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Precious Metals & Minerals

Ramp-ups: What to expect when expecting a new mine

The birth of a new mine takes time

We believe the ramp-up phase is one of the more challenging phases in the life cycle of a mine as it takes 10 quarters on average for a new mine to reach designed throughput levels. The relatively long ramp-up curve is due to a number of factors including unforeseen design issues, operational challenges, new bottlenecks as loads through the processing plant increase, natural learning curve, and inherent volatility/variability until the operation is stabilized.

Setting realistic expectations is critical out of the gate

One of the more manageable risks of a ramp-up is the setting of expectations which if not met can have a material impact on a company's share price performance. While ramp-up data highlights the time it takes to bring a new mine up to full production, many companies fail to recognize the underlying realities/risks and as a result set overly optimistic expectations. In our view, this sets the stage for disappointment and can lead to share price weakness, under-estimated working capital and loss of investor confidence (Exhibit 1).

Share price performance tends to follow four phases during a ramp-up

The successful ramp-up of a new project can have a material impact on the performance of a company's share price, especially for single-asset companies and those bringing a material new operation into production. The share price performance of companies with a key project entering or in the ramp-up period tends to follow a similar pattern which we believe is denoted by four phases (Exhibit 2). In the **Start-up Phase**, shares tend to underperform the broader peer group ahead of commissioning. In the **Transition Phase**, shares tend to trade in-line with peers as the market waits to see how well the ramp-up will go. In the **Re-rating Phase**, shares tend to outperform as project risk declines and investor confidence improves. Finally, in the **Consolidation Phase**, shares tend to reflect underlying fundamentals and valuation as companies begin to trade as a producer and not a developer.

New mines take on average 10 quarters to reach designed throughput levels

We have compiled a database of 100+ ramp-ups (historical and ongoing), and have found that it takes on average 10 quarters for new mines to achieve steady state capacity (Exhibit 3). While declaration of commercial production can be quickly achieved within 2 quarters, it often takes a longer period of time for a new operation to achieve 100% of capacity. As well, larger operations (>15 Ktpd) take an average of 3-4 quarters longer to ramp-up versus smaller operations (Exhibit 4).

Achieving designed recoveries and reserve grade tends to occur more quickly

In contrast to throughput, reserve grade and design recoveries are often achieved at a much quicker pace, typically within 2 quarters (Exhibit 5 and 6). The data collected also highlights processed grades tend to average 10% above initial reserve grade levels during the first few years in operation and recoveries appear to stabilize much faster than throughput and grade.

Key aspects for investors to consider with ramp-ups

Recent/upcoming mine start-ups include Hope Bay (TMAC), Olympias (Eldorado), Brucejack (Pretium), Rainy River (New Gold), Fekola (B2Gold), Hounde (Endeavour Mining), Cerro Moro (Yamana) and Copler Sulfides (Alacer) (Exhibit 7). In analyzing the potential risks around a project ramp-up, investors should take into account the processing method employed, size of project, mining method and mining rates entering start-up, reliance on new/modified technology, seasonal factors during start-up period and, most importantly, management track-record and experience in building and commissioning new mines. Investors should also evaluate a company's ramp-up assumptions, as failing to set realistic expectations can lead to material share price weakness when expectations are not met.

Ramp-ups: What to expect when expecting a new mine

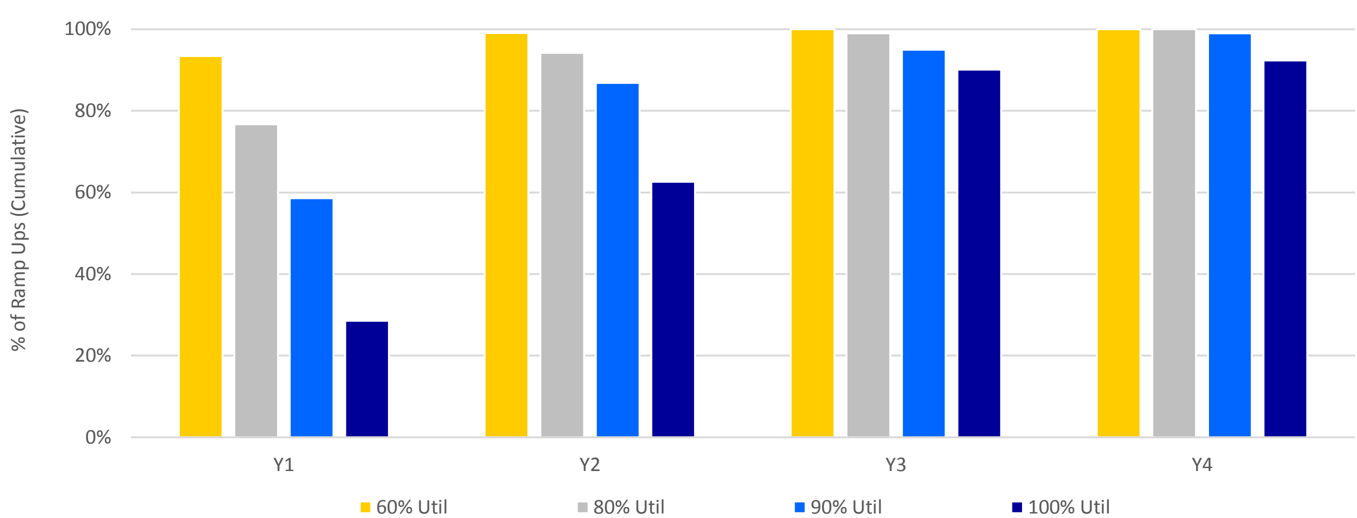
We believe the ramp-up phase is one of the more challenging phases in the life cycle of a mine as it takes 10 quarters on average for a new operation to reach designed throughput levels. The relatively long ramp-up curve is due to a number of factors including unforeseen design issues, operational challenges, new bottlenecks as loads through the processing plant increase, natural learning curve, and inherent volatility/variability until the up-stream and down-stream sides of the operation are stabilized and brought into unison.

Setting realistic expectations is critical out of the gate

One of the more manageable risks of a ramp-up is the setting of expectations, which if not met can have a material impact on a company's share price performance. While ramp-up data highlights the time it takes to bring a new mine up to full production, many companies fail to recognize the underlying realities/risks and as a result set overly optimistic expectations. In our view, this sets the stage for disappointment and can lead to share price weakness, under-estimated working capital and loss of investor confidence.

Taking a look at the cumulative timeline for 100+ ramp-ups, reaching designed throughput on the processing side takes time. Based on our analysis, approximately 30% of new mines achieve processing design capacity in Year 1, approximately 65% by the end of Year 2 and roughly 90% after Year 3. In a number of cases, some mines had yet to reach design levels even after 4 years in operation (Exhibit 1).

Exhibit 1: Cumulative historical capacity utilization shows only ~65% of mines reach full processing capacity after 2 years



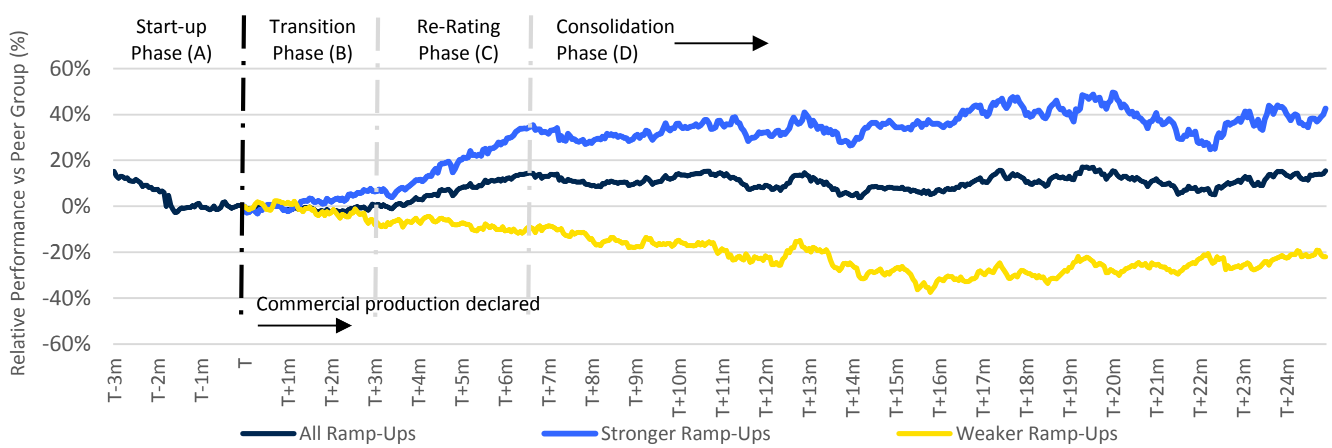
Source: Company Reports, RBC Capital Markets

Another factor evident in the data is that achieving commercial production (typically 60% of capacity for a period of 30-45 days) occurs fairly quick relative to the time it takes most mines to reach full throughput. Although commercial production tends to be a focus for market participants and companies, we caution commercial production does not always correspond to the point at which a new mine begins to generate positive free cash flow.

Share price performance tends to follow four phases during a ramp-up

The successful ramp-up of a new project can have a material impact on the performance of a company's share price, especially for single-asset companies and companies bringing a material new operation into production. While the below summary is primarily based on single-asset companies, we believe the implications are valid for companies about to commission a key driver of future production and free cash flow growth. On average the share price of companies which delivered stronger ramp-ups outperformed their peers by more than 40% two years following declaration of commercial production while those with weaker ramp-ups underperformed by more than 20% (Exhibit 2).

Exhibit 2: Relative share price performance of companies with successful ramp-ups tend to follow a similar pattern



Note: Data based on the share price performance of 36 companies (primarily single asset producers)
Source: Bloomberg, RBC Capital Markets

On aggregate, the relative share price performance for companies bringing key projects into production tends to follow a similar pattern which appears to occur via four phases:

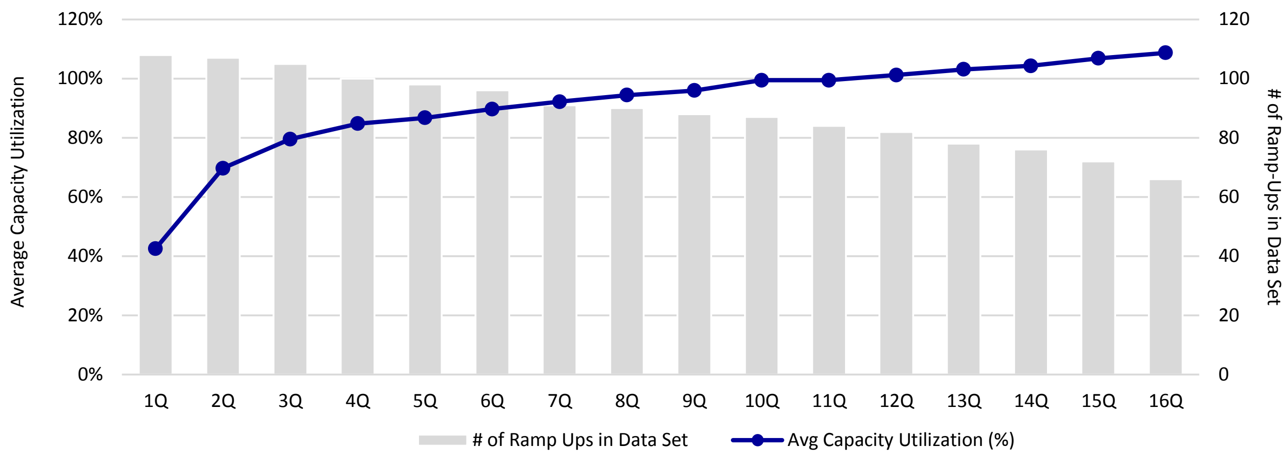
- **Start-up (A):** This phase starts prior to the commissioning and tends to reflect a period of share price underperformance. We believe the performance reflects a number of factors including capital cost overruns, project delays, commissioning challenges and/or increased investor caution ahead of a key de-risking phase.
- **Transition (B)**: This period tends to occur post the commissioning phase and lasts 2-3 months. We believe during this time, the market remains on high-alert for any potential red flags and often overreacts to positive/negative updates as overall risk remains elevated.
- **Re-rating (C)**: This period tends to begin 2-3 months after commercial production is declared and lasts approximately 3 months. While share prices tend to outperform during this period, the actual performance is highly dependent on the overall level of success. Those companies with ramp-ups deemed stronger tended to materially outperform their peers while those with weaker ramp-ups tended to underperform.
- **Consolidation (D)**: This phase tends to occur 6 months after commercial production is declared. During this phase the market begins to fully price in future expectations, and begins to focus on relative valuation and underlying fundamentals as companies successfully transition from developer to producer. This phase tends to be less structured in time and more reflective of the pace at which a ramp-up occurs.

The birth of a new mine takes time

New mines take on average 10 quarters to reach designed throughput levels

We have compiled a database of 100+ ramp-ups (historical and ongoing), and have found on average, it takes 10 quarters for new mines to achieve designed throughput levels on a steady-state basis. While declaration of commercial production (typically defined as operating at 60% throughput capacity over a 30-45 day period) can be quickly achieved within about 2 quarters, it often takes a longer period of time for a mine to operate consistently at full capacity (Exhibit 3).

Exhibit 3: A typical mine takes an average of 10 quarters to reach to full design capacity



Note: Data based on 108 ramp-ups which are in progress or have been completed (capped at 16 quarters)
Source: Company Reports, RBC Capital Markets

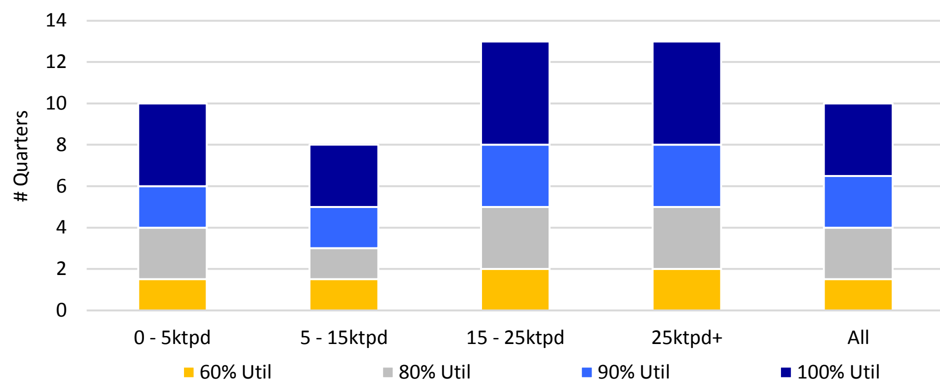
The flattening of the ramp-up curve in our view reflects the challenges associated with pushing higher levels of material through the processing plant, which can initially lead to increased wear-and-tear on key components, lead to new bottlenecks as loads are increased, and can in some cases highlight potential design flaws. During the later stages of a ramp-up, productivity gains become more incremental in nature as the operation is fine-tuned and stabilized.

During the later stages of a ramp-up, incremental gains are often made after design processing capacity is achieved. This is a result of natural gains as stability and consistency is attained along with built-in expansion potential, which may be unlocked by pushing the limits of the mill. Additional throughput can also be added via sequential expansions as free cash flow is re-invested in the required infrastructure to unlock a step-wise change in throughput.

Larger operations can take 3 to 4 quarters longer to ramp-up

Looking at the size of operations, we can see that the ramp-up curve of a larger project tends to occur at a more gradual pace, and can take 3 to 4 quarters longer to ramp-up versus a smaller operation. On average, smaller projects (processing rates of less than 15 Ktpd) have ramped-up to 90% capacity within 6 quarters and 100% capacity within 9 quarters. This compares to larger operations, which on average have taken 8 and 13 quarters to achieve their respective utilization rates (Exhibit 4).

Exhibit 4: Larger operations (greater than 15 Ktpd) take an average of 3-4 quarters longer to achieve design capacity



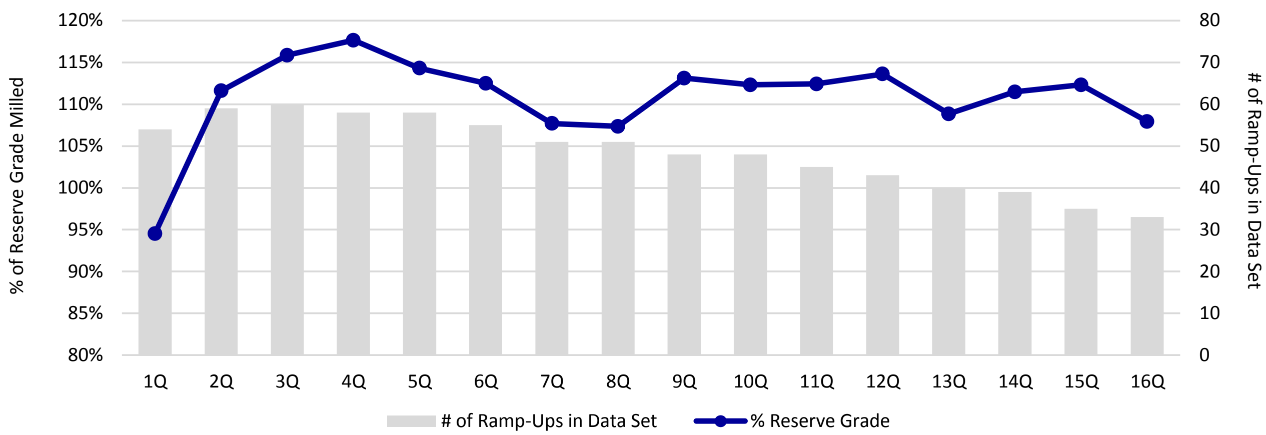
Source: Company Reports, RBC Capital Markets

We attribute the quicker ramp-up of smaller projects to the fact that these projects tend to employ greater levels of conventional, proven and tested technology/equipment, tend to be less complicated in design, and tend to place less stress on the mining and processing sides of the system given scale relative to larger more complex operations. While smaller mines tend to ramp-up quicker, we note a lot of factors come into play when bringing a new mine into production. Therefore investors should always be cognizant of the potential for a longer than anticipated ramp-up.

Achieving designed recoveries and reserve grade appears to occur more quickly

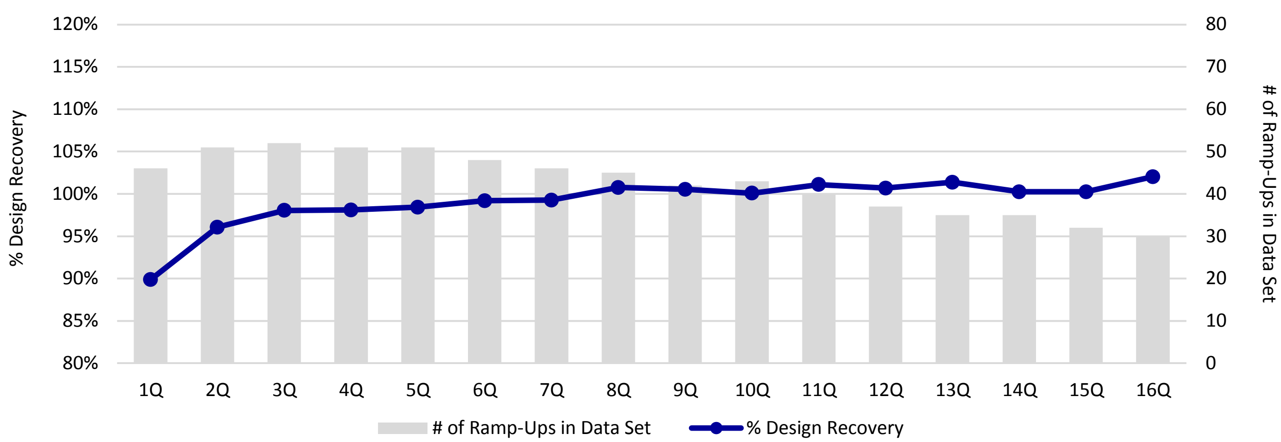
Analysing the grade profile of 60 historical/recent start-ups, it appears new mines tend to achieve reserve grades within the first semester of operation and that processed grades tend to average 10% above initial reserve grades through the first 4 years of operation. Similar to throughput, there is significant variability within the data set which in our view reflects a number of factors including mine sequencing, natural grade profile within every deposit, and ability to selectively stock-pile lower grade ore (Exhibit 5). Similarly, designed recoveries are typically achieved within 2 quarters and tend to exhibit greater stability relative to throughput and grades (Exhibit 6).

Exhibit 5: Ramp up to reserve grade is typically achieved within 2 quarters



Note: Data based on 60 ramp-ups which are in progress or have been completed (capped at 16 quarters)
Source: Company Reports, RBC Capital Markets

Exhibit 6: Design recoveries tend to be achieved fairly quickly and tend to offer greater stability



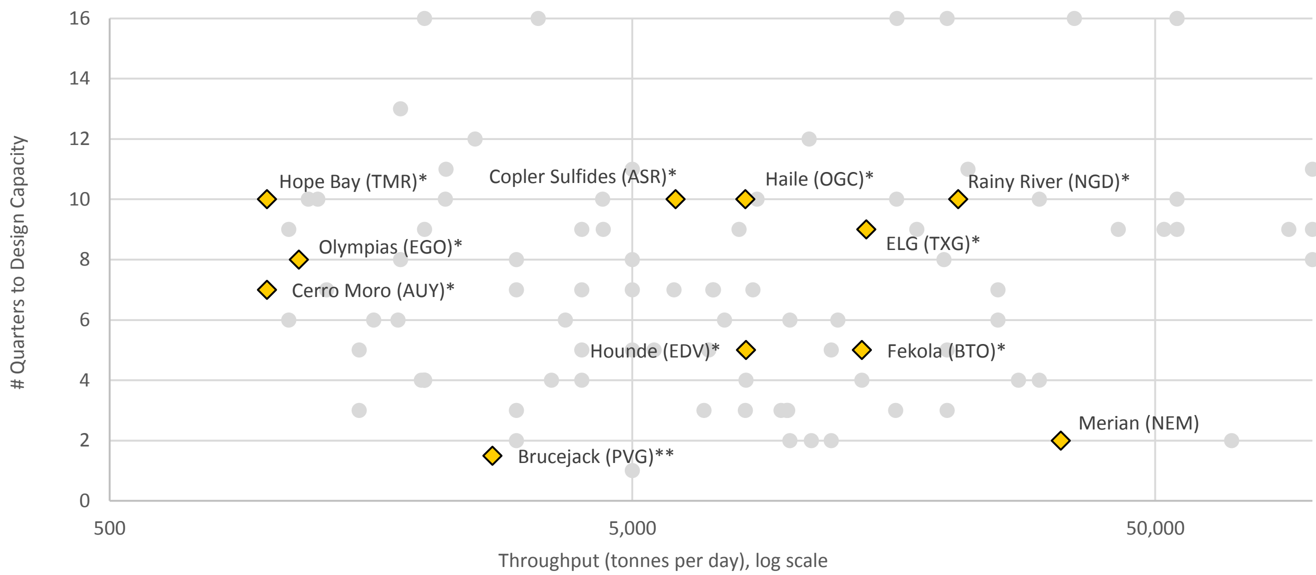
Note: Data based on 52 ramp-ups which are in progress or have been completed (capped at 16 quarters)
Source: Company Reports, RBC Capital Markets

The data shows that lower grade material is generally put through the plant initially, followed by higher grade material once recoveries near design levels, reducing the amount of metal sent to the tailings. We note that the processing of higher grades also tends to result in better recovery rates. The processing of higher than reserve grade material post the initial commissioning period is not surprising given the potential positive implications on cash flow and pay-back. Higher grades also help offset lower initial economies of scale given the inherent time it takes most new operations to achieve 80% and 90% of designed throughput.

Use of conservative ramp-up estimates warranted

Below, we highlight a number of projects moving through or about to enter the ramp-up phase as we anticipate each of these projects will play a role in the share price performance of each of their respective companies over the next 12 months (Exhibit 7).

Exhibit 7: Highlighting new mines entering/moving through the ramp up phase versus past and recent builds



Note: Grey circles represent historical projects; yellow diamonds represent recent/near-term ramp-ups; Time-line capped at 16 quarters; *RBC estimate, **As interpreted based on data released to date
Source: Company Reports, RBC Capital Markets estimates

Overall, a majority of our ramp-up forecasts for new processing plants are based on our findings. However, in addition to applying our in-house ramp-up curve, we also look to take into account a number of other factors which could lead to a faster than predicted ramp-up. These factors include ramp-up curve for comparable projects, level of stockpiles amassed entering commissioning, ore hardness, process complexity and seasonality, as commissioning a mine in the winter or the rainy season adds another level of complexity.

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