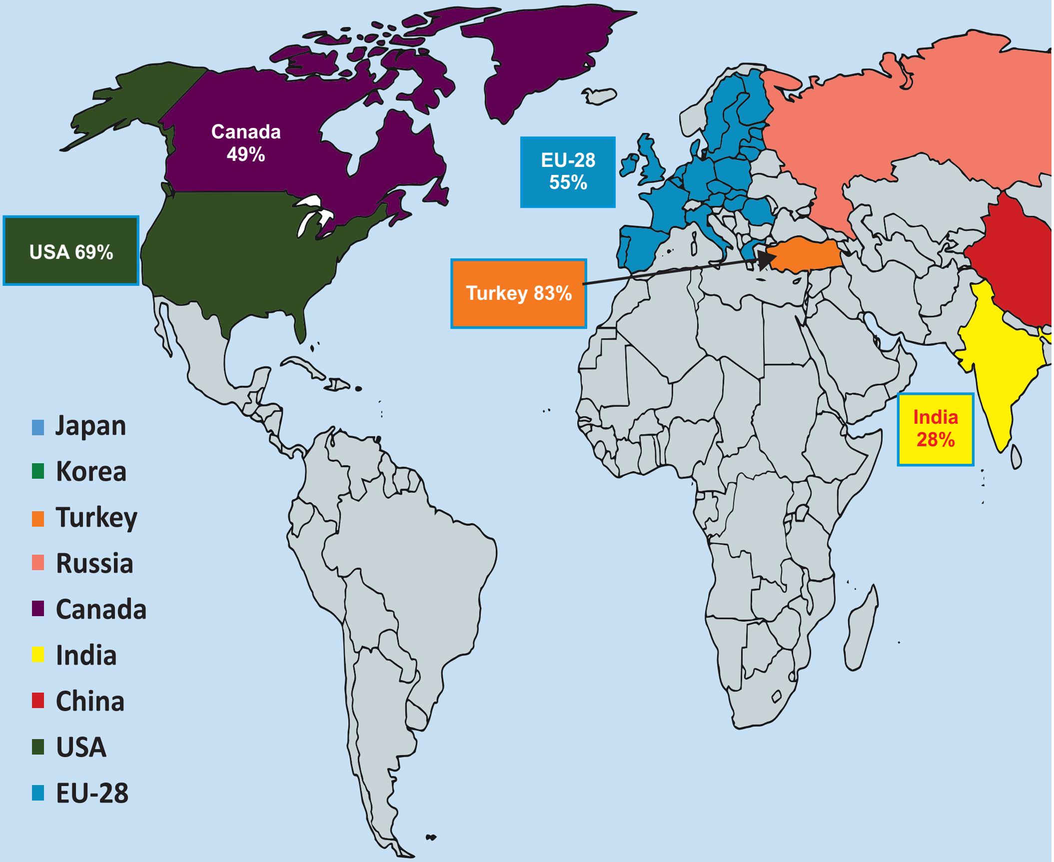
INTERGENERATIONAL EQUITY
– A BYGONE CONCEPT

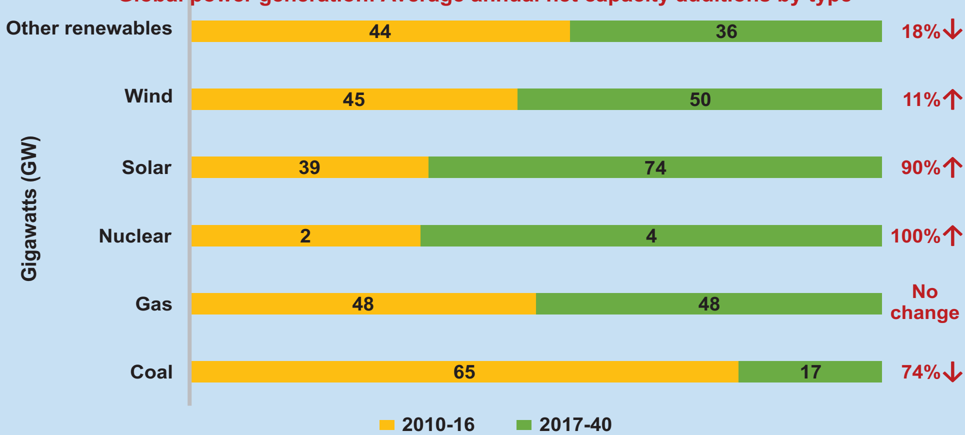
SEPTEMBER, 2020

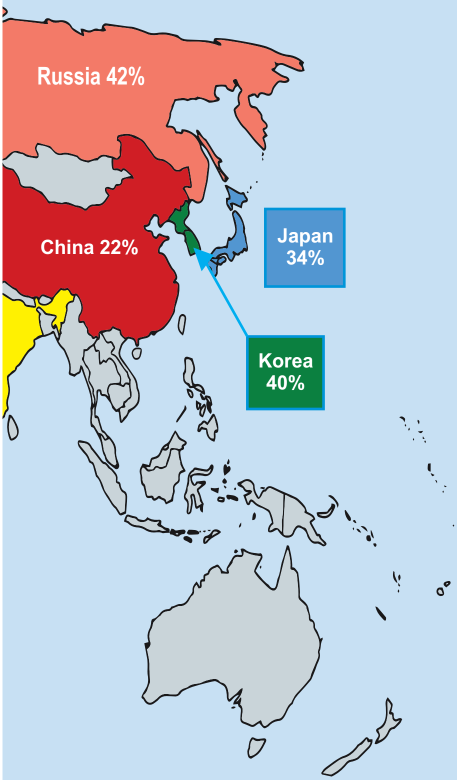
FEDERATION OF INDIAN MINERAL INDUSTRIES
FIMI HOUSE, B-311, Okhla Industrial Area, Phase-1, New Delhi - 110 020 (India)
Tel.: +91-11-26814596; Fax: +91-11-26814593/26814594
E-mail : fimi@fedmin.com; Website: www.fedmin.com

% of scrap use in steel production

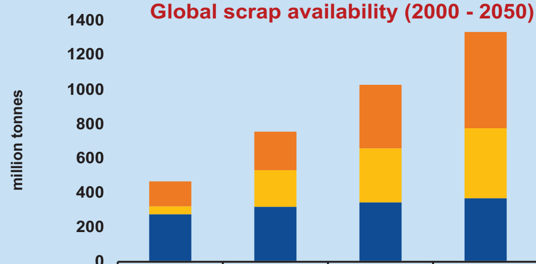


Global power generation: Average annual net capacity additions by type





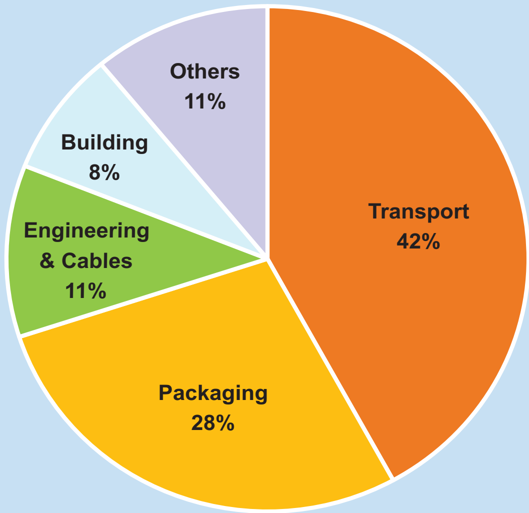
Global scrap availability (2000 - 2050)



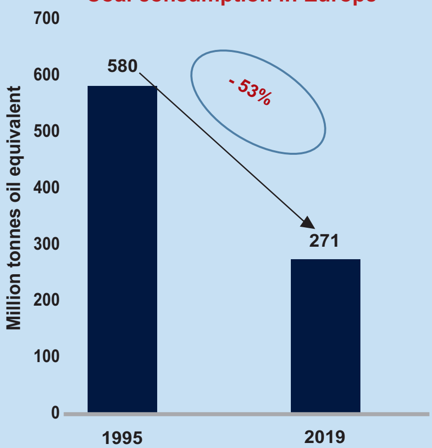
	2000	2017	2030	2050
Rest	143.72	222.173	366.532	554.85
China	46.02	211.404	311.086	404.286
EU-NAFTA- Japan	273.828	316.736	342.901	366.226

EU-NAFTA-Japan China Rest

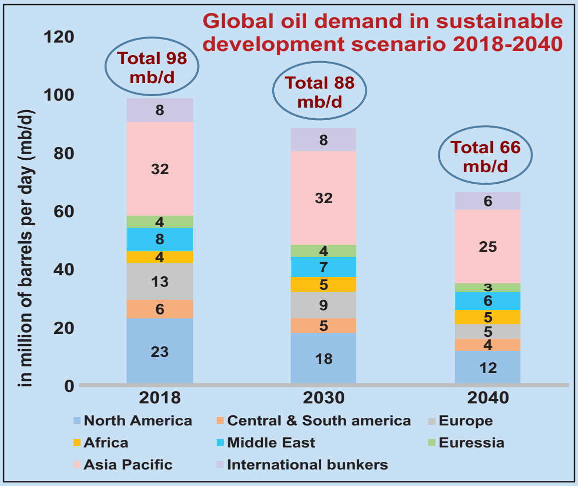
Global share of aluminium scrap from various sector



Coal consumption in Europe



Global oil demand in sustainable development scenario 2018-2040



PREFACE

Intergenerational equity is a principle of distributive justice which relates to the past, present and future generations. It is justified in those areas / disciplines where there is a need to balance needs of the present with that of subsequent generations, such as in environmental matters, climate change, public finance etc. But treating intergenerational equity as the '*be-all and end-all*' of human existence and applying it to all sorts of disciplines is neither right nor necessary.

When it comes to mineral resources, the concept of intergenerational equity has lost its relevance. Future generations are likely to have much better living standards than present generation, as has been proved across human history. Further, emerging evidence suggests that through human ingenuity, technology in beneficiating yesterday's waste, increased focus on recycling and circular economy, the world has been able to increase its mineral resource base multiple times despite growing production. Thus, there should not be any fear of scarcity of resources for humankind in the foreseeable future. In fact, applying the principle of intergenerational equity in mineral resources may deprive the present generation from utilizing its mineral potential, which future generations may not even require at that level of technological development, besides making the existing resources redundant.

Intergenerational equity for minerals, which has caught judicial attention in India of late, is a bygone concept as it fails to capture the role of technological advancements, exploration and the *'invisible hand'* of market forces. The concept has long been forgotten by the western world.

This publication titled "**Intergenerational Equity – a bygone concept**" is an attempt to explore whether it is justifiable to deprive the present generation from utilizing the mineral resources, especially when these are *'infinitely finite'*.

New Delhi
12 September, 2020

(R. K. SHARMA)
SECRETARY GENERAL

I – ORIGIN OF THE CONCEPT

Termination of World War II resulted in catapulting economic and social fabric of the people world-wide. Establishment of peace and better health and education facilities and growth in population, particularly in the newly freed colonies, required re-engineering of the manufacturing process. During early sixties "re-engineering" of a company was a fashionable concept. However, in late eighties, a new and more catchy phrase "sustainable" was coined which has since become *sine qua non* for everything that one does or lives with.

2. The World Commission on Environment and Development, popularly known as Brundtland Commission (constituted in 1983), in its report submitted to UN in 1987 defined sustainable development "*to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs*". The Brundtland Commission's definition came out of a scare generated by Club of Rome which in 1956 warned that the rate at which the mineral resources were being exploited, a day was not far when the world would be left without any resources. This scare was repeated in 1974 when the Club of Rome argued that there would be limits to growth based on availability of resources. In the case of mineral resources, it was believed that global depletion of certain resources was imminent within the next few decades.

—

II – ALARMIST APPROACH NOT WARRANTED

3. By the time Brundtland Commission report was submitted, it had become outdated. The alarmist attitude of Club of Rome was probably because of the fact that they had not anticipated the phenomenal technological developments. Over the course of time, the efficiency of usage of metals had increased by a factor of four and subsequently by a factor of ten. New technological developments have since taken place which has put the apprehension of Club of Rome way behind.

4. In past few decades, advancements in mineral exploration and beneficiation have led to much larger resource base than what has been consumed by humankind. Humans have been able to search deeper into the land, oceans and space, identify deep-seated, concealed resources in remote and inaccessible places. Today, we are mining the waste dumps and beneficiating lower grade ores, which were considered waste rock decades ago.

5. Moreover there cannot be any unbridled exploitation of resources even if one wants to because of the *'invisible hand'* of market forces. One can exploit to the extent it is demanded and at an economic price. The myth that the present generation is exploiting resources unmindful of the future generation is not borne out by facts. This sort of thought-process may deprive the present as well as future generations of optimal utilisation of resources. Scientific and technological developments have made yesterday's waste into today's resources. It may be that what we preserve today, the future generation may not require that at all. We cannot envisage what the world will require, let us say, 100 years from today at that level of technological developments. We will therefore be depriving the present generation of the opportunity of utilising the known resources which the future generation may not require.

—

III – MINERALS ARE ELEMENTS OF NATURE AND RECYCLABLE

6. It is important to distinguish between resource renewability and material renewability. Wood fibers come from a renewable resource but because of degradation, their properties are not retained when recycled i.e. they are a non-recyclable material. On the other hand, metals come from a non-renewable resource but because they are elements, their properties can be fully restored when recycled i.e. they are recyclable material. Most metals and industrial minerals are not *'consumed'* while in use. Actual recycling rates vary across metals and markets depending on market size, collection facilities and many other factors.

(a) Global averge recycling rates of different metals

7. As per *UNEP (2011) Recycling Rates of Metals – A Status Report*, the following table represents the global average recycling rates for various metals.

Table I : Metal recycling statistics

Minerals	EOL-RR (%)	RC (%)
Lead (Pb)	52% - 95%	42% - 63%
Chromium (Cr)	87% - 93%	18% - 20%
Titanium (Ti)	91%	52%
Steel / Iron (Fe)	52% - 90%	28% - 52%
Tin (Sn)	75%	22%
Aluminium (Al)	42% - 70%	34% - 36%
Cobalt (Co)	68%	32%
Nickel (Ni)	57% - 63%	29% - 41%
Zinc (Zn)	19% - 60%	18% - 27%
Niobium (Nb)	50% - 56%	22%
Copper (Cu)	43% - 53%	20% - 37%
Manganese (Mn)	53%	37%
Molybdenum (Mo)	30%	33%

Source: UNEP (2011) Recycling Rates of Metals – A Status Report

(i) **End of Life Recycling Rate (EOL – RR)** =

$$\frac{\text{Metal recycled (from EOL scrap)}}{\text{Metal available for recycling (EOL scrap)}}$$

(ii) **Recycling content (RC)** = $\frac{\text{Metal recycled (from EOL scrap)}}{\text{Metal produced}}$

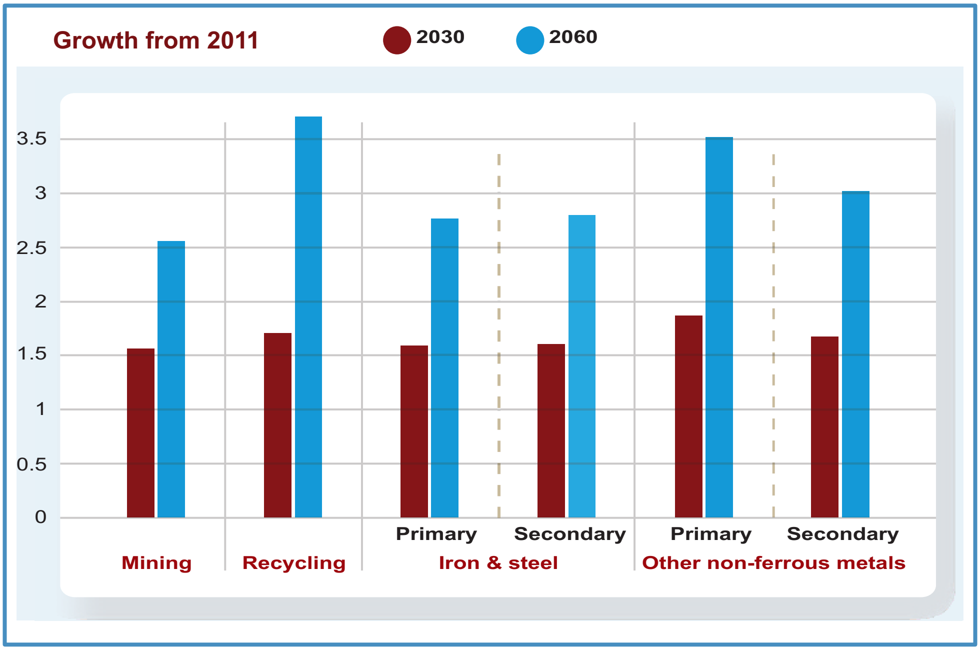
Source: https://www.ilzsg.org/static/recyclingrates.aspx?from=1

(b) OECD Report on Global Resources Outlook to 2060 : Economic Drivers and Environmental Consequences

8. In its recent report, *"Global Material Resources Outlook to 2060 : Economic Drivers and Environmental Consequences",* OECD has stated that *"Recycling will gradually become more competitive than mining of minerals thanks to projected technological developments and changes in relative prices of production inputs. This leads to growth in the recycling sector outpacing growth in mining, as well as growth in GDP, albeit less strongly".*

9. Although the share of recycling in the global economy is ten times smaller than the share of mining in terms of GDP share, recycling will economically increase until 2060 by 3.7 times from its 2011 level, compared to an increase in mining / materials use by 2.6 times during the same period. Primary and secondary iron and steel will grow by 2.8 times. Primary and secondary non-ferrous metals are expected to grow by a factor of 3.5 and 3.0 respectively from 2011 until 2060.

Chart I :
Recycling is projected to grow faster than mining or materials use (in factor)



Source: Global Material Resources Outlook to 2060, OECD report

10. In the following paragraphs, for the sake of brevity, only two most widely used metals have been analysed in detail.

(c) Commodity-wise analysis

(I) Steel

11. In US, around 69% of its steel production is through recycled scrap. In EU-28, around 55% of used steel products are recycled to produce new steel. In Turkey, about 83% of crude steel is produced by the scrap. In India, around 28% of crude steel is produced by the scrap. Scrap usage in Canada and Russia are also increasing.

Table II :
Steel scrap use and crude steel production in key countries and regions

Million tonnes

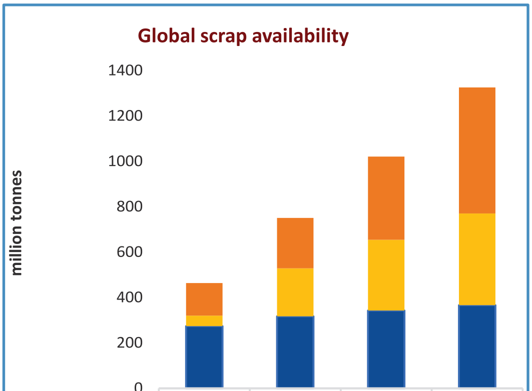
	Steel Scrap Consumption (MT)	Crude steel production (MT)	% of scrap use in steel production
China	215.93	996.34	21.67%
EU-28	87.55	159.43	54.91%
USA	60.70	87.93	69.03%
Japan	33.68	99.28	33.93%
Russia	30.40	71.57	42.47%
Korea Republic	28.54	71.42	39.96%
Turkey	27.90	33.74	82.68%
Canada	6.28	12.79	49.10%
India	25.00	89.60	27.90%
Total	**515.98**	**1622.1**	**31.81%**

Source: Bureau of International Recycling, 2019
For India (2015) : Ministry of Steel, Draft-Steel Scrap Policy, 2019

12. Scrap availability stood at about 750 million tonnes in 2017, 630 million tonnes of which was recycled by global steel and foundry casting industries. Global scrap availability is expected to reach about one billion tonnes in 2030 and 1.3 billion tonnes (equivalent to about 1.82 billion tonnes of iron ore) in 2050.

13. In 2017, as per World Steel Association, it is estimated that global steel industry uses about 575 million tonnes of scrap to produce 1.7 billion tonnes of crude steel annually. Therefore, around 34% scrap is used in crude steel production in 2017.

Chart II :
Global Steel Scrap Scenario



	2000	2017	2030	2050
Rest	143.72	222.173	366.532	554.85
China	46.02	211.404	311.086	404.286
EU-NAFTA-Japan	273.828	316.736	342.901	366.226

EU-NAFTA-Japan China Rest

Projected growth rates for the available scrap quantities 2000-2050

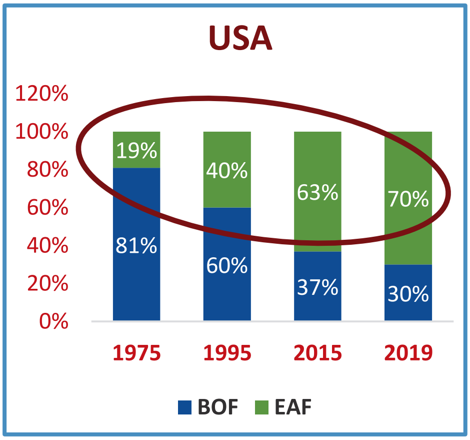
EU-NAFTA-Japan	34%
China	779%
Rest	286%

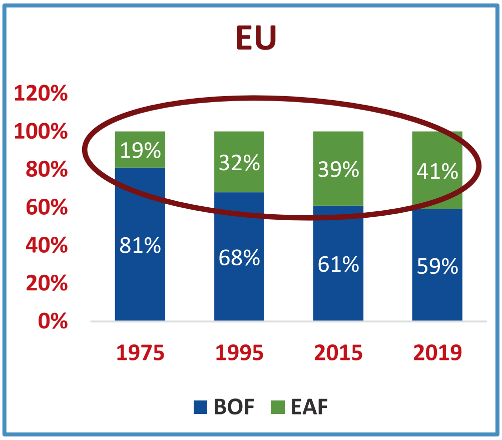
Source: World Steel Association, Brussels (2nd May, 2018)
https://www.worldsteel.org/media-centre/blog/2018/future-of-global-scrap-availability.html

Scrap availability in China is estimated to reach roughly 300 million tonnes by 2030 and 400 million tonnes by 2050 from about 216 million tonnes in 2019.

14. Mature markets like USA and EU have shifted towards Electric arc furnace (EAF) process for producing steel which mainly depends on the scrap:

Chart III :
Historical shift towards EAF process

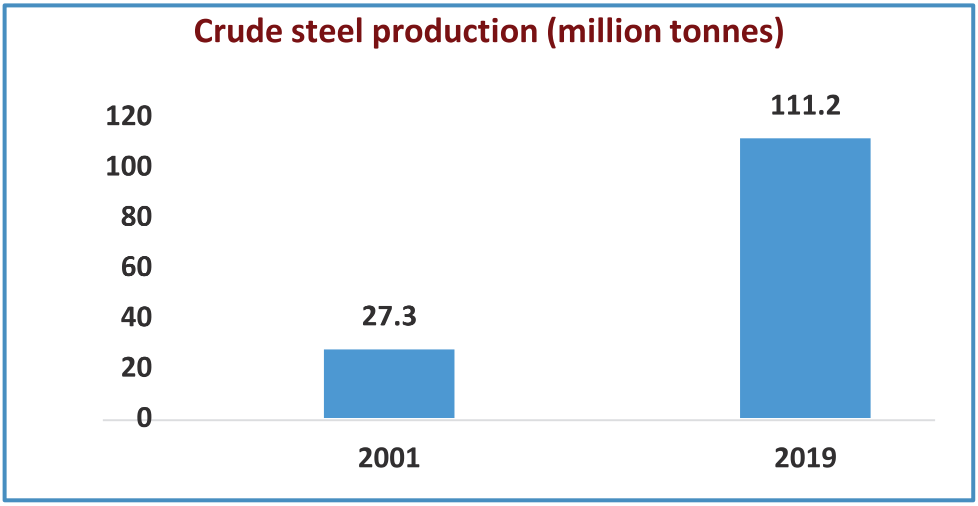


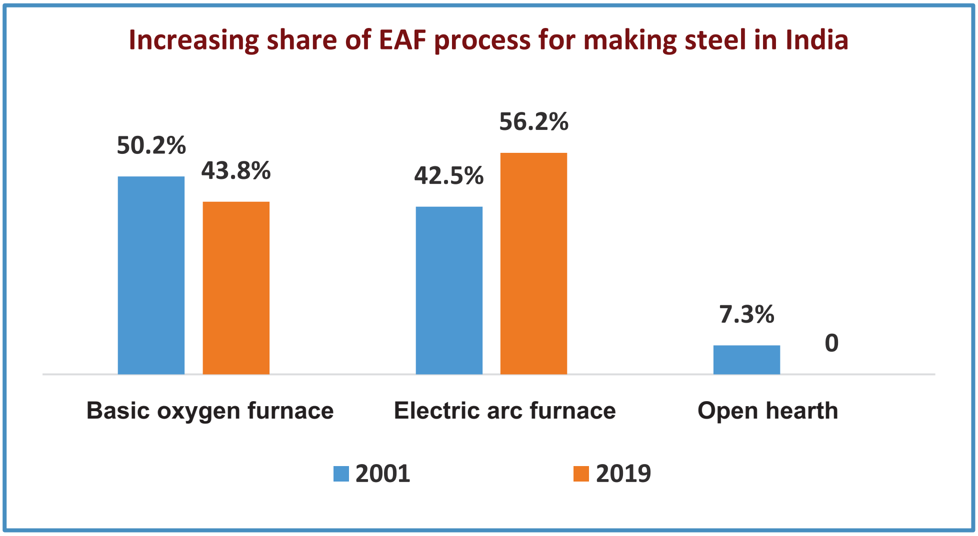


Source: World Steel Association, Brussels
Note: At present (in 2017), EAF process globally use 79% steel scrap, whereas EAF can be charged with 100% steel scrap.

15. If this rate continues, it may be that in times to come, steel production through iron ore may be limited to emerging economies like India and many of the steel producers may not be interested to set up blast furnace based steel plants.

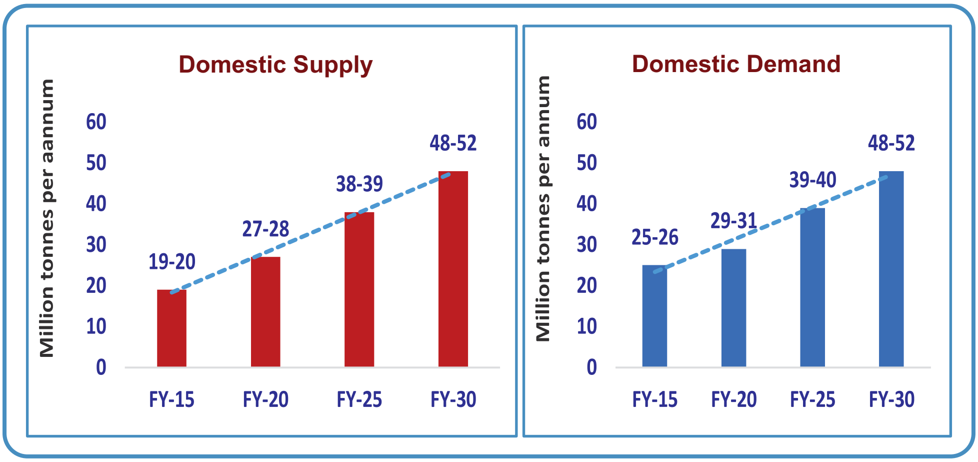
Chart IV :
Crude Steel Production by Process in India





Source: World Steel Association, Brussels

Chart V :
Demand – Supply Scenario of Scrap in India



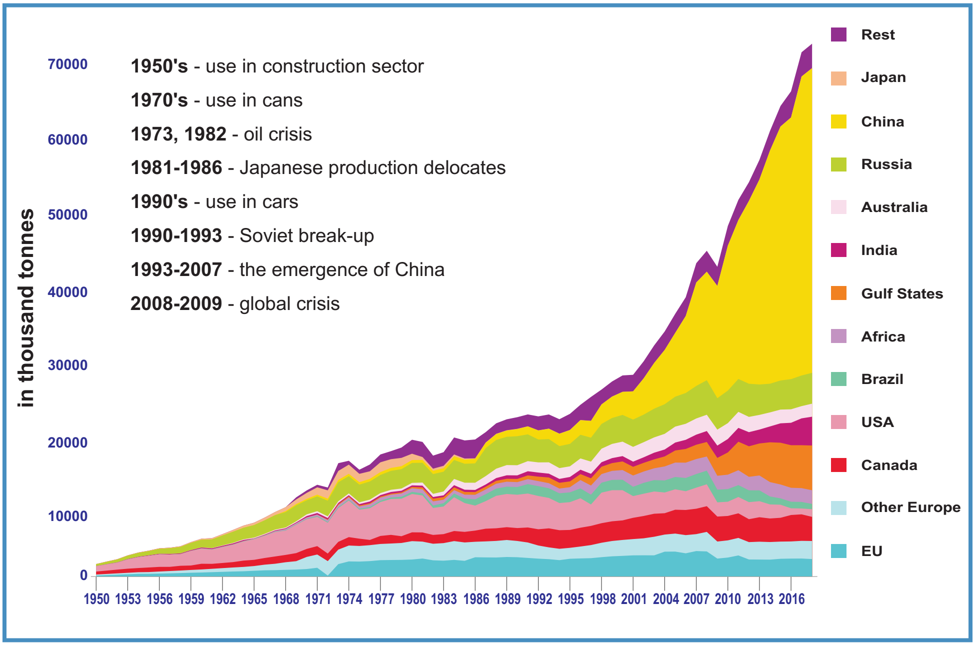
Source: Ministry of Steel, Draft-Steel Scrap Policy, 2019

16. The efficient use of scrap for steel production becomes very crucial for India. In 2015 India used 25 million tonnes of scrap to produce 89.6 million tonnes of crude steel i.e about 27.90% scrap is used in steel production. The Ministry of Steel envisages that the share of scrap in steel production will increase by 35%-40% to produce 300 million tonnes of steel in 2030.

(II) Aluminium

17. Use of aluminium picked up after 2nd World War, but it accelerated with the emergence of China in 1993 and continues to do even now. After the 2009 sub-prime crisis, production has been steadily growing in India and Middle East, with a commensurate decline in US aluminium production.

Chart VI :
Aluminium producers in the world : 1950-2016



Source: European Aluminium Vision 2050

18. China has also been the main driver of global aluminium consumption with a majority share of 54%, followed by US (8.5%), Germany (3.6%) and India (3.4%). In 2019, 88.1 million tonnes of aluminium was consumed globally, roughly 73% of which came from primary aluminium produced from bauxite and remaining 27% was derived from scrap.

Table III :
Global : Primary Aluminium Production vis-à-vis Demand

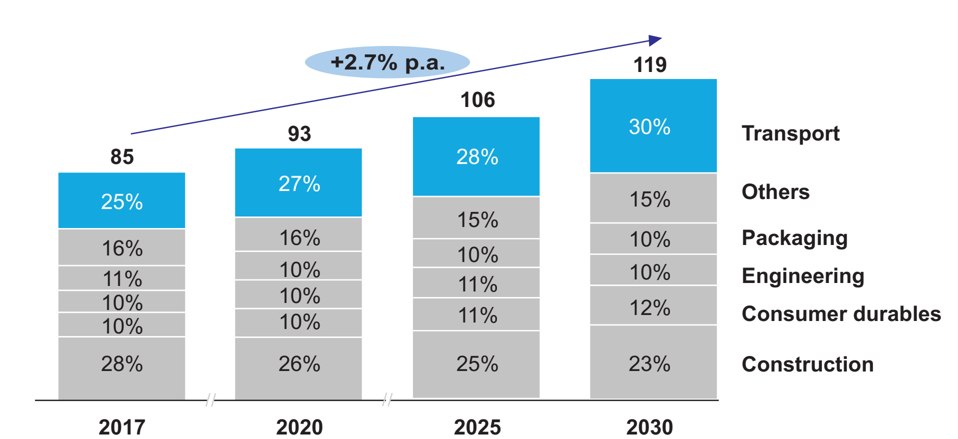
Million tonnes

	2018	2019	2020 (forecast)
Demand (Consumption)	87.6	88.1 (India 4.0)	90
Production (primary)	64.3	63.7 (India 3.7)	64.6
Balance is met through scrap (secondary aluminium)			

Source: International Aluminium Association

19. The two prime drivers for aluminium demand in the world are transport and construction sectors, which account for 53% of the total demand. McKinsey projects that global aluminium demand will rise at a modest CAGR of 2.7% till 2030. Sectoral growth projections indicate that transport sector will be the key driver of future growth, as shown below:

Chart VII :
Sector wise global aluminium demand forecast

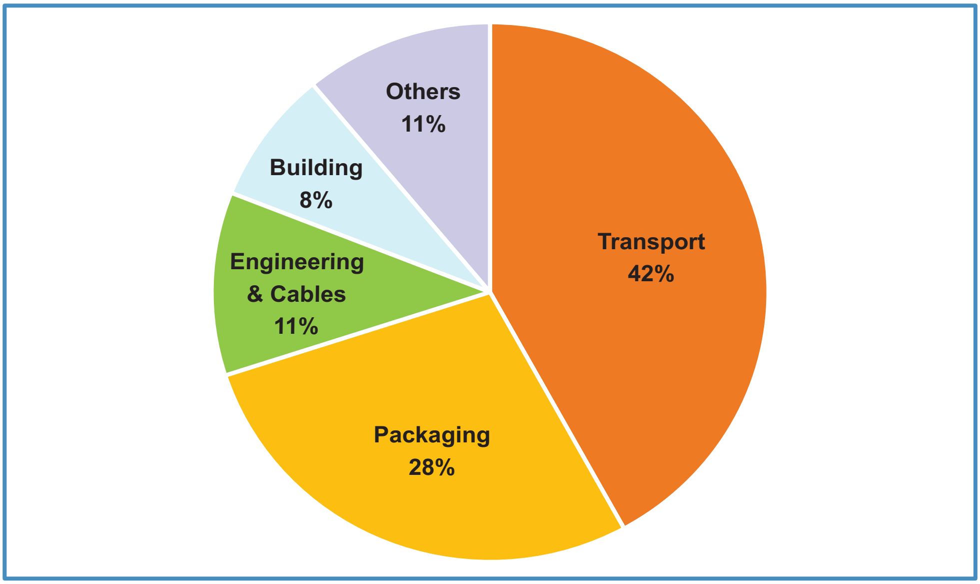


Source: McKinsey, 2018

20. Global aluminium outlook remains modest, owing to a multiplicity of factors including oversupply in the market, slowing global growth and the prolonged China-US trade negotiations, etc. Although the Coronavirus pandemic will lead to a flat demand in the near-term (1-2 years), demand may bounce back to its normal growth projections of 2.7% annually.

21. **Global share of aluminium scrap:** The following pie chart shows global share of aluminium scrap from various sectors. It is evident that transport sector with 42% share is the major source for aluminium scrap, packaging sectors contributed around 28% of aluminium scrap, engineering, cables and building sectors contributed around 11% and 8 % respectively.

Chart VIII :
Global share of aluminium scrap from various sectors



Source: Ministry of Mines, Draft National Non-Ferrous Metals (Aluminium and Copper) Scrap Recycling Policy
https://mines.gov.in/writereaddata/UploadFile/policy27032020.pdf

Table IV :
Global aluminium scrap production (in'000 tonnes)

	Country	2011	2012	2013	2014	2015	2016	2017	2018
1	China	4400	4830	5270	5650	5780	6200	6200	6250
2	Japan	142	137	143	143	149	151	159	156
3	US	3110	3370	3420	3560	3560	3580	3640	3700
4	Europe	2591	2543	2543	2640	2637	2645	2859	2855

Source: Ministry of Mines, Draft National Non-Ferrous Metals (Aluminium and Copper) Scrap Recycling Policy
https://mines.gov.in/writereaddata/UploadFile/policy27032020.pdf

22. **Aluminium recycling in Europe and India:** Statistics from European Aluminium and Metal Packing Europe's recent report show that the overall recycling rate for aluminium beverage cans in the European Union, Switzerland, Norway and Iceland reached an average of 74.5 per cent in 2017 – an all-time record. Rising 2.3 per cent from the previous year, almost 31 billion cans were recycled in the EU and EFTA countries in 2017, representing a total of more than 420,000 tonnes of aluminium and underscoring its contribution to the European circular economy.

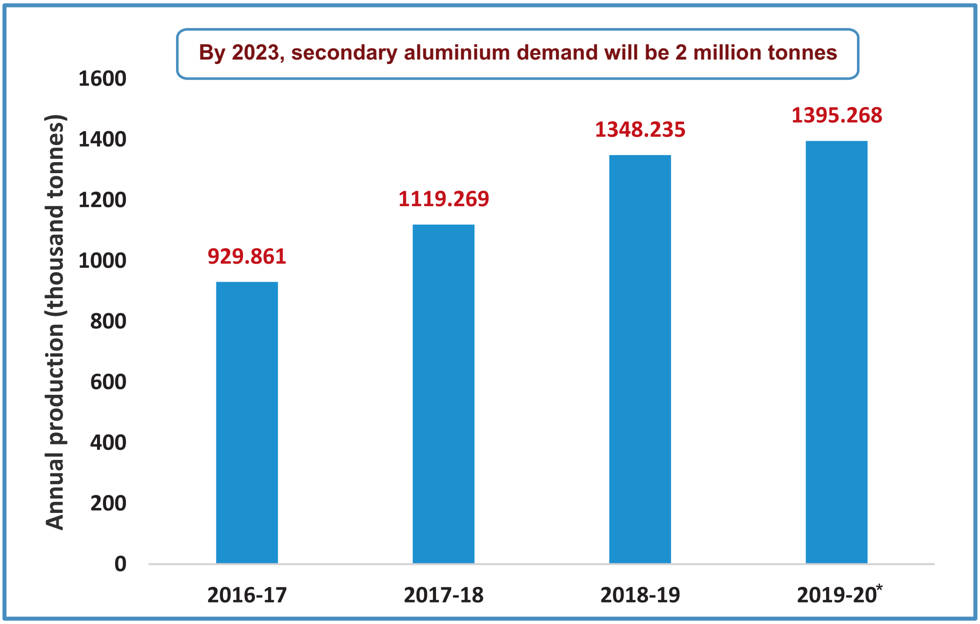
23. According to the data, Germany had the highest aluminium can recycling rate at 99 per cent, followed by Norway, Finland and Belgium, all reaching 98 per cent.

Chart IX :
Recycling of Aluminium Cans in Europe

Source: European Aluminium
https://european-aluminium.eu/

24. India has been a country that consumes aluminium in sectors having typically long useful life and lower recoverability rate. Production of secondary aluminium in India is shown in following chart. In India, 1.4 million tonnes of recycled aluminium was produced during 2019-20.

Chart X :
Aluminium recycling scenario in India



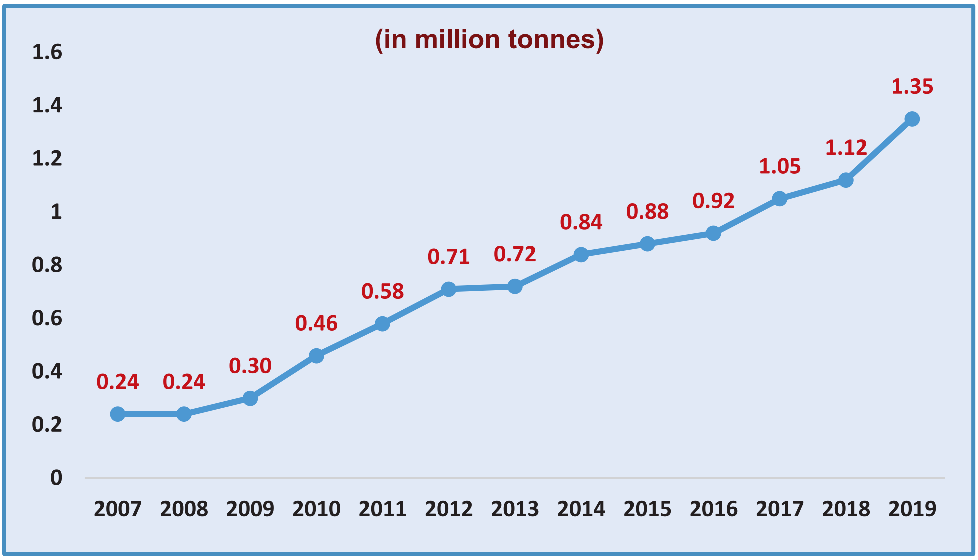
Source: Ministry of Mines, Draft National Non-Ferrous Metals (Aluminium and Copper) Scrap Recycling Policy
https://mines.gov.in/writereaddata/UploadFile/policy27032020.pdf

Note: *Estimated value based on 1st quarter production which is 3,48,817 tonnes during 2019-20

25. Secondary aluminium accounts for around 30% of India's overall aluminium consumption of around 3.7 million tonnes. Over the past 6 years, secondary aluminium demand grew @ 12% from 0.56 to 1.3 million tonnes, mainly driven by increased penetration across end-use sectors, especially automotive sector. By 2023, secondary aluminium demand will be 2 million tonnes.

26. Demand for aluminium scrap is increasing in India, resulting in increase in import of aluminium scrap over the years, which can be shown in the following chart.

Chart XI : Imports of aluminium scrap in India



Source: Ministry of Mines, Draft National Non-Ferrous Metals (Aluminium and Copper) Scrap Recycling Policy
https://mines.gov.in/writereaddata/UploadFile/policy27032020.pdf

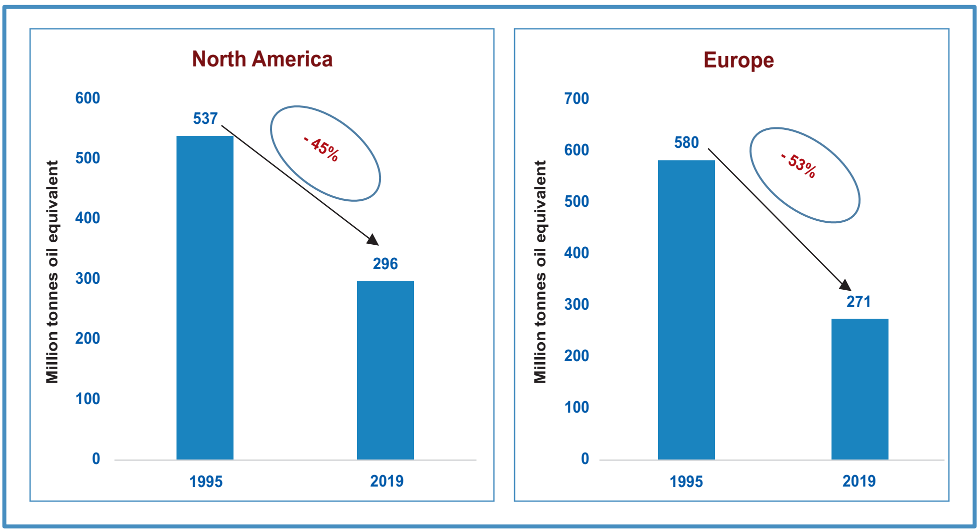
—

IV – FOSSIL FUELS

(A) Coal

27. There is constant pressure of environmentalists with regard to carbon emissions and commitments made in Paris Agreement to be achieved by 2030. For example, UK has brought down consumption of coal from as high as 39 mtoe (million tonnes of oil equivalent) in 2012 to 7.6 mtoe in 2018. Coal output fell to just over 1.6 mtoe in 2018 and accounted for less than 7% of electricity. Germany has passed its '*coal-exit law*' to end coal-fired power generation by 2038. Coal is being replaced by gas and other renewable energy like solar and wind. Overall situation with regard to consumption in North America and Europe emerges as under:

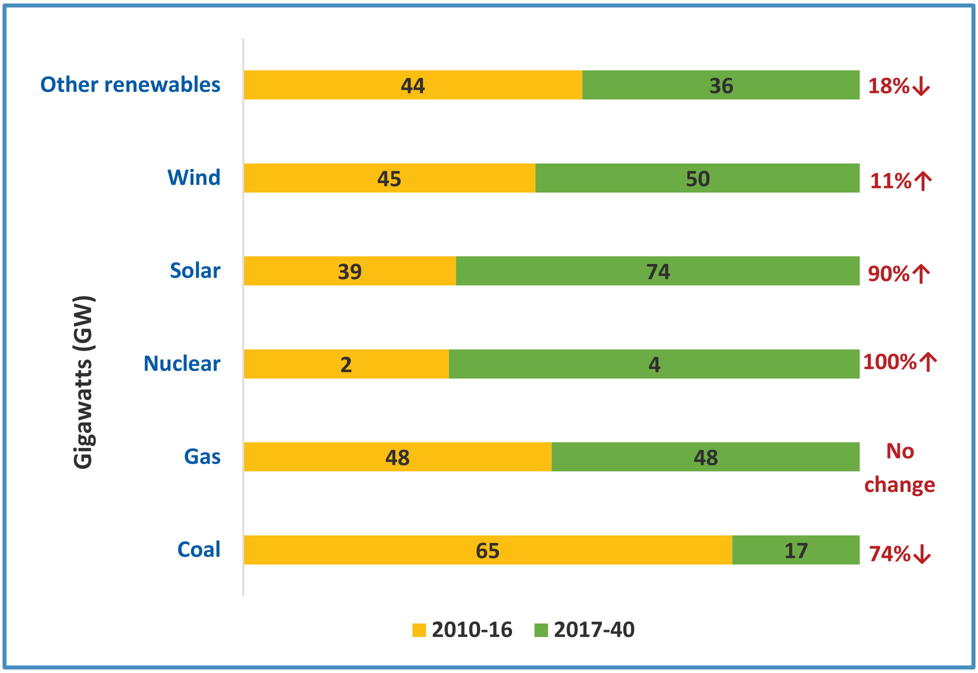
Chart XII : Total Coal Consumption in Major Regions



Source: BP Statistical Review of World Energy

28. Renewables are likely to capture two-thirds of global investment in power plants by 2040, as they become the least-cost source of power generation for many countries. Rapid deployment of solar photovoltaics (PV), led by China and India, will help solar become the largest source of low-carbon energy by 2040, occupying more than 30% share in total power generation. By 2040, renewables are likely to contribute 70% of the total power generation.

Chart XIII :
Global power generation: Average annual net capacity additions by type, 2010-2040



Source: International Energy Agency (IEA)

29. In India the wind power is now being quoted around Rs. 3 per unit. Further, the country is well endowed with bright sun-shine in most parts of the year. Solar power tariff in India has also reached a low of Rs 2.36 per KwH as off-peak rate.

(B) Oil

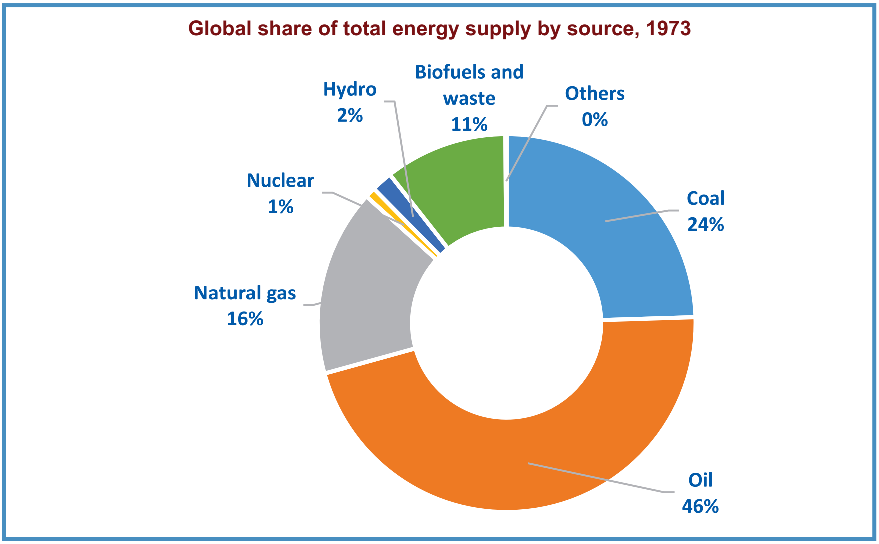
30. Until recently, the internal combustion engine has been the main tool of powering vehicles on land and at sea for most of the twentieth century. There is now a gradual shift from fuel and piston to lithium-ion battery packs and electric motors. The electrification has thrown the car industry into turmoil. Compared with existing vehicles, electric cars are much simpler and fewer parts. It offers environmental and health benefits and according to America's National Resources Defence Council reduces carbon emissions by 54%.

31. Exxon Mobil, OPEC and Bloomberg have estimated electric vehicles sales ranging from 100 millions to 266 and 525 million vehicles respectively by 2040. Britain and France have both declared that by that time, new cars reliant on internal combustion engines will be illegal. However, internal combustion engine is likely to still dominate shipping and aviation sector for decades to come.

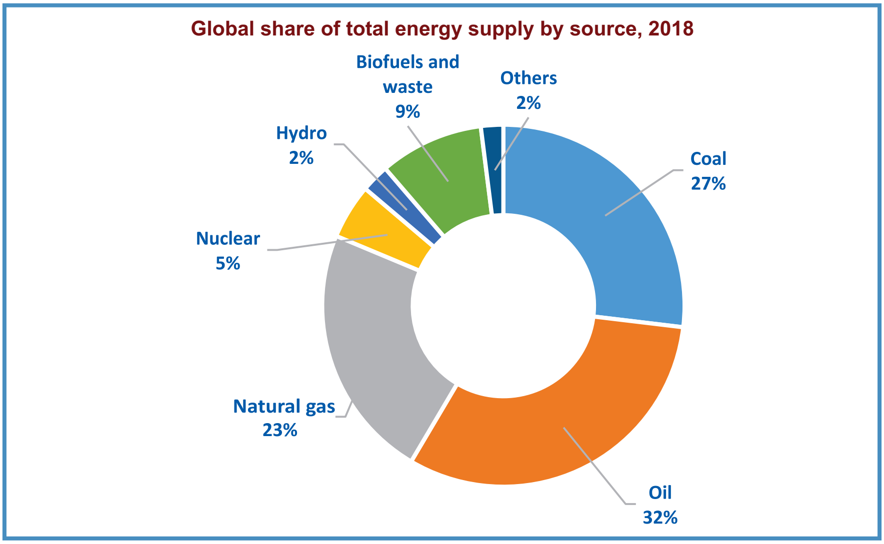
32. One can visualise its effects on oil industry. Roughly two-thirds of oil consumption in US is on roads and a fair amount of rest is used in by-products of refining crude to make petrol and diesel. With more electric cars in times to come, petrol will become surplus, putting the economy of many oil producing countries into great stress.

33. Global Fuel consumption in energy generation is declining year after year. The following charts bring this out:

Chart XIV : Global share of total energy supply by source 1973-2018



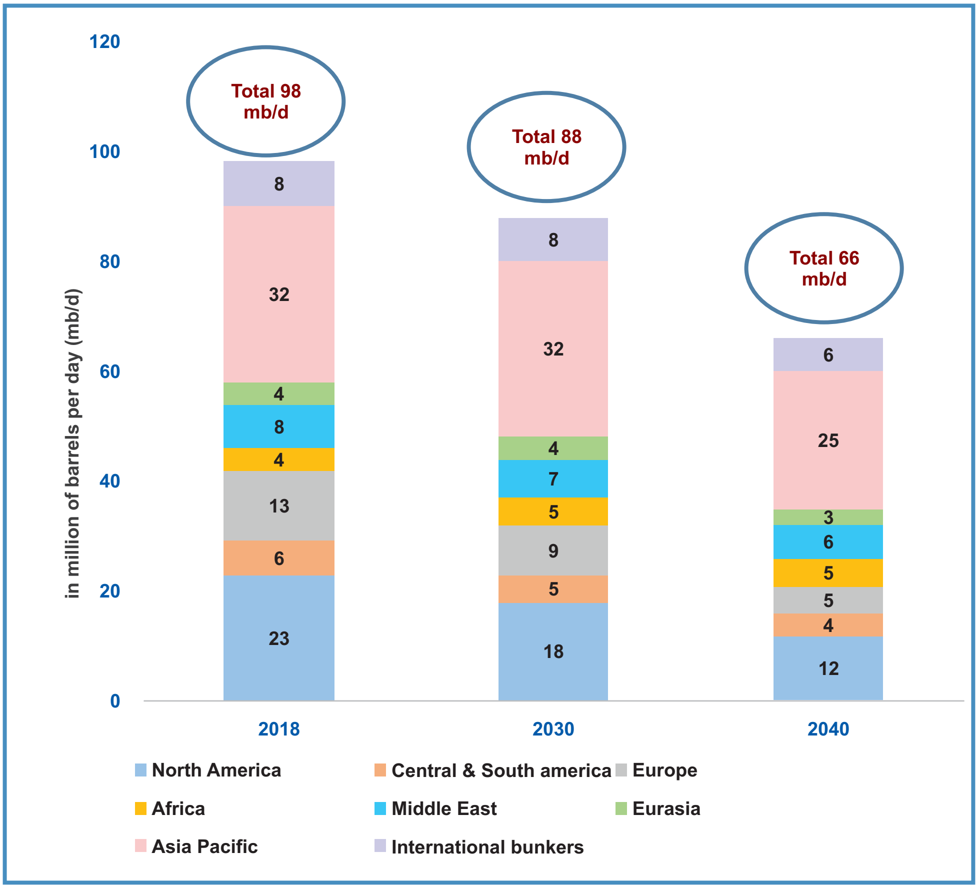
Source: International Energy Agency (IEA)



Source: International Energy Agency (IEA)

34. The International Energy Agency (IEA) has worked out region-wise oil demand in sustainable development scenario during 2018-2040:

Chart XV :
Oil demand by region in sustainable development scenario, 2018-2040



Source: International Energy Agency (IEA)

V – MINERALS ARE INFINITELY FINITE: EXPLORATION PLAYS KEY ROLE

35. Iron is the earliest metal to catch the human imagination; Iron age followed just after Stone age. Since iron ore (Fe_2O_3) is one of the most wide-spread mineral (other being alumina (Al_2O_3)) constituting 5% (alumina 8%) of the earth crust upto a continental depth of 75 kms, human civilization has not so far faced any scarcity of the ore / metal; nor is it expected that it ever will. U.S. Geological Survey (USGS) has estimated world resources of iron ore to be greater than 800 billion tonnes, although country-wise resources are not available. However, these resources convert into reserves (following exploration) when the demand for a mineral increases following the demand for metal for which it is a raw material.

36. The following tables bring out how the resources of some of the important minerals have been increasing despite increasing production. Market forces determines production level to meet the demand. Increase in production would require exploration which results in discovering more resources and reorientation of mining operations in line with market demand:

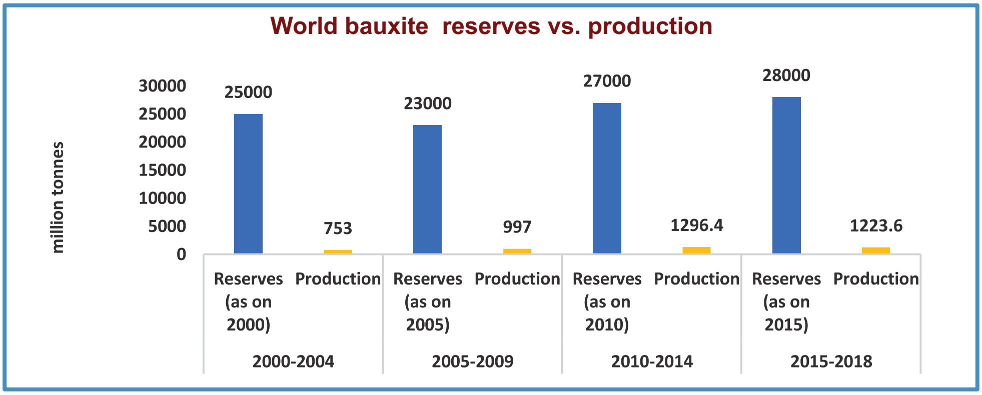
(A) MINERAL-WISE SCENARIO

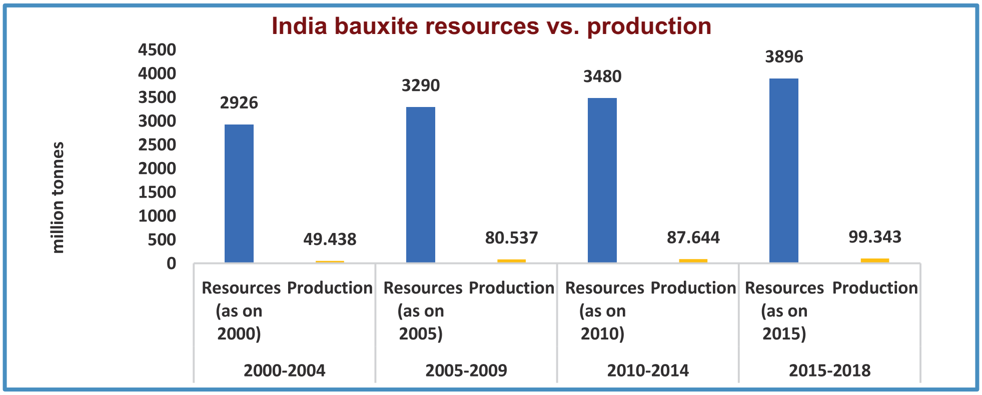
(I) BAUXITE

Table V :
Bauxite: World vs. India scenario

Million tonnes

World (Reserves) / India (Resources)	2000-2004		2005-2009		2010-2014		2015-2018	
	Reserves/ Resources (as on 2000)	Production	Reserves/ Resources (as on 2005)	Production	Reserves/ Resources (as on 2010)	Production	Reserves/ Resources (as on 2015)	Production
World	25,000	753	23,000	997	27,000	1,296	28,000	1,224
India	2,926	49	3,290	81	3,480	88	3,896	99





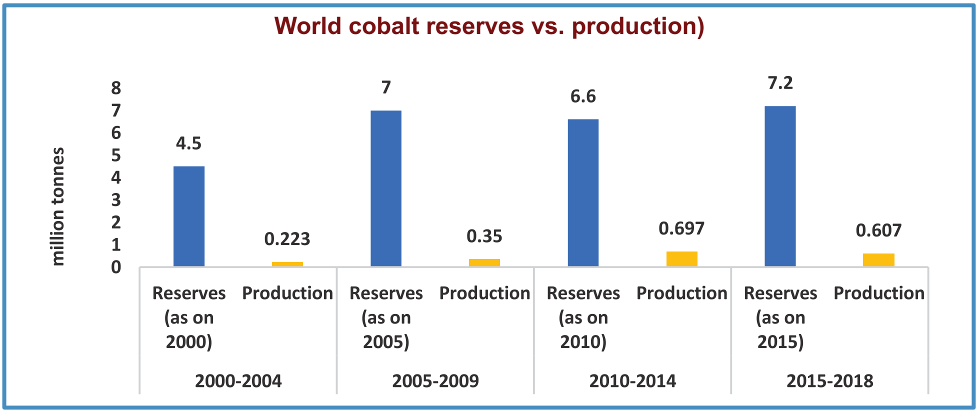
Source: IBM; USGS Mineral Commodities Summaries; World Mineral Production, British Geological Survey
Note: In world bauxite resources are estimated to be 55 billion to 75 billion tonnes in 2018

(II) COBALT

Table VI : Cobalt: World vs. India scenario

Million tonnes

World (Reserves) / India (Resources)	2000-2004		2005-2009		2010-2014		2015-2018	
	Reserves/ Resources (as on 2000)	Production	Reserves/ Resources (as on 2005)	Production	Reserves/ Resources (as on 2010)	Production	Reserves/ Resources (as on 2015)	Production
World	4.5	0.223	7	0.35	6.6	0.697	7.2	0.607
India	44.91	-	44.91	-	44.91	-	44.91	-



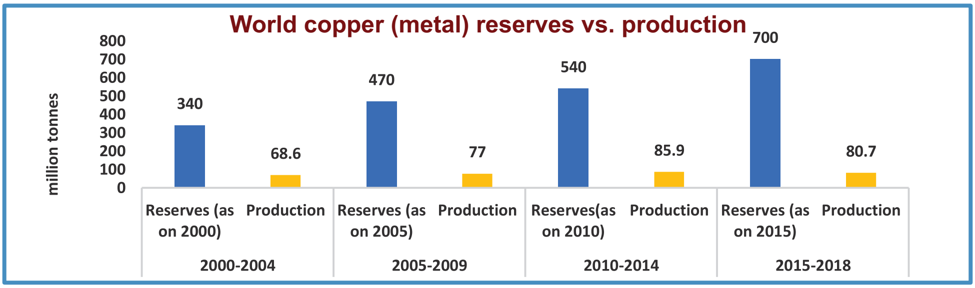
Source: IBM; USGS Mineral Commodities Summaries; World Mineral Production, British Geological Survey
Note: As per IBM, presently there is no production of cobalt in the country from primary cobalt resources. The demand for cobalt is usually met through imports

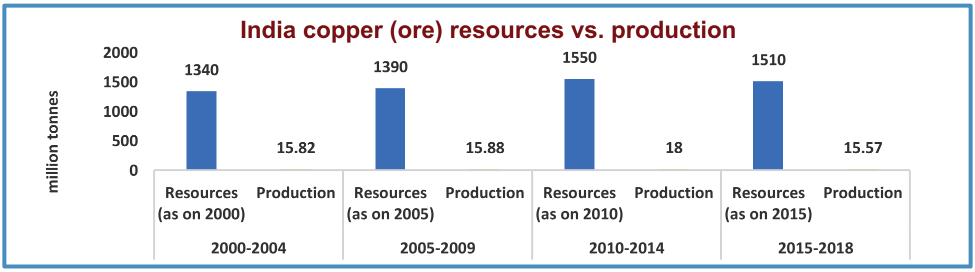
(III) COPPER

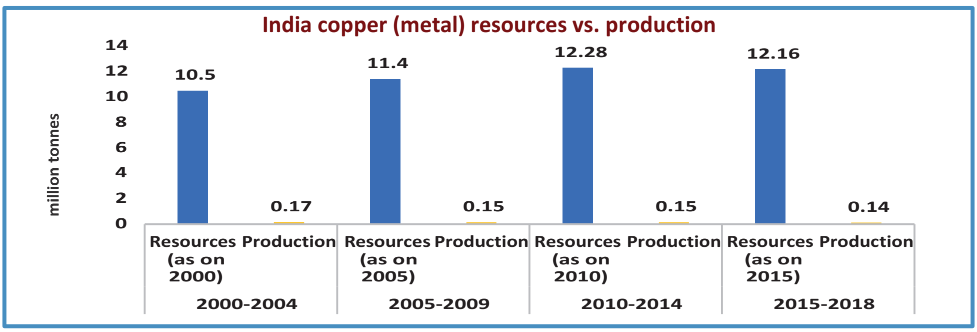
Table VII : Copper: World vs. India scenario

Million tonnes

World (Reserves) / India (Resources)	2000-2004		2005-2009		2010-2014		2015-2018	
	Reserves/ Resources (as on 2000)	Production	Reserves/ Resources (as on 2005)	Production	Reserves/ Resources (as on 2010)	Production	Reserves/ Resources (as on 2015)	Production
World (Metal)	340	69	470	77	540	86	700	81
India (Ore)	1,340	16	1,390	16	1,550	18	1,510	16
India (Metal)	10.5	0.17	11.4	0.15	12.28	0.15	12.16	0.14







Source: IBM; USGS Mineral Commodities Summaries; World Mineral Production, British Geological Survey

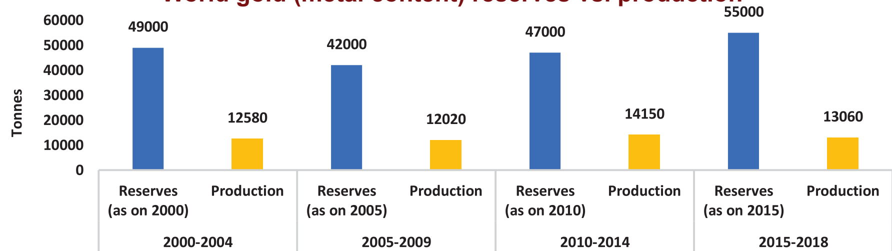
Note: World resources are 5.6 billion tonnes (identified+ undiscovered) in 2018

(IV) GOLD

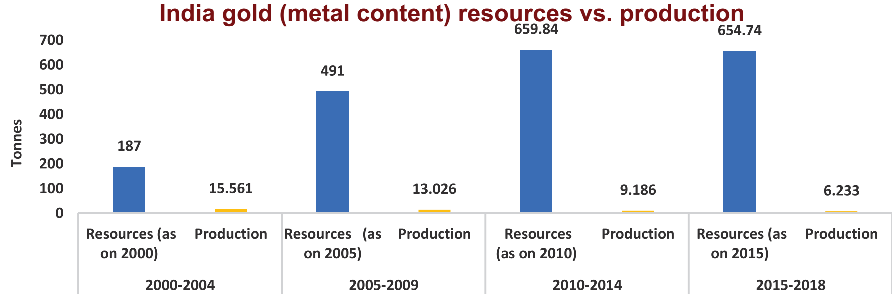
Table VIII : Gold: World vs. India scenario

World (Reserves) / India (Resources)	GOLD (metal content)						Tonnes	
	2000-2004		2005-2009		2010-2014		2015-2018	
	Reserves/ Resources (as on 2000)	Production	Reserves/ Resources (as on 2005)	Production	Reserves/ Resources (as on 2010)	Production	Reserves/ Resources (as on 2015)	Production
World	49,000*	12,580	42,000	12,020	47,000	14,150	55,000	13,060
India	187	16	491	13	660	9	655	6
	GOLD ORE						Thousand tonnes	
India	184,480	2,694	390,290	2,778	493,690	2,605	501,830	2,261

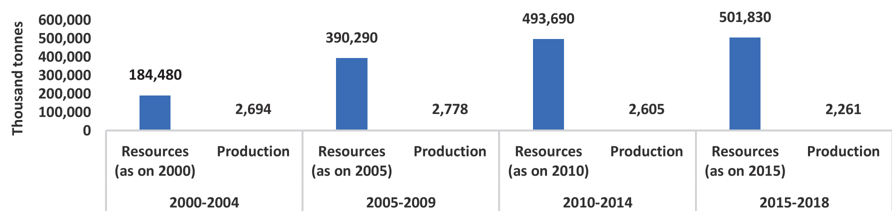
World gold (metal content) reserves vs. production



India gold (metal content) resources vs. production



India gold (ore) resources vs. production



Source: IBM; USGS Mineral Commodities Summaries; World Mineral Production, British Geological Survey

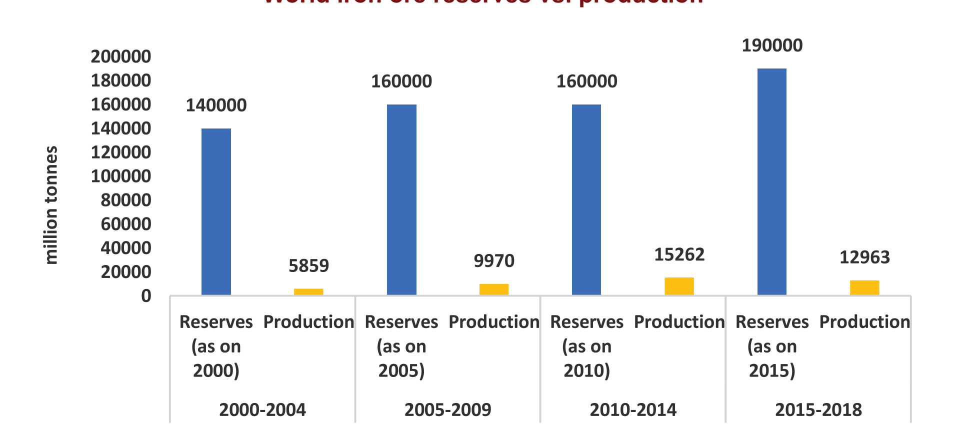
Note: An assessment of U.S. gold resources indicated 33,000 tons of gold in identified (15,000 tons) and undiscovered (18,000 tons) resources. * excluding China and some other countries for which reliable data were not available

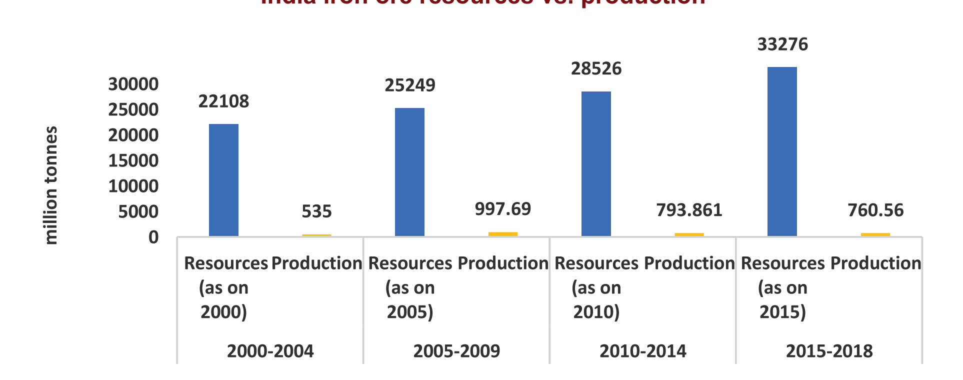
(V) IRON ORE

**Table IX :
Iron ore: World vs. India scenario**

Million tonnes

World (Reserves) / India (Resources)	2000-2004		2005-2009		2010-2014		2015-2018	
	Reserves/ Resources (as on 2000)	Production	Reserves/ Resources (as on 2005)	Production	Reserves/ Resources (as on 2010)	Production	Reserves/ Resources (as on 2015)	Production
World	140,000	5,859	160,000	9,970	160,000	15,262	190,000	12,963
India	22,108	535	25,249	998	28,526	794	33,276	761





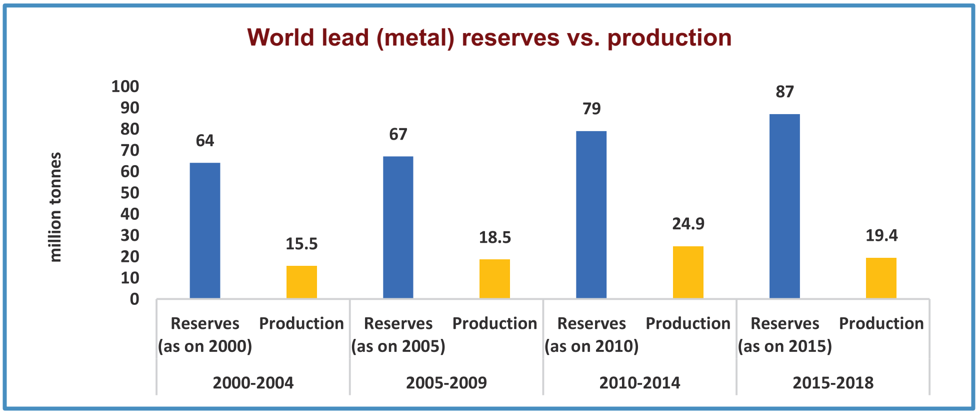
Source: IBM; USGS Mineral Commodities Summaries; World Mineral Production, British Geological Survey
Note: World resources are greater than 800 billion tonnes in 2018

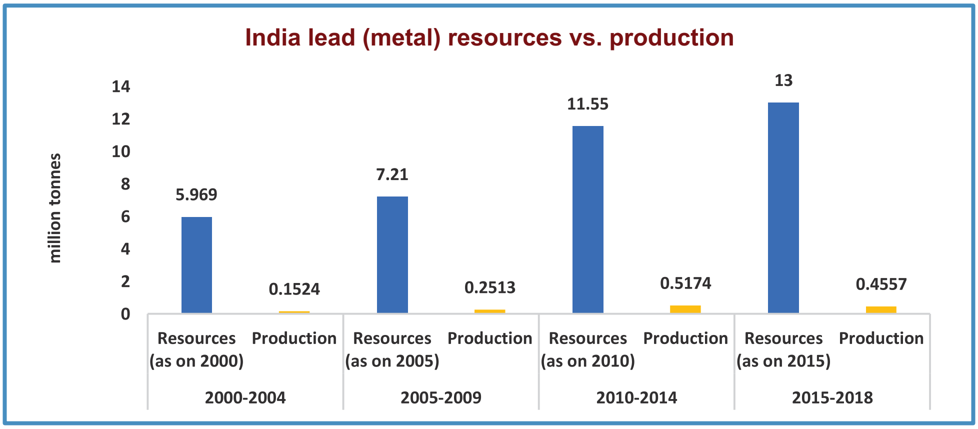
(VI) LEAD

**Table X :
Lead: World vs. India scenario**

Million tonnes

World (Reserves) / India (Resources)	2000-2004		2005-2009		2010-2014		2015-2018	
	Reserves/ Resources (as on 2000)	Production	Reserves/ Resources (as on 2005)	Production	Reserves/ Resources (as on 2010)	Production	Reserves/ Resources (as on 2015)	Production
World (Metal)	64	15.5	67	18.5	79	24.9	87	19.4
India (Metal)	6	0.15	7	0.25	12	0.52	13	0.46*





Source: IBM; USGS Mineral Commodities Summaries; World Mineral Production, British Geological Survey

Note: World resources are greater than 2 billion tonnes in 2018

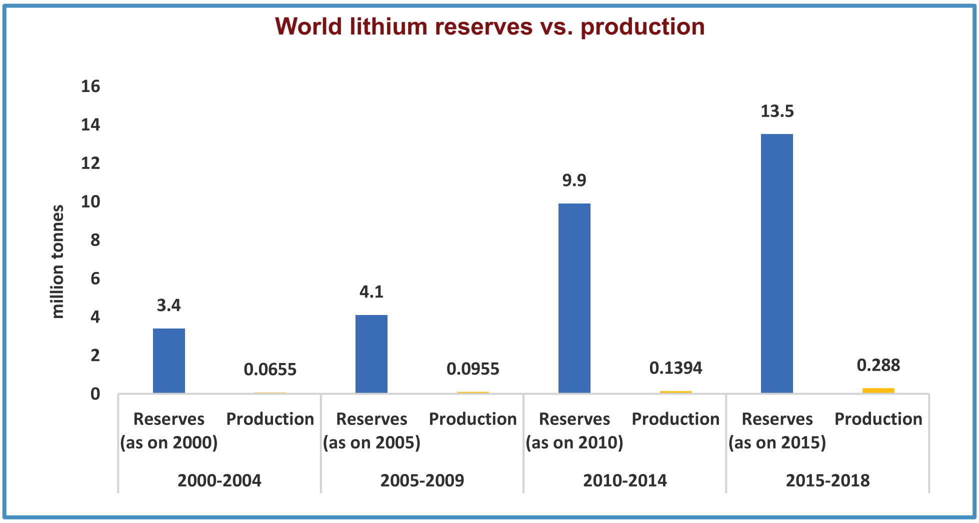
*Due to unavilability of data production is taken for 3 years

(VII) LITHIUM

Table XI :
Lithium: World vs. India scenario

Million tonnes

World (Reserves) / India (Resources)	2000-2004		2005-2009		2010-2014		2015-2018	
	Reserves/ Resources (as on 2000)	Production	Reserves/ Resources (as on 2005)	Production	Reserves/ Resources (as on 2010)	Production	Reserves/ Resources (as on 2015)	Production
World	3.4	0.0655	4.1	0.0955	9.9	0.1394	13.5	0.288
India	-	-	-	-	-	-	-	-



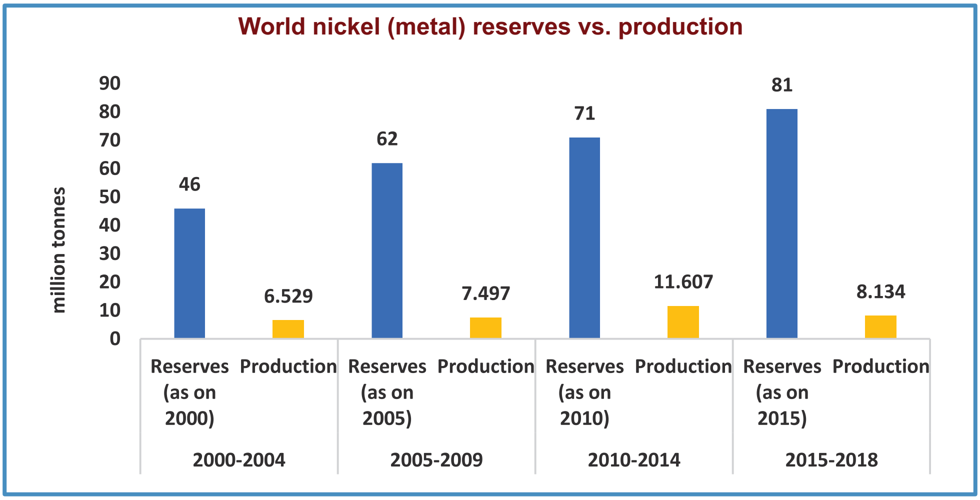
Source: IBM; USGS Mineral Commodities Summaries; World Mineral Production, British Geological Survey
Note 1: identified lithium resources have increased substantially worldwide and total about 80 million tons.
Note 2: In India there is no reserves and production of lithium

(VIII) NICKEL

Table XII :
Nickel: World vs. India scenario

Million tonnes

World (Reserves) / India (Resources)	2000-2004		2005-2009		2010-2014		2015-2018	
	Reserves/ Resources (as on 2000)	Production	Reserves/ Resources (as on 2005)	Production	Reserves/ Resources (as on 2010)	Production	Reserves/ Resources (as on 2015)	Production
World (Metal)	46	6.529	62	7.497	71	11.607	81	8.134
India	189	-	189	-	189	-	189	-



Source: IBM; USGS Mineral Commodities Summaries; World Mineral Production, British Geological Survey

Note 1: Identified land-based resources averaging 1% nickel or greater contain at least 130 million tons of nickel, with about 60% in laterites and 40% in sulfide deposits.

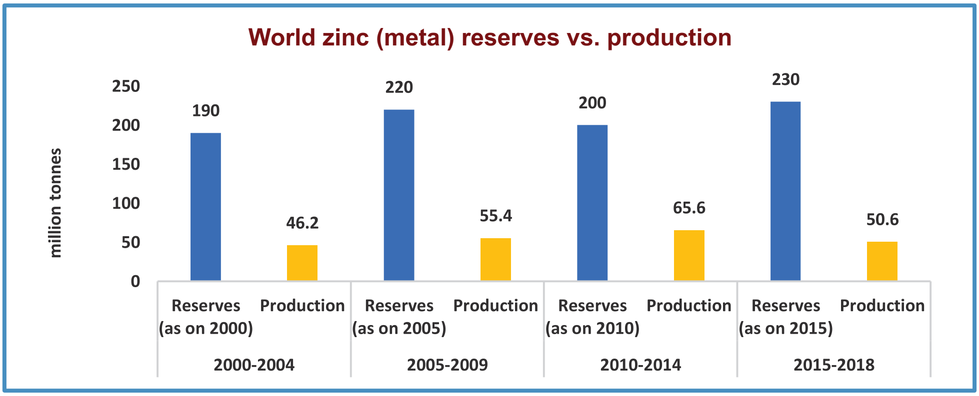
Note 2: As per IBM, Nickel is not produced from primary sources in India and the entire demand is met through imports.

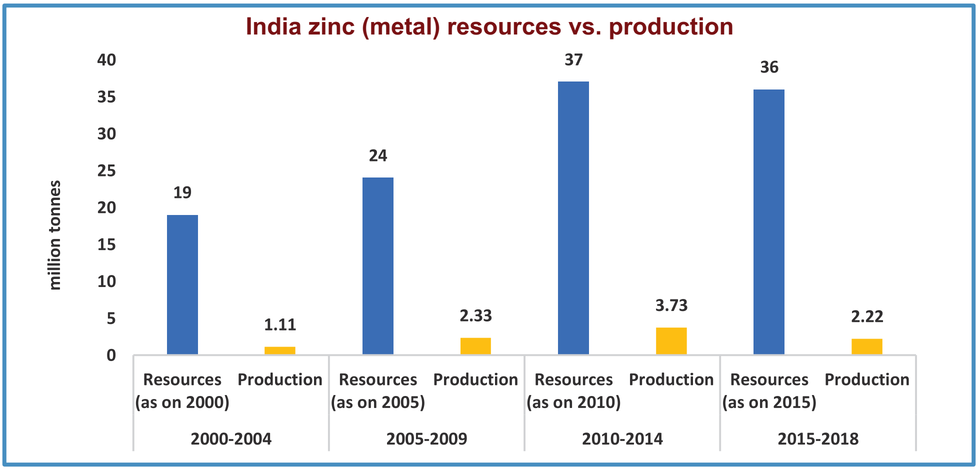
(IX) ZINC

Table XIII :
Zinc: World vs. India scenario

Million tonnes

World (Reserves) / India (Resources)	2000-2004		2005-2009		2010-2014		2015-2018	
	Reserves/ Resources (as on 2000)	Production	Reserves/ Resources (as on 2005)	Production	Reserves/ Resources (as on 2010)	Production	Reserves/ Resources (as on 2015)	Production
World (Metal)	190	46.2	220	55.4	200	65.6	230	50.6
India (Metal)	19	1.11	24	2.33	37	3.73	36	2.22*





Source: IBM; USGS Mineral Commodities Summaries; World Mineral Production, British Geological Survey
Note: Identiied world zinc resources are about 1.9 billion tonnes in 2018
*Due to unavilability of data production is taken for 3 years

(B) EXPLORATION DEPENDENT ON MARKET DEMAND

37. As mentioned above, what we explore / exploit today is based on market demand at a particular point of time. If indexing of unit cost is done, probably it may be cheaper or costlier but there has to be market demand. Resources that are not demanded by the market forces can be dubbed *"neutral stuff"*. The demand plus technology and advancement of knowledge turn these *"neutral stuff"* into resources which are replenished upon use by further advance of technology and knowledge that enable us to tap into resources previously beyond reach.

38. Market forces are the best instruments for proper allocation of natural resources. If the unit price, being the main yardstick, goes beyond the reach of the consumer, there will be resistance. Efforts then get initiated in the direction of finding a viable substitute or alternative resource. This is very well borne out in the case of mica where India had monopoly at one time. When the market forces were interrupted and the item was canalized through MMTC, which made it costly, a synthetic substitute was developed with better chemical and physical properties. India, the sole producer of mica, lost the market for ever. There is hardly any production of mica now in India.

—

VI – TECHNOLOGY MAY MAKE TODAY'S RESOURCES REDUNDANT

39. From the beginning of human history, innovations have been experimented with all kinds of elements, from the ordinary to the invisible, to try to come up with new, improved materials. The invention of plastic in 1907 herald an era of synthetic materials that are stirred up in laboratories, greatly expanding the possibilities for creating an endless variety of useful products. One cannot envisage the pace of technological developments or quiet revolution taking place without much fanfare worldwide. Already work is on full pace on the development of nano-technologies* leading to production of light, low-density and high strength materials to replace steel and other metals. Prof. Ray Baughman of University of Texas created a material in 2004 which is stronger than steel, transparent and very light. A hectare-size sheet would weigh just 280 grams.

40. Carbon in the form of graphite is soft, malleable and easily broken. But carbon nanotubes, a very thin sheet of graphite formed into a tube-a tiny strawlike cylinder as small as half a nanometre wide-are upto 100 times stronger than steel and six times lighter. These are hardest, stiffest, strongest materials known and are among the world's best conductors of heat and electricity. They can carry some 1000 times more electrical current than copper wire. Further, there are technologies under development to derive energy from nuclear fusion which may make coal redundant for energy generation. The most recent 787 Dreamliner aircraft has almost done away with the usage of aluminium or steel and is made of composites, high tech ceramics and carbon-plastic material to save fuel. Efficient and better usage of these elements of nature would almost ensure that the world will never be able to foresee a time when there is a possible danger of resource exhaustion, renewable or non-renewable.

---

*Nano comes from the Greek word for dwarf. Usually nanotechnology is defined as the study and manipulation of matter smaller than 100 nanometres - that's the scale of things like molecules and viruses. Ten hydrogen atoms nestled up against each other are just one nanometre long. And one million nanometres fit into a millimetre. Hard to grasp? Think of it this way: if a person was a nanometre wide, then 13 million of them, standing shoulder to shoulder, would fit on your thumbnail.

VII – SUPER MATERIALS: SOME RECENT TECHNOLOGICAL INNOVATIONS

41. Sometimes, scientists concoct materials that have no clear use at first. Aerographite is a form of carbon with a sponge like structure. It is water-repellent, highly resilient and extremely light. It also conducts electricity. Its inventors believe it could be used in electric car batteries-a lighter load cuts operating costs. They have yet to determine how to benefit from its ability to absorb almost all light, which makes it blacker than coal.

42. Further, scientists crushed a naturally occurring kind of carbon called buckminsterfullerence (the molecules look like soccer balls) to create a material strong enough to dent diamonds. As yet unnamed, it may find use in industrial manufacturing and deep-well drilling.

43. A human hair is almost a million times thicker than a layer of graphene. The material is made of a single layer of carbon atoms arranged in a honeycomb pattern. In theory, a string of graphene with a diameter of just one-tenth of a square millimeter- the size of a very sharp pencil point-could hold up a thousand-pound piano. To take advantage of that incredible strength though, scientists will have to figure out a way to embed this atomic-scale element in other materials.

44. In a US$ 3.5 billion sponsored R&D programme in the campus of Lawrence Livermore National Laboratory, near San Francisco, Dr. Edward Moses, who calls his lab National Ignition Facility (NIF), has developed a model of a size of tiny pellet which is supposed to provide an endless supply of safe and clean energy. The real version of pellet will contain a few milligrams of deuterium and tritium, isotopes of hydrogen that can be extracted from water. If one blasts the pellet with a powerful laser, one can create a reaction like the one that takes place at the centre of the sun. After harnessing the reaction, it would be possible to create a star on earth, and with the heat from that star, one can generate electricity without creating any pollution. What Moses is working on is controlled nuclear fusion-fusing nuclei rather than splitting a nucleus as happens in ordinary nuclear-fission power plants. In a fission reaction, the nucleus of a uranium atom is split into two smaller atoms, releasing energy in the form of heat. The heat is

used to make steam, which drives a turbine and generate electricity. In fusion energy, the second half of this process (heat makes steam makes electricity) remains the same. But instead of splitting the nucleus of an atom, one is trying to force a deuterium nucleus to merge, or fuse, with a tritium nucleus. When that happens, one produces helium and throw off energy.

45. Dr. Moses has already branded the product as Laser Inertial Fusion Energy or LIFE and believe that utility companies could be building prototype power plants called "LIFE engines" any time soon. By 2030, real fusion plants would start running which by 2050 could be common. It is estimated that by 2100, as many as 1000 fusion reactions could be operating in the United States, if utilities embrace the technology and invest in it. If this materializes, there would be no need for nuclear plants, coal, oil, wind or solar power.

46. The invention of these types of super materials in all branches of human activities may make use of many minerals and metals redundant. It is thus not wise to deprive the present generation of materials which the future generation may not even require.

VIII – CONCLUSION

47. The concept of inter-generational equity, which has caught judicial attention in India of late, has been long forgotten in US and West European countries because of the recent scientific advancements some of which have been detailed above. It is a concept which will not only deprive the present and future generations of the fruits of resources utilisation but, by its very nature, is anti-development. While on the one hand recyclability of metals and the abundance of resources make them infinitely finite, on the other, the so-called renewable resources i.e. fish, agricultural land and fresh water are under intense pressure and threat of scarcity.

—

NOTES

NOTES

NOTES

NOTES

NOTES