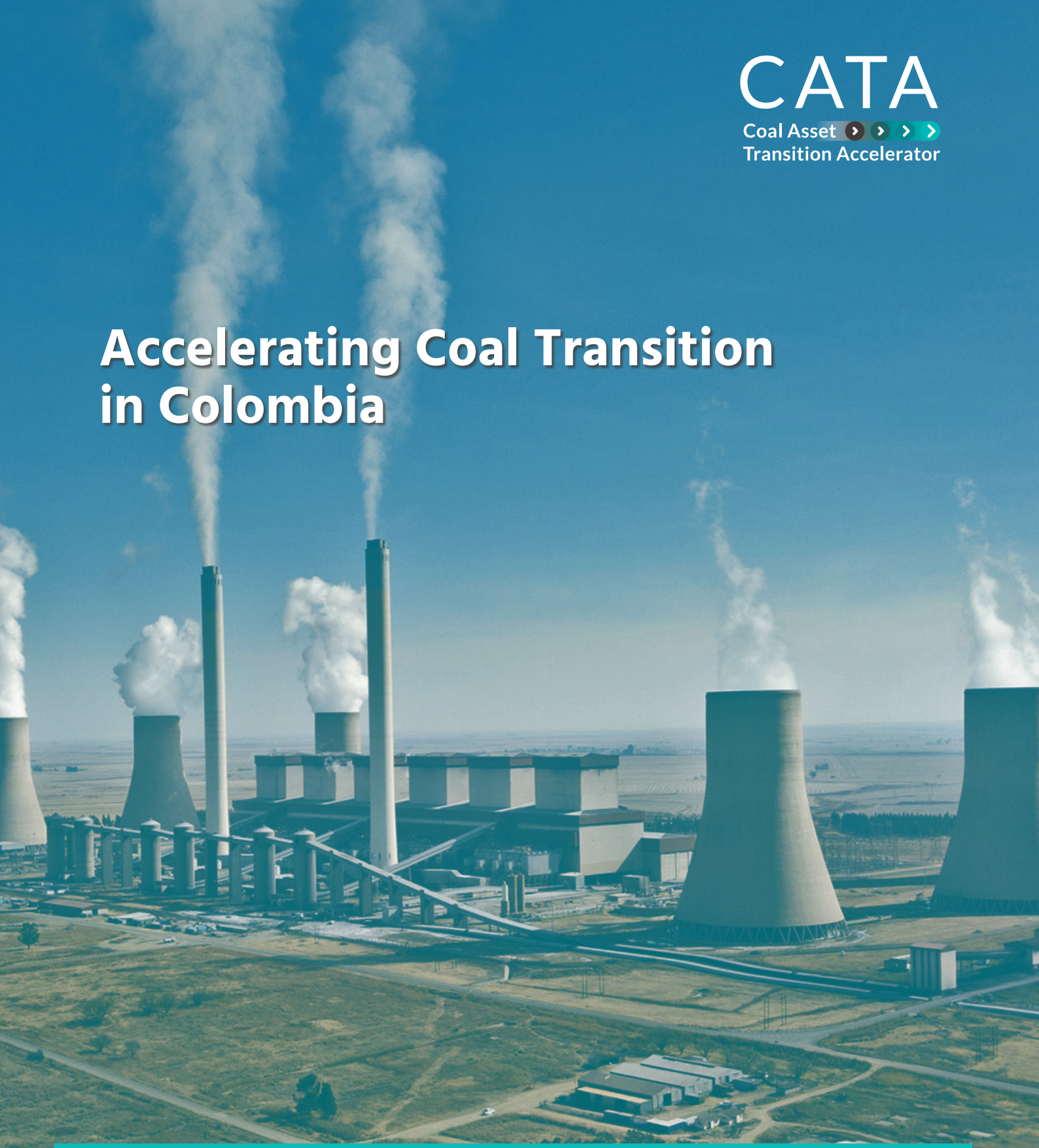
CATA
Coal Asset Transition Accelerator

# Accelerating Coal Transition in Colombia



**Disclaimer:** For confidentiality, the company name and identifying details have been withheld. This case study illustrates the support provided by the Coal Asset Transition Accelerator (CATA) for the company's decarbonisation strategy.

## Summary

Colombia's power sector contributes nearly 30% of national greenhouse gas emissions, with coal-fired generation accounting for 24%. In 2023, the government announced plans to repower one of two major coal plants operated by a state-owned utility. With support from CATA, the Carbon Trust and Transforma developed a comprehensive decarbonisation strategy using a five-step methodology: coal portfolio analysis, economic feasibility, Just Transition framework, financing mechanisms, and policy insights.

## Approach

CATA, in partnership with the Carbon Trust and Transforma, supported the company in transitioning two coal plants (Plant 1 and Plant 2) to renewable energy. Objectives included:

- Accelerating the transition to renewables
- Mitigating social and economic risks under a Just Transition framework
- Mapping financial mechanisms
- Informing policymakers on coal transition challenges

## Work Packages

The project was structured into five work packages:

1. Coal Asset Portfolio Analysis (WP1)
2. Economic Feasibility Assessment (WP2)
3. Just Transition Framework (WP3)
4. Financial Mechanism Evaluation (WP4)
5. Policy Insight Generation (WP5)


*Figure 1. Description of the project´s Work Packages*

## Work Package 1: Coal Asset Portfolio Analysis

**Phase 1: National Energy Context Assessment**

The project began with a comprehensive review of Colombia's national energy landscape, including climate policies, commitments, and long-term objectives. This phase assessed key policy and regulatory enablers, existing incentives and subsidies across generation technologies, barriers to coal transition, and future energy demand forecasts to inform generation planning.

**Phase 2: Transition Scenario Development**

A long list of 15 transition scenarios was developed for Plant 2, ranging from full decommissioning to retrofitting for flexible operation, conversion to small modular reactors, and replacement with solar PV. Each scenario was evaluated using a Red-Amber-Green (RAG) analysis across 10 criteria, including site characteristics, cost, technology readiness, environmental impact, and implementation feasibility.

**Scenarios were then grouped into three categories:**

- Good Choice
- Contingency Plan
- Big Bet


*Figure 2. Top scored alternatives in each category for Plant 2*

**Phase 3: Multi-Criteria Analysis (MCA)**

In the third phase, the five top-performing transition scenarios for Plant 2 were assessed using a Multi-Criteria Analysis (MCA). This involved evaluating each scenario against 12 indicators spanning technical, financial, environmental, and social dimensions. A baseline scenario - representing business-as-usual coal plant operations—was developed using real operational data provided by the company.

Each scenario was scored from 0 to 1 based on its relative performance against the baseline, with higher scores indicating stronger alignment with the defined criteria. This process enabled a comparative ranking of scenarios, highlighting their potential without prescribing a definitive path forward.

Outcome:

The highest-scoring scenario was the conversion of Plant 2 to enhanced geothermal. Based on this result, the company selected this option for further analysis in Work Package 2 (WP2).


*Figure 3. Alternatives ranking from MCA for Plant 2*

**Additional Assessment: Plant 1**

For Plant 1, a third-party organisation had already conducted pre-feasibility studies exploring the replacement of the coal plant with a solar PV installation, integrated with energy storage and synchronous condensers. However, a key challenge emerged: most of the land within the project area is expected to be designated as a DRMI (Integrated Management District), significantly limiting development potential.

In response, the company explored an alternative approach - connecting to a nearby substation and expanding both the land area and capacity. While this option presents regulatory hurdles, it was deemed spatially and logistically feasible.

The third-party analysis also identified repurposing the plant to natural gas as the most technically and financially viable option. Their recommendation included a phased approach: begin with natural gas and transition to hydrogen within 10–15 years, ultimately phasing out fossil fuels.

Aligned with these findings, the Carbon Trust conducted an MCA for Plant 1, evaluating the following three scenarios (ranked from most to least feasible):

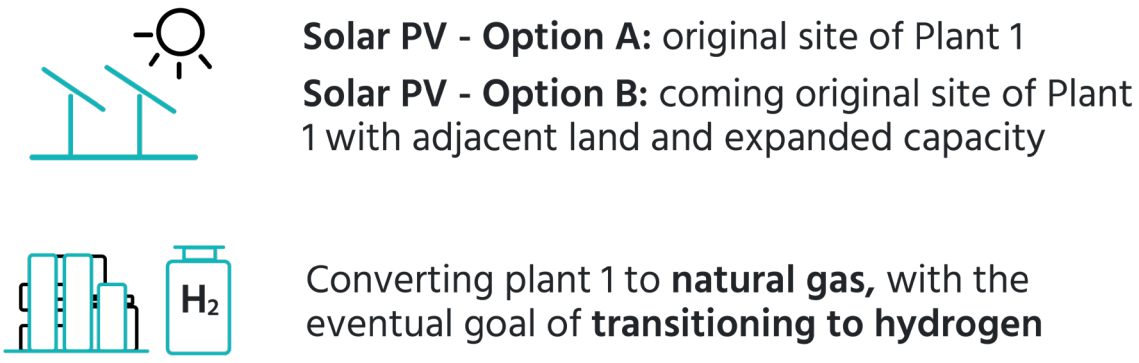



*Figure 4. Alternatives for repurposing Plant 1, in order of feasibility*

## Work Package 2: Economic Feasibility considering alternative of enhanced geothermal

To confirm the financial viability of the geothermal transition, a detailed break-even and sensitivity analysis was conducted. This included evaluating capital and operational costs, electricity price assumptions, carbon tax impacts, and broader social costs.

The first step involved identifying the break-even point - where the benefits of the transition would offset the investment costs. A financial analysis compared the transition scenarios against a baseline scenario in which the coal-fired power plant continues operating until the end of its lifespan.

The analysis aimed to ensure long-term economic sustainability and included:

- Cost analysis of the geothermal transition
- Economic modelling of the baseline scenario
- Sensitivity testing to assess how changes in key variables (e.g. fuel prices, carbon taxes) could affect outcomes

The results confirmed that the geothermal option could achieve cost recovery under a range of plausible future conditions, supporting its selection for further development.

## Work Package 3: Just Transition Framework

### Phase 1: Worker and Stakeholder Impact Assessment

The first phase focused on understanding how the transition would affect workers and other stakeholders. The Carbon Trust conducted a plant-level assessment to map the full extent of impacts - not only on direct employees, but also on those in the value chain, as well as indirect and induced workers.

### Phase 2: Job and Livelihood Impact Analysis

This phase assessed the implications of asset closure or repurposing on employment and local livelihoods. The analysis identified the types of jobs at risk, the availability of worker support systems, and potential alternative livelihood opportunities. Based on these insights, recommendations were developed for support measures and skills development to inform Just Transition planning.

### Phase 3: Development of Worker Support Pathways

Building on the previous assessments, this phase focused on designing potential pathways to support affected workers. A structured framework was used to integrate findings from the worker impact assessment, alternative livelihood analysis, and identified support needs. These pathways aim to ensure a fair and inclusive transition for all impacted groups.

## Work Package 4: Financial analysis of transition scenarios

### Phase 1: Baseline Cost and Revenue Analysis

The first phase focused on analysing the projected costs and revenues under the business-as-usual (BAU) scenario, where the coal plant continues operating until the end of its lifespan. This included assessing the financial impact of early retirement and comparing it with the projected costs and revenues of transitioning to enhanced geothermal generation.

### Phase 2: Financial Implications of Early Retirement

The Carbon Trust then evaluated the financial implications of retiring the coal plant ahead of schedule. This involved modelling a baseline scenario alongside three alternative Coal Transition Mechanism (CTM) scenarios, developed and approved in collaboration with the company. These CTMs were designed to explore different financial strategies to support the transition.

| No Transition | Transition | | |
|---|---|---|---|
| BAU | Financial BAU | Coal Transition Mechanisms | |
| 1 Business-as-Usual | 2. Existing Arrangements | 3. Sustainable Debt Product | 4. Special Purpose Vehicle |
| Plant 2 continues to operate over their useful economic life (UEL). At the end of their UEL they are decommissioned. | The company borrows via existing arrangements and funds are flowed through to the assets to fund retirement and geothermal replacement.<br>On-balance sheet option. | The company issues green bond backed by sovereign guarantee, with commercial and concessional tranches. Funds flow through to assets.<br>On-balance sheet option. | Retirement and replacement managed by a new majority company owned SPV which is funded by mix of commercial and concessional capital.<br>Off-balance sheet option. |

*Figure 5. Financial mechanism scenarios for Plant 2*

### Phase 3: Analysis from the CTMs and the BAU cases

Comparisons between the analysed CTMs and the BAU case were drawn to provide insights into the best CTM alternative. The scenarios were compared using several financial metrics.

### Phase 4: Sensitivity analysis

For the last phase the Carbon Trust conducted a sensitivity analysis to consider the impact of different variables on the scenarios. Multiple variables were considered, such as: CAPEX, retirement date, percentage of concessional capital, cost of debt, carbon prices.

## Work Package 5: Policy Insights

### Phase 1:

Analysis of government-led programmes and initiatives. This phase providing insights for government-led programmes or initiatives that offer financial incentives for coal phase-out, as well as to assess potential considerations for carbon pricing mechanisms to support the plant owners to transition away from coal.

### Phase 2: Challenges of energy transition.

This phase involved identifying challenges and barriers that hinder the energy transition at a national level as well to identify Colombia´s priorities to accelerate the transition. Additionally, recommendations at a plant level were shared to support a smoother transition for the company.

## Key Findings

- **Holistic scenario assessment:** Evaluating transition scenarios across financial, technical, environmental, and social dimensions ensures balanced, well-informed decision-making. This comprehensive approach enhances the legitimacy and acceptability of the transition plan and can serve as a replicable model for other contexts.

- **Clean energy as a strategic investment:** Transitioning to clean energy offers long-term benefits, including reduced operational costs, improved energy security, and environmental gains. While challenges such as high upfront investment, policy uncertainty, and short-term electricity price fluctuations exist, the long-term advantages are substantial.

  Plant-specific outcomes:

  - *Plant 1:* Replacing coal with solar PV eliminates air pollutants and $CO_2$ emissions, reduces land degradation, and cuts operational costs by 99%.

  - *Plant 2:* Transitioning to enhanced geothermal increases annual energy output by 13%, boosts revenue by 15%, and reduces operational costs by 24% compared to the baseline. It also avoids 2.9 million tonnes of $CO_2$ equivalent emissions annually.

- **Workforce impact and retention:** Early engagement was critical to understanding the full employment impact across the value chain. Up to 20% of Plant 1's workforce could be retained and retrained for natural gas and future hydrogen operations. For Plant 2, approximately 57% of workers could be retained, with additional jobs created during development and construction.

- **Financing as a key enabler:** Even with strong technical and economic cases, existing financing structures can hinder progress. Early identification and mobilisation of Coal Transition Mechanisms (CTMs) or concessional finance instruments are essential to reduce capital costs, mitigate liquidity risks, and improve bankability. The choice of CTM may depend on company preferences around equity, control, and access to guarantees such as those from MIGA.

- **Role of carbon pricing:** A well-designed carbon pricing mechanism can accelerate coal phase-out by incentivising sustainable practices, supporting decarbonisation strategies, and enabling access to sustainable finance. It also encourages innovation, energy efficiency, and emissions reductions.

- **System-wide transition planning:** Developing a comprehensive, company-level strategy for coal plant replacement is essential. Such strategies must prioritise energy security while addressing grid stability and reliability. A system-wide perspective is needed to identify alternatives that can provide ancillary and secondary services to support overall power system performance.

## Next Steps

**Plant 1:** Advance JT dialogues and retraining plans.

**Plant 2:** Conduct feasibility studies and develop CTM strategy.

**Both Plants:** Engage financiers and government to define optimal financing structures.

## Lessons Learned

Early engagement with stakeholders was essential. The partnership between Carbon Trust and Transforma ensured robust analysis and local ownership. The RAG and MCA methodologies are replicable across other coal assets.

This project serves as a flagship example for Colombia and Latin America on how to plan and execute early coal retirement in a technically robust, socially just, and financially viable manner.

## Methodology

The feasibility assessment for transitioning Plants 1 and 2 away from coal was conducted through a structured, multi-phase approach. This included technical, financial, environmental, and social analyses, supported by a Multi-Criteria Analysis (MCA) framework to evaluate and compare transition scenarios.

### 1. Multi-Criteria Analysis (MCA)

An MCA was conducted for both plants to evaluate a long list of transition scenarios against a set of weighted indicators across four dimensions: technical, financial, environmental, and social. Each scenario was scored and ranked to identify the most viable alternatives.

- For **Plant 1**, the preferred scenario was the replacement of the coal plant with a solar PV installation.

**Transition Scenario Ranking**

| Rank | Transition Scenario | Average Scores | | | | |
|---|---|---|---|---|---|---|
| | | Technical | Financial | Environment | Social | Total |
| 1 | Option A - Replace with solar PV | 0.38 | 0.33 | 1.00 | 0.50 | 0.55 |
| 2 | Option B - Replace with solar PV, expand land and capacity | 0.50 | 0.33 | 0.83 | 0.25 | 0.48 |
| 3 | Option C - Convert to natural gas / hydrogen | 0.63 | 0.17 | 0.83 | 0.00 | 0.41 |

*Figure 6. Scores of each transition alternative scenario for Plant 1*

- For **Plant 2**, enhanced geothermal emerged as the highest-scoring option.

| Transition Scenario Ranking | | | | | | |
|---|---|---|---|---|---|---|
| Rank | Transition Scenario | Average Scores | | | | |
| | | Technical | Financial | Environment | Social | Total |
| **Good choice** | | | | | | |
| 1 | Convert to synchronous condenser | 0.75 | 0.67 | 1.00 | 0.00 | 0.60 |
| 2 | Replace with solar PV + BESS | 0.38 | 0.33 | 1.00 | 0.25 | 0.49 |
| **Contingency plan** | | | | | | |
| 1 | Retrofit to run flexibly | 0.88 | 0.33 | 0.50 | 0.75 | 0.61 |
| 2 | Retrofit for biomass co-firing | 0.75 | 0.17 | 0.17 | 1.00 | 0.52 |
| **Big bet** | | | | | | |
| 1 | Convert to enhance geothermal | 0.75 | 0.50 | 0.83 | 0.50 | 0.65 |

*Figure 7. Scores of each transition alternative scenario for Plant 2*

## 2. Technical Feasibility

**Plant 1 – Solar PV:**

- Existing transmission infrastructure can be reused, but the site would require ground-levelling and more than double the current land area.
- Solar PV would generate approximately 20% of the baseline energy output**.**

**Plant 2 – Enhanced Geothermal:**

- Existing grid infrastructure and major plant equipment can be reused.
- Additional infrastructure is required, including drilling rigs, high-pressure pumps, and heat exchangers.
- A 70% capacity factor would result in a 344 GWh annual energy surplus compared to the baseline.
- Heat maps confirm strong geothermal potential, though the site's seismic activity requires further assessment.

## 3. Financial Analysis

**Plant 1 – Solar PV:**

- Operational costs would decrease by 99%, primarily due to the absence of fuel costs.
- However, revenues are expected to drop by 80% due to lower installed capacity and capacity factors.

**Plant 2 – Enhanced Geothermal:**

- Operational costs are projected to decrease by 24% compared to the baseline.
- Revenues could increase by 15% through wholesale market sales and capacity payments.
- Drilling and exploration alone would require an investment of $3–5 billion, with a construction timeline of 5–10 years.

## 4. Environmental Impact

**Plant 1 – Solar PV:**

- Negligible emissions and improved land use through the removal of coal infrastructure..

**Plant 2 – Enhanced Geothermal:**

- Minimal air pollution and $CO_2$ emissions.
- Potential environmental risks include induced seismicity and high water consumption, which may conflict with other local uses.

## 5. Social Impact

**Plant 1 – Solar PV:**

- Around 7% of the current workforce could be retained.
- Construction jobs would be created, though these are short-term and require specialised skills.
- Social resistance may emerge due to job losses and disruption of local customs.

**Plant 2 – Enhanced Geothermal:**

- Approximately 60% of the workforce could be retained and retrained.
- Additional employment opportunities are expected during the 5–10 year development and construction phase.
- Potential social resistance may arise due to unfamiliarity with geothermal technology and perceived job losses.