Strategic and Critical Elements

Different Viewpoints, Different Definitions

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The U.S. View over Time

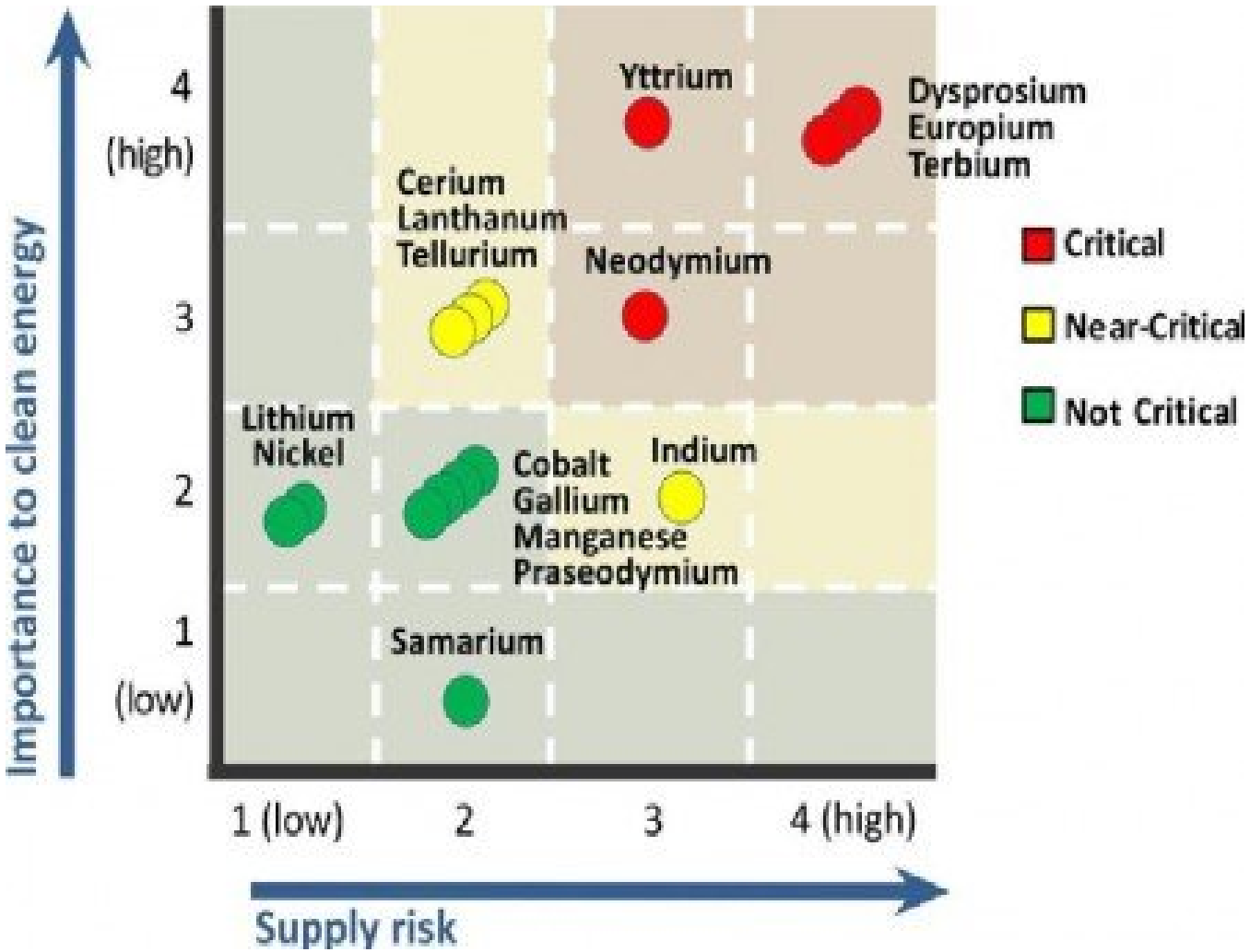
- In 1776, the Committee of Secret Correspondence of the Continental Congress was considered the first U.S. intelligence agency
- The agency sent William Carmichael to Europe to survey several economic matters crucial to the emerging U.S. government
- Money was primarily the strategic and critical material, derived mainly from American tobacco, as it had been since the country was first settled
- By the Civil War, cotton was also a major export commodity

U.S. Department of Energy

Elements classified by the U.S. Department of Energy are considered critical or essential for **Clean Energy Technologies.**

These elements, shown on a criticality chart on the next slide, are used primarily in wind turbine generators, energy storage devices, and solar panels.

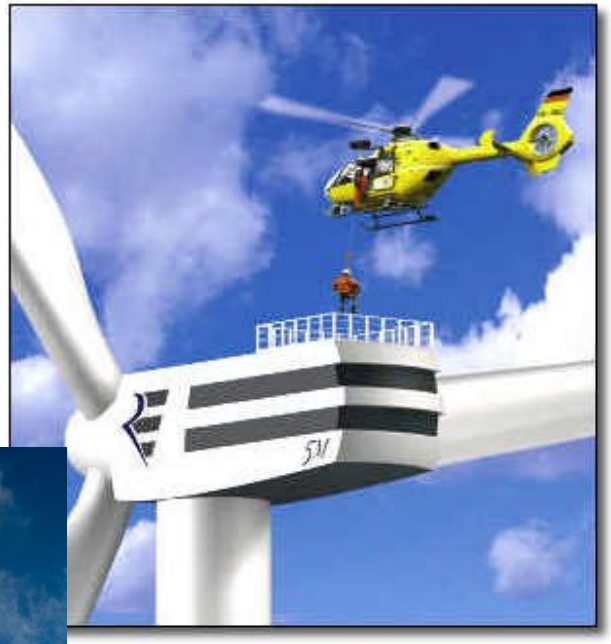
U.S. Department of Energy

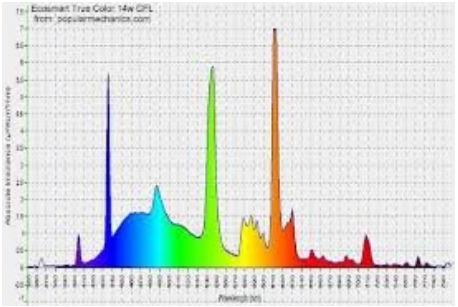


U.S. Department of Energy

Critical

- Dysprosium
- Neodymium
- Terbium
- Europium
- Yttrium





Red $Y_2O_3:Eu^{3+}$

Green $CeMgAl_{11}O_{19}:Tb^{3+}$

Blue $BaMgAl_{10}O_{17}:Eu^{2+}$ or $(Sr,Ba,Ca)_5(PO_4)_3Cl:Eu^{2+}$

U.S. Department of Energy

Near-Critical

- Cerium
- Lanthanum
- Tellurium
- Indium

Cerium oxide polishing compounds

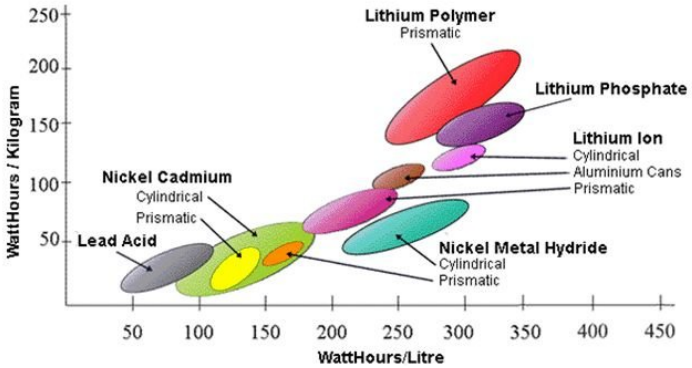
Lanthanum-based fcc oil-refining catalysts

Cadmium telluride solar panel

U.S. Department of Energy

Not-Critical

- Lithium — Lithium-ion batteries
- Nickel — La-Ni hydride batteries
- Cobalt
- Gallium
- Manganese
- Praseodymium
- Samarium



Sm-Cobalt magnets

U.S. Department of Defense

f all the definitions offered in the various government studies the one used in the 2009 Reconfiguration of the National Defense Stockpile Report is closest to the attributes used most across various studies.

"*materials required for defense and national security needs*" and

"*those materials for which the U.S. is largely import dependent, for which no viable economic*

U.S. Department of Defense

hough the latter definition seemingly precludes minerals for which the U.S. has significant domestic production and reserves, it's vital that we take this with a grain of salt. Copper, for example, is abundant domestically, yet remains an invaluable resource due to its extensive security, technology, and energy applications.

The U.S. Department of Defense has various lists of critical materials. The Office of the Secretary of Defense lists "copper as a metal that has, [Already] caused some kind of weapon production delay for the DoD."

U.S. Department of Defense

opper is a primary metal that provides byproduct strategic and critical metals which includes significant amounts of molybdenum, rhenium (nearly 75% of world's production), tellurium, and selenium (95% of world's production).

opper shortages will trigger companion metal shortages. These relationships are highlighted to demonstrate the shortsighted-ness of targeting metals based entirely on their stand-alone percentages of import reliance.

American Resources Policy Network (ARPN)

he ARPN compiled a list of critical and strategic elements at risk from a variety of U.S. Government studies.

he following are ranked based on elements and ores at most risk for supply disruption at the top of the pyramid to critical and strategic minerals and ores at lower risk to disruption at the bottom.

he list is not definitive, however it represents ARPN's best compilation of data from

American Resources Policy Network Risk Pyramid

American Resources Policy Network Risk Pyramid

Top of the Risk Pyramid

- Aluminum
- Beryllium
- Chromium
- Cobalt
- Manganese
- Niobium
- Platinum
- Tantalum
- Tin
- Titanium
- Tungsten
- Yttrium
- Zinc

American Resources Policy Network Risk Pyramid

Middle of the Risk Pyramid

- Bauxite
- Bismuth
- Copper
- Europium
- Iridium
- Lanthanum
- Molybdenum
- Neodymium
- Nickel
- Samarium
- Silicon

American Resources Policy Network Risk Pyramid

Bottom of the Risk Pyramid

- Antimony
- Beryl Ore
- Cadmium
- Cerium
- Chromite Ore
- Dysprosium
- Fluorspar
- Gadolinium
- Gallium
- Germanium
- Indium
- Lead
- Lutetium
- Mercury
- Palladium
- Praseodymium
- Rhenium
- Rhodium
- Scandium
- Silver
- Terbium
- Vanadium

U.S. Geological Survey

Import Reliance

- Annually, the U.S. Geological Survey ranks mineral and metal commodities based on import reliance. The following import reliance charts do not rate the criticality of supply of each commodity. Some materials that are sourced from reliable supply sources such as Mexico and Canada, which obviously do not represent as big of a risk as those supplied from China or the Congo.
- Following are two bar charts for U.S. Net Import Reliance for Selected Non-Fuel Minerals Materials. The years selected were 1985 and 2011 (latest).

U.S. Geological Survey - Import Reliance 1985

USGS
science for a changing world

1985 U.S. NET IMPORT RELIANCE [e/1/] OF SELECTED NONFUEL MINERAL MATERIALS AS A PERCENT OF APPARENT CONSUMPTION [2/]

Commodity	Percent	Major Import Sources (1981-84)[3/]
COLUMBIUM	100	Brazil, Canada, Thailand
MANGANESE	100	Republic of South Africa, France, Brazil, Gabon
MICA (sheet)	100	India, Belgium, France
STRONTIUM	100	Mexico, Spain
BAUXITE & ALUMINA	97	Australia, Jamaica, Guinea, Suriname
COBALT	95	Zaire, Zambia, Canada, Norway
PLATINUM GROUP	92	Republic of South Africa, UK, U.S.S.R.
TANTALUM	92	Thailand, Brazil, Malaysia, Australia
POTASH	77	Canada, Israel
CHROMIUM	73	Republic of So. Africa, Zimbabwe, Yugo., Turkey
TIN	72	Thailand, Malaysia, Bolivia, Indonesia
ASBESTOS	71	Canada, Republic of South Africa
BARITE	69	China, Morocco, Chile, Peru
ZINC	69	Canada, Peru, Mexico, Australia
NICKEL	68	Canada, Australia, Botswana, Norway
TUNGSTEN	68	Canada, China, Bolivia, Portugal
SILVER	64	Canada, Mexico, Peru, United Kingdom
MERCURY	57	Spain, Algeria, Japan, Turkey
CADMIUM	55	Canada, Australia, Peru, Mexico
SELENIUM	54	Canada, United Kingdom, Japan, Bel.-Lux.
GYPSUM	38	Canada, Mexico, Spain
GOLD	31	Canada, Uruguay, Switzerland
COPPER	27	Chile, Canada, Peru, Mexico
SILICON	23	Brazil, Canada, Norway, Venezuela
IRON ORE	22	Canada, Venezuela, Liberia, Brazil
IRON & STEEL	22	European Economic Community, Japan, Canada
ALUMINUM	12	Canada, Japan, Ghana, Venezuela
NITROGEN	8	U.S.S.R., Canada, Trinidad & Tobago, Mexico
SULFUR	5	Canada, Mexico

U.S. Geological Survey - Import Reliance 2011

Commodity	Percent	Major Import Sources (2007–10)[1]
ARSENIC (trioxide)	100	Morocco, China, Belgium
ASBESTOS	100	Canada, Zimbabwe
BAUXITE and ALUMINA	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, Japan, Belgium
MANGANESE	100	South Africa, Gabon, China, Australia
MICA, sheet (natural)	100	China, Brazil, Belgium, India
NIOBIUM (columbium)	100	Brazil, Canada, Germany, Russia
QUARTZ CRYSTAL (industrial)	100	China, Japan, Russia
RARE EARTHS	100	China, France, Estonia, Japan
RUBIDIUM	100	Canada
SCANDIUM	100	China
STRONTIUM	100	Mexico, Germany
TANTALUM	100	China, Germany, Kazakhstan, Australia
THALLIUM	100	Russia, Germany, Kazakhstan
THORIUM	100	France, India, Canada, United Kingdom
YTTRIUM	100	China, Japan, France, United Kingdom
GALLIUM	99	Germany, Canada, United Kingdom, China
IODINE	99	Chile, Japan
GEMSTONES	98	Israel, India, Belgium, South Africa
GERMANIUM	90	China, Belgium, Russia, Germany
BISMUTH	89	China, Belgium, United Kingdom,
DIAMOND (dust, grit and powder)	89	China, Ireland, Republic of Korea, Russia
PLATINUM	88	Germany, South Africa, United Kingdom, Canada
ANTIMONY	87	China, Mexico, Belgium
RHENIUM	87	Chile, Netherlands, Germany
STONE (dimension)	85	Brazil, China, Italy, Turkey
POTASH	83	Canada, Belarus, Russia
VANADIUM	80	Rep. of Korea, Canada, Austria, Czech Republic
BARITE	78	China, India
SILICON CARBIDE	76	China, Brazil, Vietnam, Norway
TIN	76	Peru, Bolivia, Indonesia, China
COBALT	75	China, Norway, Russia, Canada
SILVER	75	Mexico, Canada, Peru, Chile
ZINC	73	Canada, Peru, Mexico, Ireland
TITANIUM (sponge)	69	Kazakhstan, Japan, China, Russia
TITANIUM MINERAL CONCENTRATES	68	South Africa, Australia, Canada, Mozambique
PEAT	63	Canada
CHROMIUM	60	South Africa, Kazakhstan, Russia, China
PALLADIUM	56	Russia, South Africa, United Kingdom, Norway
MAGNESIUM COMPOUNDS	53	China, Canada, Brazil, Austria
NICKEL	47	Canada, Russia, Australia, Norway
SILICON (ferrosilicon)	42	China, Russia, Venezuela, Canada
NITROGEN (fixed), AMMONIA	41	Trinidad and Tobago, Russia, Canada, Ukraine
GARNET (industrial)	39	India, Australia, China, Canada
GOLD	36	Mexico, Canada, Colombia, Peru
TUNGSTEN	36	China, Bolivia, Canada, Germany
COPPER	35	Chile, Canada, Peru, Mexico
MAGNESIUM METAL	35	Israel, Canada, China
PERLITE	27	Greece
SULFUR	24	Canada, Mexico, Venezuela
SALT	22	Canada, Chile, Mexico, The Bahamas
BERYLLIUM	21	Russia, Kazakhstan, Japan, Russia
MICA, scrap and flake (natural)	20	Canada, China, India
VERMICULITE	20	China, South Africa, Australia, Brazil
ALUMINUM	13	Canada, Russia, China, Mexico
GYPSUM	13	Canada, Mexico, Spain
PHOSPHATE ROCK	13	Morocco, Peru
IRON and STEEL	9	Canada, European Union, China, Mexico
IRON and STEEL SLAG	8	Japan, Canada, South Africa, Italy
CEMENT	6	Canada, China, Republic of Korea, Mexico
PUMICE	5	Greece, Mexico, Iceland, Montserrat
DIAMOND (natural industrial stone)	3	Botswana, South Africa, Russia, Namibia
LIME	1	Canada, Mexico
STONE (crushed)	1	Canada, Mexico, The Bahamas

[1]In descending order of import share

Strategic Material - DOD

- The term “Strategic Material” shall mean – A material 1) which is essential for important defense systems, 2) which is unique in the function it performs, and 3) for which there are no viable alternatives. Strategic Materials include those “specialty metals” listed in 10 U.S.C. 2533b, and any other materials the Board may designate.

- Although the U.S. Department of Defense (DOD) has a definitive definition, the edges of the box are blurred when viewed from the outside. One external definition is that “strategic” are those reserves that are most needed in a national security or national emergency situation. From a DOD perspective this amounts to what is “essential to the military.” In the second tier it is “what is essential to civilian needs.” Specifically, it is those reserves critical to the economic well-being of the United States, and includes an increasing number of minerals and materials, including rare earths.

Strategic and Critical an Industry Perspective

rom an industry perspective “critical” is based on its functionality, according to Dr. Gareth Hatch of Technology Metals Research.

A critical material is not substitutable.

Strategic is seen as a subset of critical;

- Those key economic materials needed for national defense, for a national emergency, or for providing national energy needs for clean energy.
- Both the DOD and the U.S. DOE have their own definitions of strategic and critical materials, which includes several of the rare earths.
- DOE’s materials are aligned to energy

Strategic and Critical Congressional Research Service

- The impetus is to incentivize industry to reduce import dependence by:
  - Developing resources on public lands
  - Developing substitutes
  - Developing new mineral process technology
- The world is in a pattern of mercantilism and colonialism.
- Nationalism is a definite supply chain risk according to Marc Humphries of the CRS.
- To mitigate supply chain risk is much easier to accomplish earlier in the game than to wait until it becomes an international incident.
- World population growth and increased demand for higher standards of living will increase demand for metals and minerals

Strategic and Critical Views from the Past and Present

major factor that has not been discussed on Strategic and Critical materials is time.

- John M. Lucas, long-time gold commodity specialist for the U.S. Bureau of Mines (retired), noted “it is to our peril that we fail to appreciate that all the U.S. Government money in the world cannot buy us the time we (i.e. the United States) are squandering today by not searching for and evaluating our vast land mass for critical fuel and nonfuel resources on a continuing basis.”
- Former Nevada Representative Jim Santini’s warning about “off the shelf syndrome” to describe the attitude of the DOD toward the availability of minerals and other products was “spot on.”
- Rare Earths are definitely not a “COTS” product

Critical and Strategic Sayings from Past and Present

- It was once said “Haste makes waste, and waste makes want, and want makes strife between the goodman and his wife” (John Ray, 1678).
- More relevant today “Late to the game, strategic resources gather no gain, the people are left wanting with legislative shame” (James Hedrick, 2012).
- Geopolitics will continue to be the bane of a stable U.S. economy as long as the nation fails to develop its own resources and a sustainable supply.
- Colonialism targeting the U.S. economic base continues to enslave and weaken the financial markets using oil and mineral resources as its sword.
- **Geologic resources rule the world!**

The End

Of this talk, not the mineral crisis