Meeting the U.S. Minerals and Metals Needs for Energy Production

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"Energy-related systems: wind, solar, electric are typically materials intensive. As new technologies are widely deployed, significant quantities of the elements required to manufacture them will be needed. However, many of these unfamiliar elements are not presently mined, refined or traded in large quantities, and, as a result, their availability might be constrained by many complex factors. A shortage of these 'energy-critical elements' could significantly inhibit the adoption of otherwise game-changing energy technologies. This, in turn, would limit the competitiveness of the U.S. industries and the domestic scientific enterprises and, eventually, diminish the quality of life in the US."

-Energy Critical Elements: Securing Materials for Emerging Technologies"- American Physical Society, 2011.

Issue

The Nation runs on energy. It is essential for the economic growth and national security of the United States that the Nation have an adequate, sustainable, environmentally acceptable and economically viable balanced supply of energy sources, (e.g. coal, petroleum, nuclear, natural gas, solar, wind, geothermal, biomass, hydroelectric power). Therefore, the allocation of mineral raw materials to the energy-producing sector of the economy must be a top priority that requires the total demand for energy-related materials be judged in terms of domestic supply. (Figure 1)

Such assessment depends on the accuracy of two kinds of information: the demand for mineral commodities by the energy industries and the ability of U.S. producers to satisfy that demand. *Use of Raw Materials in the United States From 1900 Through 2010, USGS.*

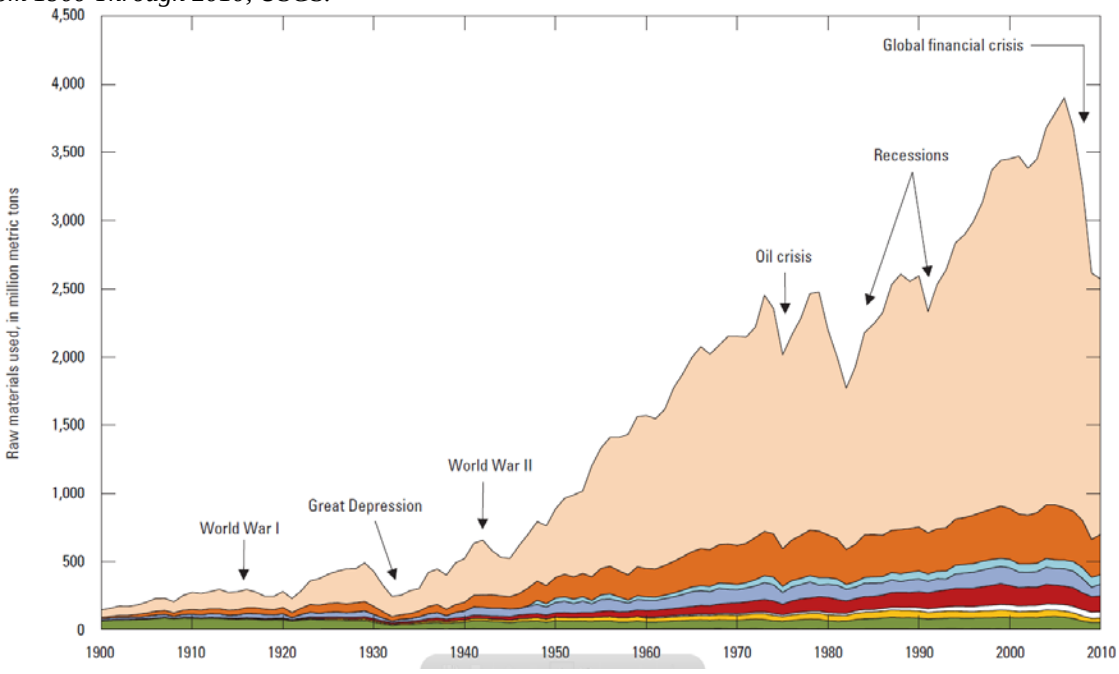

Figure 1. Source USGS 2012

The United States has a voracious appetite for energy, minerals and metals. We are greater than 50% or more import reliant on 43 of the 64 commodities tracked by the USGS (Fig 2). Dependency on other countries for those minerals exposes the U.S. to significant risk of shortages of critical commodities used for energy production technologies.

2014 U.S. NET IMPORT RELIANCE[1]

Commodity	Percent	Major import sources (2010–13)[2]
ARSENIC	100	Morocco, China, Belgium
ASBESTOS	100	Brazil, Canada
BAUXITE	100	Jamaica, Brazil, Guinea, Australia
CESIUM	100	Canada
FLUORSPAR	100	Mexico, China, South Africa, Mongolia
GRAPHITE (natural)	100	China, Mexico, Canada, Brazil
INDIUM	100	China, Canada, Belgium, Japan
IODINE	100	Chile, Japan
MANGANESE	100	South Africa, Gabon, Australia, Georgia
MICA, sheet (natural)	100	India, China
NIOBIUM (columbium)	100	Brazil, Canada
QUARTZ CRYSTAL (industrial)	100	China, Japan, Romania, United Kingdom
RUBIDIUM	100	Canada
SCANDIUM	100	China
STRONTIUM	100	Mexico, Germany, China
TANTALUM	100	China, Germany, Kazakhstan, Russia
THALLIUM	100	Germany, Russia
THORIUM	100	India, France
VANADIUM	100	Czech Rep., Canada, Rep. of Korea, Austria
GALLIUM	99	Germany, United Kingdom, China, Ukraine
GEMSTONES	97	Israel, India, Belgium, South Africa
GERMANIUM	95	China, Belgium, Russia, Canada
BISMUTH	94	China, Belgium, Peru, United Kingdom
TITANIUM MINERAL CONCENTRATES	91	South Africa, Australia, Canada, Mozambique
DIAMOND (dust grit, and powder)	86	China, Ireland, Rep. of Korea, Romania
PLATINUM	85	Germany, South Africa, United Kingdom, Canada
ANTIMONY	84	China, Belgium, Mexico, Bolivia
POTASH	84	Canada, Russia, Israel, Chile
GARNET (industrial)	83	Australia, India, China
RHENIUM	83	Chile, Poland, United Kingdom
STONE (dimension)	83	China, Brazil, Italy, Turkey
ZINC	81	Canada, Mexico, Peru
BARITE	79	China, India, Morocco, Mexico
SILICON CARBIDE (crude)	77	China, South Africa, Netherlands, Romania
COBALT	76	China, Norway, Russia, Finland
TIN	74	Peru, Bolivia, Indonesia, Malaysia
CHROMIUM	72	South Africa, Kazakhstan, Russia, Mexico
PALLADIUM	65	Russia, South Africa, United Kingdom, Norway
PEAT	64	Canada
SILVER	63	Mexico, Canada, Poland, Peru
RARE EARTHS[3]	59	China, France, Japan, Estonia
NICKEL	54	Canada, Russia, Australia, Norway
TITANIUM (sponge)	51	Japan, Kazakhstan, China
MAGNESIUM COMPOUNDS	43	China, Brazil, Australia, Canada
TUNGSTEN	43	China, Bolivia, Canada, Germany
SILICON	40	Russia, Brazil, Canada, Venezuela
NITROGEN (fixed)—AMMONIA	36	Trinidad and Tobago, Canada, Russia, Ukraine
ALUMINUM	33	Canada, Russia, United Arab Emirates, China
COPPER	31	Chile, Canada, Mexico, Peru
MICA, scrap and flake (natural)	31	Canada, China, Finland, Mexico
LEAD	30	Canada, Mexico, Australia
MAGNESIUM METAL	30	Israel, Canada, China, United Kingdom
SALT	28	Canada, Chile, Mexico, The Bahamas
VERMICULITE	25	South Africa, Brazil, China
PERLITE	24	Greece
IRON and STEEL	17	Canada, Mexico, Rep. of Korea, Brazil
PHOSPHATE ROCK	15	Morocco, Peru
PUMICE	13	Greece, Iceland, Mexico
TALC	12	China, Canada, Pakistan
BERYLLIUM	11	Russia, Kazakhstan, China, Japan
SULFUR	11	Canada, Mexico, Venezuela
GYPSUM	10	Canada, Mexico, Spain
IRON and STEEL SLAG	8	Canada, Japan, Spain, Italy
CEMENT	7	Canada, Rep. of Korea, China, Greece

Advances in alternative energy technologies are driving demand for metals as energy demand increases in developing countries.

However, there are very few large, high-grade, accessible mineral and metal deposits in the U.S. Industry must now apply innovative extraction technologies to many deposits previously regarded as too low grade or metallurgically challenged to be economical.

Background

World energy consumption recently surpassed 524 quadrillion Btu. Of this total, the U.S. consumed 95 quadrillion Btu (18%), followed by China (20%) and India (5%). EIA forecasts world energy consumption will reach about 820 quadrillion Btu by 2040. EIA, 2013

The U.S. was self-sufficient in energy until the late 1950s when energy consumption began to outpace domestic production.[1] In 2012, the U.S. produced 79.21 quadrillion Btu and consumed 95 quadrillion Btu. In order to meet current and future U.S. energy demands, a balance of fuel sources will be required.

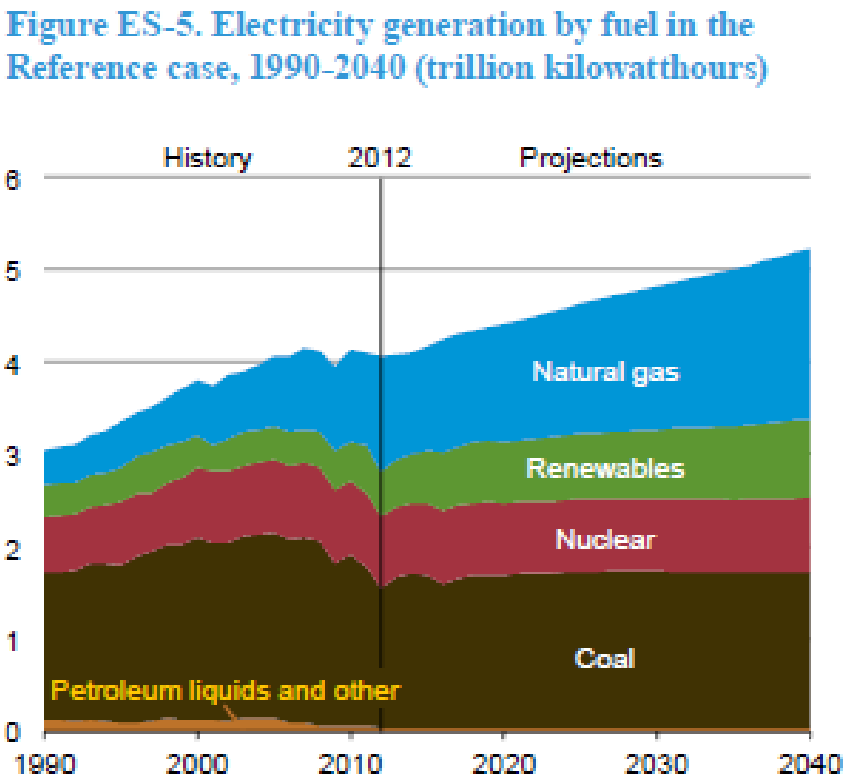

Figure 3. Source: EIA 2013.

The total estimated basic mineral materials required to build significant energy sources† was about 555 million metric tons in 1975[2]. Based on the 70% increase in U.S. electricity generation from 1975 to 2012 (2.3 to 4.1 trillion Kilowatt-hours), those same energy sources would now require, conservatively, at least 943 million metric tons of mineral materials. †coal, petroleum, oil shale, natural gas, nuclear, solar, wind, geothermal, hydro, ocean thermal conversion, biomass

[1] United States Energy Information Administration

[2] USGS report 1006-A "*Demand for Nonfuel Minerals and Materials by the United States Energy Industry, 1975-90*",

EIA's Annual Energy Outlook predicts total U.S. electricity consumption, including both purchases from electric power producers and on-site generation, to grow from 4.1 trillion KWh in 2012 to 4.7 trillion KWh in 2040 - increasing at an average annual rate of 0.8 percent. (Fig. 4)

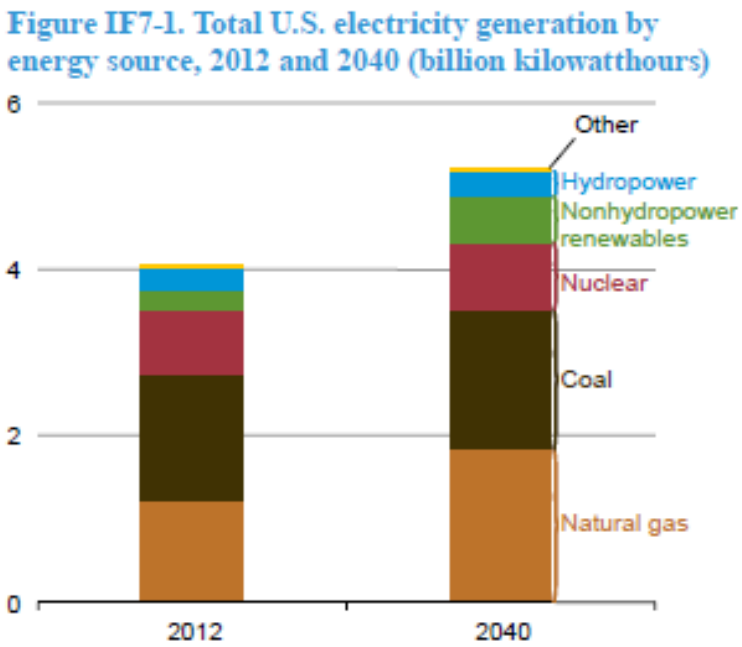

Figure 4. Source EIA 2013

The U.S. is currently focused on developing more renewable energy sources such as solar, wind and biomass. Thin-film copper-indium-gallium-selenium photovoltaic cells are generating new demand for indium and gallium as demand for solar energy increases. Scandium is used to make a strong aluminum alloy for use in the aerospace and defense industries. An accessible supply of scandium alloys would make items more durable, efficient and lighter, leading to lower energy cost to move cars, planes, etc. These strategic, energy-critical minerals are only recovered as byproducts from refining of base metal concentrates (Cu, Ni, Zn, Pb, Fe, Al). The mining industry is not able to deliver a secure supply-response to higher prices when they involve such low-volume energy-critical byproduct metals.

Demand for copper is expected to match GDP growth. The average hybrid car has 121 pounds of copper; double that of a regular gas engine car. Nanoparticle copper electrodes for batteries could make large-scale power storage on the energy grid feasible.

Demand for molybdenum and iron ore, both used predominantly in steel production, is expected to outpace GDP growth at 5.6 percent and 7.6 percent, respectively. And, as hybrid vehicles become more widespread, the demand for lithium for batteries could outpace supply within 10 years.

The USA has 99 nuclear power reactors in 30 states, operated by 30 different power companies. These plants generate about 20% of U.S. electricity (798 TWh) each year. (World Nuclear Association, 2015) However, the U.S. is 83% import dependent for the uranium used for fuel.[3]

[3]*U.S. Uranium Supplies, Part 1: Growing Energy Security Risks, The Energy Collective, 2014.*

SME Statement Of Technical Position

The development of mineral resources is a key driver of global economic growth and energy production.

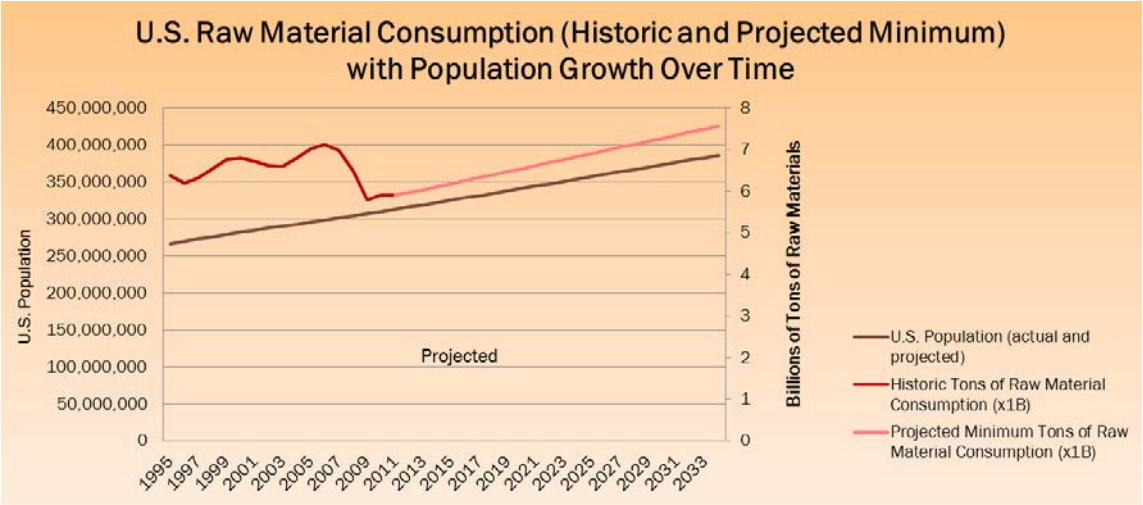

Figure 5. Source: EIA, BLS 2011

The unique properties of certain minerals make them essential, even irreplaceable components of conventional and renewable energy sources. Demand for minerals will increase with world population growth as developing countries increase energy demands and embrace new technologies and erect new infrastructure (Fig 5).

According to the USGS 2015 Mineral Commodities Summary, net export of mineral raw materials was $2.7 billion. Net import of processed mineral materials was $41billion, many of which are used in various energy applications.

There is a severe risk of medium- and long-term cumulative supply deficits (CSD) of indium and tellurium; a moderate risk of medium-term and severe risk of long-term CSD of neodymium; and limited risk of long-term CSD of cobalt and lithium (Fig 6). These scarcity risks pose a severe challenge to a nation's efforts to transition to a low-carbon global economy.[4]

[4]*Stockholm Environment Institute, Metals in a Low-Carbon Economy: Resource Scarcity, Climate Change and Business in a Finite World, 2012*

Energy Application	Minerals	% Import Dependence
Lithium-ion Batteries	Lithium minerals, Fluorspar, Graphite, Cobalt	Lithium (>50%), Fluorspar (100%), Graphite (100%) Cobalt (76%)
Fuel Cells	Borates, Graphite, Lithium minerals, Rare Earths, Zircon	Potash (84%), Rare Earths (59%)
Photovoltaic Cells	Quartz, Fused Silica, Silicon Carbide, Fluorspar, Filler minerals, Indium, Gallium, Tellurium	Quartz (100%), Silicon Carbide (77%), Indium (100%), Gallium (99%), Tellurium (>80%)
Wind Turbines	Neodymium, Boron, Graphite, Filler minerals, Bauxite, Scandium	Bauxite (100%), Scandium (100%) Neodymium (100%)

Figure 6. Source USGS 2015

With such an overall energy demand projected, the U.S.' ability to innovate and meet its growing requisite mineral needs will depend on policies that encourage the responsible development of all domestic energy resources. Government's long-term strategies should include vigorous efforts to secure conventional and energy critical mineral supplies at the international level through strategic partnerships (trade agreements, support in international forums, sharing of technology and development aid programs).

There also needs to be a uniform, government-led global metric for determining the terminal life-cycle availability of mineral resources and reserves when making critical policy and scientific determinations as to future energy requirements.

Finally, a U.S. energy policy that takes into account "all of the above" energy sources in an effort to secure domestic energy supplies and ensure energy independence, will require an equal "all of the above" commitment to domestic mineral development in order to meet that ambitious goal.