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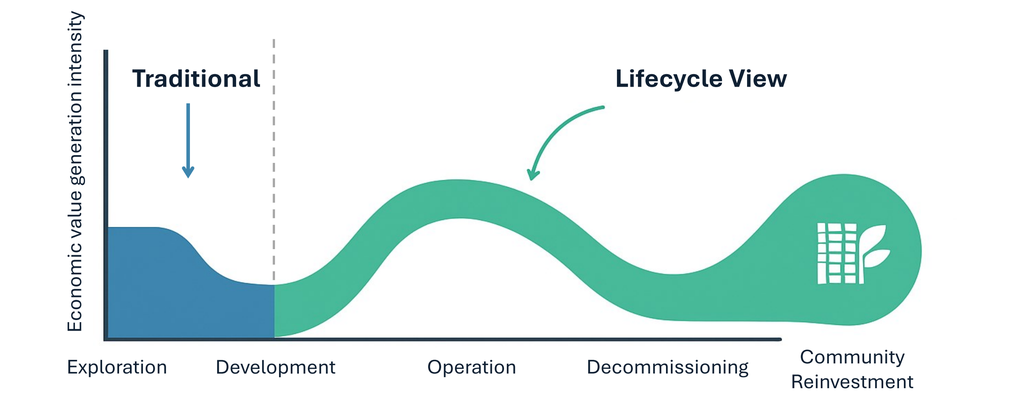
Beyond the Wellhead: Innovating Geothermal Economics for Full-Lifecycle Sustainability

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INTRODUCTION

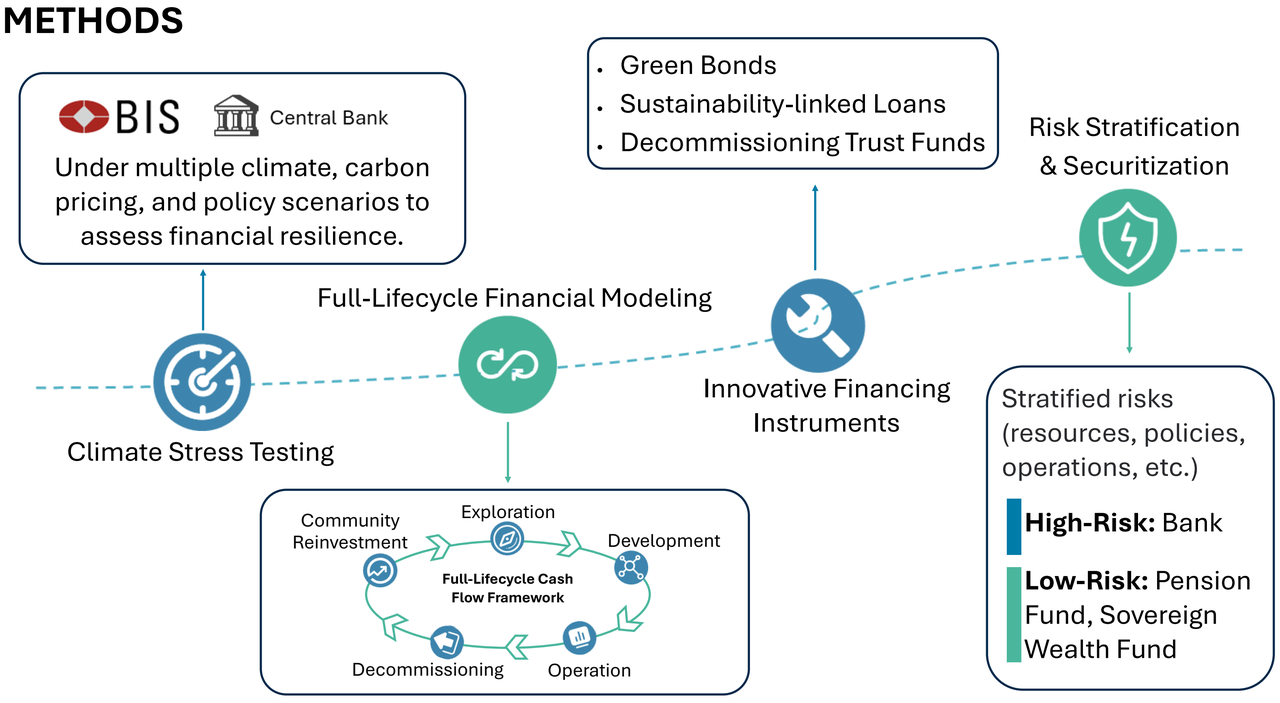
WHY: Banks and financial institutions are key enablers of the sustainable energy transition.

GAP: Geothermal energy holds great potential but traditional economic models neglect long-term environmental and social costs.



Technology Innovation **Economic System Innovation**

METHODS



RESULTS

1. The lifecycle model delivers higher IRR, lower carbon intensity, stronger fund adequacy, and greater social acceptance, showing its superior sustainability over the traditional approach.

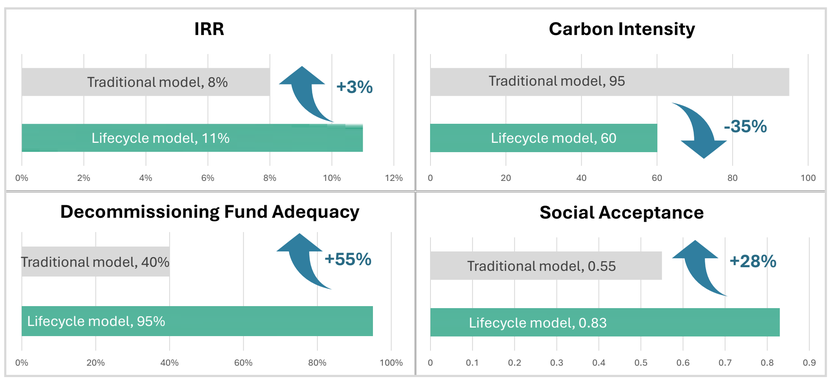


Figure 1. Lifecycle Model vs Traditional Model: Performance Improvements

2. Each financial innovation adds incremental value, resulting in a 21% higher NPV under the lifecycle model.

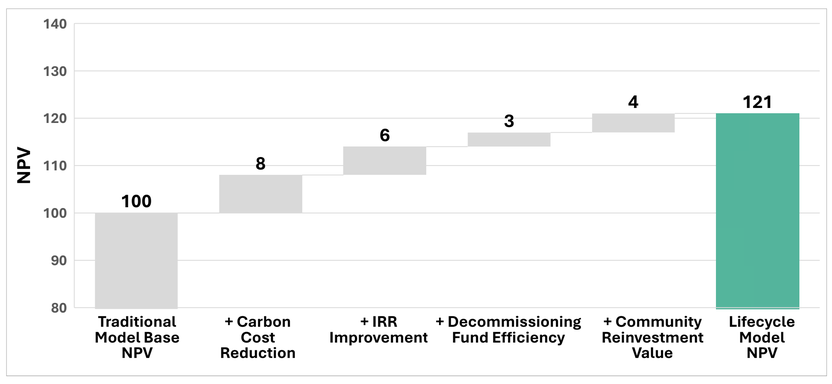


Figure 2. Cumulative Economic Value Gains Based On Lifecycle Financing

3. Case studies from Iceland, Kenya, and Indonesia reveal consistent improvements in investment return, fund adequacy, and social acceptance, confirming model adaptability across diverse policy settings.



Figure 3. Three Countries Validation of Lifecycle Framework

4. While traditional model lose value after operation, lifecycle model sustains economic and social contributions through decommissioning and community reinvestment, forming a continuous value cycle.

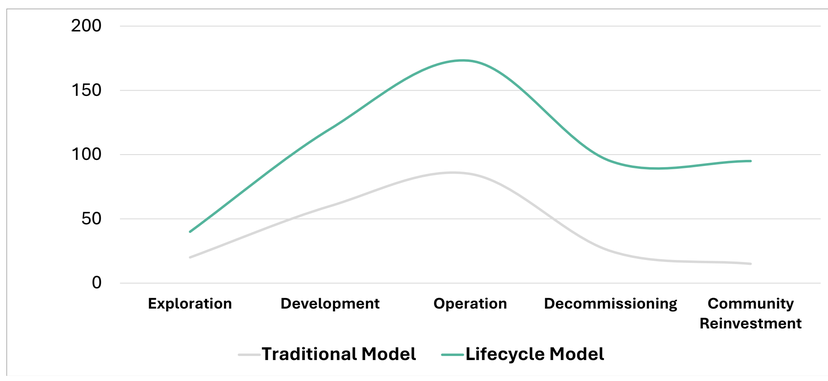


Figure 4. Extended Value Retention Across the Geothermal Project Lifecycle

DISCUSSION



The results confirm that integrating full-lifecycle financial models significantly improves geothermal project performance in terms of economic returns, environmental impact, and social acceptance.

These findings highlight the potential for banks and financial institutions to play a central role in scaling geothermal energy by supporting long-term, resilient investment frameworks.

Collaboration among banks, governments, and communities is essential to create climate-aligned financial ecosystems that foster widespread geothermal expansion.

CONCLUSION

Financial Innovation Drives Transition

Reframing geothermal economics through lifecycle finance accelerates the shift toward sustainable energy systems.

Advanced Financial Tools Enable Resilience

Stress testing, structured finance, and ESG-linked credit models strengthen geothermal investment under climate uncertainty.

Multiple Countries Replicability Validated

Multiple countries analysis demonstrates the strong adaptability of lifecycle banking frameworks under diverse policy environments.

Jointly Design Climate-Aligned Financial Ecosystems

Future collaboration among banks, policymakers, and developers will accelerate geothermal expansion through inclusive, climate-aligned finance.

Acknowledgements

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