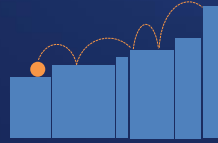


Comminution Energy Curves

Dr Grant Ballantyne



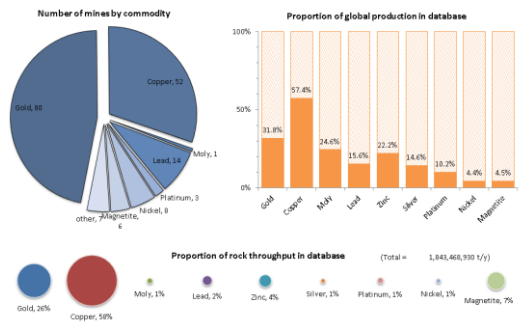
Schedule

Time	Activity
2:30	Joe Pease: introduction context setting
2:45	Grant Ballantyne: Introduction to Energy curves
3:00	Efficiency measures discussion
3:15	Grant Ballantyne: Comminution Energy Cost
3:30	Taking advantage energy price estimate
3:45	Grant Ballantyne: Different commodities
3:50	Grant Ballantyne: Ancillary equipment
3:55	Grant Ballantyne: Embodied energy
4:00	Case studies
4:30	Final remarks

Energy future

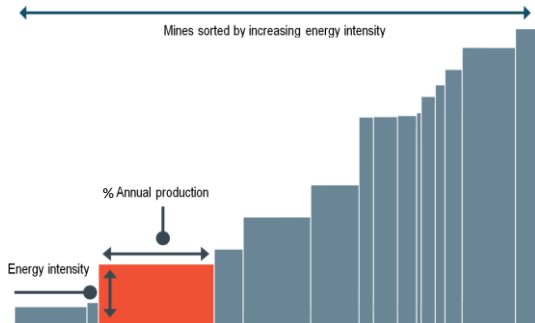


Comminution Energy Curves

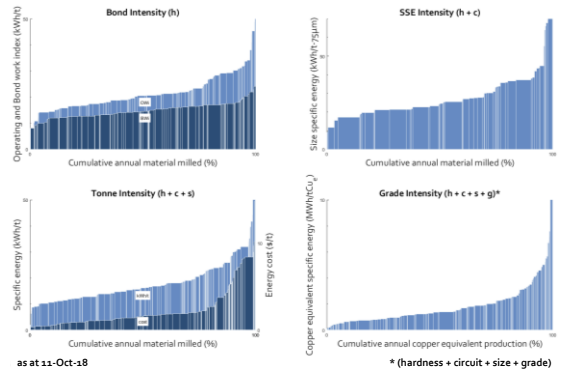


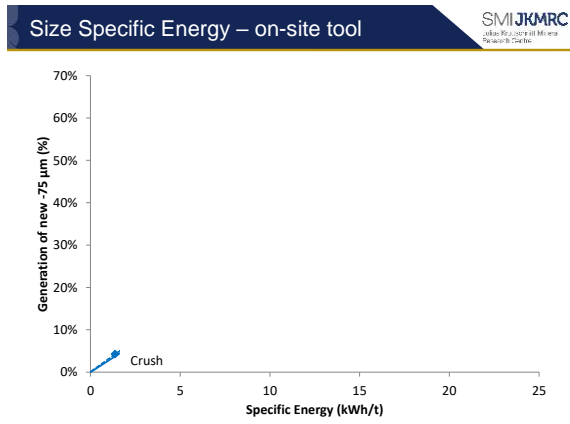
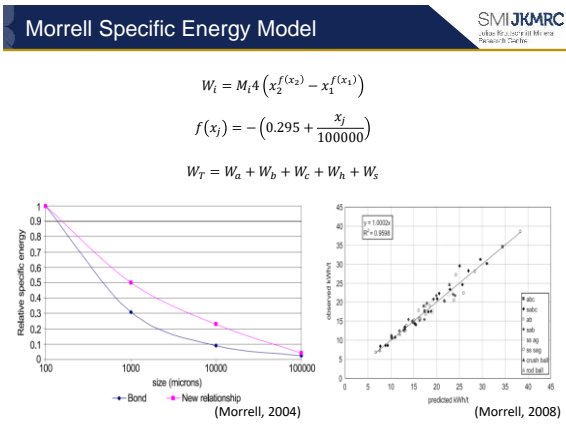
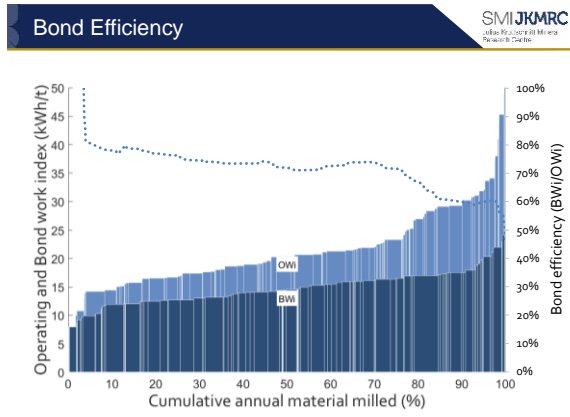
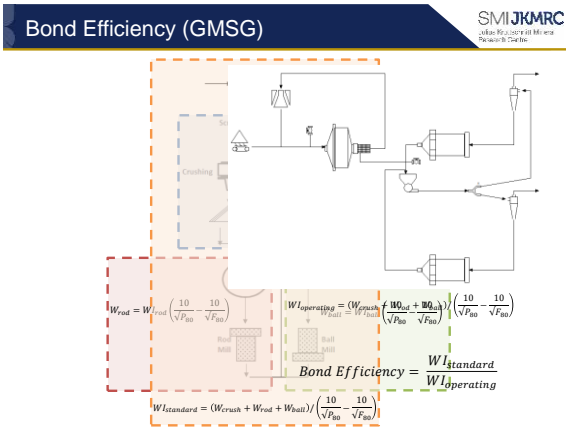
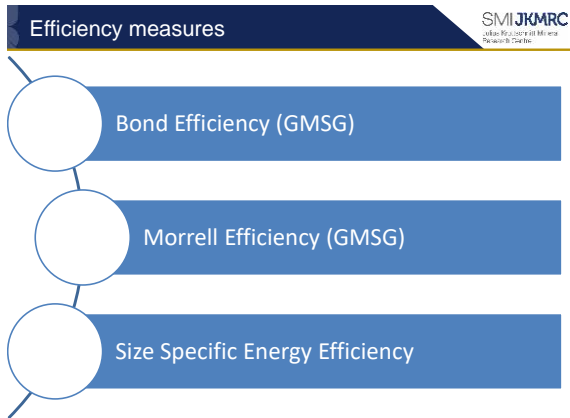
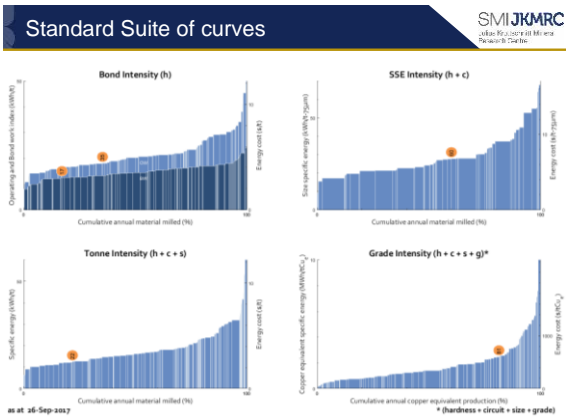
As at 23-Aug-2018

Energy benchmarking methodology (cost curve)



Standard Suite of curves

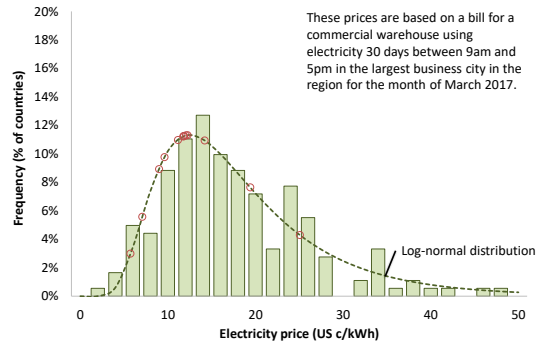




Comminution Energy Cost

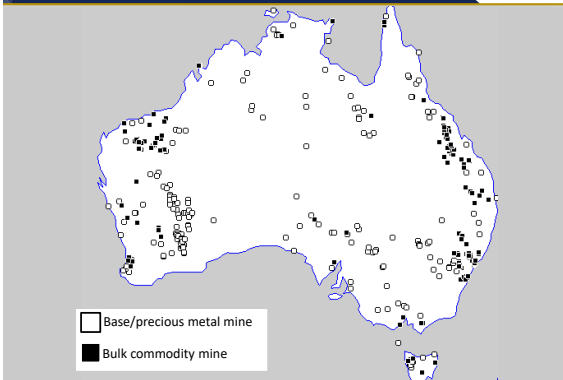


Inter-country electricity price variability

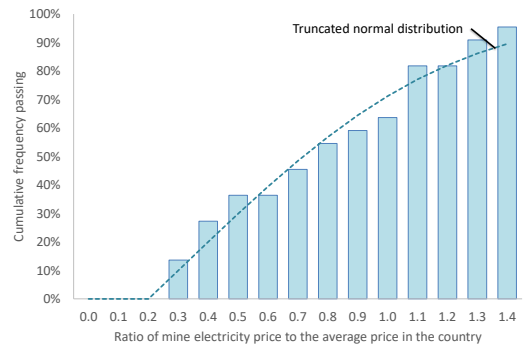


World Bank, 2017, Doing Business - Getting Electricity, www.doingbusiness.com and World Atlas, 2017, Top gold/copper producing countries in the world, <http://www.worldatlas.com>

Intra-country electricity price variability

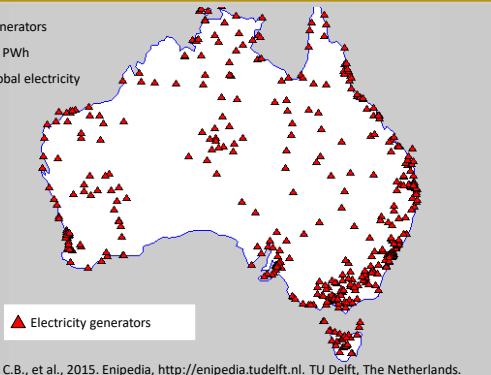


Intra-country electricity price variability



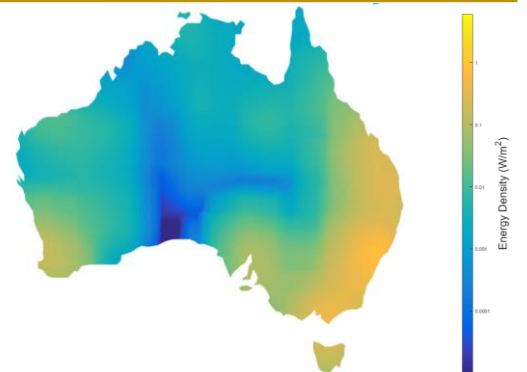
Electricity generators database

54,290 generators
Total 19.7 PWh
90% of global electricity



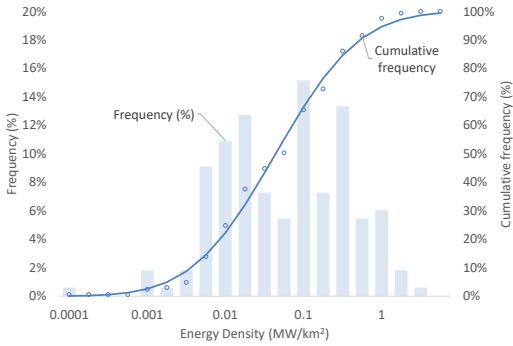
Davis, C.B., et al., 2015. Enipedia, <http://enipedia.tudelft.nl>. TU Delft, The Netherlands.

Energy Density



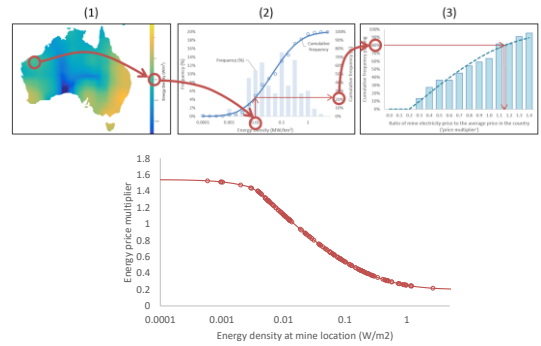
Energy density at mine locations

SMIJKMRC
Julian R. Young & Associates
Research Centre



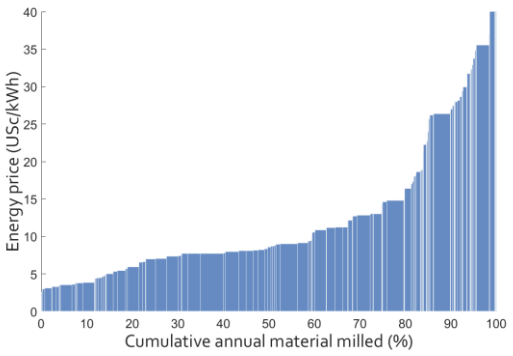
Electricity price multiplier calculation

SMIJKMRC
Julian R. Young & Associates
Research Centre



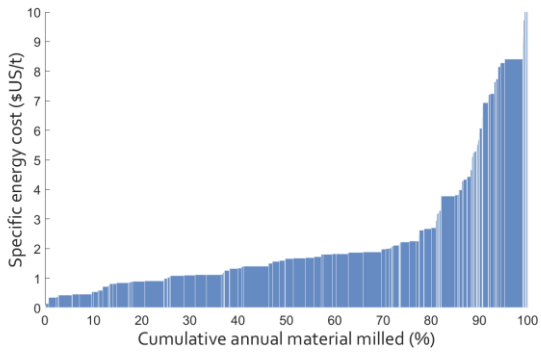
Energy price energy curve

SMIJKMRC
Julian R. Young & Associates
Research Centre



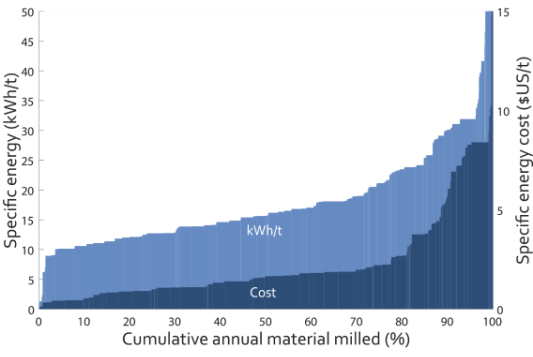
Cost Intensity Energy Curve

SMIJKMRC
Julian R. Young & Associates
Research Centre



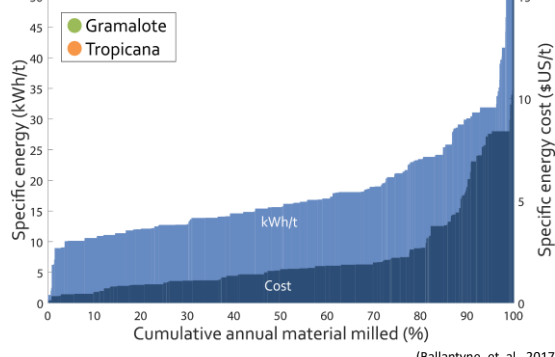
Cost Intensity Energy Curve

SMIJKMRC
Julian R. Young & Associates
Research Centre



Case Study – Gramalote vs Tropicana

SMIJKMRC
Julian R. Young & Associates
Research Centre

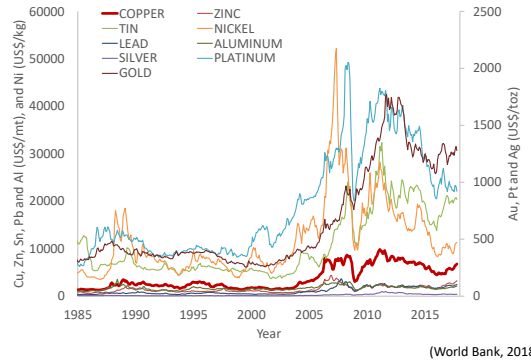


(Ballantyne, et. al., 2017)

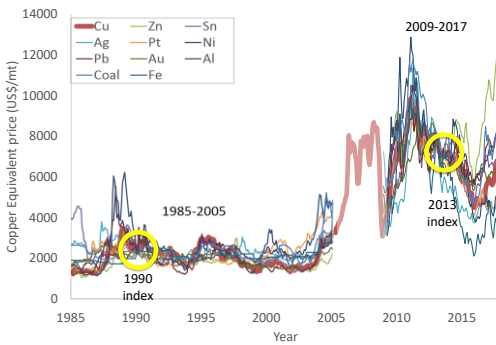
Comparing disparate commodities in a fair and equitable manner



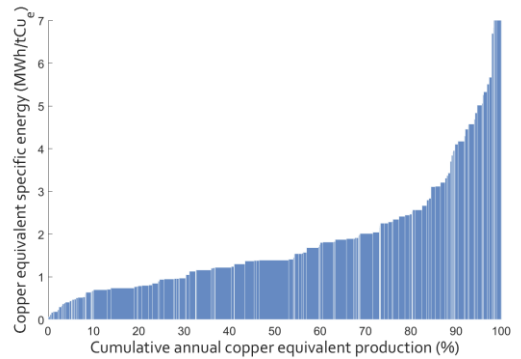
Commodity prices



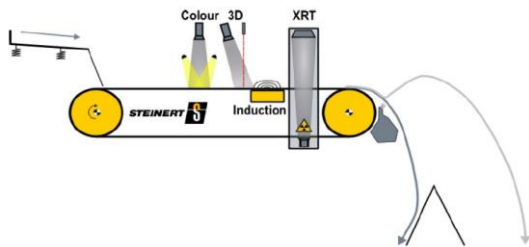
Copper equivalent price



Copper equivalent energy curve

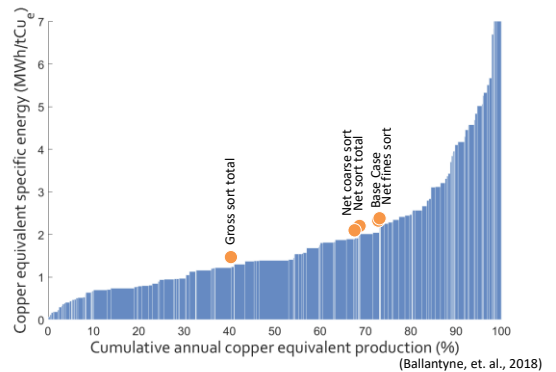


Case study: sorting

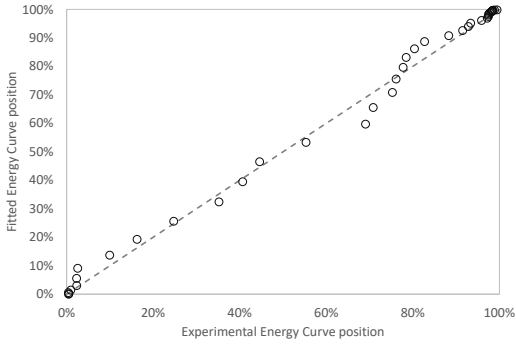


(Ballantyne, et. al., 2018)

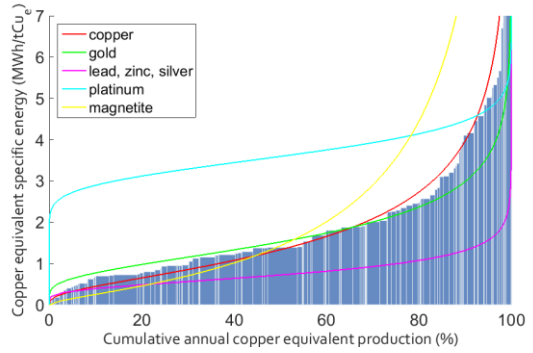
Case study: sorting



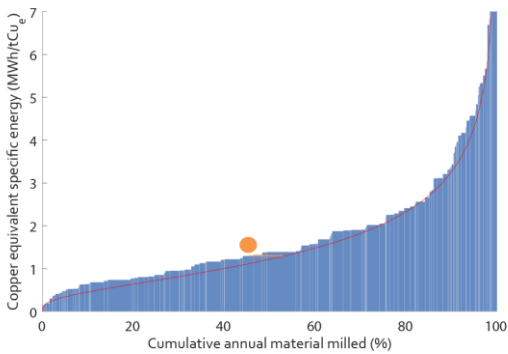
Log-normal function fit



Isolated commodities

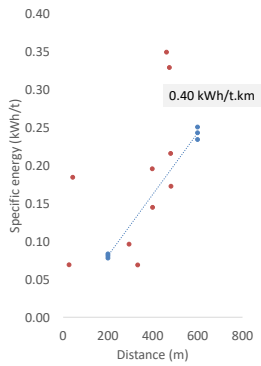


Example of visualisation



Including the power consumption of ancillary equipment like pumps and conveyors in the Comminution Energy Curves

Conveyor power calculations



Aerial imaging



Pumping power calculation

SMIJKMRC
Julius Kruttschnitt Mineral Research Centre


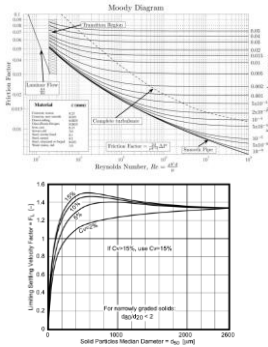
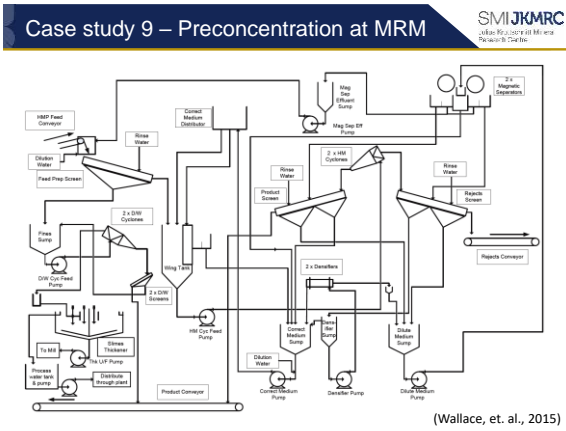
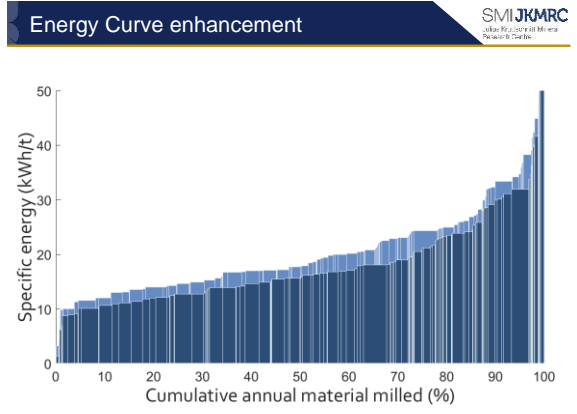
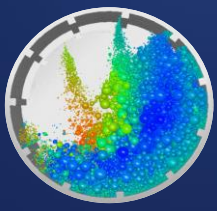



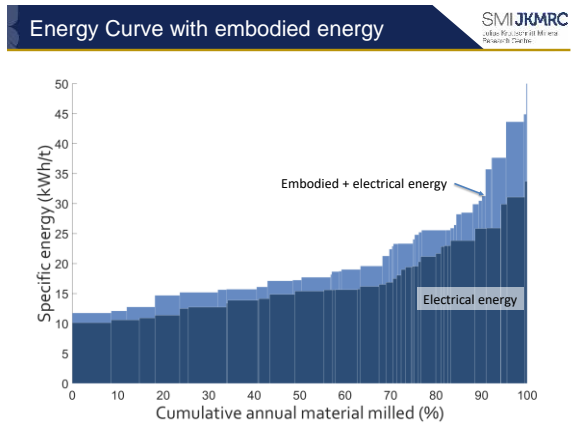
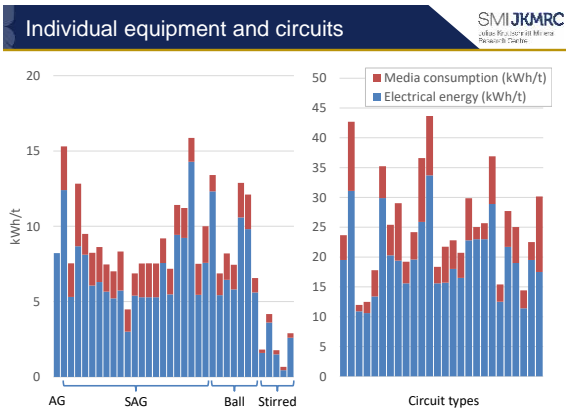
Fig. 7.1 – Durand's limiting settling Velocity graph



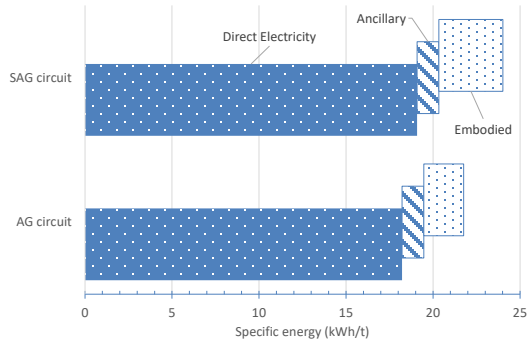
SMIJKMRC
Julius Kruttschnitt Mineral Research Centre



Including embodied energy of the grinding media in the tonne intensity curve



Case Study 10 – Cadia



Next steps



- Energy Cost
- Ancillary energy
- Commodity Curves
- Embodied Energy
- Circuit Types
- Calibrate Fine Grinding
- Liberation & Recovery
- Blasting Impact
- Global Hardness Approach



Case studies



Which energy curve to use?	$\text{Specific Energy} = \frac{(W_{crush} + W_{grind} + W_{sag} + W_{ball} + W_{leach})}{\text{throughput (t/h)}}$
How to present?	$W_{operating} = \text{Specific Energy} / \left(\frac{10}{\sqrt{P_{10}}} - \frac{10}{\sqrt{P_{80}}} \right)$
What other data is required?	$SSE = \frac{\text{Specific Energy}}{\% - 75\mu\text{m generated (prod - feed)}}$
How to sell internally?	$C_{Cu, production} = \frac{Au_{production} \times Au_{price} + Cu_{production} \times Cu_{price}}{Cu_{price}}$
How to sell externally?	$kWh/t_{Cu,eq} = \frac{(W_{total}) \times 365 \times 24 \times \text{utilisation}}{\text{annual } Cu_{production}}$
How to implement?	