



# LOSSES AND LOST OPPORTUNITIES: A SOCIOECONOMIC ANALYSIS OF OIL EXPLORATION AT THE MOUTH OF THE **AMAZON RIVER**

STUDY BASED ON THE OFFICIAL METHODOLOGY OF THE FEDERAL  
GOVERNMENT – CBA (COST-BENEFIT ANALYSIS) - 2026

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# INTRODUCTION

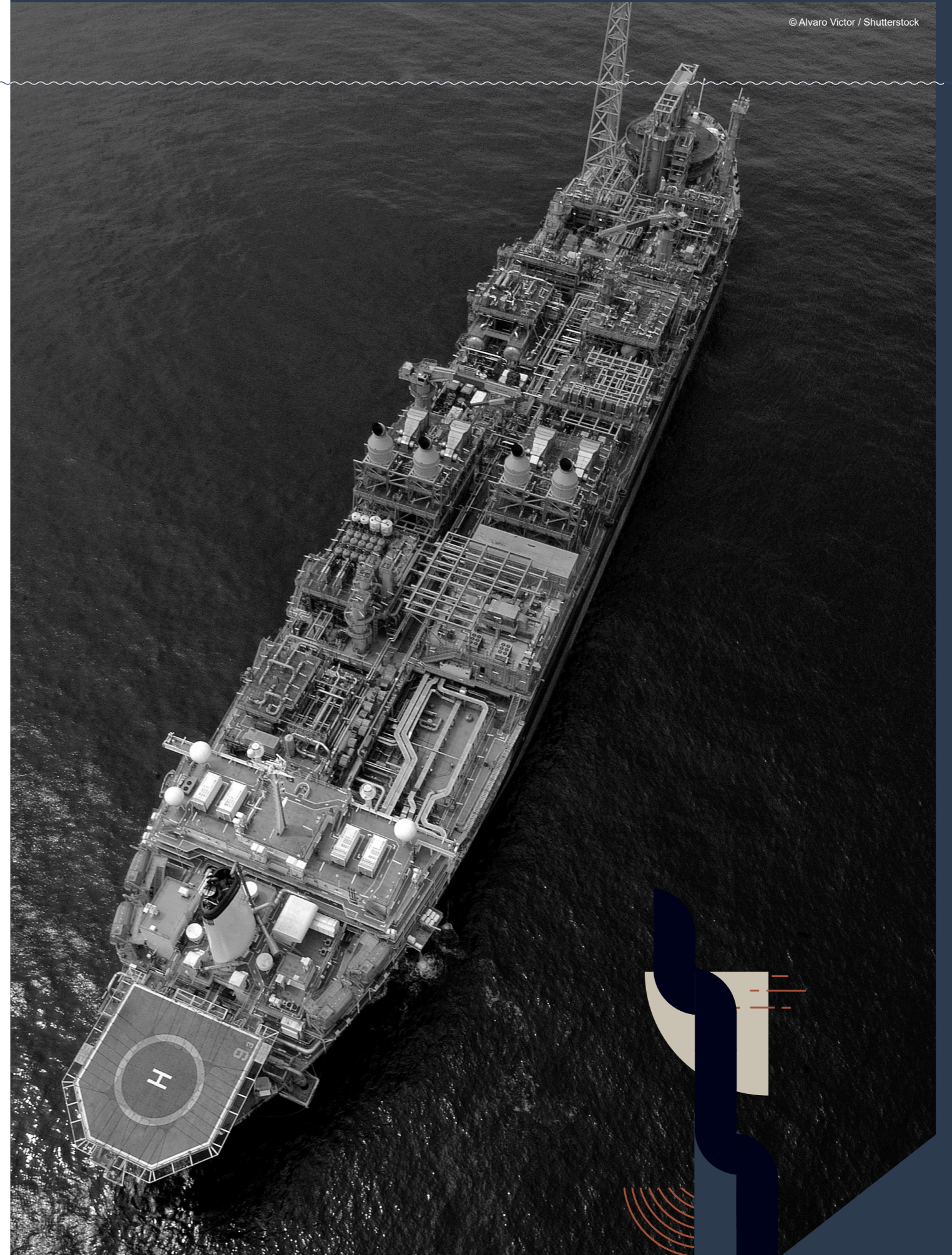
Oil exploration at the Mouth of the Amazon River is part of the public debate on oil as a development pathway: generating wealth today to sustain investment and finance the energy transition tomorrow.

**The issue is often framed in terms of production potential and public revenues, but the decisive question for the country is different: what can Brazilian society gain and lose by opening a new oil frontier in a context of accelerated energy transition and rising risks?**

It is precisely to answer this question with evidence – rather than expectations – that the study summarized in this document was conducted. Instead of limiting the analysis to financial feasibility from the investor’s perspective, it applies a Socioeconomic Cost-Benefit Analysis (CBA), the Federal Government’s official methodology for evaluating public investments, to measure the real return to society.

This means putting direct costs, benefits, and externalities all in the same equation, including those that don’t appear in the market price but affect everyone: climate risks, diffuse costs, and long-term consequences.

**The starting point is straightforward: society’s demand is for energy and energy services, not for the commodity “oil” itself. For this reason, the study compares the fossil fuel pathway with effective energy transition alternatives using equivalence criteria that ensure a fair and verifiable comparison: equal investment (Real for Real), equal energy output (BTU for BTU), and equivalent fuel production (Liter for Liter).**





## WHAT DO THE DATA SHOW?

By translating the debate into concrete figures, the study provides clear guidance for public officials, investors, and decision-makers: when costs and benefits are assessed from a societal perspective — rather than solely through the lens of private profit — **oil exploration at the Mouth of the Amazon River could generate multi-billion-dollar losses for the country.**

The findings demonstrate that persisting in the “fossil pathway” represents a serious allocative inefficiency. In other words, the proposed investment does not deliver the expected returns for Brazilian society, resulting in higher overall costs, elevated financial risks – including the likelihood of stranded assets – and negative social returns.

Losses become even greater when climate-related costs are taken into account – costs that are not currently reflected in corporate balance sheets but ultimately affect society as a whole.

**Alternative pathways offer greater energy security while reducing fiscal and climate-related risks.**

At the same time, the study makes explicit the opportunity cost: persisting in oil development means forgoing substantial social gains that could be achieved by redirecting resources toward the renewable pathway and biofuels such as ethanol, biodiesel, and biomethane. This approach delivers greater immediate socioeconomic benefits and strengthens energy security, without compromising the country’s long-term climate and fiscal stability.



### EVIDENCE FOR PUBLIC OFFICIALS AND DECISION-MAKERS

*The purpose of this analysis is to provide a clear roadmap to guide public policy choices and investment strategies based on what truly matters to society: social return, total cost, and risk exposure.*



## BRAZIL'S ENERGY MIX

Brazil's energy mix is broad, diversified, and rich in potential. The country combines hydropower, oil and gas, bioenergy, wind, and solar, with renewable sources showing consistent growth in recent years – today, **88.2%** of Brazil's electricity generation is already renewable. This combination is a strategic asset: it enhances energy security, reduces dependence on oil and gas (which still account for **43.6%** of total energy consumption) avoids reliance on a single source, and increases flexibility to respond to price shocks and shifts in the international landscape. At the same time, significant challenges remain.

**88,2%**  
of Brazil's electricity  
generation is already  
renewable

Infrastructure must be modernized, transmission networks expanded, transport electrification accelerated, and regulatory predictability ensured to attract long-term investment. It is also essential to reduce regional inequalities so that the benefits of the energy transition reach different parts of the country. The opportunities, however, are clear: expanding renewable energy, strengthening biofuels, restoring degraded lands, and advancing industrial innovation. With strategic planning and public decision-making guided by social cost considerations, Brazil can transform its energy diversity into sustainable development, competitiveness, and climate resilience.



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# WWF-BRAZIL AND THE INFRASTRUCTURE AND ENERGY TRANSITION AGENDA



WWF-Brazil is a Brazilian organization that has been active in the country since 1996, working in partnership with civil society, academia, governments, and the private sector across the national territory to address socio-environmental degradation and contribute to building a future in which people live in harmony with nature.

The organization is part of an independent international network dedicated to advancing urgent solutions to the climate emergency, promoting biodiversity conservation and the responsible use of natural resources for the benefit of present and future generations.



**From this perspective, it establishes as one of its strategic pillars the promotion of infrastructure that responds to contemporary development and sustainability challenges. This means supporting decisions and projects that take into account:**

<b>long-term positive impacts</b>	<b>efficiency in the use of natural and financial resources</b>	<b>risk and impact reduction</b>	<b>the alignment of economic and social benefits with ecosystem protection.</b>

## WE NEED RELIABLE AND EFFICIENT INFRASTRUCTURE

A reliable and efficient infrastructure network – in both scale and quality – is essential to sustain a country’s economic, social, and environmental development. This foundation requires coordinated public and private investment, supported by rigorous planning and comprehensive assessment of costs, benefits, and risks throughout the entire project lifecycle.

In this context, the debate surrounding large-scale energy projects – such as those related to oil exploration – must be conducted with transparency and a clear focus on the public interest, avoiding investments that increase societal vulnerabilities. It is within this framework that the present study on oil exploration at the Mouth of the Amazon River is situated.

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# A SOCIO-ECONOMIC COST-BENEFIT ANALYSIS (CBA) AND COLLECTIVE WELL-BEING

# WHICH ALTERNATIVE MEETS SOCIETY’S DEMAND WITH THE HIGHEST SOCIAL RETURN AND THE LOWEST TOTAL COST?



The study here presented applies the Socioeconomic Cost–Benefit Analysis (CBA) methodology, in accordance with the [Federal Government’s official guidelines](#), to assess whether oil exploration at the Mouth of the Amazon River represents an efficient allocation of scarce resources for Brazilian society, compared with effective energy transition alternatives based on renewable sources.

Socioeconomic evaluation differs from financial evaluation because it shifts the focus of the analysis. Rather than asking “how profitable is it for the investor?”, CBA seeks to determine which option generates the greatest net benefit for society as a whole, at the lowest total cost. By comparing alternative pathways – oil exploration versus electrification and biofuels – the study places the public interest at the center of the analysis: evaluating the social benefit first, before determining how it should be delivered. This approach enables transparent ranking of alternatives, identifying those that deliver greater benefits at lower overall costs, including when effects that remain invisible in private accounting – such as environmental and climate externalities – are taken into consideration.

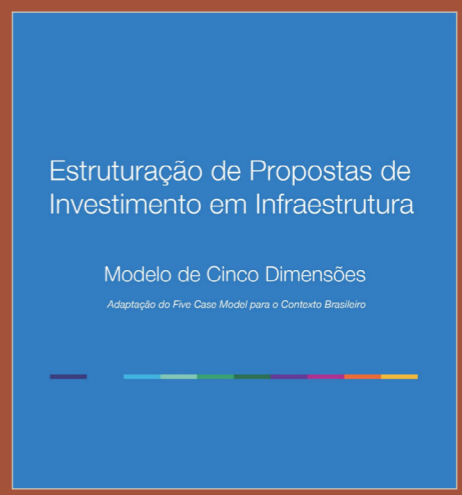
**CBA seeks to determine which option generates the greatest net benefit for society as a whole**



## ABOUT THE METHODOLOGY

Internationally recognized and applied by countries such as Chile, the United Kingdom, Australia, South Korea, and South Africa – as well as by multilateral institutions – Cost–Benefit Analysis (CBA) provides a robust framework for comparing investment alternatives and assessing whether a project’s benefits justify its costs. It allows for the consideration of impacts and risks – including those associated with climate change – the testing of different project designs and technological assumptions, the measurement of effects on ecosystem services, and the incorporation of demand-side perspectives, alongside sensitivity analyses of key variables.

The methodology has been incorporated by the Federal Government into the [Five-Dimension Model \(5DM\)](#), for infrastructure investment appraisal, guided by the General Guide to Socioeconomic Cost-Benefit Analysis, and is recommended by the Federal Court of Accounts. WWF-Brazil advocates for its adoption from the earliest project stages in order to strengthen public decision-making aligned with sustainability and collective well-being.



# WHAT COST-BENEFIT ANALYSIS (CBA) REVEALS IN THE CASE OF OIL EXPLORATION AT THE MOUTH OF THE AMAZON RIVER

Unlike a purely financial analysis, Cost-Benefit Analysis (CBA) evaluates returns to society as a whole, accounting for:



## COSTS AND BENEFITS TO SOCIETY:

Considering not only corporate profits, but also how the population gains or loses from a project, adjusting prices that do not reflect the true economic cost to the country.



## EXTERNALITIES:

Impacts not captured by market transactions, particularly the Social Cost of Carbon (climate-related damages such as droughts, floods, public health impacts, and other losses), which are ultimately borne by Brazilian society through reduced quality of life and economic disruption.



## BASELINE SCENARIO:

The reference case is a standard production unit at the Mouth of the Amazon River – an offshore platform capable of extracting 120,000 barrels of oil per day, operating over 30 years until exhausting a reserve of approximately 900 million barrels.



## COUNTERFACTUAL COMPARISON:

The study compares the oil extraction project with clean energy transition alternatives (non-hydro renewables and biofuels) from three analytical perspectives: the same level of investment (“Real for Real”), the same amount of energy delivered (“BTU for BTU”), and the same volume of petroleum-derived fuel output (“Liter for Liter”).



## ROBUSTNESS:

A Monte Carlo simulation is conducted to test risks and parameter variability, with 10,000 simulations under different risk scenarios and price fluctuations to verify whether the conclusions remain consistent.



## ALTERNATIVES AS INTEGRATED SYSTEMS

A central premise of this CBA is to compare alternatives as self-contained systems: it is not enough to simply list energy sources; it is essential to consider what is required to effectively deliver the energy service.

In constructing the scenario based on renewable electric sources, all the infrastructure required to deliver energy to society through the National Interconnected System is assessed. The full accounting is considered: firm energy produced by each source; the cost of building power plants and transmission lines; 30 years of operation, including repowering to align asset lifetimes; as

well as local impacts such as noise and land use. The cost of pollution generated throughout the entire life cycle – production, use, and disposal – is also incorporated. In the biofuels scenario, the same energy content and functional performance for end users are ensured, likewise incorporating life-cycle pollution costs.

**Therefore, the comparison encompasses the full life cycle and all associated costs, from the initial stages of production through to final consumption.**

# THE AMAZON RIVER MOUTH

The Equatorial Margin is a stretch of Brazil's coastline extending from Amapá to Rio Grande do Norte – a unique coastal and marine territory associated with a complex ecological system, including the Great Amazon Reef System.

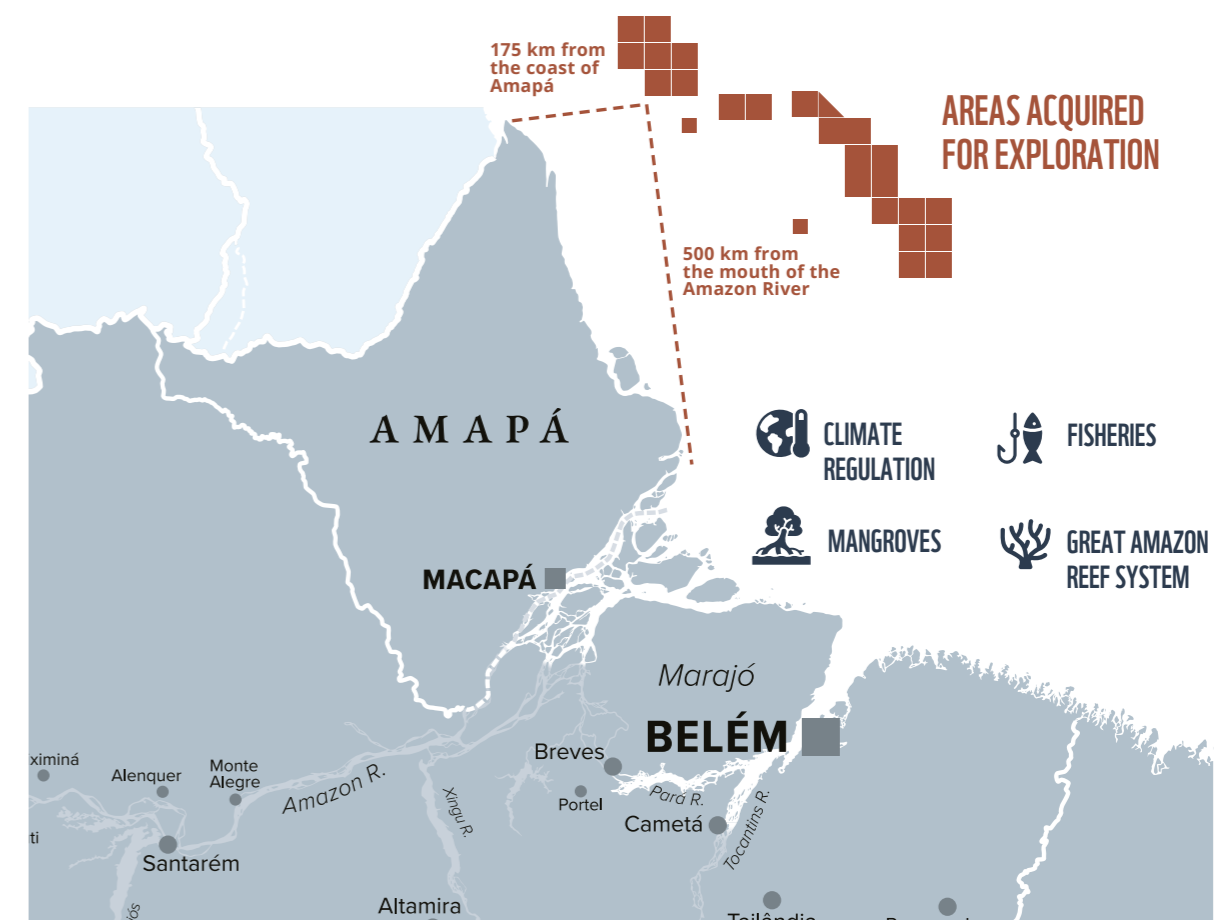
Due to these characteristics, it is an environmentally sensitive region and strategically important for ecosystem services that sustain biodiversity, fisheries, and climate regulation processes. The Amazon Mouth Basin, an area of interest for oil exploration, is part of the Equatorial Margin.



What is at stake goes beyond the financial balance sheet of a single project: at issue are the social cost of carbon, other externalities not reflected in market prices, operational risks, and the opportunity cost of an energy policy heavily dependent on oil.

This dependence encourages the allocation of public and private investment toward projects with high climate risk and the potential for irreversible losses. At the same time, at the national level, it hinders the expansion of renewable energy sources necessary for the energy transition, with negative implications for fiscal resilience and investor returns. Even when some of these effects are not fully translated into monetary values, they remain central to assessing whether oil and gas exploration in the region serves the public interest.

## SENSITIVE REGION, WITH VAST BIODIVERSITY, NEAR MAJOR RIVERS AND THE RAINFOREST.



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PART 1

# FOSSIL FUELS SCENARIO



# THE BASE PROJECT: A TYPICAL OIL MODULE IN THE MOUTH OF THE AMAZON RIVER

The production of fossil fuels derived from oil can be understood as a value chain composed of two main stages.

## UPSTREAM STAGE:

it involves exploration, drilling, field development, and subsequently the extraction and production of crude oil in an offshore environment.

## MIDSTREAM STAGE:

it includes refining and processing to transform crude oil into fuels and enable their supply for final consumption.

In this analysis, the Mouth of the Amazon River is represented by a typical module (a “representative block”), defined to enable consistent comparisons under three Socioeconomic Cost-Benefit Analysis (CBA) configurations:



**Real for Real**  
(resource allocation comparison)



**BTU for BTU**  
(energy equivalence)



**Liter for Liter**  
(fuel volume equivalence)

**The logic is straightforward: by fixing a representative module, the study is able to estimate production volumes, timelines, and costs, and from there compare alternatives using common metrics.**

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## WHAT IS THE TYPICAL MODULE

The typical module serves as the analytical baseline of the study. It is from this reference unit that production volumes, costs, revenues, and subsequently the impacts not reflected in market prices (externalities) are estimated.

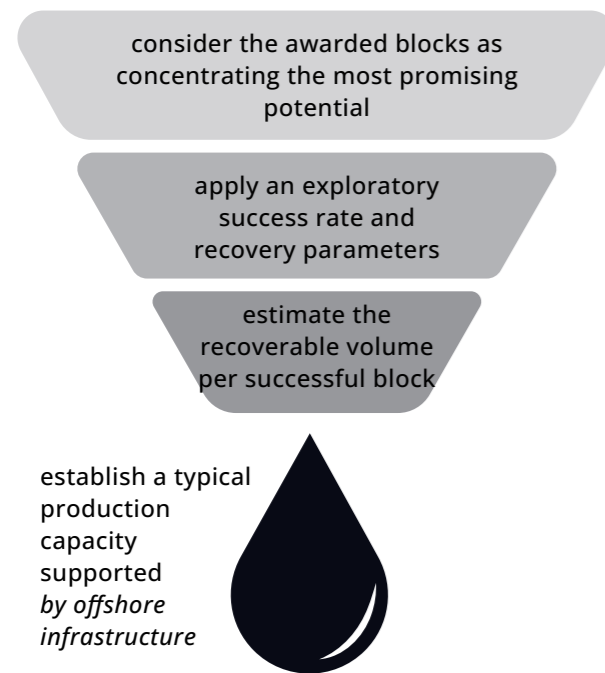
In this report, the terms “typical module”, “representative block”, and “representative module” are used interchangeably. They all refer to the oil production platform (FPSO) and the systems associated with it. Whenever these terms appear, they designate the same underlying structure.



# FROM THE POTENTIAL OF RESERVES TO THE DESIGN OF THE REPRESENTATIVE MODULE

The first step of the study is to construct, based on explicit assumptions, a bridge between reserve potential and what can effectively be produced by a typical module at the Mouth of the Amazon River. To do so, it relies on estimates attributed to the National Agency of Petroleum, Natural Gas and Biofuels (ANP) regarding Brazil's Equatorial Margin and, within it, the sedimentary basin of the Mouth of the Amazon River.

The definition of the module follows a "funnel" logic:



This framework translates geological uncertainty and exploration risk into a quantified project scenario – a necessary condition for conducting comparable calculations of cost, benefit, and risk.

## UPSTREAM PHASE: FROM RESERVES TO PRODUCTION POTENTIAL

According to Brazil's National Agency of Petroleum, Natural Gas and Biofuels (ANP), the Brazilian Equatorial Margin (BEM) holds total potential reserves estimated at 30 billion barrels of oil. Even so, once the decision to proceed with exploration is made, there is a significant time lag between the start of exploration activities and the onset of production. The study incorporates this reality: survey campaigns, drilling, well testing, and field development all precede the first commercially produced barrel.

The Brazilian Equatorial Margin (BEM) holds total potential reserves estimated at 30 billion barrels of oil

TO TRANSLATE THIS DYNAMIC INTO QUANTITATIVE TERMS, THE STUDY DEFINES A FOUR-DECADE HORIZON, WITH:



In addition, production is not constant: it includes a ramp-up phase, a plateau of full production, and subsequently a ramp-down (decline), reflecting capacity constraints and resource depletion.

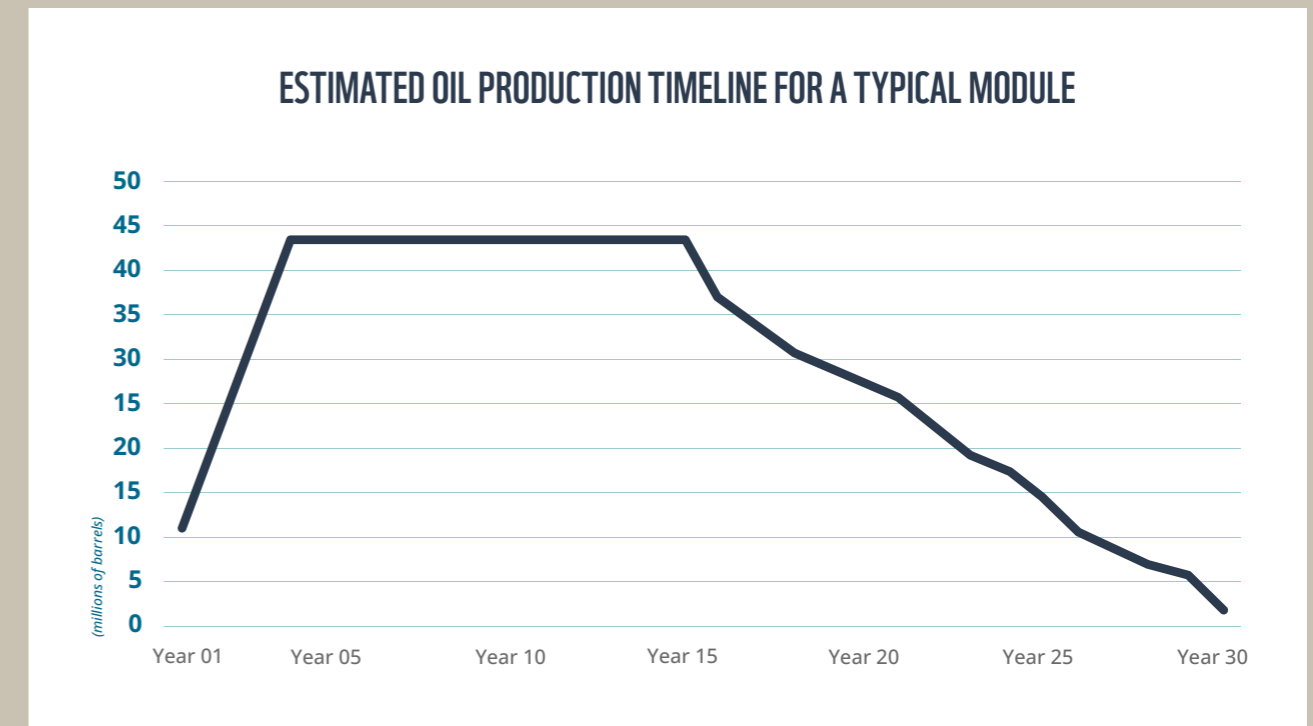
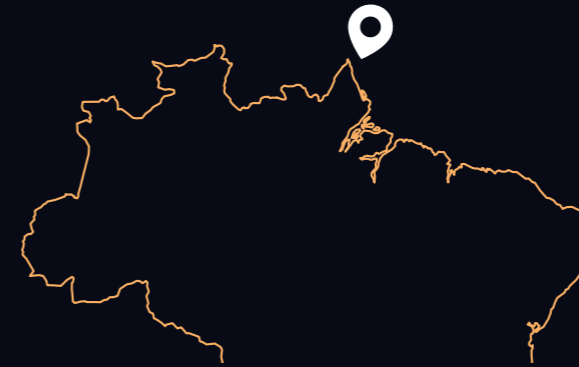


Figure 1 – Estimated schedule of oil production in a typical module



# THE PROJECT AT THE MOUTH OF THE AMAZON RIVER

## WHERE AND WHAT?



The study examines a **representative offshore exploration module** at the Mouth of the Amazon River, based on an **FPSO** platform (Floating Production, Storage and Offloading unit) with a production capacity of **120,000 barrels per day**.

## SCALE AND TIMEFRAME



Approximately **900 MILLION BARRELS** — estimated extractable volume

**40 YEARS**  
OF LIFE CYCLE

**10 YEARS** OF INVESTMENT + **30 YEARS** OF OPERATION

## THE TYPICAL MODULE IN NUMBERS

The representative module (a floating production, storage and offloading unit) is designed as an offshore system based on a facility with a production capacity of 120,000 barrels per day.

The module's total output over its operational life cycle amounts to 884.21 million barrels, distributed across different phases. During the full production period (12 years), the module operates at maximum capacity (120,000 barrels per day), accounting for the largest share of total output.

**One single module.**  
**Four decades of investment.**  
**Long-term economic and climate impacts.**



**COST TO SOCIETY**

**R\$ 32.4 BILLION**  
IN TOTAL SOCIAL COST  
(PRESENT VALUE)



**CLIMATE IMPACT**

**446 MILLION**  
TONNES OF CO<sub>2</sub>  
(LIFE-CYCLE EMISSIONS)



## BTU FOR BTU: THE MODULE AS EQUIVALENT ENERGY SUPPLY

The study begins from a straightforward premise: society requires energy, not oil as a commodity in itself. For this reason, the module's average annual oil production is converted into an equivalent measure of energy. This conversion enables a direct comparison between oil and alternative pathways capable of delivering the same energy service.

**Based on the average annual number of barrels produced, the study estimates an energy equivalent of 48.63 TWh per year. This figure serves as the benchmark to assess whether alternatives, such as electrification, can supply the same amount of energy at lower cost and with reduced environmental impact.**

## TOTAL ENERGY AND PETROLEUM-BASED FUELS

Cost-Benefit Analysis compares production at the mouth of the Amazon River under three criteria: Real for Real, BTU for BTU, and Liter for Liter. Because oil is treated as an import substitute, the Real for Real comparison considers only the costs associated with the exploration and production phase, without relying on refining or final use.

### TOTAL ENERGY – “BTU FOR BTU” CONFIGURATION

Under the BTU for BTU comparison, the analyzed module would operate for 30 years and produce approximately 884.21 million barrels in total. To enhance analytical clarity, the study uses the average annual production, estimated at 29.47 million barrels per year.

According to the conversion factors of Brazil's National Energy Balance, this volume corresponds to 48.63 TWh per year. The renewable alternative is therefore sized to continuously deliver this same amount of energy, which corresponds to firm power of approximately 5,551 MW, taking into account the capacity factors of the respective sources.

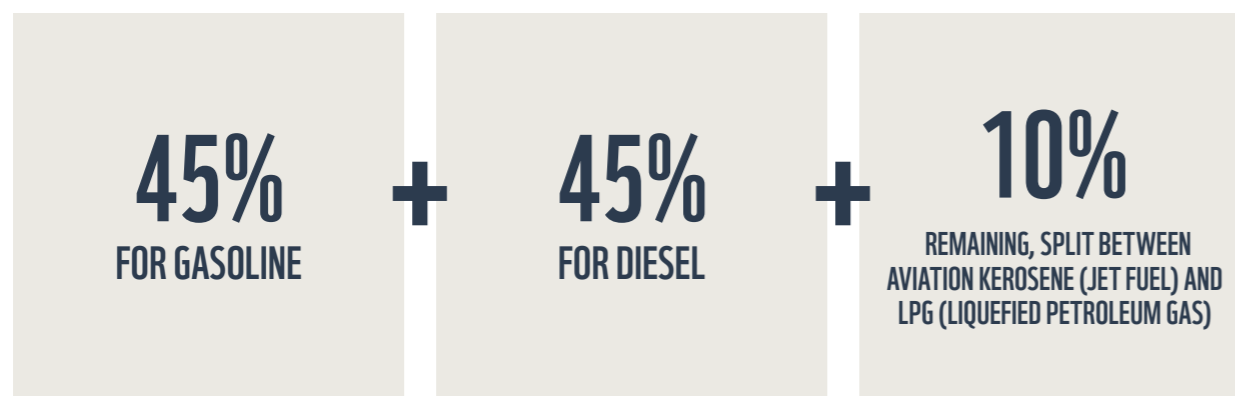
**In summary, under BTU for BTU equivalence, the central question is straightforward: which pathway delivers the same amount of energy at lower total cost and with fewer impacts on society?**



## DERIVED FUELS: “LITER FOR LITER” CONFIGURATION

Under the Liter for Liter logic, the study assesses which fuels, and in what volumes, can be derived from the oil produced. Although it is uncertain whether this oil would be refined in Brazil, the analysis adopts a theoretical equivalence of 159 liters per barrel.

**BASED ON THE NATIONAL CONSUMPTION PROFILE,  
THE VOLUME IS DISTRIBUTED IN A SIMPLIFIED MANNER:**



In the peak year, this corresponds to approximately **6,76 billion** liters of refined products.

## WHAT IS LOST ALONG THE WAY BEFORE BECOMING FUEL

Refining generates physical gains, but it also consumes energy and involves losses. To avoid distortions, the study applies a 3% adjustment, assuming that these effects largely offset one another and estimating only the volume effectively available as fuel.

## HOW THESE FIGURES ARE USED IN THE NEXT STAGES

Energy and fuel equivalences make it possible to compare costs, benefits, and externalities – particularly emissions – on equal footing, always expressed in present value and based on consistent assumptions. These parameters also guide the sizing of electrification and biofuel alternatives.

Even under conservative assumptions for the social cost of carbon, **most of the scenarios analyzed indicate economic losses over the 40-year period**. Only scenarios with high oil prices approach breakeven.

Taken together, the evidence suggests that **opening a new oil frontier at the Mouth of the Amazon River would increase climate-related risks**, place additional pressure on public resources, and **reduce** fiscal space for **investments in alternatives with higher social returns**. The viability of the fossil pathway, therefore, depends on a scenario in which the climate crisis is not effectively addressed – and its costs are borne by society as a whole.



**PART 2**  
**ELECTRIFICATION**



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## ELECTRIFICATION SCENARIO AS AN ALTERNATIVE TO OIL

The starting point of the electrification scenario is that there are pathways more efficient, cleaner, and better aligned with the country’s energy future than oil extraction at the Mouth of the Amazon River. Given that Brazil holds 16.8 billion barrels of proven reserves (2024), sufficient to meet domestic demand along a declining trajectory consistent with its climate commitments, opening new fossil frontiers in the Equatorial Margin is not an energy necessity. The resources that would be allocated to such extraction can therefore be redirected toward renewable electricity generation, strengthening the energy transition while reducing economic, social, and environmental risks.

## ELECTRIFICATION AND THE FUTURE OF TRANSPORT

Electrification is also gaining prominence in the transport sector, traditionally dependent on fossil fuels. Projections from Brazil’s Energy Research Office (EPE) indicate that electricity demand associated with electromobility is expected to increase from 627 GWh to 7.8 TWh by 2035, a growth of 1,144%. This expansion is driven by declining technology costs, a broader supply of electric vehicles, and supportive public policies. The shift is not limited to light-duty vehicles; it also encompasses buses and trucks, particularly smaller models, reshaping the way energy and mobility interact across the country.

## HOW ELECTRIFICATION IS EVALUATED IN COST-BENEFIT ANALYSIS

In the Cost-Benefit Analysis, the electrification scenario is assessed through two complementary lenses. The “Real for Real” approach compares the allocation of the same societal resources: investing in oil extraction versus directing that investment toward electrification. The “BTU for BTU” approach starts from the delivery of the same service to society – the same amount of energy – and compares the costs and impacts of producing it through fossil fuels or renewable electricity. In both cases, the focus remains on the public interest and the social return of the choices made today.

## A RENEWABLE, VIABLE AND LOW-IMPACT ENERGY MIX

The electrification scenario relies exclusively on non-hydro renewable sources, combining rapid deployment, lower environmental impact, and greater resilience of the power system.

The energy mix considered consists of **50% onshore wind, 42% solar photovoltaics, 4% biomass (sugarcane bagasse), and 4% biogas (urban solid waste, sugar-energy residues, and animal waste).**



### SOLAR ENERGY

stands out for its rapid deployment capacity – it can be installed in approximately one year – with a 25-year operational lifetime and strong expansion across Brazil.



### WIND ENERGY

demonstrates strong performance, with an average capacity factor of 42.5%, reaching 50-60% in Brazil’s Northeast region.

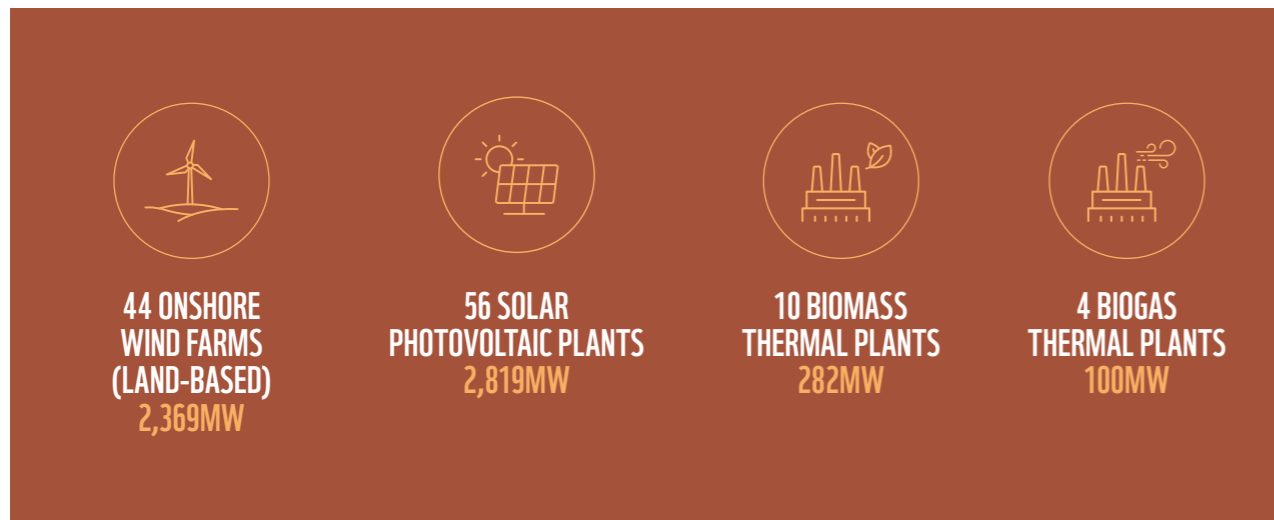


### BIOENERGY

through biomass and biogas, complements the system, helps reduce emissions, and contributes to the stability of energy supply, reinforcing a consistent pathway for Brazil’s energy transition.

## REAL FOR REAL: A PORTFOLIO WITH THE SAME SOCIAL COST

Under the Real for Real equivalence, the study asks what could be achieved with the same **R\$ 32.4 billion** in social cost associated with the oil project. The scaled portfolio includes approximately:



### COSTS, BENEFITS, AND HIDDEN IMPACTS

The study accounts for direct costs, the benefits of the energy services delivered, and externalities, while maintaining equivalence in social investment. The guiding question is: which pathway generates the highest net return for society within the same “social budget”?

### THE FINAL BALANCE FOR SOCIETY

The contrast is clear: while the **oil** pathway presents a negative average **Social Net Present Value (SNPV)**, **electrification** generates a **positive net benefit** of approximately **R\$ 24.8 billion**. The difference represents the opportunity cost: **persisting in oil development would cost society roughly R\$ 46.9 billion**.

### HOW TO INTERPRET THESE FIGURES FOR DECISION-MAKING

The message is one of allocative efficiency. When resources are scarce, the relevant decision is not merely to avoid losses, but to maximize social gains. The renewable alternative delivers higher net returns and lower risk for society.



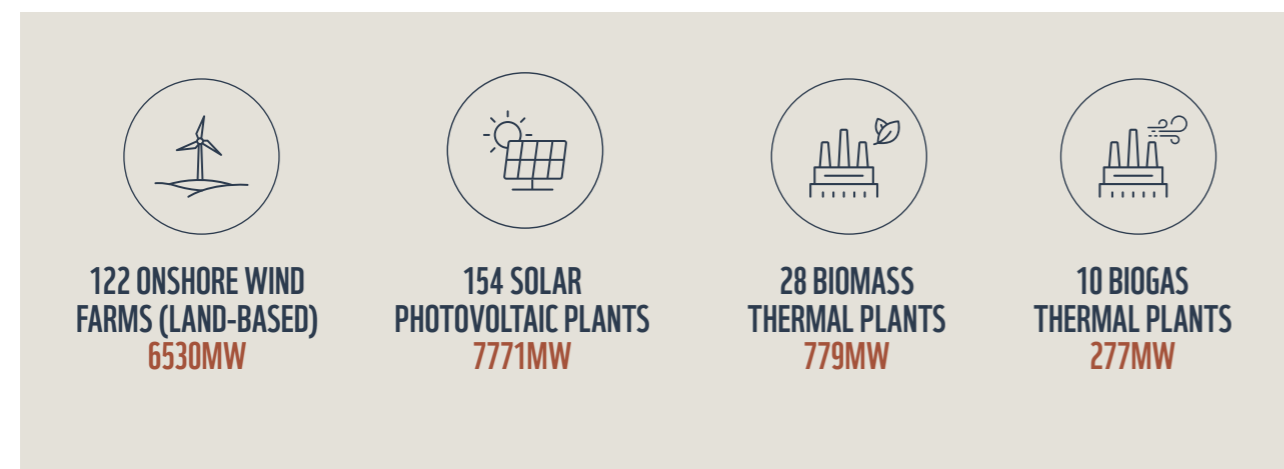


## BTU FOR BTU: COMPARING DIFFERENT PATHWAYS DELIVERING EXACTLY THE SAME ENERGY SERVICE

Under BTU for BTU equivalence, the energy benefit is fixed: delivering the equivalent of 48.63 TWh per year, associated with average firm power of 5.55 GW. The comparison then becomes: which pathway delivers this same amount of energy at lower total cost and with fewer impacts?

### WHAT WOULD BE REQUIRED TO DELIVER THE SAME ENERGY

To supply the same level of energy, the study sizes an approximate portfolio of:



### HOW MUCH EACH OPTION COSTS WHEN EVERYTHING IS ACCOUNTED FOR

With the energy benefit held constant, the study compares total costs, including externalities. The oil pathway presents total costs ranging from **R\$ 106.0 to R\$ 127.1 billion**, while electrification ranges from **R\$ 91.8 to R\$ 93.4 billion**, depending on the parameters applied.

### THE EXTRA PRICE OF CHOOSING OIL: HOW MUCH MORE THE FOSSIL PATHWAY COSTS TO DELIVER THE SAME ENERGY

The result appears as the additional cost imposed by the fossil pathway: between **R\$ 14.2 and R\$ 33.8 billion more** over a 30-year period.

## THE QUESTION THAT GUIDES THE DECISION

### WHY PAY MORE FOR THE SAME RESULT?

The study ultimately frames the issue in a simple question: why incur a higher social cost to obtain the same amount of energy? When the benefit is equivalent, the efficient choice is the pathway with the lowest total cost and the smallest impact: **the clean energy pathway.**

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PART 3  
**BIOFUELS**



## BIOFUELS AS A DIRECT ALTERNATIVE

In addition to reducing emissions, biofuels strengthen energy security by being produced from domestic resources – a strategic advantage for Brazil. According to the International Energy Agency (IEA), the global supply of renewable fuels already reduces oil demand by approximately 2.5 million barrels per day.

## AN ESTABLISHED TRACK RECORD

Brazil is a pioneer in the use of biofuels, with mandatory ethanol blending in gasoline since 1931 and the launch of the Proálcool program in the 1970s. With the introduction of flex-fuel engines, ethanol consolidated its position as a competitive fuel. In 2024, it accounted for around 20% of national transport fuel consumption, supported by a robust and mature production chain.

## PUBLIC POLICY THAT PROVIDES PREDICTABILITY

RenovaBio established a market-based mechanism to incentivize emissions reductions in the transport sector through decarbonization credits (CBIOs). The program rewards environmental efficiency, imposes safeguards such as zero deforestation requirements, and has been complemented by the Fuel of the Future Law, which set clear mandates for green diesel, sustainable aviation fuel, biomethane, and natural gas decarbonization – ensuring regulatory certainty for investment.

## GROWING DEMAND FOR SUSTAINABLE FUELS

Demand for sustainable fuels is increasing in Brazil and globally. According to IEA estimates, by 2035 they could supply:



**10% OF GLOBAL ROAD TRANSPORT DEMAND**

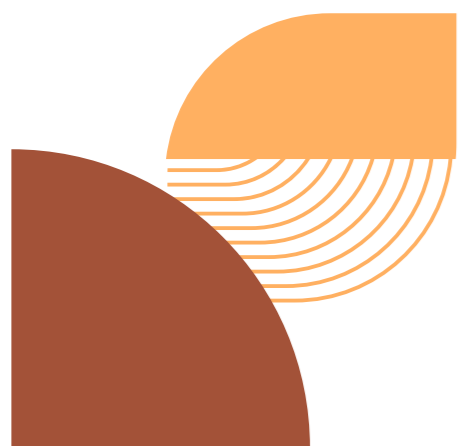


**15% OF AVIATION**



**35% OF MARITIME TRANSPORT**

In Brazil, the light-duty vehicle fleet is expected to remain predominantly flex-fuel, representing approximately 75% of the total fleet, thereby maintaining ethanol's central role in the energy transition.





## PRIVATE COSTS VERSUS SOCIAL COSTS

Next-generation biofuels still present higher market costs than fossil fuels, particularly in the case of sustainable aviation fuel (SAF), biomethanol, and green ammonia. However, these costs tend to have a limited impact on the final prices of many products. Moreover, market prices do not reflect the climate cost associated with the combustion of fossil fuels. When this externality is taken into account, substituting fossil fuels with biofuels results in net social savings.

## WHAT IS INCLUDED IN THE BIOFUELS BILL SCENARIO

The CBA estimates the cost of supplying biofuels in volumes equivalent to the fossil fuels produced by the Mouth of the Amazon River module, converting market expenditures into social costs (expressed in present value terms). These expenditures are allocated year by year according to the same “Liter for Liter” timeline used for the fossil pathway.

## IT IS NOT “EXCESS CAPACITY”: INVESTMENT MUST START FROM SCRATCH

The volumes considered are large enough to require new production facilities and dedicated infrastructure. The scenario includes the creation of additional industrial capacity to produce approximately 8.04 billion liters per year of various biofuels.

## WHERE THE COST PARAMETERS COME FROM

Capital expenditures (CapEx – including equity contributions and financing) and operational expenditures (OpEx), including feedstock costs, are primarily parameterized using data from the Energy Research Office’s (EPE, 2024) technical note on biofuels. Agricultural productivity and conversion yields are based on parameters from the Institute for Energy and Environment (IEMA, 2025) biofuels study.





## ETHANOL: COMPETITIVE AND BASED ON A MATURE VALUE CHAIN

Reference CapEx is based on integrated plants (ethanol/sugar) and sugarcane field establishment. Operational costs are largely driven by biomass, accounting for **87% of total OpEx (R\$ 1.94 per liter)**, with industrial processing costs of **R\$ 0.29 per liter**. The expenditure gap relative to gasoline is marginal (0.3%), consistent with ethanol's competitiveness.

## BIODIESEL: FEEDSTOCK DOMINATES THE COST

For soybeans, investment includes crushing (grain milling) and transesterification (conversion of oil into fuel). The opportunity cost of soybean oil is estimated based on recent average export prices, adjusted by a 15% logistics discount, resulting in **R\$ 4.61 per liter**. Animal fats/tallow follow a similar logic, with an estimated opportunity cost of **R\$ 3.53 per liter**. Glycerol revenues reduce **OpEx by approximately R\$ 0.13 per liter of biodiesel**.

## MACAÚBA: POTENTIAL TO REDUCE BIODIESEL PRODUCTION COSTS

Based on feasibility and productivity studies, **macaúba presents lower final costs than soybeans and animal fats**, given its high yield per hectare, lower land opportunity cost, and the fact that it is not a globally traded commodity. The share of macaúba significantly affects the outcome: without it, biodiesel becomes substantially more expensive; with greater participation, costs decline markedly.

## SAF (SUSTAINABLE AVIATION FUEL): THE MOST EXPENSIVE AMONG RENEWABLES

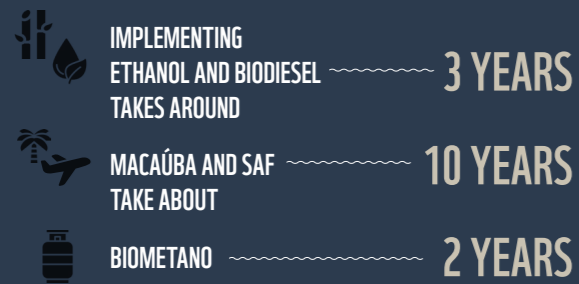
Under the HEFA (Hydroprocessed Esters and Fatty Acids) pathway, sustainable aviation fuel (SAF) entails high CapEx and elevated OpEx (processing plus feedstock). **The result is a cost more than double that of fossil jet fuel**, within the global range reported for SAF compared to conventional aviation kerosene.

## BIOMETHANE: A CLEAR ADVANTAGE OVER LPG

Despite requiring significant upfront investment, biomethane features low OpEx and reduced opportunity costs for feedstock residues. In aggregate terms, it appears approximately **43% less costly than LPG**; even under a conservative scenario with higher opportunity cost assumptions, it retains a cost advantage.

## “LITER FOR LITER” IMPLEMENTATION TIMELINE AND TECHNOLOGICAL PATHWAY MATURATION

Renewable supply begins in 2036, following the same ramp-up, plateau, and ramp-down profile as the fossil pathway.



## SOCIAL COSTS AND EMISSIONS: WHAT CHANGES WHEN THE FULL SOCIETAL COST IS CONSIDERED

Applying sector-specific conversion factors (with conservative export adjustments), total social costs amount to

**R\$ 89.80 billion** (present value), approximately 9% below market expenditures.

In terms of emissions, the renewable scenario is estimated at **85 MtCO<sub>2e</sub>** over 30 years, compared to **445,56 MtCO<sub>2e</sub>** from equivalent fossil fuels. The monetized externality of renewable emissions ranges from

**R\$ 4.03 to R\$ 8.06 billion** (present value).

## LAND USE: LARGE AREA REQUIRED, WITHOUT THE NEED FOR NEW DEFORESTATION

The estimated land requirement for this scenario is **3.89 million hectares**.

This total could be met using a portion of the **55.8 million hectares** of degraded land available in Brazil, without expanding into new areas. The study also considers the adoption of socio-environmental safeguards – such as prohibiting production in areas with recent deforestation, ensuring feedstock traceability, and applying land-use criteria – to mitigate associated risks. For this reason, deforestation-related externalities were not included in the accounting.



## WHAT CHANGES WHEN THE ACCOUNTING IS DONE FROM SOCIETY’S PERSPECTIVE

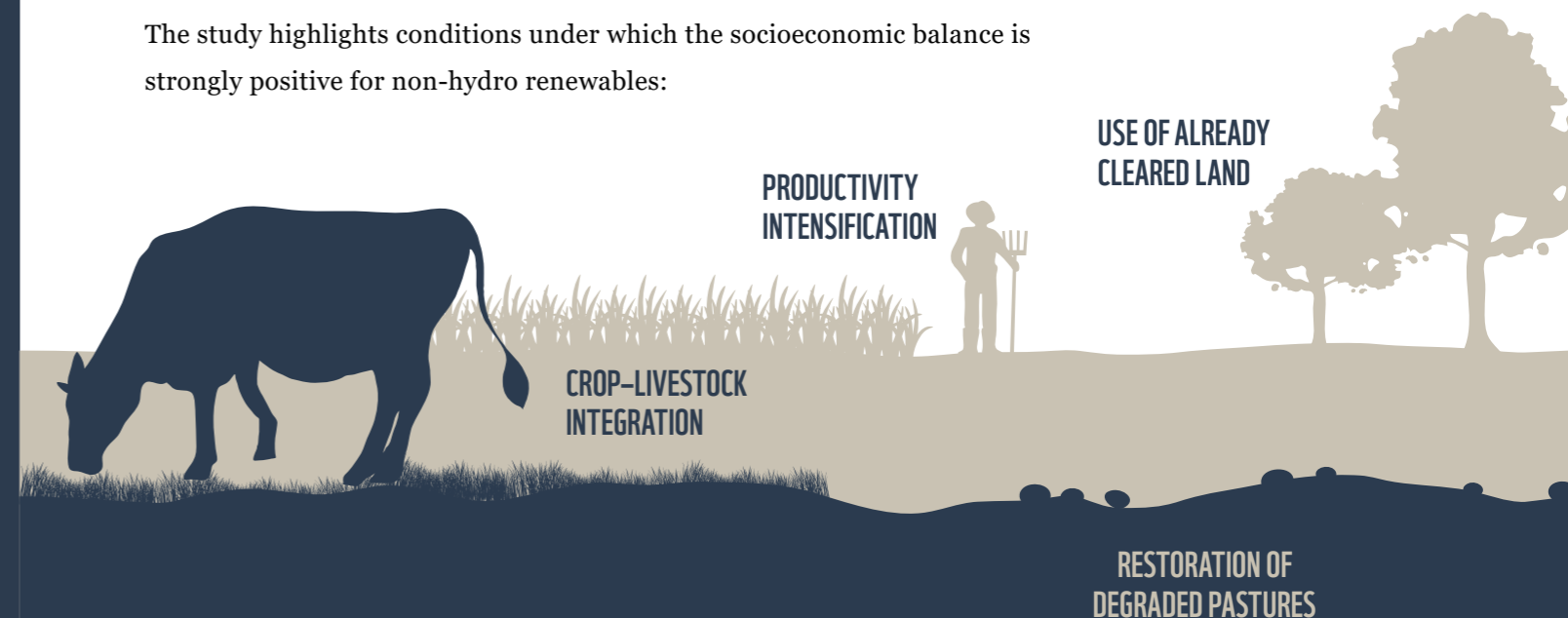
Under the “Liter for Liter” scenario, biofuels deliver the same final benefit as fossil fuels, and the comparison focuses on total costs and externalities. The model assumes new investments (with no idle capacity) and estimates total social costs at **R\$ 89.80 billion** (present value).

Life-cycle emissions amount to **85 MtCO<sub>2e</sub>** over 30 years, compared to **445,56 MtCO<sub>2e</sub>** for equivalent fossil fuels. The monetized emissions externality for renewables ranges from **R\$ 4.03 to R\$ 8.06 billion**. **Ethanol is competitive; biodiesel costs depend heavily on feedstock; biomethane is less expensive than LPG; and SAF remains the most costly option.**



## CONDITIONS FOR OPTIMAL PERFORMANCE

The study highlights conditions under which the socioeconomic balance is strongly positive for non-hydro renewables:



## WHAT THE DATA SHOW

The consolidation of results across the three CBA configurations – “Real for Real,” “BTU for BTU,” and “Liter for Liter” – reveals a consistent pattern: in every comparison, energy transition alternatives outperform oil exploration in terms of socioeconomic returns. While the fossil pathway destroys social value, renewable electrification and biofuels generate significant net benefits, regardless of the metric used for comparison.

### THE OPPORTUNITY COST OF CHOOSING OIL

Persisting in oil exploration at the Mouth of the Amazon River entails a high opportunity cost.

**When comparing what is lost through the oil pathway with what could be gained through the energy transition, Brazilian society forgoes a potential benefit ranging from R\$ 29 billion to R\$ 47 billion.** This figure does not represent abstract numbers alone, but resources that could instead be directed toward job creation, technological innovation, climate risk reduction, and the strengthening of a more resilient and decentralized energy system.

### WHY THE ENERGY TRANSITION IS MORE EFFICIENT

The energy transition pathways analyzed present structural advantages over oil. They require investments distributed across the territory, reduce concentrated environmental risks, exhibit lower sensitivity to regulatory shocks, and are aligned with the global decarbonization trajectory. Moreover, electrification and biofuels rely on mature, readily available, and competitive technologies, eliminating the need to rely on uncertain or long-term technological bets to justify their viability.

## RISK ANALYSIS AND UNCERTAINTIES

To test the robustness of the findings, the study applies Monte Carlo simulations, incorporating variations in key parameters such as oil prices, capital costs, deployment timelines, and the value of the social cost of carbon. The results show that the oil scenario remains predominantly associated with negative Social Net Present Values, even under favorable assumptions. In contrast, the electrification and biofuels scenarios display strongly positive distributions, indicating greater resilience to future uncertainties.

## PART 4

# INTEGRATED COMPARISON OF SCENARIOS

## STRANDED ASSETS AND TRANSITION RISK

Oil exploration at the Mouth of the Amazon River involves a significant temporal mismatch. The project requires a decade of investment before generating any benefits, entering operation in an international context in which global oil demand is projected to decline. This misalignment increases the risk of stranded assets – infrastructure that may be unable to recover its costs before becoming economically obsolete.

In such situations, private losses are often socialized through subsidies, financial restructuring, or the abandonment of assets.

## GOVERNANCE, SUBSIDIES, AND THE MYTH OF OIL REVENUES

A recurring argument in favor of expanding oil production is its potential to generate public revenues, such as royalties and special participation payments. However, recent experience shows that these revenues do not automatically translate into sustainable development or into effective financing for the energy transition.

The Pre-Salt Social Fund, often presented as an instrument for investing in the country's future, has allocated a significant share of its resources to public debt amortization, without generating structural impacts on education, healthcare, or climate policies. The central issue is not the lack of resources, but inadequate governance in how these funds are allocated.

The socioeconomic assessment did not incorporate sector-specific tax subsidies granted to the oil and gas industry, particularly under the Repetro regime, which provides significant tax exemptions and makes such projects considerably more attractive than they would otherwise be.

From a Cost–Benefit Analysis perspective, the forgone tax revenues associated with this regime should be treated as a social cost of the project, especially given the absence of equivalent treatment for renewable energy sources. The exclusion of this subsidy — which amounted to R\$ 18.6 billion in 2022–2023 alone<sup>1</sup> — it implies that the social costs estimated in the study represent minimum values and underestimate the project's true economic impact.

<sup>1</sup> Source: INESC (2024). Subsidies to Fossil and Renewable Sources (2022–2023): Reforming for a Just Energy Transition. Institute for Socioeconomic Studies (INESC), Brasília, DF.



# KEY FINDINGS

The question is straightforward: what happens if the same volume of resources allocated to oil exploration at the Mouth of the Amazon River is instead invested in electrification?



## “REAL FOR REAL” SCENARIO

(R\$ 32.4 BILLION IN INVESTMENT)

The results reveal a clear contrast. Investing in oil generates a **social loss of R\$ 22.2 billion**. Redirecting the same resources toward renewable electrification produces **net benefits of R\$ 24.8 billion**, enabling a diversified generation portfolio based on non-hydro renewable sources.

The gap between incurring losses and foregoing gains results in an **opportunity cost of approximately R\$ 47 billion for society**. This figure is likely conservative, as impacts such as public health damages, oil spill risks, and environmental losses were not monetized.

social loss  
**R\$ 22.2 billion**

+

net benefits of  
**R\$ 24.8 billion**

=

cost of  
**R\$ 47 billion**  
for society



## “BTU FOR BTU” SCENARIO

(SAME ENERGY: 5.55 GW)

When the comparison considers the same amount of energy delivered, the **oil pathway costs Brazil between R\$ 106.0 billion and R\$ 127.1 billion**, while renewable **renewable electrification ranges from R\$ 91.8 billion to R\$ 93.4 billion**.

In other words, the fossil route costs between **R\$ 14.2 billion and R\$ 33.7 billion** more to deliver exactly the same energy over a 30-year period. When the costs of the climate crisis are included, the oil pathway yields **negative results in all scenarios analyzed**.

the fossil route costs between  
**R\$ 14.2 billion and R\$ 33.7 billion**  
more to deliver exactly the same energy



## “LITER FOR LITER” SCENARIO

(SUBSTITUTION OF 39.2 BILLION LITERS)

In comparison with biofuels, **total costs range between R\$ 93.8 billion and R\$ 97.9 billion**, considering solutions already available in the market: ethanol, biodiesel, sustainable aviation fuel, and biomethane

By contrast, the oil pathway shows a **negative social balance ranging from R\$ 106.0 billion to R\$ 127.1 billion**. **Choosing the fossil route** implies losses between **R\$ 12.2 billion and R\$ 29.2 billion in foregone economic opportunities**. When produced under sound sustainability practices, biofuels present a strongly positive socioeconomic balance.

the fossil route implies losses between  
**R\$ 12.2 billion and R\$ 29.2 billion**  
in foregone economic opportunities

# THE ENERGY TRANSITION AS A DEVELOPMENT CHOICE

The findings dismantle the argument that oil is necessary to finance the energy transition. Exploration at the Mouth of the Amazon River represents an inefficient choice, combining stranded asset risk, high climate-related costs, and the loss of more profitable and secure opportunities.

Regardless of the metric applied – Real for Real, BTU for BTU, or Liter for Liter – electrification and biofuels generate between R\$ 29.2 billion and R\$ 47.0 billion more in social welfare, public health gains, and environmental preservation for Brazil than the oil pathway.

When climate damages are included, the projected 446 million metric tonnes of greenhouse gas emissions represent an additional cost ranging from R\$ 21.1 billion to R\$ 42.2 billion, ultimately borne by society. The misalignment is clear: even if the project proves profitable for investors, it imposes substantial losses on the country.

For an effective energy transition, resources should be directed toward non-hydro renewable sources, which offer higher social returns, lower environmental risk, and benefits distributed across the national territory. The decision to halt oil expansion in the Equatorial Margin is, above all, a strategic development choice.



## 8.8 KEY CONCLUSIONS

 **OIL EXPLORATION AT THE MOUTH OF THE AMAZON RIVER GENERATES LOSSES OF APPROXIMATELY R\$ 22.2 BILLION FOR BRAZILIAN SOCIETY.**

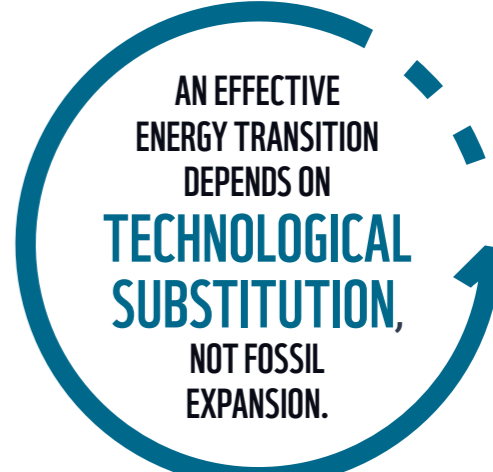
**THE OPPORTUNITY COST OF PERSISTING IN OIL REACHES R\$ 47 BILLION.**



 **THE RISK OF STRANDED ASSETS MAKES THE FOSSIL PATHWAY EVEN MORE VULNERABLE.**

 **RENEWABLE ELECTRIFICATION AND BIOFUELS DELIVER SUPERIOR SOCIOECONOMIC RETURNS ACROSS ALL SCENARIOS ANALYZED.**



 **AN EFFECTIVE ENERGY TRANSITION DEPENDS ON TECHNOLOGICAL SUBSTITUTION, NOT FOSSIL EXPANSION.**

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This catalog is based on the Final Report “The Economic Infeasibility of Oil & Gas Exploration at the Mouth of the Amazon River: A Cost-Benefit Analysis of Effective Energy Transition Options,” prepared in accordance with the Federal Government’s General Guide to Socioeconomic Cost-Benefit Analysis. The figures presented are expressed in present value terms and consider consistent time horizons, assumptions, and parameters across the scenarios analyzed.

## FULL REPORT

Access the complete Technical Report, including the assumptions and data sources used

[access the full study here.](#)

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