Finding (Re)Purpose: The Power of a Pre-Feasibility Analysis in Coal Repurposing

Case Study
RMI’s plant repurposing analysis directly informs decision-making for coal transition stakeholders in Indonesia

Indonesia is one of the world’s major coal-exporting countries, and its electricity system is characterized by fossil-intensive assets, with consumption driven primarily by coal-fired power plants (CFPPs). Most of these assets operate in dense-population centers, and together encompass a significant component of local and regional GDP.

Under the JETP announcement in 2022, Indonesia has publicly committed to a net-zero emissions goal for the power sector by 2050, with a peak power-sector emissions target of 2030. Transitioning these fossil-intensive assets at an expedited pace to meet publicly stated targets will require careful and considered financial, policy, regulatory, and community-focused efforts.

Over the course of 2023, RMI, in partnership with multiple external stakeholders, conducted an extensive repurposing analysis for a representative coal asset in Indonesia. The objective of this work was to better understand how the repurposing of coal plants can play a pivotal role in the transition to a low-carbon future.

Case Study Plant Characteristics

- Located in densely populated Java-Bali
- High-capacity coal power plant providing dispatchable power
- Notable plant balance still left to depreciate
- Debt and equity obligations to fulfill
- Land surrounding plant site biologically important or environmentally sensitive.

To assist prospective plant investors, RMI utilized and expanded on an existing asset-level model to deliver an analysis on the financial, technical, and climate impacts of various plant repurposing options.

1. **PLANT INVESTORS**
   - Ensure achievement of risk-adjusted returns
   - Accelerated transition of plant while ensuring profitability
   **Metrics**: Key financial metrics, emissions reductions

2. **ELECTRICITY SYSTEM**
   - Mitigate impact on electricity system costs
   **Main metric**: Cost of generation

3. **JUST TRANSITION**
   - Mitigate impact of transition on workers, communities, other stakeholders

While the SPV investors were the primary audience, the transaction needed to be financially viable for the utility and credible from a climate and social impact perspective.
RMI’s analysis leverages an asset-level model of the case study plant’s retirement and repurposing.

**Inputs**
- Coal plant data and inputs
- Renewable resource techno-economics
- Cost of capital assumptions

**Calculation**
- Scenario Modeling
  - Accelerated coal transition scenarios
  - Repurposing scenarios
  - Financial structuring scenarios

**Results**
- **Key impact metrics**
  - SPV financial metrics: Projection of cash flows and asset- and SPV-level returns
  - Climate metrics: Lifetime CO$_2$e emissions avoided
  - Utility financial metrics: Electricity generation costs
RMI paired its asset-level model with a marginal-cost system dispatch model to find the net effect of each retirement pathway.

**Inputs**
- Hourly load (latest available year) and projected growth rate
- Approx. intermittent renewables hourly profile
- Resource mix per year in MW by resource from RUPTL for present-2030 and from other studies for 2030-2061
- Techno-economics for each generation type: min MW, total MW, max capacity factor, marginal cost, emissions intensity

**Calculation**
- Dispatch order
  - Calculation for every hour of net load (Demand – Must-Run generation including contracted IPP, variable renewable generation, and other non-dispatchable generation)
  - Marginal cost ($/MWh)
    - Include VO&M and Fuel cost
    - Doesn’t need to consider CAPEX and FO&M when making dispatch decision as they are sunk costs
  - Total system marginal cost with case study plant in the system at hour h
  - Net load at hour h

**Outputs**
- Total generation per technology
- Total variable cost of the system
- Annual CO₂ emissions
- Renewable curtailment
- Storage requirement in MW and MWh
- Average marginal cost with and without RE replacement
RMI explored, qualitatively and quantitatively, potential repurposing options to pair with the plant’s retirement.

<table>
<thead>
<tr>
<th>Repurposing Approach</th>
<th>Technological Solution</th>
<th>Upside Possible?</th>
<th>Resource Potential</th>
<th>Space Requirement</th>
<th>Overall Assessment</th>
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</thead>
<tbody>
<tr>
<td>Post-Retirement Reuse</td>
<td>Solar PV (+ battery storage)</td>
<td>Yes, under government-regulated tariffs</td>
<td>Fair to good</td>
<td>Medium to large footprint per MW, ~5 acres/MW</td>
<td>Explored in analysis</td>
</tr>
<tr>
<td>Post-Retirement Reuse</td>
<td>Wind (+ battery storage)</td>
<td>Yes, under government-regulated tariffs</td>
<td>Fair to poor</td>
<td>High footprint, ~30 acres/MW</td>
<td>Not considered due to land constraints and lower resource potential</td>
</tr>
<tr>
<td>Post-Retirement Reuse</td>
<td>Geothermal</td>
<td>Yes, under government-regulated tariffs</td>
<td>Requires further feasibility studies</td>
<td>Small footprint, comparable to coal</td>
<td>Could be considered if resources assessed</td>
</tr>
<tr>
<td>Post-Retirement Reuse</td>
<td>Floating solar</td>
<td>Yes, under government-regulated tariffs</td>
<td>Fair to poor; due to wave height and wind</td>
<td>High footprint, but no land use issues</td>
<td>Not considered due to bay-specific challenges</td>
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<tr>
<td>Lower Emissions Continuous Output</td>
<td>Biomass co-firing</td>
<td>Yes, if it can be more cost-effective than coal</td>
<td>Sawdust potential exists, full potential requires further assessment</td>
<td>Similar to coal, dependent on volume co-fired on site</td>
<td>Explored in analysis</td>
</tr>
<tr>
<td>Operational Flexibility</td>
<td>Standalone storage (battery or thermal)</td>
<td>None under current regulation</td>
<td>Battery storage mature; thermal storage more nascent technology</td>
<td>Small footprint</td>
<td>Could be considered in future if remunerated</td>
</tr>
<tr>
<td>Operational Flexibility</td>
<td>Flexible operation</td>
<td>None under current regulation</td>
<td>Similar to continued coal operation</td>
<td>Same footprint as coal</td>
<td>Could be considered in future if remunerated</td>
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</table>
The analysis ultimately focused on four accelerated retirement and repurposing scenarios for the case study plant:

<table>
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<tr>
<th>Scenario</th>
<th>Details</th>
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</table>
| **Baseline: Continued operation to end of technical life** | - Plant operated under existing ownership  
- Used as the base case for comparing electricity generation costs in accelerated retirement scenarios |
| **Transition Scenario 1: Early retirement with no repurposing** | - Plant retired early under new ownership  
- After retirement, grid energy replaces plant generation  
- Used as base case for comparing upside of repurposing options for investors |
| **Transition Scenario 2: Early retirement with clean repurposing** | - Plant retired early under new ownership, with repurposing of site with clean energy  
- After retirement, clean energy and grid energy replace plant generation |
| **Transition Scenario 3: Co-firing with sawdust and early retirement** | - Plant retired early with biomass co-firing under new ownership  
- Requires additional capex to retrofit the plant, but possibly lower fuel costs and emissions |
| **Transition Scenario 4: Co-firing with sawdust to end of technical life** | - Plant operated until end of technical life with biomass co-firing under new ownership  
- Requires additional capex to retrofit the plant, but possibly lower fuel costs and emissions |
RMI’s analysis, supported by the findings below, indicates that early retirement and repurposing of the case study plant with clean energy is attractive, if land constraints can be addressed.

- Early retirement of the plant without repurposing results in a **financially feasible** retirement scenario for stakeholders. However, **blended financing** helps ensure **electricity costs do not increase** due to the transition.

- **Co-firing of biomass** at the plant is **only profitable under the most favorable cost conditions**—and will face additional climate and sustainability scrutiny. The additional capital investments for retrofitting generally outweigh cost savings.

- Repurposing the site with **solar PV and battery storage** can provide **additional value** to investors and emissions reductions, but is possibly constrained by **land availability**.

- Additional **innovative repurposing options** could emerge if the regulatory framework recognizes alternative opportunities for generating value.
Early retirement of the plant without repurposing results in net benefits for stakeholders, particularly if blended financing can be secured.

The PPA tariff required to realize SPV returns is higher than the business-as-usual cost of generation under the original ownership.

Blended financing allows the tariff to drop below the business-as-usual and market financing costs of generation, supporting its financial attractiveness.

Insight 1: Blended Financing Benefits

- The PPA tariff required to realize SPV returns is higher than the business-as-usual cost of generation under the original ownership.
- Blended financing allows the tariff to drop below the business-as-usual and market financing costs of generation, supporting its financial attractiveness.
Co-firing biomass at the case study plant increases overall costs, due to the need to retrofit the system and process fuel.

Insight 2: Biomass co-firing challenges

- Co-firing the plant to its current technical threshold is not profitable under moderate to high-cost assumptions.
- It only becomes attractive under the lowest cost estimates for retrofits, O&M, and capex.
- Will likely face additional climate and sustainability scrutiny.
Insight 3: Constraints on clean repurposing

Solar PV and battery storage offers an upside opportunity, but net profits—and emissions reductions—will depend on land availability.

- Early retirement with no repurposing would require dispatch of other emitting assets across the grid post-retirement.
- The greater the clean generating capacity of the repurposed site, the less potential grid emissions leakage.
- Building solar PV only on the existing site is constrained by the footprint of solar PV, resulting in a small system size.
- System sizing for greater financial upside and emissions reductions would require additional land utilization around the plant site.
Future market evolution and technology developments could warrant consideration of additional site repurposing options

**Site Hybridization**
- If additional land can be procured, the SPV could invest in clean energy at or after the point when the levelized cost of solar is cheaper than the energy component of coal.
- This approach could help increase overall site profitability, where the coal asset would still provide capacity and some energy, but the investors could realize greater cash flows by displacing some coal generation with cheaper solar generation.

**Stand-Alone (Thermal) Energy Storage**
- Instead of burning coal, thermal mass could be heated at the plant by surplus energy from the grid to charge the storage, which could then be discharged to the grid on-demand.
- Storage repurposing would continue the utilization of existing infrastructure (steam cycle, power generation, and transmission assets).
- It could also address curtailed electricity from variable renewable energy and could allow the plant to retain much of its local employment.

**Flexible Operation**
- If new regulations create a remuneration model for flexible operation, flexible PPA contract structures could reduce coal utilization rates while maintaining baseload power to the system.