Report on Methodology

On

"Inclusion of Biofuel in the annual publication 'Energy Statistics' of MoSPI"

Submitted to Expert Committee on Energy Statistics

Prepared by MNRE and TERI

Government of India
Ministry of New and Renewable Energy
सत्यमेव जयते

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Background

Apart from the conventional commercial fuels, several other energy forms are used across sectors, but they are not included and accounted for in India's energy balance. These include biomass and biofuels, comprising solid biomass/biofuels, biogases, liquid biofuels and municipal solid waste. These fuels are used across multiple end-use sectors, including households, industry, electricity generation, and transport, and play a significant role in meeting India's energy requirements. Their contribution to the overall energy mix is substantial and is in fact reflected in energy balances and statistics published by international organisations, underscoring the importance of systematically accounting for bioenergy in national energy statistics.

In India, comprehensive and directly observed data on biomass and biofuel consumption are not available for most bioenergy streams. Data related to bioenergy is scattered across administrative records, programme-level reports, and household surveys, many of which are not designed for energy accounting or for use in a national energy balance. In several cases, data are available only for selected activities or outputs, while direct consumption data are not reported at all. Consequently, the contribution of biomass and biofuels cannot be captured through simple compilation of existing datasets and requires the use of estimation approaches based on indirect indicators, survey data, and back-calculation methods.

This lack of consolidated and consistent treatment poses challenges for accurately representing India's energy structure and for ensuring comparability of national energy statistics with international frameworks such as the International Recommendations for Energy Statistics (IRES) and the Standard International Energy Product Classification (SIEC). In the absence of harmonised reporting, biomass and biofuels—despite their significance—remain underrepresented in transformation and final consumption accounts.

Recognising these issues, the Expert Committee on Energy Statistics identified the need to develop systematic methodologies for incorporating biofuels into India's energy statistics. Accordingly, under Agenda Item II (e): "Incorporating the component of Bio-fuel", the Committee recommended a focused technical exercise in consultation with key stakeholder institutions. As part of the follow-up actions to the Committee's deliberations, a dedicated technical consultation was undertaken to examine data availability, potential sources, and feasible estimation approaches for bioenergy streams across end-use sectors. The methodological approaches presented in this report are the outcome of this exercise and are consistent with national practices and international energy accounting frameworks such as the International Recommendations for Energy Statistics (IRES) and the Standard International Energy Product Classification (SIEC).

Disclaimer: It is noted that the methodologies proposed aim to capture the major components of biomass/biofuels consumption in India. However, due to limitations in data availability and reporting, certain smaller or more dispersed uses of biomass and biofuels may still remain unaccounted for. These gaps are acknowledged, and the coverage may be further refined in future iterations of the energy balance, subject to improvements in data availability and reporting.

The officials and experts associated with this technical exercise are listed below:

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Methodologies

Solid biofuels

Firewood

Households Consumption

Data Source:

Household Consumption Expenditure Survey (HCES), MoSPI: Block 8.1 of HCES pertains to Consumption of energy (fuel & light) during the last 30 days. Consumption, both in quantity (kg) and value (Rs), is reported for firewood and chips (Item Code 331).

The net calorific value of firewood has been taken from World Bank-ESMAP sources.

All India estimation procedure:

Per capita monthly consumption of firewood is multiplied by the projected population for the respective year, as taken from the *Report of the Technical Group on Population Projections (2011–2036)* of the Ministry of Health and Family Welfare, and by a factor of 12 to obtain the annual total consumption in quantity and value terms.

Conversion to Energy term in ktoe:

Data for 2022-23 and 2023-24.

Firewood	**2022-23**	**2023-24**
Quantity (Thousand Metric Ton)	169963.0	156224.0
NCV (kcal/kg)	3728.5	3728.5
Energy (ktoe)	63328.1	58208.9

Treatment in Energy balance:

Total household firewood consumption may be included under the Residential sector in the final consumption part of the energy balance.

Consumption by Unincorporated sector

Data Source:

Annual Survey of Unincorporated Sector Enterprises (ASUSE), MoSPI - In ASUSE survey, product Code '052' represents 'firewood'. Consumption of firewood from Block 3.1 to Block 3.14 of ASUSE may be

calculated at NIC level and may be clubbed at appropriate Industry level. **Only Value of consumption of Firewood is available in ASUSUE.**

Consumption by Organized sector

Data Source:

Annual Survey of Industries (ASI), MoSPI - Block H: Indigenous input items consumed may be used for extraction of data on Firewood consumption as fuel. As per ASI instruction manual, item No 20, NPCMS code – 9920400 of Block H include "*other fuel consumed like firewood consumed as fuel*"**.** From item No. 15 to item No. 19 of Block H covers almost all fuel items used by Industry such as electricity, petrol, diesel, oil, lubricants, coal (includes charcoal also) and gas. Therefore, it may be assumed that NPCMS Code-9920400 covers mostly 'firewood used as fuel'.

In view of the above, we may take the value against NPCMS- 9920400 as the firewood consumed by Industries as fuel. Firewood consumption may be estimated for the NPCMS Code of 9920400 at NIC level and may be clubbed at appropriate Industry level. Only Value of consumption of Firewood is available in ASI**.**

The net calorific value of firewood has been taken from World Bank-ESMAP sources.

Calculation of Quantity of Firewood consumed reported under ASI and ASUSE:

Quantity = Value / Unit Price

For calculating unit price two options are there.

Option 1. Price Statistics division is capturing price/Kg of firewood on regular basis. Annual average price per Kg of firewood may be used for estimating the quantity from value of consumption of firewood from ASUSUE and ASI.

Option 2: Following data are available in HCES and may be utilized for calculation of unit price from value and quantity of Non Home produce firewood

Home produce consumption		Total consumption	
Quantity	Value	Quantity	Value

Unit price of Non- Home produce firewood = (Value $_{\text{Total Consumption}}$ - Value $_{\text{Home produce Consumption}}$)/ (Quantity $_{\text{Total Consumption}}$ - Quantity $_{\text{Home produce Consumption}}$)

Purchase value of non- Home produce Firewood as per HCES 2022-23 and 2023-24 are as follows:

Year	Price /Kg of Non Home produce (Rs.)
2022-23	4.76
2023-24	4.86

Conversion to Energy Terms:

Year	Quantity (in Thousand Metric Ton)			NCV (kcal/kg)	Energy (ktoe)
	ASI	ASUSE	Total		
2022-23	89327	10380	99706	3728.5	37150
2023-24	80960	17326	98286	3728.5	36621

Sector-wise Consumption of Firewood

Categories in Energy consumers	2022-23				2023-24			
	Quantity (Thousand Metric ton)			Ktoe	Quantity (Thousand Metric ton)			Ktoe
	ASI	ASUSE	Total		ASI	ASUSE	Total	
Manufacturing construction and non-fuel mining industries	**77730**	**5684**	**83413**	**31080**	**72733**	**7054**	**79787**	**29729**
Iron and steel	10215	0	10215	**3806**	6830	2	6831	**2545**
Chemical and petrochemical	21050	36	21086	**7857**	19475	152	19627	**7313**
Non-ferrous metals	5461	0	5461	**2035**	3416	1	3417	**1273**
Non-metallic minerals	12864	3817	16681	**6215**	13148	3490	16638	**6199**
Transport equipment	491	1	492	**183**	609	1	610	**227**
Machinery	1164	29	1193	**444**	1476	50	1526	**568**
Mining and quarrying	1	0	1	**0**	2	0	2	**1**
Food and tobacco	13725	673	14398	**5365**	14885	306	15190	**5660**
Paper, pulp and print	5271	0	5271	**1964**	5252	21	5273	**1965**
Wood and wood products (other than pulp and paper)	319	472	791	**295**	336	1887	2223	**828**
Textile and leather	5432	6	5439	**2026**	5767	130	5896	**2197**
Industries not elsewhere specified	1737	649	2386	**889**	1538	1017	2555	**952**
Household*			**169963**	**63328**			**156224**	**58209**
Commerce and public services	**414**	**4295**	**4709**	**1755**	**436**	**10140**	**10577**	**3941**
Agriculture, forestry	**26**	**0**	**26**	**10**	**39**	**0**	**39**	**15**
Other non-specified sectors	**11157**	**401**	**11558**	**4306**	**7751**	**132**	**7883**	**2937**
Grand Total	**89327**	**10380**	**269669**	**100479**	**80960**	**17326**	**254510**	**94830**

*** HCES, MoSPI**

Note: In this analysis, industrial firewood consumption has been estimated using data from the Annual Survey of Unincorporated Sector Enterprises (ASUSE) and the Annual Survey of Industries (ASI). Within ASI, firewood consumption has been identified from Block H (Indigenous input items consumed), specifically Item No. 20 under NPCMS Code 9920400, which is described as "other fuels consumed", including firewood used as fuel, as per the ASI instruction manual. However, there is no explicit distinction as to whether this category also includes other forms of biomass, such as agro-residues.

Treatment in Energy balance:

Total firewood consumption estimated from ASI and ASUSE may be included under the Industry sector and Commercial and public services sector, respectively, in the final consumption part of the energy balance.

Bagasse

Consumption in Sugar Mills for Electricity Generation

Data Source:

- **For Installed Capacity of Bagasse based Co-generation plants- MNRE:** The "Year-wise Achievements" section on the MNRE website provides cumulative year-wise installed capacity for various renewable energy sources, including bagasse-based cogeneration.

- **SFC, SHR and GCV - CERC and SERC tariff orders:** The SFC is calculated from the Station Heat Rate (SHR) and Gross Calorific Value (GCV) specified in "Draft Central Electricity Regulatory Commission (Terms and Conditions for Tariff Determination from Renewable Energy Sources) Regulations, 2024" and "State Electricity Regulatory Commission (SERC) tariff orders" for various states, including the Tamil Nadu ERC order which also provides comparable values from other states. In the CERC Regulations (February 2024), GCV and SHR (for the power generation component alone) values are provided on Page 24, while the TNERC tariff order (2023) provides SHR (Page 33) and GCV (Page 35).

- **Plant Load Factor (PLF):** The Plant Load Factor (PLF) for bagasse-based cogeneration plants is taken from tariff orders issued by various State Electricity Regulatory Commissions (SERCs)**.** These tariff orders specify state-wise PLF norms, which typically lie in the range of 50–60 percent.

- The NCV of bagasse has been taken as 1,960 kcal/kg, consistent with values reported in World Bank–ESMAP studies and also aligned with GCV values used in CERC and SERC tariff orders.

All India estimation procedure:

Estimation of Electricity Generation from Bagasse-Based Cogeneration Plants:

The total electricity generation from bagasse-based cogeneration plants is estimated using the installed capacity and assumed operational characteristics of sugar mills.

For all-India estimation, a uniform operating period of 210 days and an average PLF of 53 percent are assumed, based on a review of state-wise norms specified in SERC tariff orders.

Electricity generation is calculated as:

Electricity Generation (GWh) = (Installed Capacity (MW) × 210 days × Plant Load Factor (PLF) × 24) / 1000

Where:

- Installed capacity refers to the total capacity of bagasse-based cogeneration plants operating in sugar mills.
- Plant Load Factor (PLF) reflects the extent to which installed cogeneration capacity is actually utilised, accounting for partial load operation, seasonal availability of bagasse, and planned or unplanned downtime.
- Operating days represent the average number of days during which sugar mills operate in a year.

This provides the total electricity generated from bagasse-based cogeneration plants, including electricity used internally in sugar mills as well as electricity exported to the grid.

Estimation of Specific Fuel Consumption (SFC)

To estimate the amount of bagasse used for power generation, we use the Specific Fuel Consumption (SFC) of bagasse co-generation plants.

The SFC is obtained from the Station Heat Rate (SHR) and Gross Calorific Value (GCV). Using these values:

SFC (kg/kWh) = SHR (kcal/kWh)/GCV (kcal/kg)

This SFC represents the quantity of bagasse required to generate 1 unit of electricity.

The electricity generated from bagasse based cogeneration plants, is converted to Kwh, and multiplied by the SFC to obtain the total bagasse (in Kg) consumed in cogeneration for generating electricity:

Quantity of Bagasse used for electricity generation (kg) = Electricity generated from Bagasse based cogeneration (kWh) * SFC (kg/kWh)

This gives the total bagasse consumed by cogeneration units in sugar mills for generating electricity.

Conversion to Energy term in ktoe:

Year	Installed Capacity of Bagasse Cogeneration (MW)	Operating Days	PLF	Total Electricity Generation (GWh)	SFC (Kg/Kwh)	Bagasse used for electricity generation in cogeneration plants(MMT)	NCV (kcal/kg)	Energy from bagasse used for electricity generation in cogeneration plants (ktoe)
2022-23	9433.6	210	0.53	25199	1.6	40.3	1960	7896
2023-24	9433.6	210	0.53	25199	1.6	40.3	1960	7896

Note: The SFC has been calculated using the formula given above, based on the Station Heat Rate (SHR) and Gross Calorific Value (GCV).

Treatment in Energy balance:

In a national energy balance (MOSPI / IRES-compliant), bagasse used for electricity generation from cogeneration plants may be treated as an input to Auto-producer CHP plants in the Transformation section.

Consumption in sugar-mills for process heat (non-electricity use)

Data Source:

The total sugarcane production is taken from the Ministry of Agriculture and Farmers' Welfare (Department of Agriculture & Farmers Welfare, DA&FW). The quantity of sugarcane crushed in sugar mills is taken from ChiniMandi, which provide state-wise cane-crushing data.

Bagasse recovery factor: A recovery factor of 0.3 has been used to estimate bagasse production from sugarcane crushed, consistent with values reported in national and international studies, including assessments by NITI Aayog and FAO.

Use of bagasse as fuel: It is assumed that around 90 percent of bagasse is used as fuel, mainly for power generation and process heat in sugar mills, as reported in FAO literature (Rangnekar, *Integration of Sugarcane and Milk Production in Western India*).

The NCV of bagasse has been taken as 1,960 kcal/kg, consistent with values reported in World Bank–ESMAP studies and also aligned with GCV values used in CERC and SERC tariff orders.

Estimation Procedure:

The quantity of bagasse produced in sugar mills is estimated by applying a bagasse recovery factor of 30% to the total sugarcane crushed.

Bagasse Produced (MMT) = Cane Crushed (MMT) * 0.3

From the total estimated bagasse production, it is assumed that 10 percent of bagasse is diverted to non-energy uses, such as paper and board manufacturing, packaging materials, composting, and other material applications, indicating that around 90 percent of bagasse is typically used as fuel. Accordingly, 90 percent of the total estimated bagasse is treated as bagasse available for energy use.

From this energy-use bagasse, the quantity of bagasse used for electricity generation in bagasse-based cogeneration plants (as estimated in the previous section) is subtracted. The remaining bagasse is treated as the quantity used in sugar mills for process heat and other non-electricity purposes, including steam generation for juice heating, evaporation, crystallisation, and other thermal processes within the mill.

The estimation can be expressed as:

Bagasse (energy) =0.9 × Total Bagasse

Bagasse (process heat) =Bagasse (energy) – Bagasse (electricity)

Conversion to Energy term in ktoe:

Year	Sugar-cane Production (MMT)	Cane Crushed (MMT)	Bagasse Recovery Factor	Estimated Bagasse Production (MMT)	Bagasse used for heat generation in sugar mills (MMT)	NCV (kcal/kg)	Energy from bagasse used for heat generation (ktoe)
2022-23	491	339	0.3	102	51	1960	10054
2023-24	453	318	0.3	95	46	1960	8917

Treatment in Energy balance:

Bagasse used for process heat in sugar mills may be treated as thermal energy consumption of the sugar industry and may be accounted for as the energy consumption under the industry sector.

Biomass Pellets

Consumption in Thermal Power Plants

Data Sources:

Year-wise biomass pellet consumption by thermal power plants is taken from the SAMARTH (Sustainable Agrarian Mission on Use of Agro Residue in Thermal Power Plants) portal, which reports cumulative pellet usage under National Mission on use of Biomass in Thermal Power plants.

Conversion to Energy terms in ktoe:

Year	Biomass Pellets (MT-metric tonne)	NCV (kcal/kg)	Energy value(ktoe)
2022-23	50,092.0	3150.0	15.8
2023-24	3,74,858.0	3150.0	118.0

Note: The GCV used in this analysis is the midpoint of the calorific value range (3000–4000 kcal/kg) provided in the SAMARTH FAQ section. For conversion of GCV to NCV, a factor of 0.9 is used.

Treatment in Energy balance:

Biomass pellets co-fired in thermal power plants may be recorded under the Transformation – Electricity Plants section as a fuel input to electricity generation. The energy generated from pellet is shown as a negative entry in Transformation, and the resulting electricity generated (already included) is recorded as a positive output under electricity production.

Biomass-based power plant fuel input

Consumption of Biomass in Biomass based Power-plants

Data Sources:

Electricity generation from biomass-based power plants is taken from Monthly *Renewable Energy Generation Report, published by CEA.* It provides the annual electricity generation (in Billion Units) under the Bio-power category, where electricity generation from Biomass (non-bagasse) based power-plants is separately reported.

The Specific Fuel Consumption (SFC) used to estimate biomass quantity is derived from the Station Heat Rate (SHR) and Gross Calorific Value (GCV) specified in the Draft Central Electricity Regulatory Commission (Terms and Conditions for Tariff Determination from Renewable Energy Sources) Regulations, 2024 – *Page 22*.

All India estimation procedure:

To estimate the amount of biomass used for power generation in biomass-based power plants, we use the Specific Fuel Consumption (SFC) of Biomass based Power projects.

The SFC is obtained from the Station Heat Rate (SHR) and Gross Calorific Value (GCV). Using these values:

SFC (kg/kWh) = SHR (kcal/kWh)/GCV (kcal/kg)

This SFC represents the quantity of Biomass required to generate 1 unit of electricity.

The electricity generated from biomass in Biomass based power-plants, is converted to kWh, and multiplied by the SFC to obtain the total biomass (in kg) consumed for electricity generation in these plants:

Quantity of biomass used for electricity generation (kg) = Electricity generated from Biomass based power-plants (kWh) * SFC (kg/kWh)

This gives the total biomass burned in biomass based electricity plants.

Conversion to Energy terms in ktoe:

Year	Biomass (BU)	SFC (kg/kWh)	Quantity of Biomass used in Biomass based Power Plants (MMT)	NCV (kcal/kg)	Energy from biomass used in Biomass based electricity plants(ktoe)
2022-23	3.16	1.35	4.28	2790	1194
2023-24	3.42	1.35	4.63	2790	1292

Note: The GCV value represents a normative average for biomass fuels as specified in CERC regulations and is used uniformly due to lack of fuel-wise calorific value data. For conversion of GCV to NCV, a factor of 0.9 is used.

Treatment in Energy Balance:

Biomass used for electricity generation in biomass-based power plants may be recorded under the Transformation – Electricity Plants section as a fuel input to electricity generation. The energy input from biomass is shown as a negative entry in the Transformation section, while the corresponding energy from electricity generation (already accounted for) is recorded as a positive output under electricity column.

Municipal Solid Waste

Consumption in Waste-to-Energy Plants

Data Sources:

The electricity generated from Waste to Energy plants is taken from Monthly *Renewable Energy Generation Report, published by CEA*. It provides the annual electricity generation (in

Billion Units) where electricity generation from Waste-to-Energy plants is separately reported under "others".

GCV (Gross Calorific Value) and SHR (Station Heat Rate): *"Norms for determination of generic tariff for Municipal Solid Waste/Waste to Energy projects and indicative tariff for 2015–16" – Page 8 and 9*, issued by CERC. These norms provide the calorific value range for MSW/RDF and the SHR used for tariff determination.

Estimation Procedure:

To estimate the amount of MSW/RDF used for power generation in Waste-to-Energy plants, the Specific Fuel Consumption (SFC) applicable to MSW/RDF-based WtE projects is used. The SFC is obtained from the Station Heat Rate (SHR) and Gross Calorific Value (GCV). Using these values:

SFC (kg/kWh) = SHR (kcal/kWh)/GCV (kcal/kg)

This SFC represents the quantity of MSW/RDF required to generate 1 unit of electricity.

The electricity generated from MSW in Waste to Energy plants, reported by MNRE (in BU), is converted to kWh, and multiplied by the SFC to obtain the total MSW/RDF (in kg) consumed for electricity generation in these plants:

MSW consumed for electricity generation (kg) = Electricity generated from Waste to Energy plants (kWh) * SFC (kg/kWh)

This provides the total MSW burned in Waste to Energy plants.

Conversion to Energy terms (ktoe):

Year	Waste to Energy generation (BU)	SFC (kg/kWh)	Quantity of Waste used for W2E generation (MMT)	NCV (kcal/kg)	Energy from Waste (ktoe)
2022-23	2.53	1.86	4.72	2025.00	955.70
2023-24	2.75	1.86	5.13	2025.00	1038.80

Note: For the above analysis, the calorific value of Refuse Derived Fuel (RDF), as specified in CERC tariff norms, has been used for the estimation of Specific Fuel Consumption (SFC) as well as for conversion of fuel quantities into energy terms. For conversion of GCV to NCV, a factor of 0.9 is used.

Treatment in Energy Balance:

MSW/RDF inputs to electricity-producing WtE plants may be recorded under the Transformation – Electricity Plants section as a fuel input to electricity generation. The energy input from MSW/RDF is shown as a negative entry in the Transformation section, while the corresponding energy from electricity generation (already accounted for) is recorded as a positive output under electricity column.

Dung Cake

Consumption of Dung Cake in the Residential Sector for Energy Purposes

Data Source:

Household Consumption Expenditure Survey (HCES), MoSPI: Block 8.1 of HCES pertains to Consumption of energy (fuel & light) during the last 30 days. Consumption, both in quantity (kg) and value (Rs), is reported for dung cake (Item Code 333).

The net calorific value of dung cake has been taken from World Bank-ESMAP sources.

All India estimation procedure and conversion to Energy term:

Per capita monthly consumption of dung cake, derived directly from HCES household consumption data, is multiplied by the projected population for the respective year, as taken from the *Report of the Technical Group on Population Projections (2011–2036)* of the Ministry of Health and Family Welfare, and by a factor of 12 to obtain the annual total consumption.

Data for 2022-23 and 2023-24:

Dung Cake	**2022-23**	**2023-24**
Quantity (Thousand Metric Tonnes)	30919	30018
NCV (kcal/kg)	2868.1	2868.1
Energy (ktoe)	8862	8604

Treatment in Energy balance:

Total dung cake consumption in households used directly for burning should be accounted under the Residential sector in the final consumption part of the energy balance.

Charcoal

Consumption of Charcoal in the residential sector:

Data Source:

Household Consumption Expenditure Survey (HCES), MoSPI: Block 8.1 of HCES pertains to consumption of energy (fuel & light) during the last 30 days. Consumption, both in quantity (kg) and value (Rs), is reported for charcoal (Item Code 341).

The net calorific value of charcoal has been taken from World Bank–ESMAP sources.

All India estimation procedure and conversion to Energy term:

Per capita monthly consumption of charcoal is derived from HCES data and multiplied by the projected population for the respective year, as taken from the *Report of the Technical Group on Population Projections (2011–2036)* of the Ministry of Health and Family Welfare, and by a factor of 12 to obtain the annual total consumption.

Data for 2022-23 and 2023-24:

Charcoal	2022-23	2023-24
Quantity (Thousand Metric Tonnes)	135.7	171.7
NCV (kcal/kg)	6931.2	6931.2
Energy (ktoe)	94.02	118.94

Treatment in Energy balance:

Total charcoal consumption in households may be included under the Residential sector in the final consumption part of the energy balance.

Black Liquor

Black liquor is a by-product formed during the chemical pulping of wood and agro-residues in the pulp and paper industry. Since black liquor is generated only from virgin fibre pulping, the estimation is based solely on the share of paper production using wood and agro-residues, while paper produced from recycled fibre is excluded.

Although wood-based and agro-residue-based pulping processes differ, separate conversion factors has not been applied due to the lack of reliable national-level data. Therefore, single representative factors has been used in the analysis. It is also recognised that in some small mills not all black liquor may be used for energy recovery; however, due to data unavailability of the share, it is assumed that 100% of the generated black liquor is used for energy purposes.

Data Sources:

- **Production of paper, paperboard and newsprint**: Annual production data are taken from the annual reports of the Central Pulp and Paper Research Institute (CPPRI) and the Indian Paper Manufacturers Association (IPMA).
- **Share of wood-based and agro-residue-based production**: The proportion of paper production based on wood and agro-residues is taken from CPPRI annual reports, which provide information on the fibre mix of the Indian pulp and paper industry.
- **Conversion factor from pulp to black liquor solids**: The conversion factor for estimating black liquor generation from chemical pulp production is taken from the International Energy Agency (IEA) Bioenergy study *"Black Liquor Gasification"*, presented at the IEA Bioenergy EXCO54 workshop.
- **Net calorific value (NCV) of black liquor**: The NCV of black liquor dry solids is taken from the same IEA Bioenergy study, which reports both higher and net heating values for black liquor solids.

All India estimation procedure:

The estimation of black liquor generation is carried out in the following steps.

Step 1: Estimation of wood- and agro-residue-based paper production

Total production of paper, paperboard and newsprint is multiplied by the share of wood-based and agro-residue-based production to estimate the quantity of paper produced using virgin fibre.

Wood and agro-based paper production = Total paper production × Share of wood and agro-based production

Step 2: Estimation of pulp requirement

The quantity of chemical pulp required for paper production is estimated by adjusting wood- and agro-residue-based paper output to account for non-fibrous components added during papermaking.

Pulp production=Wood and agro-based paper production × 0.9

Note: Due to the non-availability of direct national data on pulp production, an inverse conversion factor of 0.90 has been assumed, for converting paper production to pulp requirement. This factor is an approximation that accounts for the presence of fillers, additives and other non-fibrous components added during papermaking, which cause the mass of finished paper to differ from the mass of pulp fibre used. The crux of the assumption is that per unit of paper production requires 0.90 unit of pulp and 0.10 unit of other components.

Step 3: Estimation of black liquor solids

Black liquor generation is estimated by applying a conversion factor of 1.7 tonnes of black liquor (dry solids) per tonne of chemical pulp, as reported by IEA Bioenergy.

Black liquor solids = Pulp production × 1.7

The resulting quantity represents black liquor on a dry solids basis.

Conversion to Energy Terms:

Data for 2023-24 and 2024-25

Year	Total paper production (MMT)	Wood & agro-based share of production (%)	Wood & agro-based paper production (MMT)	Fibre content adjustment factor	Estimated pulp requirement (MMT)	Black liquor solids generation factor (t BL/t pulp)	Black liquor solids (MMT)	NCV (kcal/kg)	Energy content (ktoe)
2023-24	23.0	24.0	5.5	0.9	4.97	1.7	8.4	2937.4	2,479.1
2024-25	22.6	24.0	5.4	0.9	4.88	1.7	8.3	2937.4	2,434.9

Treatment in Energy Balance

Black liquor consumption may be accounted under the industry sector, within the pulp and paper subsector, as part of final energy consumption in the energy balance.

Biogases

Consumption of Biogas/Gobar gas in the residential sector

Data Source:

Household Consumption Expenditure Survey (HCES), MoSPI: Block 8.1 of HCES pertains to Consumption of energy (fuel & light) during the last 30 days. Consumption, both in Quantity in kgs and Value in Rs, are reported for Biogas, Gobar gas (Item Code 343).

The calorific value of biogas has been derived based on the range reported on the MNRE biogas portal.

All India estimation procedure and conversion to Energy term:

Per capita monthly consumption of biogas/gobar gas is multiplied by the projected population for the respective year, as taken from the *Report of the Technical Group on Population Projections (2011–2036)* of the Ministry of Health and Family Welfare, and by a factor of 12 to obtain the annual total consumption in quantity and value terms.

Data for 2022-23 and 2023-24:

Biogas	**2022-23**	**2023-24**
Quantity (Metric Tonnes)	56101.2	50619.8
NCV (MJ/m^3)	19.7	19.7
Energy (ktoe)	38.8	35.0

Note: 1 cubic meter = 0.68 kg (HCES)

The estimate reflects reported household use of biogas as a cooking fuel and represents final energy consumption. Estimates based on biogas plant capacity or production potential are not used.

Treatment in Energy balance:

Total biogas consumption in households would be included under the Residential sector in the final consumption part of the energy balance.

Consumption of CBG reported by MoPNG

Data Source:

Sale of Compressed Biogas (CBG) in tonnes is reported in Chapter 9 of the IPNG statistics published by MoPNG.

The calorific value of CBG has been taken from the International Energy Agency (IEA).

Conversion to Energy term:

Data for 2022-23 and 2023-24:

CBG	**2022-23**	**2023-24**
Quantity (Metric Tonnes)	11227	19724
NCV (MJ/m^3)	36	36
Energy (ktoe)	13.41	23.55

Note: 1 cubic meter = 0.72 kg

Treatment in Energy balance:

At present, reported CBG consumption is predominantly in the transport sector; accordingly, total CBG consumption can be included under the Road Transport sector of the energy balance.

Liquid Biofuels

Ethanol

Data Source:

Quantities of ethanol blended with petrol are reported in Chapter 9 of the IPNG statistics published by MoPNG.

Conversion to Energy Terms:

Data for Ethanol consumption for 2022-23 and 2023-24:

Ethanol	**2022-23**	**2023-24**
Quantity (Cr Litres)	508	707
NCV (kcal/kg)	6453.2	6453.2
Energy (ktoe)	2578	3586

Note: 1 litre of ethanol = 0.789 kg

Treatment in Energy balance:

Ethanol consumption should be included under the Road Transport category of the transport sector in the energy balance.

Bio-diesel

Data Source:

Quantities of biodiesel blended with diesel are reported in Chapter 9 of the IPNG statistics published by MoPNG.

Conversion to Energy Terms:

Data for Bio-diesel consumption for 2022-23 and 2023-24:

Bio-diesel	**2022-23**	**2023-24**
Quantity (Cr Litres)	6.06	43.99
NCV (kcal/kg)	8962.7	8962.7
Energy (ktoe)	48	347

Note: 1 litre of bio-diesel = 0.88 kg

Treatment in Energy balance:

Biodiesel consumption should be included under the Road Transport category of the transport sector in the energy balance.

Results

Based on the above analysis, biofuels and waste contributed an estimated 118,940 ktoe to India's total final energy consumption in 2023-24, accounting for around 16 percent of total final energy use. The residential sector emerged as the dominant consumer of biomass energy, with an estimated consumption of 66,966 ktoe, representing about 56 percent of total biomass consumption as final

energy. This reflects the continued use of traditional biomass fuels in households for cooking and other energy needs. The industrial sector was the second-largest consumer, with biomass consumption estimated at 41,125 ktoe, contributing around 35 percent of total biomass use. The commercial and transport sectors accounted for relatively smaller shares, contributing around 3 percent each to total biofuel consumption.

Treatment of Biomass and Biofuels in the Energy Balance

During the analysis and compilation of biomass and biofuel consumption, it was observed that some biofuels are already included in the national energy balance through their blending with conventional fuels. Ethanol is blended with petrol, biodiesel is blended with diesel, and compressed biogas (CBG) is blended with natural gas; as a result, their energy contribution is embedded within the corresponding conventional fuel categories and is not reported separately.

To clearly present this aspect, two tables are provided below. The first table presents biofuels that are already included in the energy balance through blending with conventional fuels but are not reported separately as distinct energy products. The second table presents remaining biomass and biofuels that are not included in the existing energy balance.

Biofuels Included in the Energy Balance through Blending

	2022-23		2023-24	
	Quantity (MMT)	**Energy (ktoe)**	**Quantity (MMT)**	**Energy (ktoe)**
Ethanol	4.01	2,577.63	5.58	3,585.91
Bio-Diesel	0.05	47.76	0.39	346.73
CBG (Transport)	0.01	13.41	0.02	23.55

Other Biomass and Biofuels not included in the Energy Balance

	2022-23		2023-24	
	Quantity (MMT)	**Energy (ktoe)**	**Quantity (MMT)**	**Energy (ktoe)**
Firewood	269.7	100479	254.5	94830
Bagasse	91.7	17950.0	85.8	16813.4
Dung cake	30.9	8861.8	30.0	8603.5
Biomass-based power plant fuel input	4.28	1194	4.6	1292
Biomass Pellets	0.05	15.77	0.37	118.00
Black liquor	NA	NA	8.45	2479.13
MSW/RDF used for electricity	4.72	955.70	5.13	1038.80
Biogas	0.06	38.82	0.05	35.03
Charcoal	0.14	94.02	0.17	118.94

Note: The above table also includes biomass and biofuels used as fuel inputs in electricity and CHP plants. These quantities are accounted for under the Transformation sector in the energy balance and should not be included in total final energy consumption.

It may be noted that, since ethanol, biodiesel and CBG are already included within petrol, diesel and natural gas consumption respectively, their quantities must first be deducted from the corresponding conventional fuel totals in order to estimate the consumption correctly. After this adjustment, the remaining quantities of petrol, diesel and natural gas should converted to energy terms using their respective calorific values. This approach avoids double counting and ensures consistency in the energy balance.

In the energy balance, under the production category of "solar, wind, others", the energy term corresponding to "others" may be deleted to avoid duplication of electricity from bio-power, as the corresponding electricity has already been appropriately accounted for through the conversion of biomass inputs such as biomass, bagasse, and municipal solid waste.

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