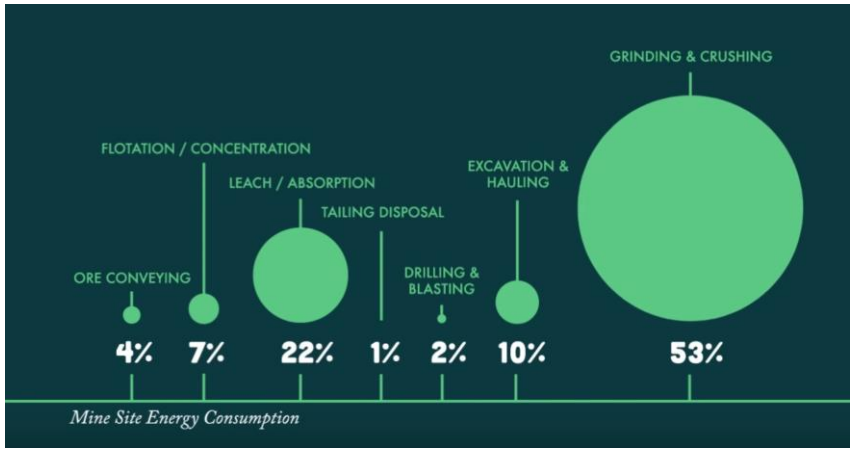
References to measure the Energy Requirements in Mining

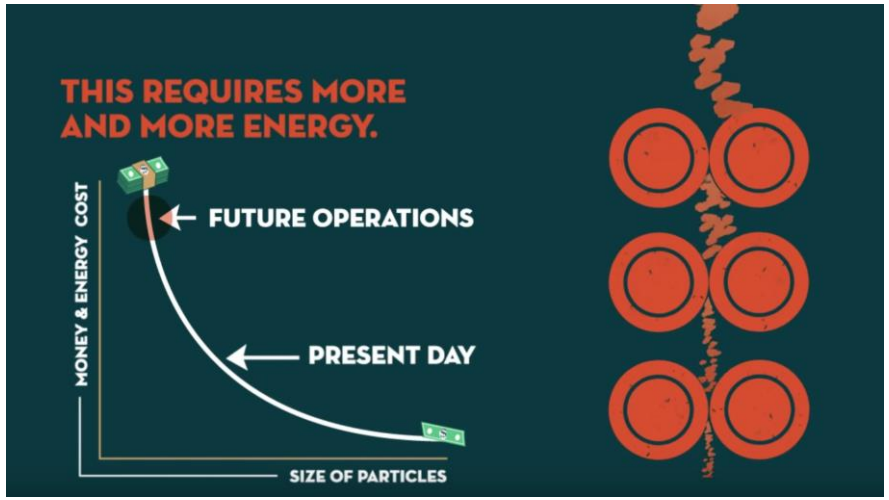
World Bank

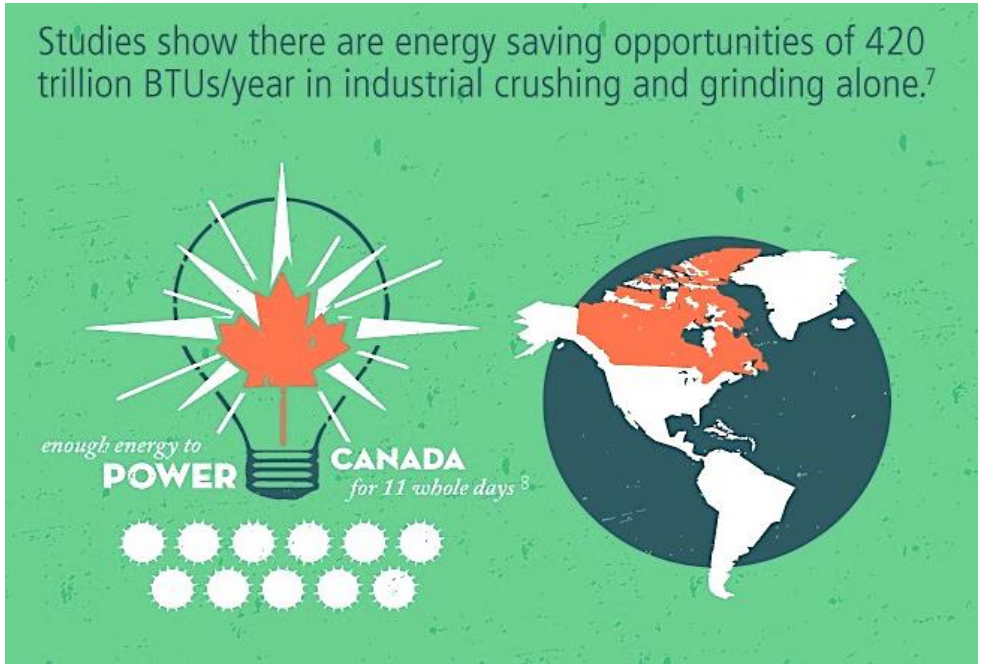
- https://openknowledge.worldbank.org/bitstream/handle/10986/21402/9781464802928.pdf

Smarter Companies are adopting Eco-Efficient Comminution strategies

https://www.youtube.com/watch?v=ZQ5YToRDiVg&t=9s







- The mining sector uses 11% of the world's primary energy and requires constant and reliable access for its operations. Energy demand by the sector is expected to increase with declining ore grades and growing mineral demand. The speed of the energy transition to combat global warming will play a key role determining mineral demand growth with 'cleantech technologies' being considerably more metal and mineral-intensive than fossil fuel technologies.
  - https://energyandmines.com/wp-content/uploads/2016/09/Rankingsandawards.pdf
  - World Bank, The Growing Role of Minerals and Metals for a Low Carbon Future, June 2017

- https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-renewables-in-mining-final-report-for-web.pdf
- According to the Paraszczak, 2012, many of the remote mining operations are located around the equator between the 35° latitude North and South parallels where the sun is intense and reliable (ex. in the sub-Saharan Africa, Australia or Northern Chile) and therefore ideal for solar power electricity generation. By some estimates the current installed capacity for wind and solar for mine projects amounts to 943MW comprising Solar PV for 352MW, Solar Thermal for 39MW, Wind for 551 MW (Energy and Mines Renewables in Mining Rankings and Awards – Factsheet 2016)
- "Energy use in the mining industry has increased by around 455 per cent in the period 1971–2012, based on data from the International Energy Agency (IEA) (…). At the same time, estimates of production of mined and quarried material show an increase of 320 per cent, (…) – mining and quarrying have overall become less efficient per tonne of material extracted" (Source: McLellan in Lodhia, Sumit. K. Mining and Sustainable Development. Routledge, January 2018).
- Mining: The Growing Role of Renewable Energy", Ernst & Young
  - http://www.ey.com/Publication/vwLUAssets/EY_-_Mining:_the_growing_role_of_renewable_energy/$FILE/EY-mining-the-growing-role-of-renewable-energy.pdf, accessed February 19, 2017
  -

HYBRID RENEWABLE POWER SYSTEMS FOR THE MINING INDUSTRY: SYSTEM COSTS, RELIABILI TY COSTS, AND PORT FOLIO COST RISKS – June 2016 (PH D tesis)

- The mineral sector is responsible for more than 38% of total industrial energy use and 11% of total final energy consumption. A rising trend in the industry is the search for cleaner, less carbon-intensive and more efficient energy technologies that can also bring new business opportunities to the industry. Evidence suggests that the inclusion of energy storage and renewables alongside traditional fuel-based power alternatives can both reduce generation costs and carbon emissions in off-grid and distributed power systems. Previous research has quantified this outcome for other industrial and domestic sectors but little investigation has taken place to characterise the potential of hybrid systems in mining settings.
- The mineral sector is responsible for more than 38% of total industrial energy use and 11% of total final energy consumption (McLellan et al., 2012). This energy consumption is set to double by 2050 compared to 2009 standards if no policy measures are taken (UNIDO, 2010). At the same time, the mining sector is coming under significant pressure to decrease the amount of energy consumed and greenhouse gases emitted (Norgate and Haque, 2010). According to the fifth report of the carbon disclosure project, the main trend in the industry is the search for cleaner, less carbon-intensive and more efficient technologies, that can also become new business opportunities to the industry.
  - McLellan, B., Corder, G., Giurco, D., Ishihara, K., Sep. 2012. Renewable energy in the minerals industry: a review of global potential. Journal of Cleaner Production 32 (0), 32–44. (Cited on pages xii, xv, 1, 2, 4, 7, 9, 10, and 11.)
  - UNIDO, 2010. Global industrial energy efficiency benchmarking. (Cited on pages 1 and 6.)
  - Norgate, T., Haque, N., Feb. 2010. Energy and greenhouse gas impacts of mining and mineral processing operations. Journal of Cleaner Production 18 (3), 266–274. (Cited on pages 1, 7, 9, 10, and 11.)

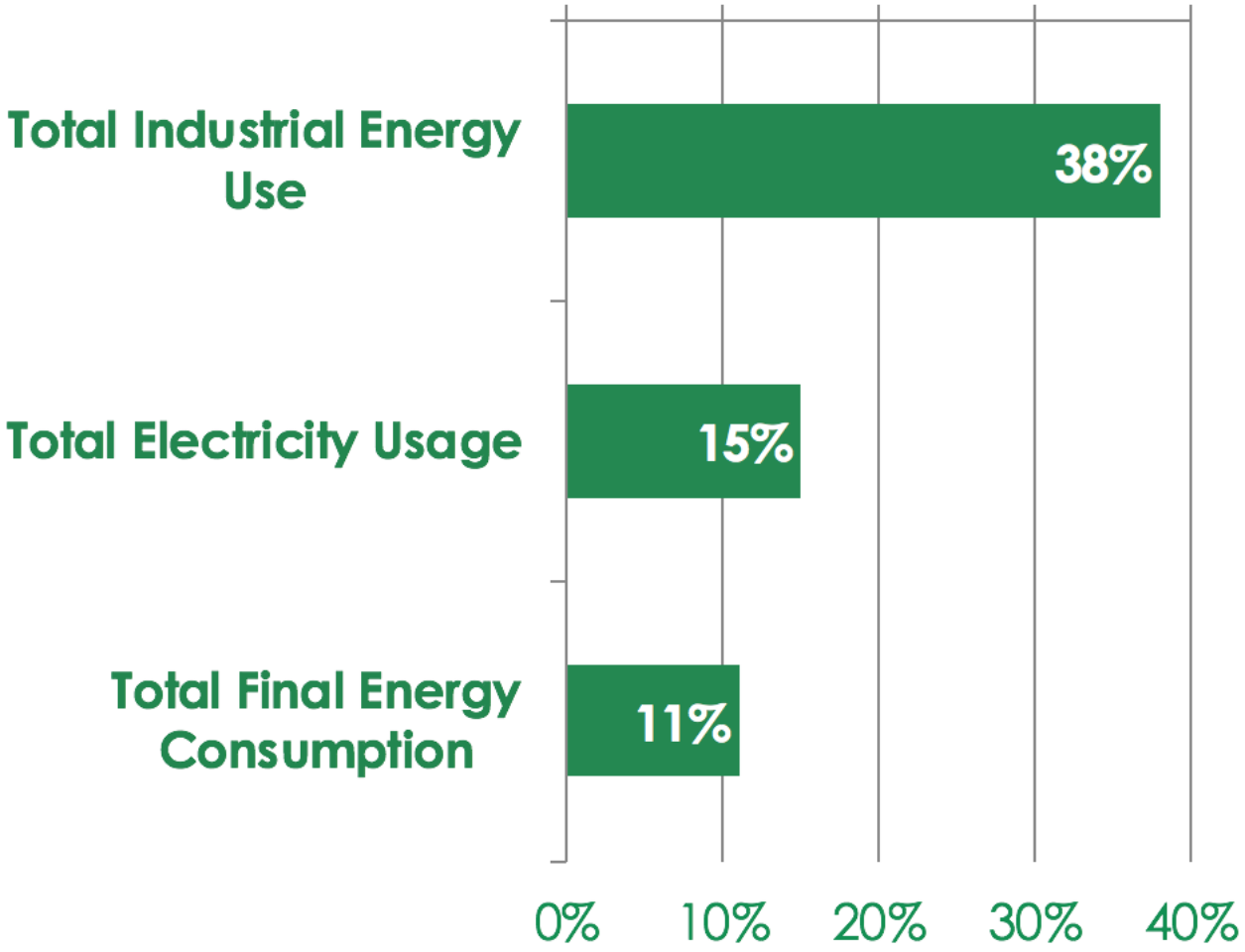
Reference: Arnoldus M. van den Hurk Workshop

4 Years of Workshops

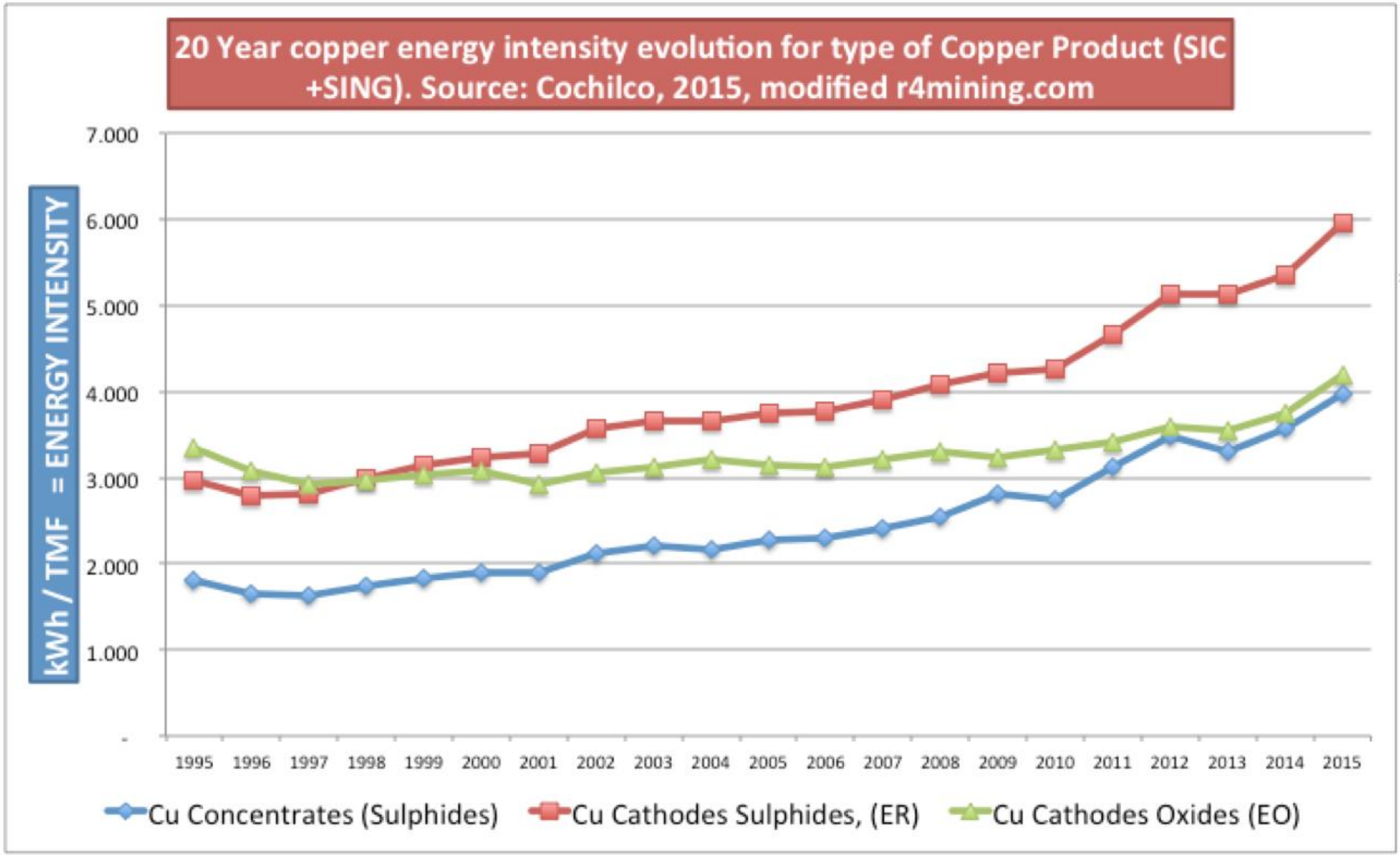
SANTIAGO
MAY

INTRODUCTION TO THE WORKSHOP

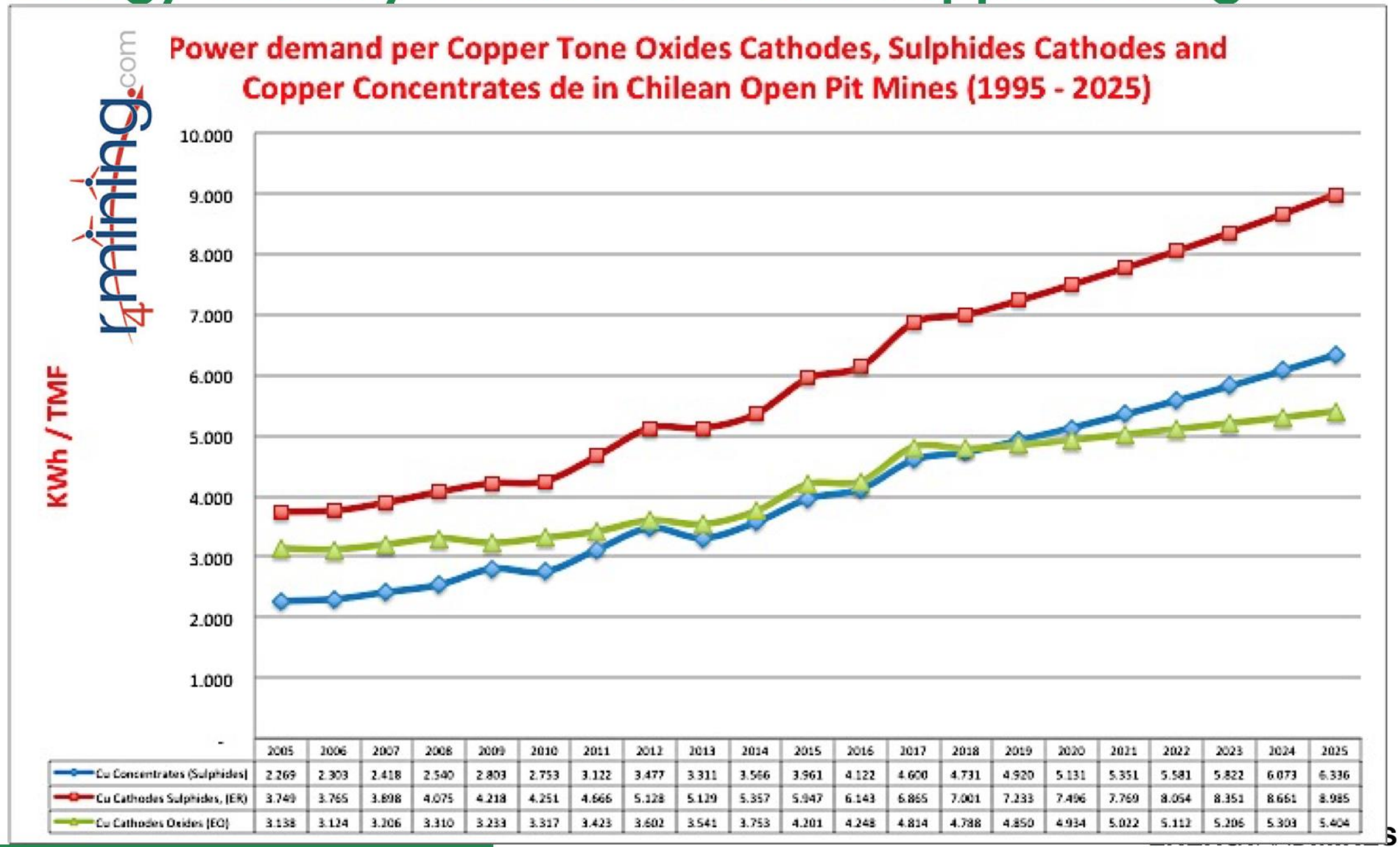
Mining, "King of energy use"



- Mining industry is a major energy user
- But relatively small in terms of the world's workforce
  - *30 million people are involved in large-scale mining*
- The global mining energy use
  - *to double by 2050 compared to 2009 taken*
  - *due to lowering ore grade*
  - *increasing demand of mineral commodities*

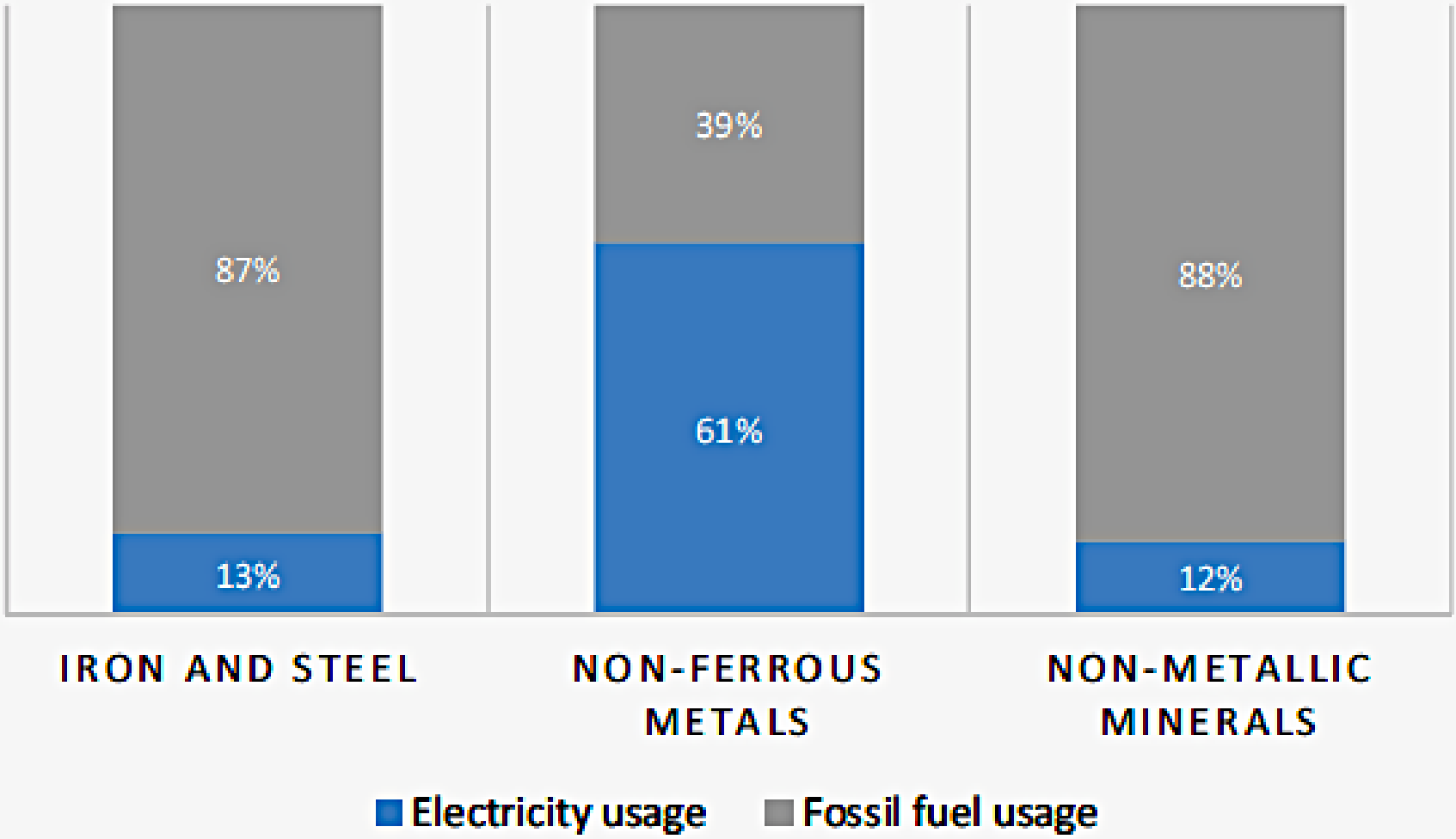

20 Year copper energy intensity evolution for type of Copper Product (SIC +SING). Source: Cochilco, 2015, modified r4mining.com
kWh / TMF = ENERGY INTENSITY
7.000
6.000
5.000
4.000
3.000
2.000
1.000
-
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Cu Concentrates (Sulphides)
Cu Cathodes Sulphides, (ER)
Cu Cathodes Oxides (EO)

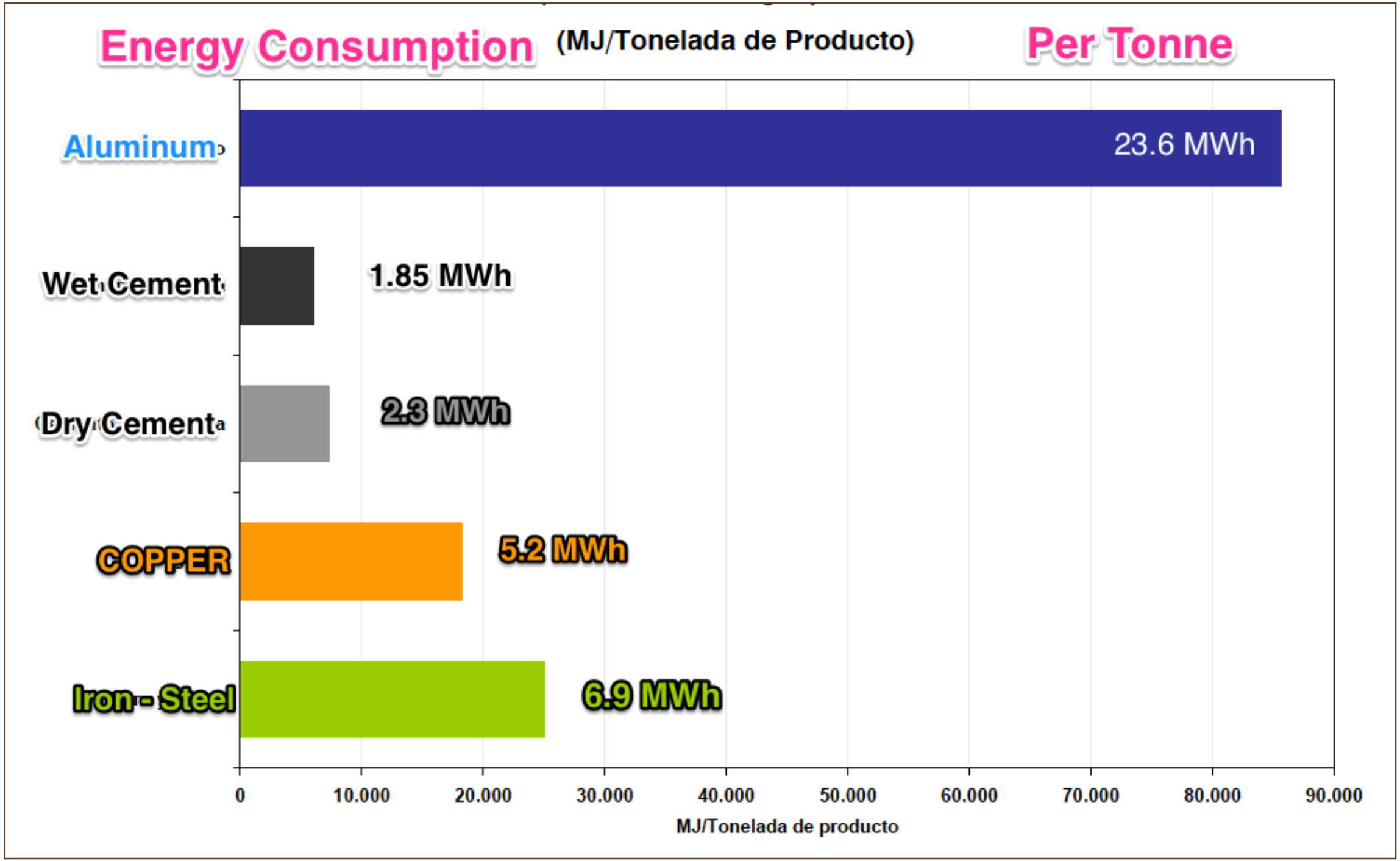
Energy Intensity trends in Chilean Copper Mining



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Cu Concentrates (Sulphides)	2.269	2.303	2.418	2.540	2.803	2.753	3.122	3.477	3.311	3.566	3.961	4.122	4.600	4.731	4.920	5.131	5.351	5.581	5.822	6.073	6.336
Cu Cathodes Sulphides, (ER)	3.749	3.765	3.898	4.075	4.218	4.251	4.666	5.128	5.129	5.357	5.947	6.143	6.865	7.001	7.233	7.496	7.769	8.054	8.351	8.661	8.985
Cu Cathodes Oxides (EO)	3.138	3.124	3.206	3.310	3.233	3.317	3.423	3.602	3.541	3.753	4.201	4.248	4.814	4.788	4.850	4.934	5.022	5.112	5.206	5.303	5.404

: Mix of the final energy consumption in the mining industry (McLellan et al., 2012)




Energy Consumption
(MJ/Tonelada de Producto)
Per Tonne
Aluminum
23.6 MWh
Wet Cement
1.85 MWh
Dry Cement
2.3 MWh
COPPER
5.2 MWh
Iron - Steel
6.9 MWh
0
10.000
20.000
30.000
40.000
50.000
60.000
70.000
80.000
90.000
MJ/Tonelada de producto

Electricity Intensity for the Aluminum industry

1. Process / Stage – 2. Product – Product Unit - Power (Electricity) + Fuel = Total Energy consumption

- *SOURCE: "Life Cycle Inventory Report for the North American Aluminum Industry" published by the Aluminium Association in Nov. 1998.*

The Economist 2013: **6% of total China electricity consumption** is linked to the their Aluminum smelters

Iceland has 3 Aluminum smelters facilities fueled by geothermal power plants

PROCESS	PRODUCT	Production Unit	POWER Energy Consumption kWh/Al. Tn Producto	FUEL Energy Consump. MJ/Unidad de Producto	TOTAL Energy Consump. MJ/Unidad de Producto
ALUMINIUM phase	Aluminio	ton	15.700 (1) 16.700 (5)	6.300 (5)	66.000 (5)
Mine	BAUXITE	ton	0,4(1)	227(1)	45 (2)
Alumina Refining	ALUMINA	ton	109 (1)	13.160 (1)	11.000 (2)
Anodes Production	ANODES	ton	266	3.938 (1)	4.880 (1)
Electrolytic Refining	ALUMINUM	ton	15.400 (1) 14.000-18.000(4)	653 (1)	25.500 (3)

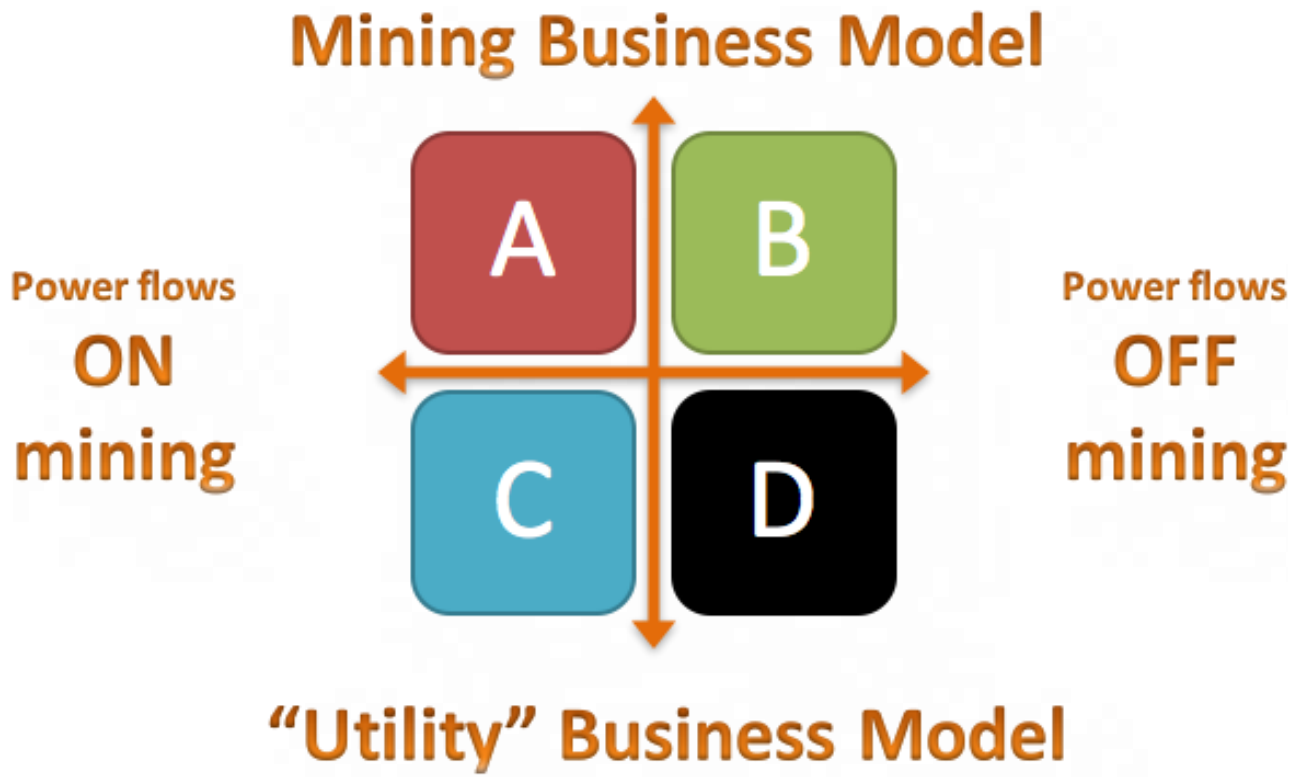
The Real Renewable Market for Australian mining

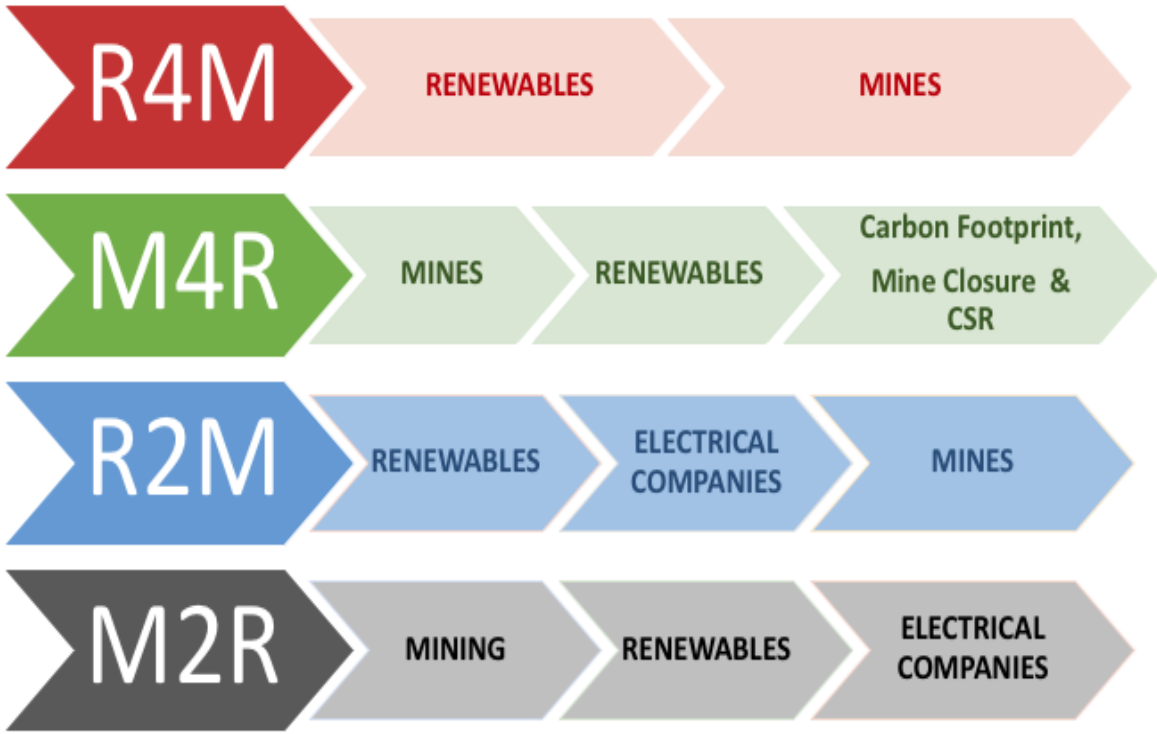
AUSTRALIAN ENERGY CONSUMPTION ENERGY UNITS (2017) data 2015-16		
	PJ to TWh	0,2778
Australian Sector	PetaJoules	Terawatts hour
Div. B Mining Energy	609,95	169,43
06 Coal Mining	128,28	35,63
8-10 Other Mining	177,42	49,28
20 Non-metallic mineral products	102,57	28,49
209 Other non-metallic mineral products	8,94	2,48
TOTAL MINING	**1.027,17**	**285,32**
211-212 Iron and steel	117,42	32,62
213-214 Basic non-ferrous metals	349,68	97,13
MINING INDUSTRY TRANSFORMATION	**467,10**	**129,75**
07 Oil and gas extraction	304,24	84,51
1701 Petroleum refining	78,60	21,83
1709 Other petroleum and coal product manufactur	13,19	3,66
Total Oil & GAS	***396,03***	***110,01***
ENERGY & MINES MARKETPLACE	1.376,85	382,46
TOTAL MINING & EXTRACTIVES	**1.890,30**	**525,08**

COUNTRY EQUIVALENTS	Year	TWh
COUNTRIES	YEAR	Terawatts hour
Thailand	2014	164,00
Qatar	2014	34,00
Algeria	2014	49,00
Morroco	2014	29,00
Mauritius	2014	2,60
Italy	**2014**	**291,00**
Denmark	2014	32,00
United Arab Emirates	2014	96,00
Sweden	**2014**	**127,00**
Findland	2014	81,00
Hungary	2014	21,55
Namibia	2014	3,70
Netherlands	***2014***	***108,00***
France	2014	431,00
Canada	**2014**	**528,00**

info@r4mining.com - www.miningrenewables.com

New perspective of the market





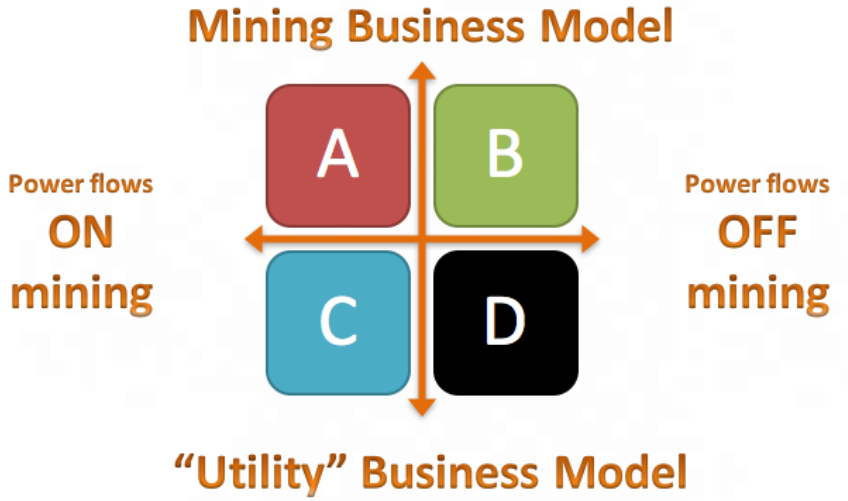
Renewables & Mining (R&M) Market Segments (A. Hurk; 2016) – BFPF Quadrant

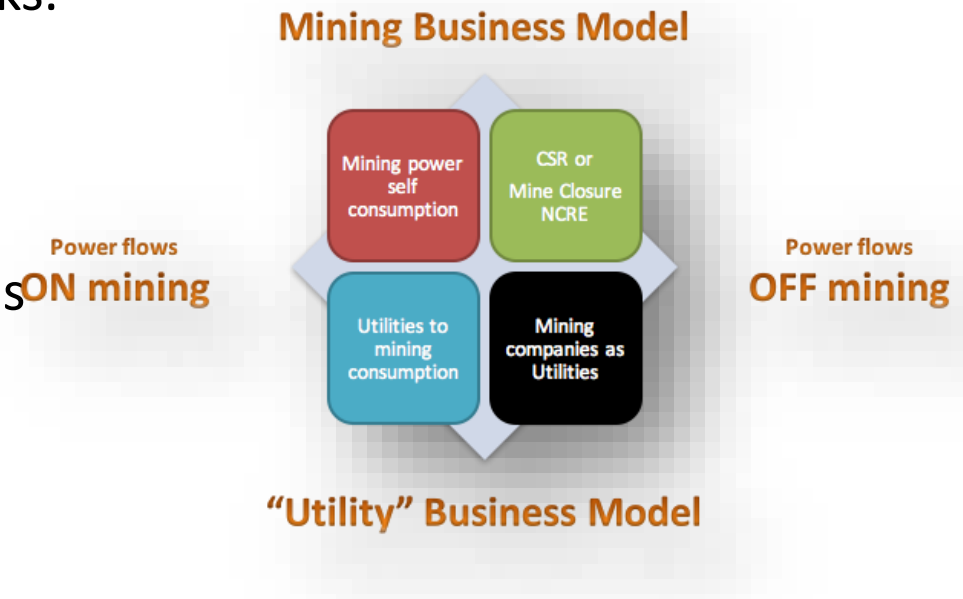
(A) Renewables FOR Mining (R4M): Self-consumption of renewables at mining location. Turnkey and / or PPA signed by the mining company. Most of case studies in the Energy and Mines Summits. On-grid and Off grid Facilities

(B)Renewables TO Mining (R2M): When mining companies develop or invest (total or partially) on renewables facilities in order to reduce their carbon footprints and / or for CSR tasks. Most of them on-grid, but it might be off grid

(C) Mining FOR Renewables (M4R): When the renewable power comes from the "grid" indirectly to the mine. The "PPA" is signed or developed by the utility.

(D) Mining TO Renewables (M2R): When mining companies diversify to renewable power production and sale. Usually managed by "energy mines" (coal, tar sands …)





More details …

- In 2016, we funded the group of experts REMIO: Renewable Energies and Mining International Observatory and we have LinkedIn Group with more than 1,350 members (Renewable Energy for Mining and Oil Industry)
  - https://www.linkedin.com/groups/4852089
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  - https://www.linkedin.com/groups/4852089
  - https://www.slideshare.net/ArnoldvandenHurk
  - https://twitter.com/R4mining