



2011

CONSULTING LTD

The Old Bishop's Almanac

**Prognostications for the future
of Vacuum Coating**

The 'Good News' Edition

This is my view of the industry

**These may NOT represent the views of
AIMCAL**

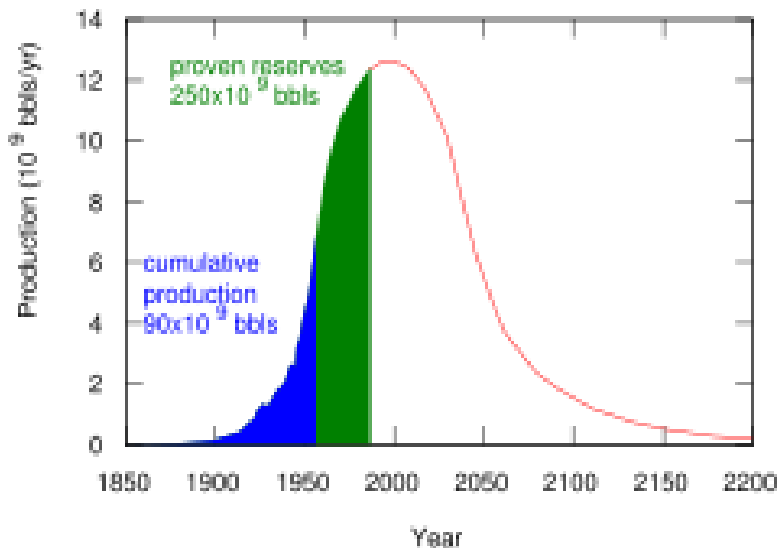
If

**you disagree & think I am wrong
shout out & let us know why**

Scarcity of materials

Hubbert peak production

Oil production



As originally suggested by
[M. King Hubbert](#) in [1956](#)

$$Q(t) = \frac{Q_{\max}}{1 + ae^{bt}}$$

Where Hubbert curve is derivative of logistic curve

Q_{\max} = Total resource available

$Q(t)$ = Total cumulative production

a & b = constants

T_{\max} = Time to peak

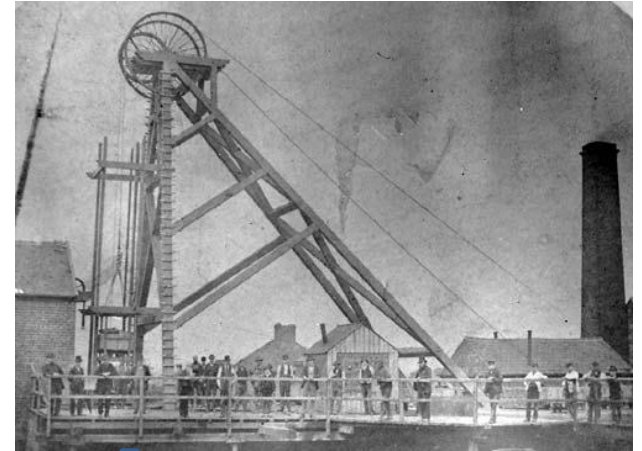
$$t_{\max} = \frac{1}{b} \ln \left(\frac{1}{a} \right)$$

Apply Hubbert process to mining

Mines.

Seam size & extent is measured and so volume calculated. This may be revised as new mining and refining processes allow for mining thinner less productive seams to be exploited.

Total - worldwide volume & extraction rates to predict material lifetime.



Materials - Possible years left

Material	Years left @ current global consumption rate	Years left – whole world consumes @ 50% US rate	Proportion of consumption met by recycling
Aluminium	1027	510	49%
Zinc	46	34	26%
Tin	40	17	26%
Tantalum	116	20	20%
Silver	29	9	16%
Lead	42	8	72%
Indium	13	4	0%
Copper	61	38	31%
Antimony	30	13	?
Gallium	?	?	?

Recycling

- **1 T electronic scrap from PC's contains more Gold than from 17 T of gold ore**



- **Add in the other materials that typically appear on PC circuit boards such as Al, Sb, As, Ba, Be, Cd, Cr, Co, Cu, Ga, Fe, Pb, Mn, Hg, Pd, Pt, Se, Ag, Zn & it becomes a rich source of materials (if a little hazardous)**

Materials are strategic

- **Governments are sensitive to key resources**
 - Hence they conceal stockpile levels & reserves
- **Wars have been fought because of materials**
 - Democratic Republic of the Congo 1998/2002 Civil War - Ta revenues
 - War does not necessarily release material into market
- **Speculation**
 - Speculators push up the price & skew the demand figures
- **Reserves**
 - Estimates of reserves appears to vary with market conditions –
cf. north sea oil reserves

Errors in information

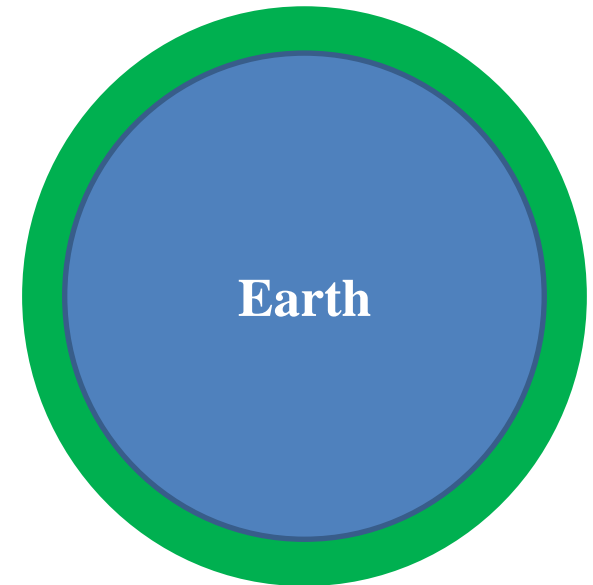
- **Reserves**
 - reserves are known deposits
- **Tends not to include**
 - **Known deposits - too expensive to mine**
 - **Deposits not known about**

Composition of the Earth

Element	Approximate % by weight
Oxygen	46.6
Silicon	27.7
Aluminium	8.1
Iron	5.0
Calcium	3.6
Sodium	2.8
Potassium	2.6
Magnesium	2.1
All others	1.5

Good News

- Volume of Earth 108.321×10^{10} cu Km
- 71% water 29% land
 - So mining may not always be easy
- Crust $<1\%$ **$\sim 1 \times 10^{10}$ cu km**
 - Mantle 84% Core 15%
- **0.1% of crust $\sim 10 \times 10^6$ cu km**



Rare-Earths

- **97% of rare earths currently supplied by China**
- **Recently China cut back supplies by 70%**
 - Lanthanum price \$10/kg 2009 – to \$160/kg 2011
 - Neodymium price \$19/kg 2009 – to \$455/kg 2011
- **Stopped all exports to Japan**
 - re. After arrest of Chinese boat Captain
- **It is expected China will need entire output for home consumption in next few years.**

Rare Earths

- **Neodymium - strong magnets**
- **Erbium - optical fibres**
- **Tellurium - solar cells**
- **Hafnium - oxide outperforms silica**
- **Tantalum – storage capacitors**
- **Dysprosium – magnetostriction**
- **Technetium – medical imaging**
- **Lanthanum & Cerium – mischmetal – batteries**
- **Europium & terbium – phosphorescent properties**
- **Rhenium - superalloys in jet engines**

Good News

- **Re-opening mines**
 - **Mountain Pass mine CA. USA Molycorp Minerals**
 - **Nolans & Mount Weld Projects, Australia**
 - **Hoidas Lake, Canada**
- **Elk Creek, Quantum Rare Earth Development, Nebraska, USA**
- **University Tokyo, Pacific Ocean high density deposits - 1 sq km ~20% current annual prodn.**
- **Hawaii & Tahiti – 2 regions estimated 100 bn T**

Good News

- **Metals such as Al, Cu, Pb & Sn**
 - **Recycling rates between 25% - 75%**
- **Rare Earths recycling rate < 1%**

An opportunity

- **Materials use reduction**
 - **GE material efficiency in manufacture & use**
 - **Industry initiatives in recycling**

Indium

Good News - Indium

- **~ 50% - 50% split Western world vs China/CIS**
 - **China reduced Indium exports by 30% - 2nd 1/2 2010**
- **Estimated only 30% of ore mined each year is processed into Indium metal**
 - **30% does not reach indium smelters**
 - **Of the 70% only about 50% is converted**
- **Almost 1000mT p.a**
 - (~70%) Sputtering targets/shields recovered primarily in China, Japan & Korea**

Good News - Indium

Alternatives to Indium Tin Oxide

- **AZO etc**
- **ITO – wire mesh – ITO**
- **PEDOT-PSS**
- **PEDOT-PSS - wire mesh - PEDOT-PSS**
- **Conducting Inkjet deposition of Copper**
- **Carbon nanotubes**
- **Carbon nanotubes in conducting polymer matrix**
- **Graphene / metal grid**

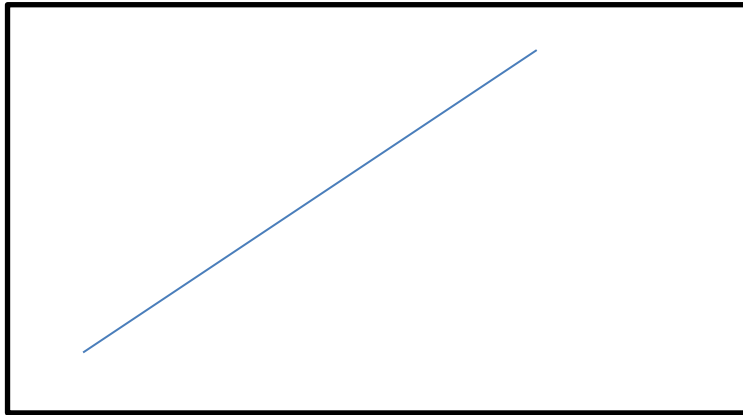
Photovoltaics

Good news - Photovoltaics

- **There is nothing wrong with the PV market**
- **PV is on track for double digit growth p.a. for many years to come**

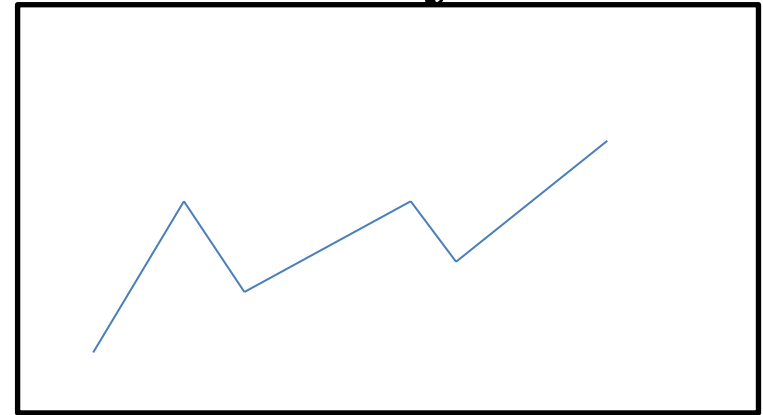
Photovoltaics

Predicted



Time

Reality



Time

Sales

Feed in tariffs - governments turn on/off

Investment problems – cannot turn investment on/off fast enough to match sales growth/shrinkage



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Thank you for listening

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