

European Union Methane Regulation: Comparing the Emissions Reduction Potential of Certification Compliance Pathways

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Introduction

Over the past several months, the [Energy Emissions Modeling and Data Lab \(EEMDL\)](#) has been working with global stakeholders on a [verification and reporting protocol for the European Union Methane Regulation \(EUMR\)](#).

Beginning 1 January 2027, EU importers must show that any crude oil or natural gas supplied under contracts signed or renewed after 4 August 2024 comes from producers operating Measurement Reporting and Verification (MRV) systems equivalent to those required under the EUMR for domestic production. As a result, importers could need emissions-intensity data for all non-EU supply placed on the EU market—including U.S. liquefied natural gas (LNG)—with reporting covering the full 2026 production year.

The EEMDL verification and reporting protocol will be finalized before 1 January 2026 to assist energy producers, shippers and EU importers to demonstrate compliance with the MRV requirements in the EUMR.

During the global stakeholder review of the protocol, several stakeholders requested additional analysis on the potential emission-reduction impacts of different compliance pathways. The primary pathways under consideration are:

- **National book-and-claim:** Production assets anywhere within a country may undergo equivalent MRV and generate tradable certificates, which encode the emissions attributes. These attributes are fully decoupled from physical LNG feedgas volumes, and importers may meet compliance obligations by procuring certificates covering commensurate volumes from any verified asset within the exporting country.
- **Basin- or regional-level book-and-claim:** Similar in structure to the national approach but with geographic constraints. Compliance requires sourcing the certificates from production assets located within the same basin or region as the LNG feedgas supply. Importers are required to define the supply chain to a basin or region border. This does *not* imply molecular tracking or real-time tracing of specific molecules.
- **Trace-and-claim:** This approach requires demonstrating MRV for the relevant production assets within the basin associated with the LNG feedgas, but it does *not* imply molecular tracking or real-time tracing of specific molecules. Rather, it is based on defining the supply chain to the asset producing the LNG feedgas and documenting and verifying the emissions profile of the feedgas.

Any of the three approaches could be implemented within a certification framework. Each would require appropriate governance, assurance, and transparency provisions; however, detailed design elements for such systems fall outside the scope of this analysis.

Although the analysis remains ongoing, preliminary findings are being shared to support stakeholders and decisionmakers in evaluating the potential implications of these emissions-tracing approaches.

Summary of Findings

The choice of a particular compliance pathway can produce major differences in projected methane emissions reductions that would result from the implementation of the EUMR import standard. For this analysis, emissions reductions across three major U.S. oil and gas production basins were estimated under national book-and-claim, basin-level book-and-claim, and trace-and-claim implementation pathways. To provide additional clarity, these estimated emissions reductions were compared to a “business-as-usual scenario” in which EUMR import standards were not in effect. The high-level observations are summarized below in Table 1.

Table 1: EUMR Compliance Pathway Tradeoffs Across U.S. Production Basins

	Business-as-usual	National book-and-claim	Basin-level book-and-claim	Trace-and-claim
Annual methane reduction	0	0	85,000 MT CH ₄ 6.9 MMT CO ₂ e ¹	250,000 MT CH ₄ 20.6 MMT CO ₂ e ¹
Increase in gas production due to avoided loss	0	0	4.9 BCF 0.013 BCF/d	14.5 BCF 0.040 BCF/d

The emissions impact of these compliance pathways reflects the wide variation in emissions intensity among U.S. production basins. The United States has a large pre-existing volume of low emissions natural gas supply, but most of that supply comes from the Appalachian Basin, which currently produces nearly a third of U.S. gas and supplies about 15 percent of Gulf Coast LNG demand. The gas produced in the Appalachian Basin largely has low methane intensity gas, but because of local demand requirements, pipeline constraints, and the cost and complexity of infrastructure projects, it is not feasible to move all this gas to export terminals.

This analysis evaluates national book-and-claim only among the Appalachian, Permian, and Haynesville basins, which together supply more than 85 percent of Gulf Coast gas. The Gulf Coast is currently the source of most U.S. LNG exports destined for the EU. Under a country-level book-and-claim system, the existing volume of low-emissions gas would be sufficient to generate the certificates needed to cover EU-bound exports.

An example that both illustrates this point and the willingness of operators with low intensity gas to generate certificates can be found in reviewing the voluntary uptake of MiQ certification.

¹ GWP₂₀ = 82.5; IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report (AR6). Chapter 7: The Earth’s Energy Budget, Climate Feedbacks, and Climate Sensitivity.

MiQ reports that roughly 25 billion cubic feet per day (Bcf/d) of U.S. certified gas is already available,² with nearly half of this volume from Appalachia. This is more than triple current EU-bound LNG exports (6-8 Bcf/d).³ To date, the supply of certified gas has greatly outpaced demand for certificates.

If the EU Methane Regulation recognizes national book-and-claim as a compliance option, operators with existing low intensity supply will have strong incentives to rapidly increase certificate availability. This wave could limit certificate value and reduce the commercial incentive for producers with higher emissions to incur the costs to mitigate.

Under regional- or basin-level book-and-claim, also known as constrained book-and-claim, certificates must be generated by production assets located in the same basin or region as the originating supply. For example, if LNG from Permian basin feedgas is imported into the EU, only certificates generated within the Permian basin can be used to show compliance with the EUMR import standard. This approach provides greater methane-emissions reductions than national book-and-claim. Implementation complexity increases since supply chains must be traced to the basin(s) or region(s) producing the LNG feedgas to validate the importer's basin or regional certificates. This tracing may require marketer or producer participation for volumes purchased at a transaction point outside the basin or region of production origin, but tradeable basin-level certificates limit the supply chain detail required (and allows marketers to keep a level of flexibility in their portfolio to transact with EU LNG importers).

Trace-and-claim offers the greatest emissions-reduction potential among the compliance pathways. It also requires more complex information about U.S. export shipments than other compliance pathways. This approach requires documenting the supply chain associated with the exported LNG volumes in sufficient detail to tie back to the specific feedgas producers' assets within a region or basin. Such tracing is relatively straightforward in some global supply regions. In the United States, it is technically feasible but would require importers to trace a more complex supply chain including transactions with flexible supply. LNG feedgas buyers source supply from marketers who hold a portfolio of contracts servicing numerous buyers and sellers with highly flexible supply chains. In addition to detailed supply-chain tracing, trace-and-claim may require the explicit participation of a broader set of stakeholders in MRV activities,

² MiQ. (n.d.). *MiQ – Methane intelligence for energy transition*. Retrieved December 11, 2025, from <https://miq.org/>

³ MiQ's current framework is not directly aligned with EUMR compliance requirements. The reporting and verification standards under which existing MiQ certificates have been issued do not fully conform to EUMR provisions, including Article 12 on measurement methodologies, Article 9 on accreditation, and Article 8 regarding the level of assurance. In addition, the temporal scope of existing certificates does not match the EUMR reporting timeline. These gaps could be addressed through adjustments to MiQ's system, but the current certificates are not transactable for EUMR compliance. Their relevance in this analysis is illustrative. They demonstrate that a significant number of producers, representing substantial national production volumes, have already pursued certification of separable emissions attributes in advance of a fully developed market. This indicates a strong underlying willingness among producers to participate in such schemes, particularly in models comparable to national book-and-claim.

since each counterparty contributing to the relevant supply chain must conduct MRV to support compliance.

Methodology

This analysis evaluates how much methane mitigation would be required for U.S. LNG exports to comply with the EUMR under three possible compliance pathways: national book-and-claim, basin-level book-and-claim, and trace-and-claim. Compliance is assessed against a target methane intensity of 0.20 percent loss rate, defined on an energy-normalized basis.

1. Supply Mix and Basins

We model emissions for the three major U.S. gas-supplying basins relevant to Gulf Coast LNG exports—Appalachia, Permian, and Haynesville—and allocate export volumes based on their current contributions to the Gulf Coast supply mix. The potential influence of changing infrastructure, evolving production patterns, and future shifts in supply mix on EUMR-related outcomes are not included in these preliminary findings.

2. Operator-Level Emissions Modeling

For each basin, we identify the operators that collectively account for approximately 90 percent of natural gas production using Enverus data.⁴ Each operator is then assigned a representative methane intensity drawn from basin-specific probability distributions. These distributions are calibrated to measurement-based basin averages reported in the scientific literature,⁵ which indicates approximate loss rates⁶ of 1.0 percent for Appalachia, 2.9 percent for the Permian, and 0.9 percent for Haynesville. The distributions follow the log-normal skew observed in empirical studies and incorporate structural variation across producers.

Operators with larger, higher-productivity assets are assigned lower intensities, while operators with many low-producing or marginal wells receive higher. Because precise emissions intensities are not available for each producer, the Monte Carlo simulations reconstruct these distributions in each instance to reflect a realistic range of operator-level outcomes. All methane intensities are calculated on an energy basis using operator-specific production data in barrel of oil equivalents (BOE) and thousand standard cubic feet (MCF), which aligns the modeling with anticipated EUMR requirements and differs from the gas-only normalization used in much of the published literature. Across all basins, this approach results in some high-volume

⁴ Enverus. (n.d.). *Oil and gas data, analytics and insights*. Retrieved December 2025, from <https://www.enverus.com/>

⁵ Omara, M., Himmelberger, A., MacKay, K., Williams, J. P., Benmergui, J., Sargent, M., Wofsy, S. C., & Gautam, R. (2024). Constructing a measurement-based spatially explicit inventory of US oil and gas methane emissions (2021). *Earth System Science Data*, 16(9), 3973–3991. <https://doi.org/10.5194/essd-16-3973-2024>

⁶ The loss rate is the percentage of the produced natural gas lost on a volumetric basis (MCF gas lost/MCF gas produced).

operators falling on the lower-intensity end of the modeled distribution, reflecting observed relationships between production scale and emissions performance.

3. Statistical Modeling of Compliance Outcomes

To evaluate how each compliance pathway performs against a EUMR methane-intensity target, the analysis uses a Monte Carlo simulation that generates 1,000 independent realizations of basin-level emissions configurations. Each iteration reconstructs a full set of operator intensities using the distributions described above. This approach reduces the influence of any single random assignment and prevents the results—particularly for trace-and-claim—from being driven by atypical combinations of operators or supply-chain configurations.

In every iteration, each compliance pathway selects operators based on its governance rules and the modeled base case export scenario of 6.3 Bcf/d of EU-bound LNG exports, sourced from Appalachia (15%), the Permian (43%), and the Haynesville (42%):

- **National book-and-claim** aggregates all operators across the three basins and selects those with the lowest allocated gas loss until the required export volume is met.
- **Basin-level book-and-claim** applies the same selection process within each basin independently, drawing only from operators in that basin until its regional base case export quota is satisfied.
- **Trace-and-claim** assigns operators at random within each basin until the basin's export quota is met, reflecting the use of the emissions characteristics of the actual supply chain rather than the ability to choose the lowest-intensity producers.

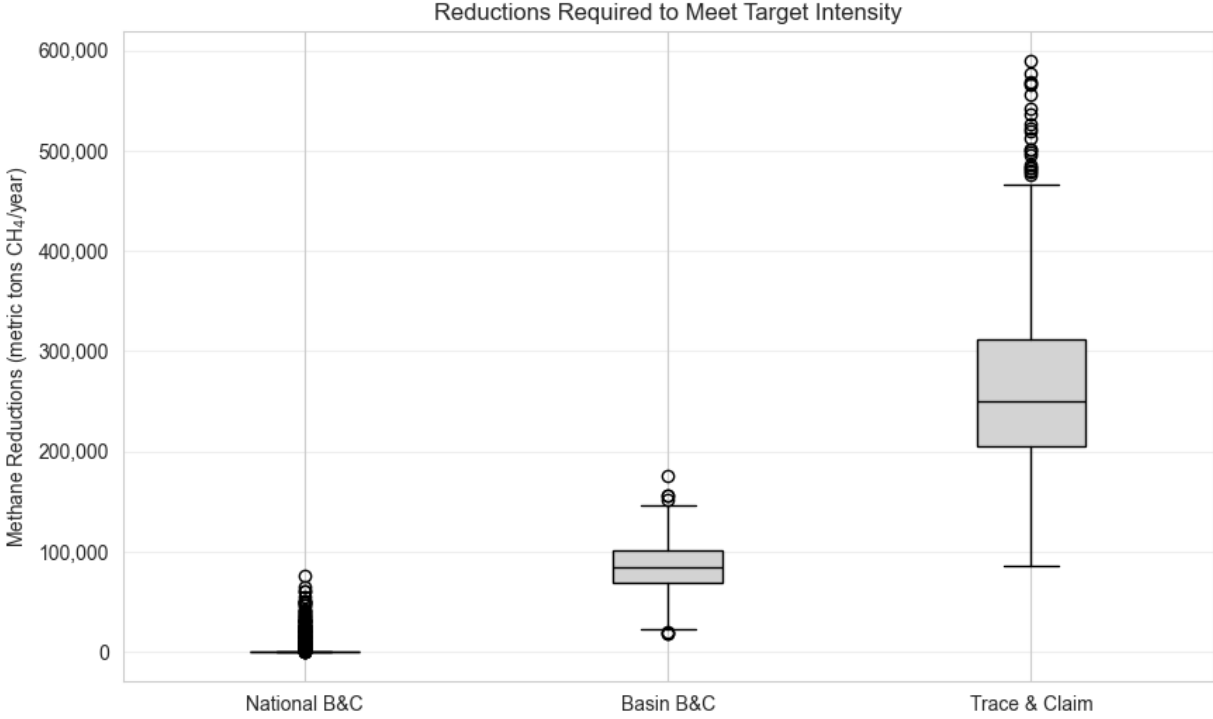
For each iteration and each pathway, the selected operators are combined to compute an export-weighted methane intensity, which is then compared with an emissions intensity target. Any required emissions reductions are expressed both as annual methane mass (metric tons per year) and as equivalent sales-quality natural gas volumes (Bcf).

Because the model assumes that the full production of a selected operator is available for export in a given iteration, and because the largest producers often exhibit the lowest emissions intensities, the resulting estimates may represent a lower bound on potential emissions reductions. Real supply chains do not source exclusively from individual operators; however, allowing this possibility within the Monte Carlo framework ensures that the simulation captures the full range of feasible supply-chain outcomes. Real supply chains may also exhibit changes in sourcing from different production basins over time and this analysis assumes that those distributions are fixed.

Modeled Outcomes

The analysis evaluates three compliance approaches for 6.3 Bcf/d of U.S. gas supply—sourced from Appalachia (15%), the Permian (43%), and the Haynesville (42%)—reflecting 2024 Gulf

Coast LNG volumes destined for the EU. We compare national book-and-claim, basin-level (regional) book-and-claim, and trace-and-claim pathways in terms of their annual methane-reduction potential relative to an energy-normalized production emissions-intensity target of 0.2%. The box-and-whisker plots below summarize the mean, median, and distribution of outcomes across all simulated supply configurations, where the median numerical values are reported in table 1.



Conclusion

The modeling results show that the three compliance pathways lead to markedly different levels of methane-reduction potential under the EUMR import standard. Trace-and-claim achieves the greatest reductions because it reflects the emissions performance of the specific supply chains serving EU-bound LNG. Basin-level book-and-claim produces a moderate level of reductions by limiting the use of emissions attributes to the producing regions that supply exports. National book-and-claim shows minimal mitigation potential under the assumptions applied in this analysis, largely due to the substantial availability of low-intensity gas in parts of the United States that do not contribute the majority of Gulf Coast export flows.

These outcomes reflect the distribution of emissions intensities across the Appalachian, Permian, and Haynesville basins and the range of supply configurations simulated in the Monte Carlo analysis. The findings illustrate how different compliance pathways can yield substantially different mitigation outcomes, depending on how closely each approach aligns with the emissions characteristics of the gas delivered to the EU.



About CEESA

The mission of the Center for Energy and Environmental Systems Analysis (CEESA) is to provide rigorous, measurement-informed insights that empower global decision-makers to drive meaningful emissions reductions and promote a sustainable energy future.

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