And the Saga Continues for Capital Cost Overruns in the Mining Industry

MMSA

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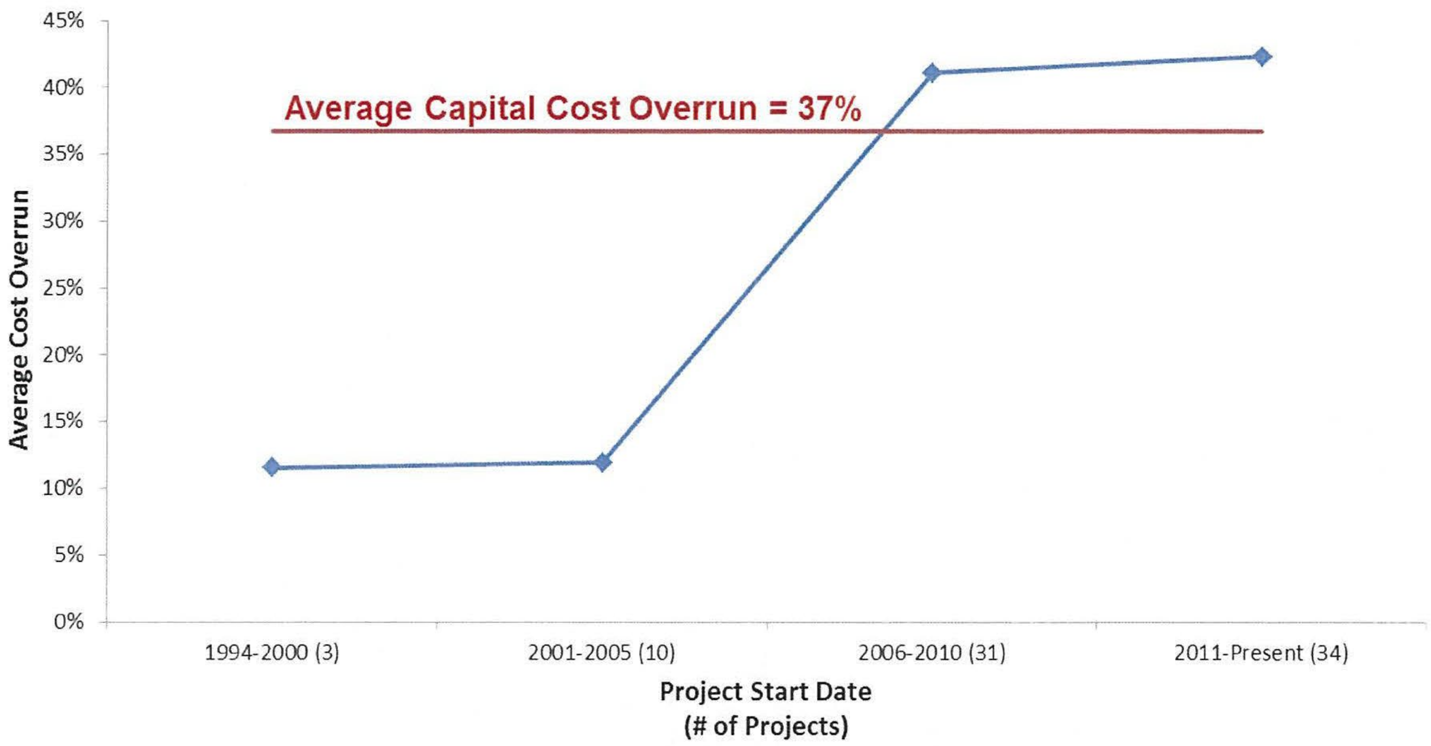
PRESENTATION OBJECTIVES

RECAP HISTORY OF CAPITAL COST OVERRUNS

Capital Cost Overrun Definition: The amount by which the actual construction cost of project exceeds its Engineering Study budget.

- ***Robert Merton (1988): Average Mining = 1.99; Process Plants = 1.67; Oil Refineries = 1.63.***
- ***Average Capital Cost Overrun = 60% (1.60);*** Survey of 40+ mining projects in last 10 years versus metrics stated in Feasibility Study; Only 20% of surveyed mining and metals projects were completed within parameters predicted during feasibility study. Published by McKinsey & Company, "Optimizing mining feasibility studies: The $100 billion opportunity". August 2019.
- ***Median Overrun = 1.28; Average = 1.38***; Internal study by RCF of Mining projects advancing from Feasibility Study stage through Construction based on evaluating 107 projects. Presented at SME's 7th Annual Current Trends in Mine Finance by Ross Bhappu, RCF, April 28, 2019.
- ***Average = 1.25 with Standard Deviation of 30%; of 63 projects, 44 with cost overruns, 7 with cost underruns; and 12 on-budget.*** Published in The Engineering Economist June 2008. Authored by Jasper Bertisen and Graham A. Davis.
- ***Average Cost Overrun = 1.37 (37%). Projects 2005 onwards. Budgeted capital cost of $1.2 billion – Actual capital cost of $1.6 billion.*** "Managing Capital Cost Overrun Risks in the Mining Industry," presented at 2017 AACE® International Technical Paper© (OWN.2657.2). Authored by Lwin, Tin (P.Eng.) and Jose Lazo, Export Development Bank Canada.

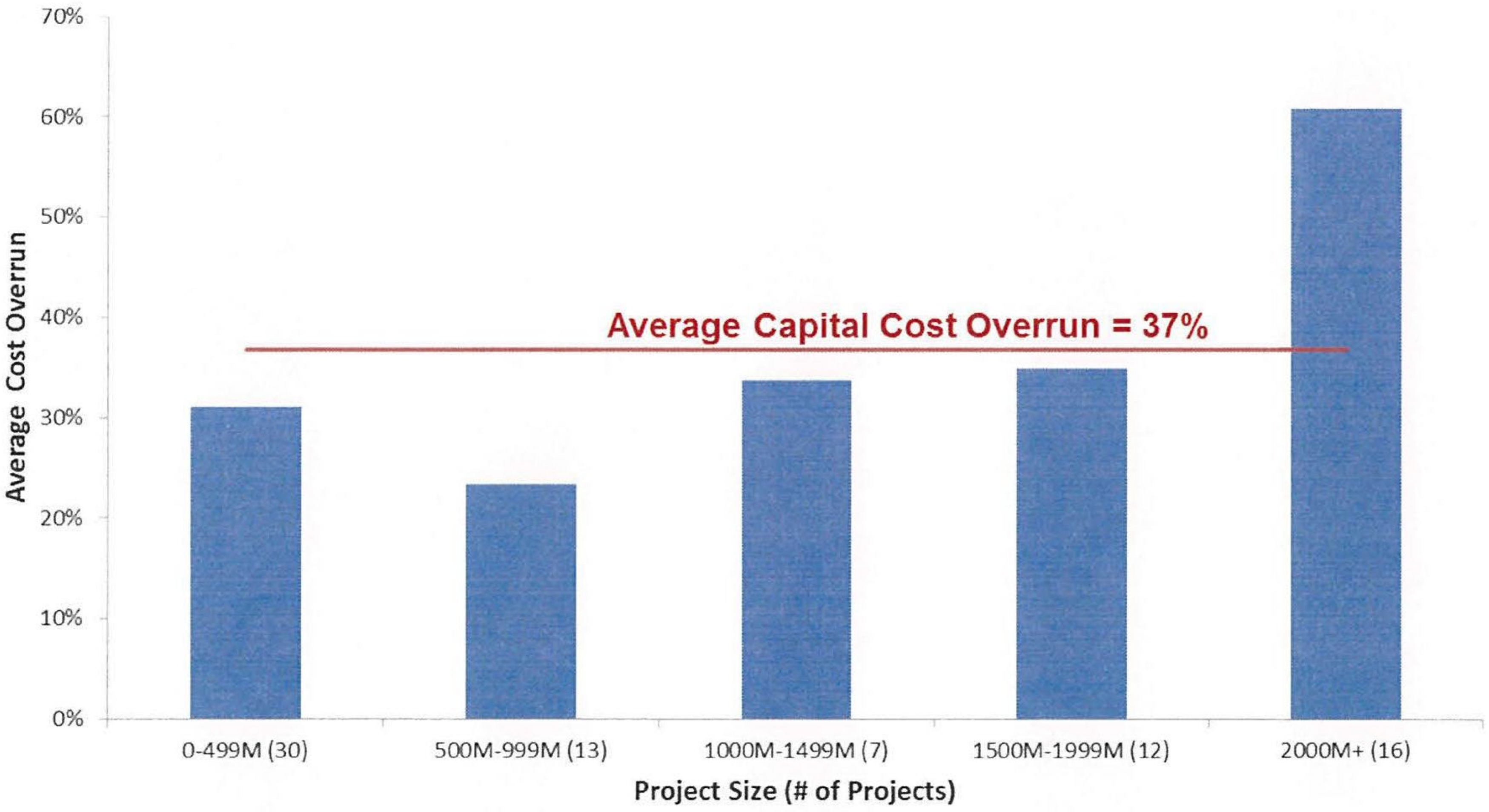
MINING PROJECT CAPITAL COST OVERRUN TREND



Post 2010 average CO growth rate is showing signs of slowing down after reaching above 40%.

Source: Lwin, Tin (P.Eng.) and Jose Lazo, “Managing Capital Cost Overrun Risks in the Mining Industry,” presented at 2017 AACE® International Technical Paper© (OWN.2657.2).

MINING PROJECT CAPITAL COST OVERRUNS BY PROJECT SIZE



Source: Lwin, Tin (P.Eng.) and Jose Lazo, "Managing Capital Cost Overrun Risks in the Mining Industry," presented at 2017 AACE® International Technical Paper© (OWN.2657.2).

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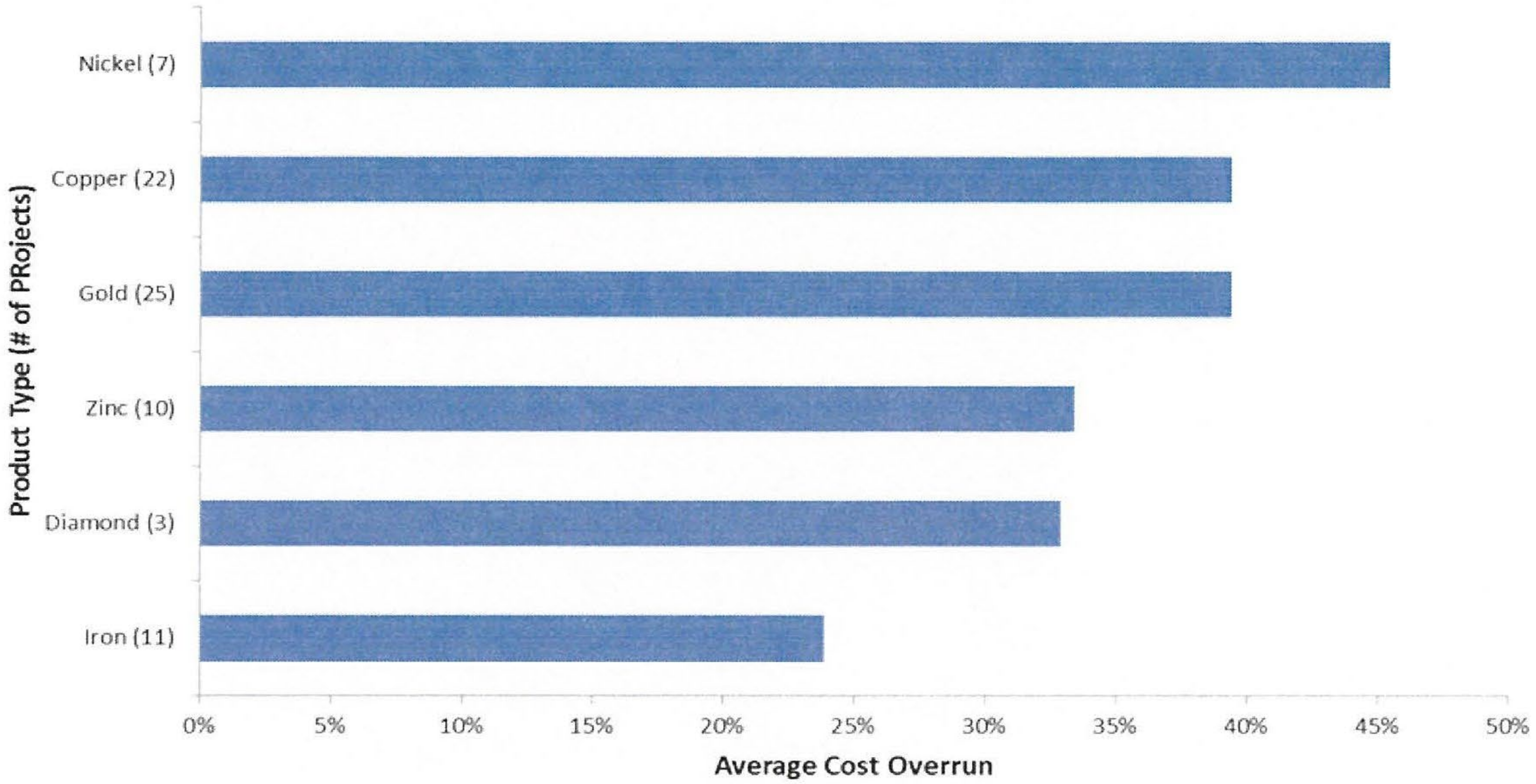
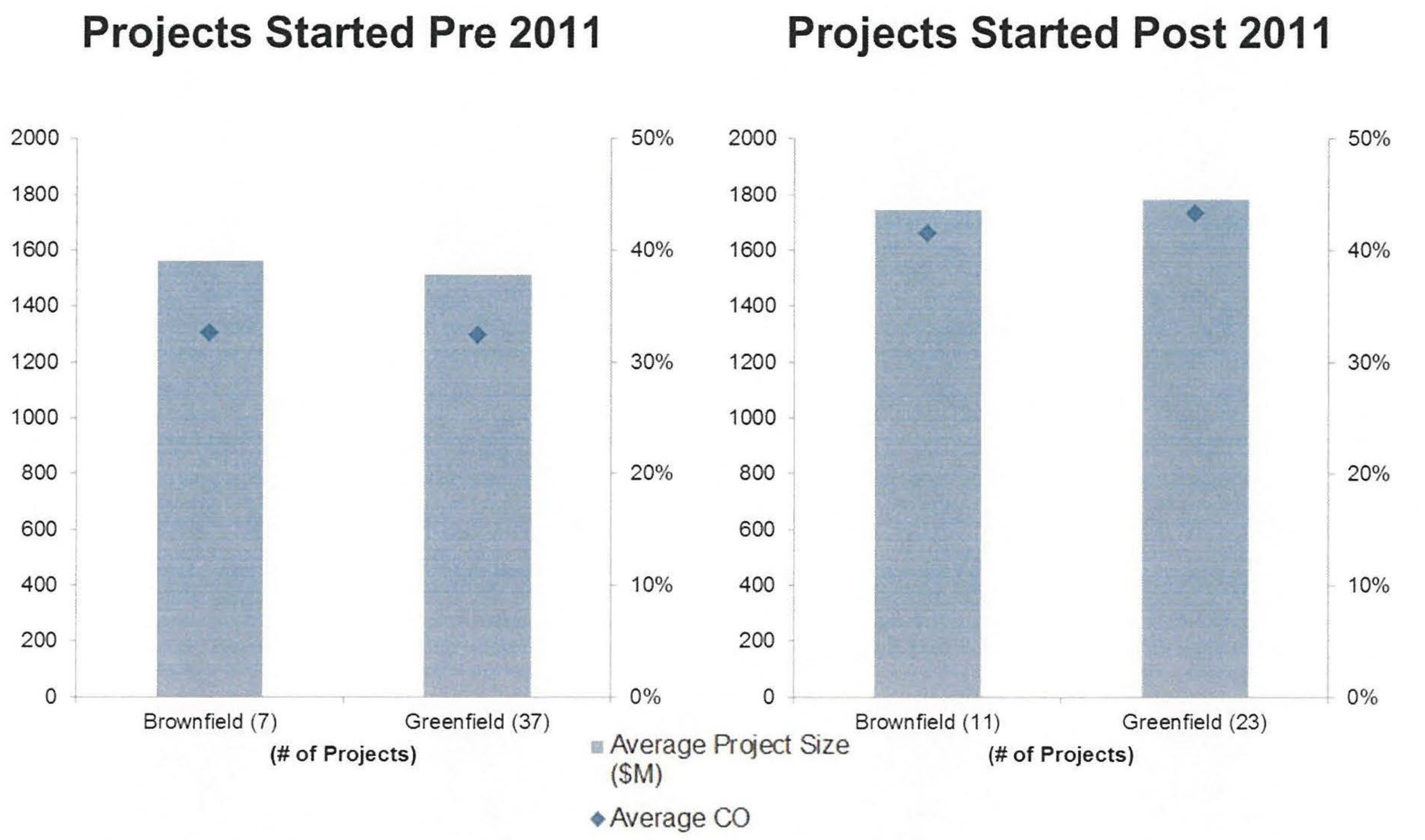
MINING PROJECT CAPITAL COST OVERRUNS BY COMMODITY TYPE



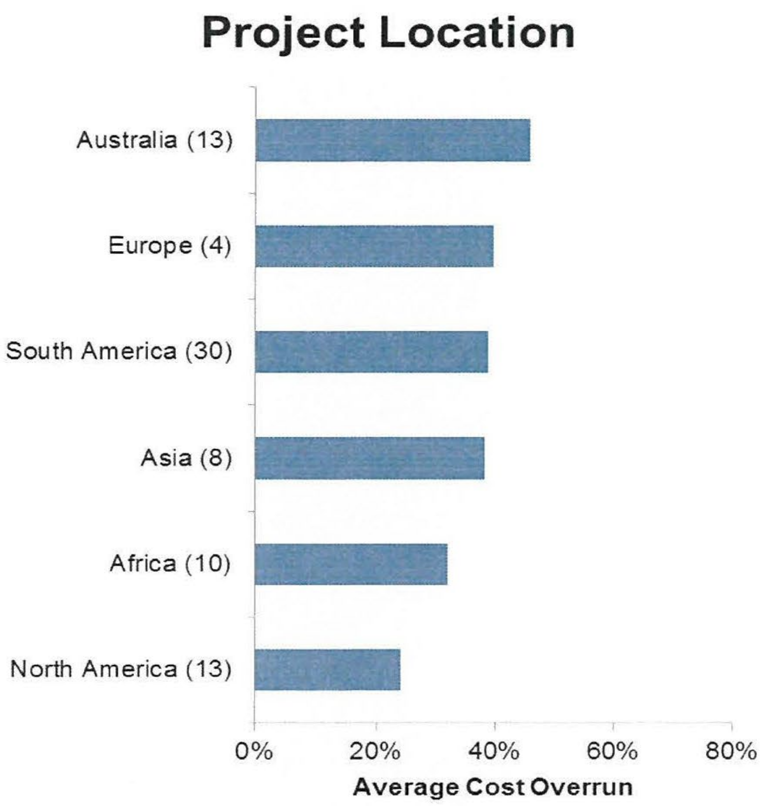
Source: Lwin, Tin (P.Eng.) and Jose Lazo, “Managing Capital Cost Overrun Risks in the Mining Industry,” presented at 2017 AACE® International Technical Paper© (OWN.2657.2).

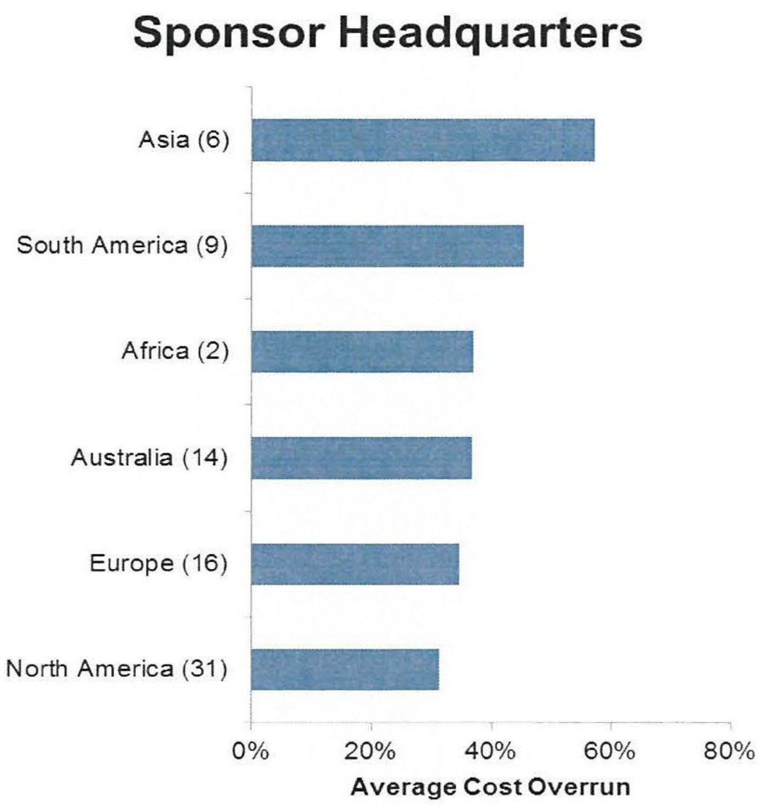
MINING PROJECT CAPITAL COST OVERRUNS BY PROJECT TYPE



Source: Lwin, Tin (P.Eng.) and Jose Lazo, "Managing Capital Cost Overrun Risks in the Mining Industry," presented at 2017 AACE® International Technical Paper© (OWN.2657.2).

MINING PROJECT CAPITAL COST OVERRUNS BY PROJECT LOCATION AND SPONSOR HEADQUARTERS





Source: Lwin, Tin (P.Eng.) and Jose Lazo, “Managing Capital Cost Overrun Risks in the Mining Industry,” presented at 2017 AACE® International Technical Paper© (OWN.2657.2).

KEY AREAS OF CONCERN FOR FEASIBILITY STUDIES

Area of Problem	Frequency
Geology, Resource and Reserve Estimation	17%
Geotechnical Analysis	9%
Mine Design and Scheduling	32%
Mining Equipment Selection	4%
Metallurgical Test Work, Sampling and Scale-Up	15%
Process Plant Equipment Design and Installation	12%
Cost Estimation	7%
Hydrology	4%

Source: McCarthy Peter. “Why Feasibility Studies FAIL” AusIMM Melbourne Branch, 2013.

STUDIES OF MINE PRODUCTIVITY PERFORMANCES

McCarthy and Ward (1999)	Start-up performance of nine Australian underground base metal mines showed that only 50% achieved design throughput by Year 3 and 25% never achieved it at all.
McCarthy (2004)	Results of 15 year study of 56 mines with Feasibility Studies showed that only 20% were successful in achieving the design production capacity.
Tatman (2003)	Study of 41 underground mines showed that 60% of ore reserves were outside of expected range, some very seriously in error.
Tatman (2004)	Study showed that Final Feasibility Study production rates of 60 steeply-dipping tabular deposits did not achieve planned production rate.
Bertisen and Davis (2008)	Study of 63 mines and smelters worldwide completed between 1980 and 2001 showed that Feasibility Study capital cost estimates averaged overruns of 25% on an as-built in actual (nominal) dollars and 14% after as-built costs when adjusted for inflation.
Bullock (2011)	Summary of eight studies of mining projects from 1965 to 2002 showed a weighted average capital cost overrun of +25% with 58 of 73 projects having cost overruns of greater than 15% but less than 100%, and eight with capital cost overruns greater than 100%.

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5 STEPS FOR ENHANCEMENT OF FEASIBILITY STUDIES

1. Set standardized criteria, such as AACE.
2. Enforce project value improvement process to avoid design changes.
3. Stress test the FS to cost benchmarks.
4. Incentivize the FS contractors to maximize project values early in the project to establish a strong contracting strategy.
5. Build a rigorous integrated master schedule and construction planning, marketing strategy and digital aspiration at every step of the FS development.

Source: McKinsey & Company. "Optimizing mining feasibility studies: The $100 billion opportunity," August 2019.

SURVEY QUESTIONS

- Aggressive and unrealistic schedules
- Costs escalated and/or factored from historic studies; no first principle estimates
- Lack of properly developed testwork/defined design criteria/work scope
- Inflation and/or changes in exchange rates
- Poor estimating methods (missing data/information)
- Overestimated accuracy/under-estimated contingency
- Client pressure to minimize the initial capital requirements
- Client pressure to quickly complete work

SURVEY QUESTIONS (CONTINUED)

- Selection of wrong mining method and/or processing flow sheet
- Underestimation of transportation and logistics
- Underestimation and/or insufficient critical data from early engineering studies
- Unrepresentative samples for geotechnical, environmental and/or metallurgical testing
- Unexpected social, cultural, political and/or environmental issues
- Estimates based on incomplete/insufficient bid packages
- Owner and/or Engineer that is not experienced in pragmatic delivery of projects
- Major changes in the funding and/or ownership of projects

TOP 5 CONTRIBUTING FACTORS

5 Overestimated accuracy / underestimatedcontingency (54)

4 Underestimation or insufficient critical data from early engineering studies (61)

3 Client pressure to minimize the initial capital requirements (90)

2 Lack of properly developed testwork / defined design criteria / work scope (102)

1 Aggressive and unrealistic schedules (116)

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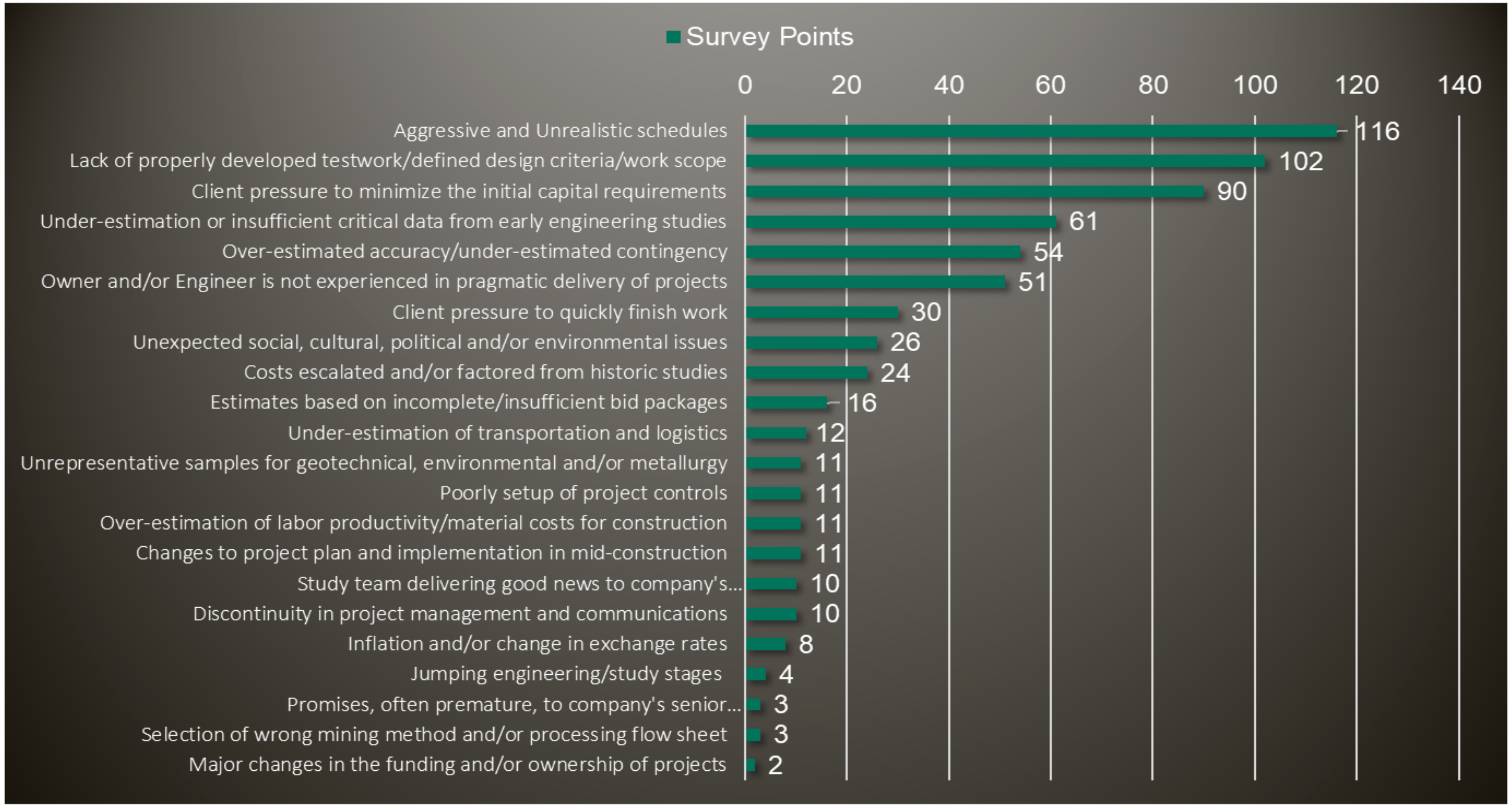
TOTAL POINTS FOR RESPONSES



Source: Kuestermeyer, Al: Capital Cost Overruns in the Mining Industry: Mistakes, Misjudgments or ?. Denver Coal Club, June 14, 2015

CITED REASONS FOR CAPITAL COST OVERRUNS

Various Documents Have Cited Reasons for Capital Cost Overruns including the following examples:

- Poor engineering/planning/costing (studies completed by unqualified engineering firms who do not have the required knowledge/expertise by mine or process type, or by project area/location/conditions).
- Poor/inexperienced management (internal and external) during engineering, construction and Owner’s team.
- Owner’s costs during preproduction period; especially if project is delayed for permitting, and Owner is attempting to show in-house costs to Analysts, Board and Budget Committees.
- Change orders as a result of inadequate engineering/design studies and not identified during due diligence process (internal and external).
- Forecasting high labor productivity during construction, especially in skilled labor areas and countries where legislated laws specify labor requirements.
- Indirects where percentages are used versus actual engineered estimates/quotes
- Site remoteness/location
- Weather
- Exchange rate
- Inflation

PROJECT CHARACTERISTICS FOR CAPITAL COST OVERRUNS

No or Weak Association

- Financing (internal or external)
- Company Size (market cap)
- Project Size (capex/capacity)
- Mining Method
- Project Location (continent)
- Primary Commodity
- Processing Method
- Project History (greenfield vs brownfield)

Strong Association

- Commodity Market (hot)
- Integrated Design/Build Team
- Project Quality

Source: Haubrich, Christopher. "Why Building A Mine On Budget Is Rare," CIM MES 16 October 2014.

COST OVERRUNS BY PERCENT

OVERRUN AREAS	PERCENT (1)
Owner Labour	58%
Other Indirects	58%
Direct Labour	50%
Materials	50%
Escalation	42%
External	42%
EPCM Labour	42%
Equipment	42%
Delay	25%
Foreign Exchange	17%
Scope Changes	17%

(1) Figure shown for each driver represents % of projects that encountered overrun for that drive.

Source: Lwin, Tin (P. Eng) and Jose Lazo, “Export Development Canada: Managing Capital Cost Overrun Risks in the mining industry,” 2017 AACE® International Technical Paper© (OWN.2657.2).

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CAPITAL COST OVERRUNS BY SOURCE

SOURCES OF OVERRUNS	NUMBER
Scope of Changes	2
Delay	3
Equipment	5
Material (2)	6
Labour (3)	7
External (1)	12

(1) Permitting, escalation, custom clearances, logistics and foreign exchange.
(2) Bulk quantities and unit prices.
(3) Engineering, Owner's, camp, training, commissioning and construction.

Source: Tin Lwin, Export Development Canada. ''Managing Mine Development Risk: Capital Cost Overruns,'' Mining Business Risks Summit 2012, Toronto, Canada.

CASE STUDY: NEMASKA LITHIUM, INC.

As a case study, the Nemaska Project, Quebec, Canada, was reviewed. The Nemaska Project is comprised of the Whabouchi open pit mine-process plant and Shawinigan electrochemical plant. Whabouchi will produce a spodumene concentrate from open pit and underground mining using conventional processes. Spodumene concentrate will be shipped to Nemaska's electrochemical plant at Shawinigan, Quebec, for producing lithium products. The following NI 43-101 Technical Reports were completed for Nemaska starting in 2014:

- "NI 43-101 Technical Report; Feasibility Study on the Whabouchi Lithium Deposit and Hydromet Plant" Prepared for Nemaska Lithium Inc. by Met-Chem Canada, Inc. Issue Date: June 26, 2014.
- "NI 43-101 Technical Report; Feasibility Study Update on the Whabouchi Lithium Deposit and Hydromet Plant (Revised)" Prepared for Nemaska Lithium Inc. by Met-Chem Division of DRA Americas Inc. Revised Date: June 8, 2016.
- "NI 43-101 Technical Report -- Feasibility Study on the Whabouchi Lithium Mine and Shawinigan Electrochemical Plant" Prepared for Nemaska Lithium Inc. by Met-Chem, a division of DRA Americas Inc. Issue Date: February 21, 2018.
- "NI 43-101 Technical Report; Report on the Estimate to Complete for the Whabouchi Lithium Mine and Shawinigan Electrochemical Plant" Prepared for Nemaska Lithium by a consortium of companies (DRA Met-Chem, SGS, Hatch, BRA, SNC-Lavalin and Noram). Effective Date: May 31, 2019.

In February 2019, Nemaska Lithium announced in a press release that there would be a C$375 million capital cost overrun on the 2018 Technical Report estimate, of which C$150 million would be for the mine-process plant. Nemaska's explanations for this overrun were for: (1) new, higher estimates for indirects, and (2) lower labor productivities and higher unit costs for construction labor. On October 15, 2019, Nemaska Lithium announced that due to delays in financing the laying off of 64 employees, ceasing of operations at the Phase 1 Plant at the end of December 2019, and slowing down of work at Whabouchi until the winterization of the site is complete.

This case study focuses on the capital cost estimates in the 2016-2019 studies.

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SELECTED DATA COMPARISON: TECHNICAL REPORTS 2016-2018

		Technical Reports	
Descriptions	**Units**	**2016**	**2018**
Open Pit Reserves	P & P M tonnes	20.0	24.0
Open Pit Grade	%Li2O	1.53	1.53
Underground Reserves	P & P M tonnes	7.3	12.7
Underground Grade	%Li2O	1.28	1.16
Cut-Off Grade Open Pit	%Li2O	0.43	0.34
Cut-Off Grade Underground	%Li2O	0.80	0.63
Ore Production	Tonnes Processed/Year (000s)	1,031	1,031
LOM Ore Production	Million Tonnes	27.3	36.7
Li Concentrate Design	Tonnes/Year	261,485	215,022
LOM Concentrate	Tonnes (000s)	5,590	7,105
Process Recovery	%	83.8	85.2
Concentrate Grade	%Li2O	6.0	6.25
Price Li-OH	US$/Tonne	9,500	14,000
Price Li2CO3	US$/Tonne	7,000	9,500-12,000
IRR (After-Tax)	%	30.3	30.5
Pay-Back (After-Tax)	Years	2.7	2.9
LOM Financial Model	Years	26	33

Sources: Nemaska Technical Reports for 2016 and 2018.

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COMPARISON OF NEMASKA CAPITAL COSTS

Cost Descriptions	Capital Costs (M C$)			% Change	
Direct Costs	**2016 TR**	**2018 TR**	**2019 Update**	**2016-2019**	**2018-2019**
Whabouchi	154.0	158.6	264.4	71.7%	66.7%
Shawinigan	230.2	347.3	518.3	125.2%	49.3%
Sub-Total Direct	384.2	505.9	782.7	103.7%	54.7%
Indirect Costs					
Whabouchi	63.3	81.8	127.4	101.3%	55.7%
Shawinigan	45.6	114.3	176.6	287.3%	54.5%
Sub-Total Indirects	108.9	196.1	304.0	179.2%	55.0%
Nemaska Corporate					
Whabouchi	0	0	27.8	NAp	NAp
Shawinigan	0	0	28.3	NAp	NAp
Sub-Total Nemaska Corp.	0	0	56.1	NAp	NAp
Contingency					
Whabouchi	21.7	29.7	18.3	-15.7%	-38.4%
Shawinigan	34.5	69.7	92.3	167.5%	32.4%
Sub-Total Contingency	56.2	99.4	110.6	96.8%	11.3%
Others					
Labor Cost Escalation (1)	0	0	5.9	NAp	NAp
Closure/Rehabilitation (2)	3.7	2.5	9.2	148.6%	268.0%
Sub-Total Others	0	0	15.1	NAp	NAp
Totals By Site					
Whabouchi	242.7	272.6	447.1	84.2%	64.0%
Shawinigan	310.3	531.3	821.4	164.7%	54.6%
Project Totals	**553.0**	**803.9**	**1,268.5**	**129.4%**	**57.8%**

(1) Shawinigan.

(2) Whabouchi.

Sources: Nemaska Technical Reports: 2016, 2018 and 2019.

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SCHEDULED CAPITAL COSTS FOR 2019-2021 (C$ MILLIONS)

Description	**Year**			
Whabouchi Mine-Plant	**2019**	**2020**	**2021**	**Totals**
Mine Development	7.7	3.9	0.0	11.6
Infrastructure	21.4	49.9	0.0	71.3
Mine Equipment	2.0	4.6	0.0	6.6
Crushing	0.7	1.6	0.0	2.3
Process Plant	39.8	92.9	0.0	132.7
Sub-Total Whabouchi	**71.6**	**152.9**	**0.0**	**224.5**
Shawinigan Plant				
Process Plant	8.8	268.3	162.7	439.8
Buildings	3.1	95.1	57.7	155.9
Infrastructure	2.2	66.1	40.1	108.4
Sub-Total Shawinigan	**14.1**	**429.5**	**260.5**	**704.1**
Totals	**85.7**	**582.4**	**260.5**	**928.6**

Excludes: Working Capital, Sunk Costs, Tailings and Sustaining. Source: Table 22.5 - Cash Flow Statement (Base Case); NI 43-101 Technical Report, Report on the Estimate to Complete for the Whabouchi Lithium Mine and Shawinigan Electrochemical Plant"; prepared for Nemaska Lithium, Inc. Effective Date: May 31, 2019

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SUMMARY AND CONCLUSIONS

The topic of capital cost overruns in the mining industry has been examined for over 50 years from the mid-1960s to now. Recent studies have shown average capital cost overruns between 25% and 60%. Major contributing factors to the capital cost overruns are under-estimation in the Feasibility Study as well as the project completion costs during project development/construction for:

- Owner's (Corporate) Costs
- Contingency
- Indirect Costs
- Costs for external factors
- Labor Costs (EPCM, engineering, management and construction)

The amount of capital cost overrun appears to be a function of different variables such as project locations/execution and commodity. Available data also indicate a correlation between commodity prices and capital cost overruns, but not at the same rates.

In summary, ?? Is the real answer to ask one-self ?? ?? Are capital cost overruns actually a manifestation of inadequate engineering definitions and estimates at the various study stages (PEA, PFS and FS) -- resulting in the capital cost overruns during project development schedule, plan of execution and construction ?? **I think YES and NO!** Most important here, the mining industry and its engineering companies/consultants have **not** learned from its mistakes, or made the necessary corrections to its estimating methodologies and will continue to have capital cost overruns into the future.

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