and pursue aviation emissions reductions. This could create potential export opportunities for India.

Key considerations

Long-term demand

India has taken important steps to create demand for liquid biofuels such as ethanol and biodiesel with medium-term blending mandates. However, only short-term blending targets exist for SAF. Without clearly defined timelines or long-term goals, SAF could struggle to scale up, as project investors, supply chain actors and infrastructure developers await stronger medium- to long-term policy certainty.

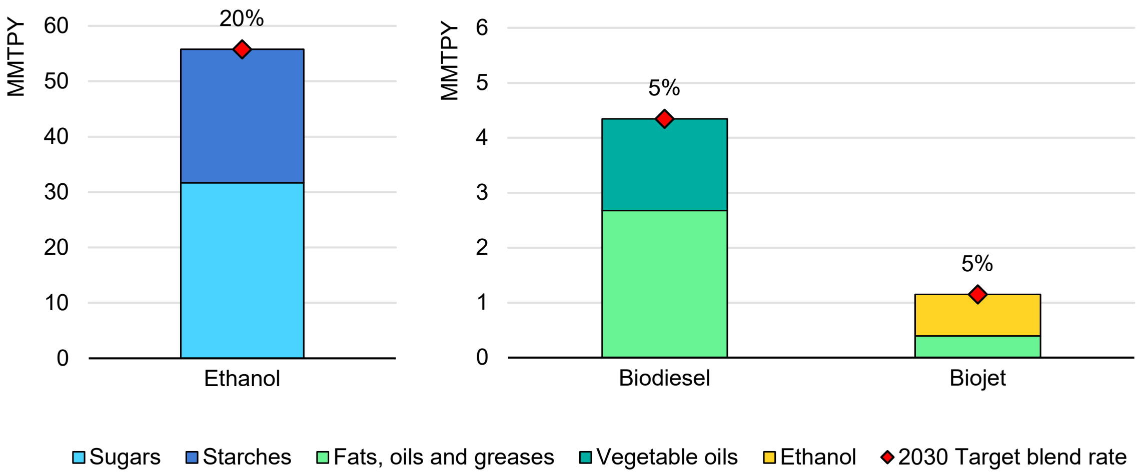
To support the continued scale-up of SAF, India could consider developing a long-term sustainable aviation strategy with clear SAF targets, supported by coordinated plans for supply chains and infrastructure (as in the United Kingdom's Jet Zero Strategy). Alternatively, India could adopt a broader sustainable fuels strategy covering bioenergy, hydrogen, and e-fuels, with defined targets for SAF and other sustainable fuels (e.g., as in Brazil's Fuel of the Future Law), while ensuring alignment of resources, leveraging synergies across value chains, and avoiding competition between sectors that rely on sustainable fuels for emissions reductions.

Feedstock availability

While there are enough feedstocks for ethanol, there are not enough fats, oils and greases to meet India's blending targets for biodiesel and biojet produced from co-processing or the hydroprocessed esters and fatty acids (HEFA) production pathway. This could limit investments in new biorefineries as well as create competition between fuel producers for existing feedstock, which could increase the overall cost of biodiesel and biojet.

To meet India's announced liquid biofuel targets for ethanol, biodiesel and SAF, feedstock demand is expected to increase by 70% from 2024 to more than 60 MMT. Assuming historical shares of feedstock demand, more than 30 MMT of sugar and 20 MMT starches will be required to meet and maintain a 20% ethanol blending rate. For biodiesel, nearly 5 MMT of vegetable oils, fats, other oils and greases will be required to meet a 5% blending rate. For 2030, it is expected that almost all SAF will be produced as biojet from co-processing biogenic oils and fats with conventional crude oil feedstocks in existing refineries, the HEFA pathway or via the alcohol-to-jet (ATJ) route. Given the supply challenges for fats, oils and greases, it is anticipated that more than 0.5 MMT of ethanol (500 million litres per year (MLPY)) of ethanol would be used for SAF production, via the ATJ fuel production pathway. The remaining feedstock from fats, oils and greases would be used for co-processing and the HEFA fuel production pathway, to meet the 5% blending rate.

Figure 2.5 Feedstock requirements to achieve 2030 blending targets in India



India could consider reducing the short-term import duty to allow fuel producers to meet blending targets while developing price guarantees, as has already been done with ethanol under the NPB, for biodiesel and biojet made from specific feedstocks. Significant volumes of UCO are available in India that could be used to address this feedstock shortage, with collection and distribution a key challenge. A guaranteed price for biodiesel or biojet produced from UCO would drive demand, thereby helping to develop necessary supply chains and businesses (e.g. third-party aggregators) to collect and distribute it. There is also potential to continue to increase domestic oil feedstocks through improving intercropping in domestic agriculture of non-edible short gestation oilseed crops such as Jatropha and Napier grass.

Providing financial support for continued research, testing and piloting of isobutanol in diesel blending could support India's diesel blending target. It could also reduce potential competing demands for fats, oils and greases between biodiesel and biojet production. While there are some limitations as to how much can be blended in diesel, isobutanol can be made during the ethanol production process, and could therefore leverage India's strong ethanol production capacity and supply chain.

Supply chain and infrastructure

Biojet production is – and will remain in the short term – regionally concentrated due to feedstock availability and planned production projects. This could limit the overall supply of SAF at airports and make achieving India's SAF targets difficult in the short to medium term.

In the short term, India could consider leveraging existing domestic fuel storage and distribution networks, and adapt as needed, to continue to facilitate distribution and storage of biojet. This could include blending biojet at oil storage depots or terminals, so it is blended before distribution at airports.

In addition, developing – or participating in an existing – book-and-claim system in the short to medium term could ensure early demand for biojet as supply chain and infrastructure challenges are addressed and scaled-up (e.g., the RSB Book and Claim). It could be phased out over time as the cost of SAF declines and demand increases to support market competition.

Innovation

To meet India's 2030 SAF targets, production will need to scale up. However, the cost of SAF can be two to five times more expensive than petroleum-based aviation fuels. This could limit supply, or increase costs, to meet India's targets.

India could replicate similar programmes used for ethanol (e.g. the Pradhan Mantri JI-VAN Yojana initiative and ethanol distillation scheme) to offer grants and loan support for pilot-, demonstration- and commercial-scale SAF facilities. India could also consider developing government-funded innovation challenges, used in other parts of the world, where stakeholders compete to develop fuel technologies and finalists receive funding to support commercialisation (e.g. Canada's The Sky's the Limit Challenge).

Meanwhile, India could continue to pursue international collaboration through leadership in the Global Biofuels Alliance, as well as pursuing bilateral agreements with leading sustainable fuel producing countries, to share knowledge on research, development, demonstration and scale-up of fuel technologies (e.g. Brazil and Japan's Initiative for Sustainable Fuels and Mobility).

Sustainability

Without carbon accounting and a sustainability framework to demonstrate emissions reductions and the sustainability of liquid biofuels, foreign investments, export opportunities and compliance with international regulations (e.g. the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)) could be challenging.

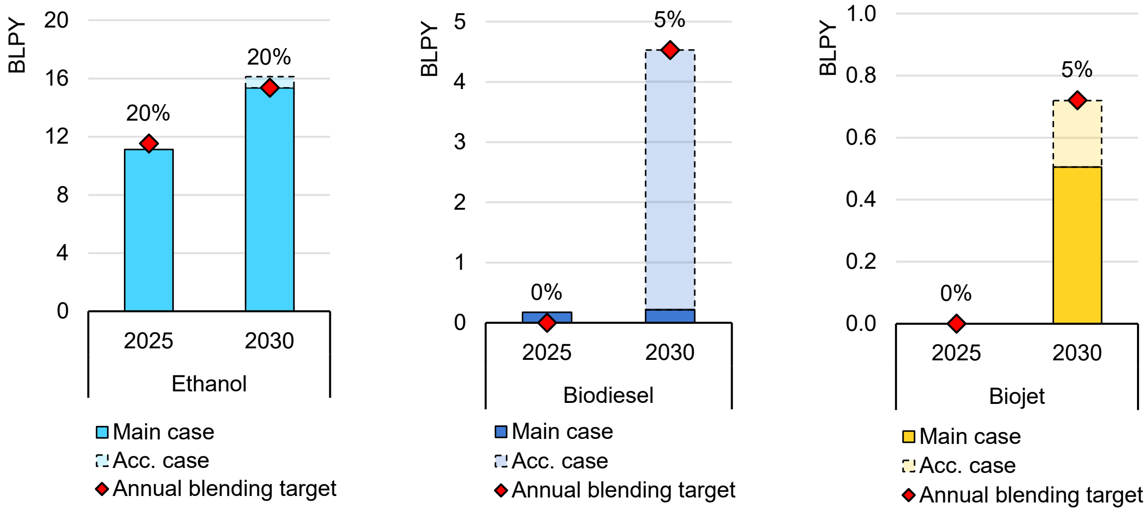
India could consider developing a carbon accounting and sustainability framework for liquid biofuels, or all biofuels more broadly, that aligns – or is interoperable – with international frameworks to ensure compliance, investment and trade opportunities. This could build upon work already completed under India's carbon market, which includes bioenergy as one pathway to generate voluntary credits, by developing a complementary carbon accounting and sustainability framework. As international demand for sustainable fuels increases, investors and fuel consumers will look to ensure appropriate carbon accounting, sustainability and traceability mechanisms are in place.

Supply forecast to 2030

Given current policies and forthcoming demand, India's liquid biofuel sector is forecast to grow. In the main case forecast, which considers current policies, projects, feedstock availability and market conditions, India's liquid biofuel sector is expected to grow by more than 40% between 2025 and 2030, reaching more than 16 BLPY. Ethanol is anticipated to make up almost all of this growth given strong existing policy support via blending mandates, expansion of eligible feedstocks for ethanol production and financial support for scale-up of supply chains. Biojet makes up the remaining growth, with several new projects expected to be developed within the next 5 years.

In an accelerated case forecast, which considers blending targets continue to be – or are – met based on increases in production capacity, greater feedstock availability, scale-up of technology and projects, and financing, liquid biofuel demand increases by 85% to more than 21 BLPY, with growth across all liquid biofuels. Ethanol makes up roughly half of this growth, again due to strong policy support, while biodiesel and biojet make up the remaining amount.

Figure 2.6 Liquid biofuel supply forecast in India, main and accelerated cases, 2025-2030



Notes: Blending targets based on total, gas, diesel and kerosene demand. "Main case" refers to the forecast main case and "Acc. case" refers to the forecast accelerated case.

Ethanol

In the main case, ethanol is forecast to grow by more than 35%, to over 15 BLPY by 2030. This assumes overall fuel demand continues to increase, with India maintaining its already achieved 20% blending target, and India's suite of supportive policies and access to feedstocks for ethanol remain in place.

In an accelerated case, ethanol is forecast to grow by 45% to more than 16 BLPY by 2030. This assumes additional increases in overall fuel demand, greater deployment of flexible-fuel vehicles by 2030 due to India's Production Linked Incentive, and a potential small blending increase to 21% to support the industry. Current ethanol production capacity is sufficient to support this, but would require facilities to operate at over 80% capacity. Any additional growth in ethanol demand beyond this would likely require additional investments in ethanol production capacity. Deployment of ethanol-compatible infrastructure would also likely need to increase.

Biodiesel

In the main case, biodiesel is forecast to remain stable at just over 200 MLPY by 2030, limiting India's ability to reach its 5% blending target by 2030. This assumes feedstock challenges remain and that biodiesel producers are unable to access sufficient sources of oils, fats and greases to produce sufficient volumes of biodiesel.

In an accelerated case, biodiesel is forecast to grow over twenty-fold, to more than 4 billion litres by 2030 as India achieves its 5% blending target. This assumes biodiesel producers have sufficient access to feedstock through improving collection of feedstocks (e.g. UCO), increasing the supply of oil crops grown by farmers and the development of other supportive feedstock supply oriented policies as done for ethanol. In addition, production capacity would need to rapidly scale up, requiring roughly a twofold increase from current capacity, to meet demand.

Sustainable aviation fuel

In the main case, biojet is forecast to reach more than 500 MLPY by 2030. Several OMCs intend to develop co-processing capacity at existing facilities beginning in 2026, such as Indian Oil Corporation's Ltd (Indian Oil) recent announcement to produce 38 MLPY of biojet from UCO at the Panipat Refinery in Haryana after having received International Sustainability & Carbon Certification CORSIA certification in 2025. Additional production capacity is also expected to increase with advances in technology such as Indian Oil's announced partnership with LanzaJet to develop an additional 109 MLPY of SAF production capacity at the Panipat Refinery, using ATJ technology, with production expected to begin by early 2028.

In the accelerated case, biojet production is forecast to reach over 700 MLPY by 2030 as India achieves its 5% blending target. This assumes, that like biodiesel producers, biojet producers have sufficient access to feedstock, there is greater deployment of existing technologies (e.g., HEFA) and emerging technologies (e.g. ATJ), and that additional production capacity beyond already announced projects is developed.

Chapter 3. Biogas and compressed biogas

Overview

India has a long history of biogas production, dating back to the 19th century, with small-scale facilities expanding extensively in rural areas since the 1980s. In recent years, the Indian government has increasingly emphasised biogas, and its upgraded form biomethane, also know in India as CBG or bio-CNG, as a key component of the country's energy strategy. The multiple benefits that biogases can provide to India are driving this growing momentum. They can enhance energy security by reducing dependence on imported liquefied natural gas (LNG), support waste management and revalorisation, stimulate rural economic development and employment, and, when produced and used sustainably, biogases can play a key role in reducing emissions across different sectors.

India has a large feedstock potential for the production of biogases, and has begun to significantly scale up output, especially CBG, over the past 5 years. This expansion is bringing new challenges to stakeholders and the Indian government. Such challenges are related to developing a robust value chain that includes feedstock collection, processing operations, and product and co-product distribution and marketing.

Incentives and regulations

In recent years, the Indian government has been very active in developing policy instruments to support the production and use of biogas and CBG. Financial aid provided through the Central Financial Assistance (CFA) scheme, linked to the Waste to Energy (WtE) Programme and the National Biogas Programme under the Ministry of New and Renewable Energy (MNRE), is available for biogas projects of all sizes (small, community and industrial plants) and for CBG facilities. In addition, in 2018, the Sustainable Alternative Towards Affordable Transportation (SATAT) initiative was launched to support CBG offtake in the transport sector, through guaranteed pricing and long-term agreements with oil and gas marketing companies.

As the first CBG plants started operations, it became clear that gaps in other parts of the value chain needed to be developed in parallel to CBG production. One of these components was the CBG offtake and logistics infrastructure. The **CBG-CGD Synchronisation Scheme**, introduced in 2021 and operated by GAIL, therefore complements the SATAT initiative by supporting transport of CBG from production plants to retail outlets and city gas distribution (CGD) networks at fixed rates, either via mobile cascades or through injection into CGD grids. Additionally, as the national natural gas network expands under the One Nation One Gas Grid programme, CBG producers and CGD entities can build their own pipeline connections to the grid with financial support. This support covers around 50% of the investment cost under the Development of Pipeline Infrastructure (DPI) scheme released in 2024, thus reducing expensive transport costs via cascades.

Other recent policy tools are looking into supporting the collection of agri-residues at large scale (e.g. the Biomass Aggregation Machinery (BAM) finance scheme launched in 2024) or supporting the creation of new markets for co-products that need to be disposed of, such as fermented organic manure (FOM), which can be sold as an organic fertiliser (Market Development Assistance (MDA) launched in 2023).

A clear accelerator for CBG plant investment is the blending obligation introduced in 2023, starting from 1% in fiscal year (FY) 2025/26 and rising to 5% by FY 2028/29. This is key to providing a long-term demand signal for the sector. However, there is a lack of reinforcement mechanisms to ensure compliance. The section on demand below discusses alternatives for reinforcement.

In addition to national policies, several states have released state-specific incentive programmes. Andhra Pradesh, Haryana and Uttar Pradesh offer capital support for CBG plants as well as a variety of duty waivers or tax exemptions. Maharashtra offers capital support and interest subsidies, while Punjab has simplified approvals for waste-to-energy projects. Bihar and Madhya Pradesh also have incentive programmes in place. State policies are generally well aligned with national strategies, but the degree of development varies greatly from one state to another.

Table 3.1 Selected biogas and CBG policies in India

Policy	Year	Main ministry	Key information
Galvanizing Organic Bio-Agro Resources Dhan (GOBARdhan) Initiative	2018	Ministry of Jal Shakti and MoPNG	Comprises several initiatives encouraging valorising organic waste through transformation into CBG or organic manure. The Unified Registration Portal for biogases was launched in 2023.
Sustainable Alternative Towards Affordable Transportation (SATAT)	2018	MoPNG	Enables purchase offtake agreements with oil and gas companies, with a minimum purchase price guaranteed until 2029; provides some tax exemptions.

Policy	Year	Main ministry	Key information
Waste to Energy (WtE) Programme	2022	MNRE	Targets an increase in energy production from urban, industrial and agricultural wastes. Provides financial assistance for generation of biogas, power from biogas and bio-compressed natural gas (bio-CNG), from INR 4 crore for plants producing 4.8 tonnes per day (TPD) to a cap of INR 10 crore for plants producing 12 TPD or more.
National Biogas Programme	2022	MNRE	Offers financial assistance for setting up small- and medium-sized biogas plants (up to 2 500 m^3/day).
CBG Blending Obligation (CBO)	2023	MoPNG	Mandates blending of CBG in transport fuel and domestic piped gas, starting at 1% in FY 2025/26 and rising to 5% in FY 2028/29. It targets 750 CBG established projects.
CBG-CGD Synchronisation Scheme	2021, updated 2023	MoPNG	Operated by GAIL, sets tripartite contracts between CBG producers, CGD entities and GAIL at a set price, managing transport via mobile cascades or injection into CGD networks and natural gas pipelines.
Unified Registration Portals for biogas and CBG	2023, updated 2025	Ministry of Jal Shakti and MoPNG	Unified Registration Portals operating under the GOBARdhan initiative for biogas (managed by the Ministry of Jal Shakti) and CBG (managed by MoPNG) projects. Central registry and central hub for subsidy information.
Market Development Assistance (MDA) for Promotion of Organic Fertilizers	2023	Department of Fertilizers (DoF)	Available from FY 2023/24 to FY 2025/26, it supports the marketing of FOM, liquid fermented organic manure (LFOM) and phosphate-rich organic manure (PROM), by-products of biogas and CBG plants, with aid of INR 1 500 per metric tonne (MT). Products need to comply with the Fertilizer Control Order (FCO) and pass quality tests.
Biomass Aggregation Machinery (BAM)	2024	MoPNG	Provides financial assistance to CBG producers for procurement of machinery, up to 50% of cost or INR 90 lakh per set.
Fertilizer Control Order (FCO)	1985, amended February 2025	DoF	Introduces a new category for organic carbon enhancers from CBG plants.
Development of Pipeline Infrastructure (DPI)	2024, revised August 2025	MoPNG	Provides up to 50% financial support for the laying of connection pipelines and CBG injection points into CGD grids and into the national gas pipeline network.

Feedstock potential

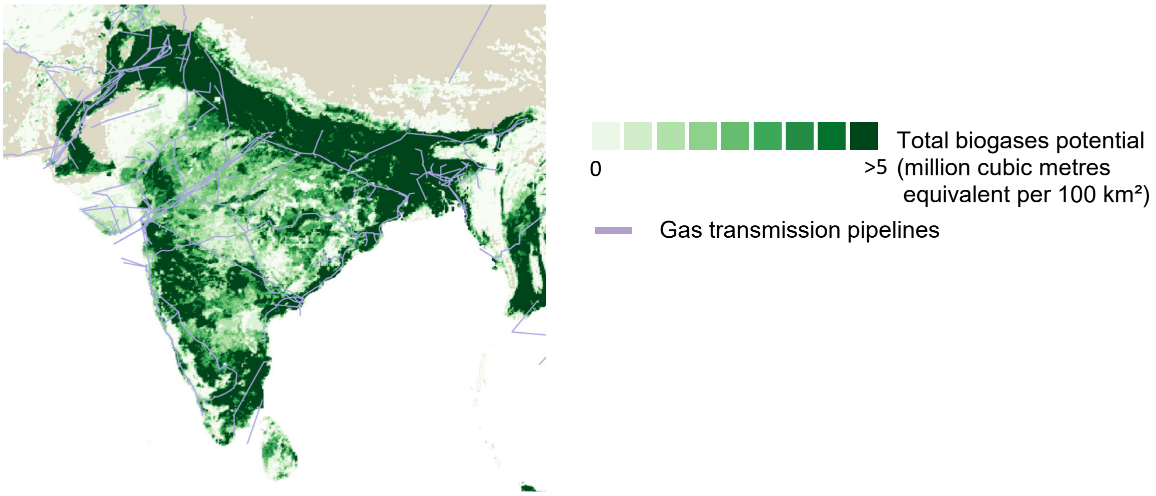
This assessment considers 30 types of feedstocks for biogases across India's agricultural and waste management sectors. They can be broadly grouped together as crop residues, manure and biowaste. This analysis assesses feedstocks that can be processed without direct competition with food for agricultural land or animal feed, and that do not have any other adverse sustainability impacts.

We estimate up to 90 billion cubic metres equivalent (bcme)[3] of CBG could be produced sustainably each year in India. This technical potential is equivalent to around 120% of India's natural gas demand in 2024. Other external estimates also point to major potential.

More than 45% of the total potential is from crop residues – most of which arise from cereals and grain crops – and about 30% is from animal manure. Biowaste makes up 24%, most of which comes from the organic fraction of municipal solid waste (MSW), with the rest stemming from industrial waste and wastewater.

Traditionally, a significant share of crop residues has been burned in fields, particularly in northern India, contributing to severe air pollution. Diversion to anaerobic digestion for biogas production offers a triple benefit: providing a renewable energy source, mitigating open-field burning and its environmental impacts, and producing a nutrient-rich digestate that can be used as a biofertiliser.

Figure 3.1 Assessed potential for biogases development in India and surrounding areas, 2024

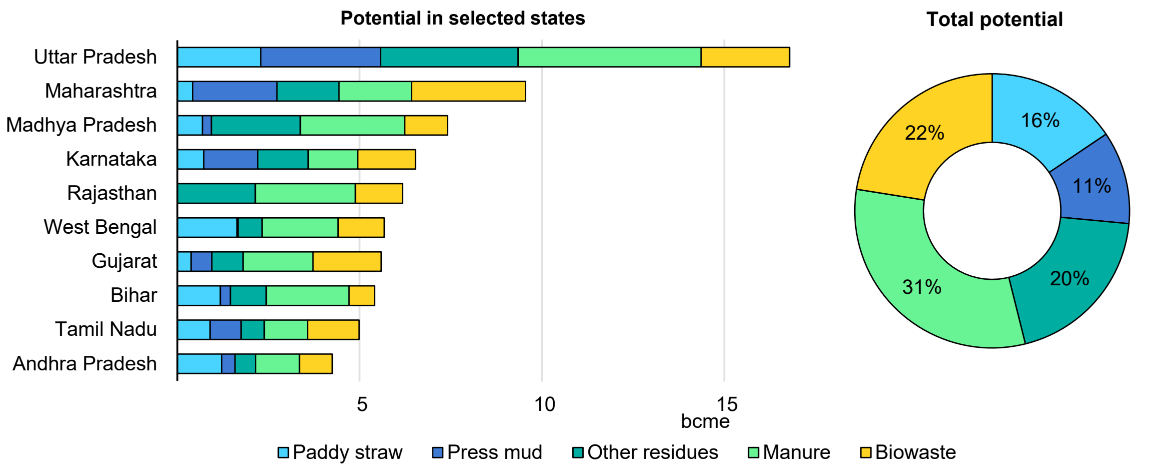


Source: adapted from IEA (2025), Outlook for Biogas and Biomethane.

[3] One bcme is a unit of energy. In this report, it is used with an equivalence of 36 PJ/bcme.

The focus of development in India is on four main feedstock types: paddy straw, press mud, animal manure and segregated organic MSW. Together, these feedstocks make up around 70% of the total identified potential. Uttar Pradesh, Maharashtra and Karnataka have a large share of press mud, while paddy straw is abundant in Uttar Pradesh, West Bengal and Andra Pradesh. There is significant potential for using manure, particularly in small-scale plants, in states with a high cattle population, including Uttar Pradesh, West Bengal, Madhya Pradesh and Bihar. Municipal waste is available in all urban areas. Some cities (e.g. Indore) have implemented strict waste management practices that can help direct the waste to CBG plants. Napier grass is also being considered for use, given its high biomass yield, suitability for use in marginal lands, potential for multiple harvests and relatively limited requirements for water. However, Napier grass is not included in this assessment, as it is grown on marginal land, the potential for which is not captured by our datasets.

Figure 3.2 CBG potential in selected states in India by feedstock, 2024



Source: adapted from IEA (2025), Outlook for Biogas and Biomethane.

Current status

India produces biogas and biomethane. Biogas is produced in all ranges of plant sizes, from small, to community size to industrial scale. However, CBG production requires an expensive gas purification step, and is normally generated in medium and large plants. Historical and current production of biogases is reported in a fragmented form, under the different subsidy programmes. It is generally tracked as installed capacity, or number of plants for the small units.

Biogas

According to MNRE reports, more than 5.1 million **small plants (1-25 m^3/day)** have been installed in rural India since 1981. These plants, built in rural and semirural areas, normally use animal manure from household cattle as feedstock, and produce biogas that is mainly burned for clean cooking. A series of national programmes under MNRE has supported this. Under the Bioenergy Programme, MNRE provides Central Financial Assistance (CFA) of between INR 9 800 and INR 70 400 per plant, depending on the size and location.

The number of these plants increased rapidly during the 1980s and 1990s, when 168 000 new plants were installed each year on average. However, the growth then slowed considerably, down to around 15 000 per year since 2020. Therefore, 82% of total installed plants today are older than 15 years, and only 7% are newer than 10 years.

Some studies report small biogas plants are usually abandoned well before their theoretical technical lifetime. While plants can be designed for a 10-20 year lifetime, depending on the digester technology, average utilisation lifetime can be as low as 6 years. Technical failure, lack of maintenance services, insufficient availability of feedstock, change of fuel for cooking, migration of population from rural areas or other issues can cause abandonment of small plants.

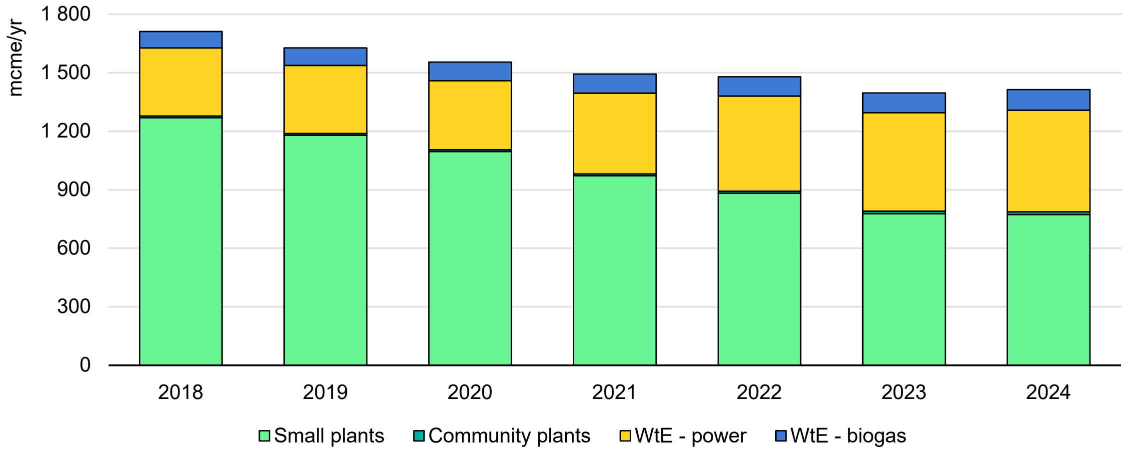
There is no official tracking of biogas production from small biogas plants. To estimate current biogas production, we assume plants over 15 years old are not active, in those built 10-15 years ago, 50% are active and in those newer than 10 years, 85% are still active. Overall, about 500 000 small plants are estimated to be operative. Furthermore, we assume an annual utilisation rate of around 35% to take into account that plants are not operating at their full capacity all year round. Current final biogas production from small plants is thus estimated at 643 million cubic metres equivalent per year (mcme/yr).

MNRE is also funding medium and large **community-scale plants (25/30 2 500 m^3/day)** under the Biogas-based Power Generation (Off-Grid) and Thermal Applications Programme, to produce power and heat from biogas in remote areas not connected to the grid. A cumulative number of 361 community-scale plants have been built across India, with a power generation capacity of 11.5 MW. Estimated biogas generation for this power production, considering a utilisation rate of 35%, is around 14 mcme/yr.

Biogas is also generated in **medium and large facilities** (typically over 2 TPD or 120 m^3/day). The MNRE Waste-to-Energy programme supports these plants, which can produce biogas for direct use in industrial heating, power from biogas or CBG/bio-CNG. Considering only biogas production for direct use and for power generation, annual production is estimated at 630 mcme/yr (at 35% utilisation factor).

Production from small plants has been declining, almost halving from 2018 to 2024. While other sizes of plants have increased their output, overall, the production of biogas has been decreasing in recent years.

Figure 3.3 Biogas production in India under different programmes, 2018-2024



Source: IEA analysis based on data from MNRE Annual Reports 2017-18 to 2024-25.

Biomethane (CBG/bio-CNG)

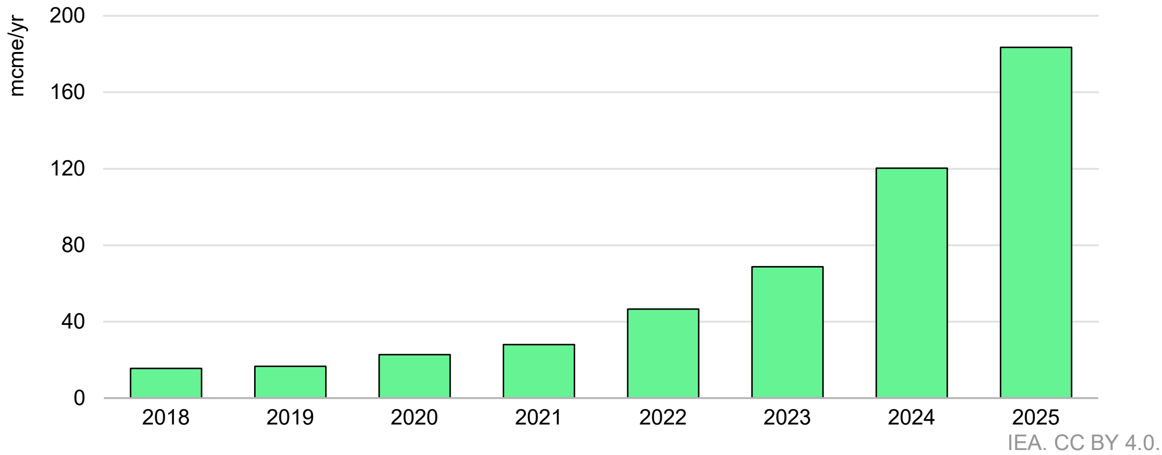
CBG and bio-CNG plants upgrade biogas to meet quality standards required to be blended and used in natural gas infrastructure and equipment. The GOBARdhan registry has reported installed capacity of operational plants since 2023, gathering information on facilities under the MNRE WtE programme and the MoPNG SATAT initiative.

Historical information from different sources differs. The GOBARdhan registry and WtE programme track installed capacity. The SATAT initiative and CBG-CGD Synchronisation Scheme report monthly sales. Production from operating plants varies greatly depending on their utilisation rate, which, in Indian CBG plants, currently varies between 20% and 60%. Additionally, sales under SATAT do not include some smaller transactions completed directly between producers and buyers.

As production takes off, it becomes more relevant to develop tools that track performance and production rates in addition to installed capacity. Given the low plant capacity factors found in India compared to other regions (in Europe, average capacity factors are above 80%), it becomes key to track plant performance and analyse how the sector is maturing.

Assuming an average capacity factor of 35%, estimated production based on the GOBARdhan registry shows significant growth, with estimated production growing over eightfold from 2020 to 2025.

Figure 3.4 Estimated CBG production in India, 2018-2025



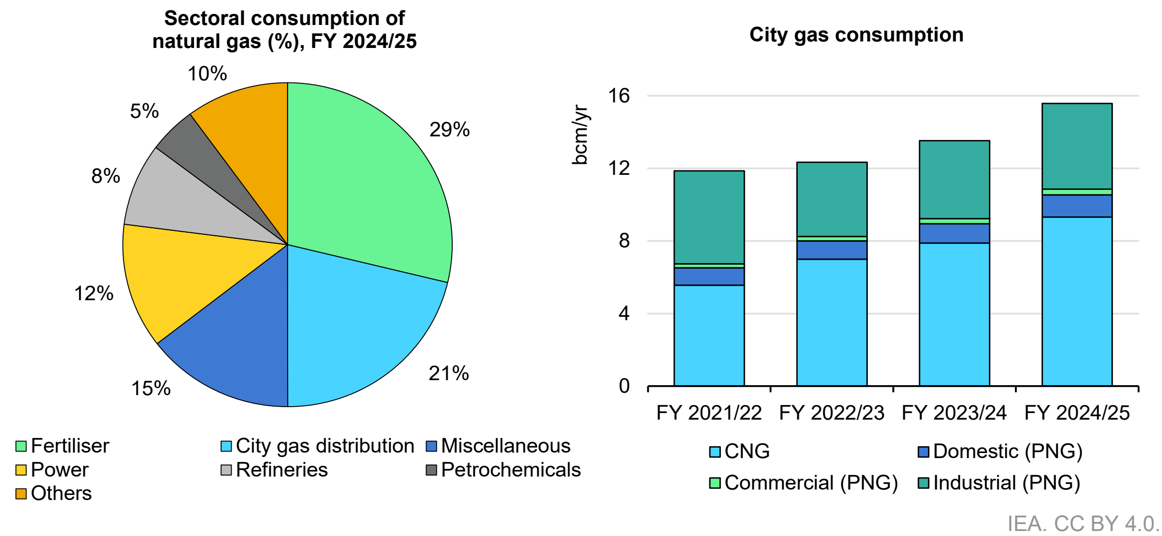
Source: IEA analysis based on data from GOBARdhan Unified Registration Portal, December 2025.

Demand

Biogas can be used directly to provide clean cooking and heat to households and industry, and to produce electricity. CBG is a locally sourced drop-in substitute for natural gas.

India's government is supporting the increase in natural gas consumption and the development of gas infrastructure. CGD networks accounted for 21% of natural gas consumption in India in FY 2024/25. These local grids supply gas for domestic, transport, commercial and industrial uses. City gas consumption has been growing fast, with an average annual 10% growth in the last 3 years.

Figure 3.5 Natural gas consumption per sector in India, FY 2024/25 (left) and historical consumption of city gas, FY 2021/22-2024/25 (right)



Note: bcm/yr = billion cubic metres per year, PNG = piped natural gas.
Source: IEA based on data from MoPNG Petroleum Planning and Analysis Cell (PPAC) (July 2025), India's Oil & Gas Ready Reckoner.

The CBG Blending Obligation (CBO) mandate requests certain shares of CBG use in the transport (CNG (T)) and domestic piped gas (PNG (D)) segments of CGD networks, starting from 1% in FY 2025/26, 3% in FY 2026/27, 4% in FY 2027/28 and 5% from FY 2028/29 onwards. A Central Repository Body will monitor and implement the blending mandate. This will be the main growing vector for CBG/bio-CNG, although the beginning of injections into high-pressure pipelines and the overall expansion of natural gas grids will enable further mix of CBG into natural gas uses.

As CBG is generally more expensive than natural gas, it is recommended to add reinforcement mechanisms to the blending obligations to ensure targets are met. Different alternatives are being used in different countries with this aim.

Nascent biomethane markets have traditionally used publicly funded tools, such as feed-in-tariffs and feed-in-premiums, as guaranteed subsidy payments to producers. In feed-in tariffs, for example in France (until 2020) or in Germany (for power production from biogas and biomethane), the government purchases biomethane at a certain price, establishing long-term contracts of around 15 years. In contrast, feed-in premium contracts, such as the ones operating in Denmark or Italy, subsidise the difference between biomethane production cost and the price producers receive when selling their molecules at the price of natural gas plus a margin.

As markets mature and production becomes more efficient, some governments look for market-based tools that do not rely on public subsidies, but pass the cost to end users. Some mandates are an example of this. Obligated parties, usually gas marketing companies, are required to buy certain green certificates from biomethane producers to prove compliance with obligations. This is the case in France, which has recently moved from a feed-in tariff system supported by government subsidies to a mandate-based system. To reinforce compliance with the mandate, there are penalties of EUR 100/MWh for non-compliance. Brazil's 2024 regulation under the Fuel of the Future Law sets biomethane blending mandates and indicates administrative fines and the possibility of partial or total suspension of operations for non-compliance. In the United States, the Environmental Protection Agency has the possibility to release cellulosic waiver credits if annual production of biomethane is expected to be lower than obligated volumes. Obligated parties can then purchase waiver credits to show compliance.

As Indian biomethane production is in its early development stage, government support would be beneficial to ensure fast development. Systems that integrate feed-in-premiums or other public support could be applied to control the cost that is passed to final consumers while the sector is still streamlined. Blending obligations can set the reference for volume subsidy needs. As production matures and optimises and production costs decrease, public incentives can be lowered and market-based tools could be introduced.

Transport

In India, compressed natural gas (CNG) is the largest segment in city gas (60% in FY 2024/25) and the fastest-growing one, with an average growth of 22% per year from FY 2021/22 to FY 2024/25. There are currently around 8 000 CNG service stations across the country, with a target to establish 17 500 pumps by 2030 to supply an increasing fleet. Sales of CNG passenger vehicles have tripled from a share of 6.3% in 2020 to 19.5% in 2025. India's CNG vehicle fleet is mainly represented by private passenger vehicles, auto-rickshaws (three-wheelers), taxis and, to a minor extent, public buses and commercial vehicles.

The Government of India has a strong focus on the adoption of CBG in transport, supporting it through the SATAT scheme, the CBG-CGD Synchronisation Scheme and the CBO.

Unlike in India, bio-CNG in Europe is mainly consumed by heavy duty vehicles and buses (e.g. urban bus fleets). Liquified biomethane (bio-liquefied natural gas (bio-LNG)) is used, to a lower extent, in long-haul trucks. A higher use of CNG and bio-CNG in trucks in India, or the production of bio-LNG for long-haul trucks, could be an opportunity to displace some of the use of diesel for long-haul transport.

Additionally, bio-LNG, not produced in India at the moment, can be used in maritime shipping, fuelling gas-powered vessels. This market is in its early stages in some countries in Europe and in the People's Republic of China.

Industry

In FY 2024/25, industry subsectors consumed around half of natural gas demand in India, with fertilisers representing 29% of the total use, followed by refineries (8%) and petrochemicals (5%). Additionally, about one-third of city gas was consumed in industry. There is an opportunity to provide CBG for industrial uses, for energy and non-energy uses, such as in fertiliser production, substituting fossil fuel sources (natural gas, coal and oil). Industry's interest is rising, driven by voluntary corporate decarbonisation goals, where emissions intensity plays a key role. Additionally, regulated entities and sectors in Phase 1 under the Indian Carbon Market (iron and steel, fertilisers, petroleum refining, petrochemicals and textiles) will have binding emissions targets when the market becomes operational, expected in mid-2026. Under this scheme, CBG use will not count towards fossil fuel emissions.

There are three main requirements to enable a wider adoption of CBG in industry in India:

- Implementation of a fully operational market for carbon credits and reduction obligations in industry. The Indian Carbon Market will cover scope 1 and scope 2 emissions. There is an approved methodology to account for emissions reductions due to CBG use.

- Transparent and credible certifications for renewable gases. As CBG is increasingly mixed with natural gas, it will be necessary to track its renewable origin, via guarantees of origin or similar certificates. Additionally, although not used in India yet, many countries set sectoral emissions reduction targets (e.g. for transport or heating) and fuels entering the pool must report their carbon footprint, calculated using a lifecycle analysis methodology that includes all production steps in the supply chain. This allows comparison of renewable fuels among themselves and with fossil fuels, as well as to set rewards based on best performance and environmental benefits.
- To allow for open access to gas grids. Mechanisms such as mass-balancing or book and claim could support market access to those industrial sites that do not have a direct connection to a CBG plant and give offtake flexibility to producers. These would enable the use of renewable gas purchase agreements between producers and industry, similar to power purchase agreements (PPAs). In the international context, the European Union applies a mass-balance approach, allowing sales between buyers and producers that are physically connected through the European gas grid, even in different countries, following a specific protocol. The United States operates a book-and-claim system, where environmental certificates are traded between producers and consumers even without a grid interconnection. In this case, rigorous registries to extend and cancel certificates are critical to avoid double-counting and keep high credibility in the system.

Key considerations

Biogas and biomethane are homegrown resources, generally produced close to where they are consumed, thus creating local value for rural and urban communities. The technologies and supply chains required to produce biogases are mature and well known, and they score highly on energy security.

However, although India has had decades-long experience with small-scale biogas production, the CBG sector is still in an early phase of development. While the main policies in place are driving investment and demand, they are still under development and being adapted. The key issues the sector is facing in India are:

- feedstock management, including aggregation, storage and pretreatment
- cost-competitiveness of CBG production
- creation of a market for the co-product of anaerobic digestion, FOM
- development of gas infrastructure and injection into pipelines or CGD networks
- development of an industrial and technological ecosystem for biogases, including technical standards and prospects for international collaboration

- incorporating sustainability indicators into the policy architecture for CBG that can galvanise the sector, including the potential for monetising biogenic carbon dioxide.

Feedstock logistics

India's vast potential for leveraging organic waste is matched by the daunting complexity of the supply chains needed to harness them. A large share of India's agricultural residues is dispersed across multiple relatively small landholdings, complicating feedstock aggregation and logistics. Many landowners lack the infrastructure for gathering and storing feedstock; in situ stubble burning is a more common way of managing residues. The residues collected have competing uses such as animal feed, composting or soil mulching, which can limit availability.

Seasonal variability complicates plant operation, as biomethane facilities require a steady and predictable feedstock supply to remain economically viable. The period during which paddy straw is available for collection is usually less than 2 months. This compresses gathering and logistics operations into a short window, thus increasing competition for equipment and complicating efforts to secure offtake agreements with farmers. Long-term storage of sileage can alleviate this issue, but there are risks such as potential fire, moisture management or loss of methane yield over time (which also raises environmental concerns linked to fugitive methane leakage).

Feedstock quality and consistency present another significant challenge, particularly for municipal waste streams. Pre-segregation of waste is the main hurdle to scaling up the use of MSW in CBG plants. Inadequate source segregation leads to contamination with plastics, inert materials and hazardous waste, which can damage digestion equipment and reduce biogas yields. Pretreatment requirements (e.g. sorting, shredding and slurry preparation) add to capital and operating costs. Similar issues arise with agro-industrial effluents, where variations in composition, high sulphur content or toxic compounds can inhibit anaerobic digestion if not carefully managed.

The Indian CBG sector is overcoming feedstock procurement challenges through several initiatives, such as through farmer producer organisations. These bodies, operating at the block or district level, can aggregate and diversify feedstock supplies, improve project bankability, and spread contract and credit risks. Nonetheless, many remain weakly capitalised, and farmer producer organisations work best when paired with anchor buyers and clear performance-linked contracts.

A scheme to subsidise machinery to collect paddy straw and other crop residues has been ongoing since 2018 and has helped distribute around a quarter of a million machines to farmers across India. This has been instrumental in closing the gap between residue generation and consistent commercial supply to CBG producers. However, utilisation of equipment is sometimes uneven, and transport, storage and densification requirements can add costs and logistical hurdles that farmers alone may be unable to bear.

Cost-competitiveness

The cost-competitiveness of CBG in India remains one of the central challenges to scaling up the sector, despite strong policy support and abundant feedstock availability. At present, the levelised cost of CBG production is generally higher than the delivered price of natural gas, particularly domestically produced gas and administratively priced gas supplied to priority sectors. This cost gap persists even though CBG delivers environmental and social co-benefits that are not fully reflected in market prices.

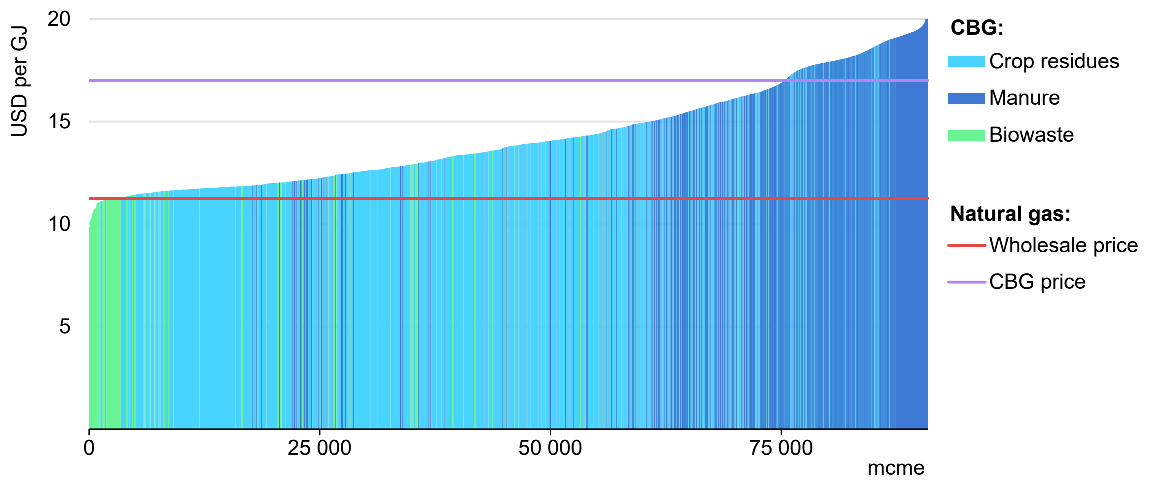
The cost of collecting and transporting low-density biomass can represent a substantial share of the total project expenditure. Farmers are generally hesitant to enter into long-term offtake agreements with CBG producers, making feedstock costs an uncertain part of overall operating expenditure. Additionally, the high cost of land can be an impediment. There is also potential competition for feedstocks for other bioenergy pathways, for example through the pelletisation of crop residues for co-firing in coal-fired power plants.

In our assessment, we assume paddy straw costs around INR 1/kg; beyond INR 3/kg, the price becomes uneconomical. For manure, the cost of collection and storage is assumed to be around INR 0.2/kg. For biowaste – primarily the organic fraction of MSW but also industrial waste and wastewater – the cost is assumed zero, as the capital and operating costs associated with segregating the feedstock are assumed to net out the waste disposal charge collected by the CBG producers. Some CBG producers have secured pre-segregated MSW or residues from the sugar industry for zero cost.

There is considerable variation in these values, depending on how plants are developed. For example, many CBG plants target a single feedstock. While this avoids extra capital and logistics costs associated with processing multiple waste streams, mixed feed plants can offer higher yields as well as greater feedstock security through diversification. In our feedstock allocation model, areas are clustered based on density and diversity of feedstock, as this can drive down overall costs per unit. The economic case for biogas improves when biodigesters have a high capacity, are favourably located (e.g. close to feedstock sources, gas networks or local offtake) and where co-benefits (e.g. the ability of biogas plants to treat wastewater with high levels of organic pollutants) are recognised and remunerated.

CBG plants also require capital investment. These include for anaerobic digestion, biogas purification, compression and bottling infrastructure to meet automotive fuel or grid-injection standards. For small- and medium-scale projects, these upgrading and compression systems can account for a large share of total project costs, thus limiting the economies of scale. However, even though the technologies to produce biogases are mature, we assume there are significant learning effects that can drive down costs in India (see the section below on technological development).

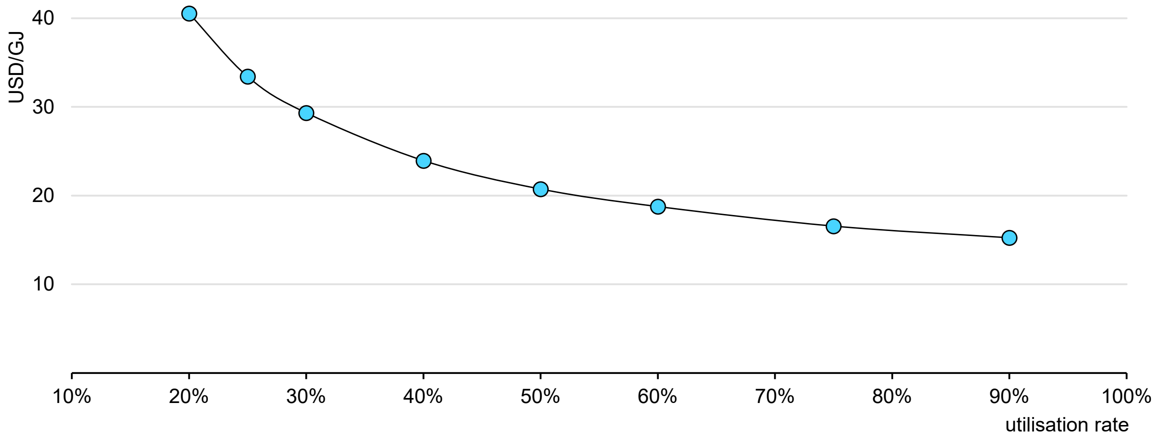
Figure 3.6 Cost curve for CBG production in India by feedstock compared to benchmark prices, 2024



Our analysis suggests around 80% of India's biomethane potential, or around 75 bcme, can be produced for under the CBG procurement price of around USD 17/GJ (INR 1 478 per million British thermal units (MMBtu), or 85% of average CNG prices). This analysis assumes plants operate near their nameplate capacity. However, several existing large-scale plants appear to be operating much below their nominal capacities. A report by the Petroleum and Natural Gas Regulatory Board indicates the range of installed capacity use can be 20-60%. This range is much lower than those in other regions with mature industry such as Europe, where utilisation rates are usually above 80%. The causes range from seasonal variability in feedstock availability, operational downtime due to maintenance, limits to the amount of FOM that can be locally absorbed and other constraints that reduce effective operating hours. This increases production costs because the capital costs of the plant are spread across less output, straining the economic competitiveness of biomethane projects.

We undertook a sensitivity case analysis exploring the median cost of biomethane under different utilisation rate assumptions. Operating at 90% of nameplate capacity can mean biomethane can be produced for around USD 15/GJ (this is around 25% higher than imported LNG in 2025). However, an average utilisation factor of 35% raises median costs above USD 25/GJ, two-thirds higher than imported LNG in 2025.

Figure 3.7 Biomethane median cost under different utilisation rate assumptions in India, 2024



Even with high utilisation rates, biomethane may still struggle to be economic in India, as its outputs compete with other subsidised energy products. CBG is typically sold to OMCs under long-term offtake agreements at fixed prices or injected into CGD networks and sold at a uniform administered price. In both cases, OMCs and CGD operators blend CBG into their broader gas supply portfolios.

In practice, CBG is procured at a premium to natural gas by these offtakers. However, gas prices further downstream, whether for natural gas or CBG, are subject to administered pricing mechanisms. These constrain the ability to fully pass through the higher cost of CBG to end users, despite the positive environmental externalities (see the sustainability and green certification section below).

Moreover, as a fungible substitute for natural gas, CBG ultimately competes with subsidised liquefied petroleum gas in household and commercial energy use, limiting its pricing headroom. The co-products of CBG (e.g. fermented organic manure) must also compete with chemical fertilisers, which are heavily subsidised and sold at maximum retail prices that are often below their cost of production.

Marketing organic fertilisers

As biogas and CBG production expands in India, the management and commercialisation of digestate as a co-product is increasingly emerging as a limiting factor for the sector's growth. To address this challenge, some producers are exploring ways to develop a viable market for FOM derived from digestate and other value-added products to improve overall project economics.

Once biogas is produced, the remaining digestate – comprising the exhausted material after anaerobic digestion – is filtered to separate the solid and liquid fractions. The liquid fraction can either be recirculated back into the digester, in the case of plants using paddy straw as a feedstock, or it can be used directly as LFOM for soil application, where it contributes valuable nutrients. Meanwhile, the solid fraction is rich in organic carbon and contains a nutrient composition that varies according to the type of feedstock from which it was derived.

In February 2025, a new regulatory amendment introduced a specific category for **organic carbon enhancers** under which FOM can be formally recognised. This development is particularly significant in the Indian context, where soil organic carbon levels have declined sharply from around 1% in the 1950s to just 0.3-0.6% in 2025 – well below the 1-1.5% threshold considered necessary for healthy soils. Soil organic carbon plays a critical role in maintaining soil fertility and structure, improving water retention and erosion resistance, and supporting beneficial microbial activity. By supplying stable organic matter, FOM can help rebuild soil organic carbon over time and enhance land productivity. While FOM also contains nutrients such as phosphorus, potassium and nitrogen, its composition is variable, which is a negative aspect for farmers. It should be used as a supplement to chemical fertilisers rather than a full substitute; however, as soil fertility improves, reliance on chemical inputs is expected to decrease progressively.

This type of product is still relatively unknown among farmers. To address this, CBG producers are conducting awareness campaigns, including free product trials, to demonstrate the agronomic benefits of FOM. Some producers are developing enriched formulations such as PROM that would add value to their co-products.

Targeted policy instruments can help to support the development of this nascent market. The existing MDA scheme, providing INR 1 500 per tonne of FOM, LFOM or PROM sold, and available for 3 years (FY 2023/24 to FY 2025/26) is well perceived by producers, who are demanding it is prolonged after April 2026.

However, MDA implementation poses some challenges. In the first place, some agriculture regulations limit digestate spreading on fields with standing crops. This constraints its application to a narrow window between harvesting and sowing of the new crop. Given the large volumes of digestate generated, this may prevent plants to be operational all year round at their full capacity. Additionally, MDA applicants need to provide quality certifications, but laboratories accredited by the National Accreditation Board for Testing and Calibration Laboratories are scarce. Moreover, plants need to conduct certain inspections. All these create delays for the plants to obtain the MDA support. FOM regulation falls under the Ministry of Agriculture and Farmers Welfare, the Department of Fertilizers, and, as a CBG co-product, the MoPNG, plus additionally state authorities that intervene in the implementation. Cross-sectoral synchronisation of measures is necessary to ensure harmonisation and streamlining of bottlenecks.

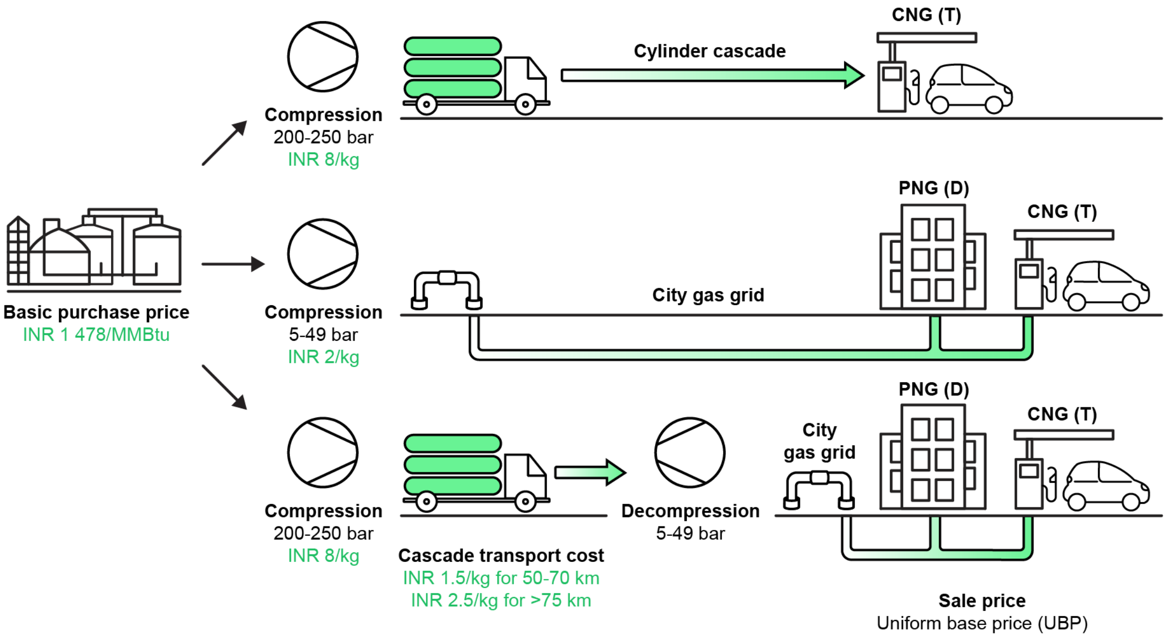
Building distribution infrastructure

As part of its energy strategy, the Government of India aspires to increase the share of natural gas in the primary energy mix from current levels of around 6% to 15% by 2030. As a result, and also due to the expected overall energy consumption increase in India, natural gas demand is forecast to increase by 60% by 2030 from 2025 levels. To support this growth, the MoPNG has developed the One Nation One Gas Grid programme, to expand the pipeline infrastructure across the country, with a 63% expansion already under construction.

In this context, the Government of India is supporting the production of national CBG. This will decrease the need to import LNG, with two policy tools focusing on enabling CBG distribution: the CBG-CGD Synchronisation Scheme and the DPI.

The **CBG-CGD Synchronisation Scheme** was issued in 2021 and extended in 2023 to complement the SATAT programme. The scheme fills in the distribution gap between CBG producers and oil and gas marketing companies, obligated CBG offtakers under SATAT. Through the synchronisation scheme, GAIL, as the mandated aggregator, sets tripartite contracts with CBG producers and CGD entities at a CBG regulated price (uniform base price). This includes fees for compression and transport in mobile cascades (pressurised cylinders on trucks) or injection in city gas grids. The scheme is well perceived by producers, as it gives them a structured offtake route.

Figure 3.8 Options for CBG delivery to retail outlets and domestic users under the CBG-CGD Synchronisation Scheme



Notes: Basic purchase price set in June 2025. Transportation and compression charges as in the pricing structure under the CBG-CGD Synchronisation Scheme applicable from 1 November 2025 to 30 April 2026.

As of 2025, only 17 CBG plants are connected to CGD networks, comprising 15% of functional plants. Most transport their output via mobile cascades that enable CBG offtake when production is far from the retail outlets or CGD networks, without investment in infrastructure. However, it is relatively expensive and requires complex truck logistics to match production and daily demand from retail outlets. Transport via direct injection is more flexible and safer, has a lower carbon footprint and is more adequate for large production volumes. With new bigger plants of around 20 TPD capacity and mandatory blending obligations, pipeline infrastructure will become increasingly essential for a reliable offtake.

Distribution technology is developing fast. In July 2025, India's first steel pipeline was used to connect a CBG plant to a CGD network – an upgrade from medium-density polyethylene pipelines.

The **DPI** scheme, issued in 2024 and revised in 2025, is allowing for faster construction of connections. It provides financial support for the laying of new pipelines to connect CBG plants to CGD networks or to the gas pipeline network. It covers around 50% of the project cost, depending on pipeline material and distance. CGD entities, CBG producers or gas pipeline operators can apply for it. Gathering production from CBG plants in a cluster is preferred. The scheme targets the connection of 100 CBG plants.

Technological development

India's industrial ecosystem for the production of biogas and CBG is just beginning, but it is improving rapidly. There has been a surge in national technology providers in recent years. Indian technology is now available for anaerobic digestion systems. In addition, specific equipment (e.g. compressors, gas purification systems or odorisation units) is increasingly being manufactured domestically. Nevertheless, technologies for gas upgrading, especially pressure swing adsorption units and separation membranes, still depend on imports.

Some existing technologies, initially developed for operation in Europe, need adapting to India's local conditions. For example, biodigester design needs adapting for a tropical climate (e.g. temperature variations or monsoon impacts), and pretreatment and processing equipment and biomass aggregation machinery, need adapting to domestic feedstock. In terms of feedstock, technology is well established for press mud, cow manure or chicken litter, but needs development for rice straw.

Availability of a skilled workforce for operations, quality control and microbiology monitoring is still limited in India, but training of personnel is increasing. There are few accredited laboratories for quality testing for compliance with the CBG standard, and limited real-time gas quality monitoring systems are installed in plants. It is recommended to develop protocols and production equipment for digestate processing and FOM, LFOM and PROM production.

There is a growing service network providing maintenance in the states with the highest plant concentration, such as Gujarat, Haryana, Punjab and Uttar Pradesh. However, there are major regional disparities in technical ecosystems, with Punjab and Haryana being more advanced than other states such as Madhya Pradesh, Rajasthan or the eastern states.

Technical standards

In term of standards, there is a clear CBG quality standard: the Indian Standard (IS) 16087:2016, recently revised to IS 16087:2025, specifies a minimum methane content of 95% mol, and a maximum combined content of carbon dioxide, molecular nitrogen and molecular oxygen of 5% mol, among other specifications.

However, as the industry evolves and grows in India, it will be necessary to develop standards for production operations and safety and environmental safeguards, facility construction, gas conditioning and injection, and digestate handling.

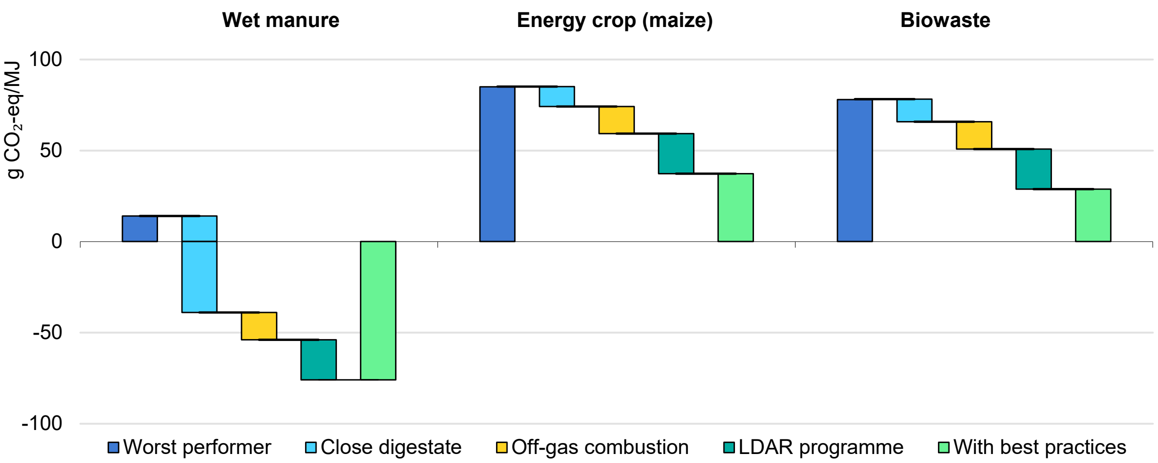
International co-operation

International co-operation to create local expertise can be useful to accelerate the sector's growth. There have been some positive international collaboration models, such as the Germany-India co-operation, the India-Japan partnership or the creation of the Global Biofuels Alliance. Other mechanisms to boost local expertise development are technology transfer agreements with licensors, joint research projects, training programmes or technology missions to leading biogas countries for knowledge acquisition.

Sustainability and green certification

As biogas and CBG production develops, it is good practice to ensure it contributes effectively to a more sustainable energy system. Sustainability covers many different aspects, such as reduction of GHG emissions, preservation of biodiversity, sustainable water management and compliance with social safeguards.

Figure 3.9 Reference emissions reduction in biomethane production in the European Union when best practices are implemented



Notes: g CO_2-eq/MJ = grammes of carbon dioxide equivalent per megajoule, LDAR = leak detection and repair. The value for worst performer using wet manure includes a methane avoidance credit. "Close digestate" refers to closed digestate tanks. "Off-gas combustion" relates to the flaring of off-gases generated in the upgrading and purification of biogas.

Sources: IEA (2025), Outlook for Biogas and Biomethane, based on data from the European Union (2023), Renewable Energy Directive, Annex IV, updated with revised methane leakage values from European Commission Joint Research Centre (2024), Methane emissions in the biogas and biomethane supply chains in the EU.

The use of biogas and CBG/bio-CNG has the potential to lower GHG emissions, when considering the whole lifecycle, compared to fossil fuels. However, their emissions performance will largely depend on what type of feedstock is used, how the process is designed and operated, the carbon footprint of the energy sources used in production, and the management of methane fugitive emissions in CBG production and transport. When best practices are used, significant reductions in

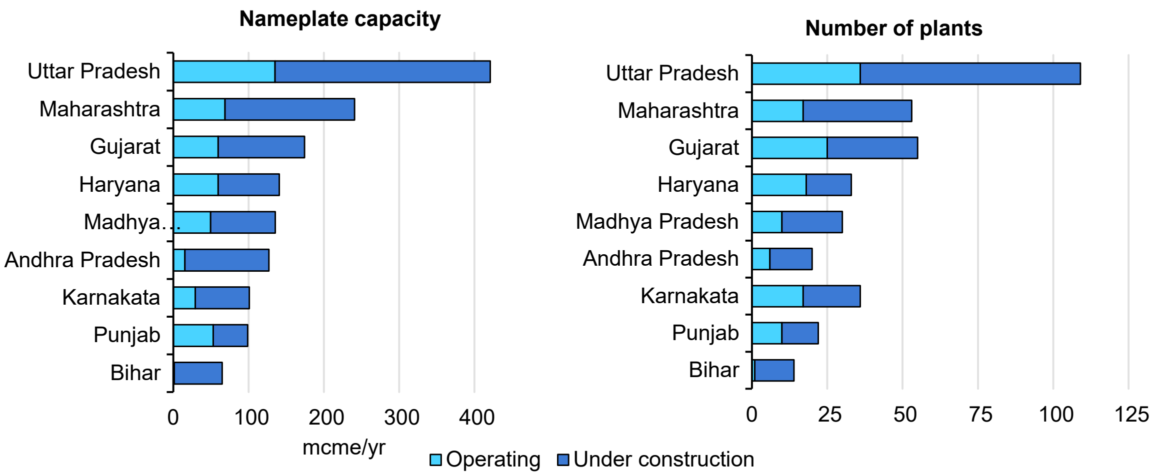
GHG emissions can be achieved for different types of feedstocks. Crop inputs generally have higher emissions than wastes or residues, as their score includes energy used in the cultivation.

Supply forecast to 2030

New projects

Despite slower than expected growth in SATAT's first years of implementation, the pipeline for new projects is expanding quickly in India. From 34 operating plants in 2020, at the end of 2025, 173 CBG plants were functional and a further 288 were being commissioned or under construction. This brings the total nameplate capacity in coming years to almost 3 700 TPD (1.8 bcme/yr), up from 1 140 TPD or 0.5 bcme/yr in 2025. More than 800 other projects have been registered in the GOBARdhan registry, but have not yet started construction. Uttar Pradesh leads with 36 operating plants and is set to triple capacity to more than 0.4 bcme/yr, with 77 plants under construction.

Figure 3.10 Operating and under construction CBG plants in India, 2025



Note: "Under construction" includes plants completed but not yet functional.
Source: IEA analysis based on data from GOBARdhan Unified Registration Portal, December 2025.

The sector is attracting investment interest among major national and international companies. Several joint ventures between oil and gas companies and engineering or operating CBG companies have been announced.

Forecast to 2030

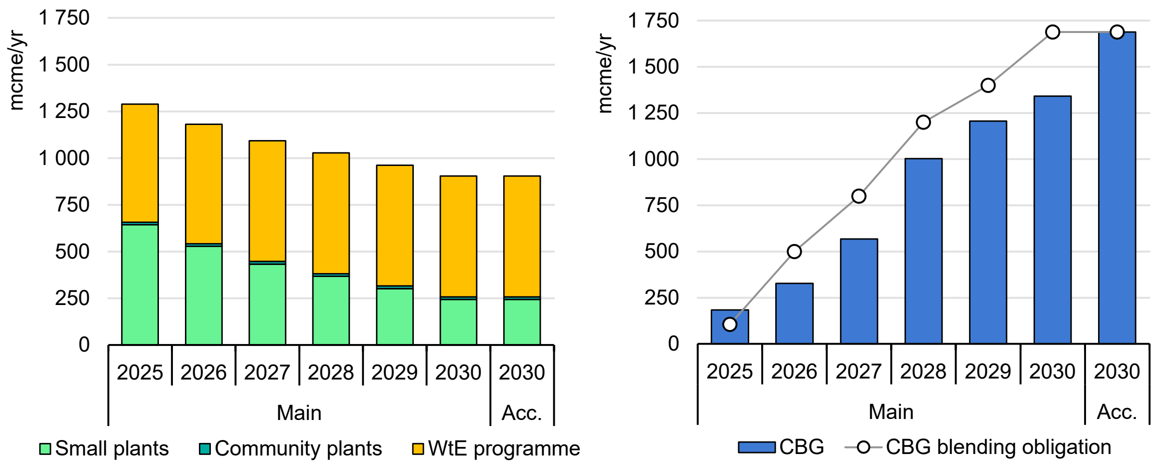
Taking into account current policies and development of the sector, expected growth for biogas and CBG combined is 53% between 2025 and 2030 in the main case forecast. This forecast includes the continuation of the slow decrease in the production of **biogas** seen in the last decade, especially in small household facilities in rural areas. MNRE's National Bioenergy Programme Phase I ends in March 2026. It is not known if the programme will release a Phase II.

CBG and bio-CNG are expected to grow more than sevenfold during 2025-30 in the main case forecast, reflecting the wave of projects under construction and announced registered in the central GOBARdhan registry.

The blending obligation mandates a 5% mix from FY 2027/28 onwards. Future annual volume obligations will depend on the pace of natural gas consumption growth. For reference, consider the Petroleum and Natural Gas Regulatory Board's Good-to-Go projections for natural gas consumption to 2030 (around 297 million standard cubic metres per day (MMSCMD) natural gas consumption by 2030, of which about 87 MMSCMD is expected in the CGD sector). Under this scenario, expected production from registered projects, with the current average utilisation rate, would fall 21% below the 2030 target. However, it is expected new projects will be added to the registry in coming years if the positive perspectives for the sector continue. Another aspect that could boost CBG production further on is an improvement in plant utilisation rates. With the existing project pipeline and an increase of utilisation rate to an average of 44%, the blending targets could be reached without further investment in new plants. This highlights the importance of increasing the plant utilisation rates.

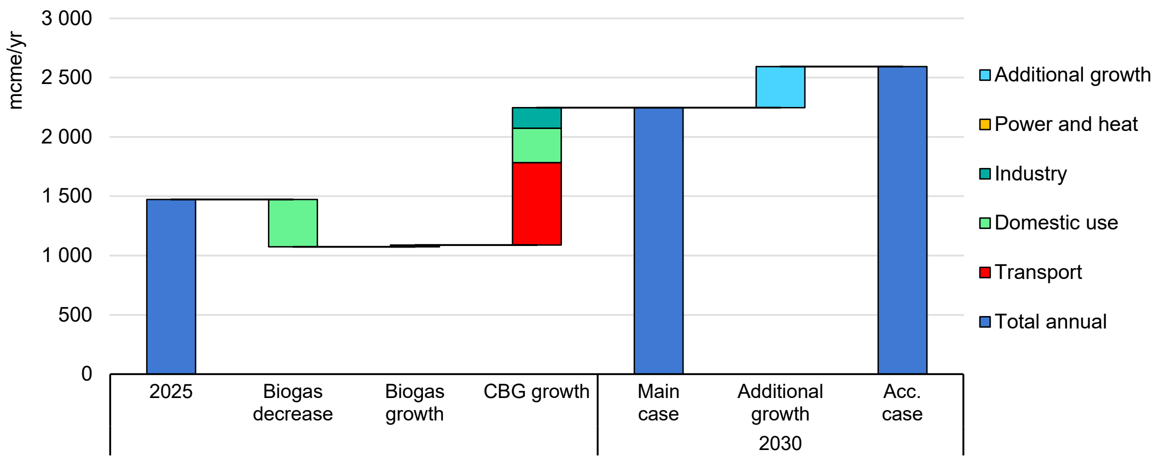
The forecast main case reflects the current status of project pipeline and utilisation rate. The accelerated case assumes the blending targets are achieved, either with additional investment or with a production increase in existing plants.

Figure 3.11 Production forecast of biogas (left) and CBG (right) in India, 2025-2030, and estimated CBG volumes under blending obligations



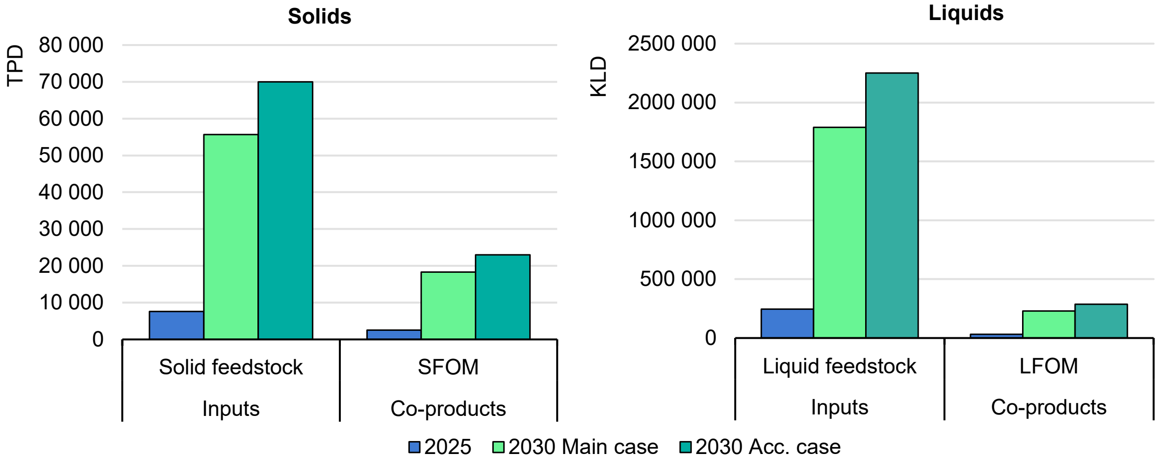
Growth in 2025-2030 is expected to supply mainly transport use, supported by a growing gas-powered fleet and related blending targets. Additionally, the domestic sector in CGD networks, also under the CBO, will continue to increase its consumption. Industry will see slower demand growth, from sites connected to CGD grids and also from direct connections and transfers through the high-pressure pipelines. However, a more accelerated growth in industry is expected after 2030, as the gas grid infrastructure develops and a broader green certificate market is available.

Figure 3.12 Forecast growth of combined biogas and CBG per sector to 2030 and additional growth in an accelerated case in India



As new plants are constructed and start operation, it is important to take into account **how this growth affects the supply chain**. To achieve blending targets, solid feedstock will need to increase from the current 7 600 TPD (reported in GOBARdhan registry entries) to around 70 000 TPD in 2030. On the output side, the co-products produced from digestate will grow from around 200 TPD now to 23 000 TPD in 2030, only for the solid fraction of the digestate. These numbers highlight the importance of supporting the development of robust supply chains especially regarding feedstock collection and digestate offtake, as discussed in previous sections.

Figure 3.13 Forecast growth of feedstock needs and digestate co-products for CBG production to 2030 in India



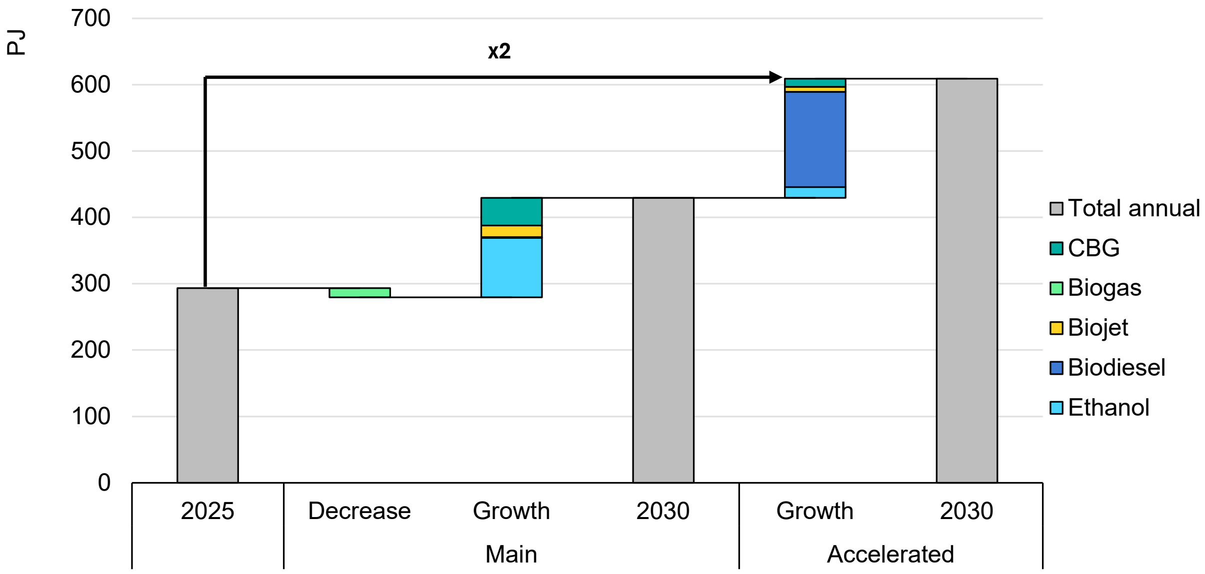
Note: KLD = thousand litres per day, SFOM = solid fermented organic manure.

Chapter 4. Conclusions and policy priority actions

Liquid and gaseous biofuels forecast to 2030

With supportive policies and increasing demand for renewable energy, demand for liquid and gaseous biofuels is forecast to increase over the next five years. In the main case demand grows by nearly 50% - from 293 PJ in 2025 to 429 PJ by 2030. Ethanol makes up over 60% of this growth with continued support from a suite of supply, demand and innovation policies, while CBG makes up 30%, driven by the large number of facilities under construction. Biodiesel and biojet make up the remaining amount.

Figure 4.1 Liquid and gaseous biofuels demand forecast in India, main and accelerated cases, 2025 and 2030



In the accelerated case, demand more than doubles - from 293 PJ in 2025 to 609 PJ by 2030. Biodiesel makes up 80% of this growth, as India rapidly scales up biodiesel and achieves their 5% blending target, while ethanol makes up 10% of this growth with additional growth supported by policy and greater deployment of flex-fuel vehicles compared to the main case. CBG and biojet also grow as gas grid infrastructure develops, broader green certificate markets are established, and support for biojet increases to improve feedstock supply, innovation and investment in new production capacity.

Policy priorities for action

India has quickly begun to scale up the deployment of liquid and gaseous biofuels over the last several years, with strong success already in some liquid and gaseous biofuels such as ethanol and biogas. Short- to medium-term targets and demand-oriented policies, financial support for innovation and supply chain development have initially driven this scale-up. However, targeted support will be necessary for continued deployment of liquid and gaseous biofuels to 2030.

At the thirtieth session of the United Nations Conference of Parties (COP), Brazil announced the Belém 4x Pledge on Sustainable Fuels - a global initiative to quadruple the use of sustainable fuels by 2035. The Pledge was endorsed by India and over 20 other countries. The IEA provided the analytical baseline for the pledge in the Delivering Sustainable Fuels: Pathways to 2035 report which suggested key policy recommendations to support their deployment. This chapter suggests adapted recommendations for policy priority action in India.

Priority 1: Establish roadmaps, targets and policies for implementation to support long-term demand

Challenge: India has taken strong supportive actions, such as the development of the NPB, EBP, SATAT initiative and CBO, to grow demand for liquid and gaseous biofuels. These have provided important investment signals for ethanol and CBG. However, broader longer-term roadmaps, targets and demand are needed for SAF to support deployment, giving investment certainty and allowing for the development of economies of scale, supply chains and infrastructure.

Policy response: Development of a sustainable fuels strategy or roadmap, that takes into account liquid and gaseous biofuels, setting clear and time-bound targets could continue to provide long-term investment signals and scale-up of these fuels. This could also help support alignment across central and state government departments in developing and implementing targets, identifying feedstock supply and existing infrastructure, and developing funding mechanisms and policies to support deployment. Strategies or roadmaps should be done in consultation with industry and other stakeholders, and updated periodically, to ensure the appropriate policies are developed to reflect regional challenges and opportunities.

In addition, strategies and roadmaps should be complemented with a suite of policies that help achieve targets. For emerging fuels (e.g. biojet) this should encompass a range of policies to derisk investment, build supply chains, and create stable demand such as quotas, mandates, public procurement and funding for research and development. For more established fuels (e.g. ethanol, CBG) this should include continued support for demand and affordability, and compliance reinforcement through policies such as publicly supported tariffs or market-based quotas with penalty mechanisms with compliance waivers for flexibility when production is expected to be lower than quotas.

Selected policy examples:

Brazil's Fuel of the Future Law established new blending targets for ethanol and biodiesel and established programmes for renewable diesel, SAF and biomethane, building on its existing performance-based requirements (RenovaBio) and financial support for sustainable fuels in road transport, aviation and industry.

Malaysia's National Energy Transition Roadmap is a long-term strategy guiding the development of energy efficiency, renewable electricity, sustainable fuels, green mobility and carbon capture. It sets complementary targets for biogas, biodiesel and SAF, and outlines their use across power generation as well as road, aviation and marine transport.

In Europe, feed-in-tariffs for biomethane are in place in Finland, France (until 2020) and Germany. Austria and Italy use feed-in-premiums, taking into account natural gas market price plus a premium. France has recently moved to a mandate based on green certificate trading, and Ireland has a similar approach to biomethane used for heating.

Priority 2: Develop supply chains and address infrastructure and integration needs

Challenge: Accelerating the adoption of liquid and gaseous biofuels in India requires well-designed supply chains and distribution infrastructure to meet growing demand. Many feedstocks are by-products or residues from other sectors and are often disaggregated across the country, making fuel producers dependent on external value chains. In addition, some co-products from the CBG industry (e.g. FOM) need to develop new markets at a large scale. Furthermore, the distribution and storage of biofuels can sometimes rely on existing infrastructure designed for conventional fuels or require expansion to meet growing demand.

Policy response: India could bring together relevant central and state government departments to support the development of integrated supply chains that leverage commonalities among fuel producers, feedstock suppliers and existing infrastructure. This could include the development of a national biomass inventory, using agricultural statistics, to help support strategic planning and avoid competition for feedstocks. Infrastructure planning should also anticipate long-term needs, including feedstock aggregation and competition, transportation networks and storage facilities.

Selected policy examples:

India's National Green Hydrogen Mission provides support across the entire value chain from public funding for research, pilot, demonstration and hydrogen infrastructure projects, to the development of codes and standards in partnership with industry, to labour market development. This can be replicated for other fuels.

France has developed a tailored legal and regulatory framework to favour a planned biomethane injection in grids. This includes a "right to inject" principle to ensure equal and fair access to the network, based on techno-economic criteria and cost-sharing. It also engages gas system operators to adapt networks, including meshing pipes and reverse-flow stations. All biomethane plants in France are connected to a transmission or distribution gas grid.

The United States periodically publishes the Billion-Ton Report, which is an assessment of its national biomass availability to support strategic bioeconomy policy development and investment decisions. The report outlines supply, estimated price, geographical density and distribution, and sustainability limits.

Priority 3: Support innovation to narrow cost gaps

Challenge: Ethanol, biodiesel and CBG can be produced with technologies available at a commercial industrial scale. Although adaptation of some parts of the process to local feedstocks still needs to advance, they are considered mature technologies. Conversely, biojet is deployed in a limited way, capital costs are high and technical readiness is low. Without targeted support, biojet and other emerging fuel technologies will struggle to become commercially viable.

Policy response: India could support innovation to gradually reduce the cost of emerging biofuels. Measures such as grants, low- or free-of-interest loans for pilot and demonstration facilities, or innovation competitions, could support scale-up of fuel pathways and accompanying technologies. India could also continue to seek out public-private partnerships and international collaborations to accelerate learning and knowledge diffusion to develop solutions tailored to the country's needs.

Selected policy examples:

Singapore's Aviation Sustainability Programme provides funding to projects that seek to reduce emissions across the entire aviation sector. This includes funding for test beds, improving airport operations and energy efficiency measures, transitioning to low-carbon fuels, standards development and public-private partnerships to continue to develop the sector's ecosystem.

Canada's Energy Innovation Program – Clean Fuels and Industrial Fuel Switching provides public funding to support pilot and demonstration projects and accelerate deployment of new fuel technologies. It is one element of Canada's broader support for sustainable fuels, alongside the Clean Fuel Regulations, the Clean Fuels Fund and the Hydrogen Strategy for Canada.

Australia's Future Made in Australia Innovation Fund will provide up to 1.5 billion Australian dollars in grants to support precommercial innovation, demonstration and deployment of renewable energy and low-emissions technologies, including low-emissions hydrogen and sustainable liquid fuels, to advance Australia's transition to a net zero economy.

Priority 4: Develop carbon accounting and sustainability frameworks

Challenge: While liquid and gaseous biofuels – and bioenergy more broadly – are considered carbon neutral under India's national carbon market, it does not yet have a carbon accounting or sustainability framework for these fuels. Without these, foreign investments, export opportunities and compliance with international regulations (e.g. CORSIA) could be challenging. This could also affect broader public trust in these fuels.

Policy response: India could consider adopting robust and interoperable carbon accounting methodologies that enable transparent lifecycle assessment and support performance-based policy design. The development of a national framework should follow international best practices, cover the full life cycle of fuels, and be designed to ensure comparability across different types of fuels, including fossil fuels, bioenergy and other emerging fuels, such as hydrogen-derived ones. Independent monitoring, reporting and verification mechanisms must complement accounting methodologies, to ensure integrity. Greater alignment with international systems, for example with the International Maritime Organization for shipping fuels or the International Civil Aviation Organization CORSIA for aviation fuels – through multilateral co-operation or bilateral agreements – would also support cross-border trade and help Indian producers access global markets.

Selected policy examples:

California's Low Carbon Fuel Standard sets a carbon intensity benchmark for fuels. Biofuels with carbon intensity scores below the benchmark generate credits that can be sold to producers of higher-carbon fuels, rewarding biofuel producers for reducing the carbon intensity of their fuel and incentivising innovation. The Low

Carbon Fuel Standard is also continually improved by updating data and the addition of new fuel pathways to continuously support sustainable fuel growth.

The European Union's Renewable Energy Directive sets carbon accounting for bioenergy based on a life-cycle GHG assessment that covers emissions from feedstock production, land-use change, processing, transport, distribution and end use. Total life-cycle emissions are expressed in grammes of carbon dioxide equivalent per unit of energy and compared against fossil fuel equivalents. Bioenergy must achieve minimum GHG savings thresholds (70-80% for most biofuels) to be eligible. Emissions reductions from practices such as improved agriculture or carbon capture can be credited. Compliance can be demonstrated using European Union default values or verified calculations under recognised certification schemes.

Brazil's RenovaBio establishes long-term national GHG reduction targets for the country's fuel mix. These national targets are then translated into mandatory annual targets for individual fuel distributors based on their share of the fossil fuel market. Carbon accounting under RenovaBio uses a life-cycle assessment to certify the emissions avoided by each biofuel producer yielding carbon credits. Fuel distributors can buy credits to demonstrate compliance with their assigned emissions reduction targets.

Abbreviations and acronyms

ATJ	alcohol to jet
BAM	Biomass Aggregation Machinery
bio-CNG	bio-compressed natural gas
bio-LNG	bio-liquefied natural gas
CBG	compressed biogas
CBO	CBG Blending Obligation
CGD	city gas distribution
CNG	compressed natural gas
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
DPI	Development of Pipeline Infrastructure
EBP	Ethanol Blended Petrol
FCO	Fertilizer Control Order
FOM	fermented organic manure
FY	fiscal year
GHG	greenhouse gas
GOBARdhan	Galvanizing Organic Bio-Agro Resources Dhan
IS	Indian Standard
LDAR	leak detection and repair
LFOM	liquid fermented organic manure
LNG	liquified natural gas
MDA	Market Development Assistance
MNRE	India's Ministry of New and Renewable Energy
MoPNG	India's Ministry of Petroleum and Natural Gas
MSW	municipal solid waste
NPB	National Policy on Biofuels
OMC	oil marketing company
PNG	piped natural gas
PROM	phosphate-rich organic manure
SAF	sustainable aviation fuel
SATAT	Sustainable Alternative Towards Affordable Transportation
SFOM	solid fermented organic manure
UCO	used cooking oil
WtE	Waste to Energy

Units

bcm/yr	billion cubic metres per year
bcme	billion cubic metres equivalent
bcme/yr	billion cubic metres equivalent per year
BLPY	billion litres per year
EJ	exajoule

EUR	euro
g CO_2-eq/MJ	gramme of carbon dioxide equivalent per megajoule
GJ	gigajoule
INR	Indian rupee
kg	kilogramme
KLD	thousand litres per day
m^3	cubic metre
mcme	million cubic metres equivalent
mcme/yr	million cubic metres equivalent per year
MLPY	million litres per year
MMBtu	million British thermal units
MMSCMD	million standard cubic metres per day
MMT	million metric tonnes
MMTPY	million metric tonnes per year
MT	metric tonne
MW	megawatt
MWh	megawatt hour
PJ	petajoule
PJ/bcme	petajoules per billion cubic metres equivalent
PJ/yr	petajoules per year
TPD	tonnes per day
USD	United States dollar

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