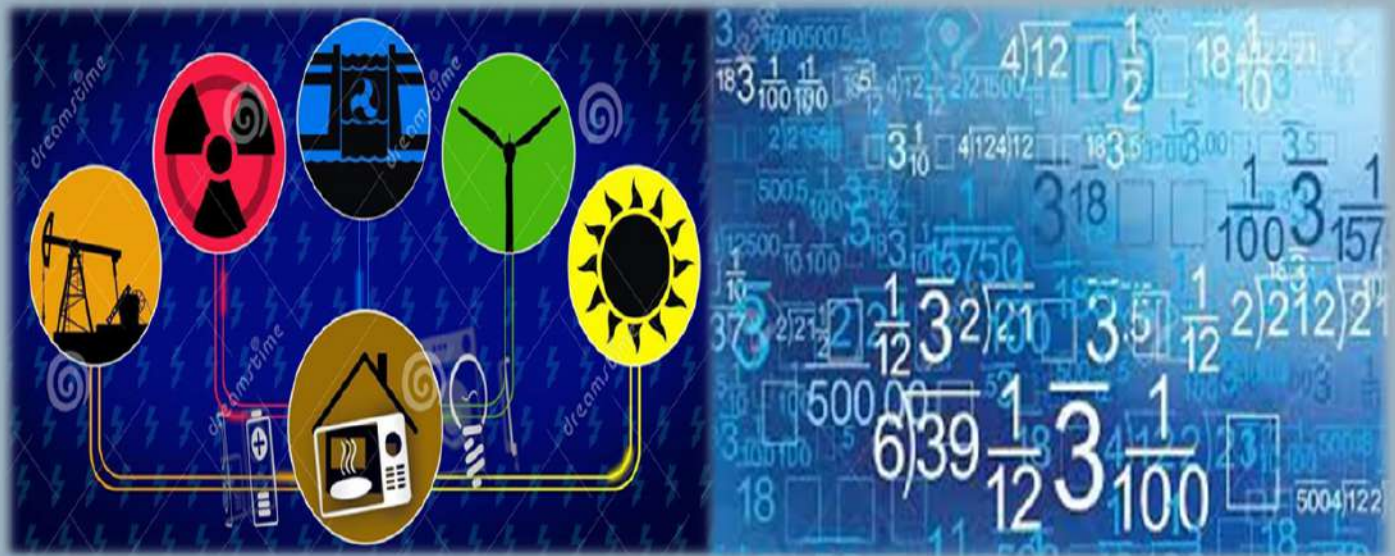
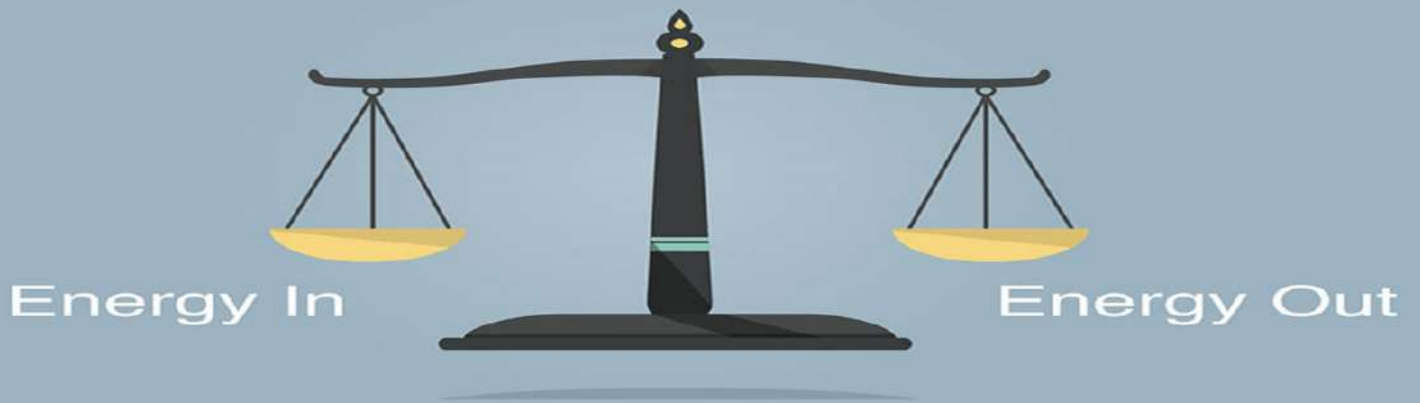


ENERGY BALANCE AND SANKEY DIAGRAM



CHAPTER 7

Energy Balance and Sankey Diagram

Commodity Balance

The purpose of commodity balance is to show the sources of supply and various uses of particular energy product with reference to national territory of the compiling country. The balance is compiled for any energy commodity provided that the commodity remains homogeneous at each point in the balance.

International Recommendations on Energy Statistics (IRES) recommends that the format of energy balance and all applicable concepts are consistently used in the compilation of a commodity balance to ensure data consistency. The major sources for commercial energy in India are coal, oil products, natural gas and electricity. Non-energy producing sectors derive energy from the resources available in primary form such as coal, crude oil, natural gas, hydro-power and nuclear power. Some of the energy resources are converted into other (final) energy products that are used for purposes other than energy generation.

Coal is also used as a final product or intermediate for power generation. Similarly, natural gas is also used directly or as an intermediate in power generation. Many petroleum products, such as HSDO, Naphtha etc. are used as a final product by the non-energy producing sectors and also used for power generation. This indicates that the same energy source can be used in various forms at various stages of consumption. This creates a possibility of over-estimation or under-estimation of energy consumption in totality as well as for different sources.

Energy Balance

An energy balance is a framework to complete data on all energy products entering, existing and used within a given country during a reference period (e.g. a year). It expresses all data in common energy units, which makes it possible to define a “total” product.

The purpose of compiling an energy balance starting from the various commodity balances are numerous; they are to:

- Provide a comprehensive overview of the energy profile of a country, to monitor energy security, energy markets, relevant policy goals and to formulate adequate energy policies;
- Provide the basis for aggregate socio-economic indicators, as well as for estimates of CO₂ emissions;
- Compare data of different reference periods and different countries;
- Provide a tool to ensure completeness, consistency and comparability of basic statistics;

- Calculate efficiencies of transformation processes, as well as relative shares of different sectors or products in the country's total supply or consumption

An energy balance generally takes the form of a matrix of products and flows, with varying levels of disaggregation, although graphical formats also exist (e.g. sankey diagram).

Two major components of the energy balance statistics are Total Primary Energy Supply (TPES) and Total Final Consumption (TFC) of energy commodity. Within a balance, the total final consumption is disaggregated into sectors, like industry, transport, residential, services and others. However, the level of disaggregation of such energy data is not enough to monitor energy efficiency, as no information is available, for example on the residential or services end uses, nor on the transport vehicle types or segments. The energy balance will therefore be useful to assess the largest consuming sectors within a country where the energy saving potential will have more impact, before starting more detailed collection programmes on data for energy efficiency indicators.

A note on Methodology used for Energy Balance

Energy (in KToe) = Quantity of Commodity * Conversion factor

where 1 Toe = 41868 MJ

Therefore, Conversion factor = $\frac{\text{Net Calorific Value (NCV)}}{\text{Mega joules per ton of oil equivalent}}$

where Net Calorific Value (NCV) is in kj per kg and

Net Calorific Value (NCV) = Gross calorific value (GCV) - (% Moisture Content)

The difference between net and gross calorific values are typically about 5% to 6% of the gross value of solid and liquid fuels and about 10% for Natural gas.

Net Calorific Values are, as recommended by IEA for all commodities.

Sankey Diagram

The concept of data visualization in the digital age has revived interest in a style of chart called a Sankey diagram. This style of diagram makes it easy to see the dominant flows within a system and highlights where losses occur. The Sankey diagram is very useful tool to represent an entire input and output energy flow in energy system after carrying out energy balance calculation. The thicker the line, the greater the amount of energy involved.

The data of Energy Balance (Table 7.2) is used to construct the Sankey diagram, in which flows of energy are traced from energy sources to end-use consumption. The resulting diagram provides a convenient and clear snapshot of existing energy transformations in India which can usefully be compared with a similar global analysis. It gives a basis for examining and communicating future energy scenarios.

Highlights

- In this 30th edition of Energy Statistics, attempt has been made to generate the Energy Balance table of India using the domestic conversion factors (especially for Coal). Since Coal has always having the dominant share of Energy resources in India, thus a shift of conversion factors from IEA to Domestic, results in a significant reduction of Energy supplied and consumed in India. Attempt has also been made to generate the final version of Energy Balance table of India from 2012-13 onwards, based on the audited final database, received from all the source Ministries and using the domestic conversion factors.
- In 2021-22 (P), Primary Energy Supply added up to 7,39,386 Kilo Tonne of Oil equivalent (ktoe) (Table 7.2).
- Two major contributors to the total energy supply in the country were Coal which accounted for 56.13% of the total and Crude Oil which accounted for 33.40%.
- In 2021-22 (P), final Energy Consumption (End Use) was 5,25,708 ktoe. The industrial sector was the largest consumer of energy in the country with this sector itself using more than half, i.e., 50.59% of the total final energy consumption.
- Within the industry sector, the most energy intensive industries were iron and steel, which accounted for 15.29% of the industrial energy use followed by Chemicals and petrochemicals 5.36 % and construction 2.09%.
- The consumption of the residential, agriculture, commercial & public sectors, No-specified(others) and non-energy purpose represented 38.53% of the total final consumption in the country, whereas, transport sector accounted for 10.88% of Total Final Consumption.
- The Energy Balance table of India, based on the final audited figures as available from different Ministries and on Domestic conversion factors have been computed from the FY: 2012-13 to FY: 2019-20. The same can be found in *Annexure – V*.

Chapter 7 : Energy Balance and Sankey Diagram

Table 7.1 : Energy Commodity Balance for the year 2020-21(Final)

Supply	Coal	Lignite	LPG	Naphtha	Kerosene	Diesel (HSD+ LDO)	Fuel Oil	Lubricants	Bitumin	Petrol/Motor Spirit	Other Petroleum Products*	Natural Gas	Electricity
	(000 tonnes)											MMSCM	(GWh)
Production	716083	37895	12072	19403	2393	101170	7242	1069	5245	35779	49140	28673	1373187
From Other Sources													224827
Imports	215251	19	16476	1199	3	648	6454	2693	2055	1351	12369	33031	9548
Exports	-2945	-187	-452	-6509	-15	-30576	-1177	-15	-7	-11606	-6412	0	-9574
Stock changes	27628	-514											
Domestic Supply	956017	37212	28096	14093	2381	71242	12519	3747	7293	25524	55097	61704	1597988
Transfer													
Statistical difference	-49685	1280	-538	8	-583	2325	-6932	350	231	2445	-23003	210	-14939
Transformation	581233	32937	0	70	0	456	237	0	0	0	0	10836	0
Electricity plants	581233	32937	0	70		456	237					10836	
Energy industry own use	0	0	0	0	0	0	0	0	0	0	0	18210	80472
Oil and Gas extraction												5730	
Petroleum refineries												7911	
Own use in electricity, CHP and heat plants													80472
Other energy sector												4569	
Distribution losses												67	272369
Final Consumption	325099	5555	27558	14030	1798	73112	5350	4097	7524	27969	32094	32801	1230208
Industry Sector	325099	5555	2102	14030	0	3314	2162				28396	555	508776
Iron and steel	69738	24		0		204	826						
Chemical and petroleum	1527			11405		162	532						
Non-ferrous metals						21	349						
Machinery						125	21						
Mining & Quarrying						1650	92						
Paper, pulp and print	1045	566											
Construction	6779	1239				1080	148						
Textile and leather	80	290				20	39						
Non-specified	245930	3436	2101	2625		53	155				28396	555	508776
Transport Sector	0	0	119	0	0	3262	1022	0	0	27969	3698	9669	14668
Road			119			1375	132			27969		9230	
Domestic Aviation						2							
Rail						1223	0						14668
Pipeline transport												439	
Domestic navigation						662	890				3698		
Non-specified							0						
Other Sectors			25337	0	1798	66536	2165	4097	7524			1077	706764
Residential			25128		1587								330809
Comm. And public services					69								86950
Agriculture/forestry			28			586	87					177	221303
Non-specified			180		143	65950	2078	4097	7524			900	67701
Non-Energy Use												21500	

(P): Provisional

Statistical Difference is defined as final consumption + use for transformation processes and consumption by energy industry own use + losses - domestic supply

Final consumption = Total Consumption in Transport + Total Industrial Consumption+Consumption by Other sectors+Non energy Use

* Include ATF, Pet Coke, Paraffin waxes, petroleum jelly, LSWR, MTBE and reformat, BGO, Benzene, MTO, CBFS and Sulfur etc.

Chapter 7 : Energy Balance and Sankey Diagram

Table 7.2: Energy Balance of India for 2020-21 (Final)

All figures in KToE

	Coal	Crude Oil	Oil Products	Natural Gas	Nuclear	Hydro	Solar, Wind, Others	Electricity	Total
Production	2,97,775	31,165	0	26,522	11,214	12,955	13,279	0	3,92,909
Imports	1,15,541	2,00,783	42,915	30,554	0	0	0	821	3,90,614
Exports	-2,026	0	-59,090	0	0	0	0	-823	-61,939
Stock changes	11,521	0	0	0	0	0	0	0	11,521
Total primary energy supply	4,22,811	2,31,947	-16,174	57,076	11,214	12,955	13,279	-2	7,33,105
Statistical differences	-6,473	18,012	-23,136	194	0	0	0	-1,285	-12,687
Main activity producer electricity plants	-2,43,521	0	-769	-10,023	-11,214	-12,926	-12,663	1,18,094	-1,73,021
Autoproducer electricity plants	0	0	0	0	0	-29	-616	19,335	18,690
Oil refineries	0	-2,26,652	2,37,827	0	0	0	0	0	11,175
Energy industry own use	0	0	0	-16,844	0	0	0	-6,921	-23,765
Losses	0	-23,308	0	-62	0	0	0	-23,424	-46,794
Final consumption	1,72,818	0	1,97,748	30,341	0	0	0	1,05,798	5,06,704
Industry	1,72,818	0	47,051	513	0	0	0	43,755	2,64,137
Iron and steel	36,805	0	984	0	0	0	0	0	37,790
Chemical and petrochemical	806	0	12,923	0	0	0	0	0	13,729
Non-ferrous metals	0	0	348	0	0	0	0	0	348
Machinery	0	0	149	0	0	0	0	0	149
Mining and quarrying	0	0	1,792	0	0	0	0	0	1,792
Paper, pulp and print	680	0	0	0	0	0	0	0	680
Construction	3,860	0	1,256	0	0	0	0	0	5,116
Textile and leather	108	0	57	0	0	0	0	0	165
Non-specified (industry)	1,30,558	0	29,542	513	0	0	0	43,755	2,04,368
Transport	0	0	38,331	8,944	0	0	0	1,261	48,537
Road	0	0	31,608	8,538	0	0	0	0	40,146
Domestic aviation	0	0	3,941	0	0	0	0	0	3,941
Rail	0	0	1,264	0	0	0	0	1,261	2,526
Pipeline transport	0	0	0	406	0	0	0	0	406
Domestic navigation	0	0	1,517	0	0	0	0	0	1,517
Non-specified (transport)	0	0	0	0	0	0	0	0	0
Other	0	0	1,12,365	996	0	0	0	60,782	1,74,143
Residential	0	0	29,963	0	0	0	0	28,450	58,413
Commercial and public services	0	0	68	0	0	0	0	7,478	7,546
Agriculture/forestry	0	0	719	164	0	0	0	19,032	19,915
Non-specified (other)	0	0	81,615	832	0	0	0	5,822	88,269
Non-energy use	0	0	0	19,887	0	0	0	0	19,887
Non-energy use industry/transformation/energy	0	0	0	19,887	0	0	0	0	19,887
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	43,029	1,50,639	1,54,405	0	3,48,073
Elec output-main activity producer ele plants	0	0	0	0	43,029	1,50,300	1,47,248	0	3,40,576
Elec output-autoproducer electricity plants	0	0	0	0	0	339	7,158	0	7,497

* Final consumption refers to End Use Consumption

P: Provisional

Chapter 7 : Energy Balance and Sankey Diagram

Table 7.3 : Energy Commodity Balance for the year 2021-22(Provisional)

Supply	Coal	Lignite	LPG	Naphtha	Kerosene	Diesel (HSD+ LDO)	Fuel Oil	Lubricants	Bitumin	Petrol/Motor Spirit	Other Petroleum Products*	Natural Gas	Electricity
	(000 tonnes)											MMSCM	(GWh)
Production	778190	47490	12238	19994	1916	107980	8327	1173	5111	40238	57328	34024	1484442
From Other Sources													235000
Imports	208934	68	17120	1268	0	75	9024	3106	2638	671	8160	30776	7597
Exports	-1169	-18	-513	-6861	-14	-32407	-1716	-10	-6	-13482	-7703	0	-9232
Stock changes	-40171	-1592											
Domestic Supply	945784	45948	28845	14401	1902	75648	15636	4269	7743	27426	57785	64800	1717807
Transfer													
Statistical difference	82339	3125	-515	-124	-409	2060	-9381	301	131	3423	-24906	2529	-46241
Transformation	709860	38756	0	6	0	502	341	0	0	0	0	10157	0
Electricity plants	709860	38756	0	6		502	341					10157	
Energy industry own use	0	0	0	0	0	0	0	0	0	0	0	20298	83856
Oil and Gas extraction												5758	
Petroleum refineries												5312	
Own use in electricity, CHP and heat plants													83856
Other energy sector												9229	
Distribution losses												80	291410
Final Consumption	318263	10317	28329	14271	1494	77205	5914	4570	7874	30849	32879	36793	1296300
Industry Sector	318263	10317	2422	14271	0	3138	2410				27871	829	533500
Iron and steel	74053	268		0		228	913						
Chemical and petroleum	1463			11904		136	581						
Non-ferrous metals						27	390						
Machinery						140	19						
Mining & Quarrying			3			1551	127						
Paper, pulp and print	1250	782											
Construction	7312	2090				977	184						
Textile and leather	82	3398				19	33						
Non-specified	234103	3779	2419	2367		60	162				27871	829	533500
Transport Sector	0	0	123	0	0	4095	1159	0	0	30849	5008	12661	19800
Road			123			1696	172			30849		12175	
Domestic Aviation						3							
Rail						1749	0						19800
Pipeline transport												486	
Domestic navigation						648	986				5008		
Non-specified							0						
Other Sectors			25784	0	1494	69973	2345	4570	7874			1226	743000
Residential			25502		1292								334000
Comm. And public services					64								107500
Agriculture/forestry			30			548	71					156	229000
Non-specified			253		138	69424	2273	4570	7874			1070	72500
Non-Energy Use												22077	

(P): Provisional

Statistical Difference is defined as final consumption + use for transformation processes and consumption by energy industry own use + losses - domestic supply

Final consumption = Total Consumption in Transport + Total Industrial Consumption+Consumption by Other sectors+Non energy Use

* Include ATF, Pet Coke, Paraffin waxes, petroleum jelly, LSWR, MTBE and reformat, BGO, Benzene, MTO, CBFS and Sulfur etc.

Chapter 7 : Energy Balance and Sankey Diagram

Table 7.4: Energy Balance of India for 2021-22 (Provisional)

All figures in KToE

	Coal	Crude Oil	Oil Products	Natural Gas	Nuclear	Hydro	Solar, Wind, Others	Electricity	Total
Production	3,23,501	30,344	0	31,471	12,278	13,070	15,429	0	4,26,093
Imports	1,15,985	2,16,643	42,216	28,468	0	0	0	653	4,03,964
Exports	-791	0	-65,425	0	0	0	0	-794	-67,010
Stock changes	-23,662	0	0	0	0	0	0	0	-23,662
Total primary energy supply	4,15,032	2,46,987	-23,209	59,939	12,278	13,070	15,429	-141	7,39,386
Statistical differences	51,533	24,910	-26,483	2,339	0	0	0	-3,977	48,322
Main activity producer electricity plants	-2,94,450	0	-845	-9,395	-12,278	-13,040	-14,698	1,27,662	-2,17,044
Autoproducer electricity plants	0	0	0	0	0	-30	-731	20,210	19,449
Oil refineries	0	-2,47,020	2,58,615	0	0	0	0	0	11,594
Energy industry own use	0	0	0	-18,776	0	0	0	-7,212	-25,988
Losses	0	-24,876	0	-74	0	0	0	-25,061	-50,011
Final consumption	1,72,115	0	2,08,077	34,033	0	0	0	1,11,482	5,25,708
Industry	1,72,115	0	47,185	767	0	0	0	45,881	2,65,948
Iron and steel	39,561	0	1,091	0	0	0	0	0	40,652
Chemical and petrochemical	780	0	13,478	0	0	0	0	0	14,259
Non-ferrous metals	0	0	393	0	0	0	0	0	393
Machinery	0	0	163	0	0	0	0	0	163
Mining and quarrying	0	0	1,723	0	0	0	0	0	1,723
Paper, pulp and print	845	0	0	0	0	0	0	0	845
Construction	4,377	0	1,183	0	0	0	0	0	5,559
Textile and leather	818	0	51	0	0	0	0	0	869
Non-specified (industry)	1,25,733	0	29,104	767	0	0	0	45,881	2,01,485
Transport	0	0	43,802	11,712	0	0	0	1,703	57,216
Road	0	0	35,063	11,262	0	0	0	0	46,325
Domestic aviation	0	0	5,338	0	0	0	0	0	5,338
Rail	0	0	1,808	0	0	0	0	1,703	3,511
Pipeline transport	0	0	0	450	0	0	0	0	450
Domestic navigation	0	0	1,593	0	0	0	0	0	1,593
Non-specified (transport)	0	0	0	0	0	0	0	0	0
Other	0	0	1,17,091	1,134	0	0	0	63,898	1,82,123
Residential	0	0	30,093	0	0	0	0	28,724	58,817
Commercial and public services	0	0	63	0	0	0	0	9,245	9,308
Agriculture/forestry	0	0	667	144	0	0	0	19,694	20,505
Non-specified (other)	0	0	86,268	990	0	0	0	6,235	93,492
Non-energy use	0	0	0	20,421	0	0	0	0	20,421
Non-energy use industry/transformation/energy	0	0	0	20,421	0	0	0	0	20,421
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	47,112	1,51,977	1,79,412	0	3,78,502
Elec output-main activity producer ele plants	0	0	0	0	47,112	1,51,627	1,70,912	0	3,69,652
Elec output-autoproducer electricity plants	0	0	0	0	0	350	8,500	0	8,850

* Final consumption refers to End Use Consumption

P: Provisional

Figure 7.1 : Year-wise comparison of TPES and Energy Supplied from Coal_IEA Vs. Domestic Conversion Factors

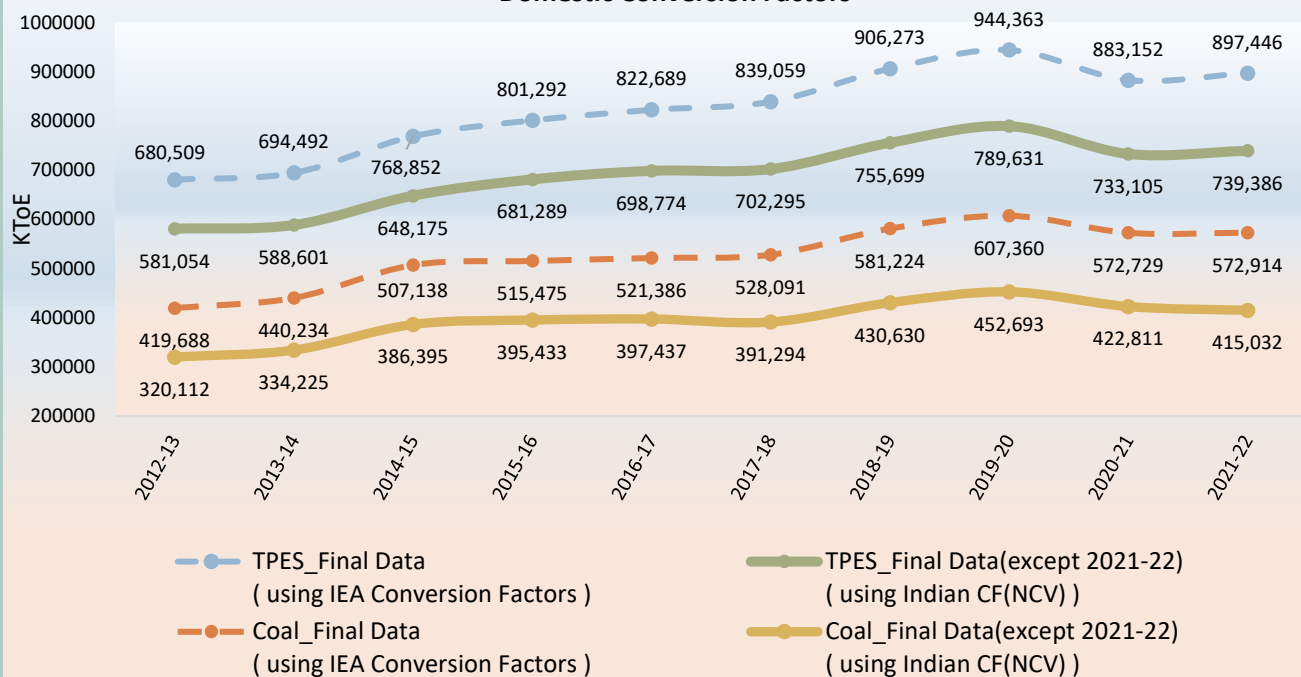


Figure 7.2 : Year-wise comparison of Energy Consumption using IEA Vs. Domestic Conversion Factors

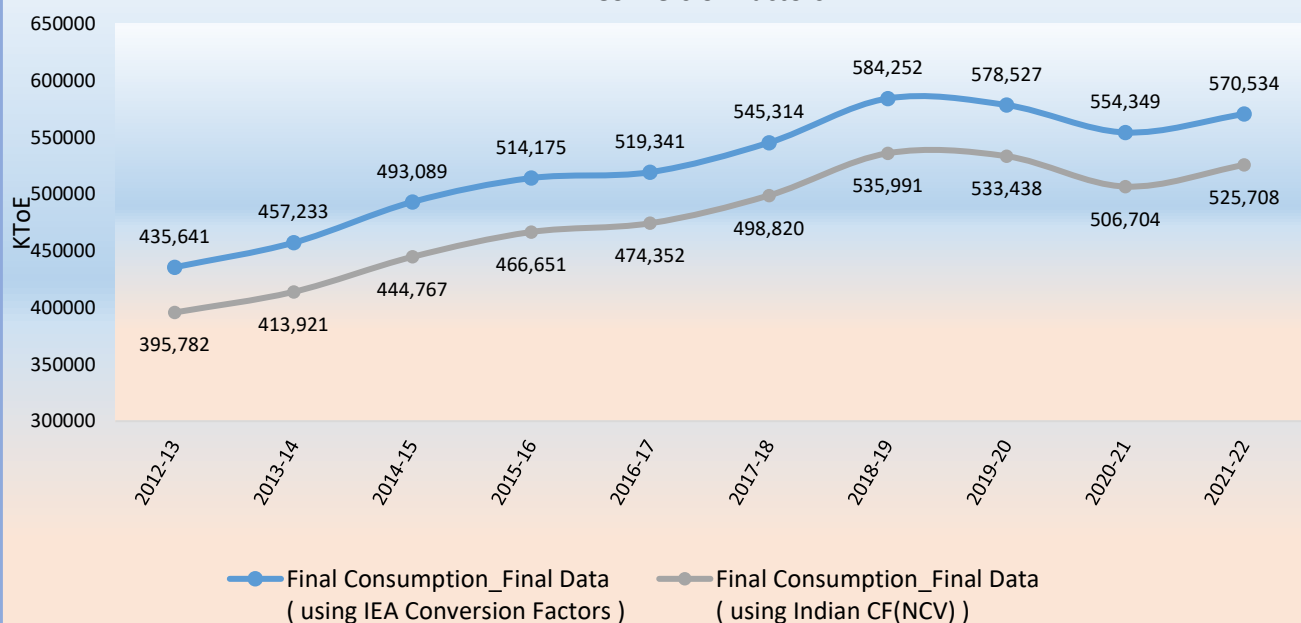
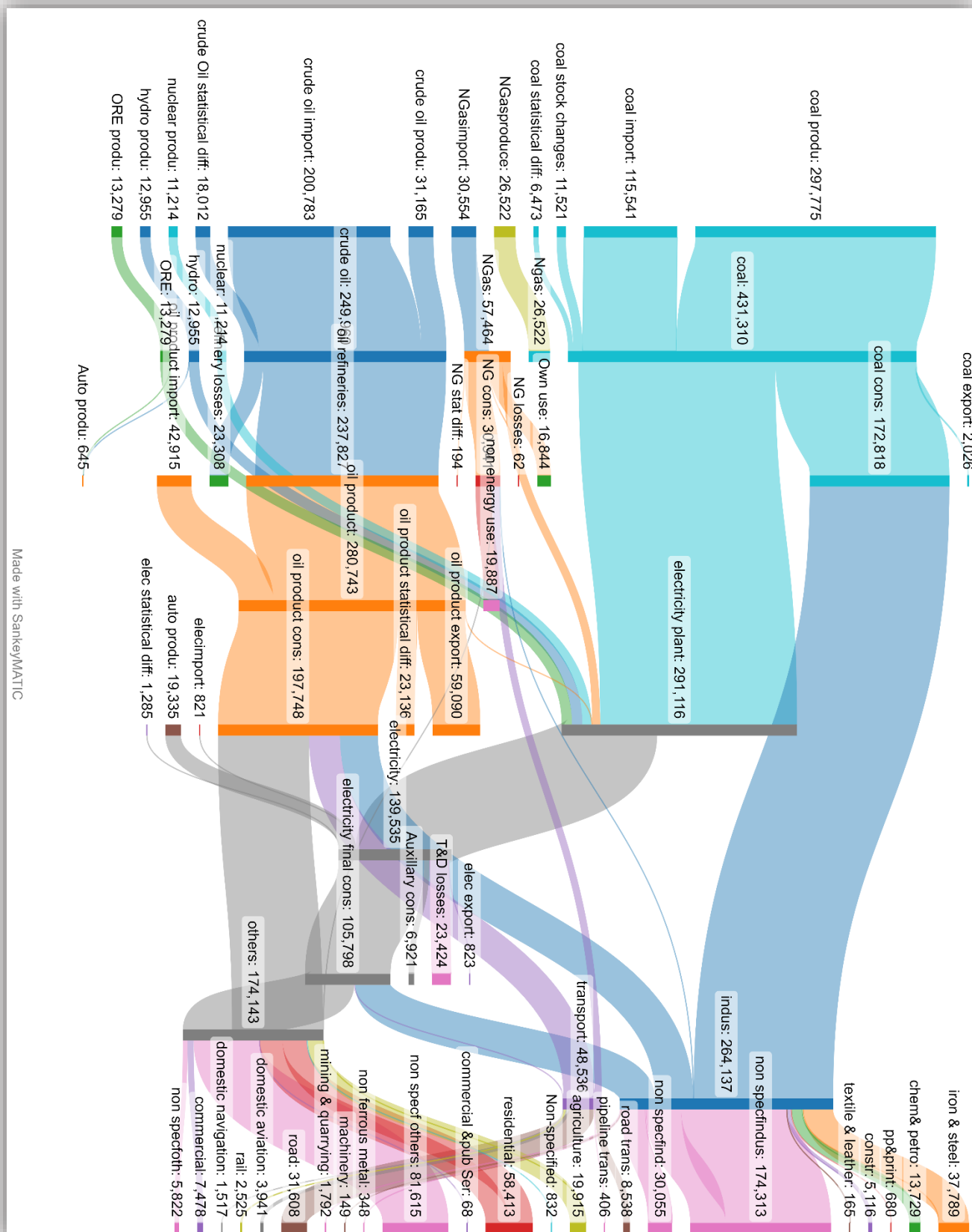
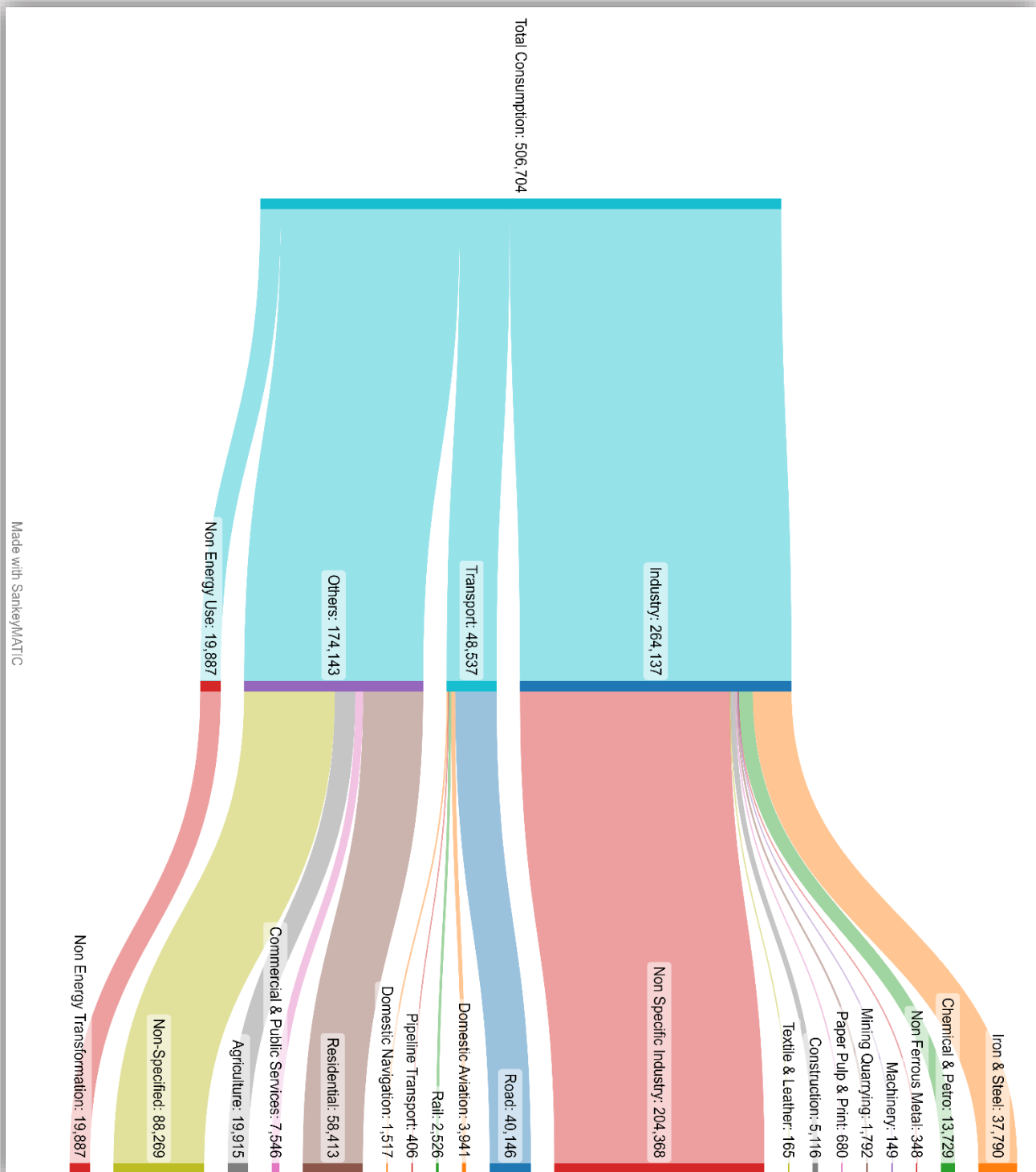


Fig. 7.3: Sankey Diagram on Overall Energy Flow in India during FY: 2020-21(Final) (in KToe)



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Fig. 7.4: Sankey Diagram on Final Consumption by sectors in India during FY: 2020-21(Final) (in KToe)



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Fig. 7.5: Sankey Diagram on Overall Energy Flow in India during FY: 2021-22(P) (in KToe)

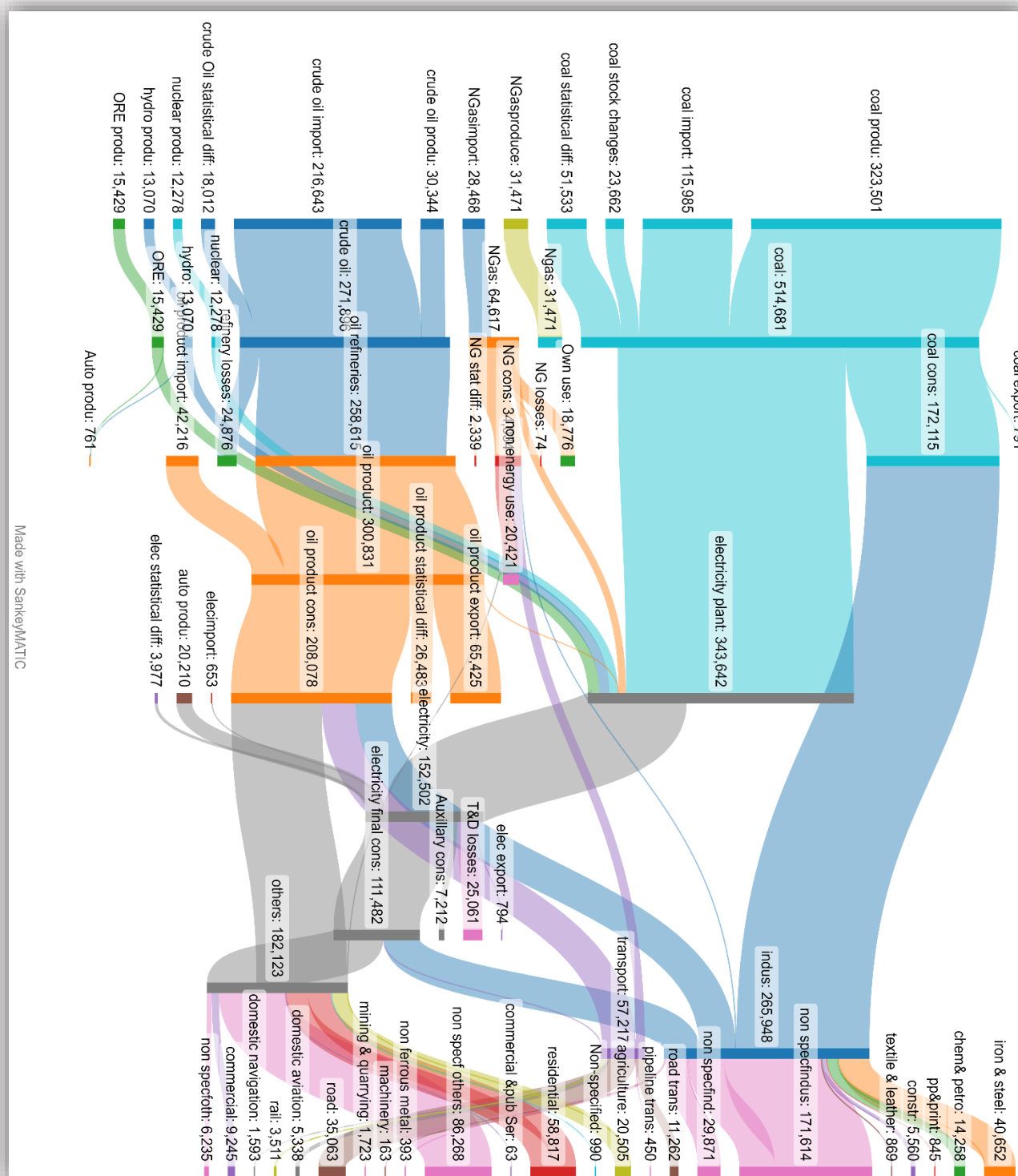
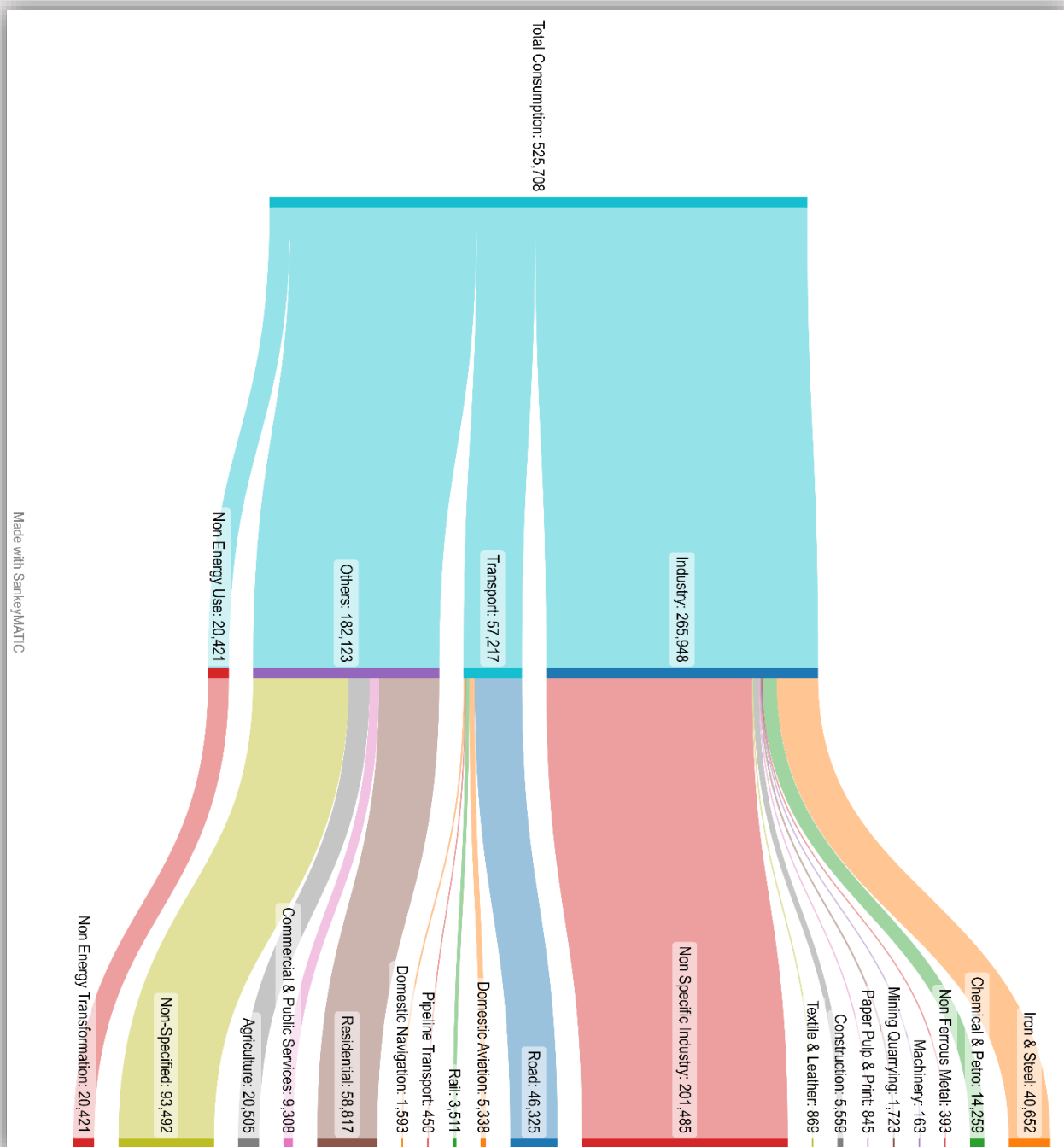


Fig. 7.6: Sankey Diagram on Final Consumption by sectors in India during FY: 2021-22 (P) (in KToe)



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