SUNSHINE FOR MINES

A SECOND LIFE FOR LEGACY MINING SITES

INSIGHT BRIEF

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HIGHLIGHTS

- **Innovative renewable energy and storage solutions can establish productive secondary lives for legacy or inactive mine sites**, generating revenue, reducing greenhouse gas emissions, and offering a sustainable energy solution for neighboring communities.
- **Sunshine for Mines has developed a cost-effective methodology** for evaluating a company's portfolio to determine which sites have the greatest value proposition for renewables development.
- Portfolio analyses are effective in highlighting **optimal sites, locations, technologies, and solutions** ready for the next phase of development.

INTRODUCTION

While renewable energy technologies such as solar photovoltaics (PV) and wind power can reduce emissions and demonstrate sustainability at operating mine sites, Rocky Mountain Institute's Sunshine for Mines program has also identified key opportunities specific to legacy, or inactive, mine sites. Our solutions can transform these liabilities into revenue-generating assets.

CHALLENGE:

- The **mining industry** faces the challenge of decommissioning mines at the end of their productive life (once the resource has been exhausted or extraction is no longer profitable), restoring the land and waterways to an acceptable state, and managing **long-term care and maintenance of closed or legacy sites** in line with regulations and without incurring exorbitant costs.
- Due to contamination from mining activities, **productive, alternative uses for the site—and therefore potential revenue sources—are limited**.
- **Site supervisors** and **mining executives** may not be **aware** of the **possibility to develop renewables and/or storage on legacy sites**.
- **Site supervisors** and **mining executives** may fear that renewables development will require **higher upfront capital costs** or will not be **cost-effective** in the long run compared to business as usual.
- **Mining executives** may not have the **expertise to screen their portfolio of closed sites for optimal solar, wind, and storage assets**.

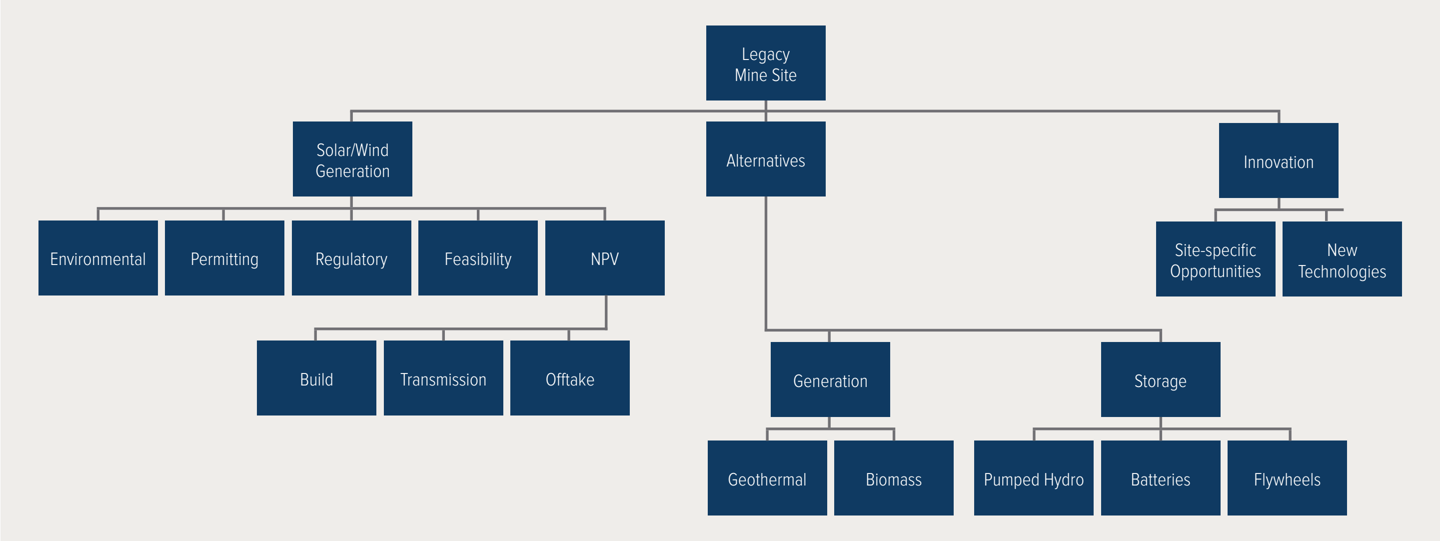
SOLUTION:

Developing renewable energy at legacy mine sites highlights a very large opportunity. Renewable developments are not only an appropriate alternative use for these sites, but they also have the potential to produce a sustainable revenue stream, thereby transforming these sites from liabilities into assets for the controlling company. For companies interested in taking advantage of this insight, RMI's Sunshine for Mines team developed a methodology for screening legacy sites for renewable resource availability and when applicable, assessing the feasibility and value of their development. The end result is an overall scorecard of prioritized sites for development with their respective preferred technologies.

KEY ELEMENTS

The methodology developed by the Sunshine for Mines team can be broken into discrete components, as described in the workflow below.

Figure 1: Legacy Mine Site Workflow



The Sunshine for Mines team simultaneously assesses the feasibility of solar/wind, alternative storage and generation, and innovative options for each site. Net present value (NPV) is assessed for solar/wind opportunities since costs are mature for these technologies. In the future, as costs become more standard, NPV may be assessed for alternative options as well.

ENVIRONMENTAL, PERMITTING, AND REGULATORY CONSIDERATIONS

Legacy sites have a history of being operated as active mine sites. This can typically create conditions of soil contamination, maintenance requirements of tailings and waste areas, water management and mitigation requirements, and other operational liabilities. Moreover, the sites themselves may be subject to local, state, or federal regulations regarding land use and environmental impact. Before considering which technologies are optimal for a legacy site, the site must undergo an environmental, permitting, and regulatory screening to ensure that renewable development is favorable. RMI's exhaustive examination criteria include:

- Permitting and land management (local, state, federal)

- Natural, recreational, and scenic resources
- Land use, public services, and infrastructure
- Surface waters, floodplains, and wetlands
- Soils, geology, and groundwater
- Threatened and endangered species

The following resource map is a sample output of the screening.

Figure 2: Sample Resource Map

An environmental, permitting, and regulatory scorecard is then generated based on the screening criteria, as shown below, which allows for resource prioritization in developing the asset.

Site	Permitting and land management	Natural, recreational, and scenic resources	Land use, public services, and infrastructure	Surface waters, floodplains, and wetlands	Soils, geology, and groundwater	Threatened and endangered species
Site 1						
Site 2						

After site resources have been evaluated, recommendations and suggestions for innovation in the construction process should be made in an effort to further reduce impacts to resources. For example, bird-deterrent solar panel designs could potentially reduce rates of incidental bird deaths where threatened or endangered bird species are identified, or construction during times of frozen ground may reduce disturbance to any present wetlands.

FEASIBILITY

Technical site feasibility assessments include both resource screening and reserve quantification for each site.

RESOURCE SCREENING:

Each site is screened for solar, wind, and alternative resources. This typically involves site characterization, resource mapping, and preliminary performance and levelized cost of electricity (LCOE) calculations. Site characterization also includes a review of the slope, grading, land, soils, and other features of the site.

Figure 3: Sample Land-Based Wind Speed Map

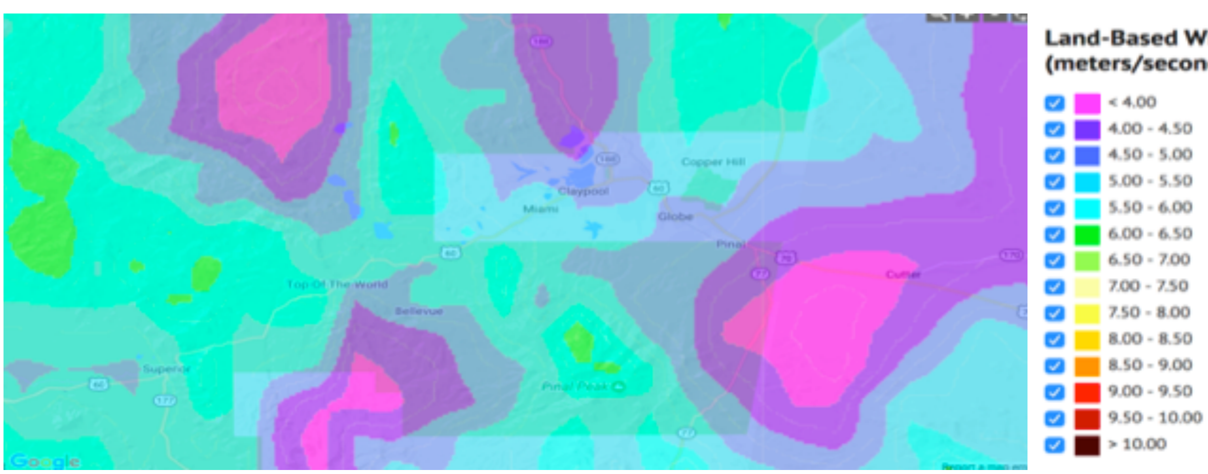
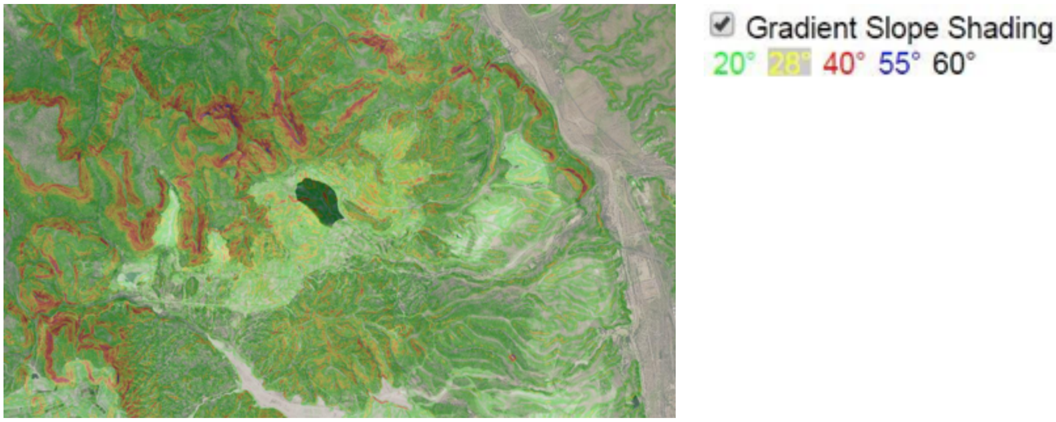


Figure 4: Sample Slope Shading Map

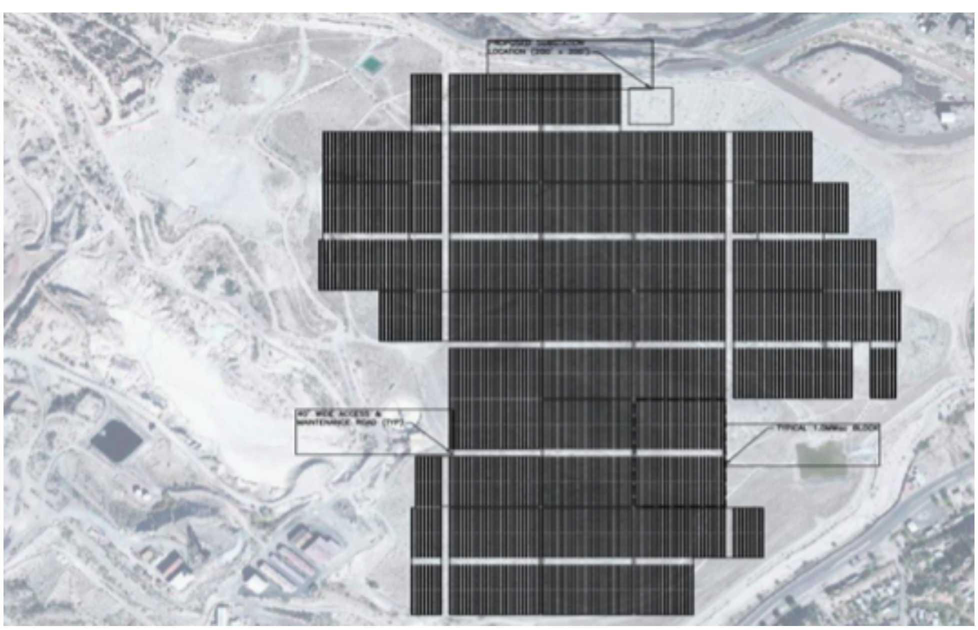


Interconnection opportunities and market access are also reviewed and considered when calculating LCOE. For example, costs of approximately $300,000–$500,000 per mile are factored in for sites far from the nearest grid substation, and the impact of these interconnection costs can make or break the economic case for development.

RESERVE QUANTIFICATION:

Sites identified to have high renewable energy resources are then evaluated with regard to their reserves. The Sunshine for Mines team evaluates solar reserve through 30 percent design and cost estimates in concert with revenue-grade performance models. Wind reserve is also evaluated through a 10-year numerical simulation across a 10x10 kilometer grid centered on the site. Using the simulation, capacity factor estimates are produced for specific turbine models. These capacity factors can be combined with useable land area and resource availability to calculate site energy yield and support an economic analysis.

Figure 5: Sample Solar PV Design and Layout



NET PRESENT VALUE

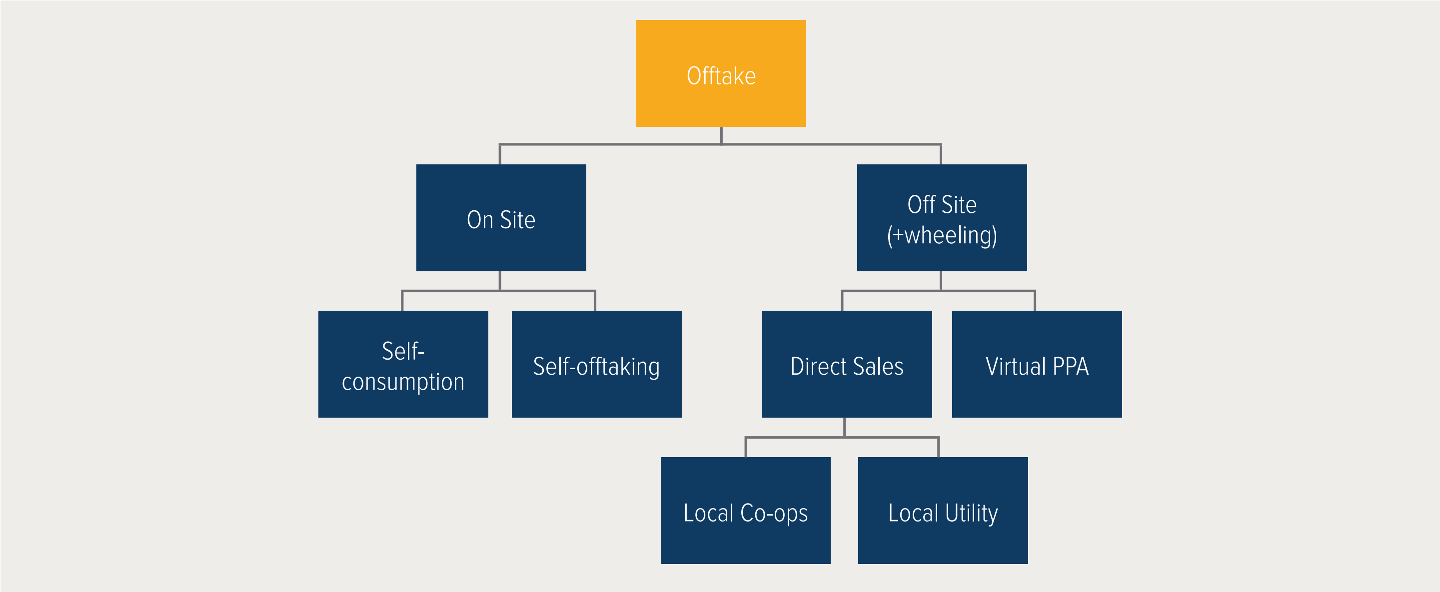
Once regulatory considerations and feasibility have been assessed, a net present value (NPV) is calculated from synthesized estimates of capital cost, operating cost, LCOE, social and environmental economic impacts, transmission costs, wheeling costs (if necessary), and market offtake value.

The estimated NPV of a project serves as guidance to rank the portfolio based on the most viable projects, as well as to compare its internal rate of return (IRR) with the hurdle rate that the client may apply to all its projects. Typically, hurdle rates in mining are high due to the profitability of mines, which may put pressure on the project economics. However, the financial assessment is based not only on NPV/IRR but also on the alternative or business-as-usual scenario of having a liability on the balance sheet. For example, a medium-sized closed site can require a staff of 5–10 people for maintenance and cost several millions of dollars a year to maintain. Furthermore, measures such as those described in the Innovation section below can be taken to improve NPV.

NPV analysis implies including both the costs—generally divided into construction (capex) and operational (opex)—and the revenue stream from electricity sales. Like all renewable energy projects, a legacy site requires most of the capex at the beginning of the project, with some required partway through the life of the project to replace some components (depending on the technology). The opex is typically low compared to capex—as well as compared to the opex of any other form of electricity generation.

The revenue stream from electricity sales can take different shapes depending on the contractual arrangements chosen. Because it's not possible to analyze all commercial options, which are location specific, the analysis includes what looks like the best theoretical offtake option. This tends to be a market hub if there is one in the region or within wheeling reach, or sales to the local utility (using known prices from the latest long-term contract as a proxy) if there is no market outlet.

Figure 6: Offtake Considerations



ALTERNATIVES

Sites are also screened for alternative energy resources and storage opportunities for added value; for example, geothermal and biomass for generation, and pumped hydro, both chemical (i.e., Li-Ion) and kinetic (i.e., flywheel), for energy storage. Many saturated energy markets, such as California, have a large demand for storage to help with production and load balancing. Similarly, flywheels are maturing as a technology and can be a great grid-balancing and load-shifting storage option.

Specific storage opportunities can be reviewed through interviews with site personnel in order to identify the highest potential across the portfolio. Any identified opportunities can then be quantified using preliminary calculation methodologies.

INNOVATION

Additional value can be created at some sites through innovative opportunities ranging from operation and maintenance savings by diversifying existing staff responsibilities to the possibility of repurposing site assets such as substations for a reduction in capex.

Innovations are also available around market access. For example, even in areas where no market is available, creative solutions such as wheeling the offtake to the CAISO deregulated market in California or entering into purchase agreements with local cooperatives may be possible. These solutions are feasible from a technical and regulatory perspective, and specific opportunities along these lines can be further explored.

BHP APPLICATION

The multinational mining company BHP recently engaged RMI to evaluate its North American portfolio of legacy sites for renewable development. Using the methodology, RMI identified significant potential for redevelopment and a clear subset of sites with a collective potential of over 0.5 GW. For most of the sites, because of their location, solar PV emerged as the largest opportunity, with a few being well suited for wind development. Various storage technologies were also explored and, in some cases, recommended. The opportunities in the subset were ranked by overall value according to the variables assessed via the scorecard system. This helped BHP prioritize activities and take action on the most attractive opportunities.

CONCLUSION

Legacy mine sites are uniquely positioned for second lives through renewable energy development. Not all the value elements of RMI's methodology will pertain to every site, given variations in size, location, regulatory environments, project goals, energy prices, and access to capital. But variations of this model can be valuable, especially under the guidance of the Sunshine for Mines team, which plays an integrative role in site prioritization, value capture, and creative financing, making such developments attractive to investors, developers, and mining companies alike.

To learn more about Sunshine for Mines' analytical and consulting work, please contact Paolo Natali at pnatali@rmi.org

ABOUT ROCKY MOUNTAIN INSTITUTE

Rocky Mountain Institute (RMI)—an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. RMI has offices in Basalt and Boulder, Colorado; New York City; Washington, D.C.; and Beijing.

ABOUT SUNSHINE FOR MINES

Sunshine for Mines, a program at RMI, rapidly accelerates the installation of on-site renewable energy capacity—especially solar photovoltaic (PV)—integrated into the power systems of on- and off-grid mines around the world.