

Renewable Energy Materials Supply Implications

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AN UNAVOIDABLE CHANGE IN ELECTRICITY MIX

World electricity generation amounted to at least 24816.4 terawatt hours in 2016 while still leaving enough scope for capacity additions as 1.06 billion people continue to live without electricity according to the World Bank's Global Tracking Framework (GTF). Not only is the electricity generation and consumption not going to be stabilized anytime soon, even the technological options for electricity provision have expanded reflecting the new energy technologies. What is remarkable in recent times is that for the first time since 1882, Britain experiences a 24 hour period in which not a single power plant burned coal. There is indeed sufficient evidence, according to the IEA, to note a shift in the global electricity mix towards a low-carbon electricity economy. Interestingly, even oil and gas spending has fallen 44 percent in the last 2 years, i.e., a decline from 2014 to 2016.

The 2015 Paris Climate Agreement's commitment to limit climate change to well below 2 degrees Celsius and the Sustainable Development Goal 7 "Ensure access to affordable, reliable, sustainable and modern energy for all" has further necessitated aggressive utilization of low carbon or renewable energy technologies for electricity generation and demand-side energy efficiency systems. About 197 member countries have stepped up efforts with strategies, plans and enabling processes as part of Nationally Determined Contributions (NDCs) to achieve emission reduction targets. A striking recent development in the electricity ecosystem is that renewable energy accounted for 62 percent of the net additions to global power generation capacity in 2016. In terms of renewable energy capacity addition solar PV accounted for largest share representing about 47 percent, followed by wind and hydropower contributing 34 percent and 15.5 percent, respectively. This shows that renewable energy is no more in its infancy. In fact the projections from the Bloomberg New Energy Outlook 2017 show that investments in renewables far exceed investments in other conventional generation technologies.

ENVIRONMENTAL AND RESOURCE IMPLICATIONS

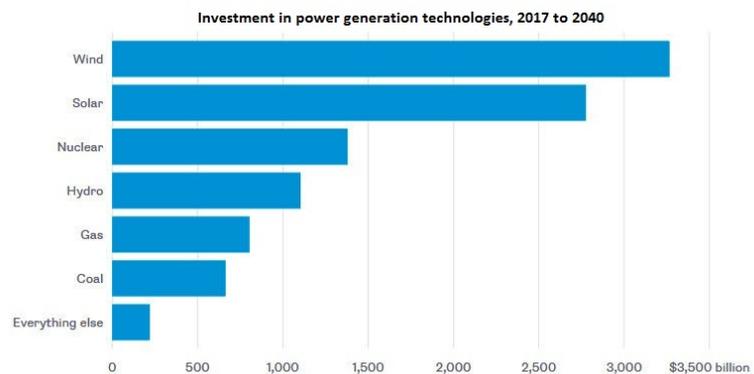
In accordance to the 2-degree Celsius scenario, supply and demand side low carbon technologies would be potentially capable of reducing pressure on water by 200 billion cubic meters (per year), avoidance of 17 million tonnes (per year) of particulate matter in PM10 equivalency and 25 billion tonnes of GHG emissions per year by 2050. As mentioned earlier, material supply depletion is the single-most prevalent impact of low carbon

technologies deployment which has been estimated to require over 600 million tonnes (measured in iron equivalency) according to ReCiPe method by 2050. Even though the magnitudes of metal demand by low carbon supply and demand-side technologies collectively consume a small share as compared to metal consumption by other economic sectors, there are implications regarding the availability of a sufficient quantity of critical metals for the capacity additions needed, especially in solar PV.

In order to manufacture a solar PV panel, 19 mineral products and metals are utilized. Out of these, eight metals face supply challenges owing to a lack of supply diversity, the complex nature of economies caused by co-production and geopolitical risks. These metal requirements differ widely based on the type of solar PV technologies. The elemental requirements of the specific solar technology are given below:

- Crystalline silicon (c-Si) - Ag, Ni, Al, Cu and Fe
- Amorphous silicon (a-Si) - Ni, Cr, Ge, Mo, Al, Cu and Fe
- Cadmium Telluride (CdTe) - Ni, Cr, Mo, Cd, Al, Te, Cu and Fe
- Copper indium gallium selenide (CIGS) - Ni, Cr, Mo, Al, Cu, In, Fe, Ga and Se

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Investment in Power Generation Technologies, 2017 to 2040
Source: Bloomberg New Energy Finance New Energy Outlook 2017

Depending on the solar PV technology, there are a number of different element/metal(s) which in turn are derived from a diverse set of ore bodies. Out of the 15 to 20 ores that cater to a range of industrial applications, there are 8 ore bodies which supply the elemental needs of solar PV technologies. These ore bodies are gold ore, nickel ore, chromium ore, molybdenum ore, zinc ore, copper ore, aluminum ore and Iron ore.

ENERGY SECURITY IMPLICATIONS OF RENEWABLE ENERGY TECHNOLOGIES

A key feature of renewables is the usage of rare earth metals. These metals are critical to the renewable energy technology manufacturing value chain. The name “rare earth” is a consequence of seeming scarcity in 18th century in an ore first discovered near Ytterby, Sweden. However it is the availability of economically extractable concentrations that makes them rare.

Like the oil embargo in the 1970s, there is high risk of other embargos driven by changes in development models, innovation and discovery of resource availability. Even if the cartelization of these critical materials is not as influential as the OPEC phenomenon, the ambitious renewable energy use resulting from many nations pursuing renewable technologies, raises the need for caution on the part of consumers of these materials. For example, the materials used for renewable energy technologies are common to other sectors such as consumer products and defense. This poses a potential for competition as well. Rare earth materials such as dysprosium, neodymium, terbium, europium and yttrium are often critical components of renewable energy hardware. Therefore, in order to maintain a conflict-free sustainable development of global renewable energy it is essential to ensure that the OPEC phenomenon does not repeat in the form of cartelization of these rare earth metals. Application of rare earths in almost all modern technologies today, including the next generation of power generation, makes them a critical parameter when considering global renewable energy development.

In terms of all minerals and metals utilized in the solar value chain, the adjacent listing indicates those which are considered critical in nature, i.e., ones which face supply risk issues.

Copper	(wiring, thin film solar cells)	Critical material
Indium	(solar cells)	Critical material
Lead	(batteries)	
Phosphate rock	(phosphorus)	
Silica	(solar cells)	
Selenium	(solar cells)	Critical material
Iron ore	(steel)	
Molybdenum	(photovoltaic cells)	
Cadmium	(thin film solar cells)	
Tellurium	(solar cells)	Critical material
Titanium dioxide	(solar panels)	
Gallium	(solar cells)	Critical material
Metallurgical coal	(used to make steel)	
Silver	(solar panels)	Critical material
Germanium	Critical material	
Tin	Arsenic (gallium arsenide semiconductor chips)	Critical material
	Bauxite (aluminium)	Critical material
	Boron minerals (semiconductor chips)	Critical material

In fact the use of critical materials is not limited to solar, but also other forms of clean technologies like wind, vehicles, lighting and phosphors. The use of neodymium and dysprosium is essential to make powerful generators used in wind technologies. Neodymium and dysprosium also find use in making motors for vehicles. In order to make Li-ion batteries for plug-in-hybrid electric vehicles, lithium and cobalt are a critical material requirement. Hybrid electric vehicle using NiMH batteries make use of rare earths such as cerium, lanthanum, neodymium and praseodymium. In order to make fuel cells, critical materials such as yttrium, platinum, palladium and some other platinum group materials

are required as catalysts and separators. Lighting (solid state and fluorescent) use rare earths such as yttrium, cerium, lanthanum, europium and terbium as part of the phosphors.

RESERVES AND PRODUCTION SCENARIO

Historically, Brazil and India were the primary sources of the world's rare earths found in placer sand deposits until 1948. After the discovery of monazite in large veins of earth in South Africa around the 1950s, it emerged as the dominant supplier of world's rare earths. The U.S. became a leading source from 1960s to 1980s after the Mountain Mine began processing in California. From 1990s onwards, China became the dominant source of the world's rare earth materials with a share of over 90 percent.

It is worth looking at the major countries with reserves of rare earths as well as the production trends in order to address the security of supplies for renewable energy technology deployment. In many cases countries with large production capacities hold high reserves while some countries have low production and high reserves. This points towards possibility of large producers of rare earths exhausting their domestic reserves while those holding on to lower production but having large reserves

holding greater dominance in the future.

As of 2016, rare earths found their use in diverse applications as follows: catalysts, 55%; metallurgical applications and alloys, 15%; ceramics and glass, 10%; polishing, 10%; and other, 10%.

CONCLUSION

Ongoing and increased exploitation of metals resources that cater to renewable energy futures shall inevitably reduce the global proven reserves of these materials. This increased critical metal use is the bedrock of modern technologies owing to its uses in a wide range of applications. The rare earths and critical metals which are essential to make solar PV and wind power have a potential of become supply constrained as economically viable concentrations of elements such as neodymium, dysprosium, indium, selenium, tellurium, terbium and gallium are found in only a handful of countries. This could shape a new geopolitics of critical metals and rare earths without which renewable energy technologies cannot be developed. This has consequently resulted in a wide consensus of the potential for the cartelization of producers of these essential metals, as was the case with OPEC.

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Source	Mine Production		Reserves
	2015	2016	
United States	5,900	-	1,400,000
Australia	12,000	14,000	3,400,000
Brazil	880	1,100	22,000,000
Canada	-	-	830,000
China	105,000	105,000	
Greenland	-	-	1,500,000
India	1,700	1,700	6,900,000
Malaysia	500	300	30,000
Malawi	-	-	136,000
Russia	2,800	3,000	18,000,000
South Africa	-	-	860,000
Thailand	760	800	NA
Vietnam	250	300	22,000,000
World total)	129,790	126,200	121,056,000

Source: U.S. Geological Survey, Mineral Commodity Survey 2017

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