Energy and Mineral Resources: Drivers, Uncertainties and Challenges

Dr. Michael Karmis,
Stonie Barker Professor, Mining and Minerals Engineering Department, &
Director, Virginia Center for Coal & Energy Research
Virginia Tech

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- 1. Major Drivers
- 2. Key Uncertainties
- 3. Critical Challenge
- Way Ahead

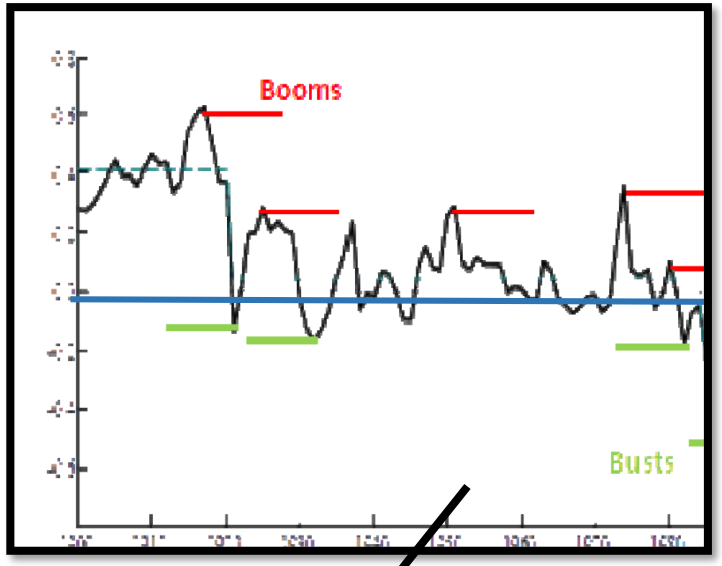
A number of references were used to develop this presentation. A reference list can be provided by the author on request.

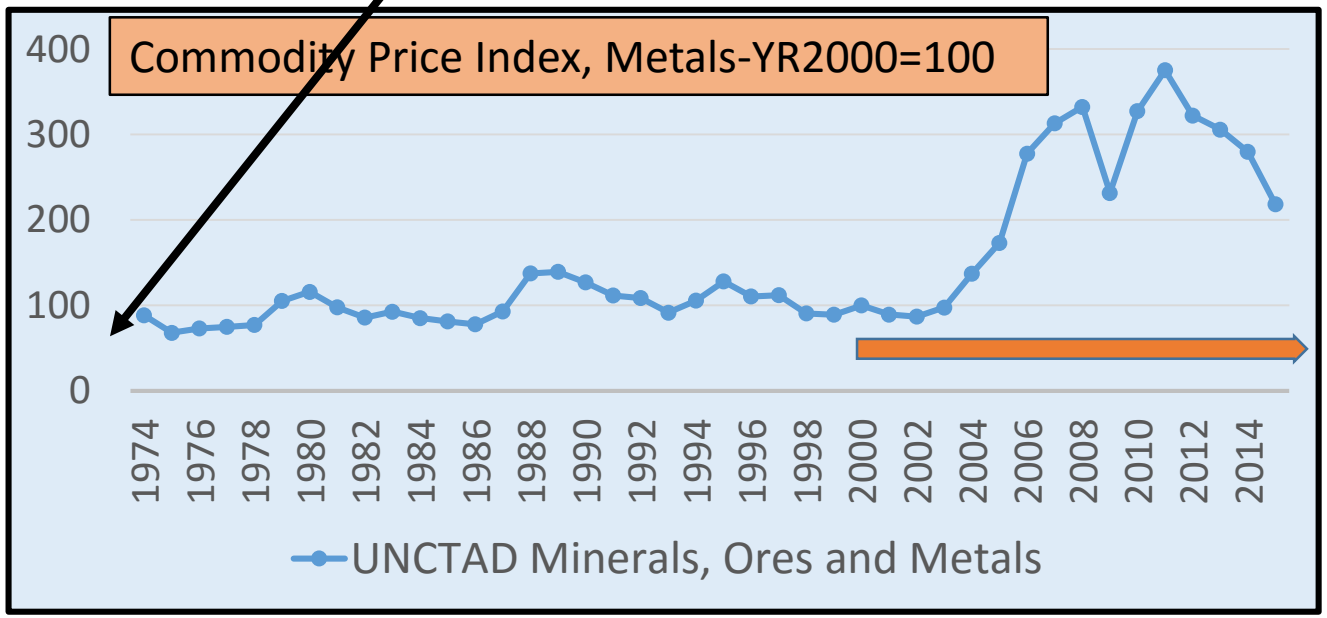
Introduction

- *“An economist is an expert who will know tomorrow why the things he predicted yesterday didn't happen today”*, Evan Esar

This presentation is from the perspective of an Engineer!!!

The Mining Roller-Coaster!





- The minerals sector fueled the post-2000 **supercycle** dominated by the expansion of the global economy
- The peak followed a decade of massive growth, 2001-11, when real price ($) rose by 140%
- Cycle shows impact of the 2008 downturn, the temporary recovery, followed by the fastest decline in real terms over a 4-year period (biggest fall since 1931!)

The Story of the Super Cycle, according to Price Waterhouse Cooper (PWC) Annual Series of "Top 40"

- *Market values down*
- *Net profits down*
- *New CEOs in 50% of the Top 40*
- *Continuous decline in productivity*
- *Major social license issues*
- *Billions $ in stranded assets*
- *Investors walk away!*

(from PWC)

- Historically, a boom is followed by a bust, and after a slump, a boom returns! But, experts agree, cycle times are lengthening and it could take years to the next boom!
- Some commodities recovered strongly at the end 2016, but is it a trend or a temporary market adjustment?

The global mineral sector is undergoing fundamental realignment and restructuring!!!

The Down Cycle and Exploration Budgets: Continuous Decline Impacting Major and Junior Prospectors

- *"Mining Exploration Plunges for Fourth Consecutive Year"* (Mining News, March 15, 2017)
  - ✓ "*The 2016 exploration budgets by 1,580 companies totaled only U.S. $6.89 billion, a year-on-year drop of 21% and barely one-third of the level budgeted in 2012*" (CES Report, Global Market Intelligence)
- Exploration budgets decreased in all regions of the world, with the largest regional budget reduction in Africa and Latin America, and the smallest decrease in the USA, the Pacific region and Australia
- The steep decline is related to a "…*significant reduction in spending by producing companies as they sought to* <u>*improve profit margins*</u>"!

The Energy/Electricity Landscape-Infrastructure

Goal: Availability, Affordability, Diversity and Dependability!!!

An Intricate Web of Interconnected Users

- Energy resources (coal, gas, oil, uranium)
- Rise of renewables
- Electric utilities
- Industrial plants
- Transportation networks
- Domestic users

+

- GEOPOLITICAL ISSUES
- FINANCIAL TRENDS
- REGULATIONS

How the energy sector will shift to gas and renewables and adapt to climate change?

How will finance, permit and construct urgently needed new energy infrastructure?

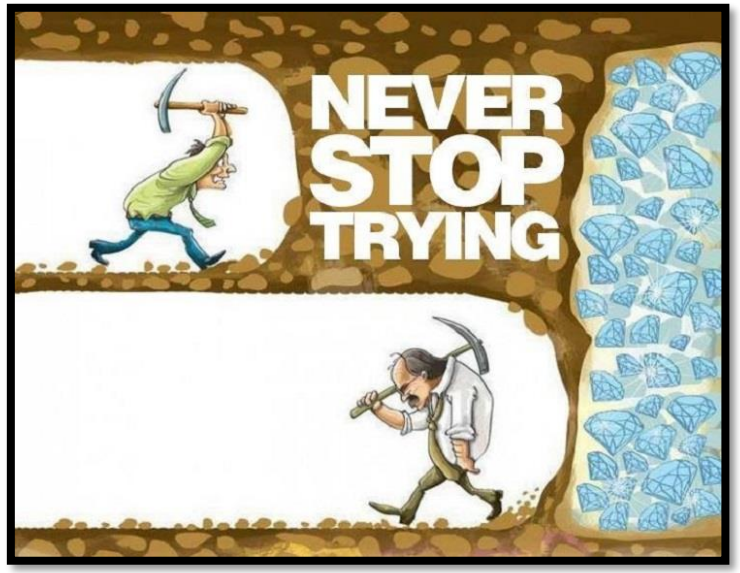
Sustainable Development Philosophy

- Any human activity should be undertaken in such a way that "*the activity itself and the products produced should provide a net positive long-term contribution to human and ecosystem well-being*" (ICMM)
- We have the opportunity to *"…to unlock trillions of dollars through new markets, investments and innovation — but to do so, we must challenge our current practices and address poverty, inequality and environmental challenges"* (World Economic Forum, Global Commission on Business and Sustainable Development, GCBSD)
- The traditional SD domains -**Social**, **Economic**, **Environmental-** are greatly impacted by two additional spheres of influence and potential intervention and interruption*:
  - ✓**Technological:** Pervasive sensing, computing, automation, autonomous motion, big data, internet of things (IoT) all are enabling potentially disruptive technologies
  - ✓**Political:** Public debate and planning, at the local, regional, national and global level, provide another domain of potential intervention

*Innovation or political action that creates or forces new processes, practices, mandates and value networks, eventually disrupting and/or displacing existing markets, networks, processes, products and alliances.

1. Primary Demand Drivers: Some good news!

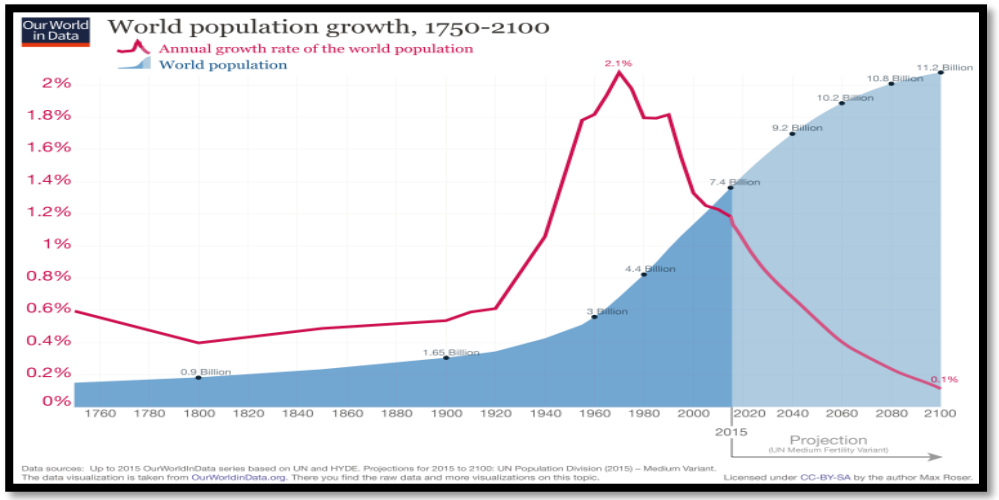
Despite short-term volatility, long-term fundamentals are positive for growth in Energy and Mineral Raw Materials



1.Demand Drivers
2.Technology Drivers
3.SD Drivers

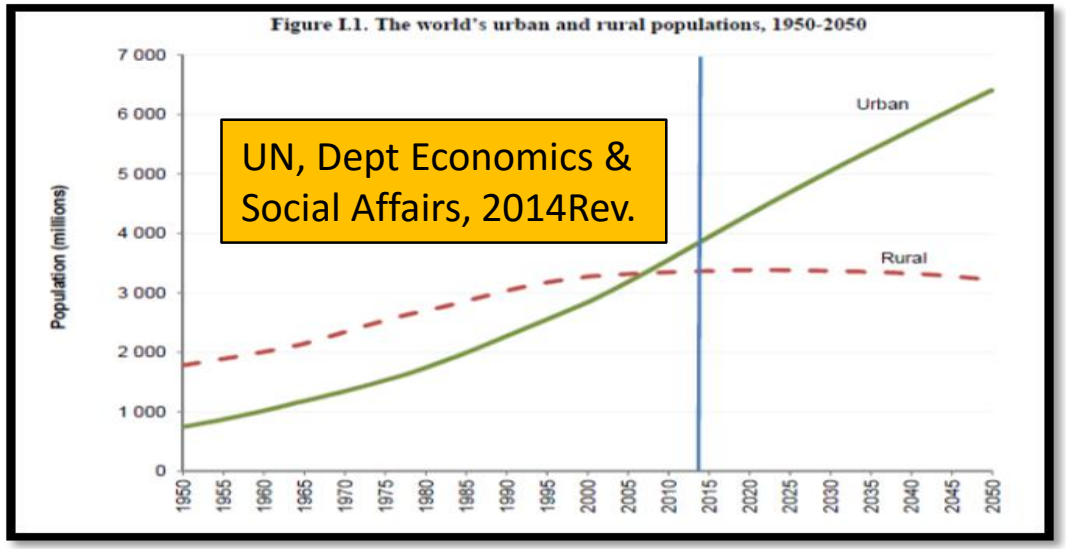
1.1. Global Population Growth: Stabilizes in mid-2100

- Currently, 2017, ~7.5 Billion
- Stabilizes around 2100
- Most growth in China, India, other Emerging Market Economies (EME)



1.2. Urbanization: Need for Infrastructure and Sustainability

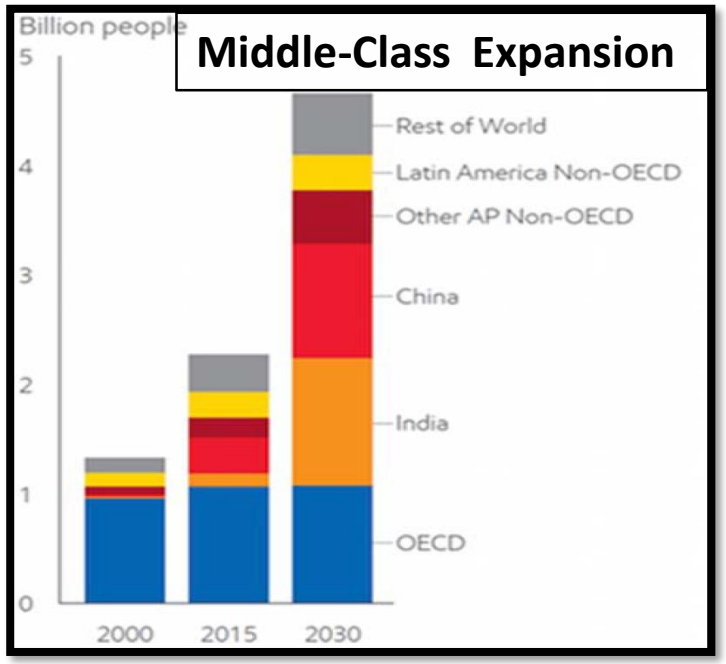
- In 2017, 55% of population (+4.1 billion) is urbanized! (43% in 1990)
- By 2050, another +2.5 billion people will urbanize, mostly in EME, or 65% of total world population



UN, Dept Economics & Social Affairs, 2014Rev.

1.3. Improved GDP: Creation of new middle class

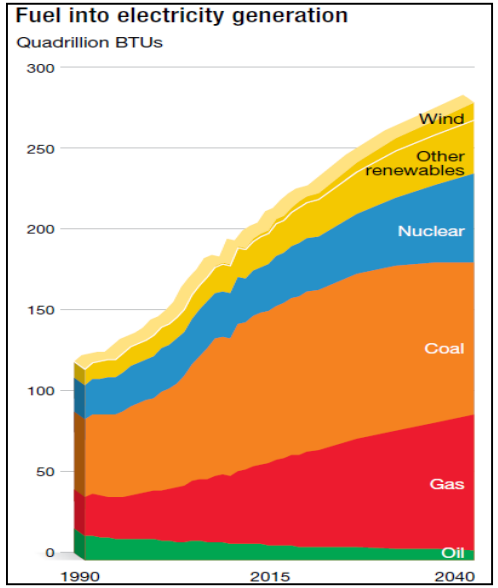
- Global GDP per Capita +160%, 2010 – 2040
- Implications of Affluence in China: Copper consumption surpasses the annual production of the world's largest copper mine, Escondida, in Chile

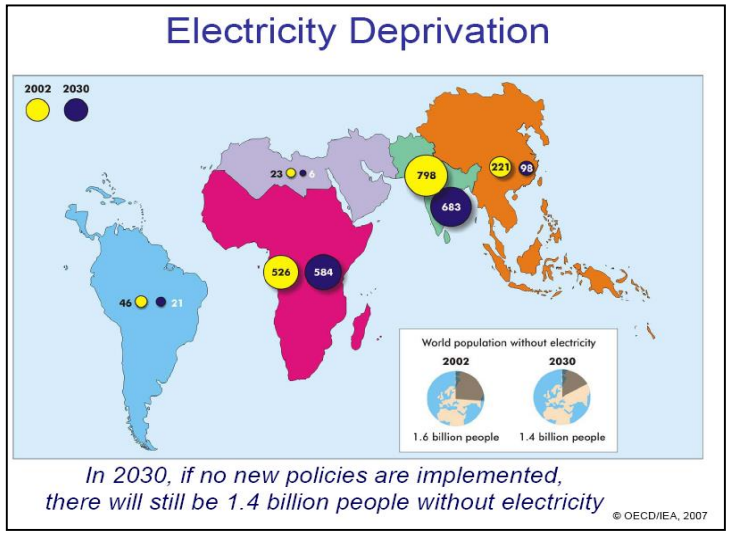


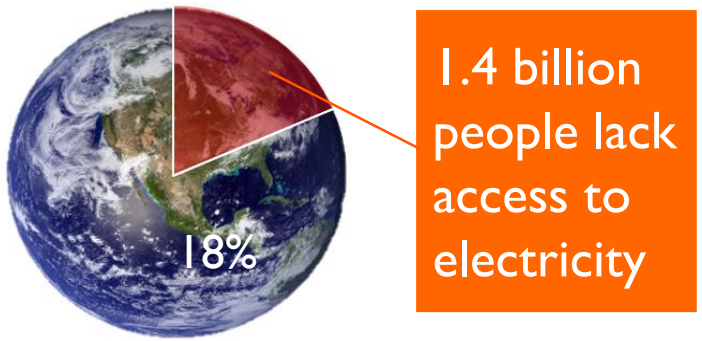
1.4. Technology/Lifestyle-Based Society: Raw Materials Dependency!

1.5. Eradication of Energy Poverty: Electricity Disparity

- By 2040, global electricity demand will be 80% higher than in 2010
- Coal, declines but still remains dominant (1/3 of generation 2035-2040)
- 18% of the world population, 1.4 billion people, lack access to electricity entirely and almost 50% of population lacks access to reliable electricity





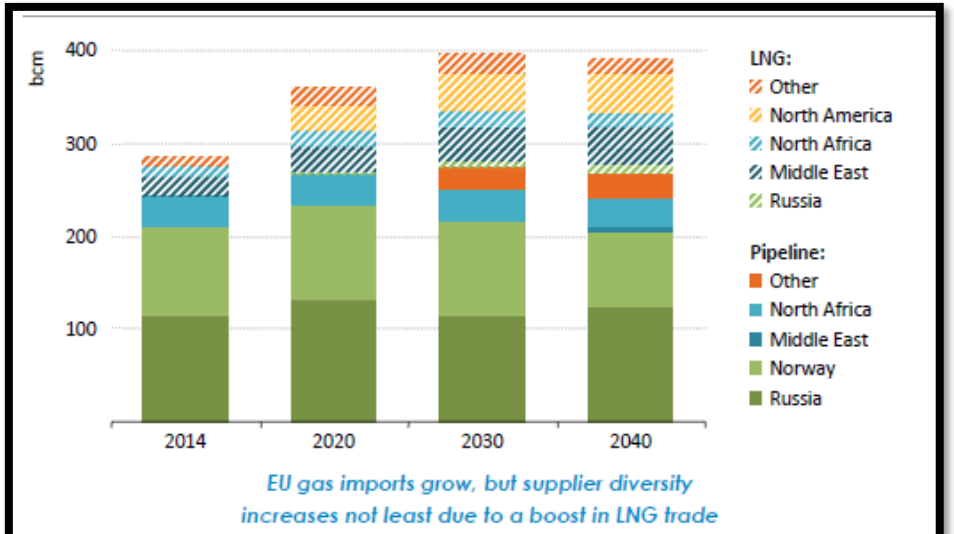


Development, construction and funding of urgently needed global energy infrastructure "eclipses" all previous global energy investments. How will be financed?

1.6. The Unconventional Gas Revolution: Here to Stay!

- **Upstream technology advances transformed unconventional gas production, while reducing costs – will continue into the future!**

***Inter-regional gas trade grows by some 70%, with 45% of the additional trade set to materialise over the coming ten … LNG captures around 70% of the additional gas trade …increases its share in inter-regional gas trade from 42% in 2014 to 53% in 2040."*- IEA 2016**



EU gas imports grow, but supplier diversity increases not least due to a boost in LNG trade

USA energy thrust (National Energy Policy?) is based on growth and stability of shale gas and the completion of gas-related infrastructure

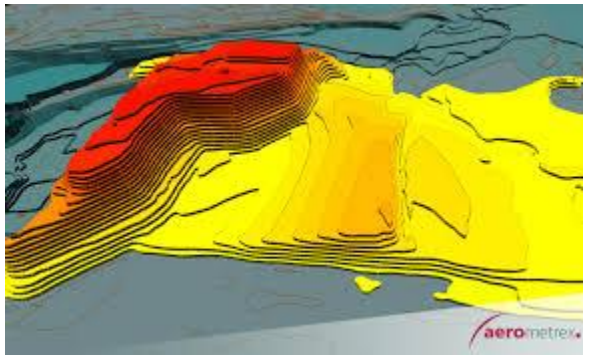
1.7. Big Data: Data Rich Information Poor!!

- Pervasive sensing, computing, network communication
- Data storage capacity doubling every 3 years - daily data production surpassed 2.5 exabytes (2.5 million terabytes) in 2015!
- Technologies such as distributed sensing, the internet of things (IoT), to wearable computing will fuel proliferation of data
- New analytics tools to identify trends and anomalies in support of human, or automated, decision making

"After careful consideration of all 437 charts, graphs, and metrics, I've decided to throw up my hands, hit the liquor store, and get snockered. Who's with me?!"

1.8. From VR to AR and AI: From Virtual to Mine Reality

- Virtual Reality (VR), Augmented Reality (AR) and Artificial Intelligence (AI) enable new ways to maximize the value of the vast amounts of miming data routinely produced
- Will be systematically introduced in mining, where visualization, conceptual/innovative design and assessment of risks are integral components of a complex geological and mining environment/systems
- Improve assessment of the economic viability of a mineral resources, enhance miming environment monitoring and control, optimize fleet management, and support SD practices
- Provide advanced engineering, performance, improve efficiency and H&S of an operation, from mine-to-mill-to post-mining, and facilitate training of employees, communities and the general public



1.9. Autonomous Systems and Robotics: Human/Machine Interaction

- Autonomous ground, marine, and air vehicles, will transform conventional mining/energy operations
- Allow perception and intervention from automated inspections, ground surveys, operation and environmental monitoring
- Will radically improve safety and efficiency and enable new capabilities for monitoring, inspection and maintenance
- Autonomous systems will revolutionary mining and energy operations of the future, from exploration to end-of-life land use, and lead to commercial Marine and Off-Earth Mining

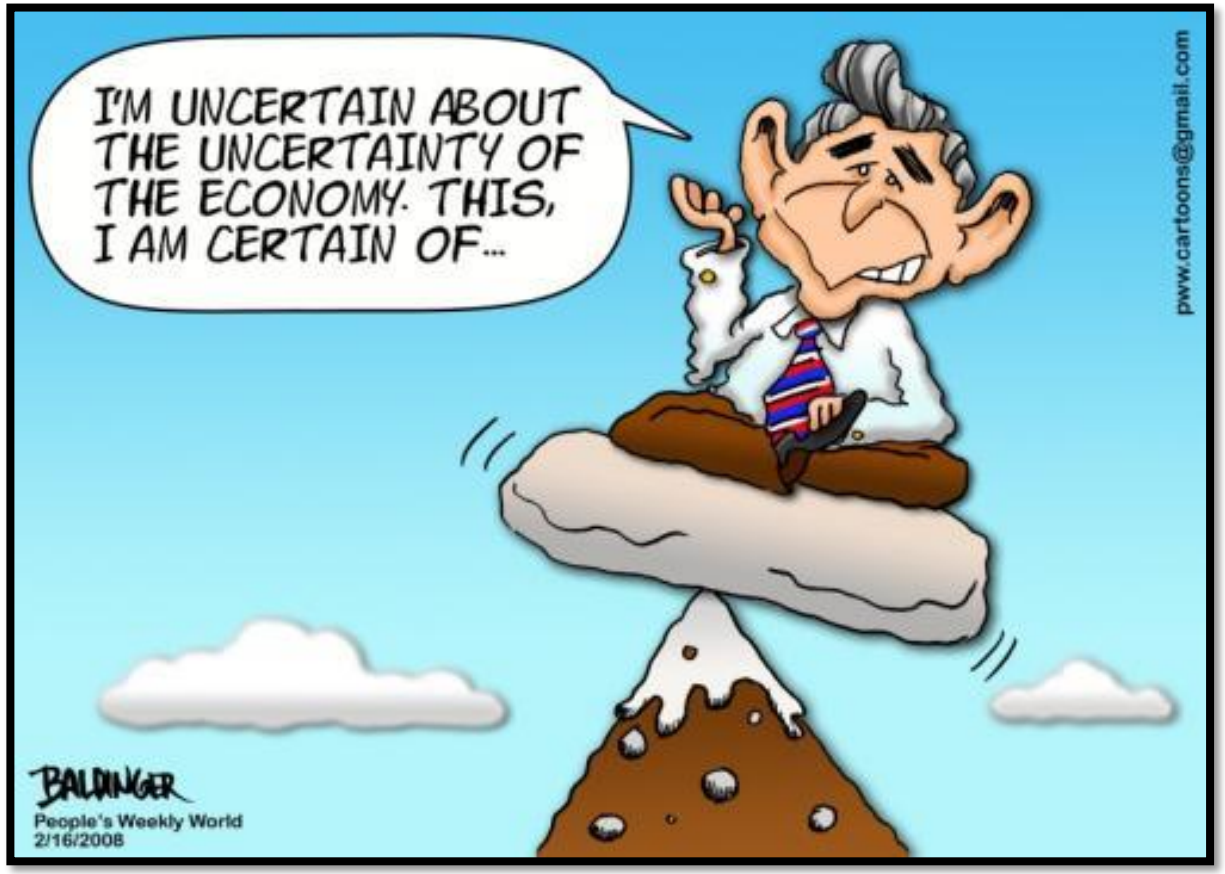
1.10. Sustainable Mining Practices: Make Sense!

- Numerous examples of SD principles and practices of the sector, both positive and negative
- There is a connection between mining and socio-economic development - - operations must minimize negative impacts and maximize benefits, building long-term mutually beneficial relationships and post-mining capacity building
- It is well accepted that Sustainable Development is based on a **process** of transparency-reporting-community engagement-improvement
- ICMM member companies have committed to 10 principles, eight position statements and transparent and accountable reporting practices.
- SD Mining Practices are now defined and implemented, but still an uphill path on improving SD performance and earning "social license*"

****Social License/Acceptance/Development: Approval of mining companies and operations by local communities and stakeholders and acceptance of their net positive contributions to the community well-being.***

2. Key Uncertainties

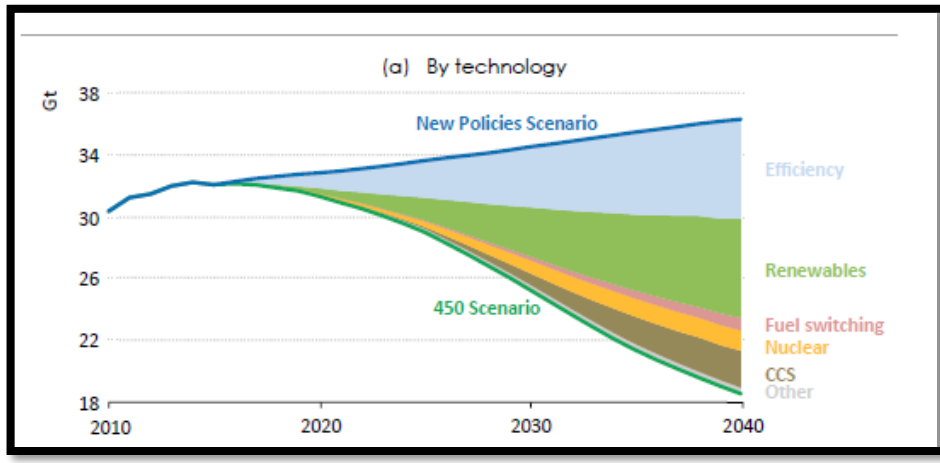
Uncertainty is a deadly enemy of decision making!

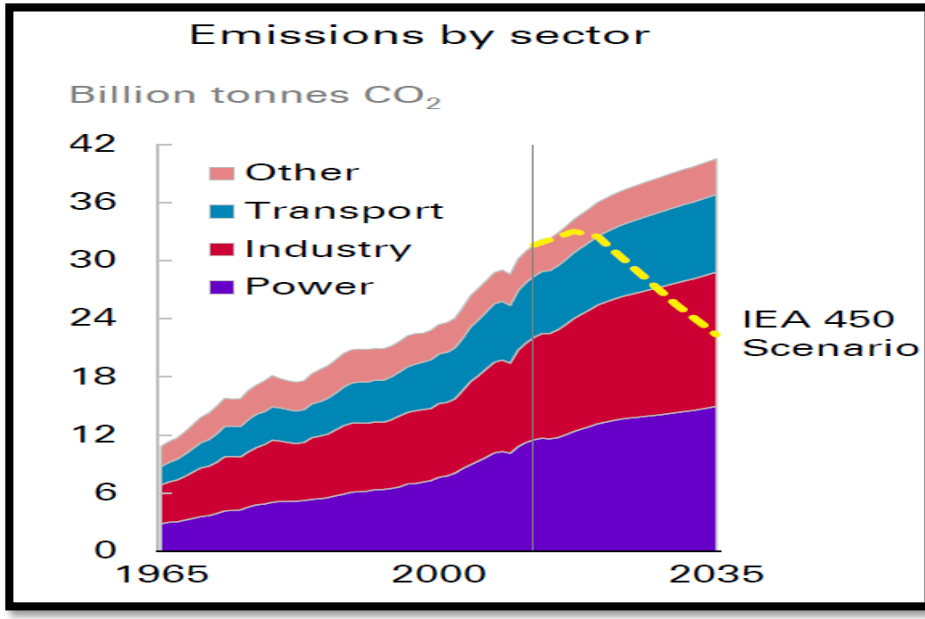


1. SD Uncertainties
2. Political Uncertainties
3. Economic Uncertainties
4. Security Uncertainties

2.1. Climate Change: Impact of Global GHG Policies

- Global **decarbonization** scenaria and treaties [Main 450 Scenario (450S); Current Policies Scenario (CPS); New Policies Scenario (NPS)] have generated debates/agreements on energy mix, renewables v. traditional sources and climate change
- Goals: Increase energy efficiency; Reduce use of fossil fuels; Implement CCS/CCUS*; Increase investment in renewable energy; Reduce CO2 from "industrial" sources; Reduce other GHG emissions
- Issues such as access, reliability, affordability, availability, GHG and air pollution, public acceptance, energy/industrial infrastructure, are tangled with trade-offs, competing priorities, and geopolitical considerations across the global energy sector





* Carbon Capture and Storage (CCS) and Carbon Capture, Utilization and Storage (CCUS)

2.2. Rules/Regulations/Policies: Politicized but Science-based?

- Regulations impacted energy and minerals production
- In USA, Mercury and Air Toxics Standards (MATS) and the Clean Power Plan (CPP) rules, contested in court and highly politicized, have altered the generation mix
  - Announced and planned coal fleet retirements/conversions 70 to120GW- already implemented or planned for completion by 2020
- Restrictions on fracking/drilling for shale gas in EU and other nations
- Questions on the future of nuclear power? About 18% of the of global nuclear baseload fleet is projected to retire by 2025!
- GHG reductions, beyond generation, in the industrial/mineral sectors
- Water-Energy/Mineral production nexus
- Additional rules in protecting biodiversity
- Regulations for disposal of waste products from the extractive industries
- Approvals for closure/post-mining land use of mining operations

2.3. Social Acceptance: Earning the "Social License"

- Responsible mining companies recognize the need to proactively engage with communities to build strong relationships based on trust and respect
- Community engagement v. conflicts

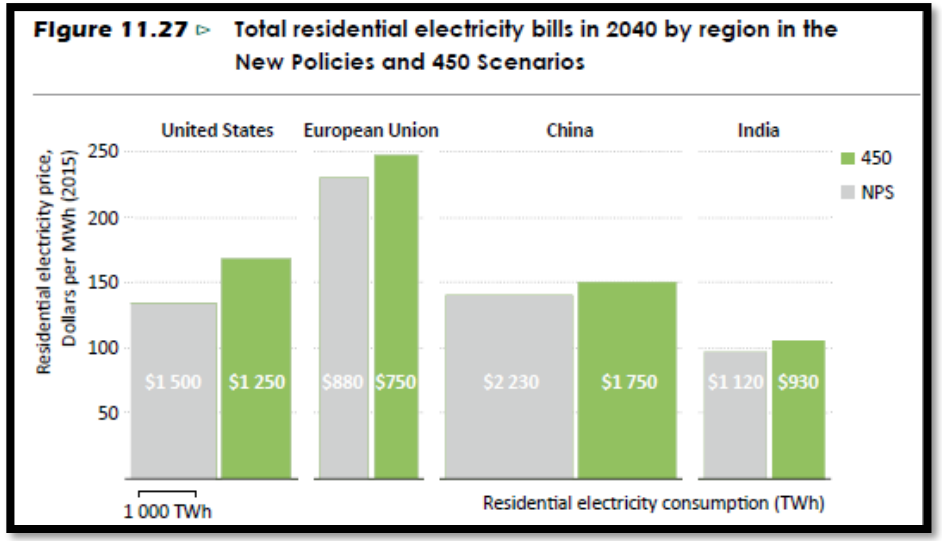
Tia Maria Copper Mine, Peru

German Miners Demonstrating

- There is a path to Sustainable Development and Corporate Responsibility
- Are the energy and minerals sectors positioned and prepared to earn a "**Social License**" to operate?

2.4.1 Energy (Electricity) Prices: Complexities and Conflicts

- *All but the cheapest renewable energy technologies have difficulty matching the LCOEs of baseload fossil-fueled power plants, at current low fossil-fuel prices (IEA,2016)*
- *Renewable energy may present a cost-effective means of achieving societal goals, but investors need a strong financial case to make robust deployment a reality*



2.4.2 Commodity Prices: Still in Flux

- Volatility as companies negotiate the impact of sustained low commodity prices, and uncertain global growth
- Some positive indications that the market may have bottomed in 2016, but to most observers, a sustained recovery is not imminent

2.6. Public and Private Investment: Attitudes and Barriers

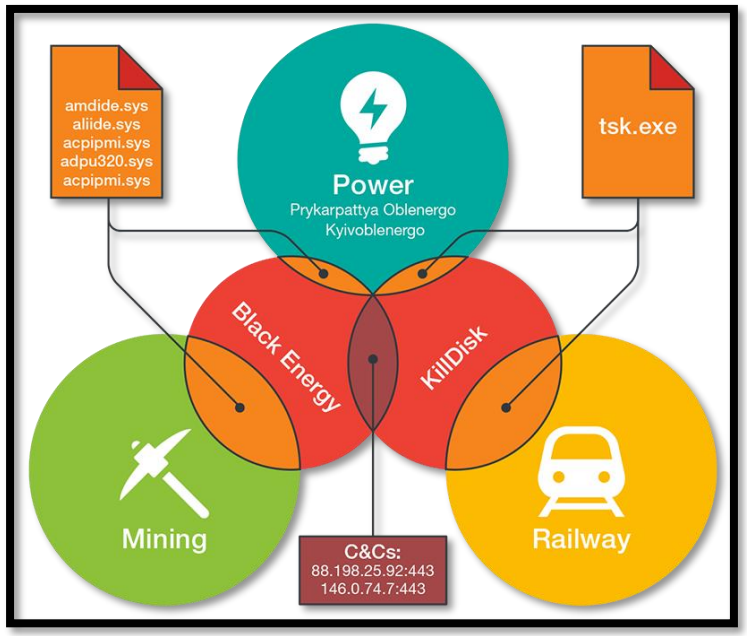
- Under the current economic/political environment, questions on the role of government and public investment in the energy and minerals sector
- Reforms on government incentives/subsidies have significant impacts
- Many private investors have walked-away from mining projects. Will they be back? When?
- Fear of stranded assets:
  - USA Energy: *"Overall, more than a dozen projects* (USA), *worth about $33 billion, have been either rejected by regulators or withdrawn by developers since 2012, with billions more tied up in projects still in regulatory limbo." WSJ, 6/1/2016.*
  - Global Mining: "*Currently, there is an estimated $25 billion worth of projects around the world that have been stopped as the consequence of a dispute or disagreement with their communities, the government or some other stakeholder."* M.Cutifani, CEO, Anglo American, 2015
- There is still money available but emphasis is on <u>quality projects</u>
- Financing competitors are now working together to diversify risk

2.7. Security of Supply: Is the Supply-Demand Cycle Inevitable?

- Even with progress to practice SD management and a "circular economy," developed economies continue to rely on imports from emerging economies, where resource production is mainly concentrated
- This is more significant within the European Union (EU), where domestic raw materials production has reached low levels - serious concerns are expressed in a variety of EU policies and documents
- The vulnerability of this supply chain is further complicated by global currency fluctuations, port access, transportation economics and, in some cases, legacy issues of the energy and the extractive industries sectors
- Concerns in producer-countries expressed by policies, taxation, royalties and expectations for greater return, demands for reduced environmental footprint of mineral operations or, simply, by vigorous opposition

2.8. Cyber-Security and Resilience: Global Vulnerabilities

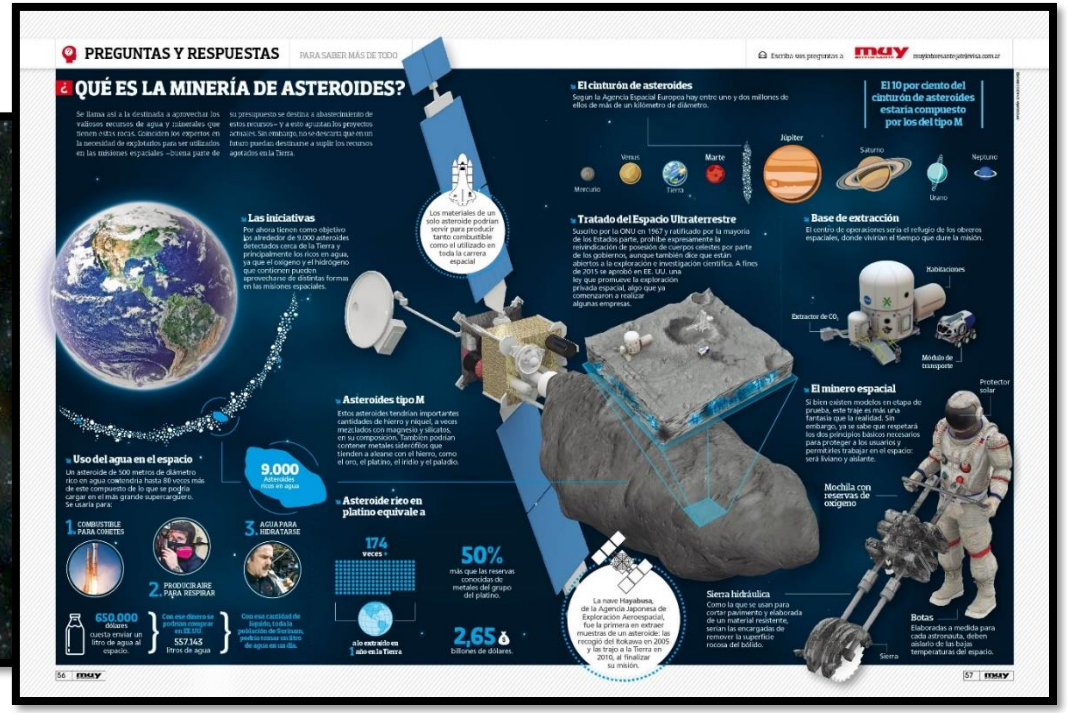
- **Cyber-Security**, **Cyber-Risk Management** and **Cyber-Resilience** are critical challenges and can impact the overall shared digital environment
- As more critical **Cyber-Assets** are interconnected, private and government facilities are more vulnerable to **Cyber-Espionage/Attacks**.
- The protection of the critical infrastructure domain - oil, gas and power generation and transmission, mining/heavy industry operations, smart cities - is of great global cyber-security concern
- Continued technological adoption and connectivity creates an urgency to address cyber security, as billions of more everyday devices are/will be connected



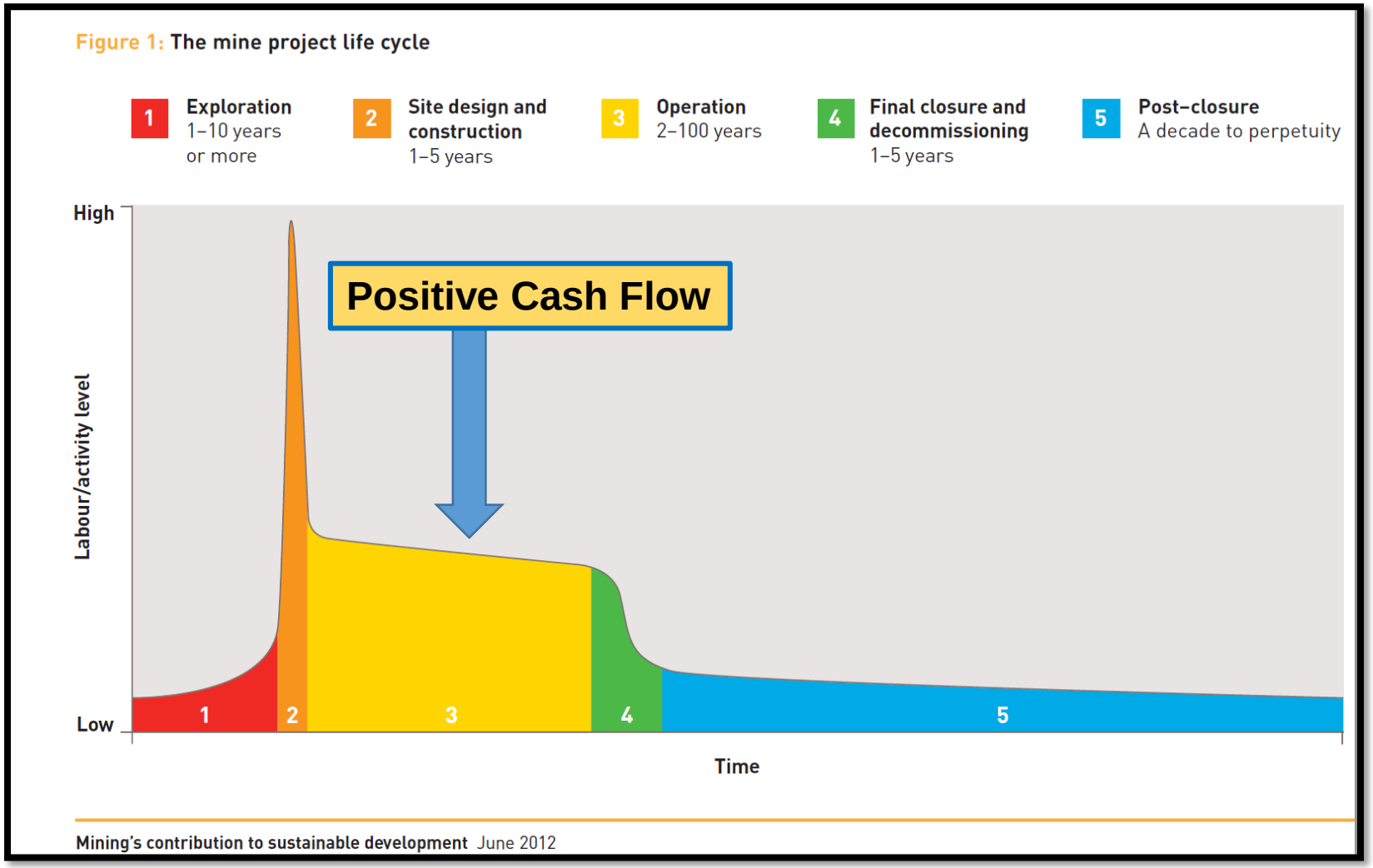
Overlap between sectors, campaigns, malware, and C&C (Command & Control servers) Cyber Threats to the Mining Industry, June 28, 2016 https://www.trendmicro.com/us/index.html

3. Critical Challenge: The Mine of the Future!

"It's not that I'm so smart, it's just that I stay with problems longer" - Albert Einstein

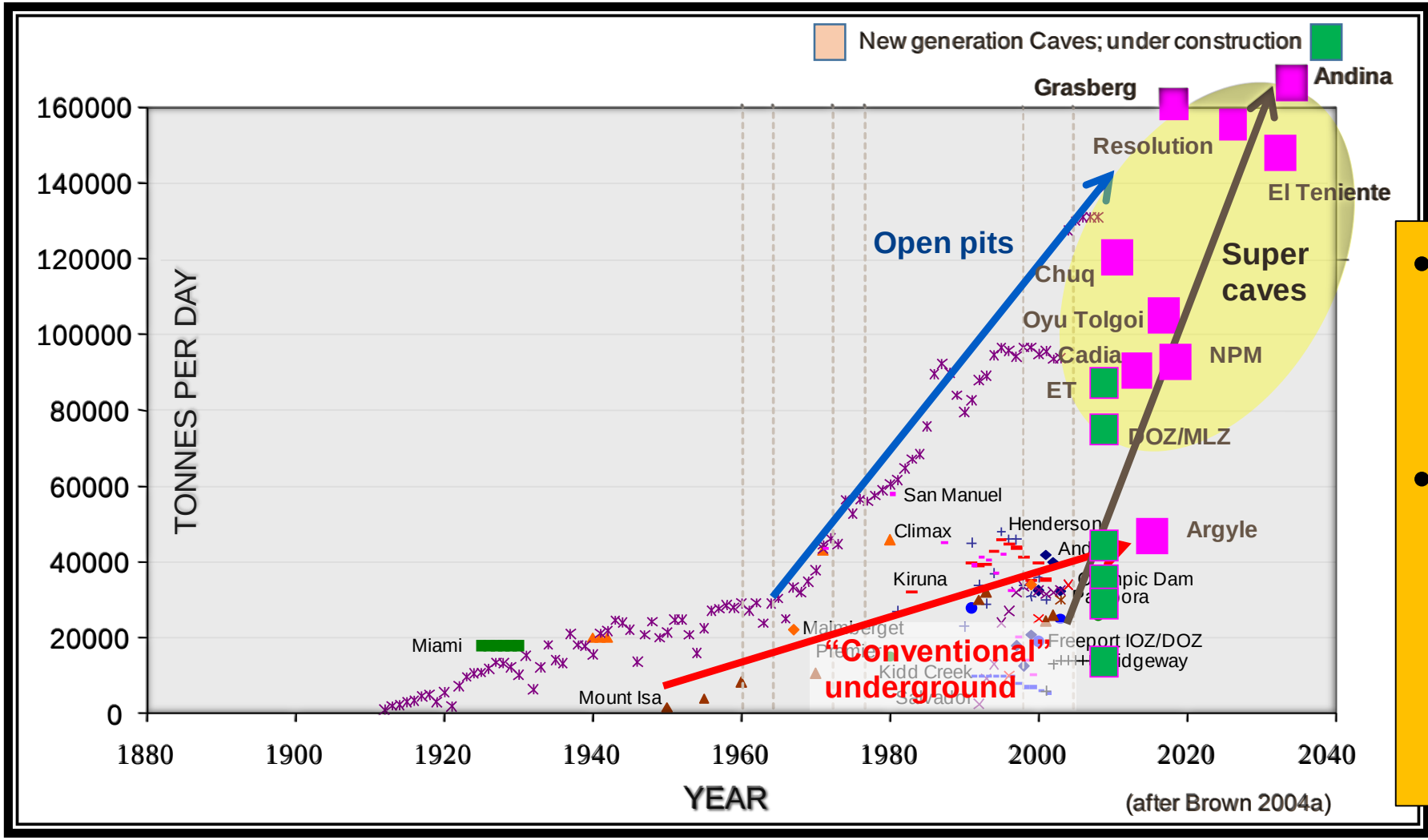


Given long life cycle, mining requires predictable, stable and competitive policy and regulatory environment



Industry, communities, civil society and government must recognize the **full life cycle** - - from exploration through to the long post-closure period - - of a mining project

Into the Future: Scale of mining continues to increase



- Increasing
  - Complexity
  - Project Timeline
- New Technologies, e.g. Copper
  - Leaching
  - Block Cave

M. Cutifani, CEO, Anglo American, & P. Bryant, Kellogg Innovation Network, *Mining Engineering*, January, 2015:

- *"**Rising costs**, **community activism, government intervention**, **resources that are more difficult to reach and lower grade ores**, **infrastructure challenges** and **the industry's poor image** are all playing a role in the struggle to meet demand"*
- Simply stated two issues: ***Social License*** ***and Productivity***

Realising mining's full potential contribution to sustainable economic and social progress requires **collaborative action** between government, companies, and civil society (ICMM)

3.1 Productivity/Efficiency: Urgently Needed!

- 1% improvement= +22MW power output; $30 million NVP over asset life; 67,000 Tons of coal; 120,000 tons CO2 emissions
- In mining, efficiency leads to significant operational, energy and water savings, GHG reductions and improved mineral recovery rates

- "***Operational excellence***" and "***Innovation-Preparing for exponential change***" emerge as the top issues facing mining companies in 2016

  *(*Report, Deloitte Touche Tohmatsu-Global Mining)

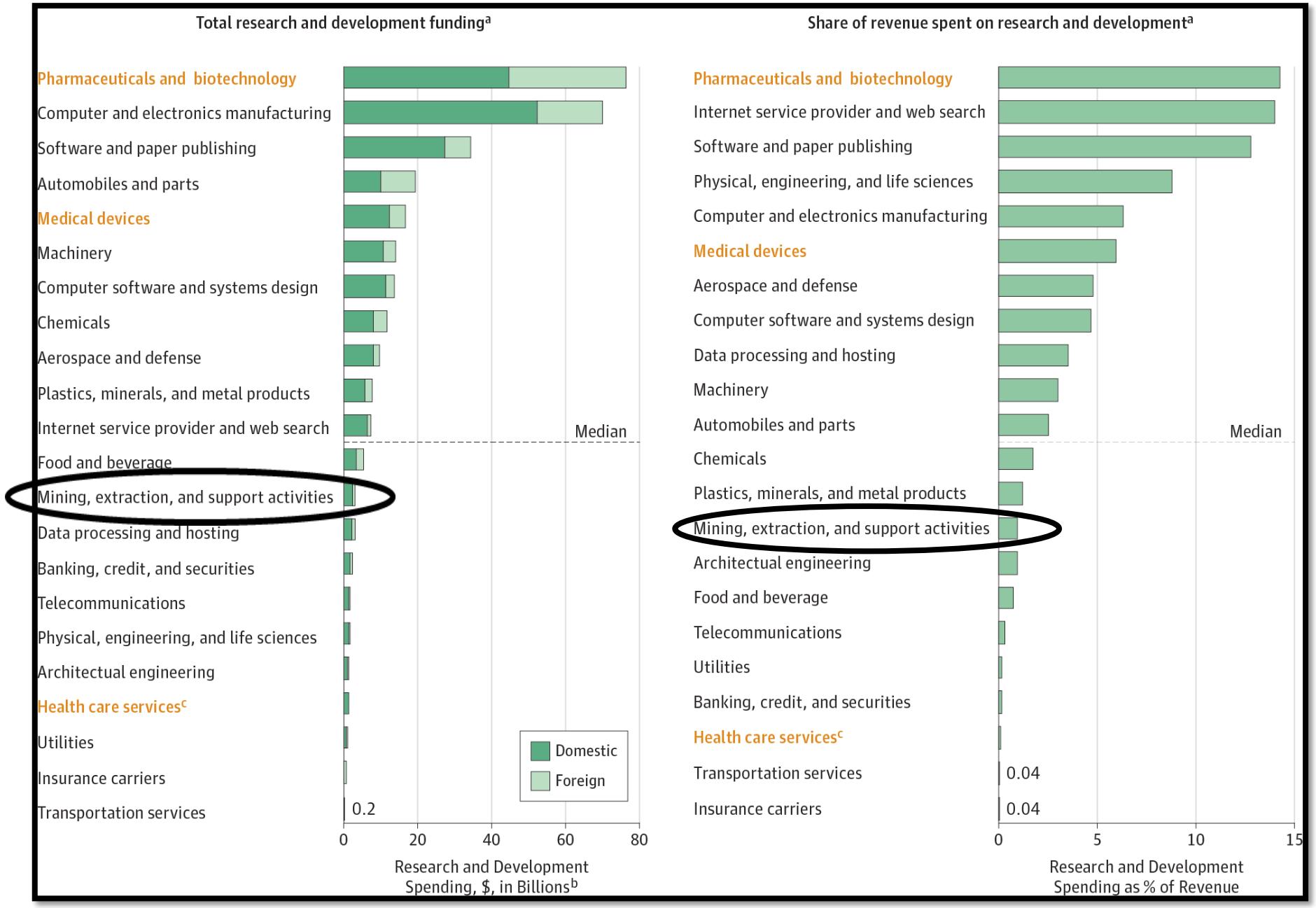
- But, improving efficiency and growth ***"involve technology or process that has never been implemented before in the company, and internal stakeholder alignment will be critical to its success."***

  (Report, Clareo Consultants, 2016)

3.2. Innovation: Revolutionary v. Evolutionary Technologies

- Integrating new generation technologies into the mining practice is a challenge
- ***Tinkering and tweaking won't suffice:***

  "...companies must look beyond incremental performance improvement to determine how they can revise their systems to embrace the broad theme of innovation" J.Beier, Deloitte-Canada
- But, "…*innovation in the mining industry is coming at too sluggish a pace, and the rising costs of extraction and transportation need to be addressed with new ideas.*" M. Cutifani, CEO, Anglo American



C.VanLang,2016, https://www.quora.com/Is-the-high-cost-of-drugs-to-offset-R-D-costs-justified

- Traditionally *"…most of the innovation is focus on technological optimization of old techniques rather than looking for new ways to configure and engage externally" Tracking the Trends 2016 Report,* Deloitte Touche Tohmatsu-Mining

Four major developments will accelerate change in the mining industry towards the Digital Transformation

Data, computational power, and connectivity	90%	Data in the world today has been created in the last two years
Analytics and intelligence	1015	More computer operations per second than since the 1960s
Process digitization	250k x	More RAM in iPhone 5 than in the Apollo 11 computer which took it to the moon and back
Robotic and Automation	50%	Reduction in cost of robots since 1990 vs. 80% increase in US labour costs

SOURCE: McKinsey & Company; HBR, *The Age of Smart, Safe, Cheap Robots Is Already Here*; IBM

Sector is fast track technology transformation by forming strategic collaborative partnerships with global technology leaders and developers

Key Partnerships	Reference
Barrick-Cisco: Digital Reinvention of Mining	https://newsroom.cisco.com/press-release-content?type=webcontent&articleId=1789153
Komatsu-BT: Global IT Infrastructure	https://www.globalservices.bt.com/uk/en/news/komatsu-chooses bt-for-its-global-it-infrastructure
Komatsu-MMSI: Autonomous Haulage System	http://www.modularmining.com/solution/autonomous-haulage/
ABB-Microsoft: Digital Industrial Transformation	https://news.microsoft.com/2016/10/03/abb-and-microsoft-partner-to-drive-digital-industrial-transformation/#sm.0001csbyil3dhe9jrpy1cp3xxu8to#cblfA8ayxzg qO4o.97
Caterpillar-Fortescue Metals: Commercial Installation of Autonomous Trucks	http://www.caterpillar.com/en/news/caterpillarNews/h/caterpilla -and-fortescue-moving-forward-with-commercial-installation-of-autonomous-trucks.html
Microsoft-Snowden: Azure-Powered Intelligence/Cloud-First Solutions to the Mining Industry	http://snowdengroup.com/snowden-and-microsoft-form-strategic partnership/ http://www.arnnet.com.au/article/610596/microsoft-isv-launches azure-powered-neuroverse-platform/

3.3. Social License/Development/Acceptance:

- Building on the Millennium Development Goals, the UN Sustainable Development Goals (SDGs), agreed by 193 world leaders in 2015, are a 17-point plan to end poverty, combat climate change and fight injustice and inequality
- Over the last decade, major organizations, industries and corporations have accepted and pursued an active sustainability and social responsibility role for their communities of interest, shareholders and employees
- **While these goals and ideals are basic principles and values, implementation, financing and progress is a long and potentially meandering pathway**
- **While there is a path to sustainable development, the energy and the minerals sectors still struggle to earn the "Social Acceptance" to operate--** demonstrated by the often massive opposition to operations and critical infrastructure projects pipelines, transmission lines, port facilities, power plants, mine sites, oil and gas development

The Way Ahead: Mines of the Future

License to Operate

- **Partnerships:** Building effective/engaging stakeholder partnerships based on mutual respect/trust
- **Sustainable Practices:** Aiming at zero ham, minimum environmental footprint, manage risk

Productivity:

- **Technology:** Improving the flow of emerging/enabling technology and adopting best practices
- **Innovation:** Embracing RD^3 and establishing strategic partnerships and mechanisms to support/fund **step-change innovations**

Mines of the Future

- **Digital Operations:** Connect people and machines seamlessly to integrate design-planning-operations to be safer, environmentally-friendly and productive
- **Workforce:** The industry transitions from “a blue collar” to “white collar”

The Mining Company of the Future

The goal should be to *"…fundamentally change the extractive business model of the mining industry from insular and reactive, to an integrated and proactive development partner, delivering on economic, environmental and social shared purpose*"

- Mining Engineering, January, 2015 (Mark Cutifani, CEO, Anglo American and Peter Bryant, Kellogg Innovation Network), 2015 SME Annual Meeting

The Mine of the Future

BHP's Perth Remote Operations Centre

The Mining Engineers of the Future