
Weighing the Price of Progress: The Fragile Balance of Economy, Society, and Environment in Unconventional Energy Extraction

Abstract

The global energy paradigm shift from conventional to unconventional resources has ignited a profound debate on sustainability. This article explores the complexities of extracting unconventional energy such as shale gas, geothermal, and coal-bed methane within the framework of the three pillars of sustainable development: economic viability, social equity, and environmental integrity. Through a critical lens, it is argued that the rapid advancement of extraction technologies often outpaces regulatory frameworks and socio-ecological safeguards. This "fragile balance" is analyzed through the phenomena of negative externalities, agrarian conflicts, and market volatility. The article concludes that energy progress must be redefined not by production volume, but by systemic integrity and intergenerational justice.

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1. Introduction

The Context of Crisis and Opportunity

For over a century, modern civilization has thrived on relatively accessible conventional fossil fuels. However, the era of "Easy Oil" has effectively reached its twilight. The phenomenon of "Peak Oil" and the drastic depletion of traditional hydrocarbon reserves have forced global industries to venture into extreme geological frontiers. Unconventional energy resources trapped in low-permeability formations requiring high-intensity stimulation has emerged as the definitive response to the fear of energy scarcity. In emerging economies and developed nations alike, this transition is greeted with fiscal enthusiasm. Geothermal projects are hailed as low-carbon panaceas, while unconventional gas is viewed as a "bridge fuel" toward a fully renewable future. However, this narrative of progress is often one-dimensional. The primary focus remains tethered to GDP growth figures and Foreign Direct Investment (FDI), while social and environmental dimensions are treated as residual variables to be mitigated "down the line" (Delannoy et al., 2021).

Problem Statement and Urgency

The fundamental question arises: How much burden can ecosystems and social structures bear before the economic gains from unconventional energy become moot? This article aims to dissect

how the economic, social, and environmental pillars collide in the practice of future energy extraction. This analysis is urgent as the world chases Net Zero targets without acknowledging the reality of continued dependence on extractive energy.

2. The Economic Pillar: Macro Gains and Micro Vulnerabilities

Investment Dynamics and GDP Growth

Unconventional energy extraction is a capital-intensive industry. The development of a single shale gas exploration well or a geothermal power plant requires capital expenditure (CAPEX) dozens of times higher than traditional oil wells. From a macroeconomic perspective, this is a massive engine for investment. The influx of large-scale capital creates a "multiplier effect" for supporting industries, including construction, high-tech logistics, and specialized technical services. For developing nations, unconventional energy offers a tantalizing path to energy independence. Reducing reliance on crude oil imports improves trade balances and strengthens national currencies. This is the "Price of Progress" in its most attractive form (Duggal et al., 2022).

The "Boom-and-Bust" Economic Trap

However, a sharper analysis reveals systemic volatility risks. The unconventional energy industry is hypersensitive to global commodity prices. Because production costs are significantly higher, a minor dip in global oil prices can render these projects instantly uneconomical. At the local level, this creates "ghost towns." When a project commences, the local economy surges; however, when resources are depleted or prices crash, investment is withdrawn, leaving behind derelict infrastructure and mass unemployment. This represents a fragile economic balance, where growth is built on the extraction of finite resources rather than sustainable foundations.

Externalities: The Unrecorded Costs

In classical economics, corporate profit is calculated as revenue minus operational costs. This model, however, fails to account for negative externalities. The destruction of public roads by heavy machinery, the decline in agricultural productivity due to localized pollution, and the public health costs associated with air quality degradation are rarely reflected on corporate balance sheets. If these costs were internalized, the net profit of unconventional energy would appear significantly lower, or even negative, in the long term (Kaczmarczyk & Sowiżdżał, 2025).

3. The Social Pillar: Fragmentation, Conflict, and Justice

The Paradox of Natural Wealth and Local Poverty

One of the most persistent social issues in energy extraction is the "Resource Curse." Regions rich in unconventional energy are often remote areas with low educational attainment. The arrival of multinational corporations creates a stark dichotomy. Specialized experts are flown in from urban centers or abroad, while locals are relegated to low-wage roles as security guards or janitors. This disparity fuels social resentment. The "progress" felt in the capital city's halls of power is often inversely proportional to the marginalization felt by the communities on the front lines of extraction.

Agrarian Conflict and the "Living Space"

Unconventional extraction requires vast landscapes. For geothermal energy, sites are often located in protected forests or indigenous territories. For shale gas, thousands of wells must be distributed across wide expanses. This triggers intense land-use conflicts. Indigenous communities, who view land as a spiritual entity and a source of life, must contend with state laws that prioritize national energy interests. Social balance shatters when compensation mechanisms are purely financial, failing to account for cultural trauma and the loss of ancestral living spaces (Pellegrini et al., 2021).

Public Health and Security Threats

Socially, public health is a fundamental right. Extraction activities involving toxic chemicals (such as in the hydraulic fracturing process) or hazardous gas emissions place communities at high risk. Respiratory issues, skin diseases, and the contamination of drinking water become daily threats. The uncertainty regarding long-term health impacts creates a collective anxiety that erodes social cohesion.

4. The Environmental Pillar: Ecological Integrity Under Threat

Water Crisis and Resource Competition

Unconventional energy is a "thirsty" industry. Hydraulic fracturing requires millions of liters of fresh water for a single well operation. In drought-prone regions, this industry competes directly with farmers and domestic water needs. Beyond massive consumption, the risk of groundwater contamination is a permanent ecological threat. If the cement casing of a well fails, toxic chemicals and methane can seep into freshwater aquifers. Once contaminated, groundwater is nearly impossible to fully remediate.

Methane Emissions and Climate Change

There is a prevailing myth that unconventional gas is a "clean" energy source because it produces less CO₂ than coal during combustion. However, if we examine the Life Cycle Assessment (LCA), methane leaks during extraction and distribution are significantly high. Methane has a global warming potential dozens of times stronger than CO₂. Without stringent monitoring, this industry may accelerate the very climate crisis it claims to solve.

Induced Seismicity and Landscape Degradation

The practice of injecting wastewater back into the earth at high pressure has been proven to trigger "induced seismicity" (human-caused earthquakes). While often minor in magnitude, repeated tremors can damage residential structures and public infrastructure. Visually and biologically, this extraction also scars the landscape, causing habitat fragmentation that threatens local biodiversity. Discussion: Seeking Synthesis in Fragility (Akbari, 2025).

Policy Reorientation: From Extractive to Regenerative

Given these vulnerabilities, a paradigm shift in policy is required. Unconventional energy must not be viewed as an end goal, but rather as a highly temporary transition tool. Government policy must shift from merely facilitating investment to tightening environmental and social oversight.

Rule of Law and Meaningful Public Participation

The fragile balance can be strengthened through transparency. Communities must be involved from the planning stage, not just during the socialization phase. The concept of Free, Prior, and Informed Consent (FPIC) must be an absolute prerequisite. Furthermore, law enforcement against environmental violations must be uncompromising, ensuring that fines significantly outweigh the profits gained from negligence.

Technology as a Solution, Not a Burden

Innovation must be directed toward mitigating negative impacts for example, the development of waterless fracturing or satellite-based methane monitoring systems. Technology should be used to patch the cracks in the social and environmental pillars, not just to accelerate economic extraction (Science et al., 2024).

5. Conclusions

"Weighing the Price of Progress" is both a technical and an ethical reflection. Unconventional energy extraction has opened new horizons for global energy security, yet it stands on a fragile foundation. If we continue to worship economic growth at the expense of social stability and environmental integrity, that progress is merely an illusion borrowed from the future of coming generations. The balance between the three pillars of sustainable development is not static; it is dynamic and must be constantly defended through fair regulation, responsible technology, and a genuine respect for human rights and nature. Ultimately, the most "expensive" energy is not the one that is hardest to extract, but the one that destroys the living space of the many to light the lamps of the few.

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