Igniting Action to Reduce Gas Flaring:
Real Opportunities. Real Projects. Real Results.

Project Case Study: Los Toldos Este II Field in Argentina



Columbia Center on Sustainable Investment
A JOINT CENTER OF COLUMBIA LAW SCHOOL AND COLUMBIA CLIMATE SCHOOL

capterio

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Context to this Case Study

This case study is part of a broader report by the Columbia Center on Sustainable Investment and Capterio, which analyzes gas flaring in depth. The report presents extensive findings and a practical set of actionable recommendations for governments, national oil companies, international oil companies, and other stakeholders. The full report and case studies are available here.

Despite bold commitments made over the past two decades, global gas flaring remains stubbornly high—at around 140–150 BCM per year—emitting up to 1 billion metric tons of CO_2-equivalent greenhouse gases annually, and representing as much as $30 billion per year in lost revenue.

We believe flaring reductions are not only technically achievable, but also commercially compelling. By capturing and using flared gas, companies and governments can increase revenue, enhance energy security, reduce emissions, and accelerate the energy transition. Among all decarbonization options, reducing gas flaring is one of the fastest and most cost-effective "quick wins."

Countries with high flaring levels can make substantial progress—if key commercial, organizational, and political challenges are addressed. Delivering flare-capture projects at scale requires a thoughtful, integrated, and collaborative approach, supported by strong leadership, aligned incentives, and a relentless focus on delivery over rhetoric.

The full report examines six case studies—including this one—to illustrate how flaring can be reduced. We go beyond analyzing the "what" and "why" of flaring, and focus on the "how" of unlocking and accelerating actual delivery. Three of these cases are project-based examples from Angola, the Kurdistan Region of Iraq, and Argentina, where flared gas has been successfully captured and used. The other three country-based studies—covering Federal Iraq, Egypt, and Algeria—highlight both progress and untapped opportunities.

The full report also explores the systemic barriers to progress, the lessons learned from the case studies, together with some innovative life-cycle considerations for greenhouse gas emissions, and a detailed set of recommendations.

We encourage readers of this case study to explore the broader report and the other case studies. Together, we hope they offer a meaningful contribution to global efforts to end routine gas flaring.

Executive Summary

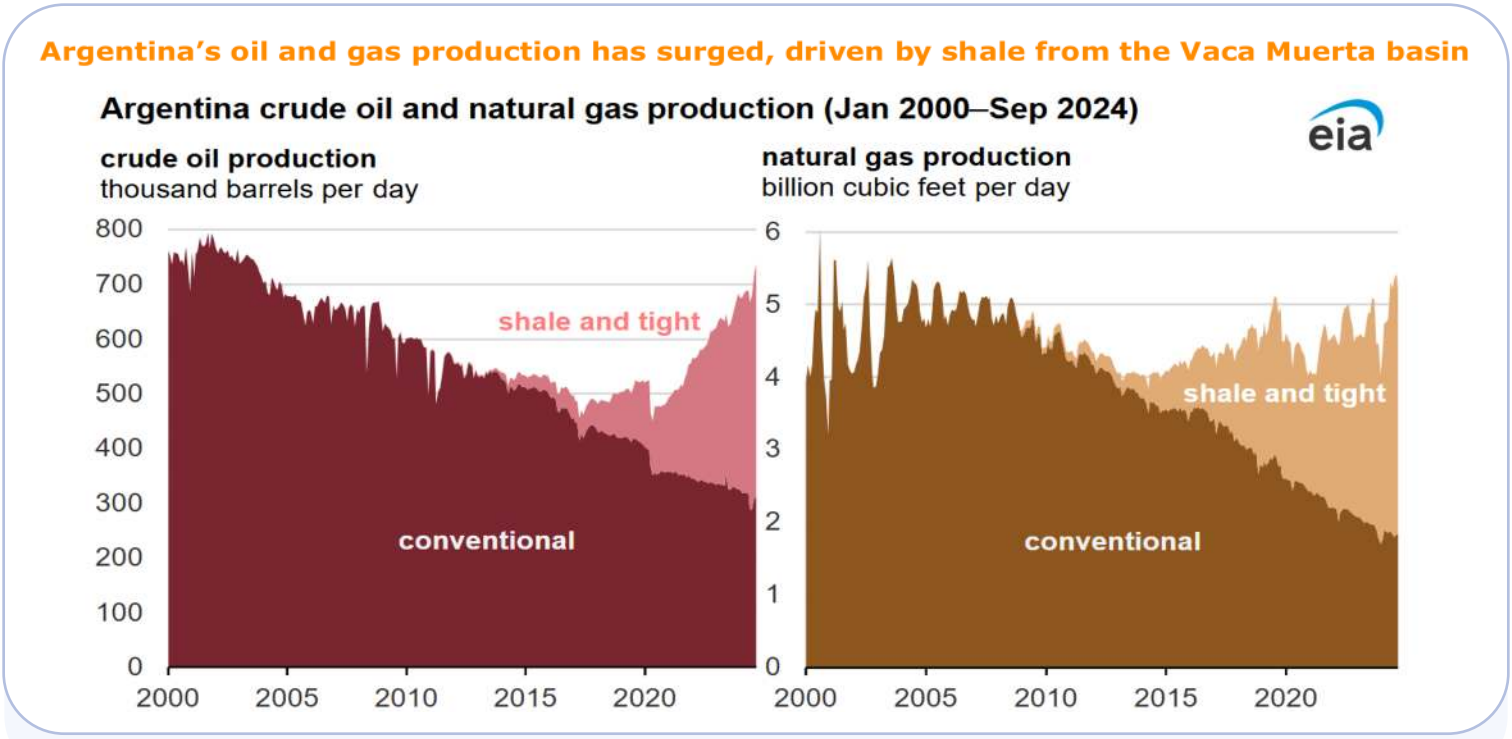
Flare Gas Recovery Through Cryptocurrency Mining at the Los Toldos II Este Field in Argentina

Flaring in the Los Toldos field has been substantially reduced as a result of a gas-flare-capture project that monetizes the waste through mining cryptocurrency.

Argentina's Oil and Gas Context

Argentina, Latin America's second-largest oil producer—with output reaching 0.7 million barrels per day in 2023—trails only Brazil (at 3.4 million barrels per day). Argentina also led the region in natural gas production in 2023, at 42 BCM.[1]

Argentina's oil and gas production has surged in recent years, driven primarily by the Vaca Muerta shale formation. Here, technologies pioneered in U.S. shale basins—such as multistage fracking, long lateral wells, and pad drilling—have been instrumental. As a result, Argentina's oil and gas sector has strengthened its trade balance and sharply reduced energy imports[2] (see Figure 1).



Source: Energy Information Agency

Figure 1: Overview of oil and gas production in Argentina, reproduced from U.S. Energy Information Administration.[3] Unconventional shale and tight oil and gas production has surged in recent years.

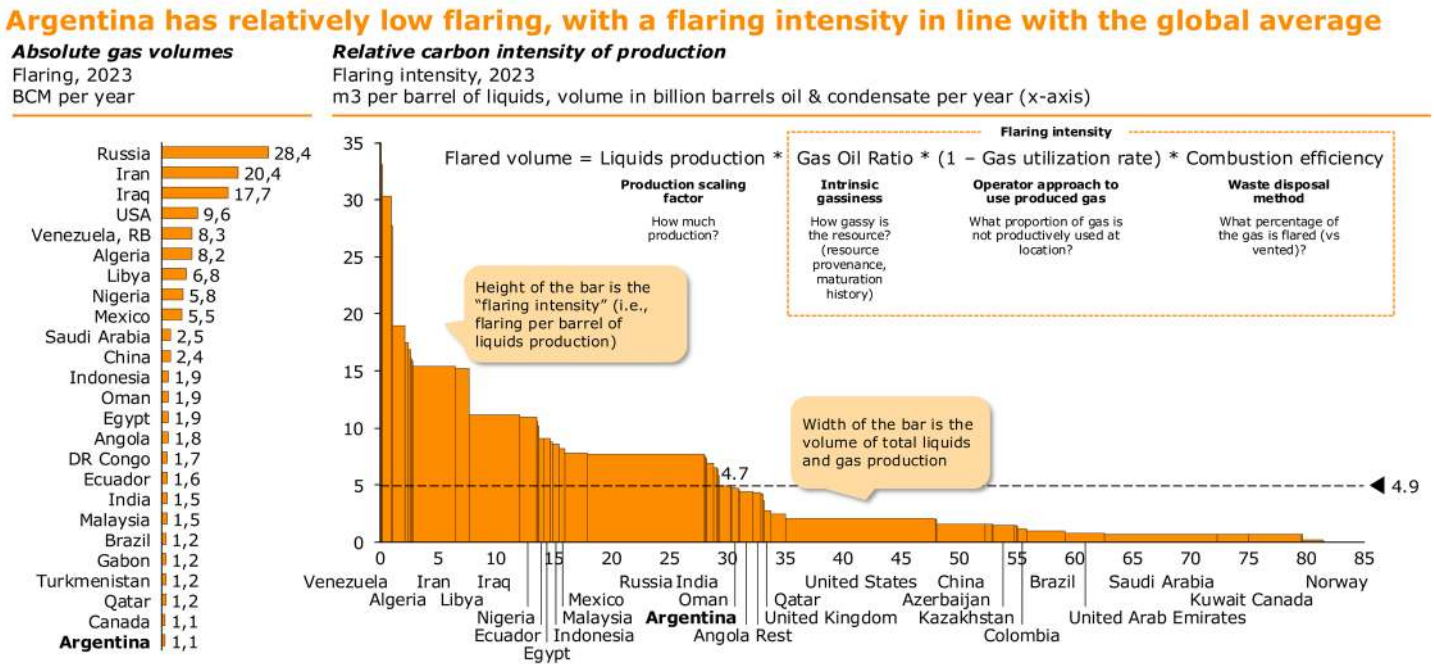
However, emissions from flaring (plus venting and leaking) in Argentina are substantial and risk increasing if policy changes are not backed by concrete action. According to estimates from the World Bank, Argentina flares some 1.1 BCM per year[4], with a flaring intensity close to the global average (see Figure 2).

1 Energy Institute. (2024). *Statistical review of world energy.* https://www.energyinst.org/statistical-review.

2 Tanner, F., & Martinez, P. (2024, April 5). Argentina's reforms likely to catalyze oil and gas export boom. *S&P Global Commodity Insights.* https://www.spglobal.com/commodityinsights/en/ci/research-analysis/argentinas-reforms-likely-to-catalyze-oil-and-gas-export-boom.html.

3 Munoz-Cortijo, E., & Arnal, M. (2024, December 5). Argentina's crude oil and natural gas production near record highs. *U.S. Energy Information Administration.* https://www.eia.gov/todayinenergy/detail.php?id=63924.

4 World Bank Group. (n.d.). *Global flaring and methane reduction partnership (GFMR): Global gas flaring data.* https://www.worldbank.org/en/programs/gasflaringreduction/global-flaring-data.



Source: Energy Information Agency

Figure 2: Overview of flaring globally, highlighting the relative position of Argentina on an absolute (left) and relative ("flaring intensity") basis (right).

When venting and leaking – plus methane emissions from incomplete combustion at flares – of 2.3 BCM are included[5], the total opportunity rises to 3.4 BCM per year, representing a potential $600 million revenue opportunity and an emissions reduction potential of 130 million carbon dioxide (CO_2)-equivalent metric tons.[6]

As Argentina increasingly looks to accelerate exports of oil and gas (plus decarbonize its own power generation, which is 51% from gas and 7% from coal and oil[1]), the carbon intensity of its energy products will become increasingly in focus. Hence, many have made concerted efforts to find solutions to gas flaring.

Oil and Gas Context in the Vaca Muerta Basin

The prolific Vaca Muerta basin lies in the Patagonian region of Argentina. The area—roughly the size of Belgium—holds the second-largest shale gas reserves and the fourth-largest shale oil deposits in the world. The rapid rise in gas production has led to proposals for new liquefied natural gas export terminals to facilitate international trade.[7,8] However, the existing gas infrastructure already operates close to full capacity and is geographically limited, meaning a substantial portion of potential production remains unreachable without investment in more infrastructure.

Some of the basin's production is somewhat constrained by regulations on gas flaring. In certain regions, such as Neuquén province, unauthorized releases of associated gas (including flared and vented volumes) above established limits are subject to hefty monthly penalties, starting at 500% of the weighted average sales price of natural gas at the custody transfer point. Further regulatory strengthening is expected on venting since

5 International Energy Agency. (2025). *Global methane tracker 2025*. https://www.iea.org/reports/global-methane-tracker-2025.

6 Assuming a national gas price of $5 per MMbtu and a global warming potential for methane of 82.5, over a 20-year period.

7 Sigal, L., & Bianchi, W. (2024, December 19). Argentina YPF y Shell firman acuerdo para desarrollo de proyecto de GNL: Comunicado. *Reuters.* https://www.reuters.com/latam/negocio/XFAADRK2CBJBJPJ2M4H44VJ2FQ-2024-12-19.

8 Raszewski, E. (2025, January 21). Argentina's YPF signs deal with Indian firms to export LNG. *Reuters.* https://www.reuters.com/business/energy/argentinas-ypf-signs-deal-with-indian-firms-export-lng-2025-01-21.

a new bill is being considered by Congress. Industry insiders also recognize that visibility around flaring and its enforcement could also be improved. As seen in other countries, even if flaring is metered at the source, data does not always reach executives with the necessary granularity and timeliness. In some cases, this is because of operational or organizational challenges associated with non-operated assets.

The Los Toldos Project

In August 2019, the governor of Neuquén granted a concession to the Los Toldos II Este field with Decree No. 1392/19. This 35-year concession covers an area of 77 km² and is aimed at unconventional oil production.

Situated at the northern edge of Neuquén, Los Toldos II Este represents the de facto northern limit of Vaca Muerta shale exploitation. Unlike other case studies in this paper, the Los Toldos project is a new oil production that consists of two key locations: (i) a producing well pad in the south, and (ii) a second production facility in the north, which includes gas processing, power generation, and cryptocurrency mining (see Figure 3).



Source: Capterio FlareIntel.

Figure 3: Overview of flaring in Argentina and the Vaca Muerta basin (highlighted, left) and the flare-capture projects at Los Toldos Este. The main facility is in the northern location, with a secondary well pad and production facility some 8 km south.

Ahead of the formal start of the project and its production, Tecpetrol conducted an extended well test (with considerable flaring; see Figure 4) at the northern site, primarily to assess reservoir productivity. Subsequently, Tecpetrol developed a flaring-reduction plan to support (and decarbonize) its production operations, based on an expected flare rate of up to 60,000 m³ per day (2.1 million scf per day). The associated gas had an unusually high methane content—over 85% by volume—with no detectable hydrogen sulfide or CO_2. The flaring-reduction plan also included a secondary two-phase

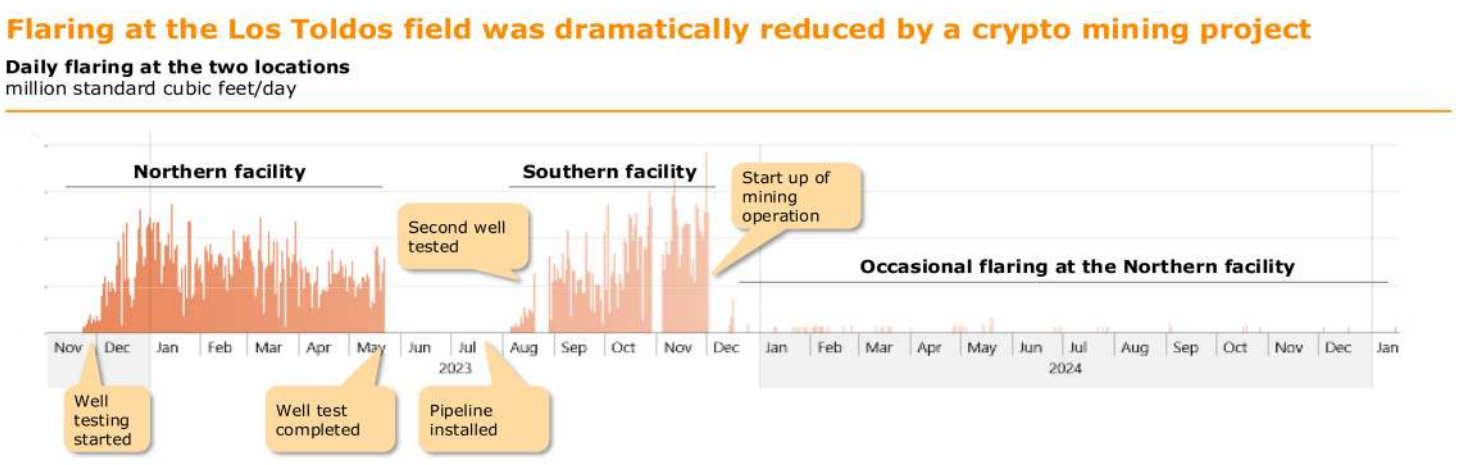
separator to extract additional condensate (added to the oil exports) and ensure that the combusted gas is lean and clean.

Multiple options to recover flared gas would typically be considered. Pipelines are often impractical (because of a lack of nearby trunk lines), and gas reinjection in this geology is often difficult because of low reservoir permeability. Other options sometimes considered include supplying gas to the local power grid or demand centers, as well as transporting it as liquefied or compressed natural gas by truck (although mountainous terrain can make trucking challenging).

The most viable solution evaluated by Tecpetrol was using the flared gas to generate power for cryptocurrency mining. An alternative—powering a data center for cloud computing services (e.g., Amazon Web Services)—was ruled out because of the critical need for low-latency, high-reliability internet. In contrast, cryptocurrency mining is a more practical solution since it requires only a low-bandwidth satellite connection.

The cryptocurrency mining project was signed in June 2023. Unblock Global—a Latin American project developer—was commissioned as the local partner to the upstream operator Tecpetrol, while U.S.-based Crusoe Energy Systems—the largest cryptocurrency miner using flared gas in North America—provided the data centers.[9]

In August 2023, Tecpetrol initiated a shorter well test at the southern site, which concluded in early December and was connected to the northern location via a 15 km (comingled oil and gas) pipeline. Bitcoin mining operations commenced shortly thereafter, in early December 2023. The flaring data from Capterio's FlareIntel platform (see Figure 4) clearly shows the main flaring events and confirms very limited flaring (hence, limited operational upsets) from the start of the project's permanent operations.



Source: Capterio FlareIntel.

Figure 4: Record of daily flaring at the two locations from FlareIntel Pro. The flaring data independently identify the main operational events, including the extended well test at the northern location from late November 2022 to late May 2023 and the well test at the southern locations from August to early December 2023. From early December 2023 to the present, there has been very limited flaring, confirming successful project operations.

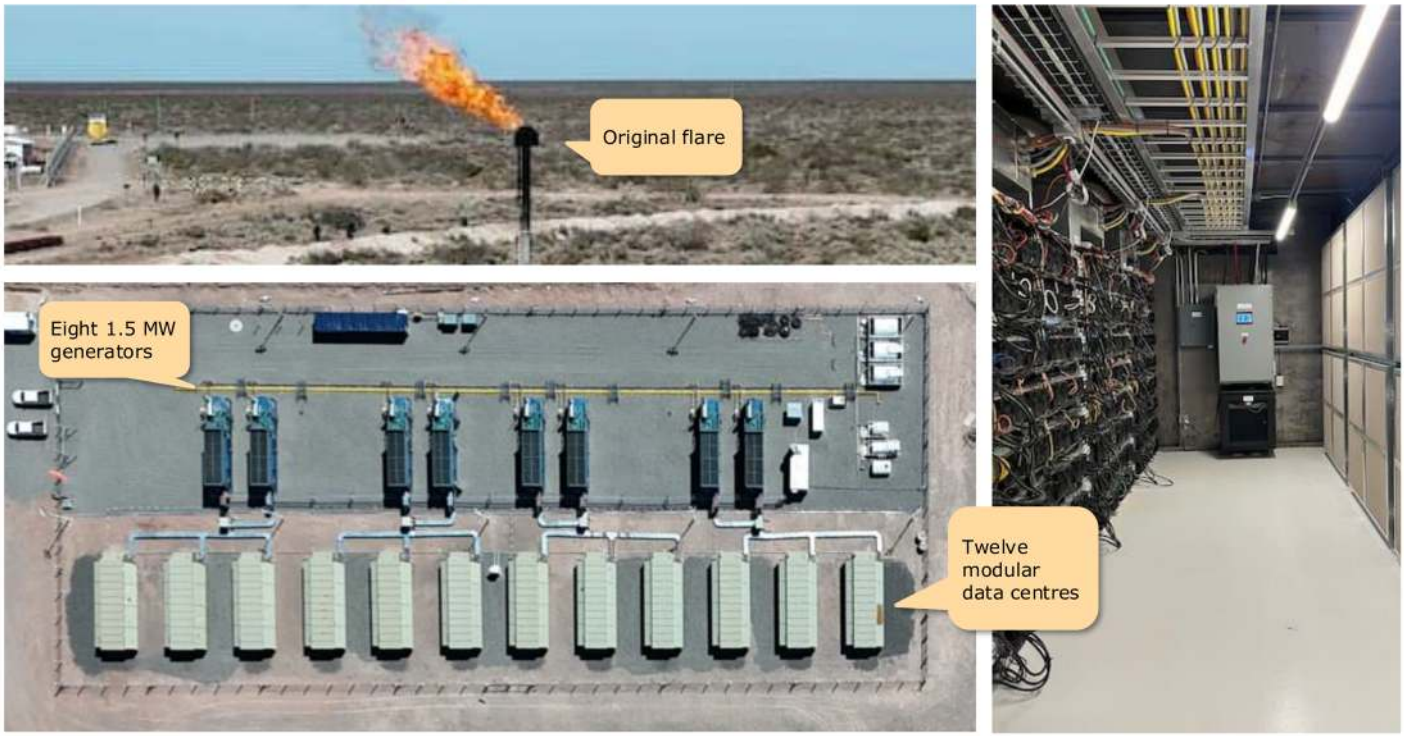
9 Saleem, K. (2023, December 16). Bitcoin miner unlocks $15m from Argentina's flared gas. *Tron Weekly.* https://www.tronweekly.com/bitcoin-miner-15m-from-argentinas-flared-gas.

How the Cryptocurrency Project was Delivered

From June to December 2023, Unblock installed a power generation unit consisting of eight 1.5 MW Jenbacher generators, chosen for their ability to handle a range of gas compositions. These generators produce up to 12 MW of power from a total gas volume of 50,000 m³ per day (1.8 million scf per day). In parallel, Unblock set up 12 modular data centers equipped with Antminer S19J Pro units, which process around 100 terahashes per second[10] at an efficiency of approximately 30 J/TH.

The total capital cost for the project was around $17 million, with $3 million allocated to the gas-gathering system, $7 million to the power generation units, and $7 million to the computing hardware. The gas was purchased at around $0.10 per MMBtu, reflecting its limited value to the operator[11] and resulting in a net levelized power cost of approximately $0.04 per kWh. Funding was provided by two of Argentina's largest companies, Pampa Energía and Petrocuyo.

At full capacity, with 12 MW of power generating 105 GWh per year, the facility is expected to mine approximately 82 Bitcoin-equivalents[12] annually, or around seven per month, generating about $8 million in revenue at current prices of $100,000 per Bitcoin. Power costs alone are projected to be around $4 million per year, and after accounting for other operating expenses, the likely annual cash flow from operations is $3 million. This suggests a payback period of 4 to 5 years. We expect that this flare-capture project lowers emissions by 100,000 metric tons of CO_2-equivalent per year.[13]



Source: Unblock Global.

Figure 5: Overview of the flare, the eight generators and twelve computing units.

10 1 TH is 1 trillion hashes per second. A hash is a cryptographic calculation used in mining to solve complex mathematical calculations.
11 Under the terms of the concession, although the gas is owned by the provincial government, the operator is entitled to exploit it.
12 In reality (as is standard in the cryptocurrency industry), the computing power delivered by Unblock is pooled with other miners to deliver a collective computing contribution.
13 Assuming a flare combustion efficiency of, say, 95% and a global warming potential of 82.5 over a 20-year period.

Sidebar on Cryptocurrency Mining

Several cryptocurrencies, most notably Bitcoin, use a proof-of-work approach to releasing new cryptocurrency through a process known as mining. Cryptocurrency miners add blocks of transactions to a blockchain by solving complex cryptographic puzzles that require significant computational power. The blockchain represents a digital ledger that lets participants track transactions across the cryptocurrency network. In exchange for adding blocks to the blockchain, miners are rewarded with transaction fees and new cryptocurrency coins. The system is designed to maintain a steady block generation time of about 10 minutes, with difficulty adjusted dynamically based on network-wide computing power. The computational power of a network mining cryptocurrency is measured as a hash rate, which represents the number of guesses or attempts to solve the cryptographic puzzle per second.

Cryptocurrency mining has come under significant scrutiny for its large power consumption, associated costs (which also include cooling), and related CO_2 emissions. The Cambridge Bitcoin Electricity Consumption Index estimates that 67 to 240 TWh of power were required to mine bitcoins (some 900 per day) in 2023, consuming 0.2% to 0.9% of energy in 2024.[14]

Given the high carbon intensity of bitcoins, it is clearly of paramount importance that the power used is not only low carbon, but that it does not consume power that could be used for more conventional uses and decarbonize the grid. The use of flared gas to generate power, therefore, is an obvious decarbonization choice if no other option to use the gas or power is available. Compared with alternative sources of power for bitcoins, a flare application arguably comes emission-free (since the emissions are already occurring). Indeed, it may even reduce emissions because the emissions of uncombusted methane from suboptimal flare operation will be minimized. As one operator said, "i*f you can't sell the molecule, and you can't sell the electron, then you may be able to sell computing services such as cryptocurrency mining or server hosting.*"

Cryptocurrency mining has several advantages over alternative computation—e.g. running a data center—since it can handle more variability in electricity supply. Equally, it can act as a flexible load, responding to demand signals. Given that high-intensity computing requires significant cooling, this monetization option works particularly well in lower-temperature environments, such as in Argentina, where the cost for cooling the computing units is lower.

Impact and Benefits of the Project

The impact of the project was twofold. First, by capturing the gas flare, emissions of CO_2 and methane were avoided, which significantly reduced the operational carbon intensity of the produced oil. A crude estimate suggests that emissions have been reduced by about 40,000 metric tons of CO_2 per year, though this figure underestimates the effect of lower methane slip. A more realistic assessment places the CO_2-equivalent impact closer to 100,000 metric tons per year.

Second, capturing the gas enabled the operator to test the appraisal wells and support their increased oil production from 40 to 300 m^3 per day (270 to 2,000 barrels per day) without a net increase in Scope 1 and 2 operational emissions. This resulted in an estimated additional revenue of around $30 million per year for the upstream operator, Tecpetrol, and

14 Morey, M., McGrath, G., & Minato, H. (2024, February 1). Tracking electricity consumption from US cryptocurrency mining operations. U.S. Energy Information Administration. https://www.eia.gov/todayinenergy/detail.php?id=61364.

its partners.[15] In this context, the financial benefits of the flare-capture project far outweigh the direct impact from emissions reduction.

Some critics might argue that the project indirectly facilitated increased oil production, and therefore higher total emissions. A more pragmatic view is that this oil would have been produced regardless. Any initiative that significantly decarbonizes its extraction can, therefore, be seen as a positive step.

Beyond emissions reduction and value creation, the operators involved report that the project also contributed to economic development by building capabilities and creating jobs. It helped establish a local supply chain for data center construction, including metallurgical work and computer hardware maintenance, while providing training for data center electronics and software operators. The project has created valuable employment opportunities in the small town of Rincón de los Sauces, about 40 minutes away, with 80 workers employed during construction and eight permanent staff supporting ongoing operations.

As Ricardo Ferreiro, the head of operations at Tecpetrol, noted, the cryptocurrency mining project *"not only helped us to de-risk the complex Los Toldos II Este project but also enabled us to meet the provincial regulations and our own high environment standards*."

Key Success Factors

The project was successful and serves as a blueprint for similar future developments and cryptocurrency mining installations. Four main factors contributed to its success.

- First, the **strong local knowledge and expertise** of Unblock and its investors played a crucial role. The project benefited from a deep understanding of logistical challenges, including staff recruitment, regulatory approvals, equipment imports, and fundraising.
- Second, the **partnership with world-class cryptocurrency operator** Crusoe Energy Systems was instrumental. With a track record of delivering 240 MW of similar projects, primarily in the United States, Crusoe brought extensive experience and technical know-how.
- Third, the **support of national and provincial governments** was a major enabler. Authorities were committed to reducing flaring and actively worked to remove bureaucratic hurdles, such as environmental permit approvals. The government had a strong incentive to facilitate the project, since it monetized the oil resource base and ensured that emissions intensity remained low and competitive.
- Finally, the **leadership of Tecpetrol's CEO was instrumental in driving innovation and making the project happen**. The company demonstrated a strong commitment to the project, taking a calculated risk on a technology that was new to Argentina and embracing its potential to transform gas-flaring mitigation.

15 Assuming a discounted notional oil price of $50 per barrel, given the transportation costs required.

To find out more, or share your feedback, please email the authors at: ptoled@law.columbia.edu or mark.davis@capterio.com.



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