Proposal for a Comprehensive Analysis of Global Nonrenewable Natural Resource Scarcity

Nonrenewable natural resources (NNRs)—energy resources, metals, and minerals—are the lifeblood of industrialized civilization; they are the enablers of the "way of life" that we in the "developed" world have come to take for granted, and to which billions in the "developing world" aspire. As a case in point, approximately 95% of the material flows into the US economy each year are NNRs. In the absence of continuously available supplies of enormous quantities of NNRs, industrialized societies would cease to exist.

Rationale

Because NNR supplies are finite—NNR reserves are not replenished by Nature—NNR supplies will become increasingly scarce, given persistent extraction, as reserves are depleted toward exhaustion. Such has been the case in the US, and compelling evidence supports the contention that NNRs are becoming increasingly scarce on a global level as well. (See - http://www.wakeupamerika.com/PDFs/Continuously-Less-and-Less.pdf; and Appendix A below.)

Since global NNR scarcity is occurring now, and since global NNR scarcity will undermine, if not preclude, the population levels and material living standards associated with today's industrialized and industrializing nations, it is critical that we understand the extent to which global NNR scarcity exists today and the extent to which it is likely to exist in the immediate future.

A comprehensive and objective analysis of global NNR scarcity spanning the period from 1950 to 2050 must be conducted, as the fundamental prerequisite to informed planning and policy development at the local, national, and global levels. The analysis must incorporate the best available data, analytical tools, and expertise.

Objectives

1. Identify factors, trends, and milestones regarding global NNR demand, supply, and utilization that have impacted or will impact NNR scarcity during the 1950-2050 time period. Specifics per NNR include demand and supply factors that determine global NNR utilization levels:
   - Socio-economic factors, trends, and milestones that determine NNR demand, e.g., population levels, per capita goods and services consumption levels (material living standards), economic stability, new technologies, new NNR applications, NNR substitution, conservation initiatives, and productivity increases.
   - Geological factors, trends, and milestones that determine NNR supply, e.g., discovery levels, "reserve growth" levels, extraction (production) levels, and recycling levels.
   - Geopolitical factors, trends, and milestones that determine NNR supply, e.g., political stability, NNR husbanding, and NNR exploration and production (E&P) investment.

2. Assess the "adequacy" associated with available NNR supplies going forward. Specific considerations per NNR include:
   - Will NNR supplies be sufficient to meet NNR demand through the year 2050?
     - If "no", when is an NNR supply shortfall (demand exceeds supply) likely to occur?
     - If "yes", will NNR supplies be sufficiently affordable in terms of financial costs, energy costs, and other natural resource costs to perpetuate an industrialized lifestyle paradigm?
   - What is the likely status of each NNR in the year 2050?
     - Abundant: NNR supply is likely to comfortably exceed demand beyond 2050.
     - Scarce: NNR supply is likely to be struggling to keep pace with demand by 2050.
     - Insufficient: NNR demand is likely to exceed supply by 2050; an NNR supply shortfall is likely to occur by 2050.

3. Assess the implications associated with global NNR scarcity on the future of industrialized human existence. Specific considerations include:
   - What are the likely impacts of NNR scarcity on industrialized and industrializing nations during the analysis period, and beyond?
   - What preemptive actions can be taken to mitigate the lifestyle disruptions—population level reductions and material living standard degradation—associated with NNR scarcity?

Method

Conduct a 101 year (1950-2050) global NNR scarcity analysis associated with each energy resource, metal, and mineral for which the USGS and/or other reputable organizations maintain global demand, supply, utilization, and pricing data. (See - http://minerals.usgs.gov/ds/2005/140/ - and - http://minerals.usgs.gov/minerals/pubs/mcs/2009/mcs2009.pdf - for the approximately 90 NNRs monitored by the USGS; add coal, oil, natural gas, and uranium.)

Use actual NNR data for the 1950 to 2009 period; develop "best available" forecasts for the 2010 to 2050 period. Consider three future scenarios: conservative, probable, and optimistic. Create, as the core of the analysis, a set of NNR profiles, each of which will contain historical and projected NNR data for a specific NNR over the 101 year period:

Global Nonrenewable Natural Resource (NNR) Profile

NNR Profile Element	Historical Data 1950………2009	Future Projections 2010………..2050
NNR Reserve Level		
Beginning Proven NNR Reserve Level		
Annual NNR Supply-side Reserve Adjustments		
New NNR Discoveries		
"Proved Up" NNRs from Previous Discoveries		
Newly Recycled NNRs		
Administrative NNR Reserve Revisions		
Total Annual NNR Supply-side Reserve Adjustments		
Annual NNR Demand-side Reserve Adjustments		
Primary NNR Utilization		
Primary NNR Extraction		
Primary NNR Inventory Change		
Total Primary NNR Utilization		
Recycled NNR Utilization		
Total Annual NNR Demand-side Reserve Adjustments		
Ending Proven NNR Reserve Level		
NNR Reserve Quality		
Geological Reserve Quality		
Geopolitical Reserve Quality		
NNR Price		

Definitions: See Appendix B for NNR Profile Element Definitions

Appendix A: Major Metals Scarcity

Following is a summary table from a work-in-process being conducted in conjunction with Dr. David Roper from Virginia Tech University. It contains projected global peak extraction (production) years and global peak supply years for 19 major metals (plus phosphate rock) based upon Verhulst curve fitting.

The results are disturbing—sufficiently disturbing that the exercise must be expanded to include all NNRs for which reliable data exist and reworked to include the best available NNR demand, supply, and utilization projections going forward.

In the most optimistic future NNR supply scenario, which includes estimated recycled NNR quantities in addition to estimated NNR quantities remaining to be extracted, global supplies associated with 14 of the 20 NNRs are projected to peak by the year 2050. In the most conservative scenario, which employs estimated NNR "reserves" as the measure of NNR quantities remaining to be extracted, global extraction (production) levels associated with 19 of the 20 NNRs are projected to peak by the year 2035.

Peak Global Extraction (Production) Level and Supply Level Estimates for Major Metals

Metal (Plus Phosphate Rock) [Metric Tons]	Peak-to-Date Year		Estimated "Ultimate" Global Peak Year		
	US Peak Extraction To Date	Global Peak Extraction To Date	Est. Peak Extraction (Using USGS Reserves Data)	Est. Peak Extraction (Using USGS Reserve Base Data)	Est. Peak Supply (Recycling Included)
Bauxite	1981	2008 (205M MT)	2035 (900M MT)	2037 (1,400M MT)	2040 (4,100M MT)
Cadmium	1969	1988 (22K MT)	1988		2002 (26K MT)
Chromium	1959	2007 (6.6M MT)	2028 (7.7M MT)	2035 (8.5M MT)	2048 (20M MT)
Cobalt	1958	2008 (71.8K MT)	2030 (68K MT)	2040 (70K MT)	2065 (130K MT)
Copper	1998	2008 (15.7M MT)	2020 (?)	2030 (?)	2038 (37M MT)
Gold	1998	2001 (2.6K MT)	2003 (2.1K MT)	2015 (2.3K MT)	2028 (4.2K MT)
Iron Ore	1951	2008 (2.2B MT)	2012 (2.5B MT)	2018 (3.9B MT)	2070 (8.7B MT)
Lead	1970	2008 (3.8M MT)	1990 (3.4M MT)		2042 (16.8M MT)
Lithium	1954	2008 (27.4K MT)	2055 (86K MT)	2065 (57K MT)	2075 (195K MT)
Manganese	1918	2008 (14M MT)	2012 (18M MT)	2023 (73M MT)	2050 (51M MT)
Mercury	1943	1971	1971		
Molybdenum	1980	2008 (212K MT)	2020 (175K MT)	2027 (180K MT)	2035 (290K MT)
Nickel	1997	2007 (1.7M MT)	2022 (1.75M MT)	2030 (1.85M MT)	2080 (7.5M MT)
PGM	2002	2006 (513 MT)	2006 (440 MT)	2010 (440 MT)	2110 (790 MT)
Phosphate Rock	1980	2008 (167M MT)	1988 (147M MT)		2030 (158M MT)
Silver	1916	2008 (20.9K MT)	2002 (15K MT)	2008 (16K MT)	2025 (28.5K MT)
Tin	1945	2008 (333K MT)	2008 (333K MT)	2018 (730K MT)	2020 (675K MT)
Titanium	1964	2007 (10M MT)	2005 (7.9M MT)	2025 (9M MT)	2050 (20M MT)
Tungsten	1955	2004 (66.6K MT)	1990 (44K MT)	2012 (53K MT)	2090 (155K MT)
Zinc	1969	2008 (11.3M MT)	2005 (9M MT)	2020 (10.3M MT)	2015 (13.1M MT)

Sources: USGS data - http://minerals.usgs.gov/ds/2005/140/ and http://minerals.usgs.gov/minerals/pubs/mcs/2009/mcs2009.pdf ; and Dr. David Roper's Mineral Depletion page - http://www.roperld.com/science/minerals/minerals.htm.

Appendix B: NNR Profile Element Definitions

- Proven NNR Reserve Level includes below ground (yet-to-be extracted) proven NNR reserves, recycled but unused NNR inventories/stocks, and previously extracted primary NNR inventories/stocks.
- New NNR Discoveries measure new “finds” of previously unknown NNR deposits that can be classified as “proven reserves”.
- “Proved Up” NNRs from Previous Discoveries measure “reserve growth” attributable to technology improvements that enable the reclassification of “uneconomical” or “inaccessible” resources to “economical” or “accessible”; and to subsequent successful exploration in previously discovered fields/deposits.
- Newly Recycled NNRs consist of new scrap and old scrap processed during the year.
- Administrative NNR Reserve Revisions are updated proven reserve estimates based on new data or new geological analyses, and are incremental to new NNR discoveries, “prove ups” associated with previous NNR discoveries, and NNR recycling.

- Primary NNR Utilization is the quantity of newly extracted (current and previous years) NNRs utilized (consumed) during the year.
- Primary NNR Extraction is the total newly extracted NNRs (virgin ore) extracted from mines, wells, or other deposits during the year.
- Primary NNR Inventory Change is the change in the stocks of yet-to-be utilized NNRs extracted during previous years. NNR inventories can be owned by private, commercial, or government entities.
- Recycled NNR Utilization is the quantity of recycled NNRs utilized (consumed) during the year.

- Geological Reserve Quality is a measure of the average “geological goodness” associated with an NNR reserve at a given point in time. Specific geological reserve quality measures can vary per NNR, but must be constant per NNR over time in order to permit time series comparisons. [Geological reserve quality is the “average” quality of the NNR deposits that comprise the reserve at a given time. Geological factors that determine NNR deposit quality include: size (ultimately recoverable resource), concentration (ore grade), accessibility, proximity to the earth’s surface, and proximity to infrastructure.]
- Geopolitical Reserve Quality: is a measure of the average “geopolitical goodness” associated with an NNR reserve at a given point in time. [Geopolitical reserve quality is the “average” quality of the NNR deposits that comprise the reserve at a given time. Geopolitical factors that determine NNR quality include: political stability and economic stability.]

- NNR Price is the average annual global NNR price expressed in constant USD.

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