ENERGY SECTOR: REFERENCE AND SECTORAL APPROACH

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U.S. Environmental Protection Agency

Approaches to Estimate Fossil FUEL Combustion Emissions

- **Sectoral approach**:
  - "Bottom-up approach": Calculation of emissions based on the amount of fuels consumed by users
- **Reference approach**:
  - "Top-down approach": Calculation of emissions based on the supply of primary fuels and external trade in secondary fuels

Approaches to Estimate Fossil FUEL Combustion Emissions

- According to the modalities procedures and guidelines (MPGs) for the enhanced transparency framework:

36. Each Party should compare the **national estimates of CO_2 emissions from fuel combustion** with those obtained using the **reference approach**, as contained in the IPCC guidelines … and report the results of this comparison in its national inventory report.

- Tiers 1, 2 and 3 in the 2006 IPCC Guidelines follow the sectoral approach.

- Reference approach is used as a verification check on the sectoral approach.

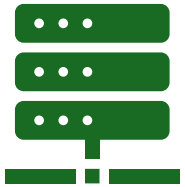
SECTORAL APPROACH

Methodology

Bottom-up approach

Focuses on individual sectors and fuels

Analyzes specific sectors to understand consumption and emission patterns



Data

Detailed sector-specific data on fuel consumption and emissions

Accounts for nuances in how fuels are utilized within each sector

Allows for a more precise estimation of emissions compared to the Reference Approach

Advantages

Provides a more detailed and sector-specific breakdown of emissions

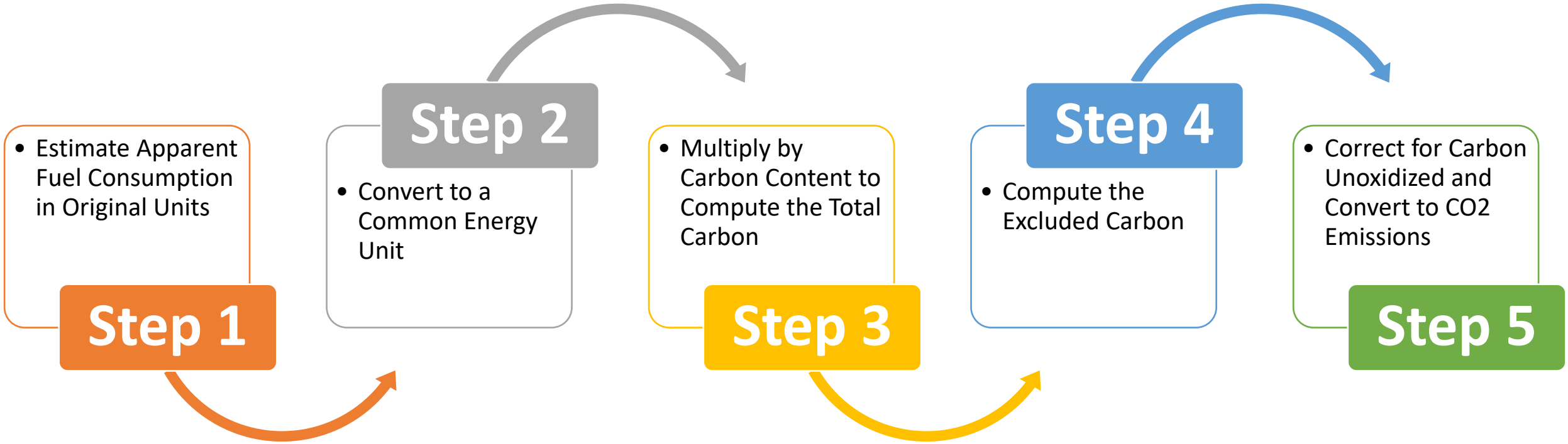
Allows for targeted interventions and policy formulation within sectors

REFERENCE APPROACH

- Aim: Provide **top-down** estimate as quality check for GHG emissions calculated in the energy sector.
- Approach:
  - Estimates based on **national energy balance** (production + imports - exports) by fuel type without information on activities.
  - Easily performed if basic energy balance sheet is available.
  - See Chapter 6, Volume 2 of the IPCCC 2006 Guidelines.
- Small difference (single digit percentage points) between the two approaches are typical.
- If there is no difference between the two approaches, there is likely something wrong!

REFERENCE APPROACH

The Reference Approach methodology breaks the calculation of carbon dioxide emissions from fuel combustion into 5 steps;



REFERENCE APPROACH (CONT)

EQUATION 6.1

CO_2 EMISSIONS FROM FUEL COMBUSTION USING THE REFERENCE APPROACH

$$CO_2\ Emissions = \sum_{all\ fuels} \left[\left(\left(Apparent\ Consumption_{fuel} \bullet Conv\ Factor_{fuel} \bullet CC_{fuel} \right) \bullet 10^{-3} \right. \right. \\ \left. \left. - Excluded\ Carbon_{fuel} \right) \bullet COF_{fuel} \bullet 44/12 \right]$$

Where:

CO_2 Emissions	= CO_2 emissions (Gg CO_2)
Apparent Consumption	= production + imports – exports – international bunkers - stock change
Conv Factor (conversion factor)	= conversion factor for the fuel to energy units (TJ) on a net calorific value basis
CC	= carbon content (tonne C/TJ) Note that tonne C/TJ is identical to kg C/GJ
Excluded Carbon	=carbon in feedstocks and non-energy use excluded from fuel combustion emissions (Gg C)
COF (carbon oxidation factor)	= fraction of carbon oxidised. Usually the value is 1, reflecting complete oxidation. Lower values are used only to account for carbon retained indefinitely in ash or soot
44/12	= molecular weight ratio of CO_2 to C.

APPARENT CONSUMPTION

For each fuel and inventory year:

- Primary fuels produced (production of secondary fuels and fuel products is not included)
- Primary and secondary fuels imported
- Primary and secondary fuels exported
- Primary and secondary fuels used in international bunkers
- Net increases or decreases in stocks of primary and secondary fuels

Apparent consumption of a primary fuel calculated as:

EQUATION 6.2
APPARENT CONSUMPTION OF PRIMARY FUEL

$$Apparent\ Consumption_{fuel} = Production_{fuel} + Imports_{fuel} - Exports_{fuel} - International\ Bunkers_{fuel} - Stock\ Change_{fuel}$$

Excluded Carbon

Adjusts for carbon which does not lead to fuel combustion emissions.

Feedstock

Naphtha

LPG (butane/propane)

Refinery gas

Gas/diesel oil and Kerosene

Natural gas

Ethane

Reductant

Coke oven coke (metallurgical coke) and petroleum coke

Coal and coal tar/pitch

Natural gas

Non-energy products

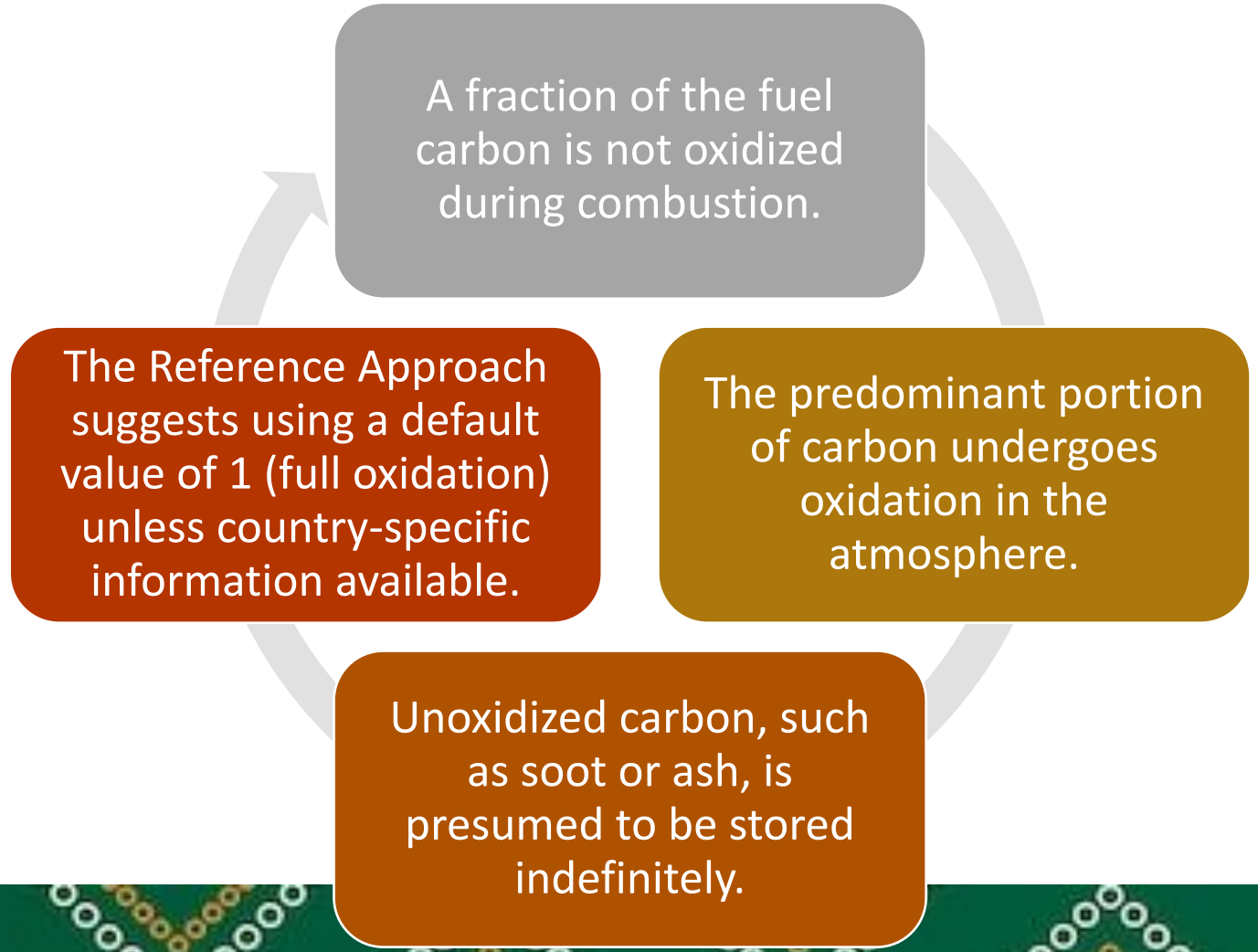
Bitumen

Lubricants

Paraffin waxes

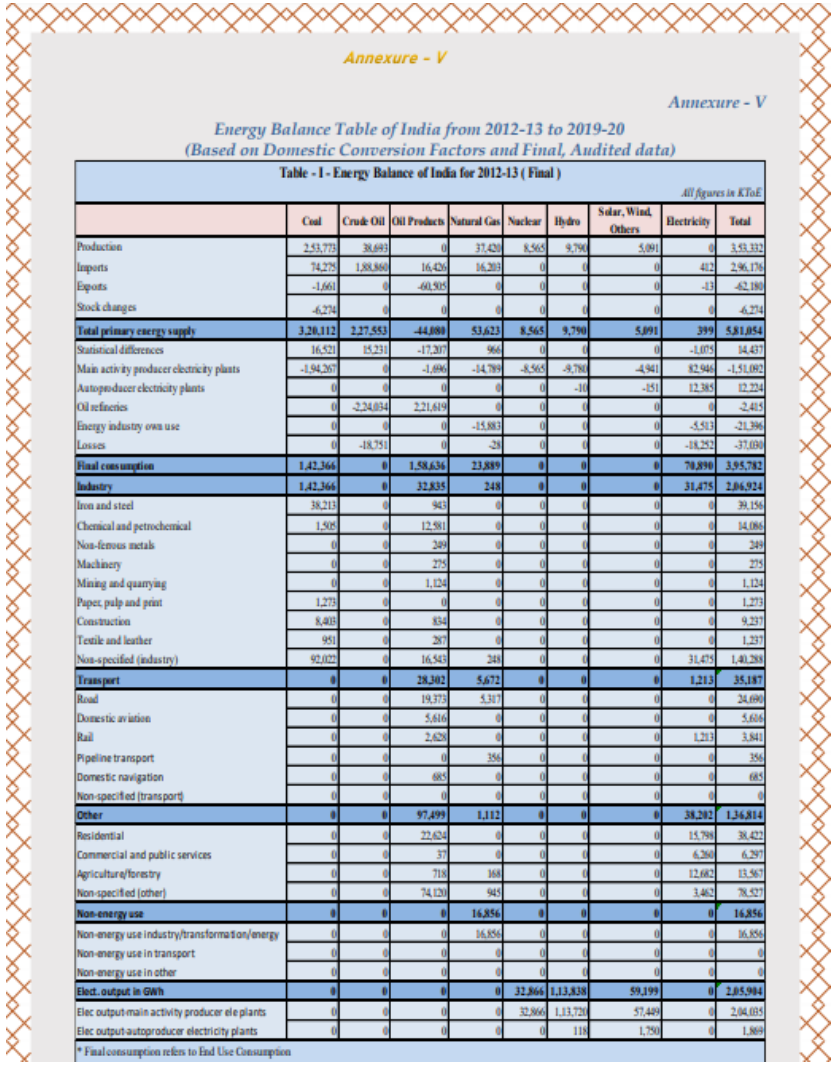
White spirit

UNOXIDISED CARBON



DATA SOURCES

- MoPNG
- Coal Directory
- Coal Statistics
- CEA
- Iron & Steel
- CMIE
- TERI
- Energy Balance Data for India available on Ministry of Statistics and Program Implementation website
  - Energy Statistics India (2023: https://www.mospi.gov.in/publication/energy-statistics-india-2023#
    - Chapter 7-Energy Balance and Sankey Diagram and Annex 5
  - Covers financial year April – March so adjustments may be required to calendar year, or used as cross check



Annexure - V

Annexure - V

Energy Balance Table of India from 2012-13 to 2019-20
(Based on Domestic Conversion Factors and Final, Audited data)

Table - I - Energy Balance of India for 2012-13 (Final)

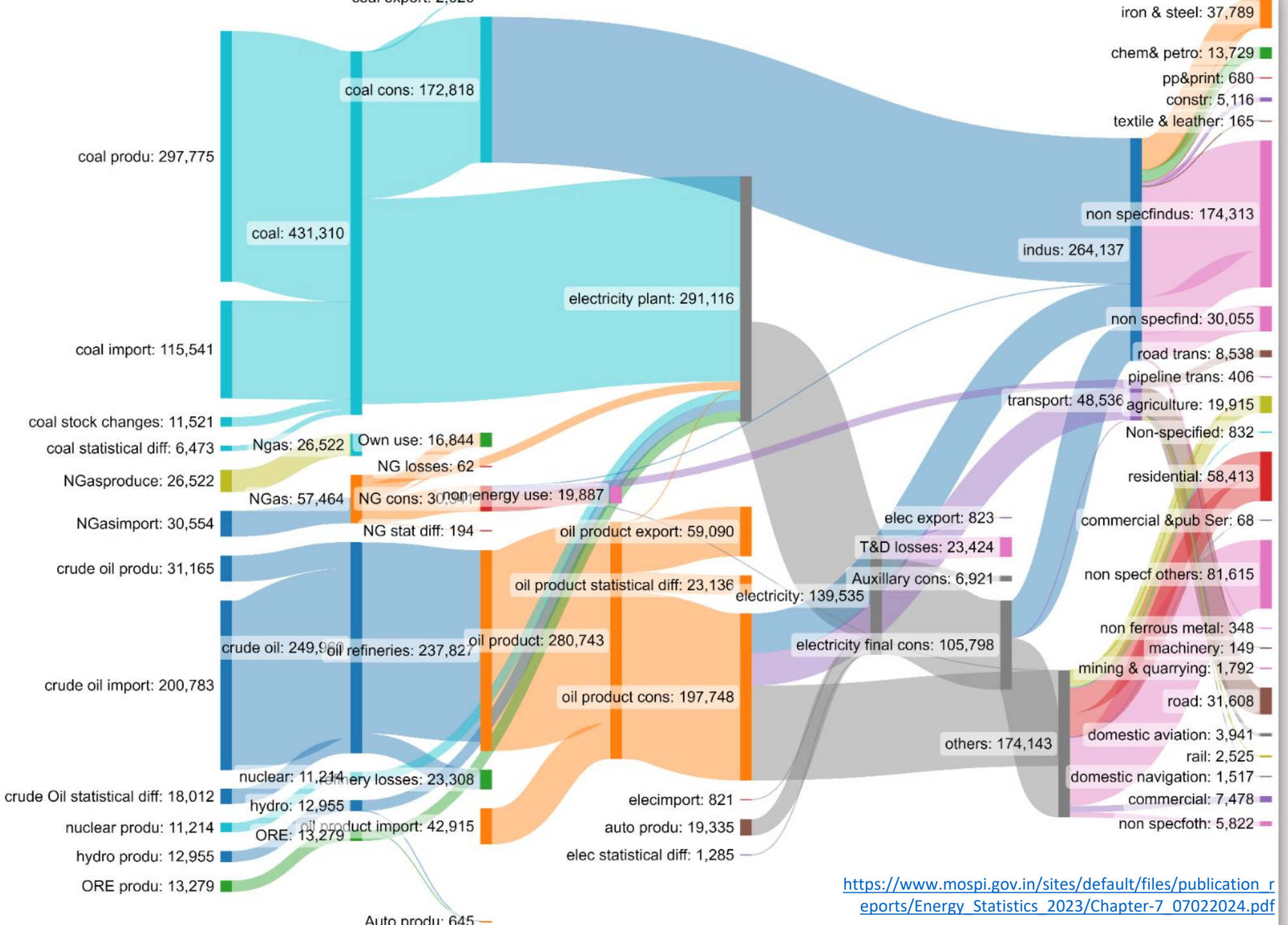
All figures in KToE

	Coal	Crude Oil	Oil Products	Natural Gas	Nuclear	Hydro	Solar, Wind, Others	Electricity	Total
Production	2,53,773	38,693	0	37,420	8,565	9,790	5,091	0	3,53,332
Imports	74,275	1,88,860	16,426	16,203	0	0	0	412	2,96,176
Exports	-1,661	0	-60,505	0	0	0	0	-13	-62,180
Stock changes	-6,274	0	0	0	0	0	0	0	-6,274
Total primary energy supply	**3,20,112**	**2,27,553**	**-44,080**	**53,623**	**8,565**	**9,790**	**5,091**	**399**	**5,81,054**
Statistical differences	16,521	15,231	-17,207	966	0	0	0	-1,075	14,437
Main activity producer electricity plants	-1,94,267	0	-1,696	-14,789	-8,565	-9,790	-4,941	82,946	-1,51,092
Autoproducer electricity plants	0	0	0	0	0	-10	-151	12,385	12,224
Oil refineries	0	-2,24,034	2,21,619	0	0	0	0	0	-2,415
Energy industry own use	0	0	0	-15,883	0	0	0	-5,513	-21,396
Losses	0	-18,751	0	-28	0	0	0	-18,252	-37,030
Final consumption	**1,42,366**	**0**	**1,58,636**	**23,889**	**0**	**0**	**0**	**70,890**	**3,95,782**
Industry	**1,42,366**	**0**	**32,835**	**248**	**0**	**0**	**0**	**31,475**	**2,06,924**
Iron and steel	38,213	0	963	0	0	0	0	0	39,176
Chemical and petrochemical	1,505	0	12,581	0	0	0	0	0	14,086
Non-ferrous metals	0	0	249	0	0	0	0	0	249
Machinery	0	0	275	0	0	0	0	0	275
Mining and quarrying	0	0	1,124	0	0	0	0	0	1,124
Paper, pulp and print	1,273	0	0	0	0	0	0	0	1,273
Construction	8,403	0	834	0	0	0	0	0	9,237
Textile and leather	951	0	287	0	0	0	0	0	1,237
Non-specified (industry)	92,022	0	16,543	248	0	0	0	31,475	1,40,288
Transport	**0**	**0**	**28,302**	**5,672**	**0**	**0**	**0**	**1,213**	**35,187**
Road	0	0	19,375	5,317	0	0	0	0	24,690
Domestic aviation	0	0	5,616	0	0	0	0	0	5,616
Rail	0	0	2,628	0	0	0	0	1,213	3,841
Pipeline transport	0	0	0	356	0	0	0	0	356
Domestic navigation	0	0	685	0	0	0	0	0	685
Non-specified (transport)	0	0	0	0	0	0	0	0	0
Other	**0**	**0**	**97,499**	**1,112**	**0**	**0**	**0**	**38,202**	**1,36,814**
Residential	0	0	22,624	0	0	0	0	15,798	38,422
Commercial and public services	0	0	37	0	0	0	0	6,260	6,297
Agriculture/forestry	0	0	718	168	0	0	0	12,682	13,567
Non-specified (other)	0	0	74,120	945	0	0	0	3,462	78,527
Non-energy use	**0**	**0**	**0**	**16,856**	**0**	**0**	**0**	**0**	**16,856**
Non-energy use industry/transformation/energy	0	0	0	16,856	0	0	0	0	16,856
Non-energy use in transport	0	0	0	0	0	0	0	0	0
Non-energy use in other	0	0	0	0	0	0	0	0	0
Elect. output in GWh	**0**	**0**	**0**	**0**	**32,866**	**1,13,838**	**59,199**	**0**	**2,05,904**
Elec output-main activity producer ele plants	0	0	0	0	32,866	1,13,720	57,449	0	2,04,035
Elec output-autoproducer electricity plants	0	0	0	0	0	118	1,750	0	1,869

* Final consumption refers to End Use Consumption

Source: https://www.mospi.gov.in/sites/default/files/publication_reports/Energy_Statistics_2023/Annexure%20V_07022024.pdf

Fig. 7.3: Sankey Diagram on Overall Energy Flow in India during FY: 2020-21(Final) (in KToe)



https://www.mospi.gov.in/sites/default/files/publication_reports/Energy_Statistics_2023/Chapter-7_07022024.pdf

INDIA'S TNC

- TNC emissions estimated by both methods (p. 82-83)
  - Sectoral approach
  - Reference approach
- 8% is considered too high

Comparison with reference and sectoral approach

A comparison of CO_2 emissions results obtained with the reference approach and the sectoral approach allows verifying the validity of the overall calculations performed. The reference approach uses the total values of national energy statistics, while the sectoral approach uses values related to each category that as a whole add up to the national energy sector.

The reference approach was also used to estimate CO_2e emissions from fuel combustion for the year 2019. The difference in estimates of CO_2 emissions from fuel combustion using the sectoral and reference approaches was around 8 per cent in 2017 to 2019. It is proposed to work on refining the GHG estimates in future communications and reduce the gap. The reference approach emissions were around 71 per cent from solid fuel combustion, around 26 per cent from liquid fuel and the remaining 3 per cent was from gaseous fuel combustion in 2019.

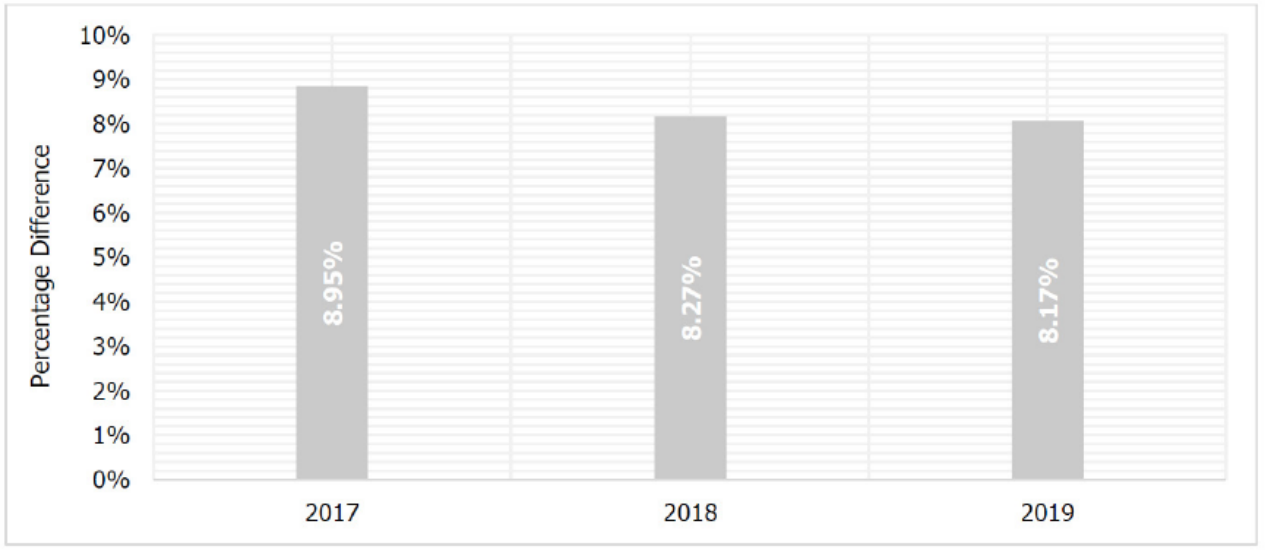


Figure 2.11: Percentage difference between CO_2 emission with the Sectoral approach and the Reference approach, 2017-2019

KEY DIFFERENCES BETWEEN REFERENCE AND SECTORAL APPROACH (2019)

- TJ:
  - Sectoral approach significantly lower for petroleum (~20%)
    - Could check if petroleum secondary products being used in IPPU?
  - Similar for solid fuels and natural gas
- Gg CO_2
  - Sectoral approach is again significantly lower for petroleum
  - Similar for solid fuels
  - Higher for natural gas
    - May be because of NG use in “other” non-energy uses, but difficult to resolve

How to identify and reduce differences

- Compare total aggregated sector demand (TJ) and emissions with reference approach on a fuel-by-fuel basis
  - Allows for identification of biggest contributors to the differences
- Confirm reference and sectoral data for these fuels is correct
- Check coverage of data on non-energy uses for these fuels
- Compare across like categories in reference and sectoral approach (e.g. reference approach appears to exclude jet bunkers)
- Triangulation with other sectors – IPPU

FINDING THE DIFFERENCES

- Large **statistical differences** between the energy supply and the energy consumption in the basic energy data.
- **Mass imbalances** between crude oil and other feedstock entering refineries and the (gross) petroleum products manufactured.
- Use of **approximate net calorific and carbon content values for primary fuels which are converted** rather than combusted
- **Misallocation of the quantities of fuels** used for conversion into derived products (other than power or heat) or quantities combusted in the energy sector.
- Missing information on **combustion of certain transformation outputs**.
- **Simplifications in the Reference Approach**.
- Missing information on **stock changes** that may occur at the final consumer level
- High **distribution losses** for gas will cause the Reference Approach to be higher than the Sectoral Approach,
- **Unrecorded consumption** of gas or other fuels may lead to an underestimation of the Sectoral Approach.
- The treatment of **transfers and reclassifications** of energy products may cause a difference in the Sectoral Approach estimation since different net calorific values and emission factors may be used depending on how the fuel is classified.
- For countries that **produce and export large amounts of** fuel, the **uncertainty on the residual supply** may be significant and could affect the Reference Approach.

(2006 IPCC Guidelines, Volume 2, Chapter 6: Reference Approach, Section 6.8 (pg 6.12))

SUGGESTIONS FOR IMPROVING TACC OF CALCULATIONS

Transparency: Well-documented enough to show an external audience how the inventory was done and prove good practice was followed
Accuracy: Close to the correct value
Completeness: All relevant categories and gases included
Consistency: Methods are consistent between years, gases, and categories to reveal real differences
Comparability: Can be compared with other inventories

- Standardized layout across sectors and sub-sectors
- Referencing other cells rather than including numbers in the calculation
  - From the energy reference sheet, X12
  - =(14987+3386)*0.25+0.75*(16115+3569)
- Conversion factors, GWP etc on their own sheet, so they only need to be changed once
- Conditional formatting to help identify outliers
- Colour coding to distinguish between constants, data and calculations

DATA REFERENCING

- IPCC guidelines include information on QA/QC
  - Following these can help support data management and increase integrity
- Referencing and documentation is key:
  - Data type (activity data, emission factor, emissions, constant, etc.)
  - Source of data for each data point
  - Sector
  - Subsector
  - Category
  - Subcategory
  - Fuel type
  - Sub-fuel type (if needed)
  - (other subcategories) as needed
  - Units
  - GHG (i.e., input data relevant for this gas, emissions for this gas)
  - Comments for any notation keys could be helpful

DISCUSSION