

DÉRIVES ÉNERGÉTIQUES ET MÉTALLIQUES: PISTES POUR UNE NOUVELLE SOCIÈTÉ

PRÉSENTATION AU COMITÉ RIVIÈRES DU GRIP-UQAM MONTRÉAL LE 4 MAI 2013

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DES INDICATEURS ET UN CONTEXTE

EMPREINTE ET IDH 2010

Ecological Footprint and Human Development

A low average Ecological Footprint and high score on the UN Human Development Index are the minimum conditions for sustainable human development. By learning to "think inside the (blue) box," we can strive toward a world where everyone lives well, within the means of one planet. At Global Footprint Network, we believe this is the ultimate goal.





EMPREINTES NATIONALES ET BIOCAPACITÉ: CHINE ET ÉTATS-UNIS



China

BAISSE INÉLUCTABLE DE L'ACTIVITÉ ÉCONOMIQUE



LE PIB « CORRIGÉ » PAR L'IPV (M\$ 2002)



ÉNERGIE: RETOUR SUR INVESTISSEMENT - ÉROI



ÉROI ET PROJECTIONS EN SENS INVERS



Figure 38. Energy available to do useful work as a proportion of total energy expended.

CONTEXTE POLITIQUE

- NOUVELLES DANS LES MEDIA, PRESQUE SANS RELÂCHE
 - UNE RÉVOLUTION EN ÉNERGIE AUX ÉTATS-UNIS
 - LES SABLES BITUMINEUX LE MOTEUR DE LA CROISSANCE AU CANADA
 - INDÉPENDANCE ÉNERGÉTIQUE PARTOUT
- NOTRE GOUVERNEMENT SOCIAL-DÉMOCRATE COMPLÈTEMENT PRIS PAR LE DISCOURS
 - COMMENT REFUSER ANTICOSTI?
 - POURQUOI NE PAS EXPLOITER LE GOLFE?
 - ADAPTER LES REDEVANCES MINIÈRES AU MARCHÉ

CONTEXTE SCIENTIFIQUE

- DES ANALYSES SCIENTIFIQUES ET DES PRACTICIENS
 - NOUS SOMMES DANS LA DEUXIÈME MOITIÉ DE L'ÈRE DU PÉTROLE: L'ÉROI EST BAS
 - NOUS SOMMES PROBABLEMENT DANS LA DEUXIÈME MOITIÉ DE L'ÈRE DES MÉTAUX
 - NOUS DEVONS RESTREINDRE NOTRE CONSOMMATION DES RESSOURCES NON RENOUVELABLES

 SANS MÊME CONSIDÉRER LES CHANGEMENTS CLIMATIQUES ET LA CATASTROPHE QU'ILS REPRÉSENTENT

EXPLICATIONS PROVISOIRES

- LES GENS D'AFFAIRES PRÉSUMENT D'UNE HAUSSE DE PRIX DEVANT LES RARETÉS
 - UNE HAUSSE DE PRIX INCITE AU DÉVELOPPEMENT DE NOUVELLES RESSOURCES
 - LES LIMITES SONT TECHNOLOGIQUES...
- LES GENS D'AFFAIRES N'ONT AUCUNE CONNAISSANCE DES ENJEUX GLOBAUX
- LES MEDIA N'ONT AUCUNE IDÉE DE CE QUI EST EN CAUSE
- LES DÉCIDEURS POLITIQUES NE PENSENT QU'À UNE CROISSANCE DE L'ACTIVITÉ ÉCONOMIQUE, PEU IMPORTE... C'EST ESSENTIEL.
- BREF: LES DÉCISIONS SONT PRISES DE FAÇON ISOLÉE, ÉCLATÉE, MYOPE

HOMER-DIXON, 2006: CING STRESS TECTONIQUES

- STRESS DÉMOGRAPHIQUES. ASSOCIÉS AUX ECARTS ENTRE LES TAUX DE CROISSANCE DES POPULATIONS DES PAYS RICHES ET PAUVRES ET À L'URBANISATION MASSIVE DANS LES PAYS PAUVRES
- STRESS ÉNERGÉTIQUES, SURTOUT DEVANT L'ARRIVÉE DU PIC DE PÉTROLE
- STRESS ENVIRONNEMENTAUX, ASSOCIÉS À LA DÉGRADATION DES ÉCOSYSTÈMES TERRESTRES, MARINS ET D'EAU DOUCE
- STRESS CLIMATIQUES, ASSOCIÉS AUX CHANGEMENTS DE LA COMPOSITION DE L'ATMOSPHÈRE
- STRESS ÉCONOMIQUES, ASSOCIÉS À LA VOLATILITÉ/INSTABILITÉ DU SYSTÈME ÉCONOMIQUE GLOBAL ET AUX ÉCARTS ENTRE RICHES ET PAUVRES

Thomas Homer-Dixon: The Upside of Down: Catastrophe, Creativity and the Renewal of Civilisation

HOMER-DIXON, 2006 : MULTIPLICATEURS DES STRESS

 LA VITESSE CROISSANTE ET L'INTERCONNECTIVITÉ DE NOS ACTIVITÉS, DE NOS TECHNOLOGIES ET DE NOS SOCIÉTÉS

 LE POUVOIR CROISSANT DE PETITS GROUPES, DANS LEUR CAPACITÉ DE DÉTRUIRE ET LES CHOSES ET LES GENS

Thomas Homer-Dixon: The Upside of Down: Catastrophe, Creativity and the Renewal of Civilisation

HUGHES SUR LES RESSOURCES ÉNERGÉTIQUES NON RENOUVELABLES NON CONVENTIONNELLES

HUGHES – PERSPECTIVES GLOBALES

KEY TAKEAWAYS – PRODUCTION ET CONSOMMATION – P.3

- World energy consumption has tripled in the past 45 years, and has grown 50-fold since the advent of fossil oil a century and a half ago. More than 80 percent of current energy consumption is obtained from fossil fuels.
- Per capita energy consumption is highly inequitably distributed. Developed nations like the United States consume four times the world average. Aspirations of growth in consumption by the nearly 80 percent of the world's population that lives with less than the current per capita world average will cause unprecedented strains on the world's future energy system.
- Oil is of particular concern given the geopolitical implications of the concentration of exporters in the Middle East, Russia and West Africa and the dependency of most of the developed world on imports.
- In the next 24 years world consumption is forecast to grow by a further 44 percent —and U.S. consumption a further 7 percent —with fossil fuels continuing to provide around 80 percent of total demand. Fuelling this growth will require the equivalent of 71 percent of all fossil fuels consumed since 1850 in just 24 years.
- Recent growth notwithstanding, overall U.S. oil and gas production has long been subject to the law of diminishing returns. Since peak oil production in 1970, the number of operating oil wells in the U.S. has stayed roughly the same while the average productivity per well has declined by 42 percent. Since 1990, the number of operating gas wells in the U.S. has increased by 90 percent while the average productivity per well has declined by 38 percent.

HUGHES – PERSPECTIVES GLOBALES

- The U.S. is highly unlikely to achieve "energy independence" unless energy consumption declines very substantially. The latest U.S. government forecasts project that the U.S. will still require 36 percent of its petroleum liquid requirements to be met with imports by 2040, even with very aggressive forecasts of growth in the production of shale gas and tight oil with hydraulic-fracturing technology.
- An examination of previous government forecasts reveals that they invariably overestimate production, as do the even more optimistic projections of many pundits. Such unwarranted optimism is not helpful in designing a sustainable energy strategy for the future.
- Given the realities of geology, the mature nature of the exploration and development of U.S. oil and gas resources and projected prices, it is unlikely that government projections of production can be met. Nonetheless these forecasts are widely used as a credible assessment of future U.S. energy prospects.
- Future unconventional resources, some of which are inherently very large, must be evaluated not just in terms of their potential in situ size, but also in terms of the rate and full-cycle costs (both environmental and financial) at which they can contribute to supply, as well as their net energy yield.

J. DAVID HUGHES: DRILL, BABY, DRILL: CAN UNCONVENTIONAL FUELS USHER IN A NEW ERA OF ENERGY ABUNDANCE?, POST-CARBON INSTITUTE, FÉVRIER 2013 - <u>http://shalebubble.org/drill-baby-drill/</u>

ÉNERGIE FOSSILE 87% DE CONSOMMATION EN 2011



Figure 1. World population, per capita-, and total-energy consumption by fuel as a percentage of 2011 consumption, 1850-2011.²

DEMANDE DE LA CHINE





HUGHES – PERSPECTIVES GAZ DE SCHISTE - 1

- KEY TAKEAWAYS GAZ DE SCHISTE P.50
- Shale gas has grown very rapidly to account for nearly 40 percent of U.S. natural gas production, although production has plateaued since early 2012. This has more than made up for declines in conventional gas production and has allowed an increase in overall gas production to record levels.
- The drilling boom which resulted in this glut of shale gas was in part motivated by "held-byproduction " arrangements in three to five year lease agreements, by requirements of joint venture arrangements and by the need to book reserves to support share valuation on the stock market.
- High productivity shale plays are not ubiquitous, and relatively small sweet spots within plays offer the most potential. Six of thirty shale plays provide 88 percent of production.
- Individual well decline rates are high, ranging from 79 to 95 percent after 36 months. Although some wells can be extremely productive, they are typically a small percentage of the total and are concentrated in sweet spots.
- Overall field declines require from 30 to 50 percent of production to be replaced annually with more drilling. This translates to \$42 billion of annual capital investment to maintain current production. By comparison, shale gas produced in 2012 was worth about \$32.5 billion at a gas price of \$3.40/mcf (which is higher than actual well head prices for most of 2012).

HUGHES – PERSPECTIVES GAZ DE SCHISTE - 2

- Capital inputs to offset field decline will increase going forward as the sweet spots within plays are drilled off and drilling moves to lower quality areas. Average well quality (as measured by initial productivity) has fallen nearly 20 percent in the Haynesville, which is the most productive shale gas play in the U.S., and is falling or flat in eight of the top ten plays. Overall well quality is declining for 36 percent of U.S. shale gas production and is flat for 34 percent.
- Dry shale gas plays are not economic at current gas prices, hence drilling has shifted to tight oil and wet gas plays which have better economics. Once the inventory of drilled-but-not-yet-on-production wells is worked off, shale gas production will decline. This will facilitate considerably higher gas prices going forward. The idea that gas prices will remain below \$5/mcf until 2026, as projected by the EIA (Figure 34), is wishful thinking.
- The EIA recently revised its estimate of unproved technically recoverable shale gas resources downward by 42 percent to 482 trillion cubic feet (tcf). Coupled with shale gas reserves this yields a total of 579 tcf, or 24 years of supply at current production rates. The EIA projects that 382 tcf, or 66 percent of this will be consumed by 2040 (Figure 32). This is an extremely aggressive forecast, considering that most of this production is from unproved resources, and would entail a drilling boom that would make the environmental concerns with hydraulic-fracturing experienced to date pale by comparison.

RÉCAPITULATION

- 410 000 PUITS SERONT FORÉS AUX ÉTATS-UNIS EN 24 ANS POUR LE GAZ DE SCHISTE
- ALLER-RETOURS PAR PUIT: 2000 CAMIONS LOURDS ET 1420 CAMIONS LÉGERS
- ÉNORMES EXIGENCES EN CAPITAUX
- ACTUELLEMENT VENDU SOUS LE COÛT
- ÉROI DU GAZ, 7.6, DU GAZ DE SCHISTE = 5
 - ÉMISSIONS PEUT-ÊTRE PIRE QUE LE CHARBON

HUGHES – PERSPECTIVES PÉTROLE DE SCHISTE - 1

- KEY TAKEAWAYS PÉTROLE DE SCHISTE P.78
- Tight oil (shale oil) has grown impressively and now makes up about 20 percent of U.S. oil production. This has allowed U.S. crude oil production to reverse years of decline and grow 24 percent above its all-time post-1970 low in 2008.
- As with shale gas, tight oil plays are not ubiquitous. More than 80 percent of tight oil production is from two unique plays: the Bakken and the Eagle Ford. The remaining nineteen plays produced just 19 percent of current tight oil production. There is also considerable variability within these plays, and the highest productivity wells tend to be concentrated within relatively small sweet spots.
- Well decline rates are steep between 81 and 90 percent in the first 24 months. The plays are too young to assess overall well lifetimes but production rates in the Bakken after five years are 33 bbls/d on average and after seven years will likely approach stripper well status (10 bbls/d). Eagle Ford wells could reach stripper well status within four years.
- Overall field decline rates are such that 40 percent of production must be replaced annually to maintain production. Current drilling rates are far higher than this level hence production is expected to continue to grow rapidly.

HUGHES – PERSPECTIVES PÉTROLE DE SCHISTE - 2

- Ultimate recovery of tight oil plays is governed by the number of available drilling locations. The EIA estimates a total of 11,725 locations in the Bakken (including the Three Forks Formation). This is about three times the current number of operating wells. A similar estimate by the EIA puts available locations in the Eagle Ford at more than three times the current number of operating wells.
- Given the EIA estimate of available well locations, the Bakken, which has produced about half a billion barrels to date, will ultimately produce about 2.8 billion barrels by 2025 (close to the low end of the USGS estimate of 3 billion barrels). Similarly, the Eagle Ford will ultimately produce about 2.23 billion barrels, which is close to the EIA estimate of 2.46 billion barrels. Together these plays may yield a little over 5 billion barrels, which is less than 10 months of U.S. consumption.
- The production trajectory of tight oil plays depends on the rate of drilling. If current drilling rates are maintained, tight oil production will grow to a peak in 2016 at about 2.3 mbd assuming the EIA estimates of available locations in the Bakken and Eagle Ford are correct. Production in the Bakken and Eagle Ford will then collapse at overall field decline rates. Assuming production in the other tight oil plays continues to grow at linear rates, tight oil production will be at 0.7 mbd in 2025. This represents a U.S. tight oil production bubble of a little over ten years duration.
- The EIA projections of U.S. tight oil production are very aggressive. They assume that 26 billion barrels, or 78 percent of its estimate of unproved technically recoverable tight oil resources, will be consumed by 2040.

PÉTROLE DE SCHISTE 2010-2025



Figure 80. Projection of tight oil production by play in the U.S. through 2025.

Based on vintaged type curve production, the number of drilling locations projected by the EIA for the Bakken and Eagle Ford plays, and the assumption of continued recent growth rates in the other plays.

RÉCAPITULATION



Figure 69. Distribution of wells in the Bakken play's area of highest concentration.¹⁴⁶

Wells in black are the top 20 percent in terms of initial productivity. Many of these sites are multi-well pads with two or more wells.

HUGHES – PERSPECTIVES AUTRE NON CONVENTIONNEL

- KEY TAKEAWAYS OTHER UNCONVENTIONAL OIL P.108
- Oil Shale: The IEA in its latest World Energy Outlook has listed a trillion barrels of oil shale as ""technically recoverable"" in the Americas. Despite many years and large expenditures, oil shale has not been produced in commercial quantities in the U.S., and has only been utilized in minor quantities elsewhere in the world. Oil shale production remains an extreme example of a rate- and net-energy-constrained resource. There is no significant production now nor is there likely to be in the foreseeable future.
- Deepwater oil is a stable part of U.S. oil supply and is projected to make up about ten percent of overall U.S. consumption for the next two decades and longer. Opening up coastal areas currently under moratoriums would expand access to relatively minor additional resources, and Arctic offshore oil production is unlikely to be more than a niche supply for the foreseeable future.
- Extra-heavy oil (Venezuela) is rate-constrained, due to above-ground geopolitical issues, as well as the capital input and infrastructure required to meet the challenges in its production. It is also a low net-energy oil somewhat similar to tar sands. Notwithstanding that Venezuela has recently claimed first place in world oil ""reserves", its extra heavy oil is unlikely to provide significant new production to offset declines in world conventional crude oil production in the short-and medium-term.
- Biofuels, which contribute about five percent of U.S. consumption, are projected by the EIA to have little growth over the
 next two decades or more. Agricultural subsidies for corn ethanol production ended in the U.S. in 2011 although State
 and Federal renewable fuel standards will ensure ample demand for corn ethanol going forward. The net energy of
 biofuels is generally very low and there is considerable controversy in utilizing food crops for their production. Production
 from non-food cellulosic- and algae-feedstocks will play a niche role going forward but is not expected to have a
 significant impact for at least the next two decades.
- Coal- and Gas-to-liquids are expected to grow to perhaps two percent of world liquids supply by 2035. The infrastructure required is high cost and the case of coal comes with heavy GHG emissions and energy conversion losses.
 - **Enhanced Oil Recovery CO2** injection to recover residual oil in depleted reservoirs has been utilized for decades, although rarely with antrhopogenic CO2 emissions. Even with a projected doubling in production by 2040, il will still meet less than 4 percent of U.S. demand.

HUGHES – PERSPECTIVES SABLES BITUMINEUX

- KEY TAKEAWAYS TAR SANDS P.109
- Canada is the United States' largest source for oil imports, accounting for 24 percent of gross U.S.
- oil imports in 2011. More than half of Canadian production comes from the tar sands.
- Tar sands provide high-cost, low-net-energy oil. Surface mineable resources have the highest net energy, at about 5:1 with upgrading. New surface mineable projects require over \$100/bbl to justify development. Eighty percent of recoverable resources are too deep for surface mining, and require very large inputs of energy to recover, which results in a net energy return of less than 3:1 with upgrading.
- The tar sands are being high-graded. Nearly 90 percent of the 25.6 billion barrels "under active development" are shallow surface mineable resources. More than 90 percent of the 143 billion barrels of resources "not under active development" are too deep for surface mining and are extractable only using in situ methods.
- The 1.84 trillion barrel in situ estimate for the tar sands is irrelevant in considering future supply. Even the purported 143 billion barrels "not under active development" estimated by the Alberta Government to be "recoverable" has no detailed engineering studies validating it.
- Growth forecasts for the tar sands tend to be very aggressive, and have historically always overestimated actual production. It has taken 40 years to grow tar sands production to 1.6 mbd, yet forecasts call for nearly tripling current production over the next 18 years. This will be very difficult and likely impossible to achieve given the logistical bottlenecks and cost inflation experienced even expanding production to current levels (projections assume nearly double the expansion rate that caused earlier problems).

Tar sands oil comes with higher environmental impacts than conventional oil through air emissions on site, full-cycle well-to-wheels CO2 emissions, and groundwater and other contaminants.

ÉROI SABLES BITUMINEUX

	Cost per Barrel of Production Capacity (\$Can/barrel)			Estimated Supply Cost (\$US WTI per barrel)			Purchased Natural Gas (mcf/barrel)			Energy Returned on Energy Invested (EROEI) Including Purchased Gas Only		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Max	Min	Mean
Stand-alone mine	55,000	75,000	65,000	70	91	80.5	0.4	0.6	0.5	15.5:1	10.3:1	12.4:1
Mine with Upgrading	85,000	105,000	95,000	96.5	110.5	103.5	0.9	1.1	1	5.6:1	4.6:1	5.0:1
In Situ (SAGD)	25,000	50,000	37,500	50	78	64	1	1.5	1.25	6.2:1	4.1:1	5.0:1
In Situ (SAGD) with Upgrading	-	-	•	-	-	-	1.5	2	1.75	3.3:1	2.5:1	2.9:1

Table 10. Capital costs of infrastructure for bitumen and synthetic crude oil production, supply costs, purchased natural gas required, and energy returned on energy invested (EROEI).¹⁸²

Steam-Assisted Gravity Drainage (SAGD) is the predominant method of in situ extraction.

Bear in mind that these estimates of EROEI are the best case. They do not include the embodied energy costs of infrastructure such as upgraders, pipelines, trucks and shovels, as well as diesel fuel and other energy inputs into the recovery process. They also do not include the energy cost of importing diluents to move bitumen through pipelines, or the energy cost of moving dilbit to markets. Although difficult to calculate precisely, these additional inputs would likely reduce the EROEI of upgraded in situ bitumen to around 2.4:1 and mined bitumen to 4.5:1 or less. Furthermore, considering that the highest quality

ÉROI DES SABLES BITUMINEUX



HUGHES – PERSPECTIVES AUTRES GAZ

- KEY TAKEAWAYS OTHER UNCONVENTIONAL GAS P.142
- Coalbed methane is and will continue to be a small player in total U.S. gas supply. Production has plateaued and reserves have fallen over the past five years. Given this the EIA's projection of flat to rising production and the consumption of nearly three times current proved reserves by 2040 seems unlikely.
- Offshore gas is projected to make up less than 10 percent of U.S. gas supply through 2040. Notwithstanding the significant undiscovered potential, it is difficult gas that will remain constrained by the "tap" more than the "tank."
- Gas hydrates have extremely large in situ resources which have resisted any significant production. They will likely remain "the fuel of the future that always will be." They are an extreme example of a rate-constrained resource with a very large "tank" and a "tap" that remains completely shut, despite decades of research at the expenditure of hundreds of millions of dollars.
- In situ coal gasification is a much hyped resource in some circles but so far has been relegated to a niche source at best, with no commercial production outside of Uzbekistan, where it has purportedly fueled an onsite power plant for decades.
- Biogas from municipal landfills is capturing and utilizing methane, which is a potent greenhouse gas, that would otherwise be vented into the atmosphere. Although it is a small niche player in terms of total supply, it provides important environmental benefits. Household-scale biogas production is also utilized in developing nations. Large-scale centralized biogas production from food crops as currently conducted in Germany is more controversial.

PROJECTIONS INSENSÉES 2010-2035 (EIA/USA)



Figure 113. World population, per capita-, and total-energy consumption by fuel as a percentage of 2011 consumption, 1850-2035,.290

This is what the world's energy consumption profile would look like in 2035 assuming the EIA reference case projection for growth in global energy consumption and forecasts of growth in world population come to fruition.

DES INCIDENCES POLITIQUES ET ÉCONOMIQUES DE TOUT CECI

PÉTROLE – IMPORTS / EXPORTS





The Middle East and West Africa, both regions prone to political instability, are responsible for 62 percent of global net exports.

PÉTROLE: PAYS RICHES, PAYS ÉMERGENTS



STEVEN KOPITS, OIL AND GAS : MACRO CONSIDERATIONS, DOUGLAS-WESTWOOD LLC. OCTOBER 2012

PERSPECTIVES DU PRIX D'ICI 2017



Brent Crude Oil Prices, Oil Company Approval Thresholds, US and China Max Carrying Capacity Source: EIA

LA CHINE ET LE PÉTROLE: LES CONTRAINTES



KOPITS

CROISSANCE PIB ET PRODUCTION DU PÉTROLE



HAUSSE DU PRIX PÉTROLE ET RÉCENTES RÉCESSIONS



MÉTAUX ET AUTRES COMMODITÉS NON ÉNERGÉTIQUES

HAUSSE DES PRIX DES COMMODITÉS



Figure 110. Price indices for energy, metals, food and non-food commodities, 1993-2012.

Prices of commodities have become increasingly correlated with the price of energy which forms a fundamental input into their supply.²⁷⁴

HUGHES

MÉTAUX ET MINÉRAUX: DURÉE DE VIE



Source: *New Scientist*, http://www.newscientist.com/search?doSearch=true&query=«+Earth%27s+natural+wealth%3A+an+audit+»%2C+David+Cohen%2C+23+May+2007

LES RESSOURCES: CHANGEMENT DE PARADIGME



Note: The GMO commodity index is an index comprised of the following 33 commodities, equally weighted at initiation: aluminum, coal, coconut oil, coffee, copper, corn, cotton, diammonium phosphate, flaxseed, gold, iron ore, jute, lard, lead, natural gas, nickel, oil, palladium, palm oil, pepper, platinum, plywood, rubber, silver, sorghum, soybeans, sugar, tin, tobacco, uranium, wheat, wool, zinc.

Source: GMO As of 2/28/11

GRANTHAM GMO http://www.resilience.org/stories/2011-04-29/time-wake-days-abundant-resources-and-fallingprices-are-over-forever

Exhibit 4 The Mother of All Paradigm Shifts

	z-score*	Probability**
Iron Ore	4.9	1 in 2,200,000
Coal	4.1	1 in 48,000
Copper	3.9	1 in 17,000
Corn	3.8	1 in 14,000
Silver	3.7	1 in 9,300
Sorghum	3.5	1 in 4,300
Palladium	3.4	1 in 3,000
Rubber	3.3	1 in 2,100
Flaxseed	3.3	1 in 2,100
Palm Oil	3.2	1 in 1,500
Soybeans	3.1	1 in 1,000
Coconut Oil	3.0	1 in 740
Nickel	2.7	1 in 290
Gold	2.6	1 in 210
Oil	2.5	1 in 160
Sugar	2.5	1 in 160
Platinum	2.4	1 in 120
Lead	2.4	1 in 120
Wheat	2.4	1 in 120
Coffee	2.3	1 in 85
Diammonium Phosphate	2.1	1 in 56
Jute	2.1	1 in 56
Cotton	2.0	1 in 44
Uranium	1.9	1 in 35
Tin	1.9	1 in 35
Zinc	1.9	1 in 35
Potash	1.9	1 in 35
Wool	1.7	1 in 22
Aluminum	1.4	1 in 12
Lard	0.9	1 in 5
Pepper	0.5	1 in 3
Natural Gas	0.2	1 in 2
Plywood	-0.1	1 in 2
Beef	-0.1	1 in 2
Cocoa	-0.1	1 in 2
Tobacco	-3.3	1 in 2000

* z-score: difference between current price and long-term trend, expressed in standard deviations

** Probability: implied probability under assumption of normal distribution of valuations

Source: GMO As of 2/28/11

Source Grantham 2011, p.9

LA CHINE COMME MARCHÉ

Exhibit 3

China's Share of World Commodity Consumption

Commodity	China % of World
Cement	53.2%
Iron Ore	47.7%
Coal	46.9%
Pigs	46.4%
Steel	45.4%
Lead	44.6%
Zinc	41.3%
Aluminum	40.6%
Copper	38.9%
Eggs	37.2%
Nickel	36.3%
Rice	28.1%
Soybeans	24.6%
Wheat	16.6%
Chickens	15.6%
PPP GDP	13.6%
Oil	10.3%
Cattle	9.5%
GDP	9.4%

Source: Barclays Capital (2010), Credit Susse (2010), Goldman Sachs, United States Geological Survey (2009), BP Statistical Review of World Energy (2009), Food and Agriculture Organization of the United Nations (2008), International Monetary Fund (2010)

Source Grantham 2011, p.8

DÉVELOPPEMENT TRADITIONNEL



Source: Mousseau, Le défi des ressources minières, MultiMondes, 2012, tiré de Ellis Connolly and David Orsmond, The Mining Industry, From Bust to Boom, Reserve Bank of Australia, 2011

PIB PER CAPITA DE LA CHINE: 1,500,000 PERSONNES

 PIB - per capita (PPP): \$8,500 (2011 est.) \$7,800 (2010 est.) \$7,100 (2009 est.) 2011 dollars US

 POUR SUIVRE LA COURBE DU PASSÉ, IL FAUT DOUBLER L'ACTIVITÉ ÉCONOMIQUE POUR UN MILLIARD ET DEMI DE PERSONNES

CUIVRE :MARCHÉ DE LA CHINE

Exhibit 8

Recoverable Copper Ore Yield Grade



Source Grantham 2011 p.16

FER: MARCHÉ DE LA CHINE

Exhibit 9

Iron Ore Prices (2011 \$/dry metric ton)



Source Grantham 2011 p.17

LA CHINE EN DÉPASSEMENT

- RESSOURCES EN EAU PAR HABITANT = LE QUART DE LA MOYENNE MONDIALE
- SUPERFICIES EN FORÊT = LE SIXIÈME DE LA MOYENNE MONDIALE
- CONSOMMATION D'ÉNERGIE PAR HABITANT = LE TRIEZIÈME DES ÉTATS-UNIS, LE CINQUIÈME DU JAPON
- SE METTRE AU NIVEAU DU JAPON = LE TRIPLE DE LA CONSOMMATION ACTUELLE DES ÉTATS-UNIS

LA CHINE EN DÉPASSEMENT

- 1940, 450 MILLIONS 2010 1,400 MILLIONS
- 2010, 20 % DE LA POPULATION, 10 % DES TERRES ARABLES
- AUTOSUFFISANCE ALIMENTAIRE POUR 950
 MILLIONS
- TERRES CULTIVÉES PAR HABITANT = LE TIERS DE LA MOYENNE MONDIALE
- RESSOURCES MINÉRALES PAR HABITANT = LA MOITIÉ DE LA MOYENNE MONDIALE



perfect storm energy, finance and the end of growth

Dr Tim Morgan Global Head of Research



http://ftalphaville.ft.com/files/2013/01/Perfect-Storm-LR.pdf

ACTIONS DE STANDARD AND POOR'S SELON 3 INDICES



KOPITS

L'EXPLOITATION MINIÈRE

LA QUESTION DES RESSOURCES MINÉRALES

- ELLES FONT PARTIE DE NOTRE CAPITAL.
- ELLES NE PEUVENT PAS ÊTRE RENOUVELÉES ET FINISSENT PAR S'ÉPUISER SUITE À L'EXPLOITATION.
- LEUR EXPLOITATION CONSTITUE UNE PERTE SÈCHE.
- SOUSTRACTIONS:
 - VALEUR DES EXPÉDITIONS
 - PERTES DE VIE
 - IMPACTS ENVIRONNEMENTAUX

ACTIVITÉ ÉCONOMIQUE VS. DÉVELOPPEMENT



L'AVENIR MINIER - 1

- BAISSE DE RETOUR SUR L'INVESTISSEMENT EN ÉNERGIE
- COMBINÉE À UNE BAISSE DU RETOUR SUR l'INVESTISSEMENT EN RESSOURCES MINIÈRES
- FIN DES CYCLES, SELON GRANTHAM ET CLUB DE ROME
- RESSOURCES NON CONVENTIONNELLES POUR L'AVENIR, ET PICS POUR PLUSIEURS ENTRE ELLES
- BREF, DES CONTRAINTES ÉNORMES

L'AVENIR MINIER - 2

- IL IMPORTE DE RETENIR LES BÉNÉFICES, EN COMPENSATION DE LA PERTE DU CAPITAL
- L'ÉTAT PAIE DÉJÀ L'EXPLORATION ET PAYERA BEAUCOUP DE L'EXPLOITATION
- OUBLIONS DONC LES REDEVANCES
- ON NATIONALISE ET ON ÉTEND DANS LE TEMPS
- ON INVESTIT LES BÉNÉFICES POUR NE RETIRER QUE L'INTÉRÊT SUR UNE BASE ANNUELLE

L'AVENIR ÉCONOMIQUE: L'EFFONDREMENT SELON LE CLUB DE ROME

L'ÉCHÉANCIER N'EST PAS UNE DÉCOUVERTE - 2025



BOUCLES DE RÉTROACTION: CLUB DE ROME 1972



BOUCLES: POSITIVES (FINANCIÈRES) ET NÉGATIVES (ENVIRONNEMENTALES)



HALTE À LA CROISSANCE! MISE À JOUR 1970-2000



Chart Sources: Meadows, D.H., Meadows, D.L., Randers, J. and Behrens III, W.W. (1972)

http://www.smithsonianmag.com/science-nature/ls-it-Too-Late-for-Sustainable-Development.html?onsite_source=relatedarticles&onsite_medium=intremallink&onsite_campaign=SmithM ag&onsite_content=ls%20it%20Too%20Late%20for%20Sustainable%20Development?

L'EFFONDREMENT DES PÊCHES



(ANTI)MODÈLE DE DÉVELOPPEMENT



HALTE À LA CROISSANCE! MISE À JOUR 1970-2000



Chart Sources: Meadows, D.H., Meadows, D.L., Randers, J. and Behrens III, W.W. (1972)

http://www.smithsonianmag.com/science-nature/ls-it-Too-Late-for-Sustainable-Development.html?onsite_source=relatedarticles&onsite_medium=intremallink&onsite_campaign=SmithM ag&onsite_content=ls%20it%20Too%20Late%20for%20Sustainable%20Development?

UNE PLANÈTE ET DEMI

