The Global Scramble for Energy and Mineral Resources—

Will the Move Towards Alternative Energy Sources Alleviate Our Import Problems?

Vincent Matthews Ph.D., Director
Colorado Geological Survey
Overall Impacts

Americans will suffer from natural-resource-driven inflation

Americans may see increasing shortages of critical raw materials

Pressures will mount to develop more of America’s natural resources

Conflicts may arise with multi-national corporations operating in America

How do we turn lemons into lemonade?
Population Comparison

China

U.S.

India

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Land Area Comparison

- **China**
- **U.S.**
- **India**
GDP Comparison - 2007

- U.S.: 13.8
- China: 3.2
- India: 1.1

Source: World Bank
GDP Growth Comparison 2004-06

- **China**: 10.4
- **U.S.**: 3.5
- **India**: 8.1

Source: World Bank
World Electrical Growth

World 8.3 terawatts increase (+70%)

China/India/U.S. 4.4 terawatts (53%)

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China/India/U.S. Electrical Growth

- U.S. 1.1
- China 2.8
- India 0.5

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World Electrical Growth

Africa

Europe-Eurasia

South & Central America

Asia-Pacific

Middle East

North America

Source: BP Statistical Review of World Energy 2009

TMS 2010
<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>45</td>
<td>1</td>
</tr>
<tr>
<td>Fluorspar</td>
<td>51</td>
<td>1</td>
</tr>
<tr>
<td>Rare earths</td>
<td>96</td>
<td>1</td>
</tr>
<tr>
<td>Aluminum</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>Antimony</td>
<td>86</td>
<td>1</td>
</tr>
<tr>
<td>Copper</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>Gold</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Lead</td>
<td>32</td>
<td>1</td>
</tr>
<tr>
<td>Magnesium</td>
<td>75</td>
<td>1</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td>Silver</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Steel, crude</td>
<td>31</td>
<td>1</td>
</tr>
<tr>
<td>Tin</td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td>Tungsten</td>
<td>87</td>
<td>1</td>
</tr>
<tr>
<td>Zinc</td>
<td>26</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: USGS, Menzie and Tse
China’s Production and Consumption of Copper

- Production supplemented by imports
- Source: USGS, Kenzie, et al

Graph:
- Copper production
- Copper consumption

Year: 1990-2005e

Million metric tons

43% Imported!
Global Impact

Cu (Cash)
USD/LB
02 Jan 2003 - 31 Dec 2009

457%

Last: 3.332 USD Dec 31, 09

Metalprices.com

TMS 2010
Metal prices fall further than during Great Depression

The price of key industrial metals has fallen further over the last four months than occurred during the worst years of Great Depression between 1929 and 1933, according to research by Barclays Capital.

By Ambrose Evans-Pritchard
Last Updated: 7:29AM GMT 03 Dec 2008
Global Impact

Cu (Cash)
USD/LB
02 Jan 2003 - 31 Dec 2009

377%
U. S. Impact

- Difficulty in manufacturing of copper products
- Increased copper thefts
- Increased costs to the consumer
- Pueblo man electrocuted while trying to steal wiring 10/27/09
- Copper mine reopening
## China’s Share of World Mineral Production in 2005

<table>
<thead>
<tr>
<th>Industrial minerals:</th>
<th>%</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>45</td>
<td>1</td>
</tr>
<tr>
<td>Fluorspar</td>
<td>51</td>
<td>1</td>
</tr>
<tr>
<td>Rare earths</td>
<td>96</td>
<td>1</td>
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<tr>
<td>Metals:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
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<td>1</td>
</tr>
<tr>
<td>Antimony</td>
<td>86</td>
<td>1</td>
</tr>
<tr>
<td>Copper</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
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<td>9</td>
<td>4</td>
</tr>
<tr>
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<td>32</td>
<td>1</td>
</tr>
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</tr>
<tr>
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<td>3</td>
</tr>
<tr>
<td><strong>Steel, crude</strong></td>
<td>31</td>
<td>1</td>
</tr>
<tr>
<td>Tin</td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td>Tungsten</td>
<td>87</td>
<td>1</td>
</tr>
<tr>
<td>Zinc</td>
<td>26</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: USGS, Menzie and Tse

M  illio n  m e tric  to n s

Year

China
Japan
Republic of Korea
Germany
United States

Trends in Demand for Steel

[Graph showing trends in demand for steel by region (China, Other Asia, Europe, Americas) from 2001 to 2004.]

- **Source:** International Iron and Steel Institute.
China

• 2005 – Opened 70,000 new supermarkets
• 2006 – Became #3 car manufacturer
• 2008 – Became #2 car market
• 2009 – Became #1 car market
• 2009 – Became #1 car manufacturer
• 2009 – Became #1 exporter
• 2009 – Became #2 economy

Source: World Bank
Price of Scrap Iron

#1 Dealer Bundles Mill Chicago (Mean)
USD/MT
Jan 01, 2003 - Apr 09, 2009

Last: 157.50 USD Apr 09, 09

Metalprices.com

559%
U.S. molybdenum exports

<table>
<thead>
<tr>
<th>Year</th>
<th>Exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>21,900</td>
</tr>
<tr>
<td>2004</td>
<td>34,500</td>
</tr>
<tr>
<td>2005</td>
<td>41,400</td>
</tr>
</tbody>
</table>
MOLYBDENUM Price

Molybdenum Oxide (Mean)
USD/LB
03 Jan 2003 - 25 Dec 2009

Last: 11.500 USD Dec 25, 09

997%

Metalprices.com
Ball mill gets real Leadville welcome
MOLYBDENUM Price

Molybdenum Oxide (Mean)
USD/LB
03 Jan 2003 - 25 Dec 2009

Last: 11.500 USD Dec 25, 09

Metalprices.com

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~ 100 Known Occurrences of Molybdenum

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Precious & Base Metal Increases 01/03 - 01/10

Gold  274%
Silver  367%
Palladium  284%
Platinum  255%
Nickel  630%
Tin  229%
Zinc  497%
Aluminum  144%
Average Price Increase  379%

TMS 2010
<table>
<thead>
<tr>
<th>Metal</th>
<th>Average Price Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimony</td>
<td>159%</td>
</tr>
<tr>
<td>Bismuth</td>
<td>671%</td>
</tr>
<tr>
<td>Cadmium</td>
<td>908%</td>
</tr>
<tr>
<td>Chromium</td>
<td>719%</td>
</tr>
<tr>
<td>Cobalt</td>
<td>581%</td>
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<tr>
<td>Germanium</td>
<td>193%</td>
</tr>
<tr>
<td>Rhenium</td>
<td>685%</td>
</tr>
<tr>
<td>Selenium</td>
<td>1620%</td>
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<tr>
<td>Tellurium</td>
<td>1123%</td>
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<tr>
<td>Titanium</td>
<td>600%</td>
</tr>
<tr>
<td>Tungsten</td>
<td>531%</td>
</tr>
<tr>
<td>Vanadium</td>
<td>2060%</td>
</tr>
</tbody>
</table>

**Average Price Increase:** 746%
Increase in Coal Spot Price

Year | Price
-----|------
2004 | 17
2005 | 37
2005 Coal Price
Spot versus Contract

- 2005 Spot: $24.4
- 2005 Contract: $24.4
- 2007: $29.75

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“Chinese companies and their rivals are scouring the globe from Australia to Africa for access to the raw materials needed to sustain the Asian nation’s growth as commodity prices surge.”

--June 23, 2006 (Bloomberg)
Renewable Energy

WIND
- Neodymium
- Molybdenum
- Iron Ore

SOLAR
- Cadmium
- Tellurium
- Indium
- Germanium
- Gallium
- Selenium
- Silicon
- Copper

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Strategic and Critical Materials with uses in Alternative Energy applications for which the U.S. is dependent on imports for 50% or more of consumption

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Primary Sources</th>
<th>Applications in Alternative Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimony</td>
<td>China</td>
<td>Thermoelectric/paraelectric materials</td>
</tr>
<tr>
<td>Barium</td>
<td>China</td>
<td>Thermoelectric/paraelectric materials</td>
</tr>
<tr>
<td>Bismuth</td>
<td>China, Mexico</td>
<td>Thermoelectric/paraelectric materials</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Kinshasa,Australia</td>
<td>Photovoltaics (solar cells)</td>
</tr>
<tr>
<td>Gallium</td>
<td>China</td>
<td>Photovoltaics, paraelectric materials</td>
</tr>
<tr>
<td>Germanium</td>
<td>Belgium,Canada</td>
<td>Photovoltaics (solar cells)</td>
</tr>
<tr>
<td>Indium</td>
<td>China, Canada</td>
<td>Solar cells, thermo/paraelectric materials</td>
</tr>
<tr>
<td>Manganese</td>
<td>Gabon, S. Africa</td>
<td>Photovoltaics</td>
</tr>
<tr>
<td>Nickel</td>
<td>Canada</td>
<td>Fuel cells</td>
</tr>
<tr>
<td>Platinum group</td>
<td>South Africa</td>
<td>Fuel cells, para/thermoelectric mtrls</td>
</tr>
<tr>
<td>Rare Earths</td>
<td>China</td>
<td>Fuel cells, para/thermoelectric mtrls</td>
</tr>
<tr>
<td>Scandium</td>
<td>China, Russia</td>
<td>Thermoelectric/paraelectric materials</td>
</tr>
<tr>
<td>Selenium</td>
<td>Canada</td>
<td>Solar cells, thermoelectric materials</td>
</tr>
<tr>
<td>Strontium</td>
<td>Mexico</td>
<td>Thermoelectric/paraelectric materials</td>
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<td>Tantalum</td>
<td>Brazil</td>
<td>Thermoelectric/paraelectric materials</td>
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<td>Tellurium</td>
<td>Belgium, Germany</td>
<td>Solar cells, thermoelectric metrls, semiconductors</td>
</tr>
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<td>Tin</td>
<td>Peru</td>
<td>Thermoelectric materials</td>
</tr>
<tr>
<td>Titanium</td>
<td>Australia, S. Africa</td>
<td>Solar cells</td>
</tr>
<tr>
<td>Vanadium</td>
<td>Czech Rep., S. Africa</td>
<td>Fuel cells</td>
</tr>
<tr>
<td>Zinc</td>
<td>Canada, Mexico</td>
<td>Photovoltaics, fuel cells, thermoelectric mtrls</td>
</tr>
</tbody>
</table>
Percent imported

- Indium
- Selenium
- Tellurium
- Vanadium
- Alumina
- Gallium
- PGM
- Zinc
- Silver
- Bromine

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REE = Rare Earth Elements = 15 + 2

neodymium, lanthanum, terbium, dysprosium
Toyota Prius

- UV CUT GLASS
  - Cerium

- GLASS AND MIRRORS POLISHING POWDER
  - Cerium

- LCD SCREEN
  - Europium
  - Yttrium
  - Cerium

- COMPONENT SENSORS
  - Yttrium

- HYBRID ELECTRIC MOTOR AND GENERATOR
  - Neodymium
  - Praseodymium
  - Dysprosium
  - Terbium

- DIESEL FUEL ADDITIVE
  - Cerium
  - Lanthanum

- HYBRID NiMH BATTERY
  - Lanthanum
  - Cerium

- CATALYTIC CONVERTER
  - Cerium / Zirconium
  - Lanthanum

- 25+ ELECTRIC MOTORS THROUGHOUT VEHICLE
  - Nd Magnets

- HEADLIGHT GLASS
  - Neodymium
In Rare Earth Metals, Chinese Dominance

China has a near monopoly on this group of 17 elements, some of which are used to make efficient light bulbs, electric car motors and wind turbines. And in recent years, the price of one of them, dysprosium, has soared.

Rare-earth oxide production

Sources: U.S. Geological Survey; Asian Metal
In Rare Earth Metals, Chinese Dominance

China has a near monopoly on this group of 17 elements, some of which are used to make efficient light bulbs, electric car motors and wind turbines. And in recent years, the price of one of them, dysprosium, has soared.

Sources: U.S. Geological Survey; Asian Metal
HONG KONG — China is set to tighten its hammerlock on the market for some of the world’s most obscure but valuable minerals.

World faces hi-tech crunch as China eyes ban on rare metal exports
—August 24, 2009 (London Telegraph)

As hybrid cars gobble rare metals, shortage looms
—August 31, 2009 (Reuters)

China Considers Rare-Earth Reserve in Inner Mongolia
—September 2, 2009 (Bloomberg News)
Cement producers

1. China
2. India
3. U.S.

22% Imported

China Consumes ½ of all the concrete in the world

U.S. cement manufacturing is 81% foreign owned
Fertilizers

Potash

$50/ton $200/ton in 2008

Sulfur

Nitrogen urea $1000/ton.

$50/ton > $500/ton in one year

TMS2010
Dr. Colin Thirtle, Professor of Development Economics, Imperial College London
### U.S. Energy Split

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Percent of U.S. energy supply</th>
<th>Percentage Price Increase 2003-07</th>
<th>Percent Imported (2007 Net)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>24</td>
<td>381</td>
<td>0</td>
</tr>
<tr>
<td>Oil</td>
<td>37</td>
<td>306</td>
<td>67</td>
</tr>
<tr>
<td>Uranium</td>
<td>9</td>
<td>481</td>
<td>89</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>24</td>
<td>206</td>
<td>16</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>2.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Biomass</td>
<td>3.6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Solar</td>
<td>0.1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wind</td>
<td>0.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0.3</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**93%**

**7%**

Source: EIA, Annual Report 2007
U.S. Primary Energy Production by Major Source (2008)

Source: Energy Information Administration, Annual Energy Review 2008, Table 1.2. (June 2009)
World Coal Consumption
COAL Consumption - China
China’s Production and Consumption of Coal

Million metric tons

Year
China begins importing coal

Appalachian Coal Spot Price 2/06 – 2/09

$38 per ton

$140 per ton
COAL U.S.

0% imported!
China/U.S. Coal

54% of world production.

51% of world consumption.
World Nuclear Consumption
NUCLEAR- China
China: 32 new plants by 2020
   4 per year through 2015
   9 GW to 60 GW

India: 17 new reactors by 2012
NUCLEAR- U.S.

The last nuclear power plant came on line in 1996

Since then has U.S. nuclear generation --

Increased?

Decreased?

Remained flat?
NUCLEAR- U.S.

Last nuclear power plant came online.
And, the largest nuclear power generator in the world?
The United States generates as much nuclear energy as—

France, Germany, Spain, Sweden, United Kingdom

combined!
World Nuclear Power Consumption

436 Plants Operating
44 Under Construction
50 - 60 Countries Applied to IAEA
The world’s existing 436 nuclear reactors currently need 180 million pounds of uranium each year.
Uranium prices
Colorado Impact


10,000+ claims filed on federal lands in Colorado in 2005-6.

10,000+ claims filed on federal lands in Colorado in 2007.
World Oil Consumption
OIL CONSUMPTION - China

53% Imported!

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OIL- CONSUMPTION India

73% Imported!

Source: BP
OIL - U.S. Consumption

65% Imported!
OIL- U.S. Production

Lower 48

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Alaska production was ramped up after the US 48 decline, but it too began to decline.
OIL- U.S. Production

1.7 billion barrels
48% less

Source: EIA
U.S. OIL PRODUCTION - 1900 to 2050

PEAK 1970
GONE: 2/3 OF U.S. OIL HAS BEEN USED. IT'S HISTORY.
How do you communicate what “2/3 of something gone” means?
In 1969, M. King Hubbert Predicted that World Production would Begin Declining in 2000.
World oil production has been on a plateau since 2005.
Cumulative OIL Consumption by the Human Race as a Percentage of Total Consumption through Yearend 2007

50% of the OIL Consumed by the Human Race Used Since 1986
90% of the OIL Consumed by the Human Race Used Since 1959

Start 1859

10% 1959
20% 1969
30% 1975
40% 1980
50% 1986
60% 1990
70% 1995
80% 2000
90% 2004

1094 Billion barrels Consumed

Copyright J. D. Hughes GSR Inc., 2008
Percentage of 2007
5.3 times
Population

Per Capita Consumption
8.6 times
OIL
GAS

Total Consumption
45 times
OIL

• Non-Renewable
• 89%
Total Consumption

• Renewable
• 11%

*Copyright J. D. Hughes GSR Inc, 2008

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85% of the world’s oil comes from just 20 of the 65 producing countries

54 of the 65 producing countries are in decline
Mexico’s declining production at Cantarell field accelerating

Mexican state oil company Pemex said Wednesday that production at its Cantarell oil field, the world’s second-largest, will drop faster than expected.

- 2005—producing 2.2 million barrels per day
- 2009—producing 0.550
IEA says existing fields have 3.7% decline in 2007

IEA says existing fields have 6.7% decline in 2008

At 5% decline rate

In only five years

The world will need

19 million barrels!

Declines never sleep!

TMS 2010
1 of 65 producing countries

United States of America

Source: BP Annual Energy Report
5 of 65 producing countries

Mexico
Norway
UK
Indonesia

Peak 1997

Source: BP Annual Energy Report
50 of 65 producing countries

Source: BP Annual Energy Report
61 of 65 producing countries

Brazil, Algeria, Canada, China, Kuwait, UAE, Nigeria, Libya, Iraq, Venezuela, Iran

Source: BP Annual Energy Report

Peak 2004

45 small producers

USA
63 of 65 producing countries

Qatar
Angola

Source: BP Annual Energy Report
64 of 65 producing countries

Source: BP Annual Energy Report
65 of 65 producing countries

FSU Former Soviet Union nations

Slight Increase

45 small producers

Source: BP Annual Energy Report
I TOLD YOU TO GET A HYBRID!
Crude Oil Prices

Monthly Cushing, OK WTI Spot Price FOB

Dollars per Barrel

Source: U.S. Energy Information Administration
Oil shale is being seriously re-appraised.
Thickness (in feet) of 25-Gallon-per-Ton Oil Shale, Piceance Basin, Colorado
NATURAL GAS CONSUMPTION - China

6% Imported!
NATURAL GAS CONSUMPTION - India

26% Imported!

TMS 2010
NATURAL GAS CONSUMPTION - U.S.

11% Imported!
Natural Gas – America’s Silver Bullet?
Natural Gas

Clean Burning!

Unlimited Supply!

Cheap!

Low Carbon Footprint!

America’s Silver Bullet?

TMS 2010
Monthly U.S. Natural Gas Marked Production

Source: U.S. Energy Information Administration

TMS 2010
Canada

United States

Exports

Imports

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Natural Gas Electrical Generation vs Natural Gas Imports

Electricity from Natural Gas

Natural Gas Imports

TMS 2010
U.S. Monthly Natural Gas Production

Well Completions

Rockies Trends

Average Reserves per Well

Average Initial Production

TMS 2010
Natural Gas Prices

$2.00 +/- $0.50

$6.50
Natural Gas – America’s Silver Bullet?
From Most Recent FOUR YEARS

60% From Most Recent FOUR YEARS

Supply Impact of 32% vs. 19-23% is Under Estimated

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Natural Gas – America’s Silver Bullet?
Hydro Generation – U.S.
Geothermal Energy

Direct Use

Geoexchange Heat Pumps
Below the 690 apartments—not to mention the gyms, bars, dry cleaners and movie theater—that make up the 15-acre Linked Hybrid residential complex in Beijing, China, are 660 geothermal wells that eliminate the need for air conditioners and boilers. Each well funnels water 325 feet beneath the ground into bedrock, where the constant 55°F temperature either heats or cools it before it’s pumped back to the surface and piped through the building’s concrete floors. The system will reduce energy costs by up to 30 percent in the summer and up to 40 percent in the winter.
The Escalator Dilemma
Natural Forces are Working Against Our Goals

Depletion of Natural Resources
Demand for Energy

Demand
Greenhouse Gas Reduction
The future is here!

Are we ready?
“The world is a football field now and you’ve got to be sharp to be on the team which plays on that field. If you’re not good enough, you’re going to be sitting and watching the game. That’s all.”

--Rajesh Rao, founder and CEO of Dhurva Interactive
The End!

Of the talk, that is.