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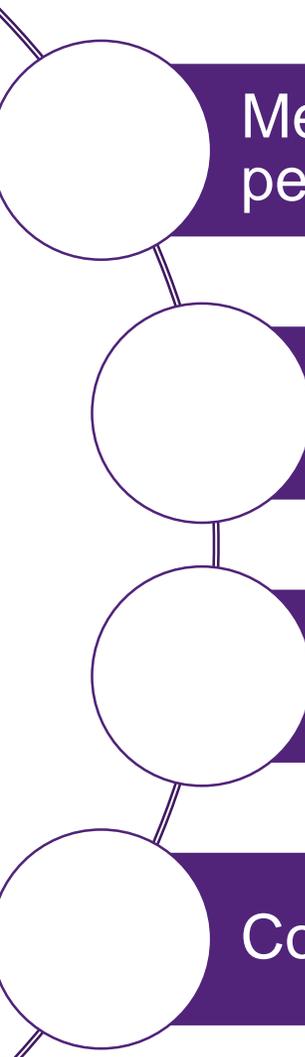
CREATE CHANGE

# Benchmarking comminution energy consumption with Energy Curves

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Sustainable Minerals Institute, University of Queensland

# The origin of Energy Curves – the CEEC roadmap 2012



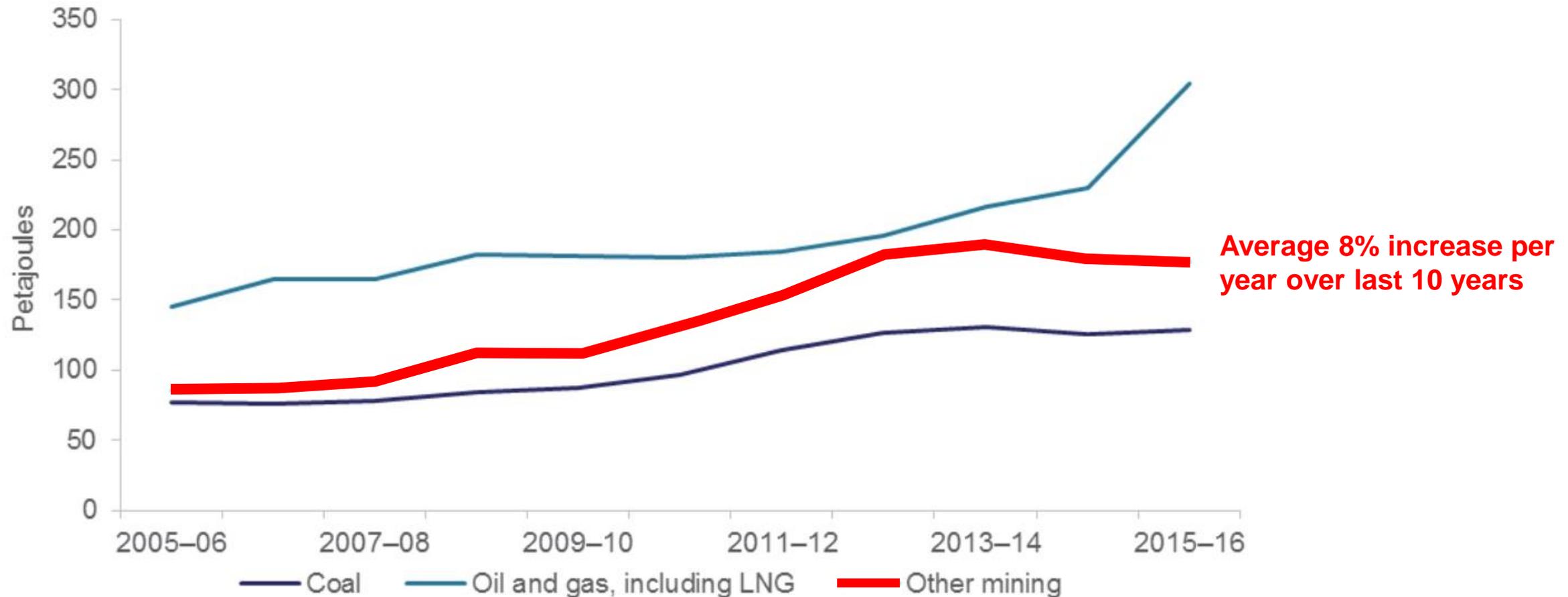
Measure performance and produce **benchmarks** that allow energy efficiency performance to be quantified and evaluated, including a 4-star energy rating.

Adopt best practice in technology.

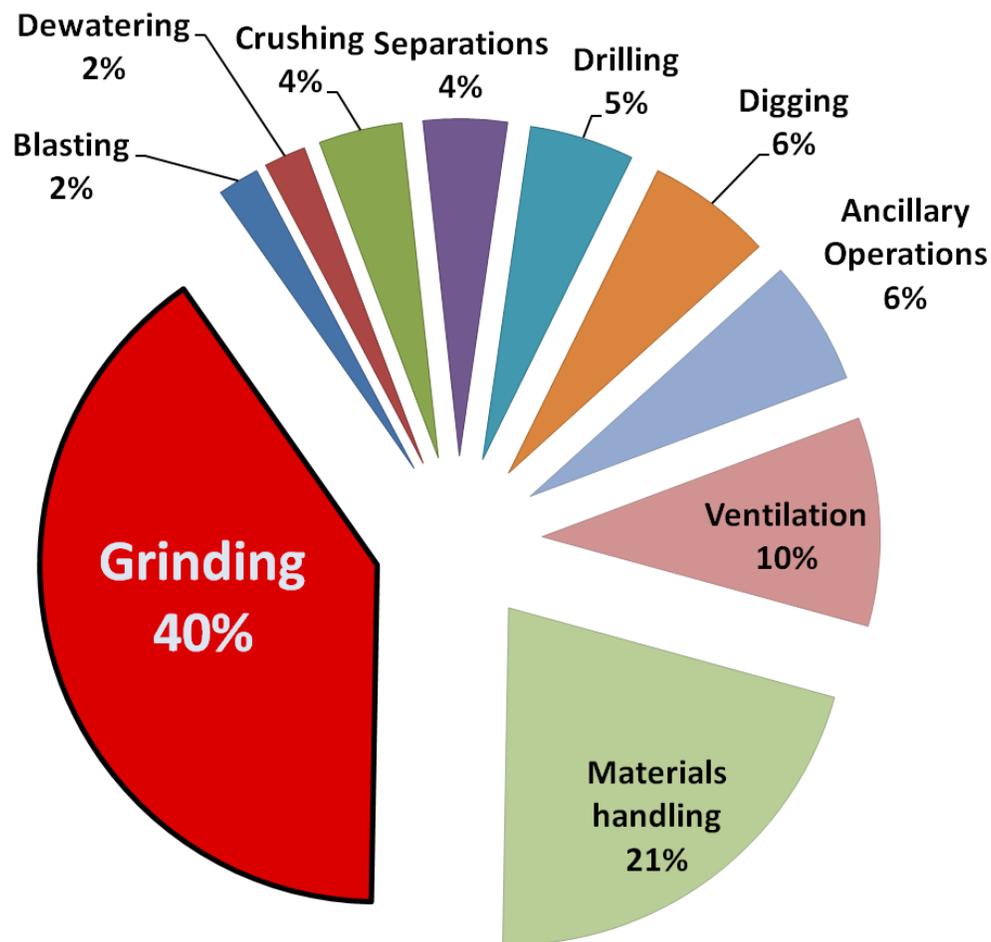
Identify and implement appropriate business drivers and KPIs.

Communicate the benefits, motivate, engage and train.

# Energy use in mining in Australia



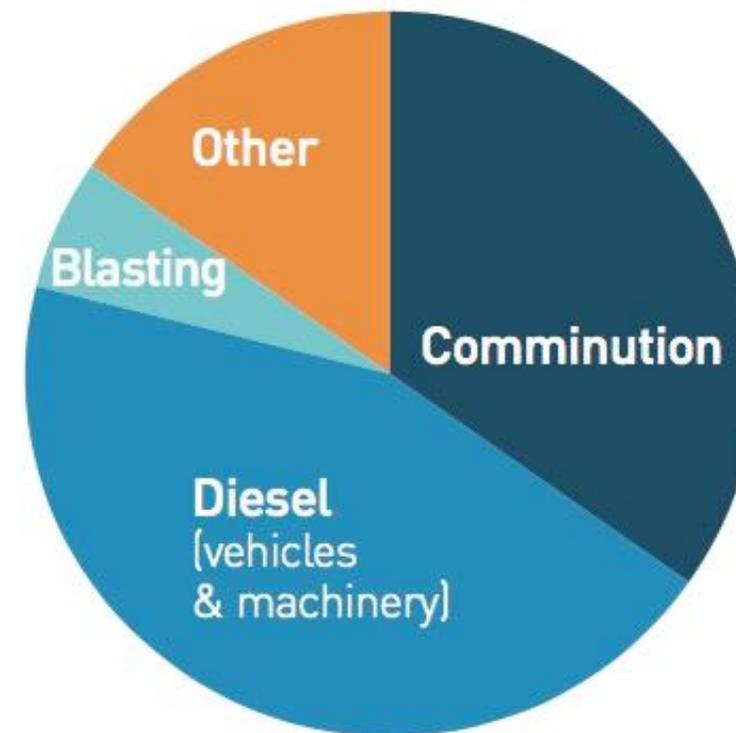
# Energy usage in comminution



US Dept of Energy, 2008, Mining Industry Energy Bandwidth Study

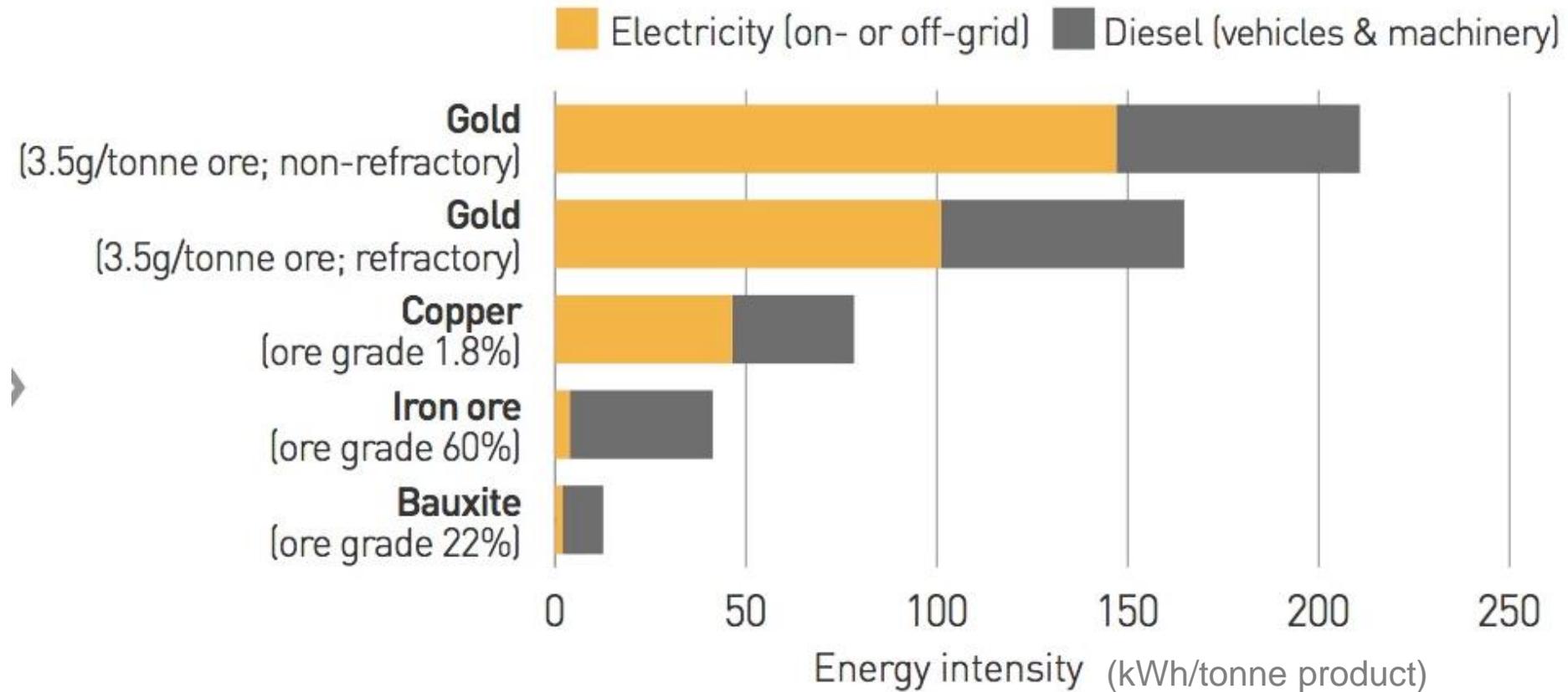
## Metals

54.5 kWh/tonne product

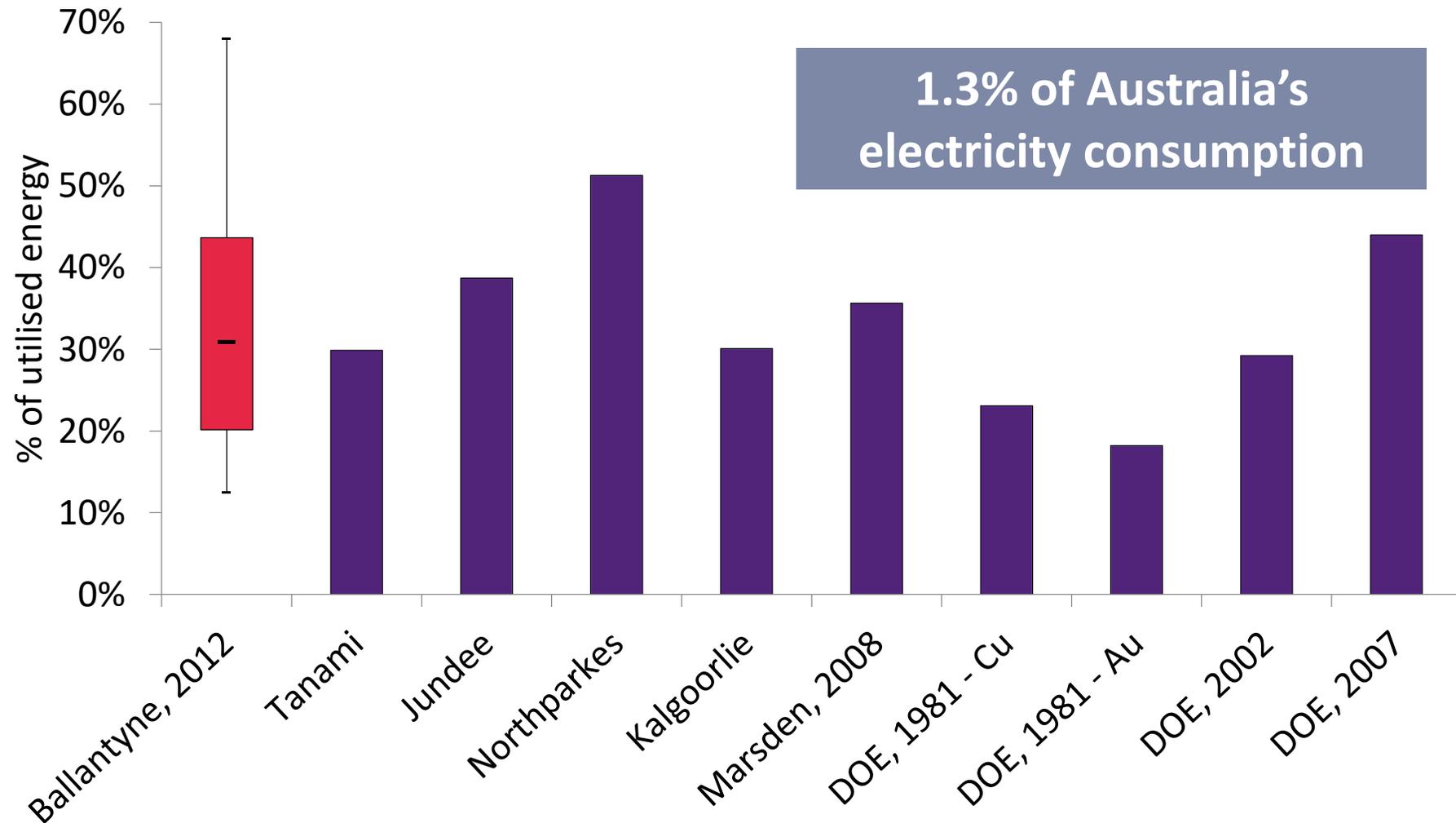


Sunshift/ARENA, 2017, Renewable energy in the Australian mining sector (<https://arena.gov.au/assets/2017/11/renewable-energy-in-the-australian-mining-sector.pdf>)

# Energy intensity in comminution



# Energy attributable to comminution in copper and gold mining



# Energy attributable to comminution

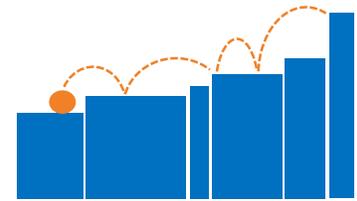
**2%** of U.S. electrical power - (DOE, 1981)

**3.3%** of the world's electrical energy and **1.3%** of the electrical energy of the United States was consumed by crushing and grinding in 1976 - (Fuerstenau and Abouzeid, 2002)

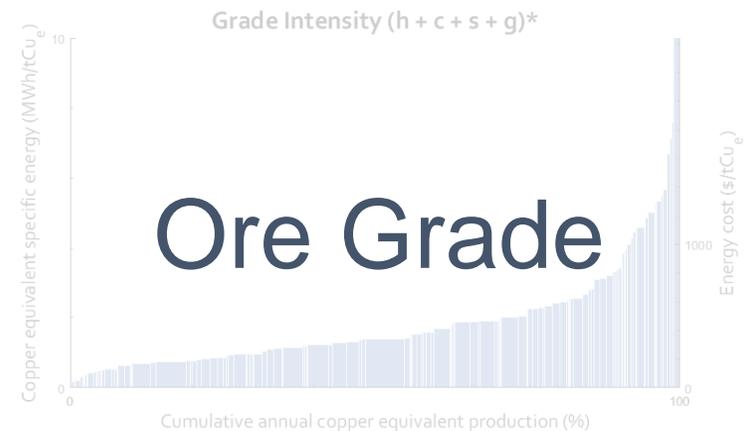
**0.39%** of United States, **1.86%** of Canadian, **1.48%** of Australian and **1.8%** of South African national energy consumption – (Tromans, 2008)

**0.56%** of the total global electrical consumption – (Daniel and Lewis-Gray, 2011)

# Energy Curves – a benchmarking tool



- Developed at JKMRRC by Dr Grant Ballantyne
- Research sponsored by the Coalition for Eco-Efficient Comminution

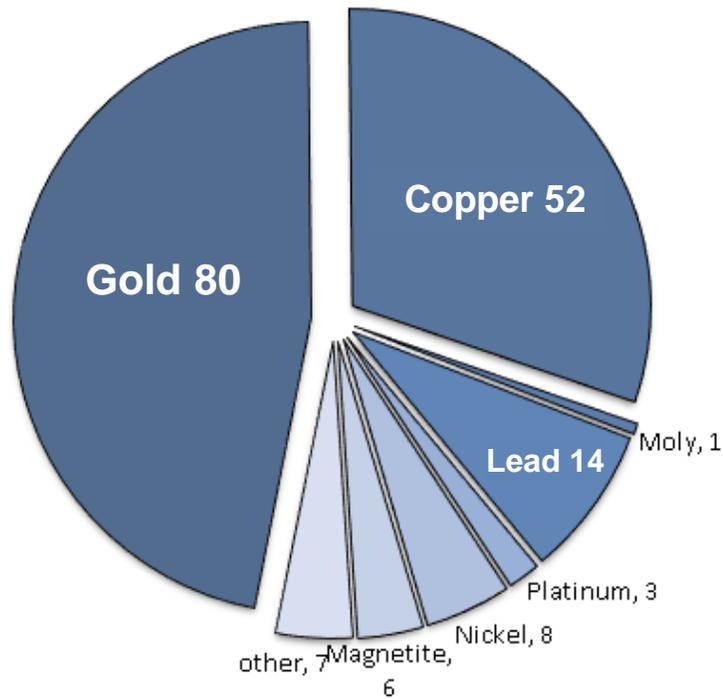


as at 26-Sep-2017

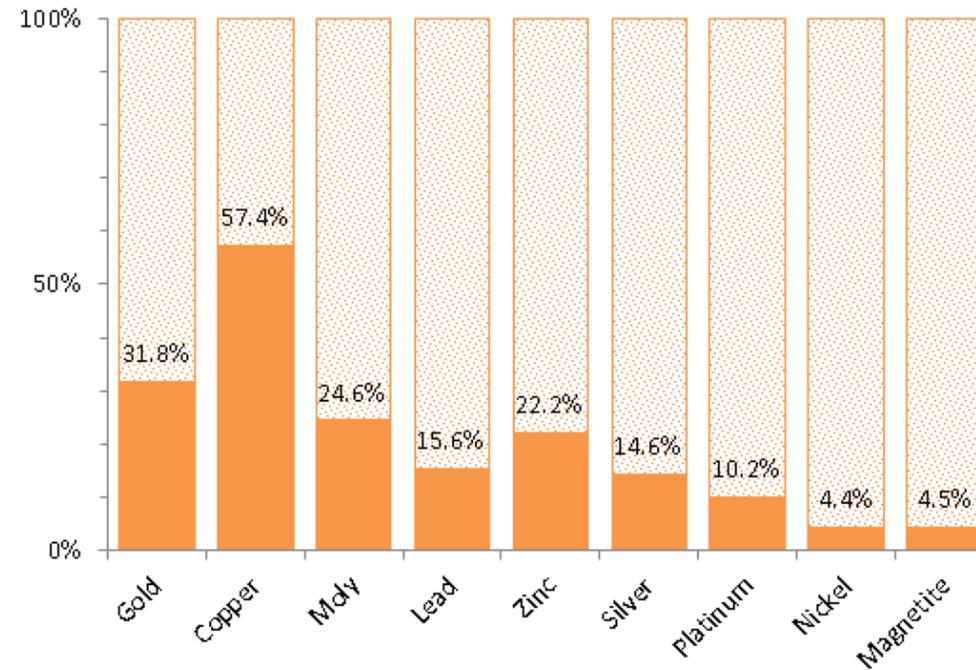
\* (hardness + circuit + size + grade)

# The Energy Curves database

Number of mines by commodity

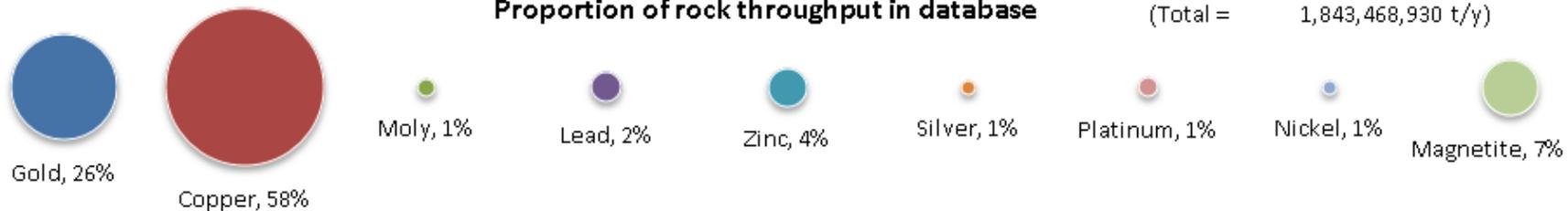


Proportion of global production in database



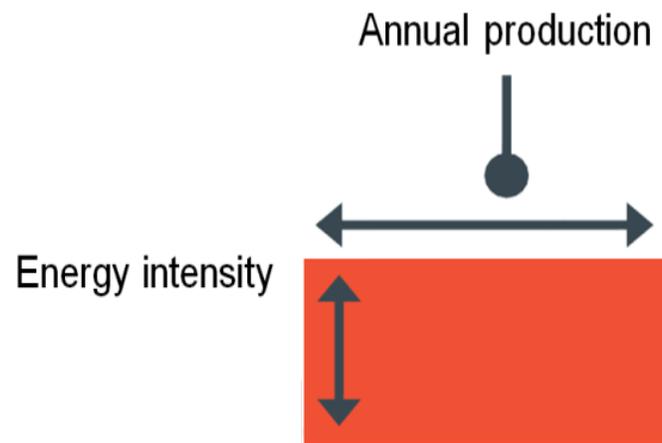
Proportion of rock throughput in database

(Total = 1,843,468,930 t/y)

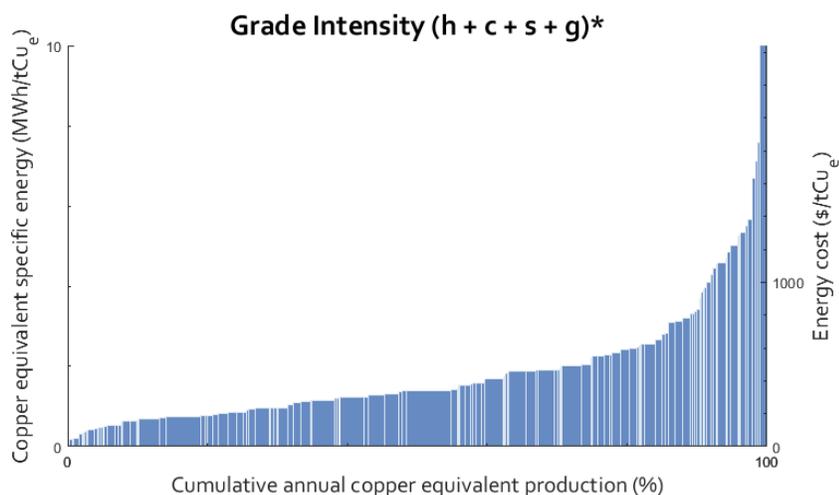
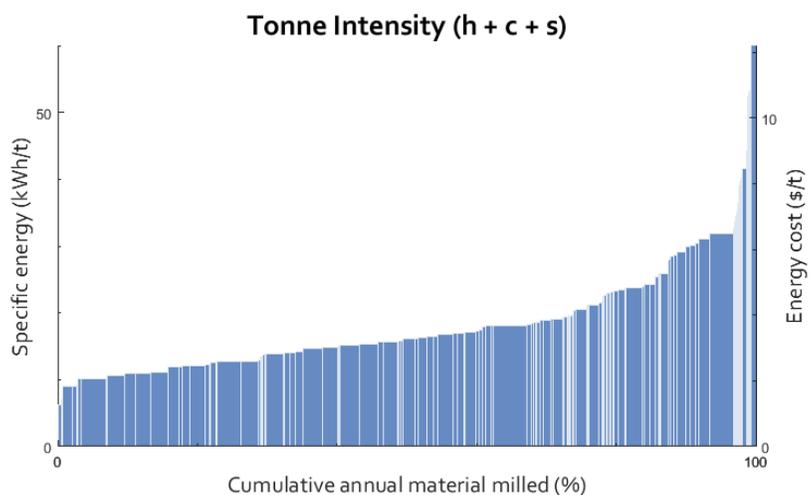
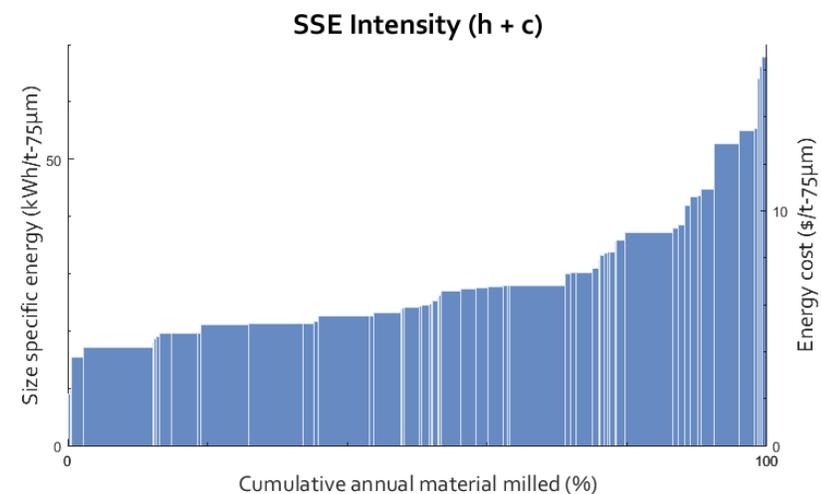
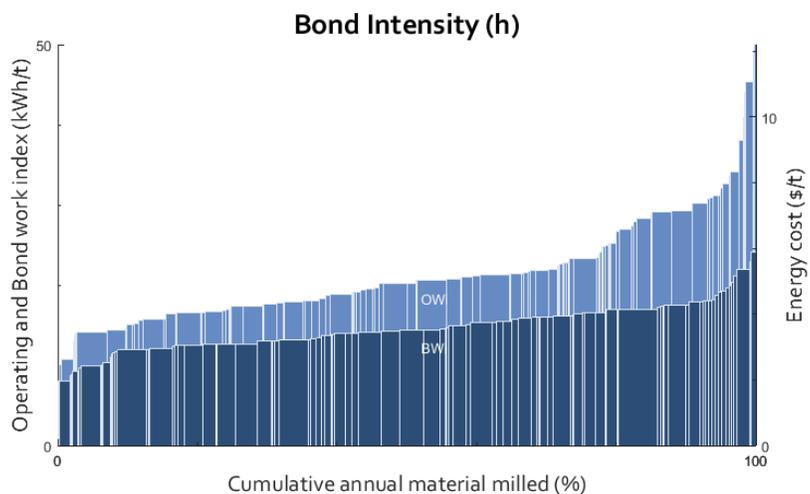


# Energy Curves methodology

Mines sorted by increasing energy intensity

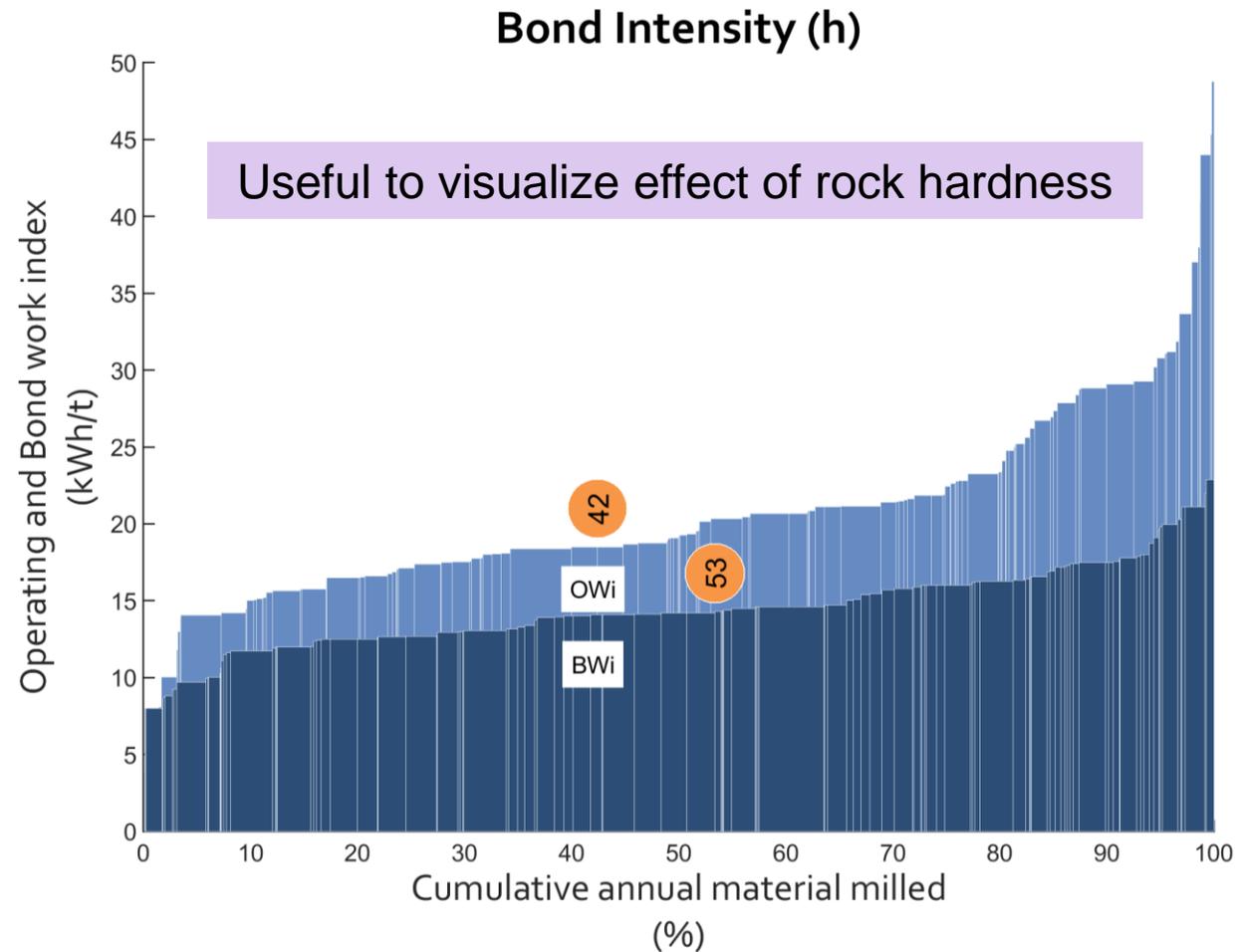


# Standard suite of Energy Curves

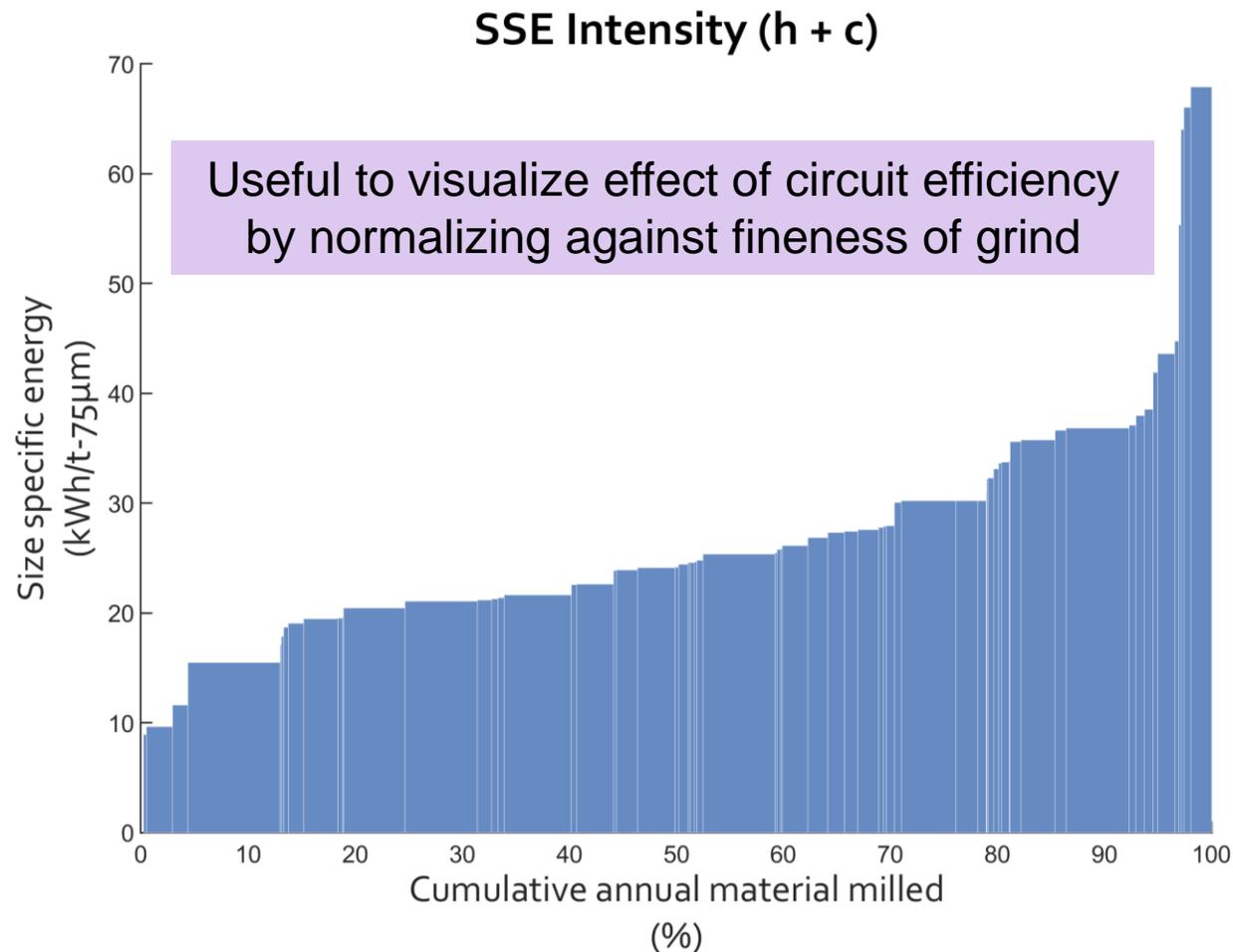


\* (hardness + circuit + size + grade)

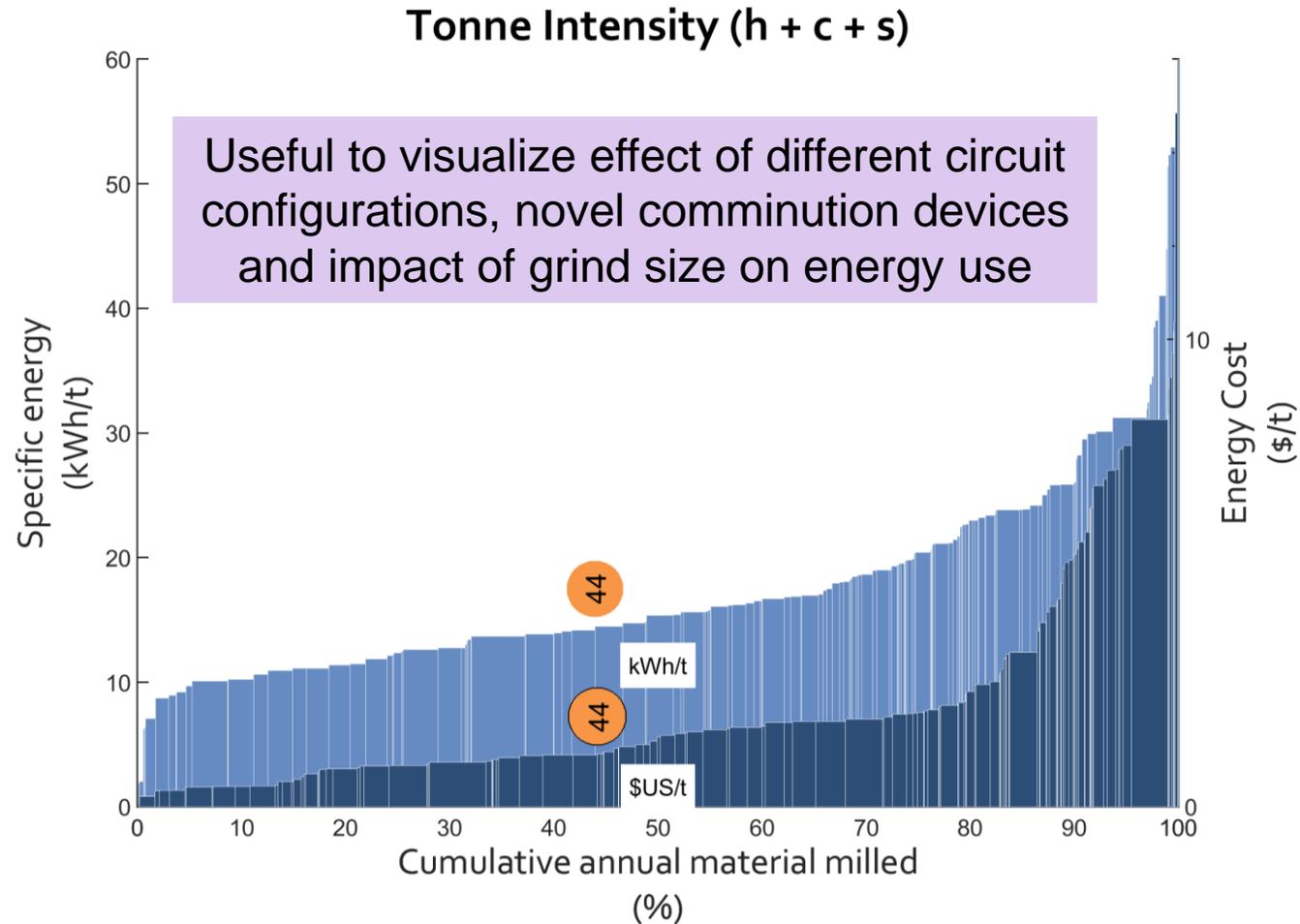
# Energy Curves – Work Index



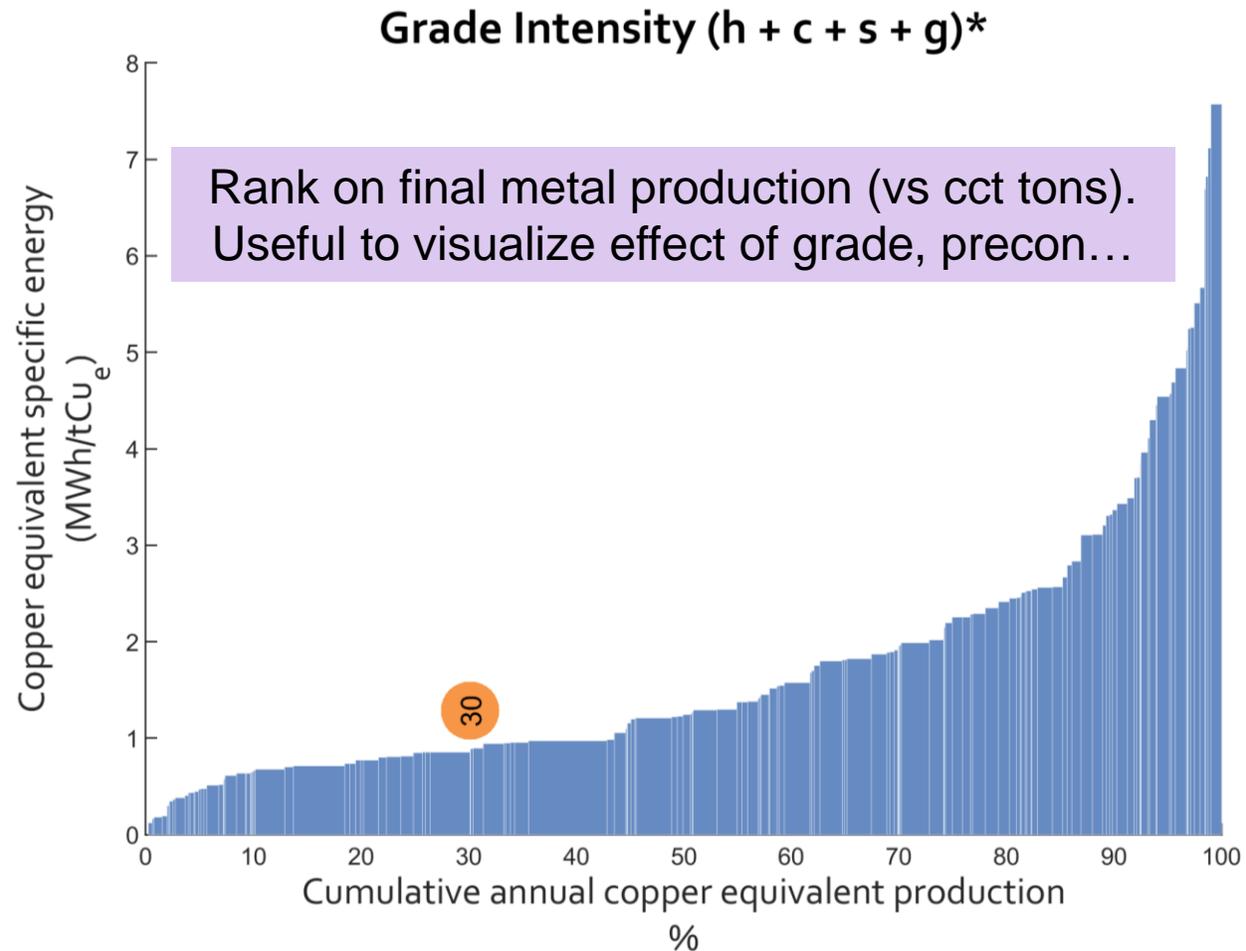
# Energy Curves – Size Specific Energy Intensity



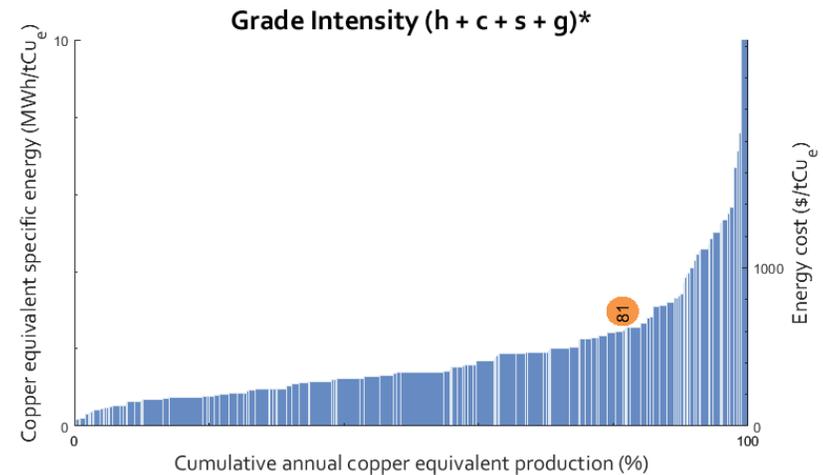
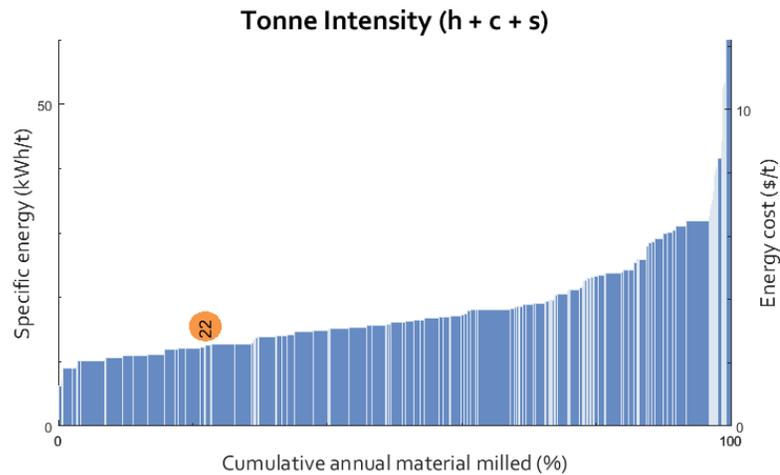
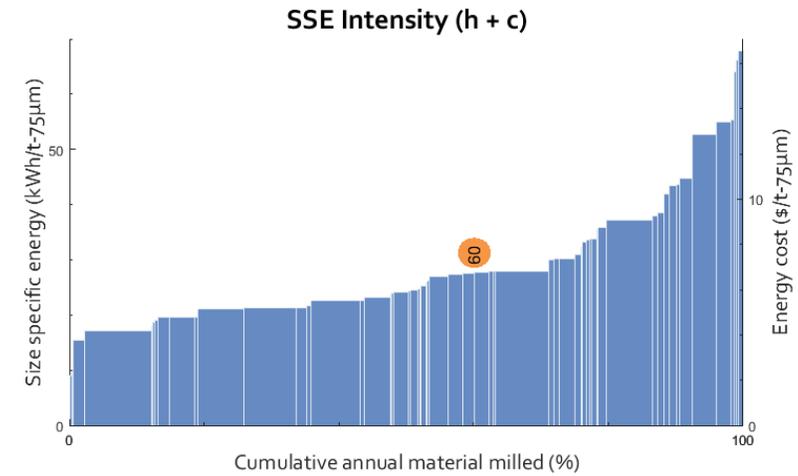
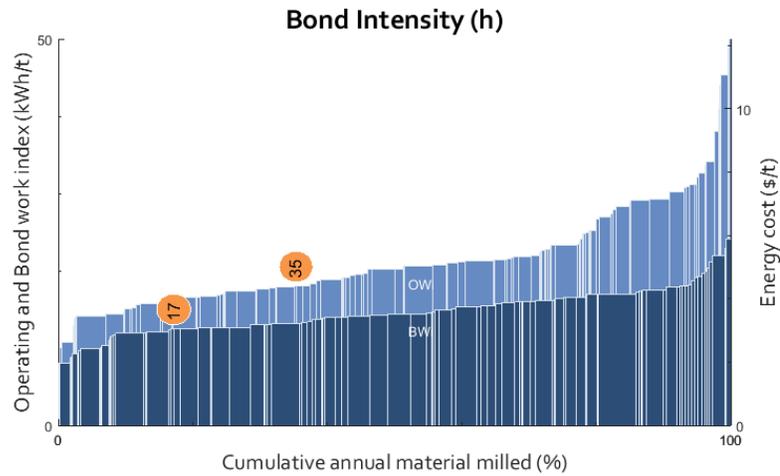
# Energy Curves – Tonne Intensity



# Energy Curves – Grade Intensity



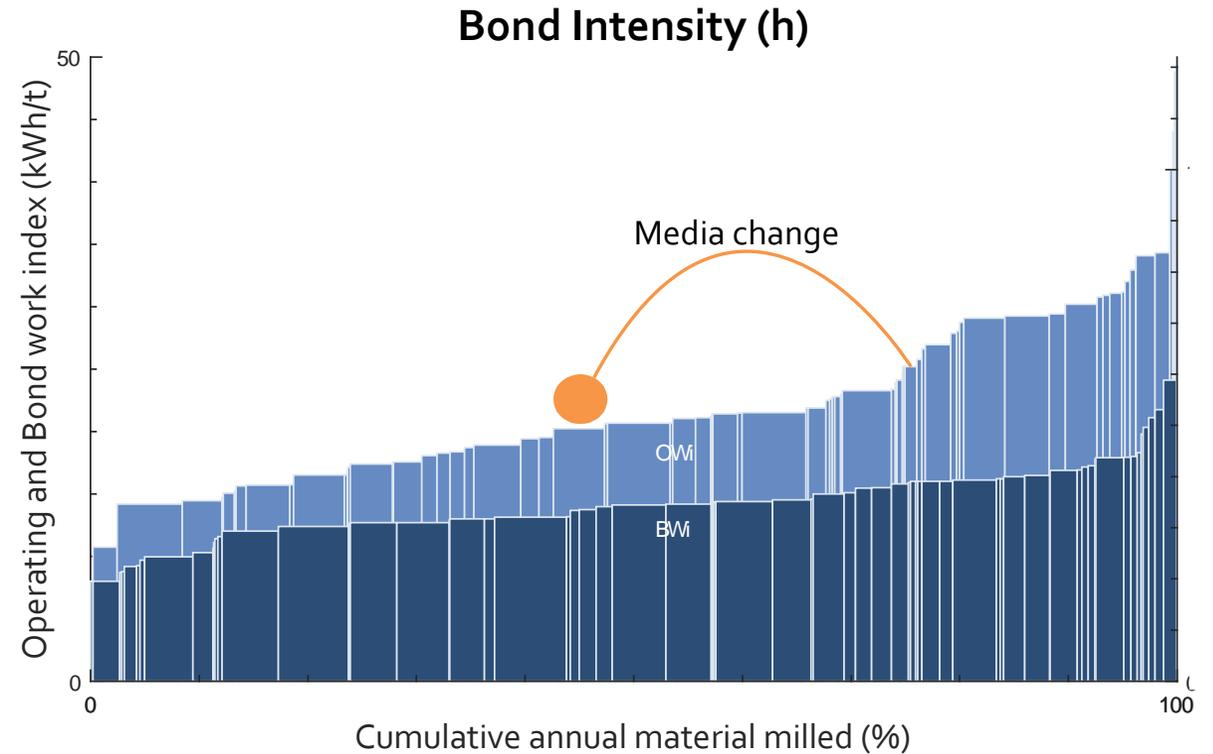
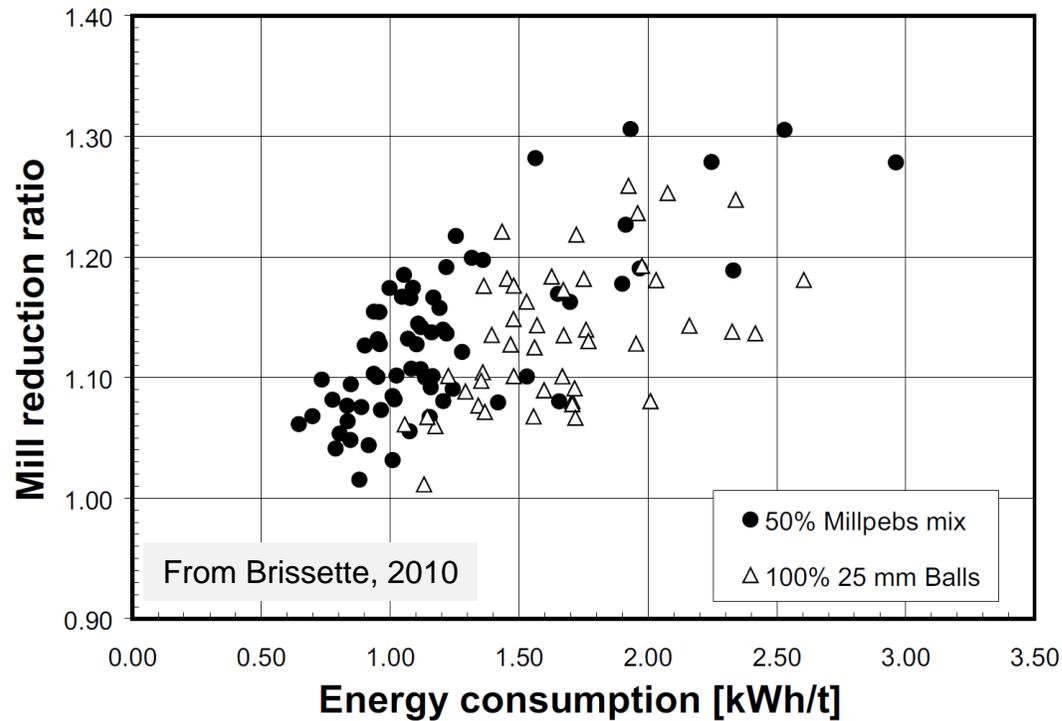
# Benchmarking for individual clients



\* (hardness + circuit + size + grade)

# Using the Energy Curves – an example

Assess the effect of changing grinding media



# Recent enhancements to the Energy Curves

- Consider energy consumption of ancillary equipment such as conveyors and pumps
- Incorporate embodied energy of consumables e.g. steel grinding media
- Assess the impact of individual equipment, as well as entire circuits
- Develop a calibration factor for fine grinding to obtain an equivalent SSE75
- Consider mineral liberation alongside grind size
- Assess the most appropriate method to compare disparate commodities in one set of energy curves
- Incorporate blasting energy and fragmentation

# How to access the Energy Curves program

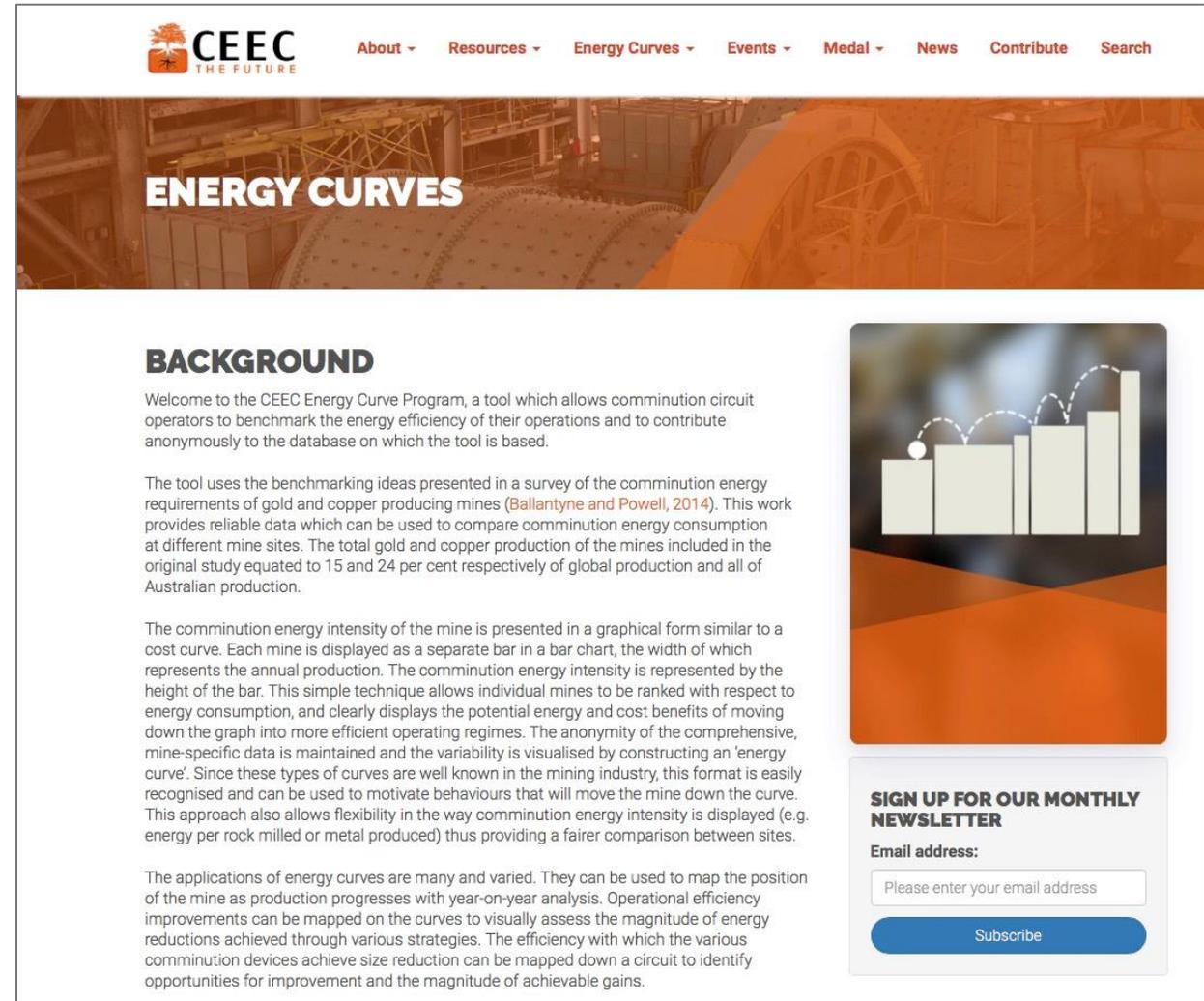
Follow link on the CEEC website

[www.ceecthefuture.org](http://www.ceecthefuture.org)

OR

Email JKMRC's Energy Curve team

[energy.curves@uq.edu.au](mailto:energy.curves@uq.edu.au)



The screenshot shows the CEEC website header with navigation links: About, Resources, Energy Curves, Events, Medal, News, Contribute, and Search. The main heading is "ENERGY CURVES".

### BACKGROUND

Welcome to the CEEC Energy Curve Program, a tool which allows comminution circuit operators to benchmark the energy efficiency of their operations and to contribute anonymously to the database on which the tool is based.

The tool uses the benchmarking ideas presented in a survey of the comminution energy requirements of gold and copper producing mines (Ballantyne and Powell, 2014). This work provides reliable data which can be used to compare comminution energy consumption at different mine sites. The total gold and copper production of the mines included in the original study equated to 15 and 24 per cent respectively of global production and all of Australian production.

The comminution energy intensity of the mine is presented in a graphical form similar to a cost curve. Each mine is displayed as a separate bar in a bar chart, the width of which represents the annual production. The comminution energy intensity is represented by the height of the bar. This simple technique allows individual mines to be ranked with respect to energy consumption, and clearly displays the potential energy and cost benefits of moving down the graph into more efficient operating regimes. The anonymity of the comprehensive, mine-specific data is maintained and the variability is visualised by constructing an 'energy curve'. Since these types of curves are well known in the mining industry, this format is easily recognised and can be used to motivate behaviours that will move the mine down the curve. This approach also allows flexibility in the way comminution energy intensity is displayed (e.g. energy per rock milled or metal produced) thus providing a fairer comparison between sites.

The applications of energy curves are many and varied. They can be used to map the position of the mine as production progresses with year-on-year analysis. Operational efficiency improvements can be mapped on the curves to visually assess the magnitude of energy reductions achieved through various strategies. The efficiency with which the various comminution devices achieve size reduction can be mapped down a circuit to identify opportunities for improvement and the magnitude of achievable gains.

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