CI Consulting

S&P Global
Commodity Insights

Renewable gas tracking systems – Value of biomethane/RNG certificates

Prepared for:

EBA European Biogas Association

eurogas

ergar European Renewable Gas Registry

THE COALITION FOR RENEWABLE NATURAL GAS

EMEA Gas, LNG and Low Carbon Gas Consulting

EMEA Agribusiness and Bio-energy Consulting

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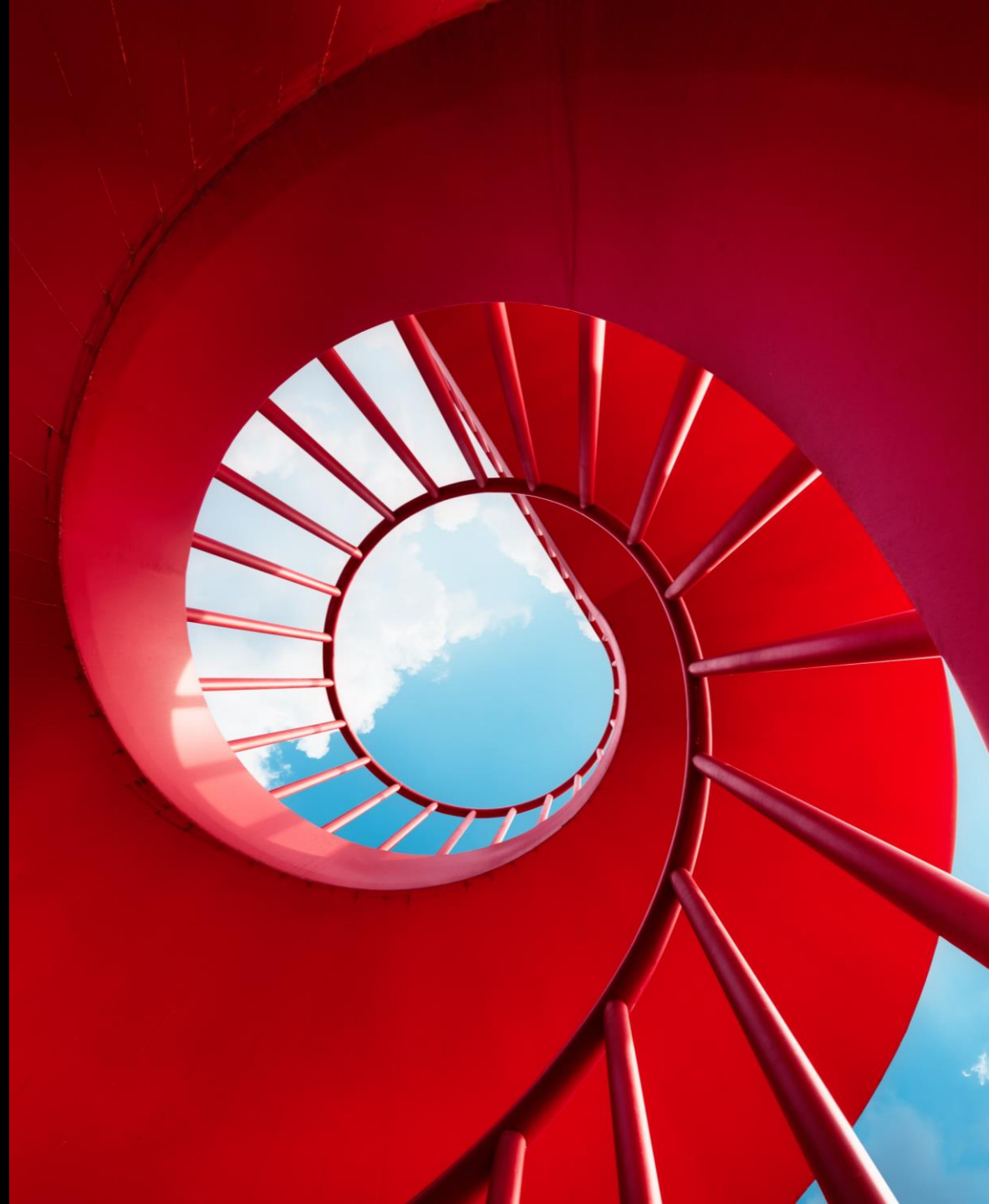

Introduction

This report has been produced by S&P Global Commodity Insights CI Consulting to support efforts to inform the revision of the Green House Gas Protocol or GHGP (2024/26) for:

- European Biogas Association (EBA)
- The trade association for gaseous energies in Europe (Eurogas)
- The Coalition for Renewable Natural Gas (RNGC)
- European Renewable Gas Registry (ERGaR)

The report demonstrates that there is a solidly regulated biomethane/RNG market in Europe and the US, which provides sustainability, guarantees and transparency; plays an increasingly important role in achieving GHG emissions reductions targets; and supports the economics of new production capacity development.

While the focus of the report is on Europe and the US, the main producers of biomethane/RNG, the existing experience with biomethane/RNG certification and tracking systems in these regions provide important lessons for increasingly globally connected bio-energy markets, especially for the nascent market for biomethane/RNG derivatives.

To that end, the report provides:

- A comprehensive overview of existing biomethane/RNG certification and tracking systems across Europe and the US
- An analysis of the evolving role of biomethane certificates for producers and consumers across key demand sectors, including the additionality in biomethane/RNG production, driven by certificates use
- An assessment of historic biomethane/RNG certificate values in Europe and the US with a review of the key price drivers

The report has been prepared by SPGCI for informational and illustrative purposes only. It is based on aggregated publicly available data and proprietary information from S&P Global, and it does not contain any confidential information.

Ongoing Greenhouse Gas Protocol revision

- The Green House Gas Protocol (GHGP) is a comprehensive global standardised framework to measure and manage GHG emissions from private and public sector operations, value chains and mitigation actions
- GHGP Corporate Accounting and Reporting Standard is used by a large share of global corporates to measure their emissions, identify reduction opportunities and track progress towards their climate goals
- Regulators and standard setters that are developing new requirements for climate-related reporting also refer to the GHGP to develop comprehensive GHG inventories, set reduction targets and track their performance
- At present, the GHGP does not provide specific guidance on the use of RNG certificates for GHG emissions accounting for non-segregated RNG supply (RNG injected into existing conventional natural gas grids)[1]
- Given the vast majority of RNG production both in Europe and the US injected into conventional natural gas grids, the lack of specific guidance on RNG certificates for non-segregated RNG in the current GHGP can be perceived as a risk factor by prospective RNG producers and consumers, particularly in the voluntary sector
- The next revision of the GHGP Corporate Accounting and Reporting Standard is expected to be published in the latter half of 2026. A stakeholder consultation was conducted between November 2022 and March 2023 and subsequently, the process of establishing technical working groups commenced in the second half of 2024, to release draft standards and guidance for public consultation in 2025
- S&P Global understands that this will include a work stream focused on market-based instruments, including RNG certificates, which were highlighted in the stakeholder survey responses on market-based approaches published in April 2024[2]
- As a potential consideration for the GHGP revision process, this report aims to provide a comprehensive fact base that demonstrates the value of RNG certification and the role it could play to help scale up the RNG market and drive emissions reductions

1 GHGP Interim Update on Accounting for Biomethane Certificates (August 2023)
2 GHGP Detailed Summary of Survey Responses on Market-based Approaches (April 2024)

Key definitions[1]

Biomethane and RNG

Biogas is a mixture of 45-85% methane (CH_4) and other gases, notably carbon dioxide (CO_2), produced from the breakdown of organic matter in an oxygen-free environment. Biomethane is a purified form of biogas containing 95-100% CH_4 which is approximately equivalent to natural gas.[2]

In Europe, the term 'biomethane' is typically used; whereas in the US the common term for biomethane is RNG.

The terms 'biomethane' and 'RNG' are interchangeable for the purpose of this report, with RNG used as the standard term to reference biomethane.

Book and claim vs mass balance principles

The Renewable Energy Directive or RED (EU/2018/2001; Art. 29 and 30) sets out the sustainability and GHG reduction criteria for RNG and other biomass fuels for all energy uses.

To demonstrate compliance with the sustainability criteria, the RED requires certification of RNG consignments by either (i) national certification scheme; or (ii) voluntary certification scheme, which must be recognised by the European Commission.

Verification of compliance is based on the principle of mass balancing, whereby there is a physical link between the production of biofuels (and bioliquids) meeting the sustainability criteria and the consumption of biofuels (and bioliquids) in the community (RED Art.30).

The physical link between the production and consumption of RNG is the natural gas network; i.e., operators must ensure the balancing of every injected consignment of RNG with the corresponding withdrawn consignment. Data required for mass balancing is contained in the Proof of Sustainability (PoS) certificate.

Where compliance with sustainability criteria does not have to be verified, Guarantees of Origin (GOs) are used to disclose the RNG renewable energy share and title (ownership) throughout the value chain. GOs can be transferred separately or along with the physical transfer of energy, generally referred to as a book and claim principle. This principle is compatible with the GHGP.

- **In the EU,** mass balance is a higher standard than book and claim, owing to the connection between the PoS certificate and the physical product
- **In the US,** while credits and molecules could be traded separately via the book and claim chain of custody model for LCFS/RFS programmes, end users must purchase gas (or associated environmental attributes) from a connected RNG pipeline supply, adhering to similar principles of the mass balancing model in EU

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1 Refer to p.111 for the list of abbreviations

2 Biomethane definition based on European Biogas Association

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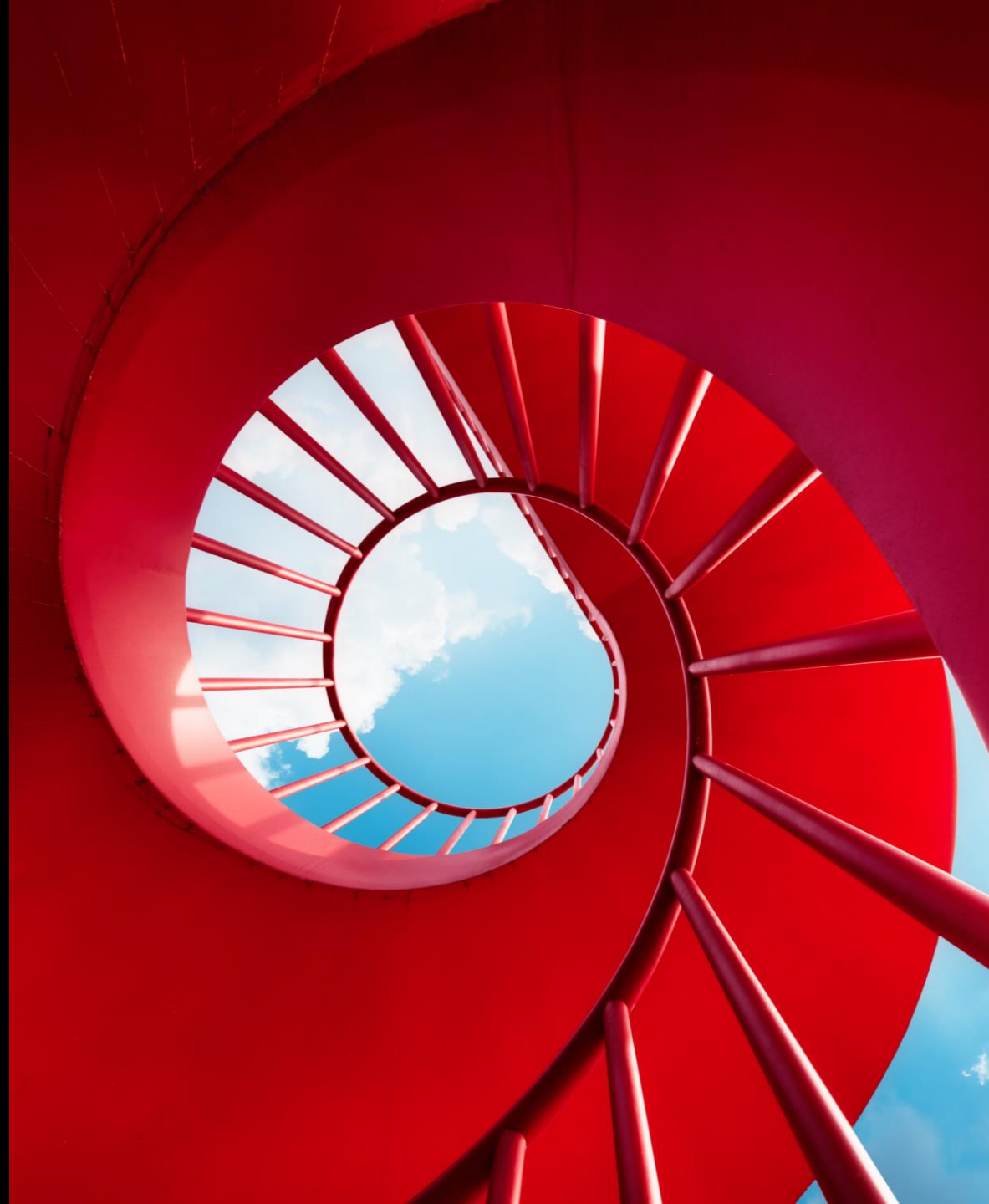


Renewable gas tracking systems – Value of RNG certificates: Key messages

1. RNG certification and tracking systems have enabled efficient use of RNG and decarbonisation efforts in compliance markets. Recognition of RNG under the GHG Protocol accounting framework could enable more efficient use of RNG in voluntary markets

2. The EU legislative framework regulates RNG through Guarantees of Origin and Proof of Sustainability certification, supporting RNG capacity development and incentivising the use of sustainable low carbon feedstock

3. The US market-based policy mechanisms, i.e., the US, RFS and California LCFS, support GHG emissions reduction in the transport and agriculture sectors and are a key driver of RNG capacity development and cost-competitiveness[1]

4. RNG production is a key driver of GHG emissions reductions, amounting to ~5 million tons of CO_2eq in the US (RNG LCFS credits data) and ~15 million tons of CO_2eq in the EU (RNG production data)[2] in 2023

5. RNG production is set to increase substantially, mainly supported by market-based mechanisms. The EU aims to reach 35 Bcm/a production by 2030, while the US has set non-transport sector targets (states and utilities) of around 6 Bcm/a

1 RFS = Renewable Fuel Standard, LCFS = Low Carbon Fuel Standard

2 Assumes 5 Bcm/a of European RNG production at 0 gCO_2eq/MJ carbon intensity; compared with conventional natural gas at 72 gCO_2eq/MJ carbon intensity

Renewable gas certification in Europe and the US has provided transparency and rigour, while supporting production growth

- **RNG tracking systems have been in place in Europe for more than a decade** with Germany's dena biogas register (and other biogas/RNG registers) supporting early European production growth in the 2010s through the provision of national certificates. The EU legislative framework now regulates GOs and sustainability certification across the 27 member states
- **In the US, market-based policy instruments, such as RIN and LCFS credits, have been key sources of revenue for RNG facilities** over the past decades, improving project economics and allowing more RNG projects to be cost-competitive against conventional natural gas and other fossil fuels. For example, if a RNG manure-based facility in the US has access to both RINs and LCFS credits, on an average between 2015-2023, it could potentially capture an additional value of $45-55/GJ value above the average natural gas price by monetising through these RNG certification schemes. This has enabled many RNG manure-based facilities to generate positive margins above their average production cost of $20-$40/GJ
- **The landscape of RNG gas tracking relies on multiple strict requirements**. Compliance markets, such as the EU RED and US renewable fuel markets (LCFS/RIN), require POS certificates and mass balance accounting; while voluntary markets use book and claim[1] systems based on GOs; and some compliance markets, e.g., the EU Emissions Trading System (EU-ETS), use a combination of both certificate systems
- It is important to note that the drivers of RNG production and demand growth to achieve ambitious European and US emissions reduction targets are rapidly changing. **While earlier European waves of RNG production growth were mainly underpinned by direct government support, such as feed-in tariffs, future capacity additions will have to increasingly rely on market-driven revenue, notably RNG certificate values.** Demand for RNG procured via RNG certificates comes from compliance markets (e.g. road transport fuels) as well as voluntary markets, with leading European and US corporations, such as food and beverage, chemicals producers or shipping companies procuring RNG via the purchase of GOs
- In Europe, certified RNG prices in the transport sector are supported by GHG emissions savings targets and the value of policy support, e.g., via the German THG (Treibhausgasminderungsquote) quota system. **For 2023, the average value of certified RNG in the German transport market is estimated to have been €50-60/GJ, compared with the projected full lifecycle cost of manure based low/negative carbon intensity-based RNG at €20-30/GJ.** High non-compliance costs for GHG emissions savings targets for German road transport, combined with certification of low/negative carbon intensity RNG, have likely supported the 19% per annum (2017-22 CAGR) increase in Germany's RNG demand for transport and a doubling of the share of manure-based RNG feedstocks at the expense of higher carbon intensity energy crops

1 In the EU, mass balance is a higher standard than book and claim due to the connection between the PoS and the physical product. In the US, the mass balance principle is used to demonstrate the physical link between RNG production and consumption; however, unlike in the EU, the common industry terminology for the transfer of certificates (e.g., RIN and LCFS) with the physical RNG delivery is generally known as book and claim

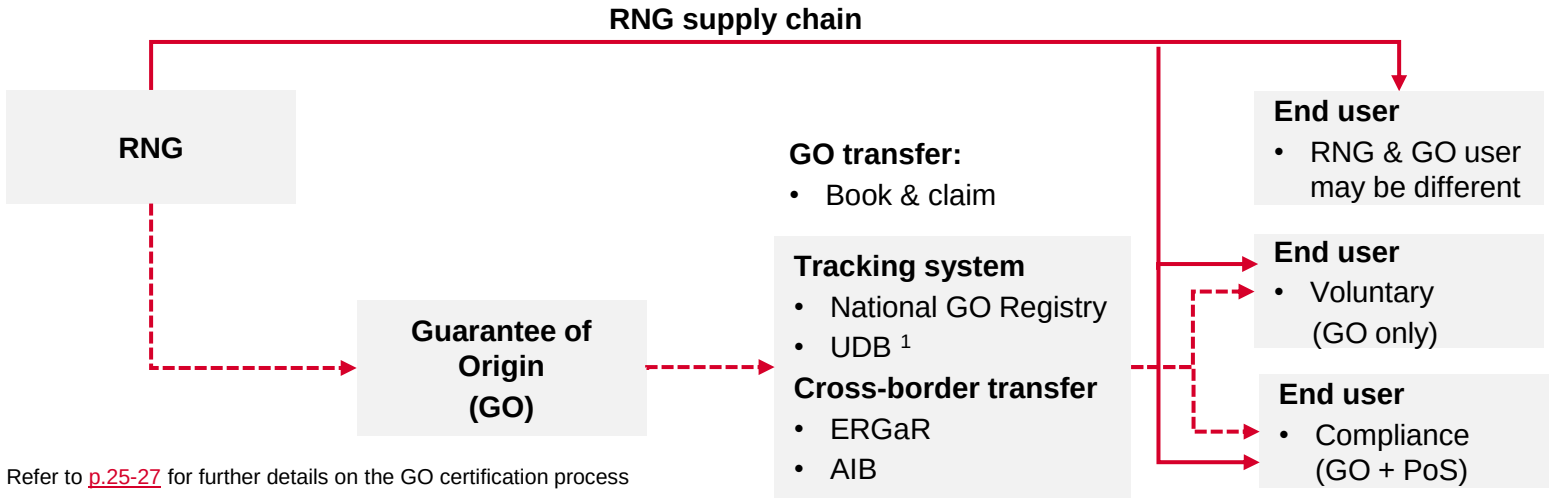
RNG production is expected to continue to grow strongly with tracking systems such as the EU Union Database for Biofuels

- **RNG certificate values are driven by a combination of different end-use market-specific factors**; **however, given the fungibility of RNG,** most markets are inter-connected. A key driver of RNG certificate values is feedstock carbon intensity (CI), which in some markets (e.g. US and EU road transport) can lead to a premium for RNG certificates over liquid biofuels
- **There is a strong need for consistent and rigorous tracking of biofuels, notably regarding specific properties, such as feedstock type and CI, which are increasingly important for GHG accounting requirements;** as well as to provide market stability to support investment in new RNG production capacity
- Important changes lie ahead in the landscape of RNG tracking certificates. **In Europe, the EU Union Database for Biofuels (UDB) will be operational at the end of 2024, improving traceability of mass-balanced certificates. In the US, demand from the non-transport sector is expected to take over as the driver for RNG demand growth**, leading to new requirements for RNG certification
- **The importance of robust RNG tracking systems and understanding the value of RNG certificates become apparent when considering the expected unprecedented growth in RNG production** to 2030. The EU has target to reach 35 Bcm/a (3.4 Bcf) RNG production by 2030 and US states and utilities are aiming for RNG targets of circa 6 Bcm/a (0.6 Bcf/d) for the non-transport sector, in addition to the current strong transport sector RNG demand. While these production ambitions represent multiples of current production, they represent only a fraction of the actual RNG production potential based on available sustainable feedstocks
- **Nascent market for RNG derivative products, such as low carbon bunker fuel, driven by emissions reductions schemes,** including FuelEU Maritime and its global implications for maritime shipping, highlight the potential impact of developing global RNG tracking mechanisms to succeed existing regional systems
- Given the role that RNG certification schemes have played in helping to scale up RNG production in the EU and US compliance-based markets, **additional clarity and alignment on the inclusion of RNG in GHGP reporting could help further develop RNG production and use in EU and US voluntary-based markets and global RNG markets**

EU RNG certification: Clearly defined and rigorous processes are in place for both voluntary (such as heating) and compliance markets (such as road transport)

Guarantee of Origin (GO)

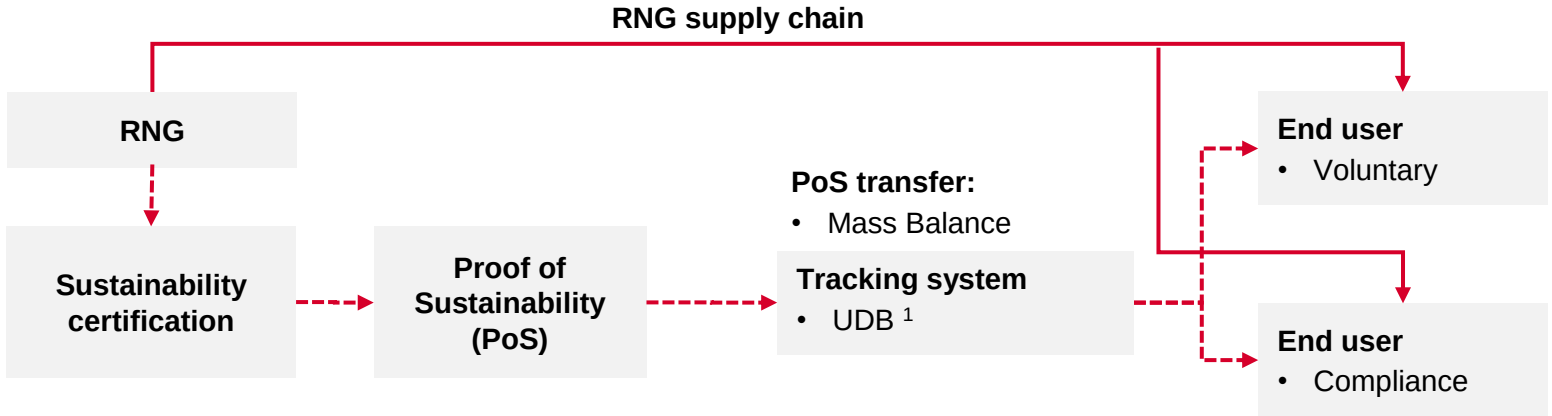
- **GO is used for disclosure of the renewable energy share in accordance with RED**
- National registries are the issuing bodies for RNG GOs, e.g., ENERGINET (DK), VertiCer (NL)
- GOs are issued to the producer's account for each MWh equivalent of RNG produced
- GOs are transferred separately from physical gas between producer/trader/end-user accounts in the national registry **(book and claim principle)**
- Cross-border transfers between registries are facilitated by ERGaR and AIB platforms



Refer to p.25-27 for further details on the GO certification process

Proof of Sustainability (PoS)

- **PoS is used to prove compliance with RED sustainability criteria**
- Sustainability certification schemes must be approved by the European Commission.
- Certification bodies (e.g., ISCC, REDcert) audit RNG producers and approved producers can issue PoS
- Certification covers the entire RNG value chain including upstream, i.e. feedstock sustainability
- PoS and physical gas cannot be separated to avoid "double counting" risk (ISCC, 2021) [2]; so a **mass balance principle** is used (EU/2022/996) [3]



Refer to p.28-30 for further details on the PoS certification process

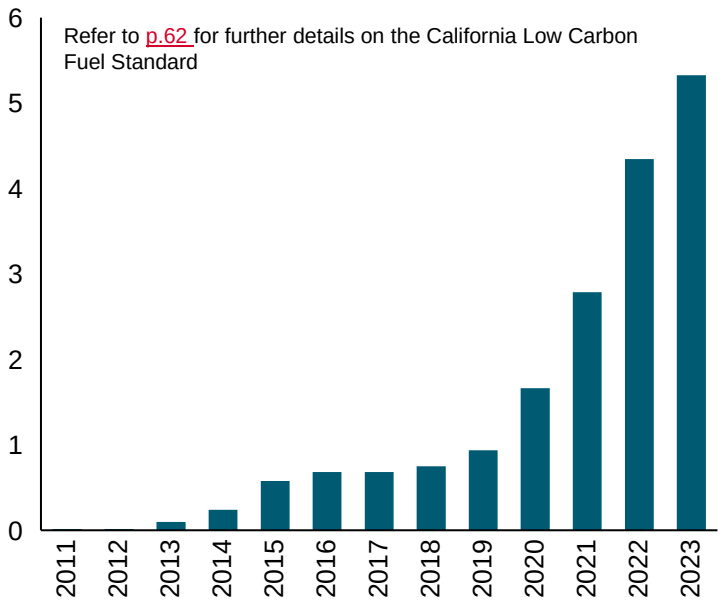
1 The European Commission is expected to implement a PoS-GO connection soon, where the GO will be bundled with the PoS for the same RNG consignment (when a GO is issued at the request of the producer)

2 ISCC (2021). ISCC EU 203 Traceability and Chain of Custody. Version 4.0. 1st July 2021.

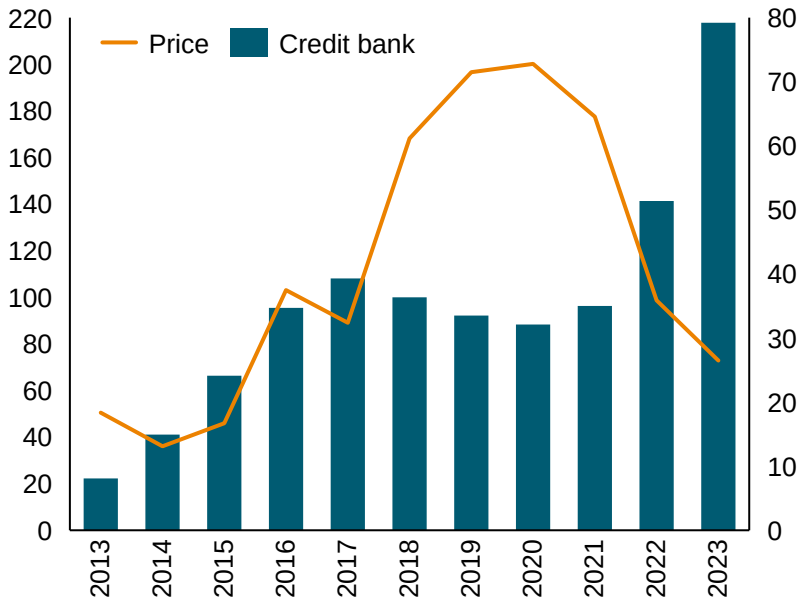
3 Commission Implementing Regulation (EU) 2022/996 (Ch.IV)

The California Low Carbon Fuel Standard is an example of how market-based instruments can support RNG production growth and reduce emissions

Annual RNG LCFS credits 2011-2023
Million tons



2013-23 LCFS prices and credit bank
$/ton (Price), million tons (Credit Bank)



Estimated LCFS-related, RNG-related emissions reduction in road transport (2011-2023)
18 million tons

Estimated LCFS-related volume increase of RNG production for transportation end uses between 2015-2023
10x

Estimated number of new landfill gas and manure RNG facilities in operation or under construction in the US since 2015[1]
200+

- LCFS is a market-based policy that is set to decrease the carbon intensity (CI)[2] of California's transportation fuel pool and to incentivise the development of low-carbon alternatives markets. Fuels that have higher CI than the benchmark will generate an LCFS deficit, while those with lower CI will generate an LCFS credit, which is equal to 1 ton of CO_2eq reduced on a life-cycle basis compared with the baseline fuel (gasoline or diesel)
- More than 200 new landfill and manure RNG facilities have come into operation or are under construction since 2015 across the US. The recent increase in LCFS credit price has sent a strong market signal for RNG producers, driving an increase in RNG production in recent years

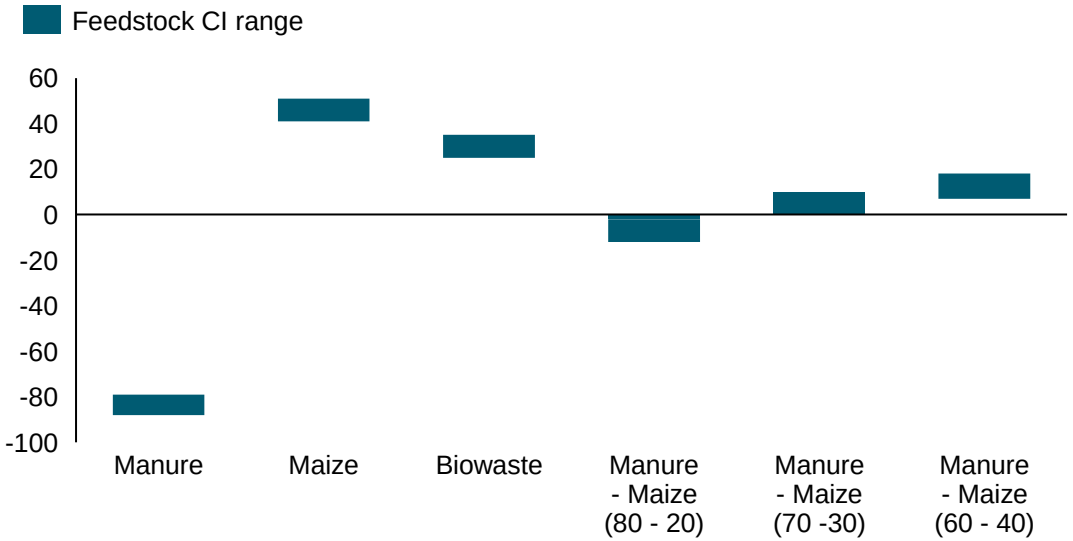
Source: California Air Resources Board, Argonne National Laboratory - Renewable Natural Gas Database

1 Number of new facilities assumed as those with production starting date between 2015 and 2023, with status as operational or in construction. It does not include projects that are planning and design phase (i.e., have not reached Final Investment Decision) 2. Carbon Intensity = grams of CO2eq per megajoule of each fuel

In Germany, GHG reduction mandates, incentivising low CI feedstocks, certified with Proof of Sustainability are likely to have driven an increase in RNG consumption

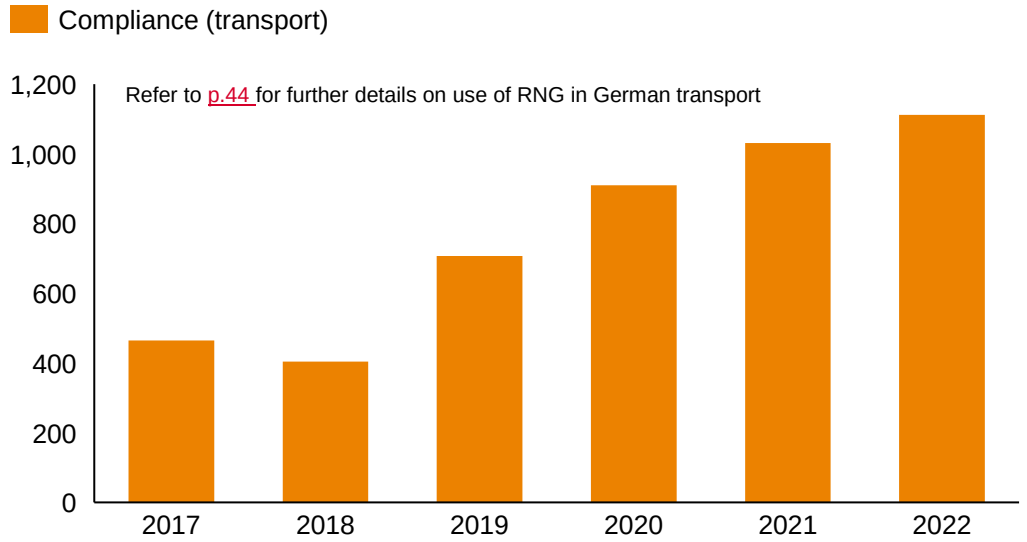
GHG emissions-saving potential of RNG (incl. LNG/CNG) feedstock

gCO_2eq/MJ



Germany RNG certificates used for road transport

GWh



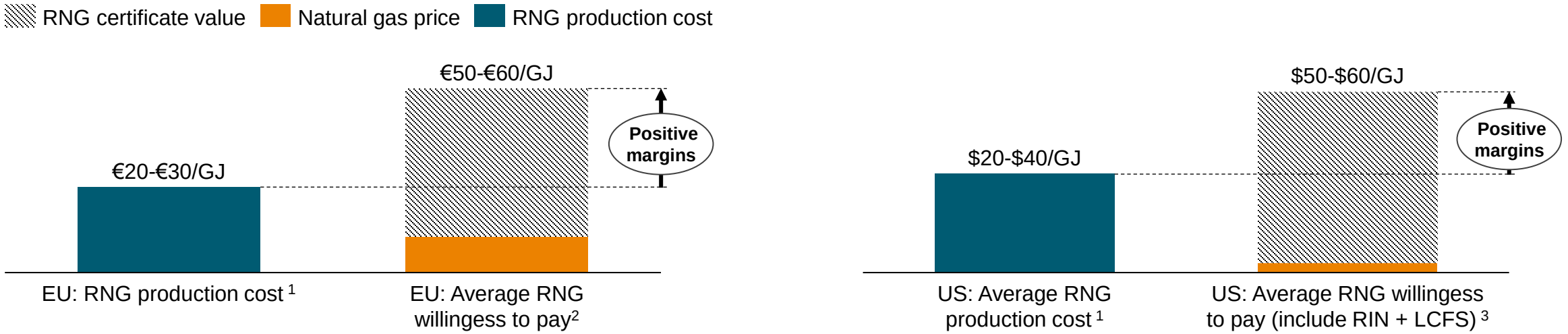
- A key advantage of RNG is that specific feedstocks such as manure deliver negative CI, increasing the competitiveness in compliance markets
- Several market-based compliance schemes incentivise the use of low/negative CI feedstock, e.g., the German THG quota (GHG quota) system for transport, in the fulfilment of their GHG emissions reduction quota obligations
- This has likely supported strong uptake in RNG use for transport fuel. This also highlights the importance of reliable certification of key sustainability attributes using PoS certificates and mass balancing to track RNG production and incentivise the use of feedstocks with lowest CI in demand sectors with the highest emissions impact

Source: Renewable Energy Directive II (RED II) Annex II for carbon intensities, dena and EBA for German RNG certificates

The implied value of German road transport THG (GHG) quotas and US LCSF/RIN credits exceeded the full life cycle costs of RNG production

RNG willingness to pay & production cost in German and US transportation sectors

€ or $/GJ



Refer to slide p.46 for further details on the value of RNG certificates in German transport

Refer to p.76 (LCFS) and p.93 (RIN) for further details on the value of RNG certificates in US transport

- In Europe, certified RNG prices in the transport sector are supported by GHG emissions saving targets and the value of policy support, e.g., via the German THG quota system (Biofuel Quota Ordinance, BiokraftQuG)
- In the US, the value of LCFS and RIN credits provide key sources of revenue for RNG facilities, improving project economics and cost-competitiveness, incentivising new capacity additions over the past decade
- Both in Germany and in the US, the willingness to pay for RNG in road transport is largely set by the market price of liquid biofuels, with RNG being able to attract a higher price per unit of energy compared with liquid biofuels owing to its lower CI (as certified by PoS certificates)

Sources: S&P Global Commodity Insights; CARB for historical LCFS values. EPA for historical RIN values

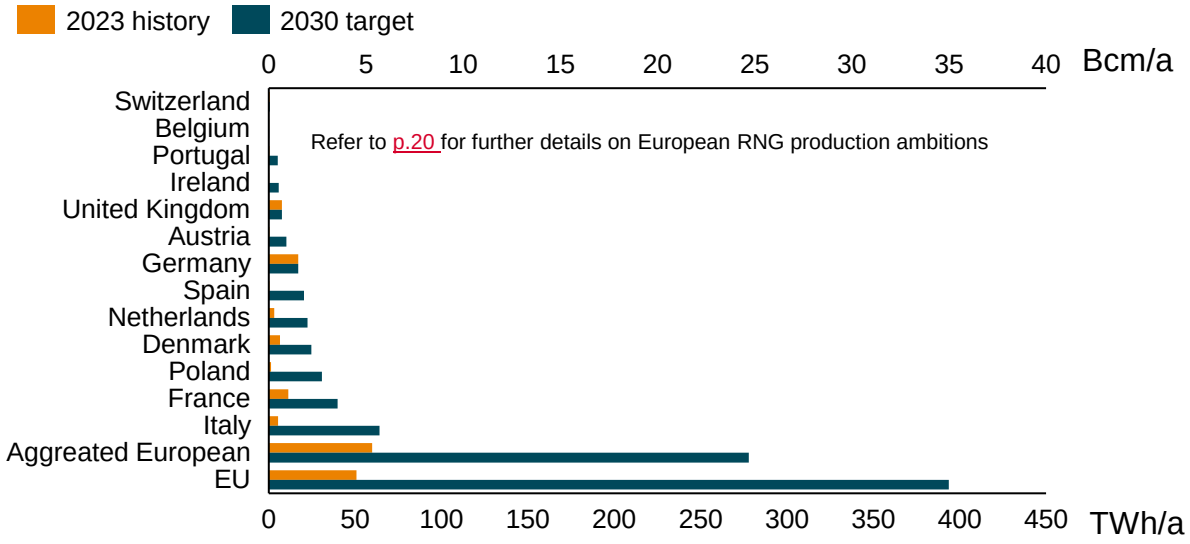
1 Estimated average production cost of manure-based RNG production pathways

2 Liquid biofuels market price implied value of policy support from German THG quota and average gas price (Dutch TTF) for 2023

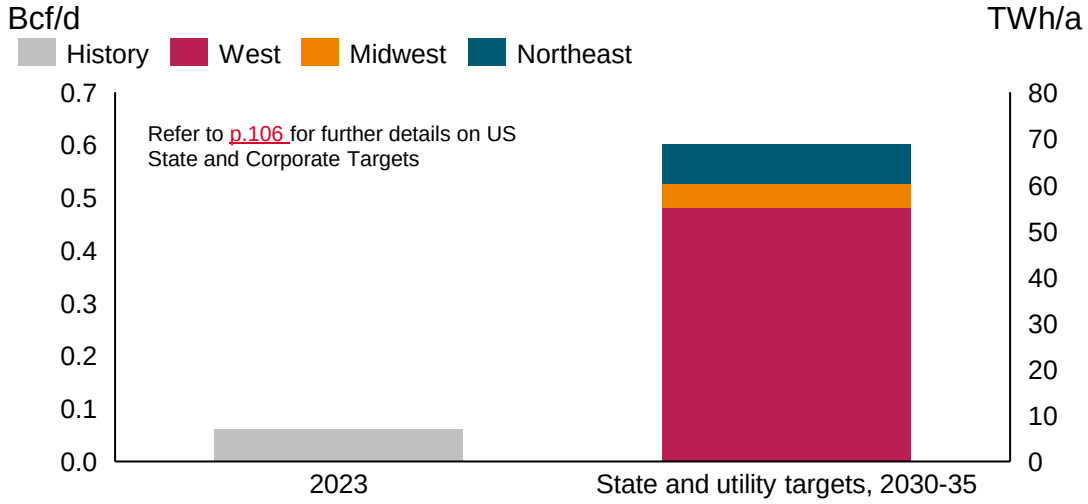
3 Average price of D3 RIN , LCFS and natural gas price (Henry Hub) from 2015-2023

Robust RNG tracking systems support the achievement of ambitious targets and optimise emissions reduction

European RNG production versus ambitions



US Lower 48 state and utility[1] RNG targets for the thermal sector by region of consumption



- Ambitious RNG production targets have been set across Europe, both for emissions reduction as well as European energy supply security. With the expiry of direct government support such as feed-in tariffs, robust RNG tracking systems are required to provide reliable revenue streams underpinning investment in new capacity and allow for accurate emissions accounting
- While the RNG production ambition set by the EU for 2030 represents a multiple of current production levels, some studies estimate the EU RNG production potential based on sustainable feedstock availability as high as 151 Bcm/a (1677 TWh/a) by 2050 (Source: EBA/Guidehouse, 2022)
- In the US, RNG demand from the non-transport sector is expected to overtake transport sector demand (75% of RNG demand in 2023) over the coming decades. Lessons learnt from successful RNG tracking systems in the transport sector may prove important to grow US RNG production beyond the currently lucrative transport sector

Sources: NECP 2024 Targets with S&P Global Analysis for Europe. Corporate website, Government announcements, S&P Global analysis for US
1 Voluntary targets set by utilities

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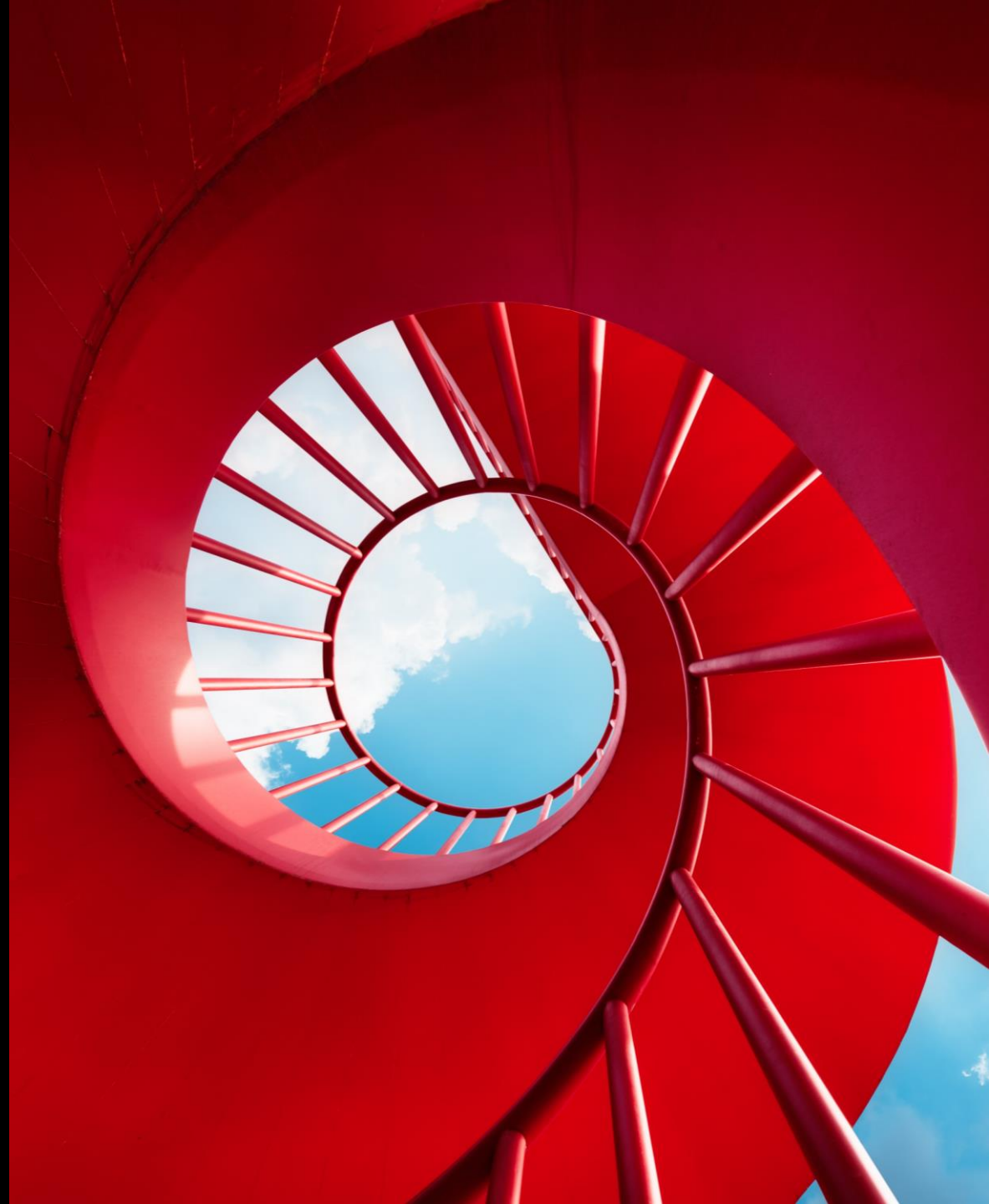
3. European Renewable Natural Gas (RNG) tracking systems and certificate values



Overview: Value of RNG certificates in Europe (1/3)

European RNG production growth

- RNG demand and production has grown sharply over the last 10 years with European pipeline injected RNG production reaching an estimated 5.1 Bcm/a (EU circa 4.3 Bcm/a) in 2023, driven by growth spurts in Germany in the early 2010s, Denmark in the late 2010s and France in the early 2020s
- Looking forward, the EU has set an ambition to grow RNG production to 35 Bcm/a by 2030, underpinned by aggressive national production goals

Importance of EU RNG tracking systems and certificates

- With the reduction in direct subsidies such as feed-in tariffs, **RNG certificates are increasingly important** to sustain production and incentivise RNG capacity development

Identification of tracking systems

- RED sets out requirements for two types of RNG certificates which **serve different roles under different regulations** and are, therefore, not mutually exclusive
  - **GO** is designed for **disclosure of the RNG renewable energy share** and title (ownership) throughout the value chain
    - Some national biogas registries were established prior to RED II entering into force and since there is no harmonised system to implement biogas tracking systems, these registries operate in accordance with national legislation. Examples include AGCS (AT), dena (DE) and GGCS (UK)
  - **PoS** is designed to **prove compliance of the RNG molecule with RED sustainability and GHG savings criteria**
    - There are also national sustainability certification schemes, e.g., in Finland and Poland, which national governments may require stakeholders to use however, unless the issuing body and certification scheme is authorised by the European Commission, certification cannot be used to meet EU obligations
  - In practice, due to the difference between the certificates, **GO is mostly claimed in voluntary markets** on a book-and-claim basis, while **PoS is used in compliance markets** to fulfil EU sustainability requirements (GHG quota and renewable energy share) under RED on a mass-balancing basis
    - Some registries operate hybrid systems which combine the functions of GO with RED II voluntary scheme compliance PoS data, e.g. VertiCer (NL) and Elering (EE) [note: EU sustainability requirements are uniform for the PoS]

Overview: Value of RNG certificates in Europe (2/3)

Efficacy of certificates

- Cross-border transfer of GOs has increased considerably in the last five years, notably into Germany, driven by use of RNG in the German transport fuel market
- Two transnational schemes operated by ERGaR and AIB facilitate cross-border transfers of GOs and national RNG certificates
- PoS certificates are widely accepted as a means to track the sustainability of RNG owing to EU-approved certification schemes (e.g. ISCC, REDcert) which facilitate cross-border transfers
- The **Union Database for Biofuels (UDB)** will cover gas supply chains from 21st November 2024 and in a later stage, the GO and PoS will be linked for consignments that have both certificates, **essentially enabling continent-wide traceability of mass-balanced RNG with PoS and GO disclosure**

Certificates and emissions reductions

- RNG certificates can be used for:
  - **disclosure of renewable energy share** and title (ownership) tracking; and for **compliance with RED sustainability criteria**
  - **Scope 1 GHG reporting under the GHGP** or other schemes such as the Science Based Targets initiative (SBTi) or Carbon Disclosure Project (CDP)
- For example:
  - **Under RED**, RNG with **PoS proves sustainability compliance** and can be used to fulfil GHG savings targets and obligations in the transport sector
  - **Under GHGP**, companies can report Scope 1 emissions from RNG use to prove compliance towards voluntary GHG targets, e.g. the SBTi [1]; however, to date there is no definitive guidance on the use of RNG certificates under the GHG Protocol and so reporting is based on external audits of compliance
  - **Under the EU Emissions Trading System (ETS)**, RNG with **PoS proves sustainability compliance** for biomass-derived fuel and provides mass balancing data

1 Science Based Target initiative (SBTi) target sets a trajectory for companies to align with the +1.5°C in 2100 climate warning limit; however, there are no definitive accounting rules and so reporting is based on external audits of compliance with target-setting program rules to ensure full transparency and compliance with accepted GHG accounting principles

Overview: Value of RNG certificates in Europe (3/3)

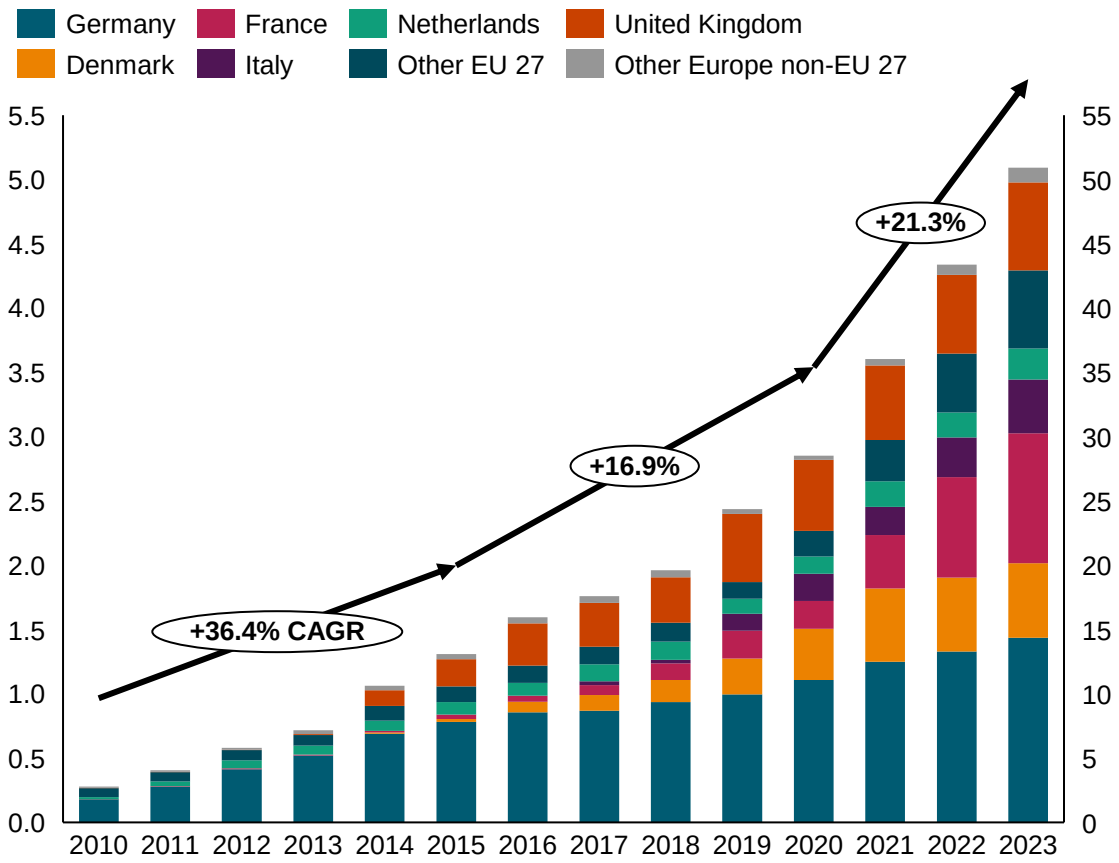
Value of RNG certificates

- The recent development of RNG certificate values, e.g. in Denmark, Germany, the Netherlands and the United Kingdom demonstrate the importance of feedstock carbon intensity and geographical origin. RNG certificates have a value for two main reasons:
  - Because they allow consumers to report lower scope 1 GHG emissions, e.g. under the GHGP or other schemes such as the SBTi or CDP;[1] or
  - a national regulator accepts that the certificate is proof of tracking to an end user, which is rewarded within a scheme like the UK Renewable Transport Fuels Obligation (RTFO) or the German Renewable Energy Sources Act (EEG; *Erneuerbare-Energien-Gesetz*)
- **GO** is primarily used to provide transparency and traceability of the origin of renewable energy (biogenic aspect of gas)
  - The GO system operates on the "book and claim" principle, meaning that GO certificates can be traded separately from the physical gas and, therefore, can have a monetary value, notably in voluntary markets to disclose the renewable energy share of total energy use
- **PoS** is used to demonstrate compliance with sustainability criteria under RED, including GHG emissions savings
  - "*Proof of sustainability* means a declaration by an economic operator, made on the basis of a certificate issued by a certification body within the framework of a voluntary scheme certifying the compliance of a specific quantity of feedstock or fuels with the sustainability and greenhouse gas emissions savings criteria set out in Articles 25 (§2) and 29 of Directive (EU) 2018/2001" (Regulation (EU) 2022/996; Art. 2 §23)
  - A PoS issued for a consignment of RNG can be transferred to another party, such as a trader or end-user; however, to avoid double counting risk "the sustainability attributes (PoS) cannot be separated from the batch of RNG and cannot be transferred, sold or otherwise used (e.g. in the framework of a national biogas register) to satisfy further obligations or commitments or to benefit from more than one renewable incentive scheme" (ISCC, 2021) [2].
  - Since tracking physical molecules of RNG blended with natural gas in national gas networks is impractical, a mass balancing approach is used "allowing mixing of raw material and fuels with differing sustainability characteristics and by allowing reassignment of the sustainability characteristics in a flexible manner to consignments withdrawn from such a mixture" (Regulation (EU) 2022/996; Ch. IV)
  - The value of a PoS is, therefore, implicit, representing a premium for certified RNG which can be used in compliance markets
- Some countries operate national certificate schemes which combine the functions of GO and PoS; e.g., AGCS (AT), dena (DE), VertiCer (NL), and Elering (EE)

1 It should be noted that to date there is no definitive guidance on the use of RNG certificates under the GHG Protocol and so reporting is based on external audits of compliance
2 ISCC (2021). ISCC EU 203 Traceability and Chain of Custody. Version 4.0. 1st July 2021.

European RNG production has increased substantially, driven by growth in Germany through to the early 2010s, Denmark in the late 2010s and France in the early 2020s

European injected RNG production history



- European RNG production for injection into gas transmission and distribution networks grew strongly in the early 2010s, reaching approximately 1.5 Bcm/a by 2016
  - Early production growth was underpinned by German and Dutch feed-in tariffs, supported by RNG certification administered by dena in Germany and VertiCer in Netherlands
- Production growth slowed from 2016 to 2019 owing to stagnation in German RNG capacity additions, but was supported by UK production growth driven by the Renewable Heat Incentive (RHI)
  - UK RNG production qualifying for RHI is tracked by the GGCS
- Since 2020, European RNG production has seen substantial growth, driven by rapid expansion of production capacity in Denmark and France
  - Danish production growth has been aided by policies such as the right to inject and the integration of RNG into the domestic gas market
  - The facilitation of cross-border trade through ERGaR and access to the lucrative German market has likely also supported production growth
- Injected RNG production is estimated to have risen to circa 5.1 Bcm/a in 2023 (EU 27 injected production is estimated at circa 4.3 Bcm/a)
- Historic European RNG growth trends highlight that specific policy, and financial incentives play a crucial role in spurring future growth in RNG production

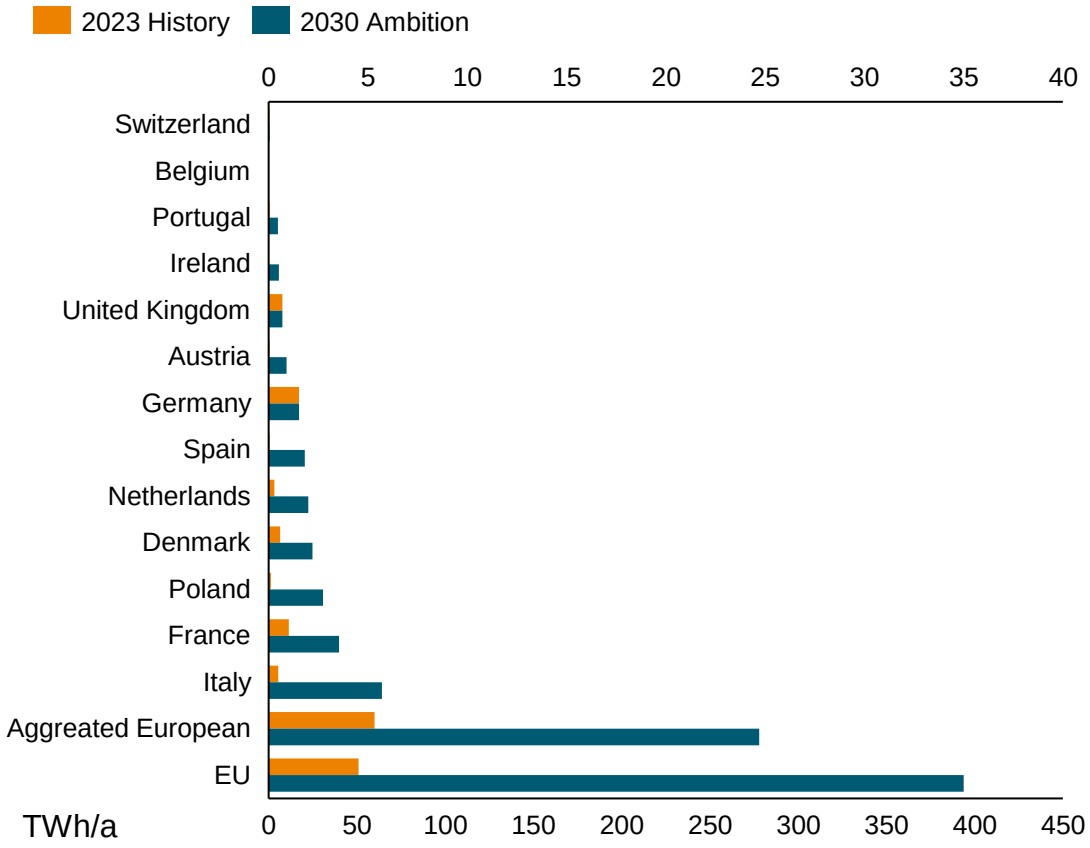
Source: EBA Statistical Report (2020-21); Danish Energy Authority; BDEW 2019 Report on the Potentials of Biogas/RNG; and SPGCI analysis
Note: Historic demand figures are subject to review

Ambitious EU and national goals for RNG production growth reinforce the need for pan-European tracking mechanisms to leverage low carbon RNG potential

- The EU has set an ambitious goal to produce 35 Bcm/a of RNG by 2030 to reduce dependence on Russian gas and contribute towards emissions-reduction targets
  - The support schemes designed to meet these goals are based on certificates and market-based mechanisms
  - Nevertheless, for this ambition to be achieved, major private investment will be required in additional production capacity, equipment manufacturing and feedstock logistics
- National RNG production ambitions in key European countries suggest a potential 2030 production of c.20 Bcm/a[1] and are more likely to be achieved
  - Italy, the Netherlands, and France have set the most aggressive growth ambition
- Germany, the largest producer in Europe, has not set a specific target, but is expected to see production grow, notably due to upgrading existing production capacity, and supported by rising GHG emissions-reduction targets for energy use in transport
- The investment outlook for RNG in Europe is strong with a 2023 dena survey suggesting that business confidence for German RNG plant operators is at its highest level on record

European RNG production versus ambition

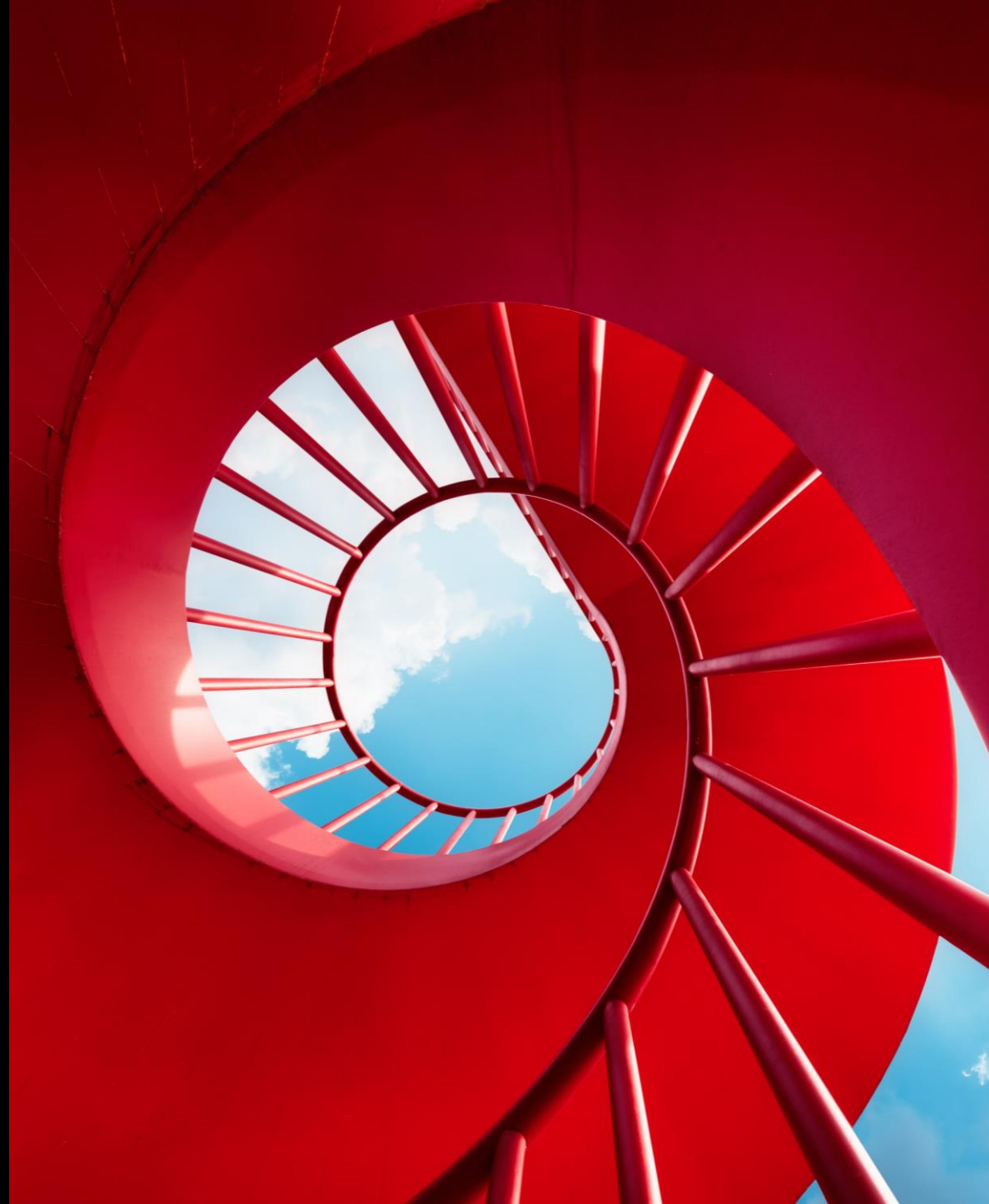
Bcm/a



Sources: NECP 2024 Ambitions with S&P Global Analysis.

1 Where no specific RNG ambition is given, the 2030 value is assumed to be equal to 2023 production. In the case of France, Poland, Portugal and Denmark, 2030 RNG ambitions are defined as a share of total natural gas demand, which are derived based on S&P Global European Long-Term Gas Demand Outlook, dated 2024.

Contents



Introduction: EU RNG certification

Guarantee of Origin certification

- The Renewable Energy Directive (EU/2018/2001; Article 19), known as RED II, sets out the requirements for RNG **Guarantees of Origin** (GOs) for the purpose of: *"demonstrating to final customers the share or quantity of energy from renewable sources in an energy supplier's energy mix and in the energy supplied to consumers under contracts marketed with reference to the consumption of energy from renewable sources."* [1]
- The purpose of GOs is **consumer disclosure,** i.e., *"Guarantees of Origin issued for the purposes of this Directive have the sole function of showing to a final customer that a given share or quantity of energy was produced from renewable sources."* (EU/2018/2001; paragraph 55)
- In practical terms, GOs meet the need for title-tracking of renewable gas blends (i.e., both fossil natural gas and renewable natural gas)
- To obtain a GO, a RNG producer must register with and be audited by the **national RNG GO registry**, which is the authorised issuing body for GO certificates and tracks the certificates throughout the supply chain. GOs can be transferred separately from physical gas delivery under the "book and claim" principle
- At the end of the process, the end-user utilises the GO for disclosure purposes and the GO is retired/cancelled in the national RNG registry
- Note: some national biogas registries were established prior to RED II entering into force and, since there is no harmonised system to implement biogas tracking systems, these registries operate in accordance with national legislation. Examples include AGCS (AT), dena (DE), and GGCS (UK)

Sustainability certification

The Renewable Energy Directive (EU/2018/2001; Art. 29 and 30) sets out the sustainability and GHG reduction criteria for RNG and other biomass fuels

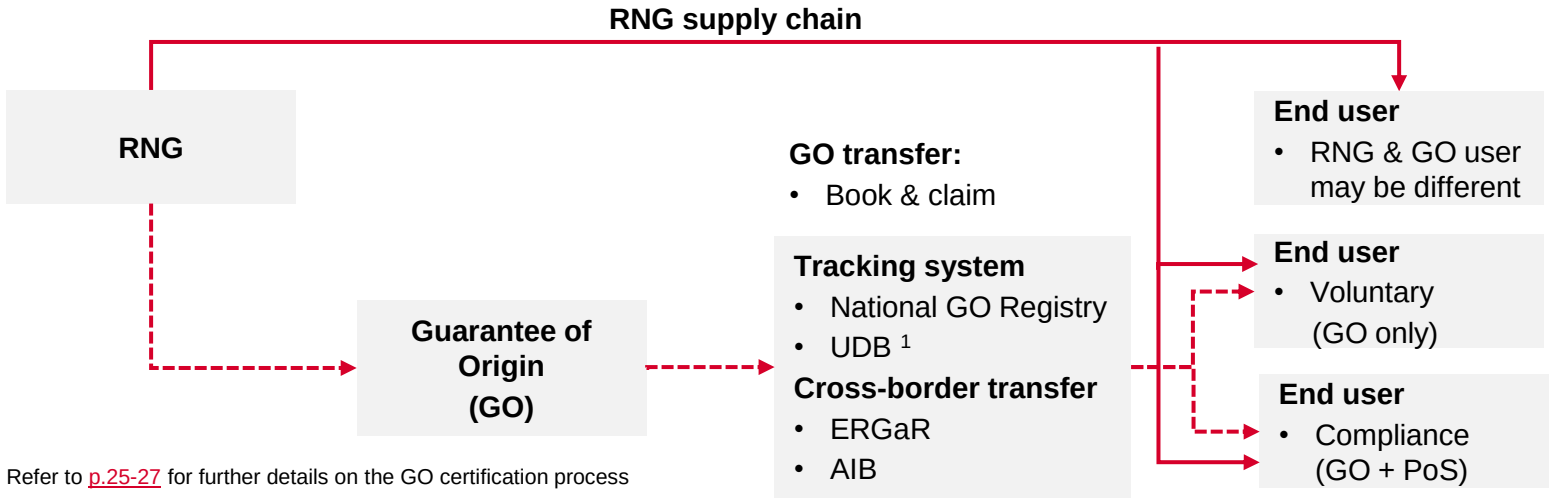
- **Sustainability Certification** guarantees legal compliance with the RED sustainability certification requirements
- **Sustainability Certification Schemes** are operated and administered by voluntary certification bodies, such as ISCC, REDcert, BetterBiomass, SURE, and 2BS, to independently certify the sustainability and GHG emissions of RNG. There are also national sustainability certification schemes, e.g., in Finland and Poland, which national governments may require stakeholders to use
- Certification schemes and bodies must be approved by the European Commission to establish the framework for proving sustainability against the RED criteria.
- RNG producers are audited by an external verifier (auditor) under the scheme; certified producers are authorised to issue **Proof of Sustainability (PoS)** autonomously for each consignment of RNG
- Note: some registries operate hybrid systems which combine the functions of GO with RED II voluntary scheme compliance PoS data, e.g. VertiCer (NL) and Elering (EE), however the sustainability requirements are uniform for PoS

1 Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC

EU RNG certification: Clearly defined and rigorous processes are in place for both voluntary (such as heating) and compliance markets (such as road transport)

Guarantee of Origin (GO)

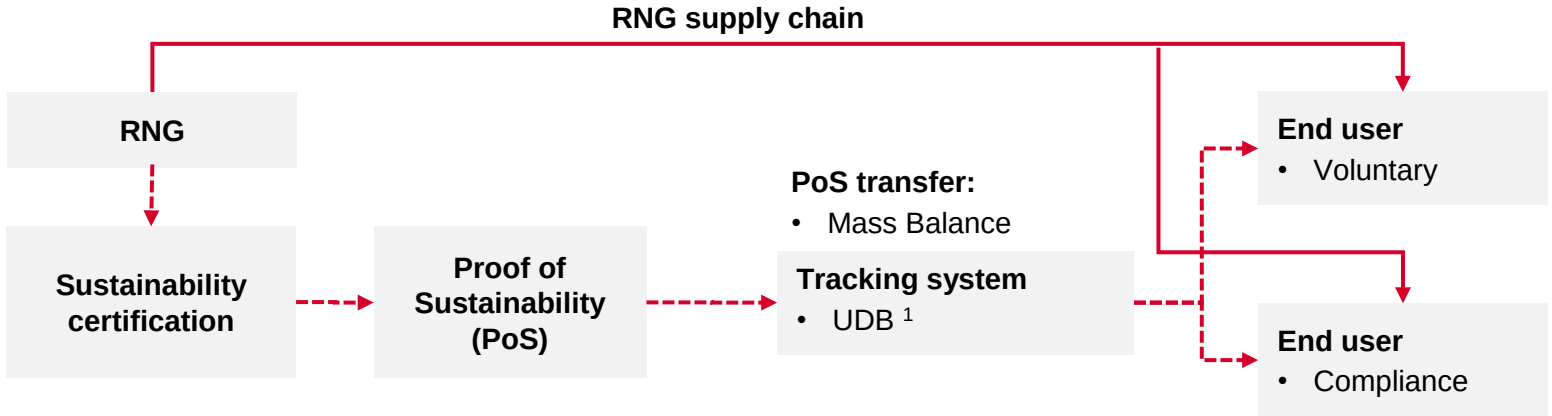
- **GO is used for disclosure of the renewable energy share in accordance with RED**
- National registries are the issuing bodies for RNG GOs, e.g., ENERGINET (DK), VertiCer (NL)
- GOs are issued to the producer's account for each MWh equivalent of RNG produced
- GOs are transferred separately from physical gas between producer/trader/end-user accounts in the national registry **(book and claim principle)**
- Cross-border transfers between registries are facilitated by ERGaR and AIB platforms



Refer to p.25-27 for further details on the GO certification process

Proof of Sustainability (PoS)

- **PoS is used to prove compliance with RED sustainability criteria**
- Sustainability certification schemes must be approved by the European Commission.
- Certification bodies (e.g., ISCC, REDcert) audit RNG producers and approved producers can issue PoS
- Certification covers the entire RNG value chain including upstream, i.e. feedstock sustainability
- PoS and physical gas cannot be separated to avoid "double counting" risk (ISCC, 2021) [2]; so a **mass balance principle** is used (EU/2022/996) [3]



Refer to p.28-30 for further details on the PoS certification process

1 The European Commission is expected to implement a PoS-GO connection soon, where the GO will be bundled with the PoS for the same RNG consignment (when a GO is issued at the request of the producer)

2 ISCC (2021). ISCC EU 203 Traceability and Chain of Custody. Version 4.0. 1st July 2021.

3 Commission Implementing Regulation (EU) 2022/996 (Ch.IV)

RNG certificates in Europe – Key differences

Guarantee of Origin (GO) and Proof of Sustainability (PoS) serve different purposes under the RED (EU/2018/2001)

Criteria	Guarantee of Origin (GO)	Proof of Sustainability (PoS)
Requirement	**Disclosure** of RNG renewable-energy share and title (ownership) tracking in accordance with RED requirements	**Compliance** with RED sustainability criteria
Sustainability	RNG must be produced from renewable sources	RNG must meet specific RED sustainability criteria
Issue	GO is issued by an official issuing body, e.g., national registry	PoS is issued by certified producers (who meet the requirements of a certification body which operates an EU approved certification scheme)
Transfers	RNG with GO is traded using the "book and claim" principle, allowing GO to be traded separately from physical RNG	RNG with PoS is traded using a mass balance approach, meaning that physical RNG and PoS should not be separated throughout the supply chain
Parties	GO is transferred to trader and/or gas supplier via national registry	PoS is transferred directly between certified RNG producers and gas suppliers.
Quotas and targets	RNG with GO only can not be used to fulfill obligations, quotas and targets set by EU legislation	RNG with PoS proves sustainability compliance and can be used to fulfill obligations, quotas and targets set by EU legislation

Guarantees of Origin (GOs) are used to disclose renewable energy use and for RNG title tracking

EU legislation

- The Renewable Energy Directive (EU/2018/2001; Article 19), known as RED II, sets out the requirements for RNG Guarantees of Origin (GOs) for the purpose of: *"demonstrating to final customers the share or quantity of energy from renewable sources in an energy supplier's energy mix and in the energy supplied to consumers under contracts marketed with reference to the consumption of energy from renewable sources."* [1]
- RED III (EU/2023/2413) entered into force on 20 November 2023.[2] Following the adoption of the "Fit for 55" policy proposals in 2021, the RED was revised to include higher targets for GHG emissions savings as well as for the use renewable fuels in transport. EU Member States should implement RED III into national legislation by 21st May 2025
- RED III also specifically includes reference to the new Union Database (UDB) (EU/2023/2413; Art. 31a) which is a centralised registry covering the entire RNG supply chain that must be used for renewable fuels to qualify for counting towards mandatory renewable energy quotas [3]
- National governments are obligated to set up a national framework to administer GOs and to designate competent bodies to adopt appropriate mechanisms for the operation of GO systems as set out in the European Standard CEN-EN 16325

European standard

- European Standard CEN-EN 16325 will be revised to facilitate the requirements of RED II, extending the GO for electricity to also include gas (including hydrogen), heating and cooling. The purpose of the CEN-EN 16325 is to develop an accurate, reliable and fraud-resistant system of GOs

Purpose

- The purpose of GOs is consumer disclosure, i.e.,
  - "GOs issued for the purposes of this Directive have the sole function of showing to a final customer that a given share or quantity of energy was produced from renewable sources." (EU/2018/2001; paragraph 55)
- GOs have no function in terms of a Member State's compliance with:
  - Article 3: Binding overall EU target for the share of energy from renewable sources by 2030; or
  - Article 7: Calculation of the gross final consumption of energy from renewable sources
- In practical terms, GOs meet the need for title-tracking of renewable gas blends (i.e., both fossil natural gas and renewable natural gas)

1 Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC
2 Directive (EU) 2023/2413 entered into force on 20 November 2023. There will be an 18-month period to transpose most of the directive's provisions into national law, with a shorter deadline of July 2024 for some provisions related to permitting for renewables.
3 RED II made reference to the UDB; however, RED III introduced the dedicated Article 31(a)

How Guarantees of Origin (GOs) operate in practice

National implementing regulations

- Each EU Member State is responsible for transcribing the Renewable Energy Directive (EU) 2018/2001 into national law
- The new Renewable Energy Directive (EU/2023/2413), known as RED III, must be implemented into national legislation by May 21, 2025
- Designated competent bodies are responsible for the issuance, transfer and cancellation of Guarantees of Origin (GOs) (Art.19; paragraphs 5 and 7)

In practice

Aspects of GOs differ between Member States, even if the general principles are the same.

- **Issue:** To obtain a GO, a RNG producer must register with the national RNG GO registry; this process includes an audit to validate the legal compliance of the company and plant. The producer must then submit a production declaration, which is verified against meter data from the network operator. Once the declaration is verified, GOs are issued to the producer's account for each MWh equivalent of RNG produced
- **Trade:** The GO system operates on the "book and claim" principle, meaning that GO certificates can be traded separately from the physical gas. A producer can make a commercial agreement to trade the GO with a trader or end-user; and the GO can be transferred from the producer's account to the trader's or end-user's account within the RNG registry. Several options are available for cross-border trading of GOs within Europe:
  - The European Renewable Gas Registry (ERGaR) provides a platform that facilitates cross-border trading of GOs and other certificates between members
  - The Association of Issuing Bodies (AIB) standard European Energy Certificate System (EECS) and platform supports cross-border trading of gas GOs[1]
  - Bilateral Agreements between national registries can also be used for cross-border trading of GOs
- **Retire/Cancel:** At the end of the process, the end-user utilises the GO for disclosure purposes
  - The end-user (or producer/trader on behalf of the end-user) retires the GO in the national RNG registry. Once retired, the GO cannot be traded further and can only be used for the disclosure of the specific company for which it was retired
  - GOs have a limited lifespan; they may be traded for a period of 12 months; but the GO is valid for 18 months (Art. 19; para. 3)
- **Residual mix:** calculation of the European Residual Mix based on all recorded GO transactions during a given period, to ensure that all GO transactions are considered, has not yet been implemented

Note: 1 - https://www.aib-net.org/facts/national-datasheets-gos-and-disclosure

National frameworks for administering RNG Guarantees of Origin

- The EU Renewable Energy Directive (EU/2018/2001; Article 19) requires national governments to set up a framework to administer RNG GOs and designate competent bodies to operate tracking systems
- 15 EU Member States (plus the UK) have official GO issuing bodies, however, not all are currently operating, e.g., UBA in Germany will become the official GO issuing body from 2026
- Some RNG certificate registries are not official GO issuing bodies, e.g., AGCS, dena
- Cross-border transfer of GOs and other national certificates is facilitated by ERGaR (European Renewable Gas Registry) and AIB (Association of Issuing Bodies) platforms
- 12 EU Member States have not yet established national GO issuing bodies
- Some third countries connected to European gas networks also have RNG registries, e.g. Switzerland (which is an official GO issuing body) and Ukraine (which is not an official GO issuing body)

National Registry		GO certificate system		Cross-border GO transfer system	
		Operating	GO Issuing Body	ERGaR	AIB
Austria	E-Control	✓	✓	×	✓
	AGCS	✓ [1]	× [1]	✓	×
Belgium	BRUGEL	×	✓	×	×
	VREG	✓	✓	×	×
	SPW Energie	×	✓	×	×
Czechia	OTE	✓	✓	×	✓
Denmark	ENERGINET	✓	✓	✓	×
Estonia	Elering	✓	✓	×	×
Finland	Gas Grid Finland	✓	✓	×	✓
France	EEX	✓	✓	×	×
Germany	UBA	× [2]	✓ [2]	×	× [2]
	dena	✓ [1]	× [1]	✓	×
Italy	GSE	✓	✓	×	✓
Ireland	Gas Networks Ireland	✓	✓	× [3]	×
Latvia	Conexus Baltic Grid	✓	✓	×	✓
Lithuania	AB Amber Grid	✓	✓	×	×
Luxembourg	ILR	×	✓	×	×
Netherlands	VertiCer	✓	✓	✓	×
Slovakia	SPP Distribúcia	✓	✓	✓	×
Spain	Enagás GTS	✓	✓	×	✓
UK	GGCS	✓	×	✓	×

1 – AGCS, dena and GGCS are not official GO issuing bodies; 2 - UBA (Umweltbundesamt; Federal Environment Agency) will become the official German GO issuing body and registry in 2026; 3 – in progress
Source: European Biogas Association; ERGaR; AIB https://www.aib-net.org/facts/national-datasheets-gos-and-disclosure

Proof of Sustainability (PoS) is used to demonstrate compliance with EU sustainability criteria

EU legislation

- The Renewable Energy Directive (EU) 2018/2001 (Articles 25-31), known as RED II, stipulates that RNG must meet specific sustainability criteria and the process by which compliance can be demonstrated.[1] PoS certification is used to demonstrate compliance
- Implementing Regulation (EU) 2022/996 establishes rules to verify sustainability, GHG savings, and low indirect land-use change-risk criteria
- The new amendment to the Renewable Energy Directive (EU/2023/2413), known as RED III, must be implemented into national legislation by May 21, 2025
- EU Emissions Trading System (ETS) Directive 2003/87/EC and established a system for greenhouse gas emission allowance trading within the EU
- ReFuelEU Aviation Regulation (EU) 2023/2405 establishes rules relating to the sustainability of air-transport fuel
- FuelEU Maritime Regulation (EU) 2023/1805 establishes rules relating to the sustainability of maritime shipping fuel
- EU hydrogen and gas decarbonisation package, consisting of Directive (EU) 2024/1788 and Regulation (EU) 2024/1789, was adopted in May 2024

Voluntary certification schemes

- Sustainability Certification guarantees legal compliance with the RED sustainability criteria. Sustainability certification schemes are operated and administered by voluntary certification bodies, such as ISCC, REDcert, BetterBiomass, SURE, and 2BS, to independently certify the sustainability and GHG emissions of RNG
- Certification schemes and certification bodies must be approved by the European Commission to establish the framework for proving sustainability against the RED criteria. The European Commission has approved 15 voluntary and national sustainability certification schemes, however, not all are applicable to RNG [2]
- RNG producers are audited by an external verifier (auditor) under the scheme; **certified producers** are authorised to issue **Proof of Sustainability (PoS)** autonomously for each consignment of RNG

National certification schemes

- There are also national sustainability certification schemes, e.g., in Finland and Poland, which national governments may require stakeholders to use
- However, unless the issuing body and certification scheme is authorised by the European Commission, certification cannot be used to meet EU obligations

Purpose

- PoS is used to demonstrate that a specific consignment of RNG meets the sustainability criteria outlined in the EU Renewable Energy Directive (EU/2018/2001; Articles 25-31)
- Compliance allows the RNG to be used to fulfil various obligations, quotas and targets set by EU legislation; whereas RNG that only has a GO (GO) cannot be used to fulfil these EU targets

1 Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC
2 https://energy.ec.europa.eu/topics/renewable-energy/bio-energy/voluntary-schemes_en#approved-voluntary-schemes-and-national-certification-schemes

How Proof of Sustainability (PoS) operates in practice

Obtaining a Proof of Sustainability (PoS)

- Sustainability certification schemes are operated and administered by voluntary certification bodies, such as ISCC, REDcert, BetterBiomass, SURE, and 2BS, to independently certify the sustainability and GHG emissions of RNG
- Certification schemes and bodies must be approved by the European Commission to establish the framework for proving sustainability against the RED criteria
- RNG producers seeking certification within an approved scheme undergo assessment by an external auditor; and upon successful evaluation, the producer is authorised to issue PoS certificates autonomously for each consignment of RNG

Transfers/trade:

- A PoS issued for a consignment of RNG can be transferred to another party such as a trader or end-user. This may be sent directly between, e.g. producer and trader; or the transfer could be in the form of an electronic certificate within a database system, e.g. Nabisy (the German governmental sustainable biomass system web application (*Nachhaltige Biomasse System*) operated by the Federal Office for Agriculture and Food (BLE))
- A RNG consignment may have both a GO and PoS; however, "it is not permitted for a (paper) trader to buy or sell a sustainability declaration (PoS) for RNG without the link to the respective amount of physical sustainable RNG" (ISCC, 2021),[1] to avoid double counting risk.[2] This is facilitated by dedicated platforms for transferring PoS (e.g. the Nabisy database); but use of such platforms is not a requirement unless specified in national legislation
- Since tracking physical RNG molecules is impractical when RNG is blended with natural gas in national gas networks, a mass balancing approach is used (Regulation (EU) 2022/996; Ch. IV). Traders undergo audits by voluntary schemes to verify compliance with mass balancing requirements
- The end-user can then use the PoS to fulfil target counting obligations, ensuring compliance with EU sustainability targets
- A cross-border mass balancing system (Union Database) is being developed by the European Commission for all POS transfers within Europe. The system should be operational for gases from November 21, 2024

1 *ISCC (2021). EU 203 Traceability and Chain of Custody. Version 4.0.* 1st July 2021.

2 To avoid double counting risk "the sustainability attributes (PoS) cannot be separated from the batch of RNG and cannot be transferred, sold or otherwise used (e.g. in the framework of a national biogas register) to satisfy further obligations or commitments or to benefit from more than one renewable incentive scheme" (*ISCC EU 203 Traceability and Chain of Custody. Version 4.0. 1st July 2021*).

Variations from the standard RNG certificate tracking frameworks

Legislative basis

- There are two standard types of RNG certificates — Guarantee of Origin (GO) and Proof of Sustainability (PoS) — as set out in the RED (EU/2018/2001; Art.19)
- National registries issue and keep track of GOs; however, some were established prior to RED II entering into force and, since there was no harmonised system to implement biogas tracking systems at that time, these registries operate in accordance with national legislation, e.g. AGCS (AT), dena (DE) and GGCS (UK)
- Some registries operate hybrid systems, which combine the functions of GO with RED II voluntary scheme compliance PoS data. E.g. VertiCer (NL) and Elering (EE) (note: the EU sustainability requirements are uniform for the PoS)

Purpose

- In addition to renewables disclosure and title tracking (the primary function of GOs), national certificate systems may have additional functions, notably:
  - Use for target accounting and eligibility proof for financial support
  - Use for mass-balancing (a key function of PoS) (note: this is specific to the dena register which requires proof of physical gas flows from producer to end user using the mass balancing principle]

Obtaining national certification:

- As for official GO systems, a producer requires an account with the registry and the information entered into the registry must be audited
- For mass balancing, producers may issue PoS autonomously for each RNG consignment if it meets the requirements of an approved sustainability scheme

Transfers/ trade:

- Trading of national certificates between producers, traders and end users is possible
- The national registry that keeps track of the ownership of these other certificates to avoid double counting
- Cross-border transfers are facilitated by the ERGaR and AIB schemes which allow the transfer of national certificates other than official GOs

Robust certification and tracking systems address the key risks relating to RNG procurement, trading, renewable energy reporting and GHG reporting

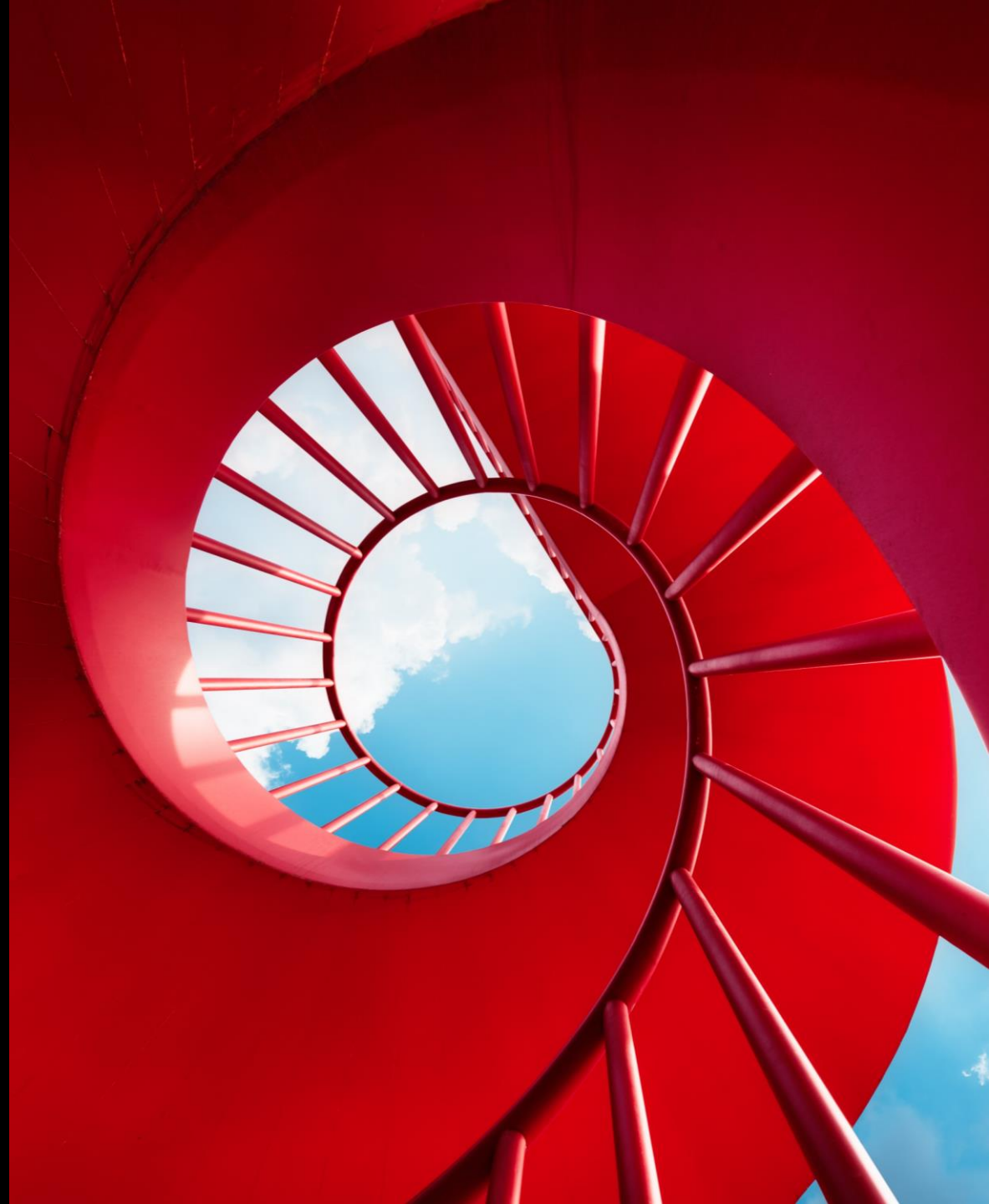
Perceived risk addressed	Risk mitigation measures
Double counting risk Possibility that a consignment of RNG is counted or claimed more than once *towards the same objective* in terms of production, sale or use (N.B. *not* counting or claiming towards *different objectives)*	**GO and PoS** A RNG consignment may have both a GO and PoS. Only one GO is issued for each unit of RNG injected into the gas network and it is only allocated to one end user. However, "it is not permitted for a (paper) trader to buy or sell a sustainability declaration (PoS) for RNG without the link to the respective amount of physical sustainable RNG" (ISCC, 2021),[1] to avoid double counting risk,[2] accounted for by mass balancing
Environmental and sustainability risk Possibility that use of unsustainable biomass could lead to: (i) deforestation; (ii) forest degradation; (iii) emissions from land use; (iv) land use change; (v) monoculture forestry; (vi) upstream greenhouse gas emissions; and (vii) air emissions from combustion	**PoS** PoS is used to demonstrate that a consignment of RNG meets the sustainability criteria outlined in the EU RED (EU/2018/2001)
Regulatory and compliance risk Possibility that renewable energy contribution to national and EU's renewable energy share and GHG emissions reduction targets could be over-stated without robust compliance certification	**PoS** Sustainability compliance certified by PoS allows RNG to be used to fulfil various obligations, quotas and targets set by the EU legislation; whereas RNG that only has a GO cannot be used to fulfil the EU targets
Tracking system and technical risk Possibility of technical and operational issues in the RNG tracking systems which are used to show that sustainability and GHG emission saving criteria have been fulfilled using the mass balance system and to enable RNG to count towards EU RED targets	**Robust RNG tracking systems** National tracking systems (approved registries) issue and transfer GOs between producer, trader and end user; ERGaR/AIB systems facilitate cross-border GO transfers between registries; from November 21, 2024, the UDB will provide a pan-EU mass balancing system

1 ISCC (2021). *ISCC EU 203 Traceability and Chain of Custody. Version 4.0*. 1st July 2021.

2 To avoid double counting risk "the sustainability attributes (PoS) cannot be separated from the batch of RNG and cannot be transferred, sold or otherwise used (e.g. in the framework of a national biogas register) to satisfy further obligations or commitments or to benefit from more than one renewable incentive scheme" (*ISCC EU 203 Traceability and Chain of Custody. Version 4.0. 1st July 2021*).

Contents

3.2 Use of certificates in national RNG tracking systems



S&P Global

National RNG tracking systems – focus on 5 registries

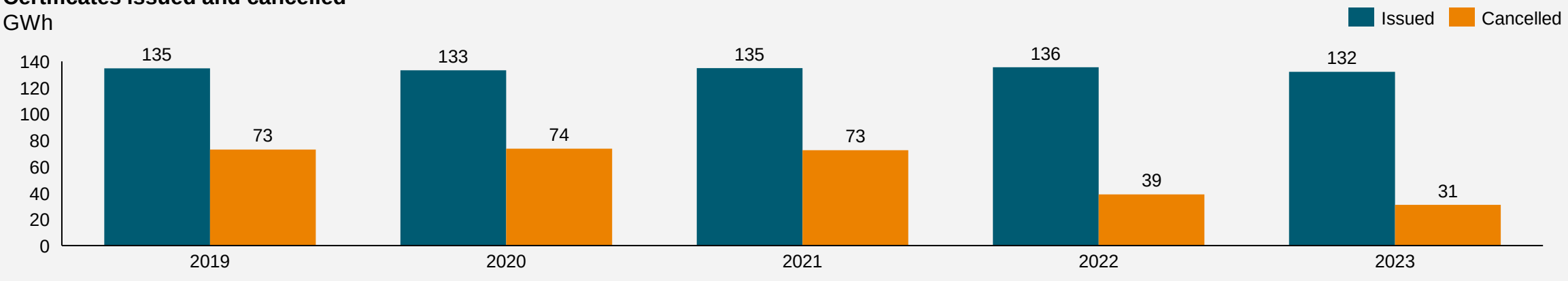
	Focus on five existing certification schemes in the EU and UK	
AGCS	**Austria**: The Austria Gas Clearing and Settlement (AGCS) operates one certification and registry system for RNG injected into the Austrian gas grid.	
dena	**Germany**: Deutsche Energie-Agentur (dena) operates the German certification and registry system for RNG injected into the German gas grid.	
ENERGINET	**Denmark**: ENERGINET is the Danish national transmission system operator for electricity and natural gas. It operates the certification and registry system for RNG injected into the gas grid.	
VertiCer	**The Netherlands**: VertiCer operates the certification and registry system for all sustainable energy carriers in the Netherlands, including RNG, electricity, thermal and green hydrogen.	
GGCS	**The UK**: The Green Gas Certification Scheme (GGCS) operates a certification and registry system for RNG injected into the UK gas grid.	

Austria: Use of certificates in the AGCS RNG tracking system

National RNG certificate body and tracking system

- The AGCS biogas registry is not a mandated GO registry (RED II; Art.19). In Austria, RNG GO is only issued by the regulatory authority E-Control. The AGCS hybrid certificate system combines the function of GO with RED II voluntary scheme compliant PoS data (RED II; Art.19). However, it is not strictly a combined GO/PoS certificate (as it cannot be used as an official GO in Austria).
- AGCS RNG certificates include: i) plant-specific data (e.g., country, metering point/feed-in point, plant type, energy source); ii) gas-specific data (MWh); iii) quality of the raw materials (substrates) used (i.e., sustainability criteria based on external RED II voluntary scheme, including GHG emissions and mass balancing data); and iv) gas transfer data (e.g., attributes to enable automatic transfer of ownership of RNG certificates, including for European exchanges).
- The AGCS system allows for direct exchange of data with the following: i) the Austrian balancing group system; ii) the database for GO;* iii) the national biofuels registry (cancellation statements can be used as basis for data entry); and iv) the German biogas registry (dena; certificates can be transferred directly). Cross-border transfers can also be made via the ERGaR scheme.
- AGCS certificates provide the basis for domestic green electricity subsidies (feed-in tariff). In order to claim the green electricity feed-in tariff, RNG certificates must be transferred from the RNG electrification plant account to the "OeMAG-Account" of the Green Power Settlement Agency (Ökostromabwicklungsstelle, OeMAG).

Certificates issued and cancelled



Source: AGCS and EBA

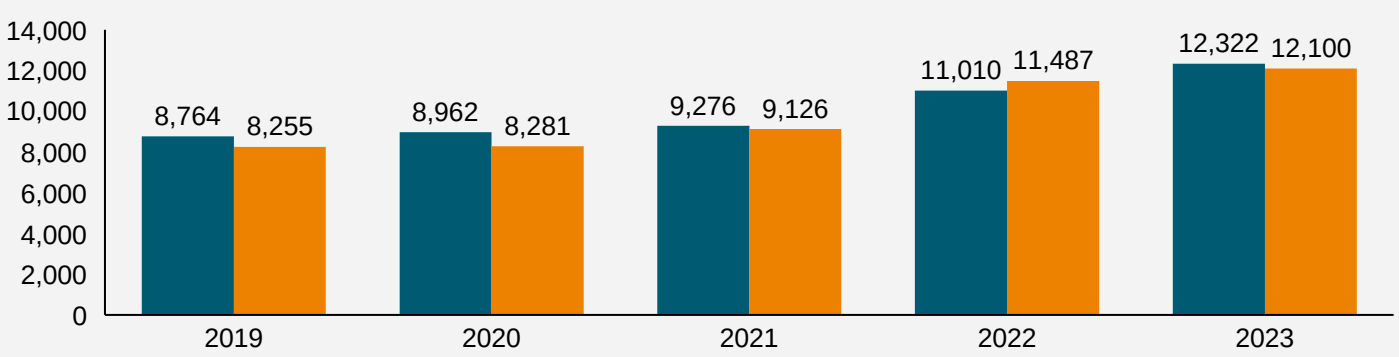
Note: * AGCS certificates can provide the necessary information for GOs and AGCS can request GOs to be issued by transferring AGCS certificates to an account; however, there is no direct interface, and the request follows "manually" by AGC

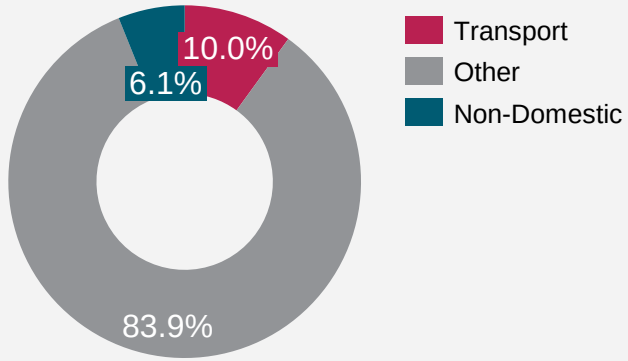
Germany: Use of certificates in the dena RNG tracking system

National RNG certificate body and tracking system

- The dena biogas registry is not an official GO issuing body (RED II; Art.19). The dena hybrid certificate system combines GO data with RED II voluntary scheme compliance PoS data within a single platform, providing standardised documentation of RNG quantity and quality in the natural gas grid.
- Under the system: i) producers must complete an environmental audit by an external verifier; ii) RNG injected into the grid is registered; iii) producers and intermediaries transfer RNG quantities purchased to the accounts of other registry participants in the supply chain; iv) end user withdraws the RNG from the natural gas grid and books out the corresponding quantity from the register; and v) consumers can then use a data extract from the register to claim statutory refunds and compensation.
- Germany's Renewable Energy Sources Act (Erneuerbare Energien Gesetz; EEG) and Renewable Energies Heat Act (Erneuerbare Energien Wärmegesetz; EEWärmeG) requires mass balancing of RNG along the entire value chain — from producer (via grid injection) to end user. Quantity, quality and sustainability are verified by an annual external audit, checked by dena and uploaded to the biogas register.
- Cross-border trading of RNG and transfer of certificates is facilitated by the ERGaR scheme, or directly between the dena registry and five national biogas registries, namely in AGCS (AT), GGCS (UK), VertiCer (NL), ENERGINET (DK) and SPP Distribúcia (SK)

Certificates issued and cancelled





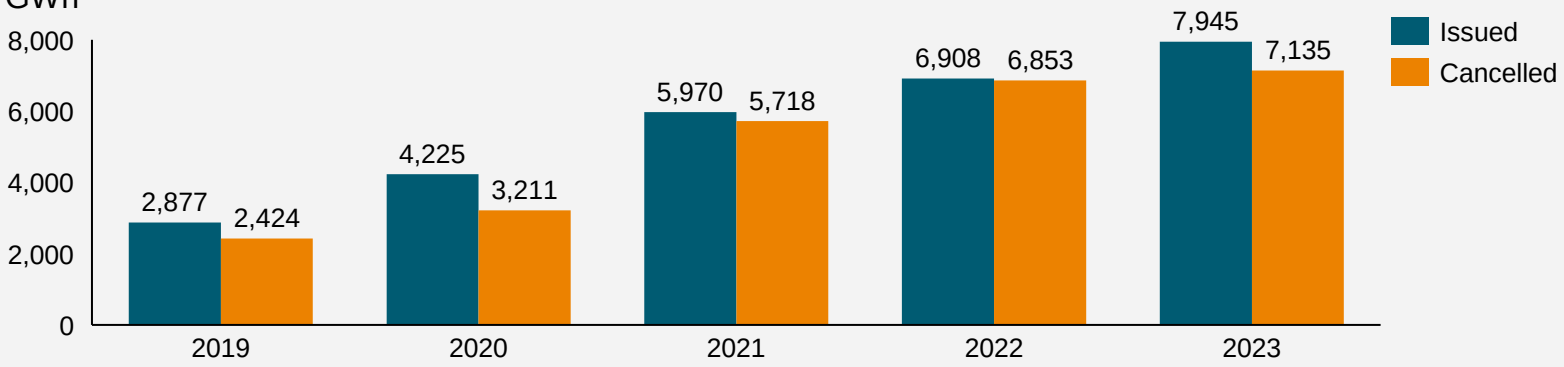
Source: dena and EBA

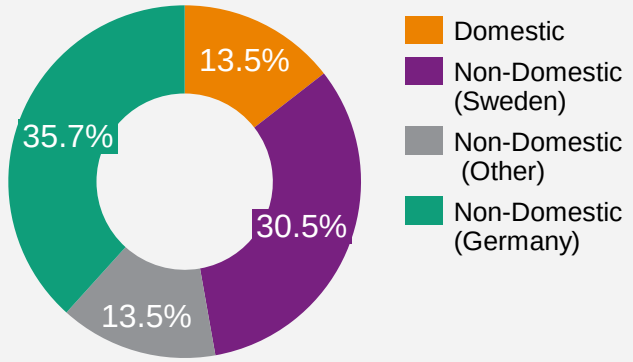
Denmark: Use of certificates in the ENERGINET RNG tracking system

National RNG GO issuing body and tracking system

- ENERGINET owns and operates the Danish electricity and gas network as an independent public enterprise owned by the Danish Ministry of Climate, Energy and Utilities.
- It is also the institution in Denmark that registers and issues GOs to biogas producers for the RNG injected into the gas distribution system.
- GOs for renewable gas may be traded by certificate account holders prior to the final transfer to a consumer. GO transfers from the producer to consumer may be direct or via energy suppliers and traders. The seller is obliged to cancel GOs in ENERGINET's register to ensure an unbroken transfer of renewable gas from the producer to consumer.
- PoS compliance is independent of the ENERGINET register via RED voluntary schemes.
- RED-compliant, sustainable RNG with PoS is required to fulfil national transport biofuel blending obligations.

Certificates issued and cancelled





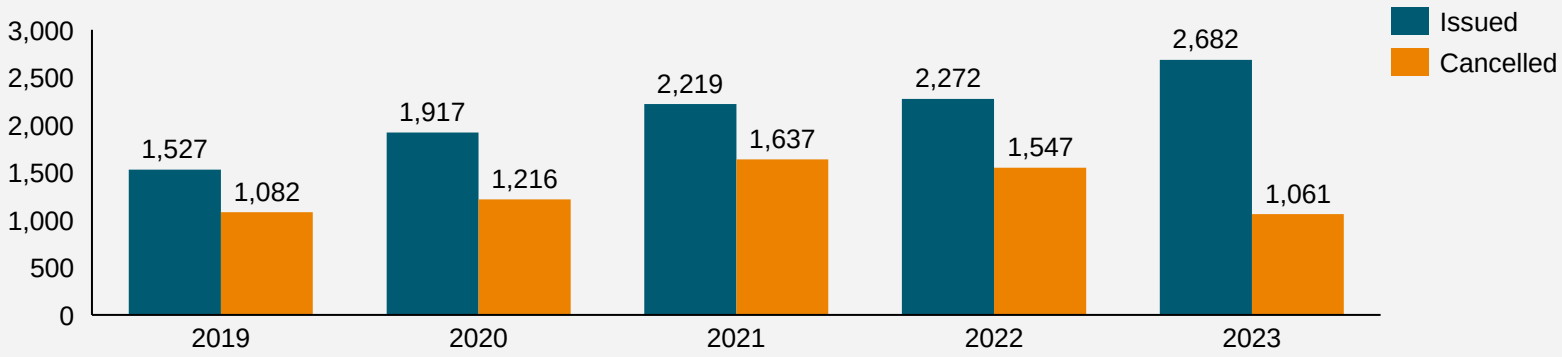
Source: ENERGINET and EBA

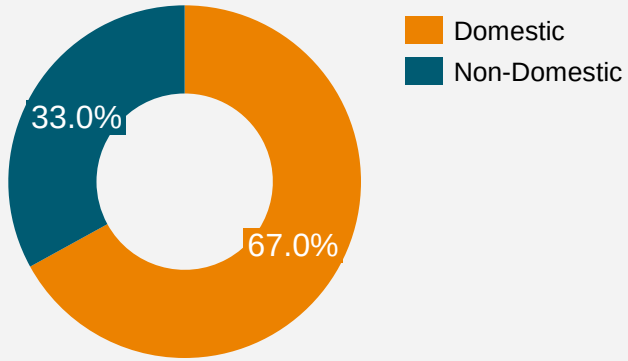
Netherlands: Use of certificates in the VertiCer RNG tracking system

National RNG GO issuing body and tracking system, which also combines the *functions* of GO and PoS

- VertiCer (formed via the merger of Vertogas and CertiQ in 2023) is the institution in the Netherlands that issues GOs for all sustainable energy carriers.
- The VertiCer system combines GO with RED II voluntary scheme-compliant PoS data which supports:
  - GO disclosure of RNG origin to consumers/end users
  - PoS certification of the sustainability and greenhouse gas emissions of RNG
  - GO and PoS verification against national regulatory targets
- VertiCer hybrid (GO-PoS) certificates can be counted against annual HBE (Renewable Energy Unit) obligations set by NEa (Dutch Emissions Authority) to comply with annual greenhouse gas emissions obligations and annual transport biofuel quotas.
- The Netherlands announced a new Green Gas Obligation law in July 2023, which if adopted will combine existing GOs with new tradeable Green Gas Units (GGEs: groengaseenheden).

Certificates issued and cancelled





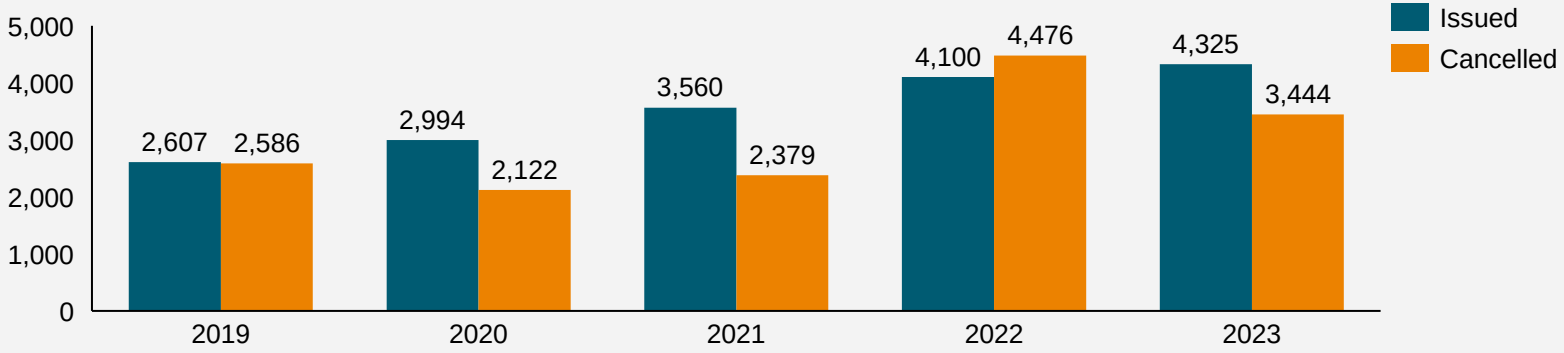
Source: VertiCer and EBA

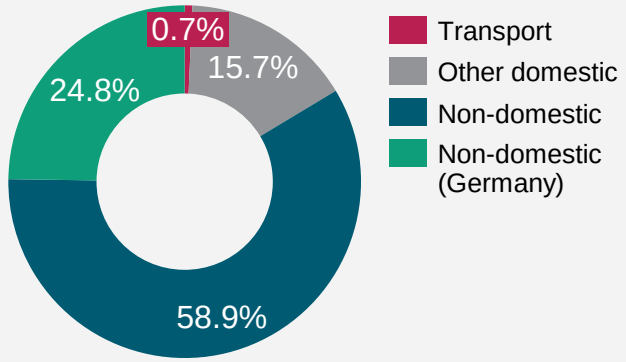
United Kingdom: Use of certificates in the GGCS RNG tracking system

National RNG certificate body and tracking system

- GGCS issues, transfers and retires Renewable Gas Guarantees of Origin (RGGOs) in the UK. Since the UK is not a member of the European Union, GGCS is not an official GO issuing body and RGGOs are not official GOs in accordance with the EU RED requirements.
- RGGOs are issued to green gas producers for units of green gas injected into the gas grid, which displace units of fossil gas. They can then be transferred between a variety of counterparties before being retired and allocated to gas consumers. GGCS mitigates the risk of double counting by ensuring that only one RGGO is issued for each unit injected, that they are transferred securely and each RGGO may be allocated to only one consumer.
- When a gas consumer buys a RGGO (or its equivalent in another country) they are matching the gas that they have withdrawn from a distribution network (a network) to a unit of green gas that was produced and placed into the same network.
- Since the UK is not fully aligned with RED II, it does not currently adhere to RED sustainability certification standards and, therefore, RNG issued with a RGGO in the UK is not automatically accompanied by a PoS for mass balancing.

Certificates issued and cancelled

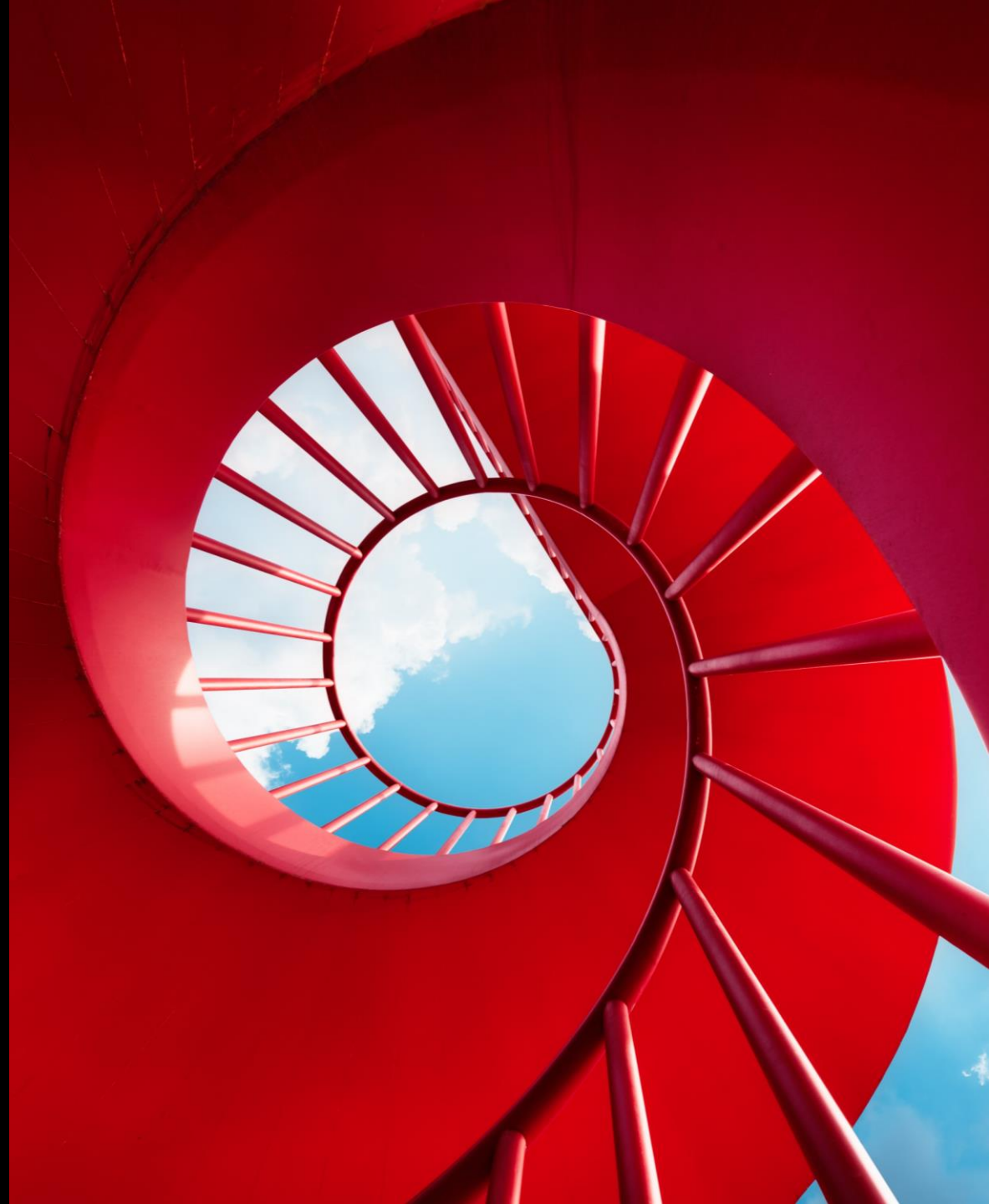




Source: GGCS and EBA

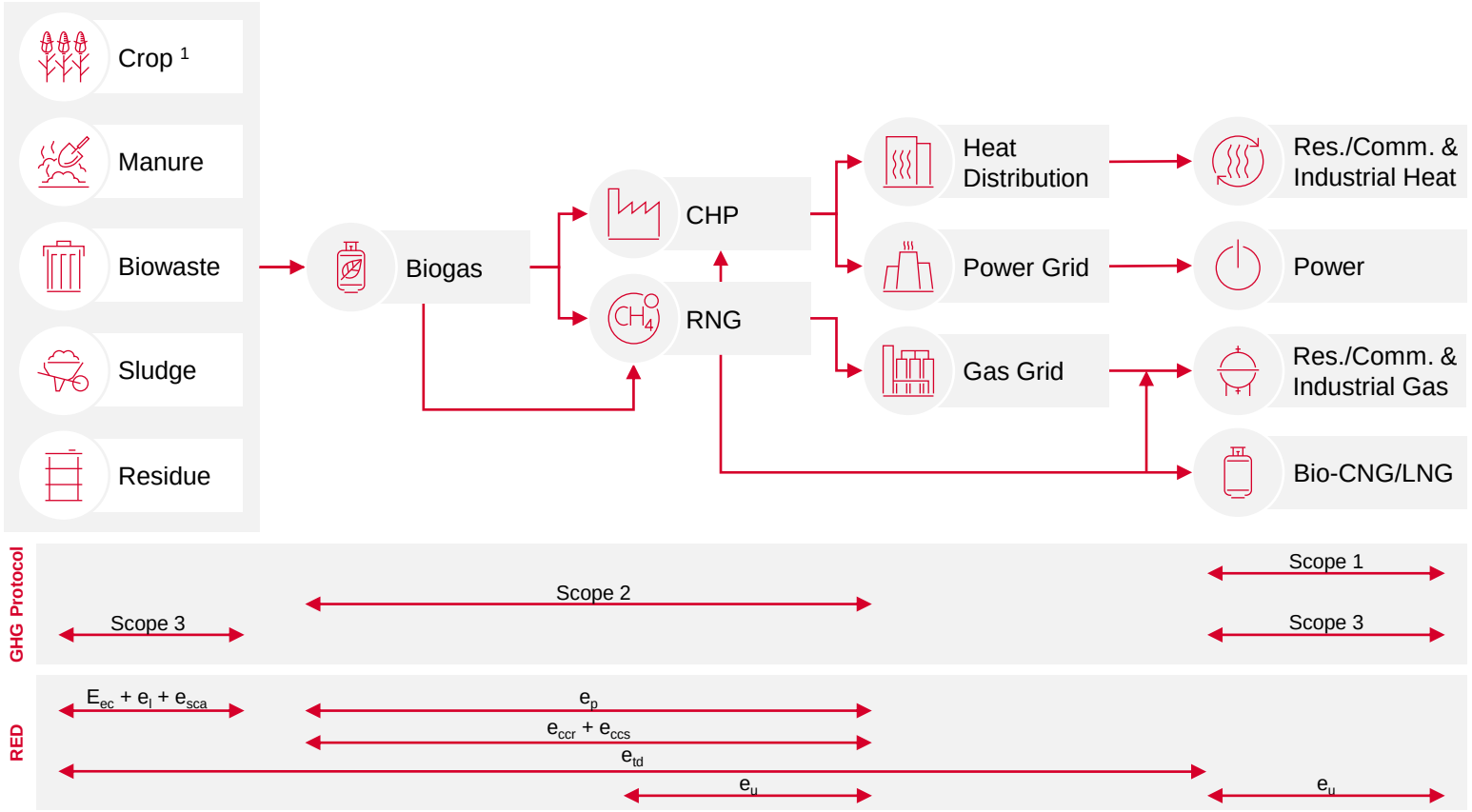
Contents

3.3 Link between certificates and greenhouse gas (GHG) emissions reduction



PoS records lifecycle GHG emissions throughout the RNG value chain in accordance with RED (EU/2018/2001)

PoS captures Scope 2 and 3 GHG emissions calculated using RED (EU/2018/2001) methodology



Refer to p.41 for further details on RED lifecycle GHG emission calculations

GHG Protocol

- GHG Protocol categorises GHG emissions as:
  - Scope 1: Direct emission from inter alia burning fuel in operations
  - Scope 2: Indirect emission from consumption of purchased electricity, heat or steam
  - Scope 3: Indirect emission from upstream and downstream activities, notably biomass production or extraction

EU RED

- RED (EU/2018/2001; Annex V and VI) establishes a methodology to calculate GHG emission values, including from:
  - Raw material production/extraction
  - Processing and biomass fuel production
  - Transport and distribution
  - Carbon management
  - Biomass fuel use

1 Agricultural practices include sustainable cropping practices that can feed RNG production as well as deliver environmental services, such as protecting and improving soil health

RED (EU/2018/2001; Annex V and VI) provides the calculation methodology for lifecycle GHG emissions throughout the value chain that are included in the RNG PoS certification

Calculation of GHG emissions

- RED (EU/2018/2001; Annex V and VI) establishes a methodology to calculate GHG emission values, using actual values, default values, or a combination of disaggregated default values and calculated actual values
- GHG emissions from production and use of biomass fuels (before conversion into electricity or for heating/cooling) are calculated using the formula:

$$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr}$$

  - Where:
    - E = total emissions from the use of the fuel
    - e_{ec} = emissions from the extraction or cultivation of raw materials
    - e_l = emissions from carbon stock change caused by land-use change
    - e_p = emissions from processing
    - e_{td} = emissions from transport and distribution
    - e_u = emissions from the fuel in use
    - e_{sca} = emission savings from soil carbon accumulation via improved agricultural management
    - e_{ccs} = emission savings from CO_2 capture and geological storage
    - e_{ccr} = emission savings from CO_2 capture and replacement

Emission savings vis-à-vis fossil fuel reference

- GHG savings potential generated from heating, cooling and electricity compared to the fossil reference is calculated according to the following formula:

$$\text{GHG saving potential} = \frac{\text{GHG emission from fossil comparator - GHG emission from heat or electricity}}{\text{GHG emission from fossil comparator}} \times 100$$

  - Where:
    - Biofuels and biomass fuels for transport = 94 gCO_2eq/MJ fossil fuel
    - Biomass fuels for electricity generation = 183 gCO_2eq/MJ electricity or 212 gCO_2eq/MJ electricity for EU outermost regions
    - Biomass fuels for heat and energy for heating/cooling = 80 gCO_2eq/MJ heat
  - Final consumer must also calculate emissions from the fuel in use (e_u):
    - Fuel in use (e_u) is given as zero for biofuels, bioliquids and biomass fuels, but
    - Emissions of non-CO_2 GHGs (CH_4 and N_2O) from the fuel in use will be included in the factor (e_u) for bioliquids and biomass fuels
    - RED II, Annex VI outlines default value information on non-CO_2 emissions from the fuel in use for some biomass fuels

GHG emissions certified by PoS may be used for carbon accounting and sustainability disclosure requirements

PoS – Attributes

	Coverage
Scope of emission	• Scope 2: Indirect emissions from consumption of purchased electricity, heat or steam • Scope 3: Indirect emissions from upstream and downstream activities, notably biomass production or extraction
Feedstock	• RED (EU/2018/2001) set out feedstock sustainability criteria [1] – Manure/slurry prevents diffuse field GHG emissions and receives a credit of 45.05 gCO_2eq/MJ biogas
Methodology	• IPCC Tier 1 calculation method [2] • RED (EU/2018/2001; Annex V and VI) sets out methodology to calculate GHG emissions • Emissions from fuel in use (e_u) given as zero for biofuels, bioliquids and biomass fuels

PoS – Applications

	GHG Protocol	RED II and RED III	ETS and ETS II
Scope of emission	• Scope 1: Direct; from inter alia burning fuel in operations • Scope 2: Indirect; from consumption of purchased electricity, heat or steam • Scope 3: Indirect; from upstream/downstream activities	• Scope 2: Indirect; from consumption of purchased electricity, heat or steam • Scope 3: Indirect; from upstream/downstream activities	• Scope 1: Direct; from inter alia burning fuel in operations
Sectors	• Voluntary	• Compliance	• Compliance
Feedstock	• Not applicable	• RED (EU/2018/2001): – Annex V – Annex IX Part A (advanced waste and residues) – Annex IX Part B (other wastes and residues)	• PoS proves compliance with EU sustainability criteria set out in RED (EU/2018/2001) [1]
PoS Compatibility	• Yes (Scope 1) • Partial (Scope 2 and 3) • Reporting under GHG Protocol Corporate Accounting and Reporting Standard	• Yes • RED calculation methodology for GHG emissions	• Yes • Emissions factor is zero related to the concept of “zero-rating” from the ETS MRR [3]

1 RED (EU/2018/2001): Sustainability Criteria according to Article 29 (2) to (7); GHG saving criteria according to Article 29 (10)
2 Intergovernmental Panel on Climate Change (IPCC) Tier 1 methodology is a basic method for estimating GHG emissions and removals using default values and other parameters based on global average emission factors
3 Monitoring and Reporting Regulation (EU/2018/2066; as recently amended 01/07/2024) http://data.europa.eu/eli/reg_impl/2018/2066/2024-07-01

GHG emission savings potential of low carbon feedstock is captured in PoS based on RED calculation formula; emission from biofuels in use is zero

EU-ETS (power generation and heavy industry)

- EU-ETS is a market mechanism to reduce end-use (i.e., combustion) emissions. Emissions from renewable energy are zero-rated, as per IPCC guidelines
  - Note that the ETS covers emissions from fuel in use (e_u), which under the RED are given as zero for biofuels, bioliquids and biomass fuels

RED II (road and rail transport)

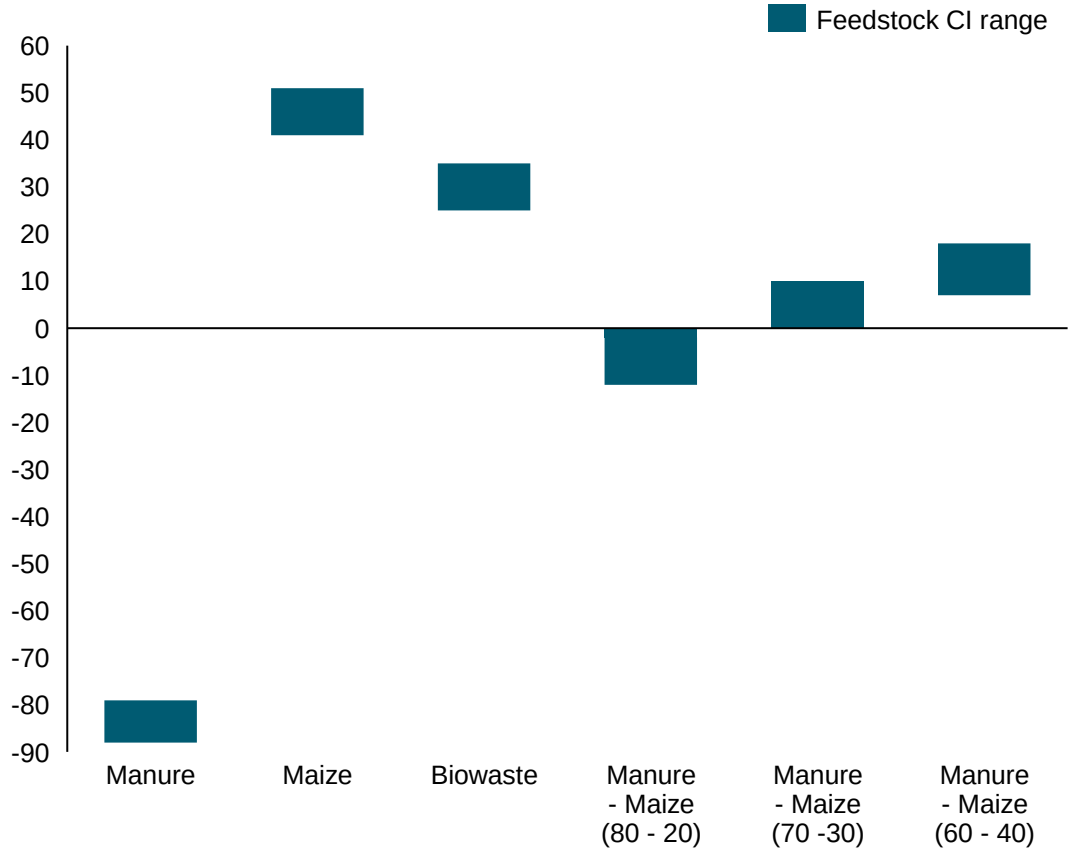
- RED II (EU/2018/2001) sets a 14% renewable energy use target for transport, and a sub-target of 3.5% for advanced (Annex IX-A) biofuels, including RNG by 2030
- Annex V and VI sets out a methodology to calculate GHG emissions, which takes into account feedstock carbon intensity, effectively incentivising the use of renewable energy that has the greatest GHG emission savings potential

RED III (2025) (road, rail, maritime and aviation transport)

- RED II (EU/2023/2413) raises the target to 29% by 2030; with a sub-target of 5.5% for advanced (Annex IX-A) biofuels, including RNG, and modifies the Annex IX-A/B lists
- EU member states may alternatively apply a 14.5% GHG emissions reduction target for transport energy use, which requires GHG emissions data from RNG PoS

GHG emission savings potential of RNG (incl. LNG/CNG) feedstock

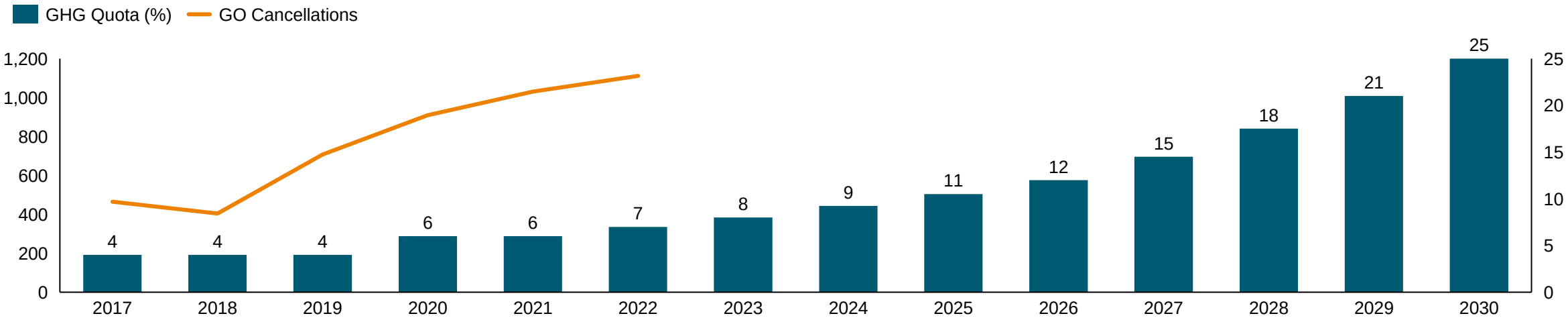
gCO_2eq/MJ



Source: Renewable Energy Directive II (RED II) Annex II

Case study: GHG emission reduction quotas for transport drives RNG use in Germany

Germany GHG quota and use of RNG in transportation
RNG GO certificates cancelled (GWh) and GHG quota (%)

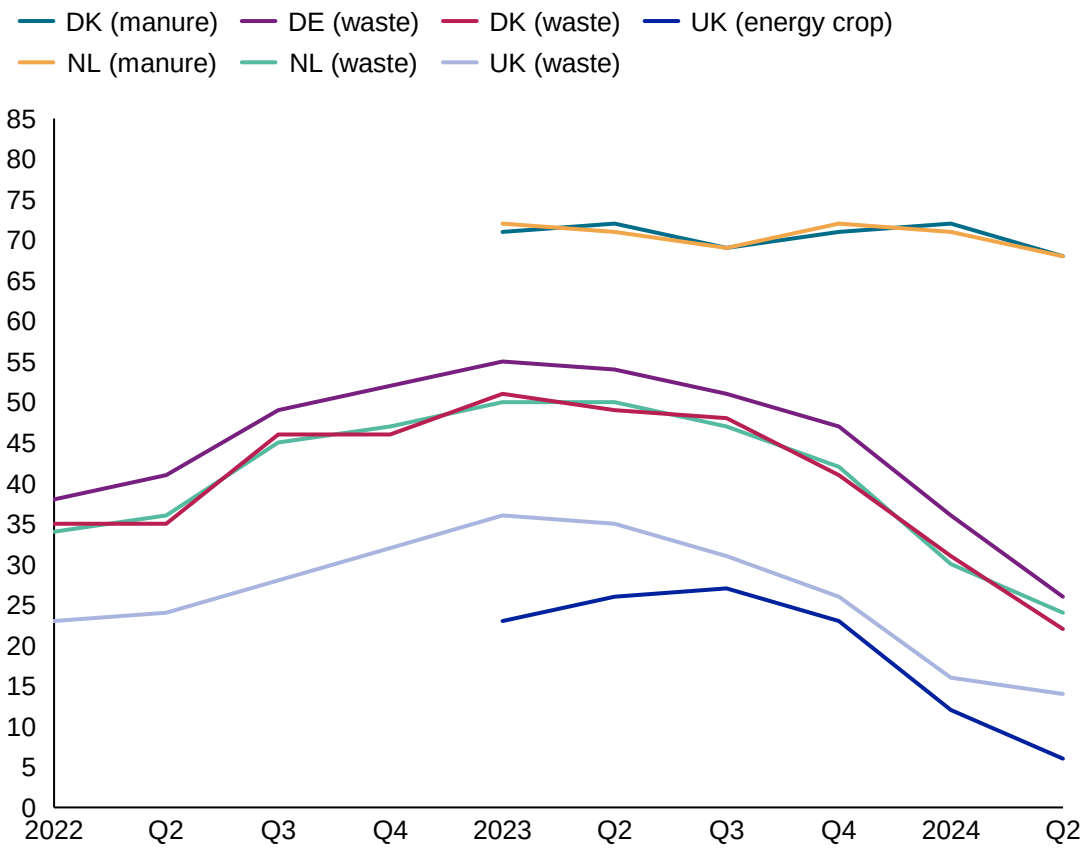


- National regulations to target GHG emissions reduction in the energy sector are increasingly based on certificate systems, and have driven RNG production and consumption
  - For e.g., in Germany, the Emission Control Act (last amended in July 2024) introduced a requirement for transport fuel suppliers to achieve specific GHG reduction quotas from the fuel that they supply (instead of a renewable energy obligation)[1]
  - The quota specifies a certain % reduction in GHG emissions that must be achieved each year, with progressively greater emissions reduction requirements to 2030
  - Fuel suppliers can meet their quotas by blending biofuels, including RNG as bio-LNG or bio-CNG, or by purchasing certificates. Suppliers that fail to meet the quota requirement face a financial penalty in the form of a buyout price (€600 /t CO_2)
  - Use of RNG certificates to fulfil quota obligations in the German transport sector increased to 1,111 GWh in 2022 from 404 GWh in 2018 (+22.4% CAGR)

1 Federal Emission Control Act in the version published on May 17, 2013 (Federal Law Gazette I p. 1274; 2021 I p. 123), which was last amended by Article 1 of the Act of July 3, 2024 (Federal Law Gazette 2024 I No. 225)
Source: dena and EBA data '

EU RNG certificate values demonstrate importance of feedstock carbon intensity, but are vulnerable to wider bio-energy market fundamentals

RNG certificate prices, 2022-2024 [1]
EUR/MWh (spot, nominal)



Key drivers for RNG certificate prices

- **Sustainability certification** – PoS certified RNG that proves compliance with RED sustainability requirements (e.g., DE, NL) attracts a premium over non-PoS certified RNG (e.g., from UK). It should be noted that DE and NL national certificate systems combine the attributes of GO as well as PoS
- **CI** – GHG emissions reduction potential drives demand for RNG produced from low-CI feedstock
  - Certificate values for RNG derived from animal manure feedstock attract a premium in markets that recognise the highest GHG emission savings (i.e., negative CI values under RED for transport)
  - Similarly, certificate values for RNG derived from waste feedstock attract a premium over energy crop-derived RNG certificates
- **Market access** – Acceptance of cross-border RNG certificate transfers between national registries (e.g., facilitated by ERGaR or AIB) may attract a premium
- **Origin** – RNG for use in compliance markets (i.e., ETS regulated sectors) must generally be of EU (notable for UK RNG) or domestic origin
  - DE stipulates domestic RNG for use in the EEG power market (compliance)

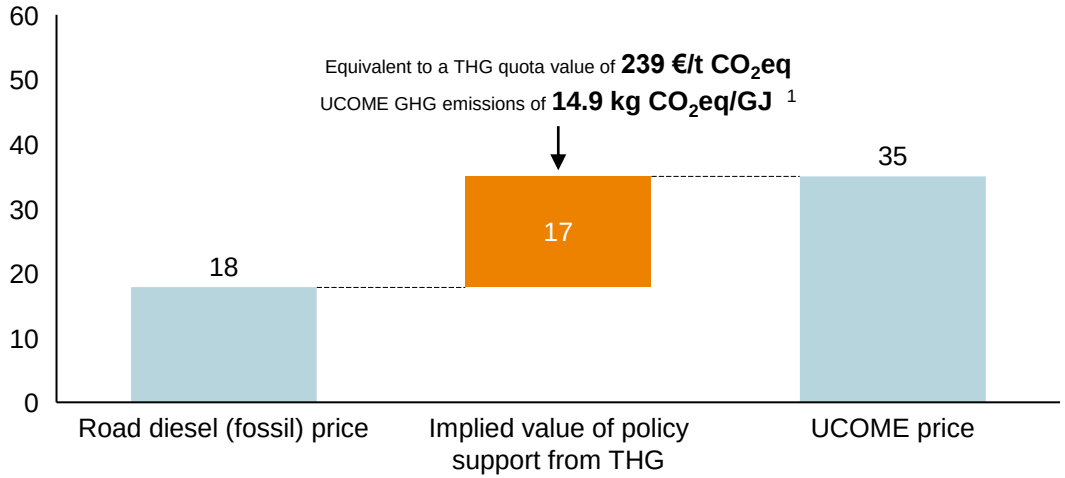
  Note: RED sustainability criteria apply independently from geographical origin
- **Since 2023**, RNG certificate values have been pressured by:
  - Supply of liquid biofuels for road transport, notably disputed imports of Annex IX-B biodiesel from China, which has lowered THG quota prices in Germany, with spillover effects for inter alia in the Netherlands and other certificate markets
  - Unfavourable macroeconomic conditions, including weaker natural gas demand
  - Industry comments suggest a reluctance of corporates to procure RNG owing to uncertainty around use of pipeline RNG certificates under the GHGP

Source: S&P Global CI Platts

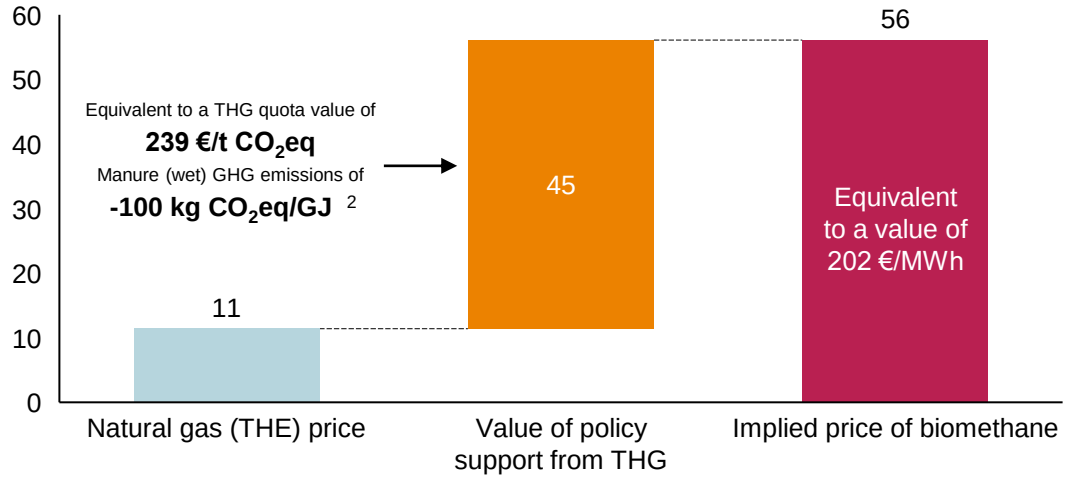
1 Spot prices have been used. Refer to S&P Global CI Platts Methodology and Specifications Guide – Low Carbon Gas for details on price assessment methodology

Value of RNG in German transport: Biodiesel and (fossil) road diesel market prices set the value of the THG quota; low CI feedstock drives RNG value

Germany: THG quota value based on road diesel and UCOME price
€/GJ (2023)



Germany: RNG price based on THG quota value and natural gas price
€/GJ (2023)

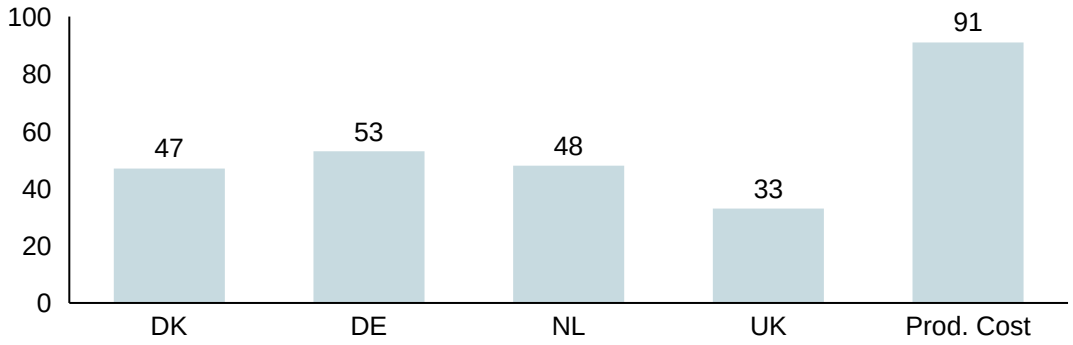


- The value of RNG in the road transport market in Germany is linked to GHG emission reduction mandates (Biofuel Quota Ordinance or BiokraftQuG) with the cost of alternative liquid biofuels, such as used cooking oil methyl ester (UCOME) biodiesel
- Biodiesel accounts for over 70% share of transport biofuel consumed in Germany and, therefore, has the greatest influence on the THG quota price
- 2023-assessed road diesel and UCOME prices for Germany imply a THG quota value of circa 239 €/t CO_2eq
- The low/negative carbon intensity of RNG produced from animal manure substrate means that at a THG quota value of 239 €/t CO_2eq and a natural gas price of 11 €/GJ (40 €/MWh), the price of RNG equated to 56 €/GJ (202 €/MWh) in 2023, substantially above the full lifecycle cost of RNG production

1 Where THG is awarded for GHG savings exceeding the mandate, as per the formula: emissions from fossil fuel comparator (94 kg CO_2eq/GJ) *less* savings required by the mandate (8% in 2023 = 7.5 kg CO_2eq/GJ) *less* emission of UCOME (14.9 kg CO_2eq/GJ) = 71.6 kg CO_2eq/GJ
2 As per the formula: [emissions from the fossil fuel comparator (94 kg CO_2eq/GJ) *less* savings required by the mandate (8% in 2023 = 7.5 kg CO_2eq/GJ) *less* emission of wet manure RNG (-100 kg CO_2eq/GJ) = 186.5 kg CO_2eq/GJ] x 239 €/t CO_2eq

RNG GO values are key drivers of production, representing up to 58% of estimated production cost and total market value exceeding €129 million

RNG GO values and production cost
€/MWh (2023)



	Certificates issued – MWh		Average price – €/MWh		Total value – € mn	
	2022	2023	2022	2023*	2022	2023
DK	7,031	7,725	41	47	288.3	363.1
DE	11,010	12,322	46	53	506.5	653.1
NL	2,272	2,682	41	48	93.2	128.7
UK	4,100	4,048	27	33	110.7	133.6

- The estimated total value of RNG GO certificate market in the four selected countries in 2023 ranges from €129 million in Netherlands to €653 million in Germany, based on:
  - Number of RNG GO certificates issued (i.e., 1 GO is equivalent to 1 MWh), and
  - Average price of a RNG GO certificate provided by S&P Global Platts

Note that certificate values in the Netherlands and Germany reflect sustainability certified RNG quantity, i.e. with PoS as per the RED sustainability criteria, which explains the higher spot prices in these countries compared with, for e.g., the UK

- RNG GO certificate values are also in part determined by feedstock CI
  - Waste-derived RNG GO values trade at higher levels than energy crop-derived GOs
  - Manure-derived GOs attract a premium in markets that recognise higher GHG emission savings (i.e., negative CI values under RED for transport)
- The sale of GO certificates could cover 36-58% of typical RNG production cost of €91/MWh

* Average price for medium CI feedstock
Source: EBA, AGCS, dena, GGCS, ENERGINET, VertiCer; and GO certificates values based on S&P Global Platts data

Regulatory and policy measures are supportive for RNG certificate values; however, role of GOs for disclosure will evolve when the UDB is launched

- The long-term outlook for RNG certificate values is supported by several key developments and policy measures, at EU and individual member state levels
- Collectively, these factors enhance the demand and value of RNG certificates, contributing to the overall RNG market growth
- The launch of the UDB to cover gas supply chains from 21 November 2024 may change the way some RNG with GO is tracked, as the UDB will track RNG molecules using the mass balance principle supported by PoS, and a link will be made for RNG covered by GO as well as PoS
  - EU-ETS is expected to align with the UDB rather than relying on GO (insufficient to claim zero emissions rating for biomass-derived fuels) and PoS
  - The European Commission will clarify the way in which GO will continue to fulfil its disclosure purpose, possibly within the framework of the UDB, notably regarding the disclosure obligation in the recently adopted Hydrogen and Decarbonised Gas Market Package (Gas Package; Annex I)[1]
- Expansion of the EU-ETS to new sectors will incentivise RNG use by consumers that must report GHG emission savings and prove sustainability compliance
  - Increased demand: Inclusion of inter alia maritime and aviation sectors in the EU-ETS increases demand for low-carbon fuels like RNG
  - Cross-sectoral integration: As more sectors become subject to carbon pricing, integration of RNG as a renewable energy source becomes more attractive
- EU Allowances (EUA) supply restraint in ETS Phase 4, which must report GHG emission savings and prove sustainability compliance:
  - Increased carbon prices: Reduction of EUA supply in ETS Phase 4 (2021-30) supports carbon prices, incentivising the switch to low-carbon energy like RNG, and supporting certified RNG values as companies seek to lower carbon compliance costs
- EU ‘Fit-for-55’, which sets ambitious decarbonisation targets, will incentivise RNG use by consumers that voluntarily disclose renewable energy use. It promotes:
  - Accelerated renewable energy adoption: EU ‘Fit-for-55’ policy package targets a 55% reduction in GHG emissions by 2030, which requires a significant increase in renewable energy usage. Policy support, such as the revision of RED II, incentivises RNG production and consumption
- EU-ETS-2 - New Carbon Market (from 2027 at the earliest) will incentivise RNG use by consumers that must report GHG emission savings and prove sustainability compliance. It will:
  - Separate ETS for buildings and road transport: A second ETS (ETS-2) for buildings and road transport creates a new market for carbon reduction credits, and enhances the role of RNG as a renewable alternative, supporting demand for certified RNG as a compliance option

1 EU hydrogen and gas decarbonisation package, consisting of Directive (EU) 2024/1788 and Regulation (EU) 2024/1789

National quota market measures and RNG market development are supportive for long-term RNG certificate values

- National quota market developments
  - Germany's THG quota system
    - Mandated GHG reductions: The German THG quota system mandates fuel suppliers to reduce GHG emissions, incentivising the use of RNG and increasing the demand for certificates to prove compliance
    - Financial incentives: The system's financial penalties for non-compliance and the ability to trade GHG savings certificates create a robust market for RNG certificates
  - Netherlands' GGE quota system
    - National renewable targets: Similar to Germany, the Netherlands has its own GGE quota system, requiring a certain % of energy to come from renewable sources like RNG
    - Market development: This creates a parallel demand for RNG certificates, enhancing their market value and encouraging RNG production
- Overall market dynamics – Supply chain investments:
  - Infrastructure development: Investments in RNG production, distribution infrastructure and grid integration are expected to increase as the demand for certified RNG grows
  - Technological advances: Continuous advancements in RNG production technology improve efficiency and reduce costs, making RNG more competitive, and increasing the attractiveness of certified supply

Summary

- The long-term outlook for RNG certificate values is strongly supported by a combination of regulatory, market and technological factors; although, the role of specific certificates (e.g., GOs) is likely to change
- The expansion of the EU-ETS to new sectors, the supply restraint of EUAs in ETS Phase 4, the ambitious 'Fit-for-55' decarbonisation targets, the introduction of ETS-2, and national quota systems such as those in Germany and the Netherlands all contribute to creating a favourable environment for RNG
- These developments increase the demand for RNG overall and enhance the relative value of certified RNG, promoting further investment and growth in the sector
- However, there is no pan-European target for RNG production or consumption, and some policy packages, e.g., REPowerEU, are not legally binding

1 Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC

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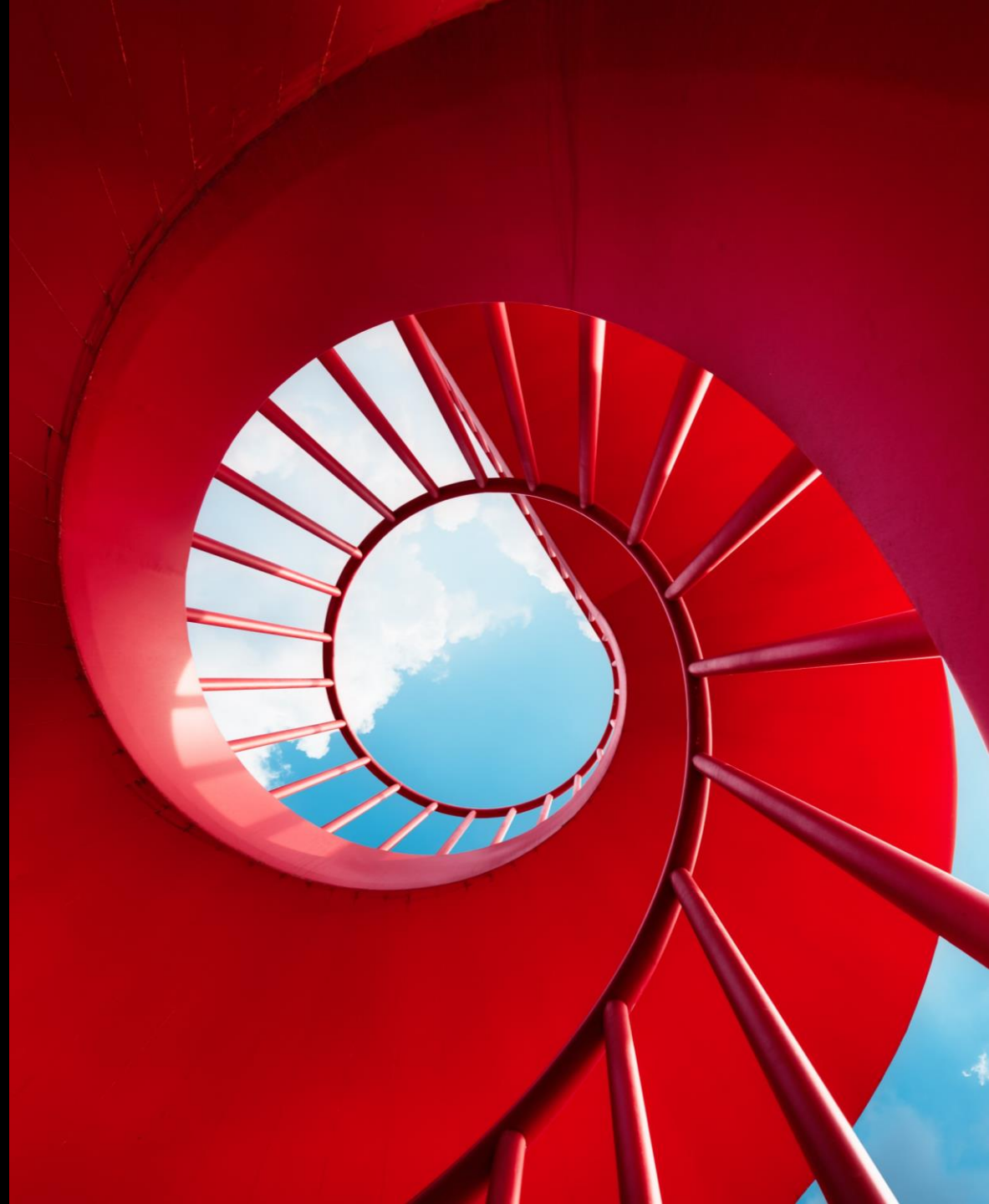
3.4 Link between certificates and RNG production and consumption



S&P Global

Certificates provide economic incentives, enhance market access and ensure regulatory compliance, thereby boosting RNG production

Link between issued certificates and RNG production

- RNG certificates are an important driver for production, for instance:
  - In **Denmark**, RNG production supported by certificates increased from 2,972 GWh in 2019 to 7,723 GWH in 2023 (+27.0% CAGR)
  - In **France**, gas distributor GRDF was mandated to develop a RNG registry in 2012, and within 6 years (2012-18) most of the RNG production was associated with GOs and 28 energy suppliers had registered to procure RNG
  - In **Germany**, RNG production supported by certificates increased from 8,764 GWh in 2019 to 12,322 GWH in 2023 (+8.9% CAGR)
  - In the **Netherlands**, RNG production supported by certificates increased from 1,527 GWh in 2019 to 2,682 GWH in 2023 (+15.1% CAGR)
  - In the **UK**, RNG production supported by certificates increased from 2,607 GWh in 2019 to 4,048 GWH in 2023 (+11.6% CAGR)
- RNG certificates provide economic incentives, enhance market access and ensure regulatory compliance, thereby boosting RNG production
  - **Economic incentives:** Certificates are a significant revenue stream for RNG producers, enabling RNG to be sold at premium prices in some markets. While GO certificates can be traded, selling certified RNG with PoS can also generate a price premium based on feedstock carbon intensity
  - **Market access:** The system for transferring GO certificates, either directly between national biogas registries or via a pan-EU scheme, such as ERGaR, improves market access for producers and end-users. Longer term, approved and certified producers can facilitate partnerships or long-term supply contracts
  - **Regulatory compliance:** RNG certification and tracking systems enable producers to supply products, which end-users require to fulfil regulatory obligations. Certification also enables producers to leverage policy incentives such as feed-in tariffs or tax credits

RNG consumption is incentivised by certificates, which enable renewable energy disclosure, GHG reporting and sustainability compliance

Link between issued certificates and RNG consumption

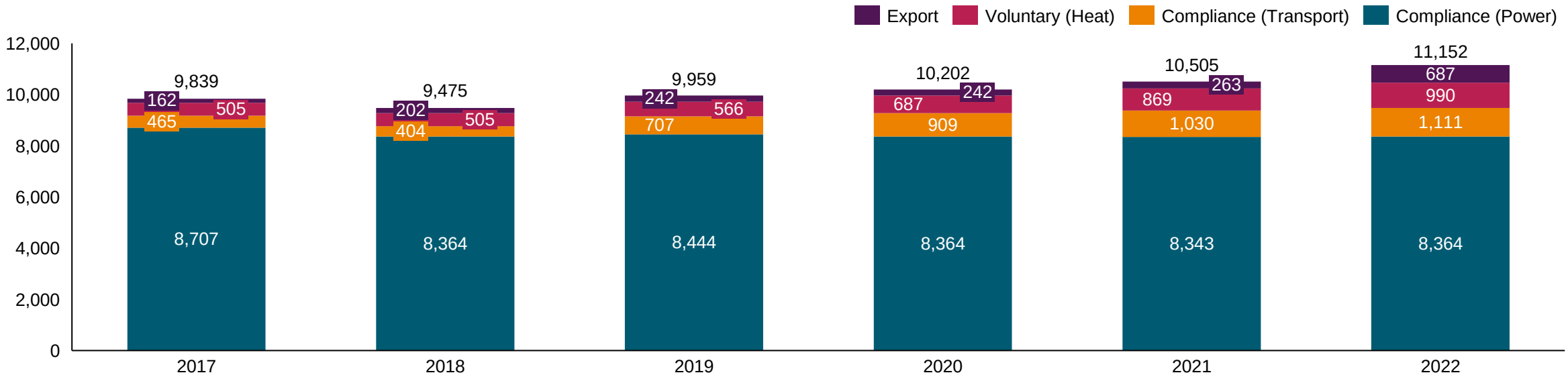
- RNG certificates are an important driver of consumption, enabling end-users to realise tax or financial incentives and supporting decarbonisation efforts. In some countries, demand-side support has been instrumental to the RNG market growth
  - **Tax exemptions:** Governments may offer tax exemptions or credits to promote consumption of renewable energy
  - **Subsidies:** Direct subsidies, to reduce the cost of RNG for consumers, effectively lower the price compared with conventional natural gas
  - **Regulatory compliance:** RNG as transport fuel is indirectly supported by the RED Annex IX-A 'advanced' feedstock list, the RES target and other end-use policies, eg FuelEU, national regulations, and e.g. in Germany by its inclusion in the accepted fuels list for GHG reduction quotas for fuel distributing companies
  - **Decarbonisation:** RNG certificates enable end-users to meet corporate sustainability goals, including voluntary decarbonisation efforts as well as to meet regulatory compliance obligations
  - **Consumer preference:** Increasing consumer preference for renewable energy drives companies to supply or use RNG, marketed as a 'green' energy source
- The different types of certificates support RNG consumption in different ways, according to renewable energy reporting requirements in different sectors
  - **GO certificates:** Separate national tracking systems and lack of mutual recognition hinder cross-border transfers. Transnational certificate tracking schemes (ERGaR) facilitate mutual recognition of national GOs
  - **PoS certificates**: The EU recognised certification schemes (ISCC, REDcert) increase acceptability for cross-border transfers
  - **UDB:** From November 21, 2024, the UDB will cover gas supply chains. At a later stage, the GO and PoS will be linked for consignments that have both certificates. However, some specific issues regarding the function of GOs within the UDB are yet to be resolved, e.g. how GOs can be used for disclosure obligations under the recently adopted Hydrogen and Decarbonised Gas Market Package (gas package; Annex I) [1]

1 EU hydrogen and gas decarbonisation package, consisting of Directive (EU) 2024/1788 and Regulation (EU) 2024/1789

Use of RNG certificates in Germany highlights their importance for compliance with GHG quota obligations and for voluntary GHG and sustainability reporting

Germany: RNG certificates used in compliance (power and transport) and voluntary (residential/commercial) markets

GWh



- The greatest share of RNG use is in compliance markets, i.e. power generation and transport, where renewable energy targets and GHG emissions savings obligations are the key driver for RNG use; and in Germany, where certified RNG use is supported by the THG quota system (Biofuel Quota Ordinance, BiokraftQuG)
- RNG certificates, which prove compliance with GHG emissions savings obligations and EU sustainability criteria (PoS or GO + PoS), are, therefore, fundamental to the uptake of RNG in the compliance markets
- RNG certificates, which disclose the renewable share of energy consumption (GO or national equivalent), support RNG uptake in the voluntary markets, i.e. residential and commercial heating, chemicals and other industrial use

Note: Data for 2023 certificates not yet available
Source: dena and EBA for German RNG certificates

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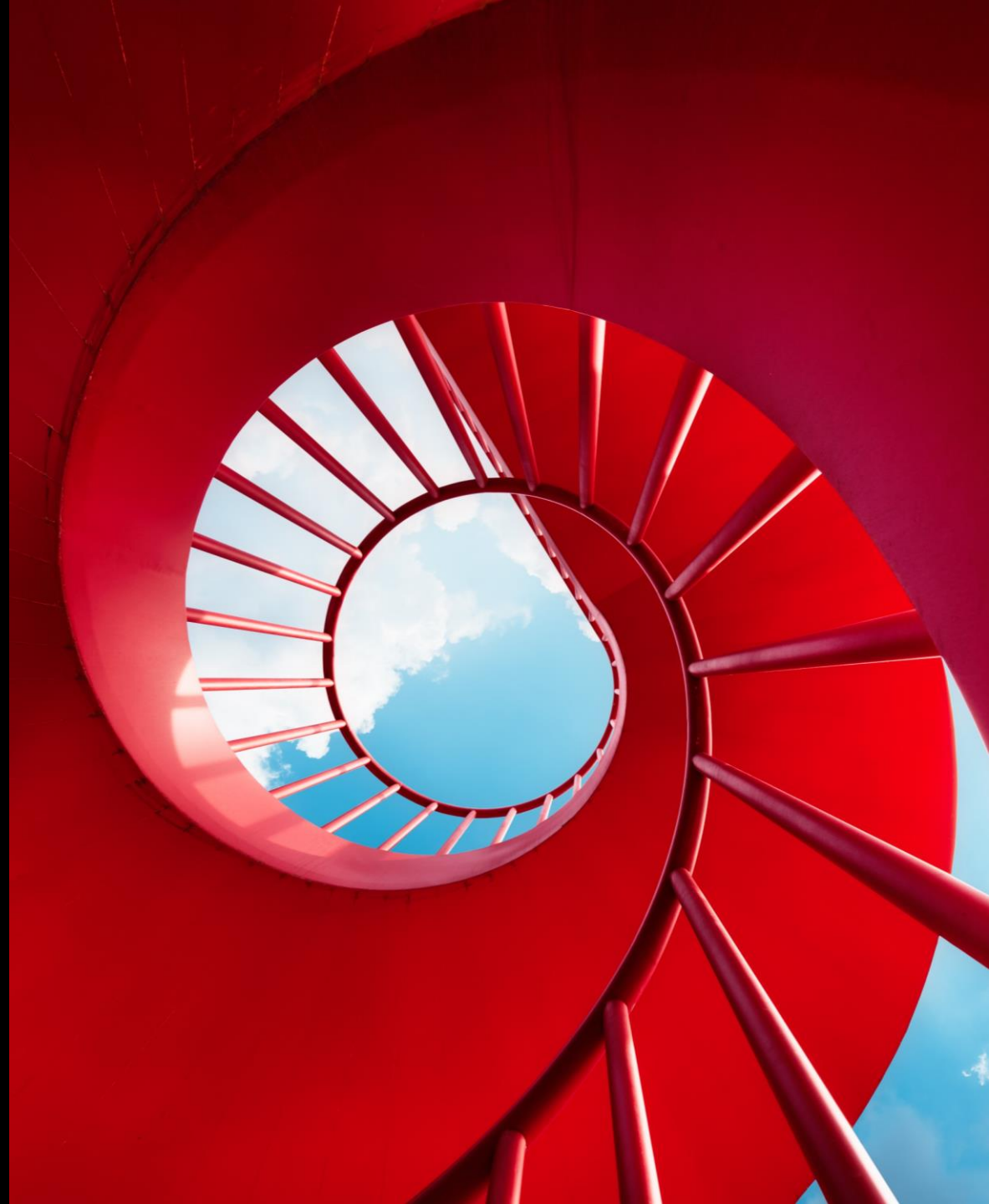
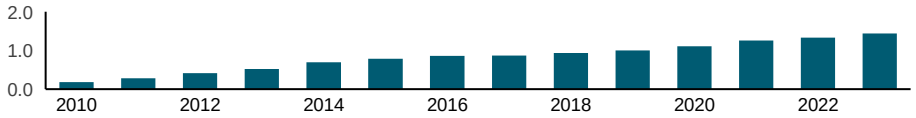
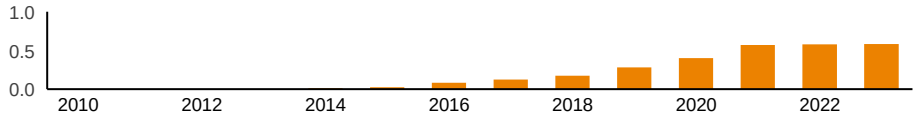
3.5 Case studies on RNG production growth drivers

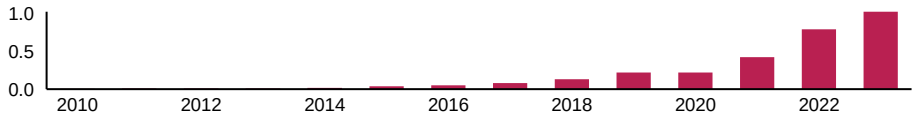
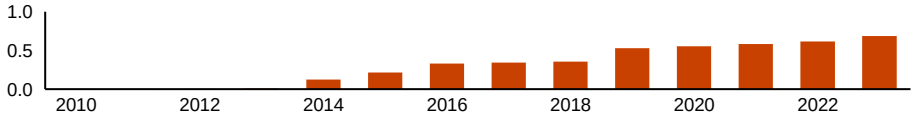


European RNG supply growth case studies: **Germany and Denmark**

Growth drivers	Germany	Denmark
Historical production growth, injected RNG (Bcm/a)		
Key messages	**Feed-in tariffs drove strong growth up to 2015 but have since been replaced partly by transport fuel quota requirements, where RNG with low and negative CIs is highly competitive**	**Right to inject, feed-in tariffs and integration into the gas market underpinned by certificate-based green premium as key drivers for 2014-2020 growth. Changes in feed-in tariffs and subsidy mechanism have slowed growth since 2020**
Visions and targets • Renewable energy targets • RNG production targets	• Renewable targets upgraded in December 2023 increased the share of renewables to 80% of electricity generation in 2030 • There are no specific targets in place for RNG production	• RNG to meet 100% of gas demand by 2040; 27 TWh RNG production by 2028
Direct investment and production support • Feed-in tariffs/premiums • Investment subsidies	• No current feed-in tariffs on new capacity • Instead, since 2021, larger RNG plants (over 150 kW) can participate in auctions for reduced feed-in payments, with maximum bidding offers of 18.4 cents/kWh for the existing plants and 16.4 cents/kWh for the new plants • Also, a flexibility premium of 65 €/kW of installed capacity per year is available for RNG plants that expand to meet demand when needed	• From 2020, the subsidy scheme for new RNG plants is based on tenders, where RNG projects bid on the level of subsidy needed to trigger investments. Under this scheme, more revenue to RNG producers from strong GO markets would reduce the required government subsidies • Guaranteed feed-in tariffs between 2012 and 2020, base subsidy was set at 0.04 €/kWh with a feed-in premium of 0.04 /kWh
Market integration enabling regulation • Right to connect • Market integration and trade	• Right to inject since 2006, with an upgrading bonus introduced in 2009 and a reduction in incentives from 2014 • To benefit from support schemes, RNG must be injected into the gas grid and integrated into the GO system administered by dena (German Energy Agency)	• Right to inject since 2013. There is also a transparent cost-sharing framework to maximise injection • National certificate register to track and verify RNG production and use. Plants recorded in ENERGINET's register can sell their GOs in Germany and potentially the Netherlands. GOs are already allowed to be used for ETS
Demand-side incentives • Tax incentives • Quota systems	• Tax incentives in heating and transport (until end-2023) • In 2007, the Biofuel Quota Ordinance (BiokraftQuG) required a certain proportion of biofuels to be added to the sale of fuels, which can be met by using RNG in natural gas fueld vehicles. Following this, RNG production has grown significantly since 2009 • In 2015, the GHG quota system mandated reduction in emissions within the transport sector, which was set at 7% reduction from 2022. Under this scheme, RNG qualifies as an advanced biofuel and contributes to reduction targets	• RNG used for heating purposes is exempt from energy taxes and tax levels are reduced for transport fuels blended with biofuels • From 2021, at least 7.6% of the total energy value of fuel sold for land transport must be from biofuels

Source: S&P Global Analysis of various sources

European RNG supply growth case studies: **France and the UK**

Growth drivers	France	UK
Historical production growth, injected RNG (Bcm/a)		
Key messages	**France has seen strong growth in RNG production after 2019, thanks to ambitious production targets, feed-in tariffs and GOs**	**UK RNG production has steadily been increasing with the government regularly updating RNG policies. Planning permission issues and constraints in the gas grid are hurdles to accelerating production growth**
Visions and targets • Renewable energy targets • RNG production targets	• Binding targets for RNG production were first made in 2015 and later supplemented • The Long-term Energy Schedule (PPE) sets a target of 14-22 TWh of RNG by 2028 and 7-10% of gas demand by 2030	• Target to decarbonise the electricity system by 2035 • Biomass strategy published in 2023 outlines a target of 30-40 TWh of RNG production by 2050
Direct investment and production support • Feed-in tariffs/premiums • Investment subsidies	• Guaranteed feed-in tariffs between 2011 and 2026. Fixed tariff range of 5-14 cents/kWh, which was increased 15% in 2023 • The French government provides direct investment subsidies to support RNG production, especially for small scale. In 2023, the government announced plans to increase subsidies for RNG plants by 10-20%	• Guaranteed feed-in tariff over 2011-2021 under the Renewable Heat Initiative (RHI). Fixed at 4.50 pence/kWh for facilities < 250 kW, 4.27 pence/kWh for facilities > 250 kW/< 500 kW, or 1.54 pence/kWh for facilities > 500 kW • Green Gas Support Scheme (GGSS) replaced the RHI from 2021, with a fixed tariff in three tiers: 5.51 pence/kWh up to 60,000 MWh, 3.53 pence/kWh for an additional 40,000 MWh and 1.56 pence/kWh for anything additional
Market integration enabling regulation • Right to connect • Market integration and trade	• Right to inject since 2011. Grid operators are obligated to address connection requests with denial transparently justified on technical/economic reasons • GO registry since 2012 • In July 2024, a decree defining the terms and conditions of the obligation to return biogas production certificates (BPCs) came into force. Natural gas suppliers will now have to return BPCs in proportion to their volumes of natural gas delivered to customers in the residential and tertiary sector to prove compliance with RNG supply share mandates (100% green gas share targeted for 2050)	• Green Gas Certification Scheme (GGCS) issues GOs for RNG injected. Each GO represents 1 kWh of RNG • Prior to the energy crisis, RGGO prices were relatively low, at ~£5-8/MWh. Prices increased sharply in 2022-23 to £30/MWh, but have since decreased in 2024
Demand-side incentives • Tax incentives • Quota systems	• Natural gas extraction and production activities are exempted from paying excise tax on the energy products they use as process energy	• In 2008, the Renewable Fuel Transport Obligation (RTFO) outlined the annual obligation, at 13% of fuel used in transport • RNG is included and producers can claim credits between 1.9-3.8 RFTC per kg of RNG dependent on feedstock

Source: S&P Global Analysis of various sources

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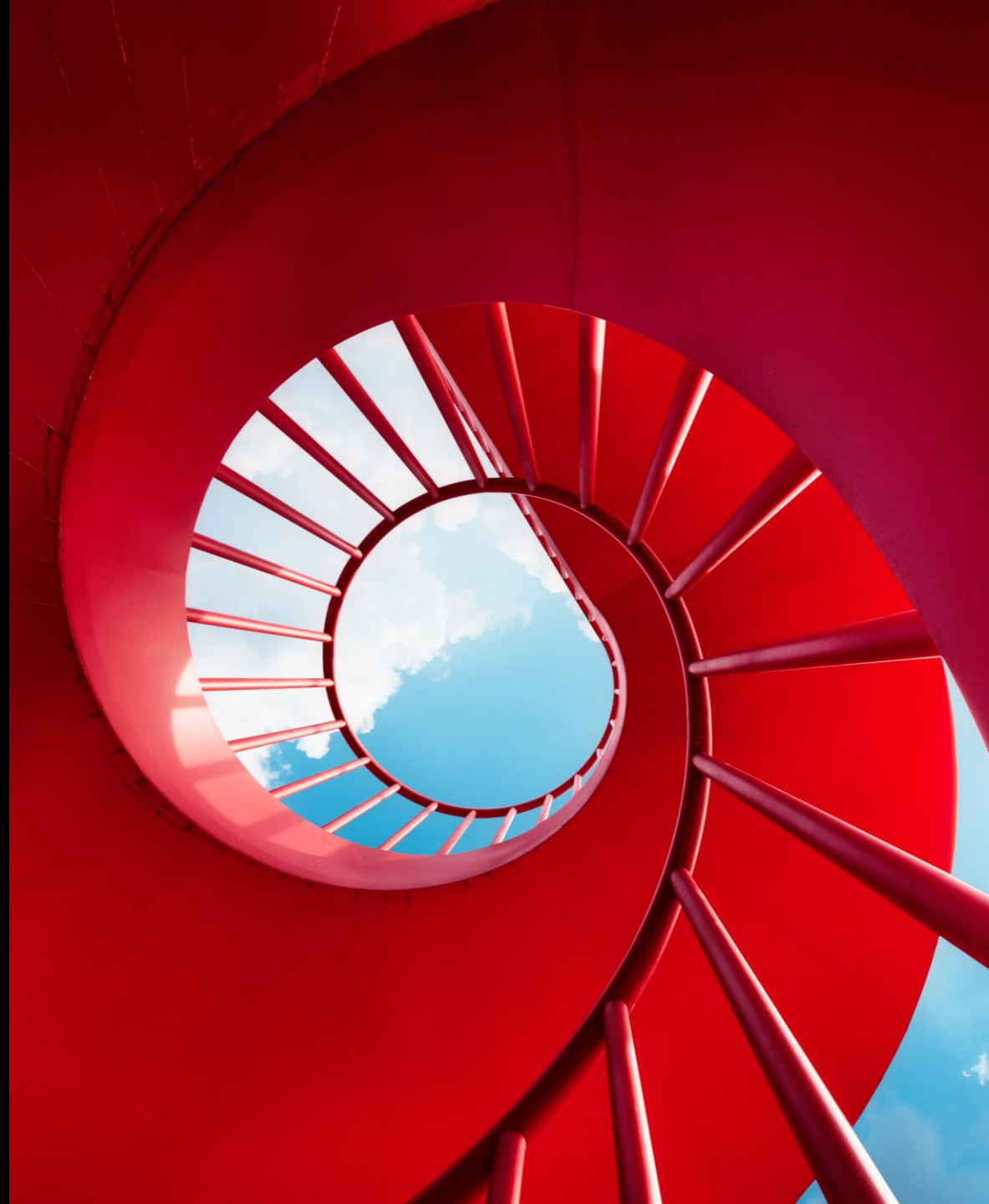
4. US RNG tracking systems and certificate values



Overview: US RNG tracking system (1/2)

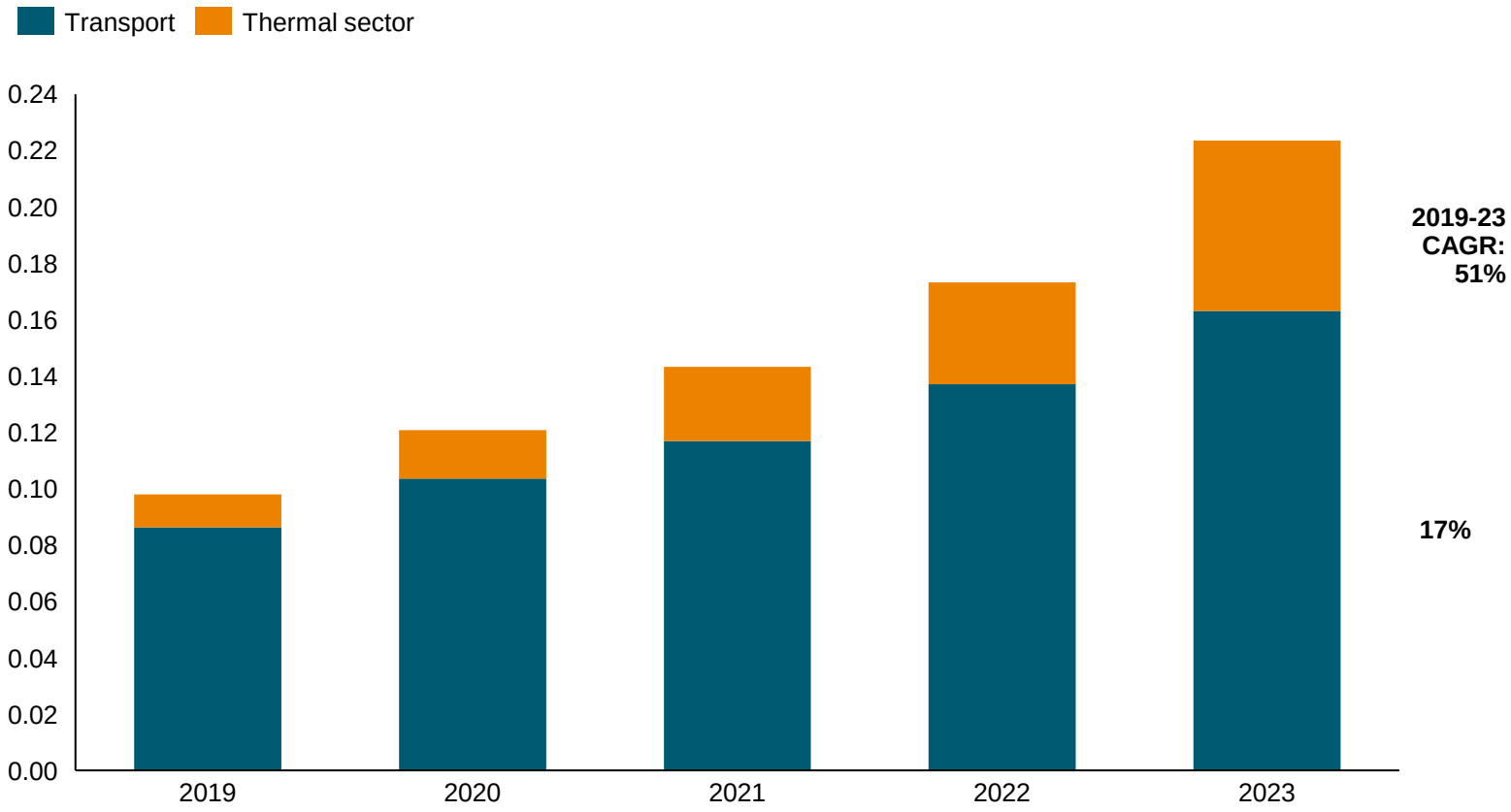
- In the US, transport accounts for the bulk of RNG demand and has grown from ~0.09 Bcf/d in 2019 to an estimated 0.18 Bcf/d in 2023
- The Environmental Protection Agency (EPA) Renewable Fuel Standard (RFS) and California's Air Resources Board (CARB) Low Carbon Fuel Standard (LCFS) programmes are two recent examples of market-based policy mechanisms that have helped scale up the RNG market and drive emissions reduction in the transport sector in the US over the past decade
- Both LCFS and RFS are compliance-based programmes with emissions reduction/volumetric mandates and an established credit market, providing demand and supply signals for the RNG market. Below are a few selected examples of how specific designs from LCFS/RFS have shaped the RNG market and driven reduction in emissions:
  - **Compliance mandates**: Both LCFS and RFS set stricter carbon intensity or renewable fuel mandates for obligated parties, driving emissions reduction in the transportation sector and providing greater market certainty. The percentage of RNG in NG vehicle fuel in California increased to 97%, trending closely to CARB's increased carbon intensity reduction target. Simultaneously, US GHG emission intensity in transportation has trended down because of a combination of federal (RFS) and state-level low carbon transportation fuel policies
  - **Book and claim:** LCFS and RFS allow credits and physical molecules to be traded separately, with verification to ensure that the RNG purchased is from a pipeline that is connected to a RNG supply and to avoid double counting. With book and claim chain-of-custody model, 80%+ of the RNG LCFS certificates are generated outside of CA, enabling scale up of the RNG sector across the US beyond CA. More than 200 new landfill and manure RNG facilities came into operation or are under construction since 2015
  - **Avoided methane crediting:** Since 2015, CARB has credited avoided methane potential from manure/food waste/landfill to RNG pathways for LCFS, resulting in negative CI and additional LCFS credit value for these pathways. Not only has this mechanism increased LCFS credits generation by these manure/food waste/landfill to RNG pathways and displaced fossil-fuel NG, according to CARB, it has played a role in helping to decarbonise the agriculture sector. Since 2015, It is estimated the average GHG emissions intensity of dairy cattle manure management decreased by ~9% in California between 2015-2022 compared to prior years. According to a recent CARB analysis, the use of anaerobic digestor is estimated to account for 80%+ of methane emission reduction in California
  - **Credit value and prices:** Given that RNG is more costly to produce than fossil nature gas, LCFS and RIN credits are key revenue source for RNG facilities, improving its project economics and allowing more RNG projects to be cost-competitive against conventional natural gas over the past decade. The recent increase in LCFS and RFS D3 RIN credit price created a strong market signal for RNG producers, driving an increased in RNG production in recent years

Overview: US RNG tracking system (2/2)

- Recent updates to the RFS and proposed changes to LCFS (increased CI benchmarks and RVO, more stringent RNG pathways provisions) will likely drive demand and tighten supply in the RNG market, putting slight upward pressure on prices for LCFS and RIN credits in the near-medium term. However, longer-term value remains uncertain and will be highly dependent on supply and demand dynamics and policy direction of the LCFS and RIN programmes.
- In addition, the increasing demand for RNG from non-transportation markets (thermal, voluntary markets) and the growing pipeline of RNG facilities could also impact the pricing dynamics of the compliance market over the longer term

RNG for transport accounts for the bulk of demand and continues to grow, but thermal sector demand driven by state and utility targets is seeing the fastest growth rates

US Lower 48 RNG demand estimates by sector
Bcf/d



- US RNG demand has experienced strong growth over the last five years, reaching approximately 0.25 Bcf/d in 2023
- The transport sector, covered by LCFS in California and RFS federally, has been the main driver of RNG demand growth, reaching around 0.18 Bcf/d in 2023
- The fastest growth rate in percentage terms has been observed in the thermal sector (non-transport), driven by utility and state targets for the share of RNG in natural gas supply
- Future RNG demand for road transport is driven by biofuel quotas under California's LCFS and the Federal RFS programme as well as the fleet of natural gas and LNG fuelled personal and commercial vehicles[1]
- Future RNG demand in the thermal sector is likely to be driven by state and utility targets for the share of RNG in the natural gas mix

1 79% of all on-road fuel used in natural gas vehicles in calendar year 2023 was RNG based on data published by the RNG Coalition
Source: Transport demand based on EPA, Thermal Sector based on S&P Global analysis of state and local distribution company goals

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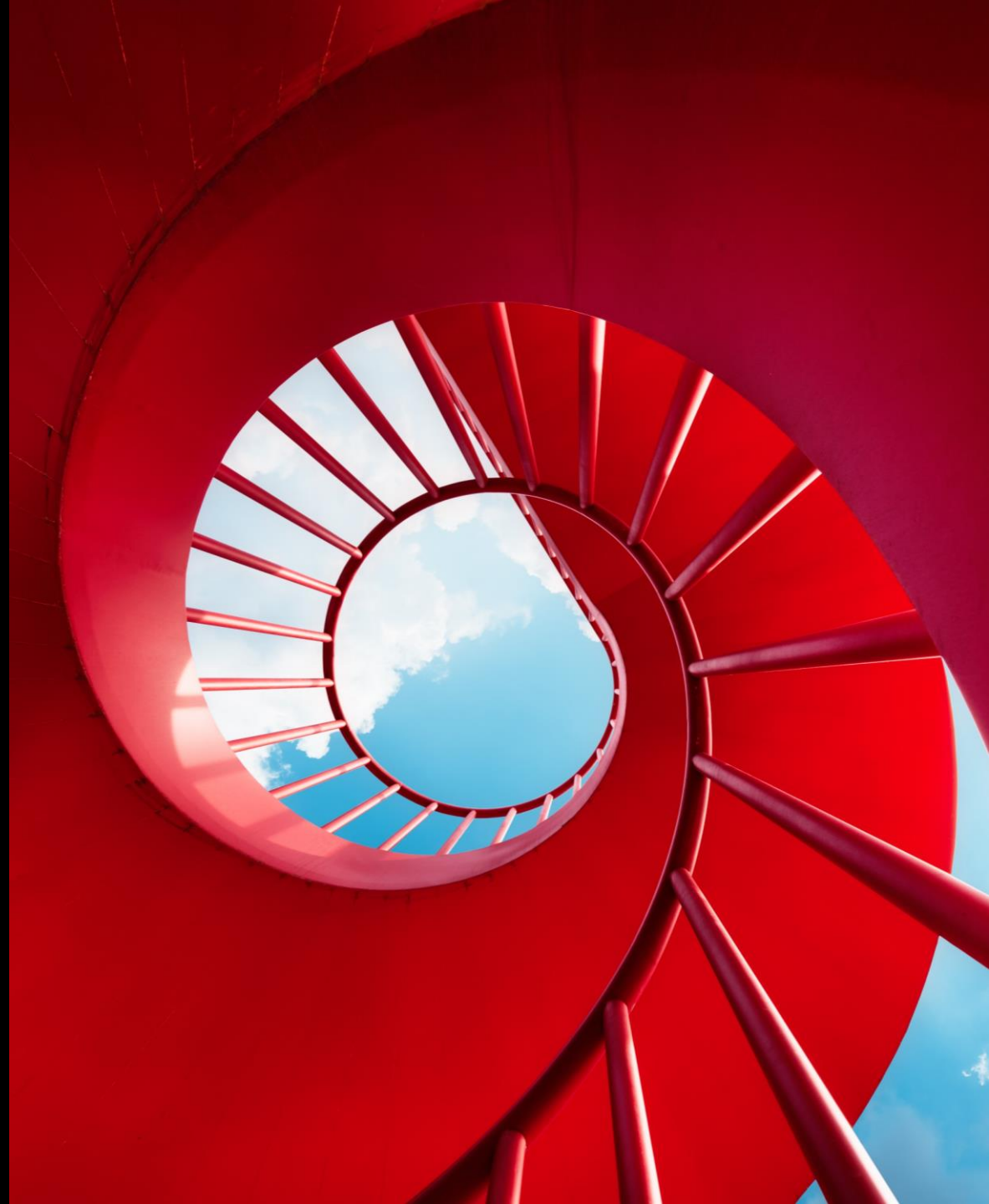
4.1 California’s Low Carbon Fuel Standards (LCFS)



California implemented Low Standard Carbon Fuel Standards (LCFS) to drive down emissions in the transportation sector and to scale up the alternatives fuel market

Policy and regulatory context

- The LCFS was established as a mechanism towards California's broad emission reduction mandate stated under the **Assembly Bill 32 - California Global Warming Solutions Act of 2006**, set to return to California's emission levels from 1990 by 2020
- The California Air Resource Board (CARB) approved the LCFS regulation in 2009 and its implementation began in 2011, with a target of reducing carbon intensity (CI) in the transportation sector by **10% in 2020** from a 2010 baseline
- In 2018, the first amendment extended the validity of the programme to 2030, as prescribed in **Assembly Bill 398**, and increased the reduction target to **20% by 2030**
- In late 2023, CARB proposed amendments to LCFS (to be finalised), including:
  - Tightening up CI reduction targets (i.e., 30% CI reduction by 2030 and 90% by 2045)
  - Phasing out RNG for transportation by 2040
  - Ending 'avoided methane crediting' by 2040
  - Adding traceability requirements on Book & Claim accounting for RNG (e.g., suppliers need to demonstrate flow within/into California)

Overview of LCFS

Objectives	• LCFS is a market-based policy to **decrease the carbon intensity** (grams of CO_2eq per megajoule of each fuel) of California's transportation fuel pool and incentivise the development of low-carbon alternatives markets
Programme requirements	• The **CARB** sets the carbon intensity (CI) benchmarks for baseline transportation fuel (gasoline/diesel), which are designed to decline over time to meet the emissions reduction target • Under the LCFS, **producers and importers of fossil and alternative transportation fuels** that are sold in California are required to meet CARB's CI Intensity benchmark by incorporating cleaner fuels and/or acquiring LCFS credits • Fuels that have a higher CI than the benchmark will generate a **LCFS deficit**, while those with lower CI will generate a **LCFS credit**, which will equal to 1 ton of CO_2eq reduced on a lifecycle basis compared to the baseline fuel (gasoline or diesel) • **Programme exception** includes any non-biomass alternative fuel, fuel supplied less than 3.6 million GGE/year, and fuel for military, aircraft or marine transport • LCFS is **technology-agnostic** and producers/importers can determine which low-carbon fuel alternatives (e.g., not restricted by feedstock) to use to meet obligations
Certified LCFS fuel pathways – LCFS credit	• LCFS credits can by generated via fuel pathways certified by CARB • 3rd party verification of the fuel pathway is required to obtain CARB certification. Annual verification of CI and transaction report is required to maintain certification • The LCFS Data Management System is the approved portal used to certify fuel pathways, report fuel transactions and trade credits

Source: S&P Global, CARB

Design attributes of the LCFS tracking system play an important role in shaping the RNG market dynamics and emission reductions (1/3)

✓ Greater impact X Less impact

LCFS: Key design attributes		Implications		
		Increase in RNG demand	Increase in RNG supply	Emission reduction
1. **Carbon intensity benchmarks**	LCFS uses CI benchmark as the performance metric, which declines gradually over time to meet decarbonisation target in the transportation sector. The CI for all pathways is calculated based on lifecycle analysis (LCA) using the California GREET model.	✓ The gradual decrease in CI benchmark will create a demand signal for low carbon fuels, such as RNG.	✓ The gradual decrease in CI benchmark will increase market demand for low carbon fuel, providing more market certainty for low carbon fuel suppliers, including RNG producers.	✓ Setting an emission-based benchmark provides direct market signal to drive emission reduction.
2. **Technology agnostic**	Obligated parties can determine which low-carbon fuel alternatives (e.g., not restricted by feedstock) to use to meet LCFS obligations.		✓ This provides the flexibility for more producers (for all feedstocks/production pathways) to participate.	
3. **Chain of custody model: Book and claim**	LCFS allows credits and physical molecules to be traded separately. While low carbon fuel can be produced in one location to generate LCFS credits and a buyer at another location can purchase and claim these credits without purchasing the physical product, a verification process is in place to ensure that the RNG purchased is from a pipeline that is connected to a RNG supply and to avoid double counting.	✓ This model enables RNG buyers to access a more extensive supply market with potentially more cost-effective supply options.	✓ This model enables RNG suppliers to access a broader offtake market.	X Potential risks of double counting. Limited traceability. Does not drive location-based emission reduction.

Design attributes of the LCFS tracking system play an important role in shaping the RNG market dynamics and emission reductions (2/3)

✓ Greater impact X Less impact

LCFS: Key design attributes		Implications		
		Increase in RNG demand	Increase in RNG supply	Emission reduction
4. **Mandatory verification from third party**	Third party verification of the fuel pathway is required to obtain CARB certification. Annual verification of CI and transaction report are required to maintain certification.	✓ Buyers will have more confidence in the quality of the credits and the programme.	X Verification cost could be a potential barrier to entry for low carbon fuel suppliers to participate in the programme.	✓ A mandatory verification programme could help improve the quality of the credits and the emission reduction impact.
5. **Avoided methane crediting**	The LCFS programme accounts for methane reduction emission potential from manure/food waste to RNG pathways in the calculation of CI (e.g., negative CI).		✓ By incorporating methane reduction emission potential in the CI calculation for manure to RNG pathways, these projects can capture more value from the LCFS programme, thereby improving RNG project economics.	✓ Drive emission reduction in the **agriculture/organic waste/landfill** and transportation sector.
6. **Stackable credits: RIN and LCFS**	LCFS allows credits and physical molecules to be traded separately. LCFS programmes allow the same project to generate LCFS credits as well as RINs from the RFS programme.		✓ Provide additional revenue streams to improve RNG project economics.	X No additional emission reduction from participating in the RFS programme.

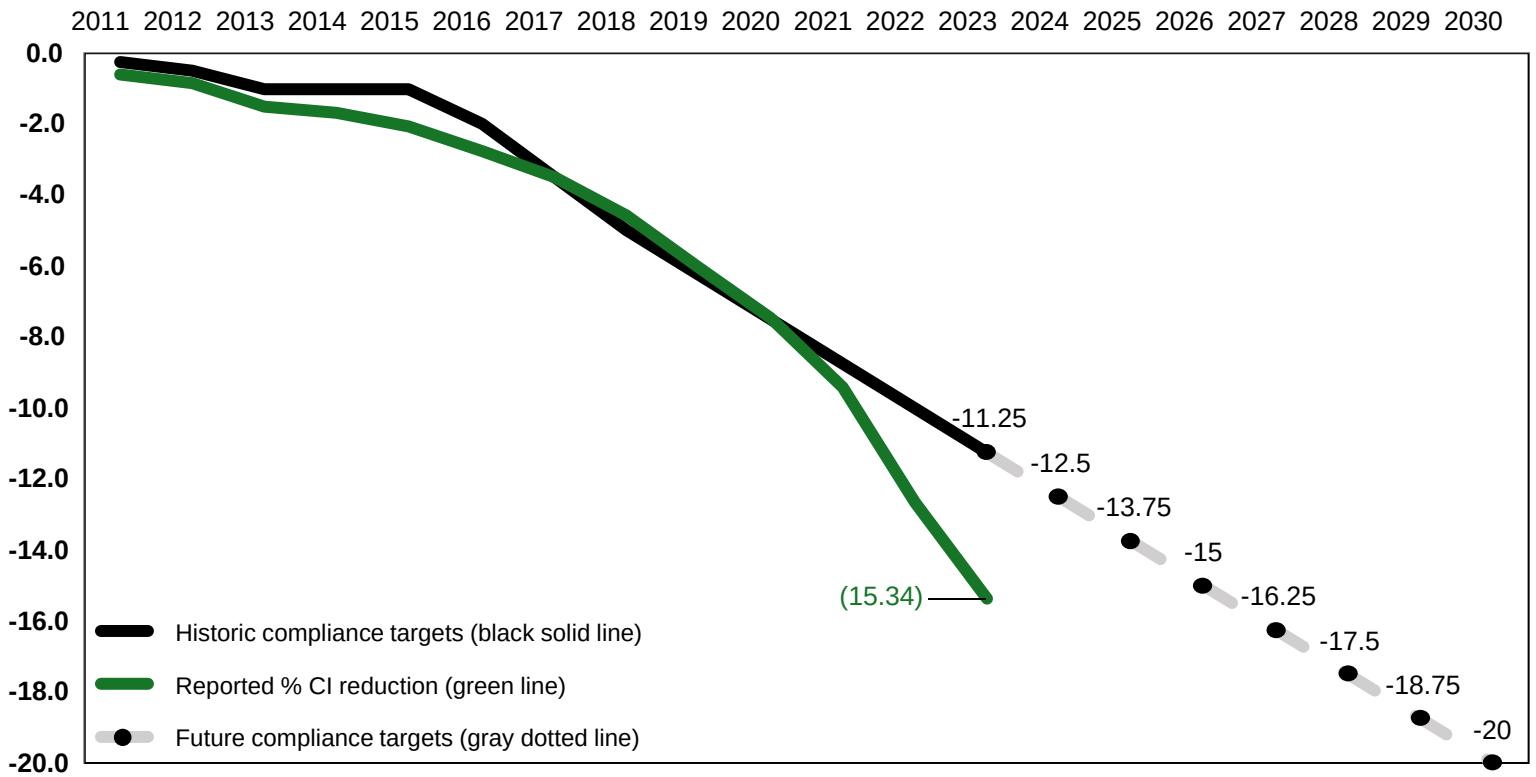
Design attributes of the LCFS tracking system play an important role in shaping the RNG market dynamics and emission reductions (3/3)

✓ Greater impact X Less impact

LCFS: Key design attributes		Implications		
		Increase in RNG demand	Increase in RNG supply	Emission reduction
7. Credit banking	LCFS credits do not expire and the surplus can be banked for future compliance.		X This could result in an oversupply of credits in the market, disincentivising additional low carbon fuel production.	
8. Price cap	CARB imposed a $200 cap on credit prices in 2016 dollars, adjusted for inflation annually.	✓ Provide additional market stability for the buyers.	X This may provide a disincentive for suppliers to participate in the market.	X Price cap could temper investments in the low carbon fuel market, directly impacting the ability to meet emission reduction targets.

Carbon intensity in transportation fuel in CA has decreased by 15% over the past decade as a result of LCFS and low carbon state-level policies in the transportation sector

Reduction in CI (%)



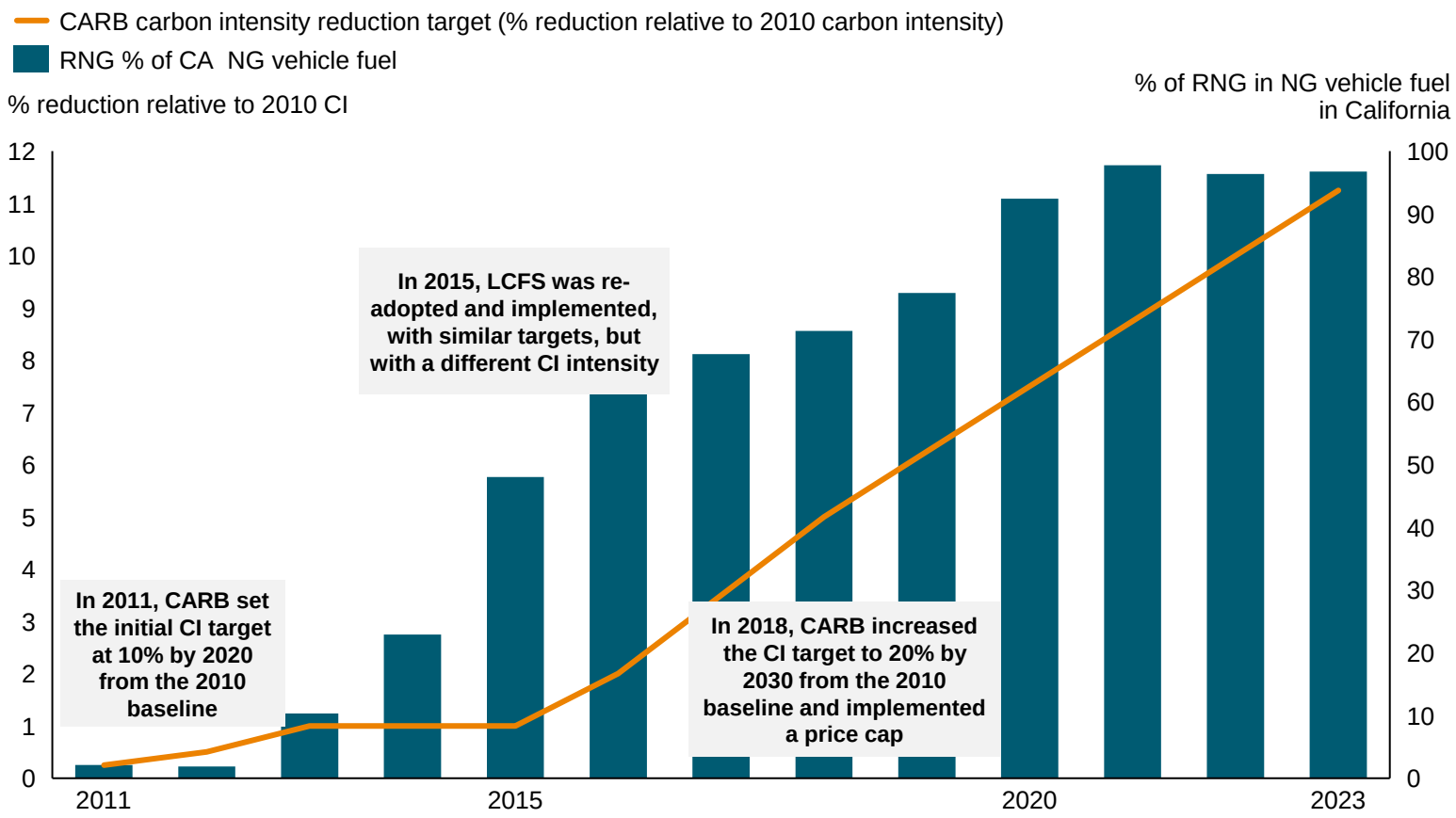
CI based on composite of gasoline and diesel fuels

- California has successfully met or exceeded its historic compliance targets for reducing CI from 2011 to 2020
- The targets set for 2022 and 2023 were surpassed significantly, indicating a reduction that exceeded expectations when compared to future compliance targets
- Overperformance in CI reduction is driven by increased adoption of low-carbon fuels (e.g., renewable diesel from 600 million gallons in 2020 to 1,200 million in 2023), technological advancements (index from 1.0 to 1.6), and strong economic incentives from the LCFS credit market (credits from 12 million to 21 million)
- Trends are expected to persist due to CARB's stricter CI benchmarks, technological advancements and robust economic incentives (index from 1.0 to 1.3). Market dynamics and regulatory adjustments will continue to drive over-compliance and long-term CI reductions

Source: CARB Website

Share of RNG in NG vehicle fuel in California has increased to 97% in the last 10 years, trending closely to CARB's increased carbon intensity reduction target

2011-23 LCFS CI reduction target vs. % of RNG in NG vehicle fuel in California

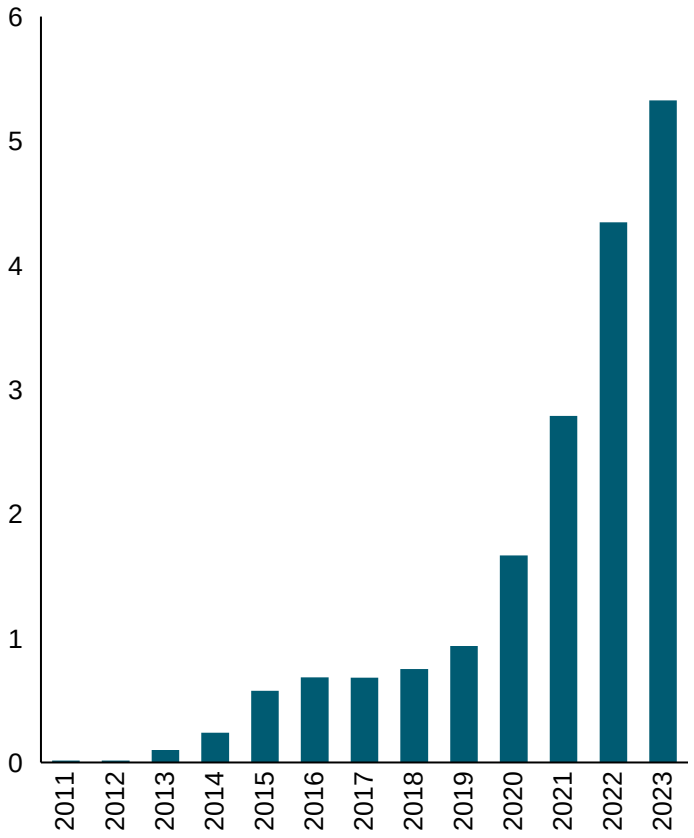


- The LCFS programme is designed to make reduction targets more stringent year by year, driving the incorporation of renewable fuels that have lower carbon intensities, while displacing the production of fossil-based fuels
- RNG has continuously increased its share of participation in the LCFS, currently providing 97% of the natural gas supplied for transport in California
- While RNG has seen a significant increase in production, the overall demand for natural gas in the transport sector is limited by the number of additional NG-powered vehicles and competition against the expansion of electric vehicles
- As RNG transportation end-use matures in California, the market is beginning to shift towards other potential end-uses (e.g., decarbonisation in hard-to-abate sectors/buildings)

Source: CARB LCFS Annual Fuel Volumes; 2011-2023 Performance of the Low Carbon Fuel Standard
The RNG % in NG Vehicle Fuel in California is calculated as the share of RNG in total NG production (RNG + fossil-based NG)

The growing interest in monetizing from market-based instruments, like LCFS credits, has helped drive emissions reduction, increased RNG production and scale-up the RNG industry

Annual RNG LCFS credits (2011-2023)
Million tons



Estimated LCFS-related RNG-related emissions reduction (2011-2023)

18
MMT

Estimated LCFS-related volume increase in RNG production for transportation end-uses between 2015-2023

10x

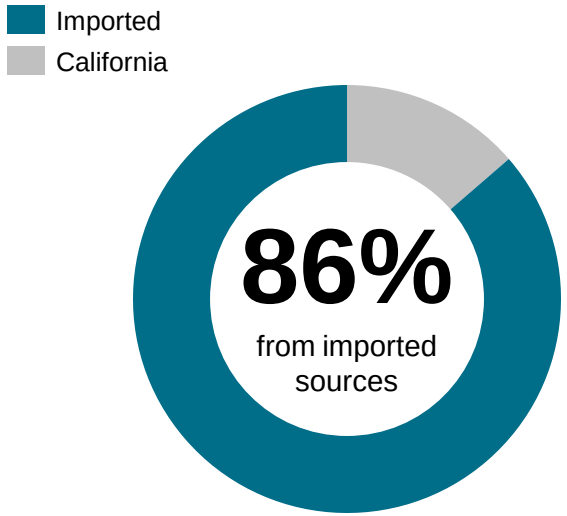
Estimated number of new landfill gas and manure RNG facilities in operation or under construction in the US since 2015[1]

200+

Source: California Air Resources Board, Argonne National Laboratory - Renewable Natural Gas Database
1 Number of new facilities assumed as those with production starting date between 2015 and 2023, with status as operational or in construction. It does not include projects that are in the planning and design phase (i.e., have not reached Final Investment Decision)

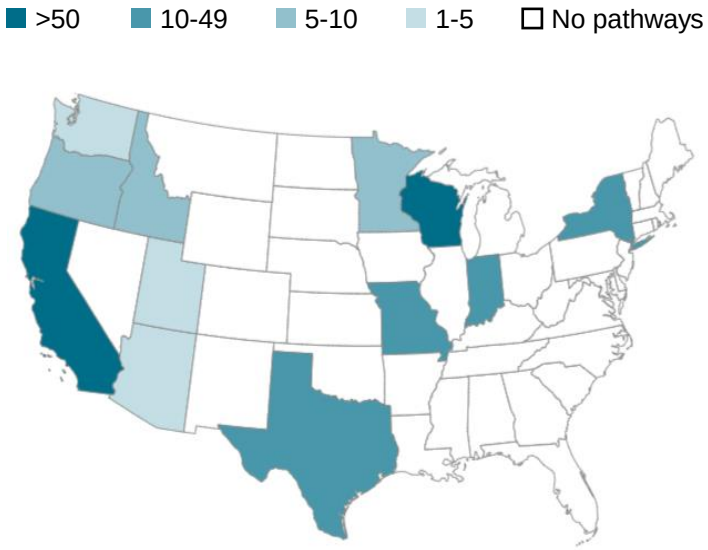
Book and Claim chain-of-custody model has enabled the scale up RNG sector across the US, allowing RNG LCFS certificates to be generated within and also outside of California

LCFS cumulative RNG volume by production location 2021-2023



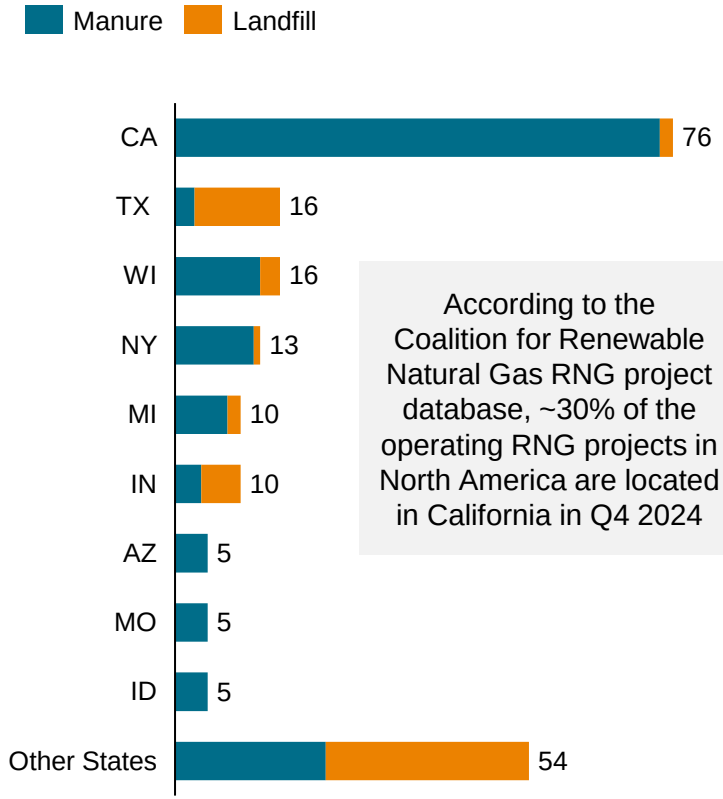
Total cumulative RNG volume produced in California: 78 million DGE

Certified LCFS RNG pathways by state 2011-2023



Foreign producers are allowed to participate in LCFS program but will need to meet additional requirements. Currently, there are no approved pathways for RNG outside of the US

Estimated # of new landfill gas and manure RNG facilities in operations or under construction since 2015[1]



According to the Coalition for Renewable Natural Gas RNG project database, ~30% of the operating RNG projects in North America are located in California in Q4 2024

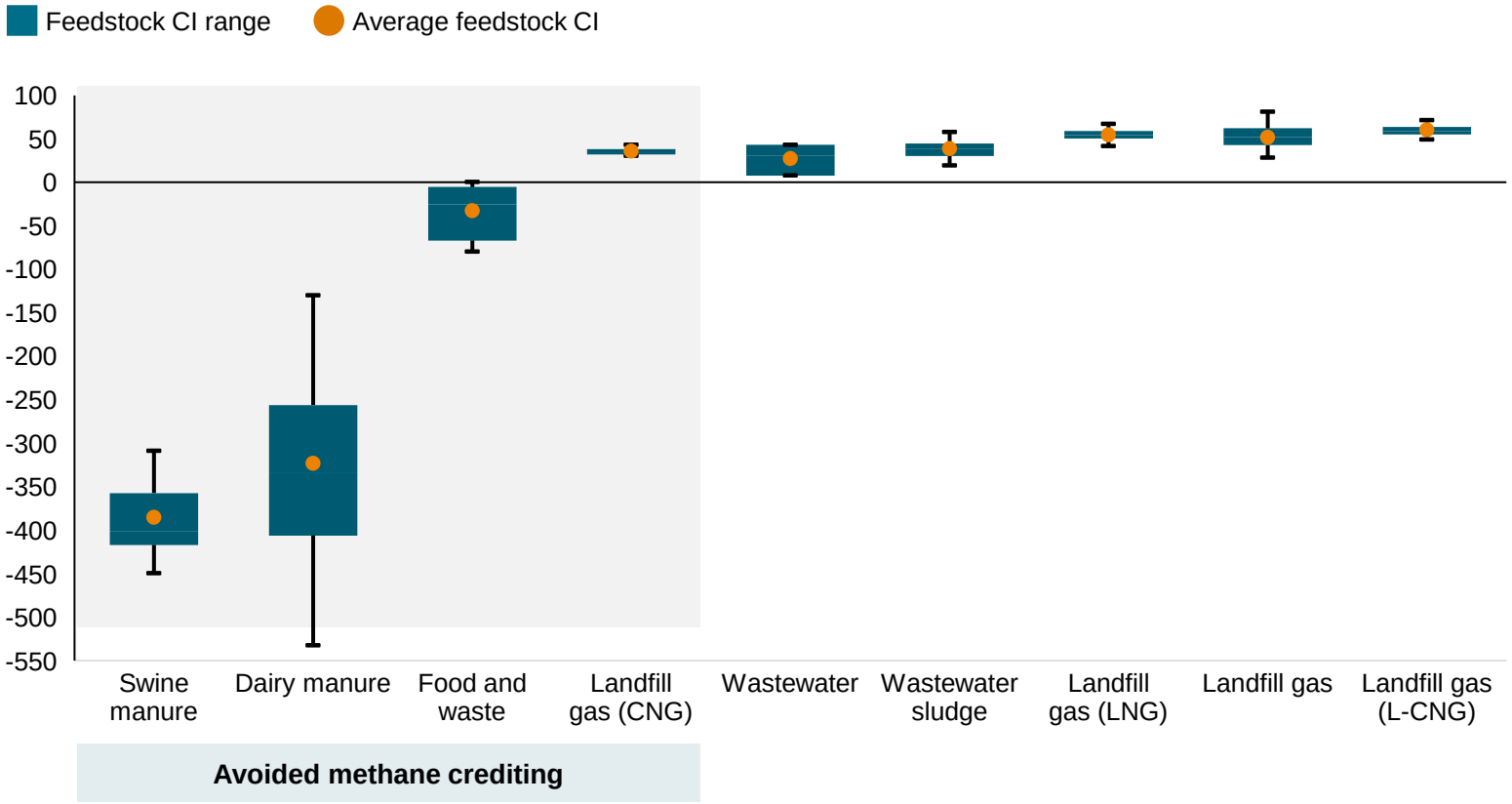
Source: CARB RNG Produced In State; Argonne National Laboratory - Renewable Natural Gas Database, RNG coalition project database (2024 Q4)

1 Number of new facilities assumed as those with production starting date between 2015 and 2023, with status as operational or in construction. It does not include projects that are planning and design phase (i.e., have not reached Final Investment Decision – FID)

Since 2015, CARB has credited avoided methane potential from manure/food waste to RNG pathways for LCFS, resulting in negative CI for these production pathways

- Starting in 2015, CARB began to recognise methane reduction emission potential from manure to RNG pathways through “avoided methane crediting” mechanism
- The “avoided methane crediting” mechanism awards credit to manure to RNG pathways producers for GHG emissions (e.g., methane) that would have otherwise been released as part of manure management in agriculture applications
- Until 2024, limited regulations are in place to regulate emissions in dairy sector in California. CARB views the LCFS programme as a vehicle to help indirectly drive emissions reduction in the agriculture sector
- Through this mechanism, CARB approves manure and food waste to RNG pathway applications using an “avoided methane venting” baseline as part of CI calculations, resulting in negative CI and additional LCFS credit value for these pathways
- In late 2023, CARB proposed ending avoided methane crediting by 2040 for RNG feedstock, but this has not been finalised at this time

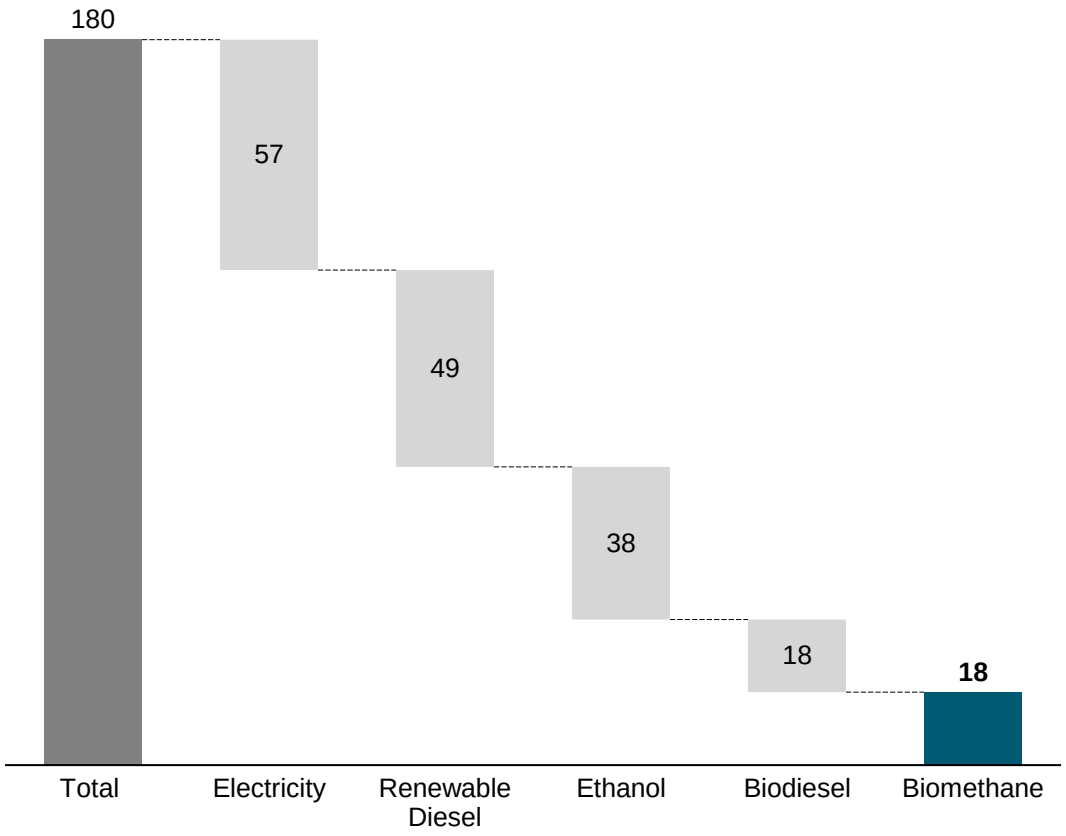
Carbon intensity of LNG and CNG pathways by feedstock
(gCO_2eq/MJ)



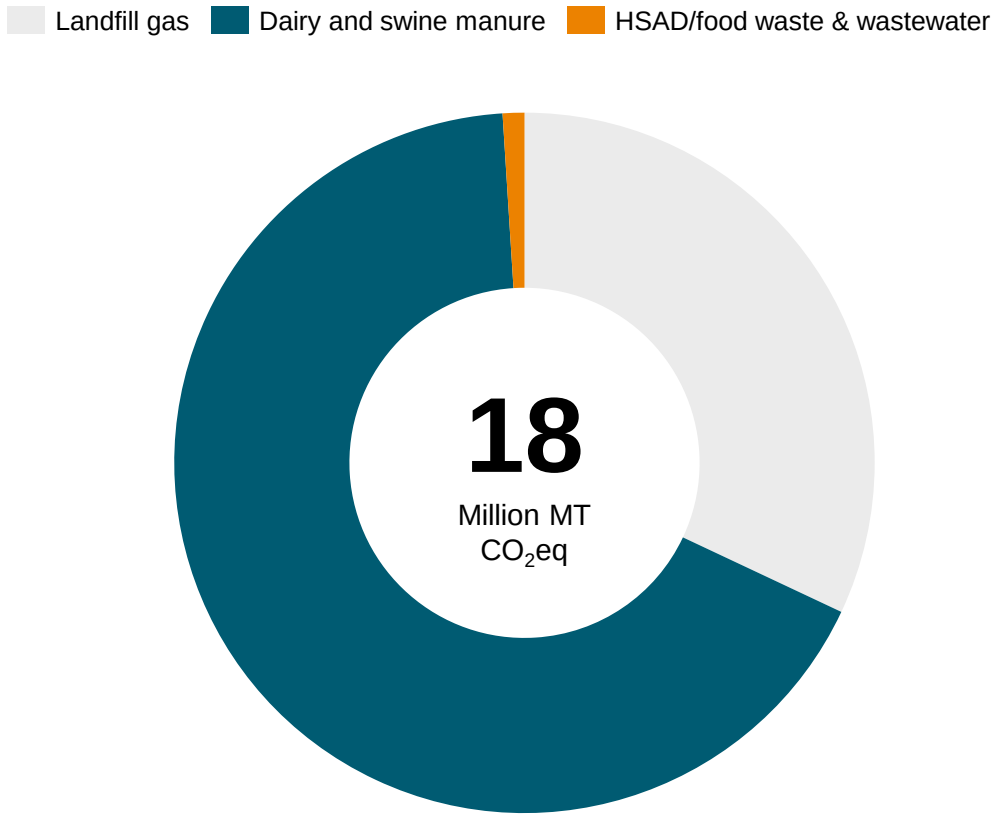
Source: California Air Resources Board

Most of the LCFS credits generated from RNG pathways come from landfill and manure projects, with more favourable economics due to avoided methane crediting

2011-2023 cumulative LCFS credits volume generated by fuel types
Million tons



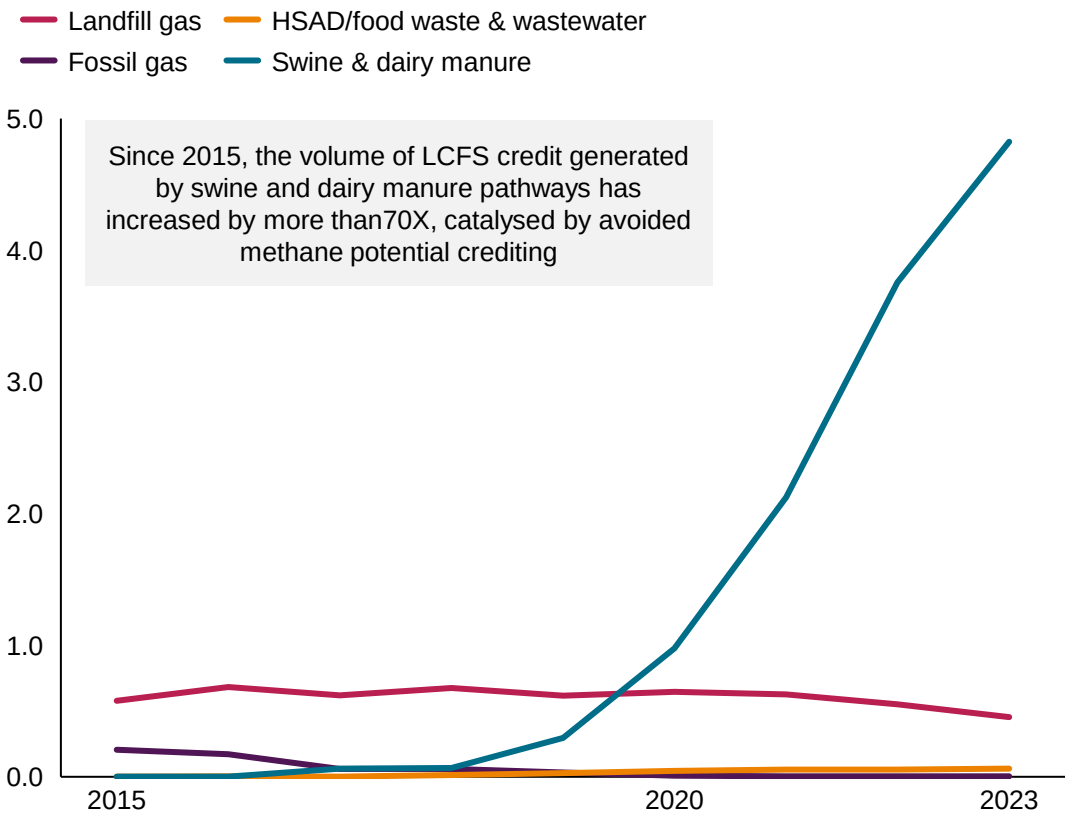
2011-2023 cumulative RNG LCFS credits volume by feedstock



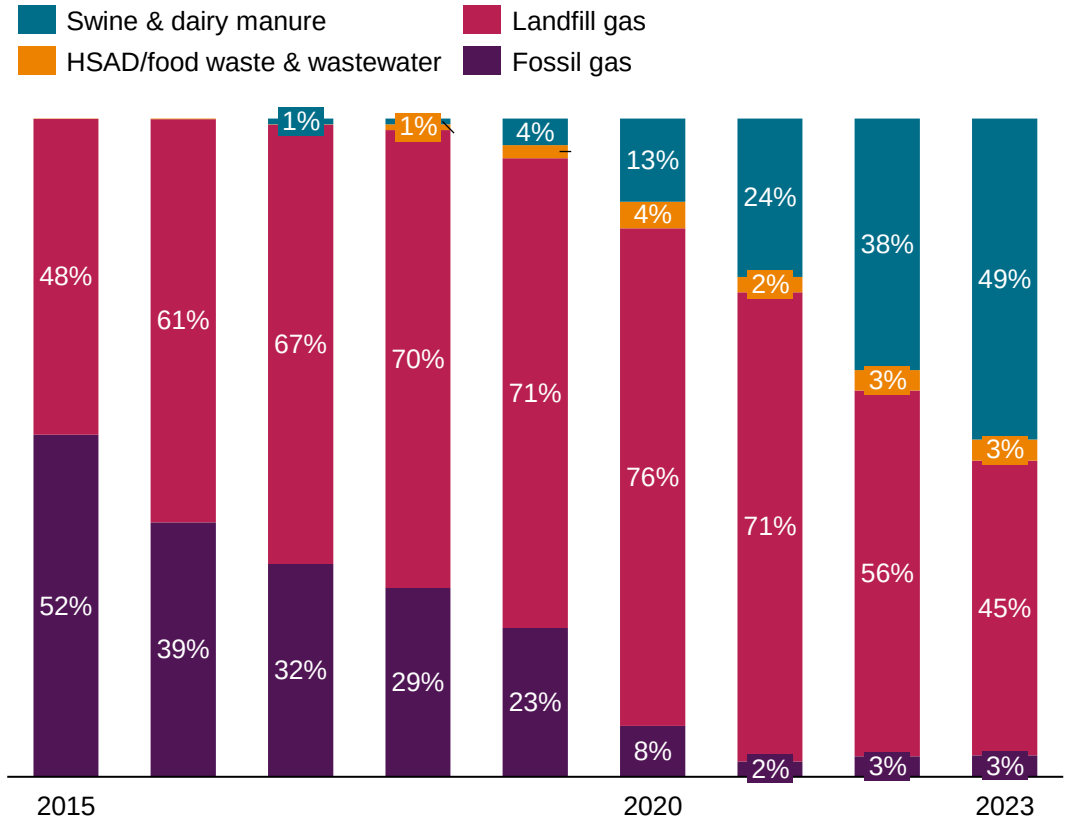
Source: CARB LCFS Data Dashboard

Since 2015, the shift towards crediting “avoided methane potential” for manure-based RNG pathways has increased LCFS credits generation by these pathways

CA LCFS: CNG & LNG annual credit generation by feedstock
(Credits in million tons of CO_2eq/year)



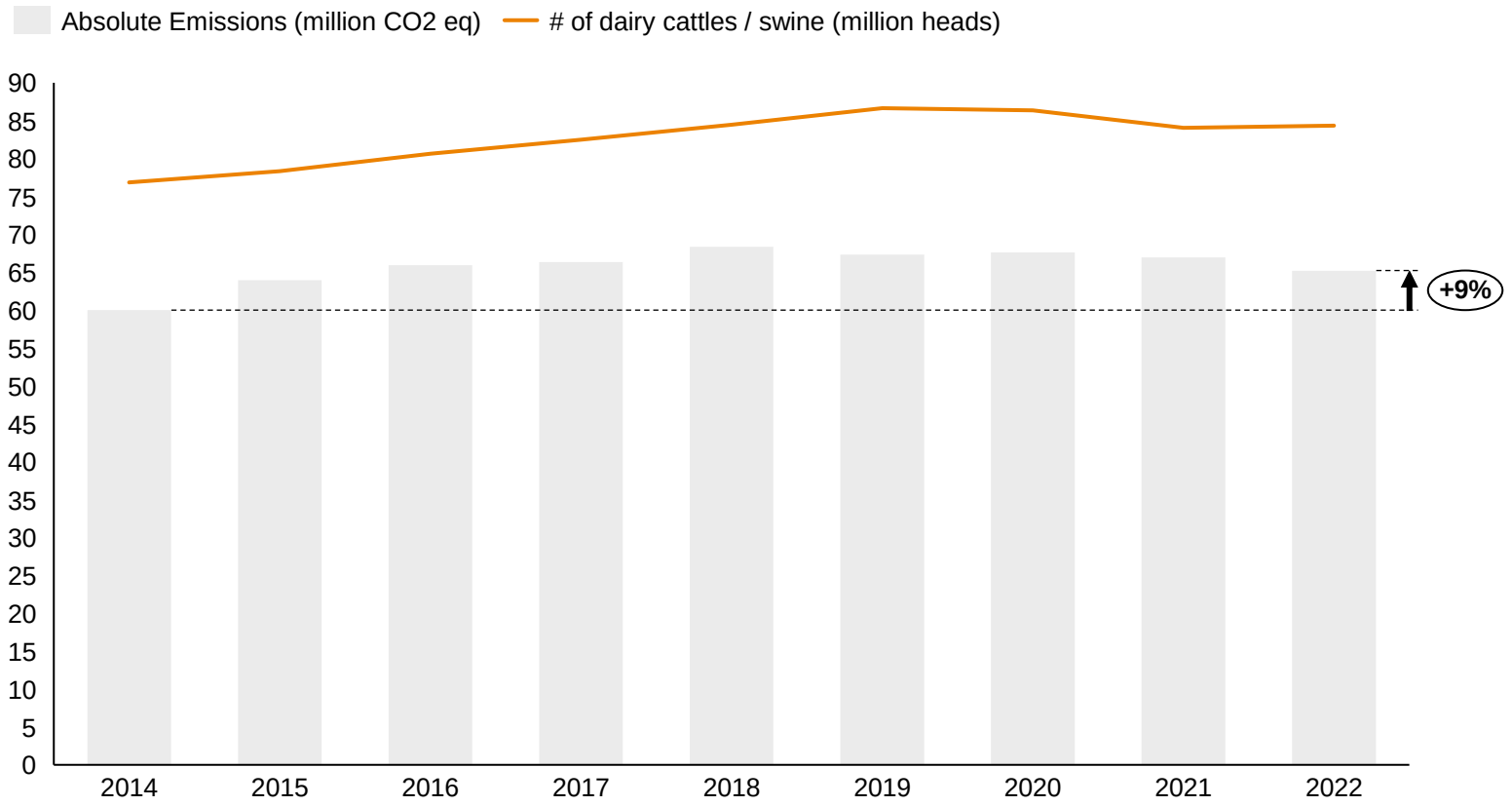
CA LCFS: CNG & LNG production volume by feedstock
(Feedstock % of total NG produced for transportation)



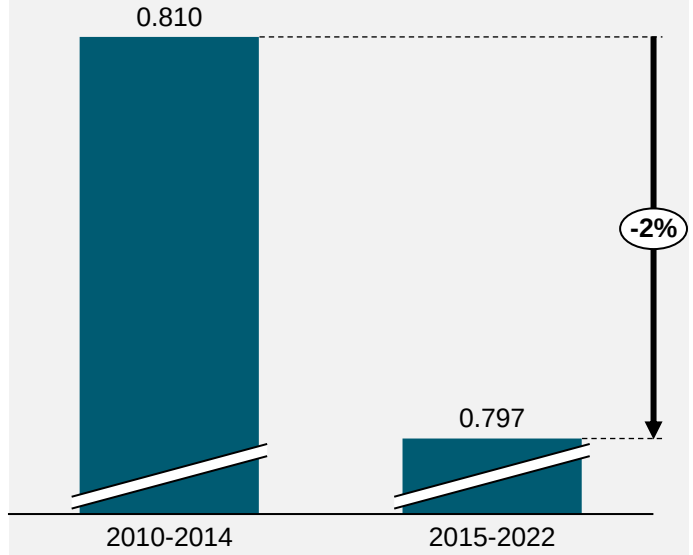
Source: California Air Resources Board

Since 2015, despite an increase in number of dairy cattle and swine, dairy/swine manure management average GHG intensity has been trending slightly downwards in the US

Annual RNG LCFS credits 2011-2023
(Million tons)



Average US dairy cattle & swine manure management: GHG emissions intensity
MMT CO_2 eq/million head

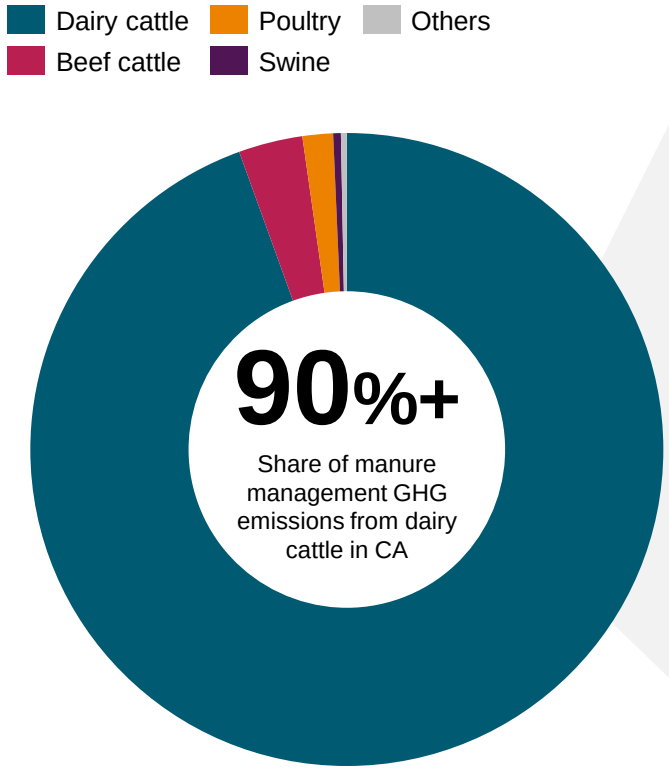


Even though absolute emissions have increased, average GHG emissions related to cattle management have decreased slightly compared with the previous period.

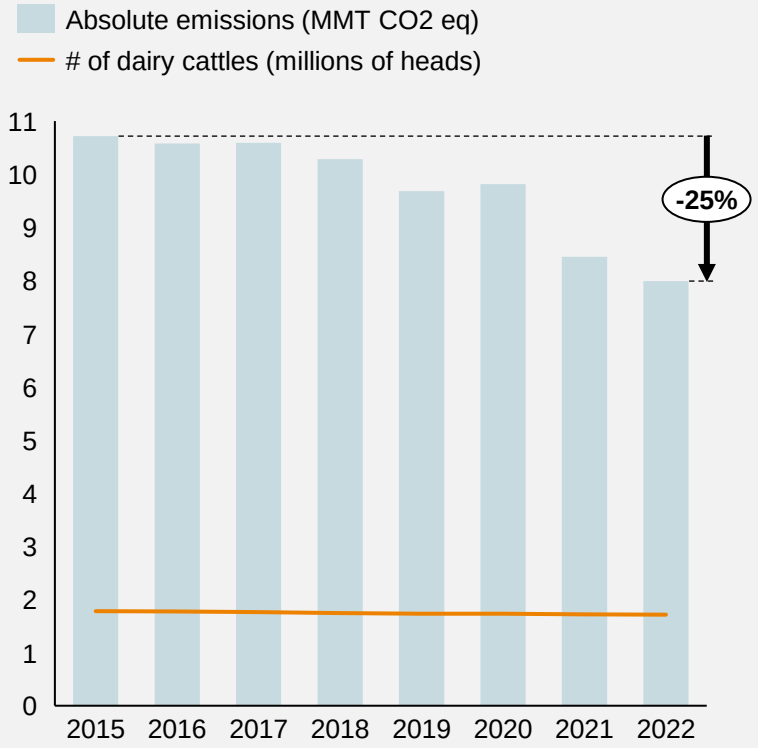
Source: US EPA Greenhouse Gas Inventory – Emissions from Manure Management, by Animal; United States Department of Agriculture (USDA) – Livestock Inventory

It is estimated the average GHG emissions intensity of dairy cattle manure management decreased ~9% in California between 2015-2022 compared with prior years

Share of manure management GHG emissions in CA by livestock type (2015-2021)

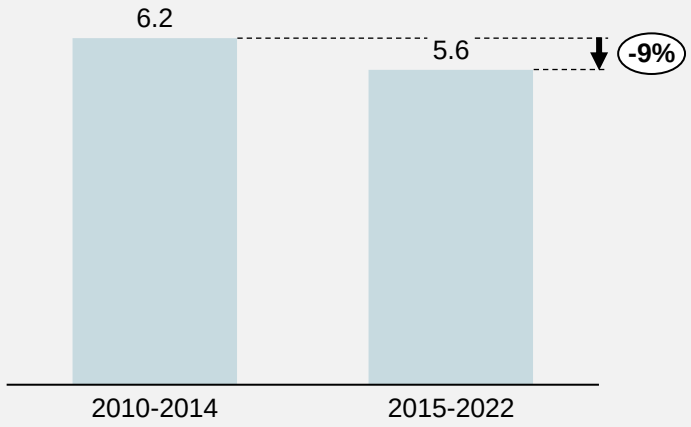


CA dairy cattle manure management: GHG emissions



Average CA dairy cattle manure management: GHG emissions intensity
(MMT CO_2 eq/million head)

According to a recent CARB analysis, the use of anaerobic digestor is estimated to account for 80%+ of methane emission reduction in California (2013-2022)

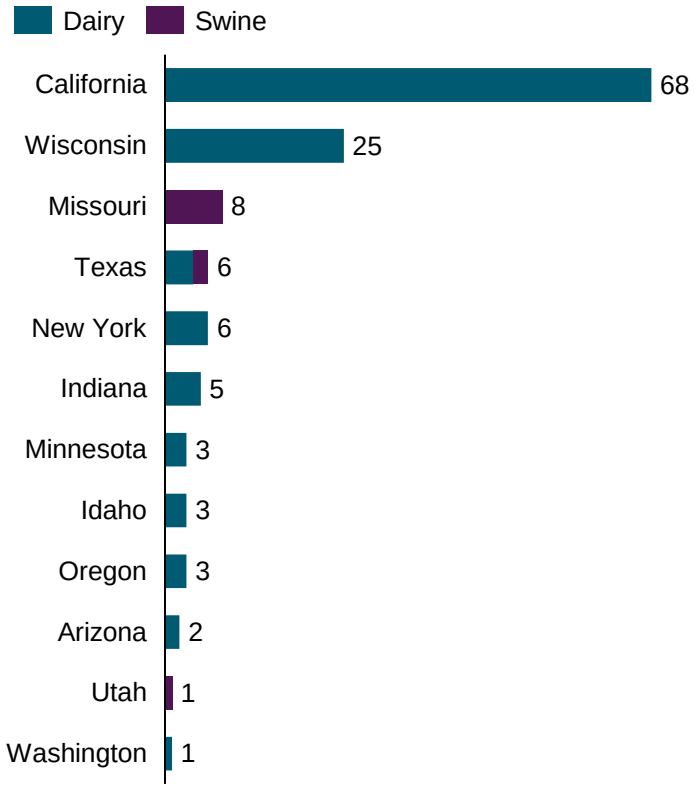


Source: United States Environmental Protection Agency – Greenhouse Gas Inventory; United States Department of Agriculture (USDA) – Livestock Inventory – Lasted updated September 2024, CARB - March 2022 Analysis of progress towards achieving the 2030 Dairy and livestock Sector Methane Emissions Targets

For swine manure-related emissions, average emission intensity decreased by 2% in MO, TX, and UT, where there are LCFS-approved swine manure pathways since 2015

LCFS-approved dairy and swine manure pathways supplying RNG

Number of pathways by state



0.94

Million heads from 2015-2021 in UT, MO, and TX

0.34

MMT CO_2eq increase in swine manure management emissions between 2015-2021 in UT, MO and TX

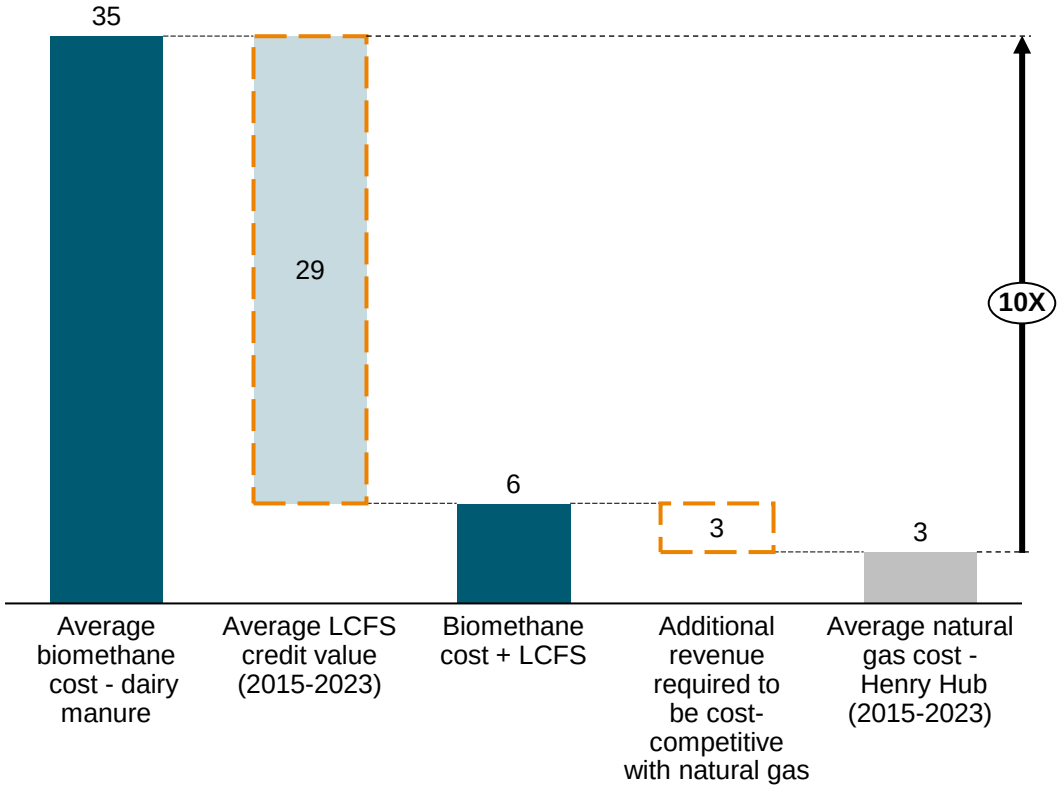
2%

Average emissions intensity swine manure management from 2015-2021 in UT, MO and TX compared with 2014-2010

Source: CARB LCFS-approved pathways; EPA Greenhouse Gas Inventory – Emissions from Manure Management – June 2024, by Animal; United States Department of Agriculture – Livestock Inventory

Given that RNG is more costly to produce compared with fossil nature gas, LCFS credits provide an additional revenue stream and enable RNG facilities to be more cost competitive

Illustrative analysis - cost-competitiveness: US RNG cost – dairy manure vs. natural gas
($/MMBtu)



Source: S&P Global, Historical, CARB LCFS Average Prices
Cost of $/MMBtu was calculated: LCFS using the latest average carbon intensity of LCFS-approved dairy pathways

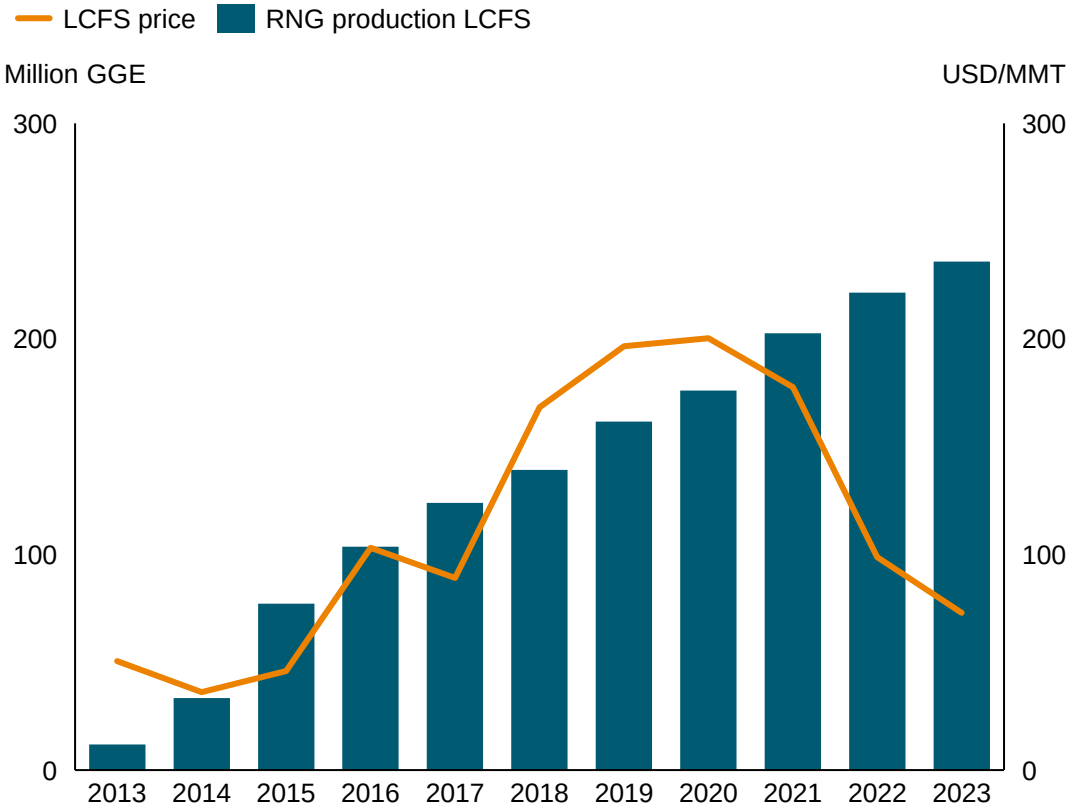
To be cost competitive, RNG suppliers would need to consider and access various sources of revenue streams

- **State LCFS:** LCFS credits can be generated if the lifecycle emissions intensity of the proposed low carbon fuel alternative (e.g., RNG) is lower than the carbon intensity standard for the existing fossil fuel (e.g., gasoline and diesel). The credit value would depend on the carbon intensity and feedstock
- **US RFS:** Under the RFS program, RNG is eligible to generate RIN credits (D3 or D5 RIN). The value of the credit will depend on the type of feedstock
- **Other state and federal grant programs:** For example, USDA Rural Energy For America program and Washington "Promoting Renewable Natural Gas" tax incentives for anaerobic digesters
- **Utility cost-recovery mechanisms:** Some states (e.g., Nevada, Ohio) allow gas utilities to recover cost of RNG investment or purchases
- **Voluntary offtake agreements:** Some RNG companies are looking to secure offtake agreements with industrial players

Historically, the book and claim chain of custody model has helped broaden RNG suppliers' access to these revenue streams by lowering cost of implementation and unlocking additional offtake markets

The rapid increase in LCFS price between 2018-2023 created a strong market signal for RNG producers, driving an increase in RNG production in recent years

2013-2023 LCFS price and annual California RNG production
US dollar/MMT; Million GGE



- The shortage of credits drove LCFS prices between 2017 and 2021
- The high prices during that period drove an increase in the production of RNG within LCFS
- California's SB 1383, implemented in 2016, targets a 40% reduction in methane emissions by 2030. This law has spurred significant investment in RNG projects, particularly those converting organic waste into RNG

Source: S&P Global & EPA

LCFS credit prices are driven by the balance of demand/supply, market satiation mechanisms (e.g., price cap), and production cost of marginal compliance fuel

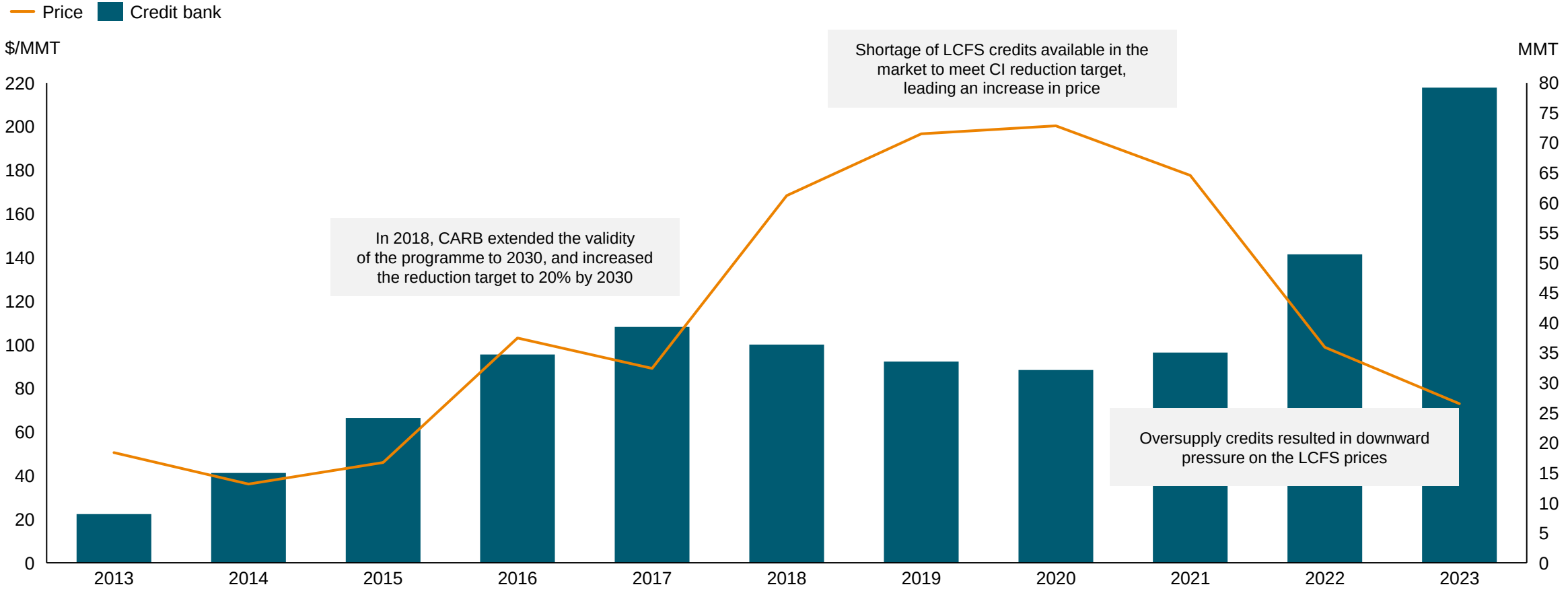
High ● ◕ ◑ ◔ ○ Low

Factors impacting LCFS prices	Level of Impact
Supply of LCFS credits: The equilibrium between the production volume of LCFS credits, generated by low-carbon fuel producers, and the demand from fuel providers needing to comply with the LCFS requirements, plays a vital role. An excess production volume of credits can result in decreased prices, whereas a shortage can drive prices higher.	●
LCFS mandate & requirements: Changes in regulations, such as stricter carbon intensity targets, can impact LCFS credit supply and demand, affecting prices. Market sentiment also influences LCFS credit dynamics, as regulations can shape market participants' perceptions and actions. CARB can shape the market by prioritising certain feedstocks or fuels to achieve CI reduction targets, thereby influencing LCFS prices.	●
Renewable diesel: Renewable diesel has historically set the price for LCFS marginal compliance fuel, which is typically the last resort for companies to meet LCFS requirements.	◔
Production costs and margins: Costs associated with producing low-carbon fuels affect the profitability and the willingness of producers to generate credits.	◑
Price ceiling: By capping the price, the ceiling prevents the cost of credits from exceeding a predetermined level, thereby providing a predictable cost environment for fuel suppliers.	◑
Trading, banking, and borrowing: The ability of regulated entities to bank excess credits, trade, or borrow against future compliance can affect credit supply and demand dynamics.	◑
Other RNG markets (non-transportation, voluntary): Interest in other RNG markets is rising, with companies securing long-term agreements that reduce exposure to RIN/LCFS volatility. The growth of the non-transportation and voluntary RNG market for other uses (e.g., utility RNG targets, hard-to-abate sectors) could provide an alternative market for RNG over the longer-term. Other RNG market alternatives could help rebalance supply and reduce price compression in the event of an oversupply of RNG in the transportation compliance market.	◔

Source: S&P Global

From 2017-2021, LCFS credit prices increased as the market scales up to meet the CI mandates, but recent oversupply of credits has led to downward pressure on the price

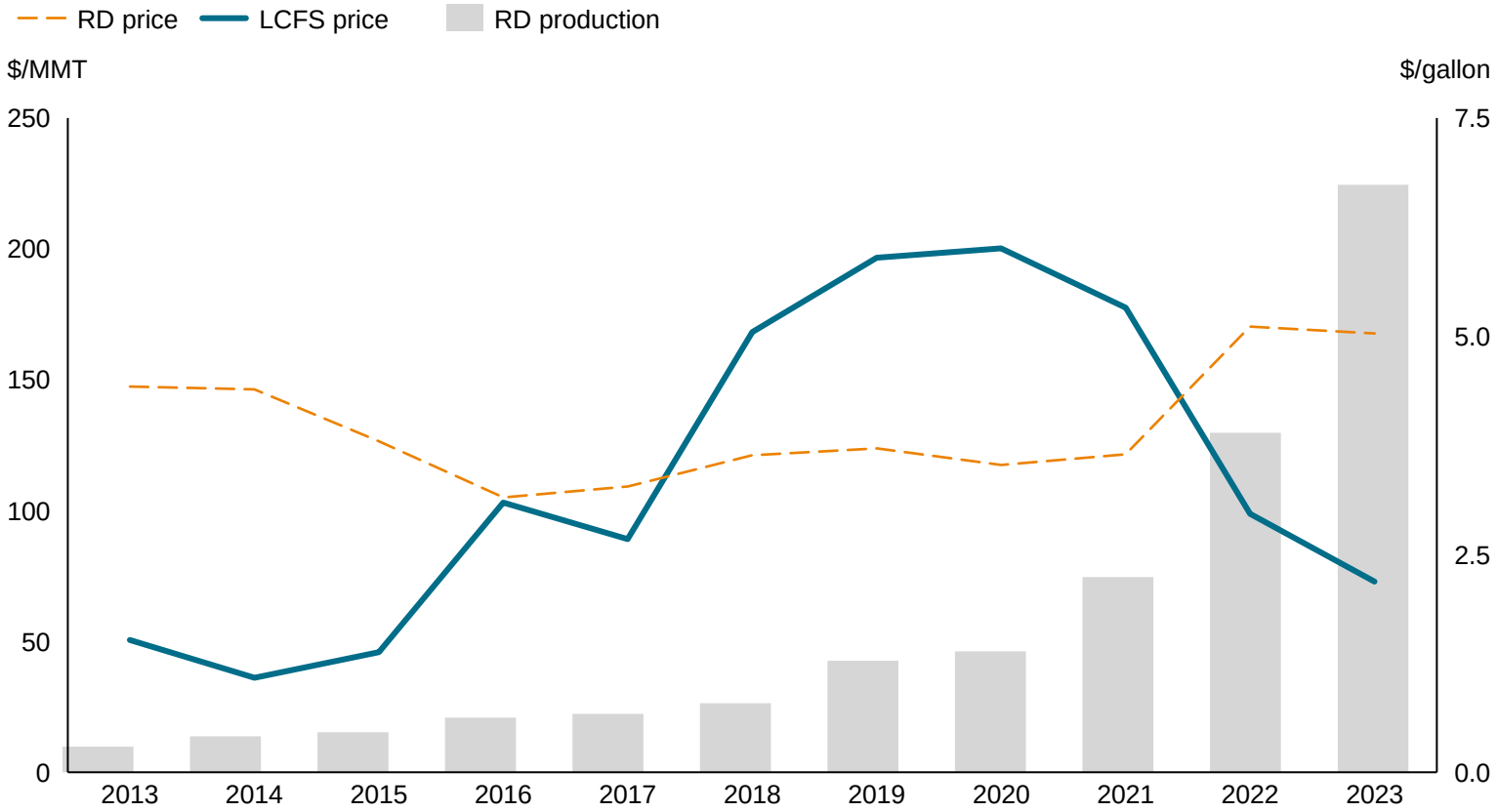
2013-23 LCFS prices and credit bank



Source: S&P Global & CARB

While Renewable Diesel (RD) sets LCFS price as the marginal compliance fuel, recent oversupply of credits has led to LCFS price decline despite the increase in RD prices

2013-23 renewable diesel production vs LCFS credit and RD retail prices
(*Output: RD in million gallon [US]; prices: LCFS in $/MMT and RD Price in $/gallon)*



- In a market where demand and supply are in balance, renewable diesel is the marginal compliance fuel that meets LCFS requirements
- The recent increase in LCFS credit prices and greater CI reduction mandates have incentivised the production of renewable diesel
- Rising renewable diesel production has driven up the supply of LCFS credits, exerting significant downward pressure on LCFS credit prices despite a continued increase in RD prices

Source: S&P Global; CARB; US Department of Energy -Alternative Fuels Data Center,

CARB's final decision on the LCFS proposed amendments in Q4 2024 could have a significant impact on pricing dynamics for the LCFS market

August 2024: Key proposed LCFS amendments

Increased CI benchmarks

The LCFS amendments increased the carbon intensity (CI) reduction targets, setting a 30% reduction by 2030 and a 90% reduction by 2045. This increase in stringency is expected to drive demand for low-carbon fuels and potentially increase the value of LCFS credits.

Jet fuel LCFS compliance exemption to expire in 2028

The exemption for intrastate fossil jet fuel could be eliminated by 2028 under the latest proposed CARB amendments to the LCFS programmes, providing a demand signal for the Sustainable Aviation Fuel (SAF) market.

Expanding the LCFS programme to support the use of electricity and low-carbon hydrogen as transportation fuel

The proposed CARB amendments call for the potential expansion of the zero-emissions infrastructure programme to include medium and heavy-duty infrastructure and the inclusion of low-carbon hydrogen injected into the pipeline network in California in the book and claim allowance.

More stringent provisions for RNG pathways

Phasing out avoided methane credits

Credits for avoiding methane emissions in dairy, swine and landfill-diversion projects will be phased out. Projects breaking ground after December 31, 2029 will have limited crediting periods: until 2040 for RNG used compressed natural gas (CNG) vehicles, and until 2045 for RNG used in hydrogen production. Projects starting before this date will retain their crediting eligibility of up to 20 years.

Phasing out RNG as transportation fuel

The LCFS amendments propose phasing out pathways for crediting RNG/RNG used as transportation fuel by 2040 and shifting focus to other renewable fuels such as hydrogen. This change aims to minimise market disruption by providing more time to find alternative uses for RNG.

RNG deliverability requirements

Proposed deliverability requirements mandate that RNG must be transported through pipelines physically flowing within or towards California at least 50% of the time annually. Projects breaking ground after December 31, 2029 must meet this deliverability requirement starting December 31, 2037, for RNG used in CNG vehicles, and early 2040s, for RNG used for hydrogen production and RNG used to produce electricity for a fuel cell EV charging

Sources: CARB

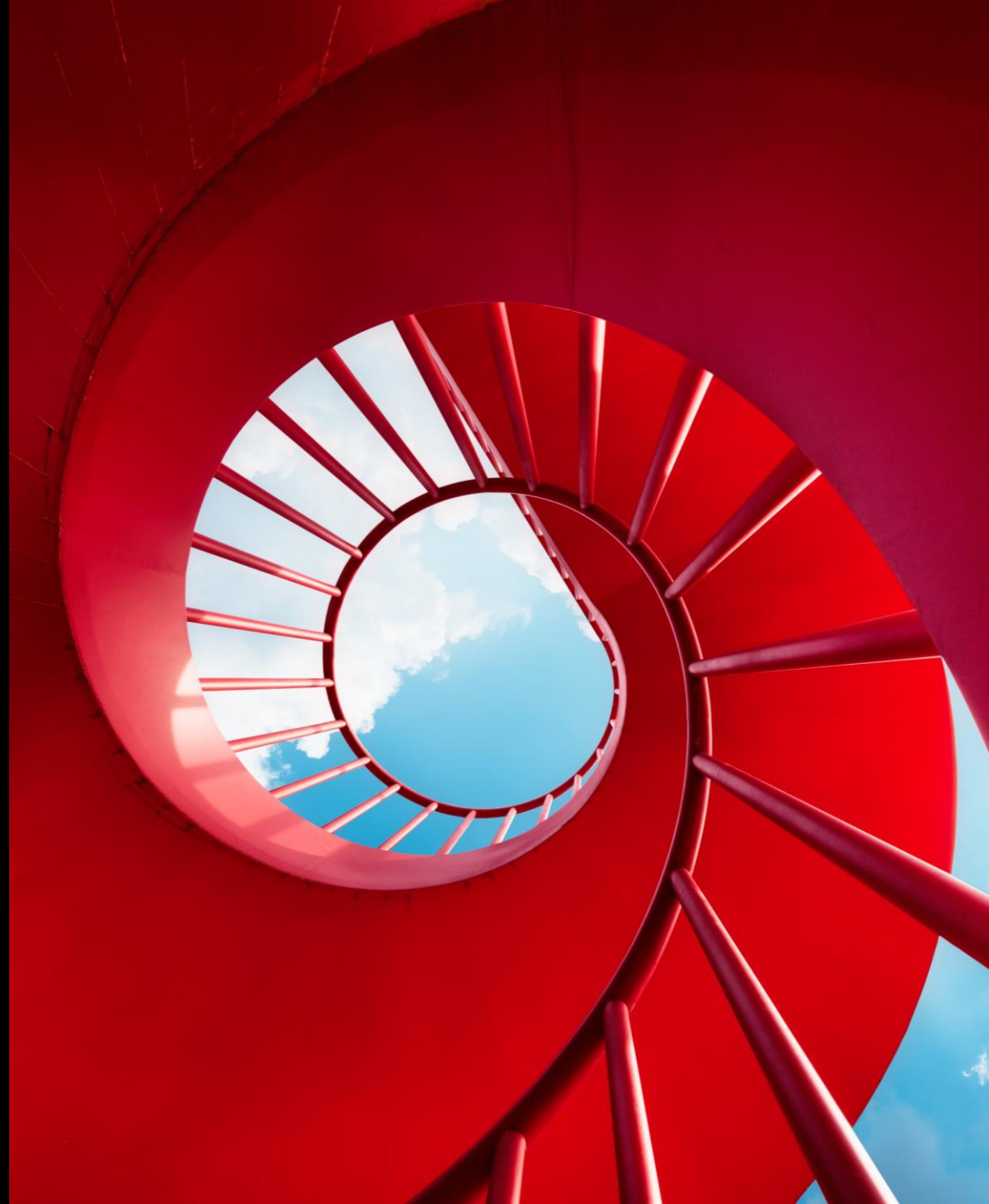
If CARB moves forward with the proposed amendments, LCFS credit prices could start to rise as supply rebalances with demand in the near-to-medium term

Emerging trends		Impact on LCFS Credits Market		
		Demand	Supply	Price
California LCFS	**Increased CI benchmarks:** This provides a demand signal for RIN credits and putting more upward price on LCFS prices.	↑	—	↑
	More stringent RNG provisions: Imposing a 50% in-state pipeline transport requirements and limit methane crediting for new projects after 2029 could make it less attractive for RNG producers to participate in the LCFS program, potentially reducing the supply of credits.	—	↓	↑
	Jet fuel LCFS compliance exemption expires in 2028: LCFS CI mandates for jet fuel starting in 2028 could increase demand for LCFS credits in the new market, driving up LCFS credit prices.	↑	—	↑
	Expanding the LCFS programme to support the use of electricity and low-carbon hydrogen for transportation: This could provide additional pathways to generate LCFS credits, increasing the supply of credits in the long term, especially in the emerging hydrogen market.	—	↑ Long-term	↓
	Potential phase-out of RNG by 2040: The proposed CARB amendments signal the potential phase-out of RNG in transportation, driving up demand in the LCFS market over the long term.	↓ Long-term	—	↓
Other market trends	**Growing other RNG Markets (non-transportation, voluntary):** The growth of the non-transportation and voluntary RNG market for other uses (e.g., utility RNG targets, hard-to-abate sectors) could provide an alternative market for RNG over the longer term. Other market alternatives could help rebalance supply and reduce price compression in a saturated RNG transportation compliance market.	—	↓ Long-term	↑

Source: S&P Global & CARB

Contents

4.2 US Renewable Fuel Standard (RFS) – D3 and D5 Renewable Identification Numbers (RINs))



US Environmental Protection Agency (EPA) implemented Renewable Fuel Standard (RFS) to provide demand signal for low carbon fuels and drive down transport emissions

Policy and Regulatory Context

- The RFS programme was established under the Energy Policy Act of 2005
- In 2007, the programme was amended by the Energy Independence and Security Act of 2007, extending its validity and setting yearly volume requirements until 2022
- EPA's final rule for 2023, 2024 and 2025 RFS volume requirements includes:
  - Deferring decision on renewable electricity provision (e.g., e-RINs)
  - Enhanced third party oversight provisions
  - Additional regulatory provision requirements for parties within in the biogas/RNG value chain to streamline the tracking process and to reduce the risk of double counting across the value chain (e.g., incorporating all transactions across the biogas value chain to be into EPA Moderated Transaction System (EMTS), additional verification and reporting requirements, clarifying only the party that upgrades the biogas to RNG can generate RIN)

Overview of the Renewable Fuel Standard Programme

Objectives	• The RFS is a US federal policy that sets **annual volume requirements** of **renewable fuel production** to drive down emissions in the transportation sector
Programme requirements	• The US EPA is responsible for administrating this program and since 2022 and has the authority to set RFS annual volume requirements for 4 fuel categories: biomass-based diesel (D4), cellulosic biofuel (D3), advanced biofuel (D5) and renewable fuel (D6) • Under the RFS, **refiners and importers of transportation fuel in the US** are required to sell or retire enough Renewable Identification Number (RIN) credits to meet the **Renewable Volume Obligation (RVO)**, and is calculated based on the company's total fuel sales • EPA uses RIN to track renewable transportation fuel under the RFS program. Compliance is demonstrated annually through reports on RIN blending and trading. Failure to comply with the annual RVO could result in civil penalty • Given the high cost and limited availability of D3 and D5 fuels, RFS allows obligated parties to purchase **compliance waivers** to meet RVO requirements
RFS-approved renewable fuel pathways - RIN credits	• A RFS-approved fuel pathway can generate **one RIN credit**, which is equal to a gallon of renewable fuel. RIN credits are specific to fuel categories (D3, D4, D5 and D6) • Approved pathways will need to meet specific fuel-category requirements for **feedstock, fuel type, production process** and **lifecycle GHG reduction** • **Third-party verification of RIN credits under Quality Assurance Plan is optional** • RIN generation and transaction are reported and tracked on the **EMTS**

Source: S&P Global, CARB

Design attributes of the RFS tracking system play an important role in shaping the RNG market dynamics and emission reductions (1/3)

✓ Greater impact X Less impact

RFS: Key Design Attributes		Implications		
		Increase in RNG demand	Increase in RNG supply	Emission reduction
1. **Renewable Volume Obligations**	RFS uses RVO as a performance metric, which increases over time to drive decarbonization of the transportation sector.	✓ Gradual increase in RVO signals greater demand for low-carbon fuels such as RNG.	✓ Gradual increase in RVO will further drive demand for low-carbon fuel, providing more market certainty for low carbon fuel suppliers, including RNG producers.	X While increasing the volume of renewable fuels will help drive down emissions reduction, RVO is a technology-based metric—not an emissions-based metric.
2. **Renewable Fuel Pathway Requirements**	Approved pathways will need to meet specific fuel category requirements for feedstock (biomass-based), fuel type, production process and lifecycle GHG emissions reduction. The definition of biomass under the RFS excludes woody biomass from ecologically sensitive forestland.		X These specific pathway requirements could be potential barriers for low-carbon fuel suppliers to participate in the programme.	
3. **Chain of Custody Model: Book & Claim**	RFS allows credits and physical molecules to be traded separately. While low-carbon fuel can be produced at one location to generate RIN credits and a buyer at another location can purchase and claim them without purchasing the physical product, a verification process ensures RNG is purchased from a pipeline connected to a RNG supplier to avoid double counting.	✓ This model enables RNG buyers to access a more extensive supply market with potentially more cost-effective supply options.	✓ This model enables RNG suppliers to access a broader offtake market.	X Potential risks of double counting. Limited traceability. Does not drive location-based emissions reduction.

Design attributes of the RFS tracking system play an important role in shaping the RNG market dynamics and emission reductions (2/3)

✓ Greater impact X Less impact

RFS: Key Design Attributes		Implications		
		Increase in RNG demand	Increase in RNG supply	Emission reduction
4. **Additional requirements for foreign producers**	Renewable fuel producers and importers located outside the US are required to comply with additional regulatory and inspection requirements.		X These additional requirements can create additional barriers to entry for foreign producers. ✓ It encourages more locally produced low carbon fuel.	✓
5. **Voluntary third-party verification**	Third party verification of RIN credits under the Quality Assurance Plan is optional. The recent EPA ruling in 2024 included additional QAP provisions for RNG pathways.	X Buyers could be at risk of purchasing lower quality credits.	✓ This could lower cost of verification for some suppliers, reducing barriers to participate in this programme.	X Quality of credits and emissions impact could vary greatly in the absence of a mandatory verification programme.
6. **Compliance waiver credits**	Given the high cost and limited availability of D3-5 fuels, RFS allows obligated parties to purchase compliance waivers to meet RVO requirements.	X Waivers could translate into reduced demand for low carbon fuel.	.	

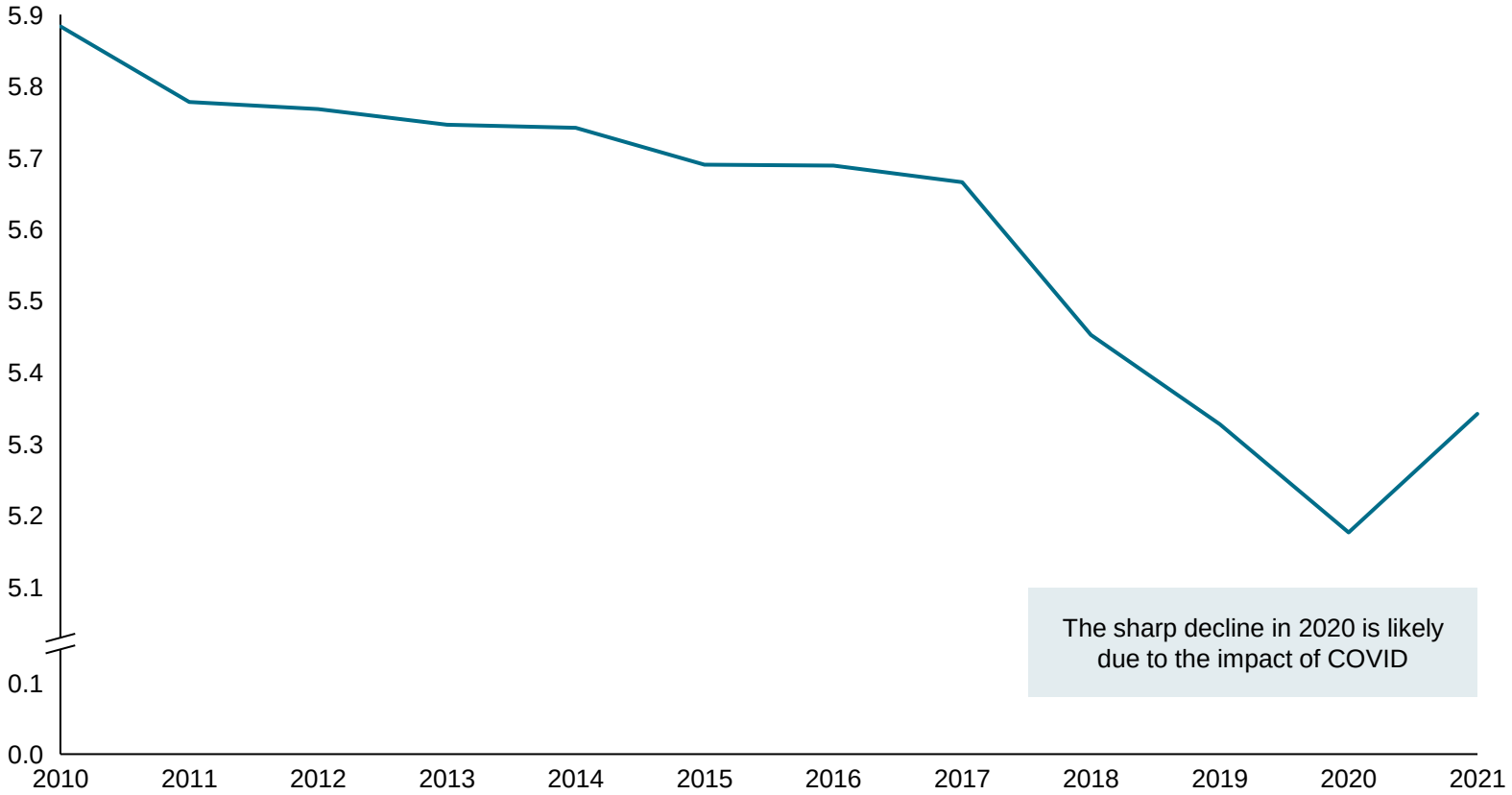
Design attributes of the RFS tracking system play an important role in shaping the RNG market dynamics and emission reductions (3/3)

✓ Greater impact X Less impact

RFS: Key Design Attributes		Implications		
		Increase in RNG demand	Increase in RNG supply	Emission reduction
7.	**Stackable Credits: RIN and LCFS** The RFS program allows the same project to generate RIN as well as LCFS credits.		✓ Provide additional revenue streams to improve RNG project economics.	X No additional emission reduction from participating in LCFS program.
8.	**Time-bound credit banking** RINs are valid for two compliance years. In other words, if a RIN is not retired for compliance in the year it was generated, it can only be carried over into the next compliance year.		✓ This ensures there is no oversupply of unused RIN in the market, encouraging the continued production of low carbon fuel.	
9.	**Tracking all transactions along the RNG value chain in EMTS** Prior to the recent 2024 ruling by the EPA, any party along the RNG value chain could generate RINs if it could be demonstrated that the RINs would be used for transportation end-uses. As of 2024, only parties that upgrade biogas to RNG can generate RINs and all transactions across the value chain need to be tracked on EMTS.			✓ This reduces the risk of double counting of emission reduction across the RNG value chain.

Over the past decade, US GHG emissions intensity in transportation has trended downwards due to federal and state-level policies on low carbon transportation fuel

2011-23 3-year rolling average of US GHG emissions intensity in road transportation sector
(excluding the impact of EVs) – million tons CO_2eq emissions per million vehicles



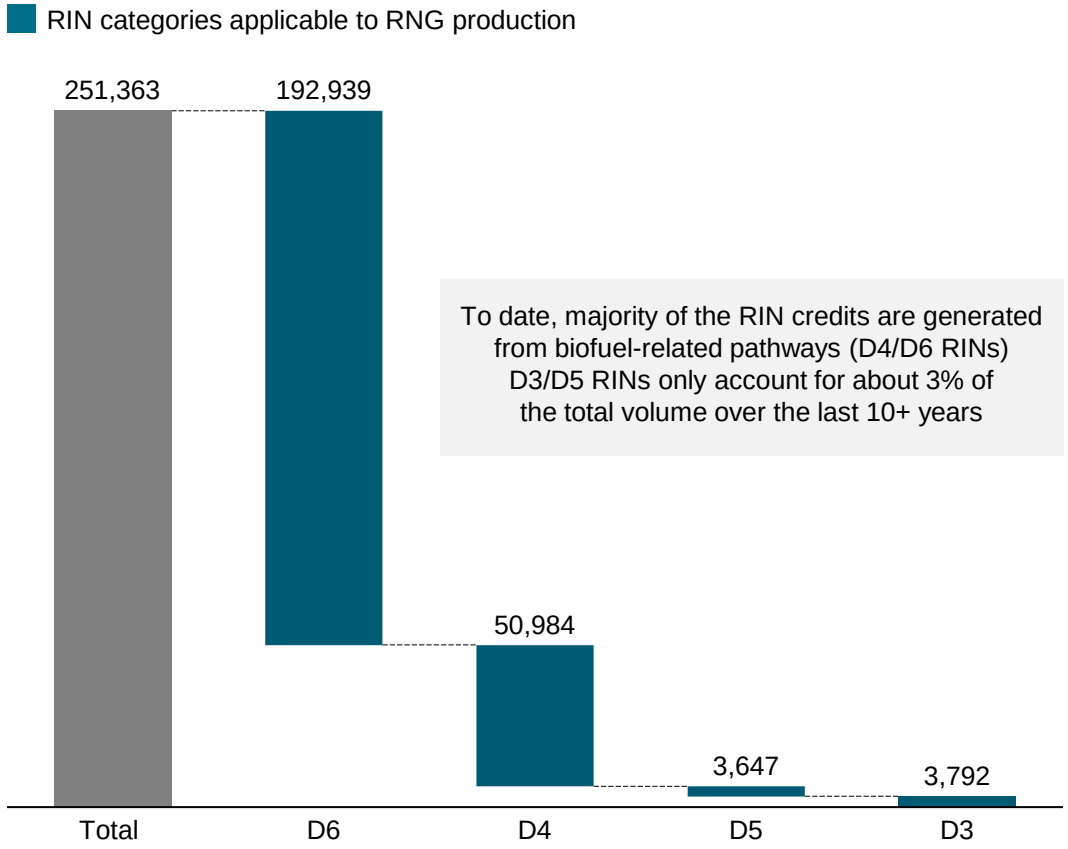
- Even after excluding the impact of EVs, fuel combustion in the US road transportation sector has been on a downward trend over the past decade
- This decline in emissions intensity in the ground transportation sector is driven by a combination of national policies (such as the EPA's RFS programme) and state programmes (e.g. California LCFS and Oregon Clean Fuels Program)

Source: EPA Greenhouse Gas Inventory – Emissions from the Transportation Sector – GHG Fuel Combustion; Bureau of Transportation Statistics – National Transportation Statistics

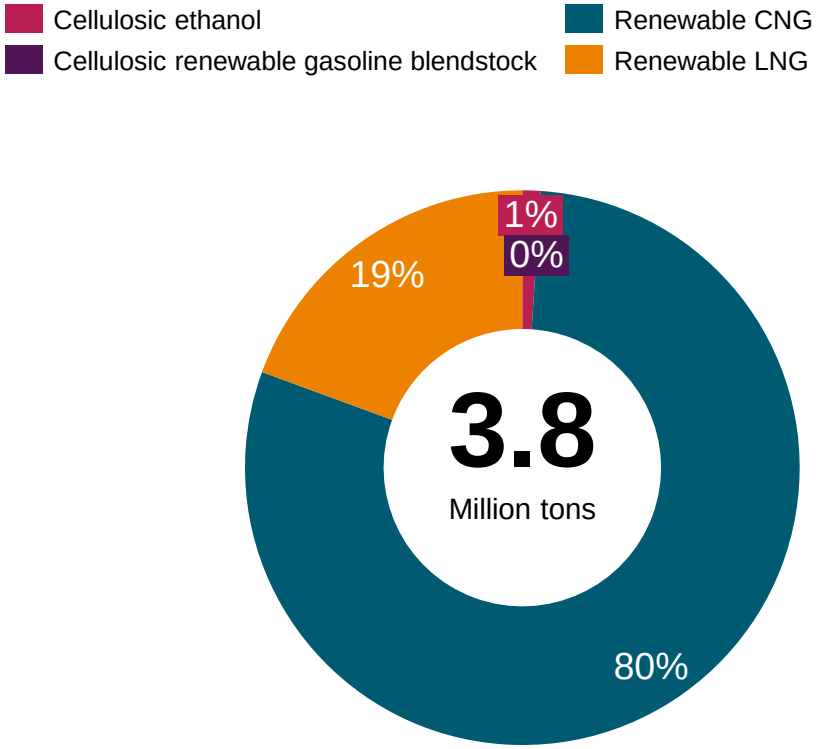
Under the RFS programme, RNG qualifies to generate D3/D5 credits, which account for 3% of the RIN credits generated over the past 10+ years

2010-2023 cumulative volume of RIN credits generated by fuel type

Million tons



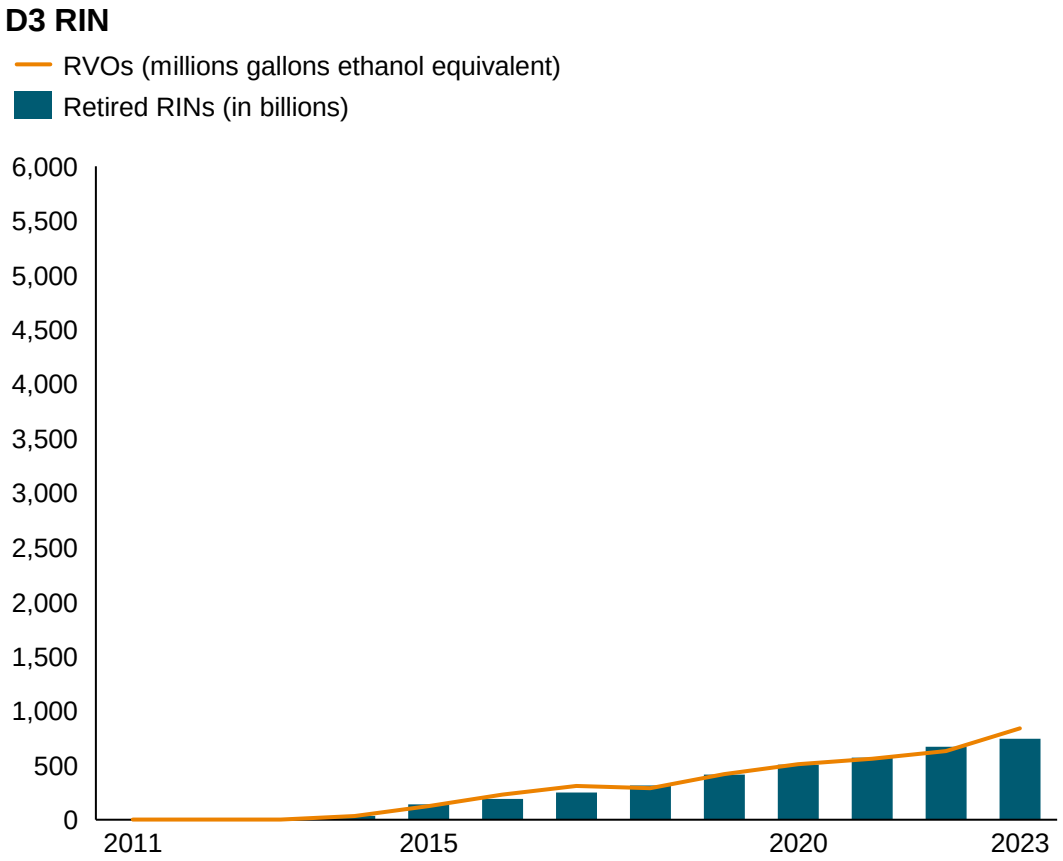
2010-2023 cumulative volume of RNG D3 credits by fuel category

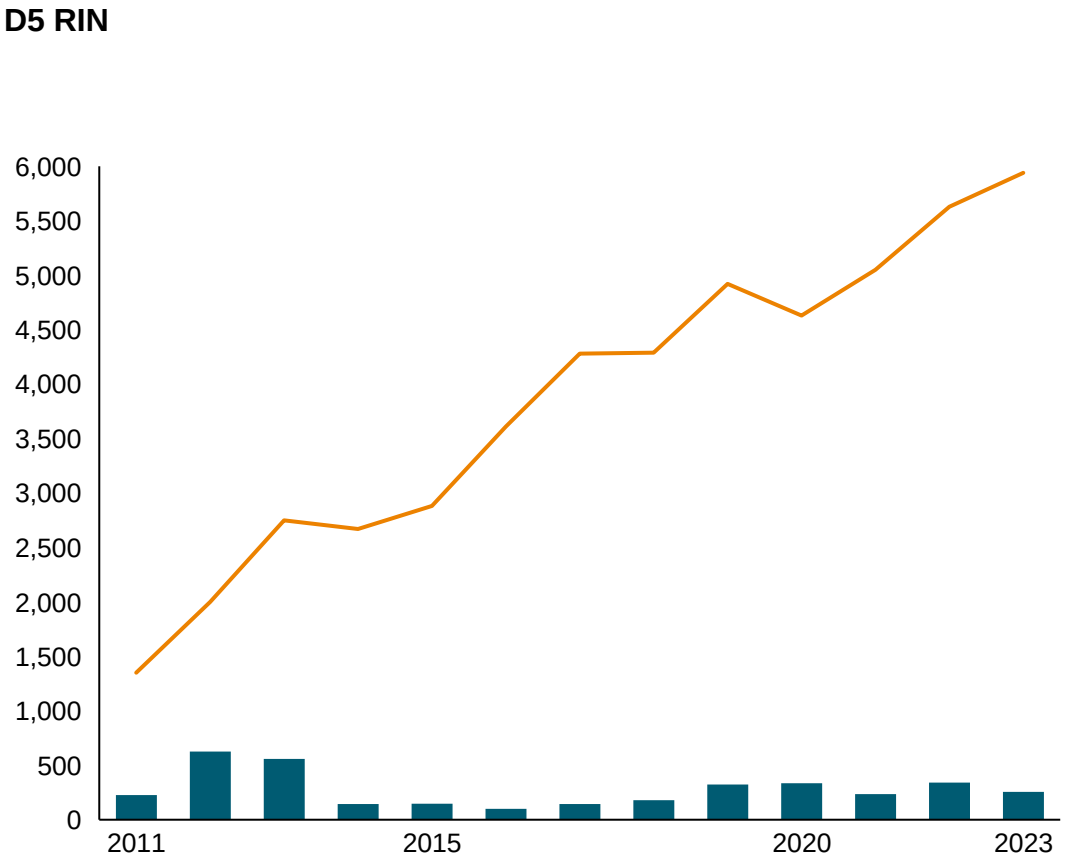


Source: US EPA RFS data

While the gradual increase in RVOs has driven a surge in D3 RIN credit retirements, the impact on the D5 RIN market is much more limited

2011-2023 RFS annual volume requirements vs. annual D3 and D5 RIN retirements

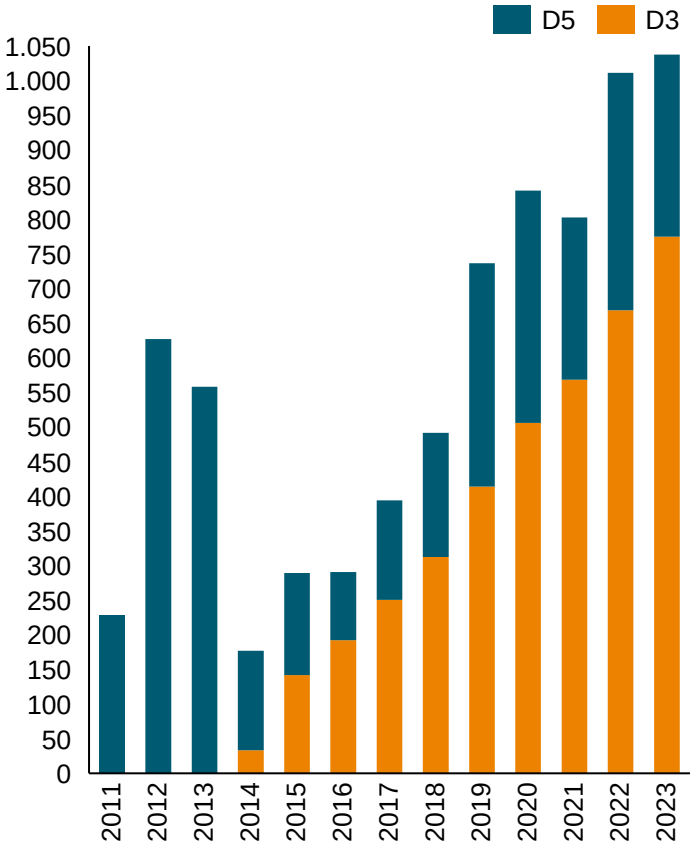




Source: US EPA RIN use and RFS volume targets

Growing interest in RNG D3/ D5 RIN credits has helped drive emissions reduction, increased RNG production and scale-up the RNG industry in the US

Annual D3 and D5 credits (2011-2023)
Million tons



Estimated RFS-related RNG related emissions reduction in the US transportation sector (2011-2023)

3.8
Million tons

Estimated RFS-related volume increase of RNG production for transportation end uses between 2015 and 2023

5x

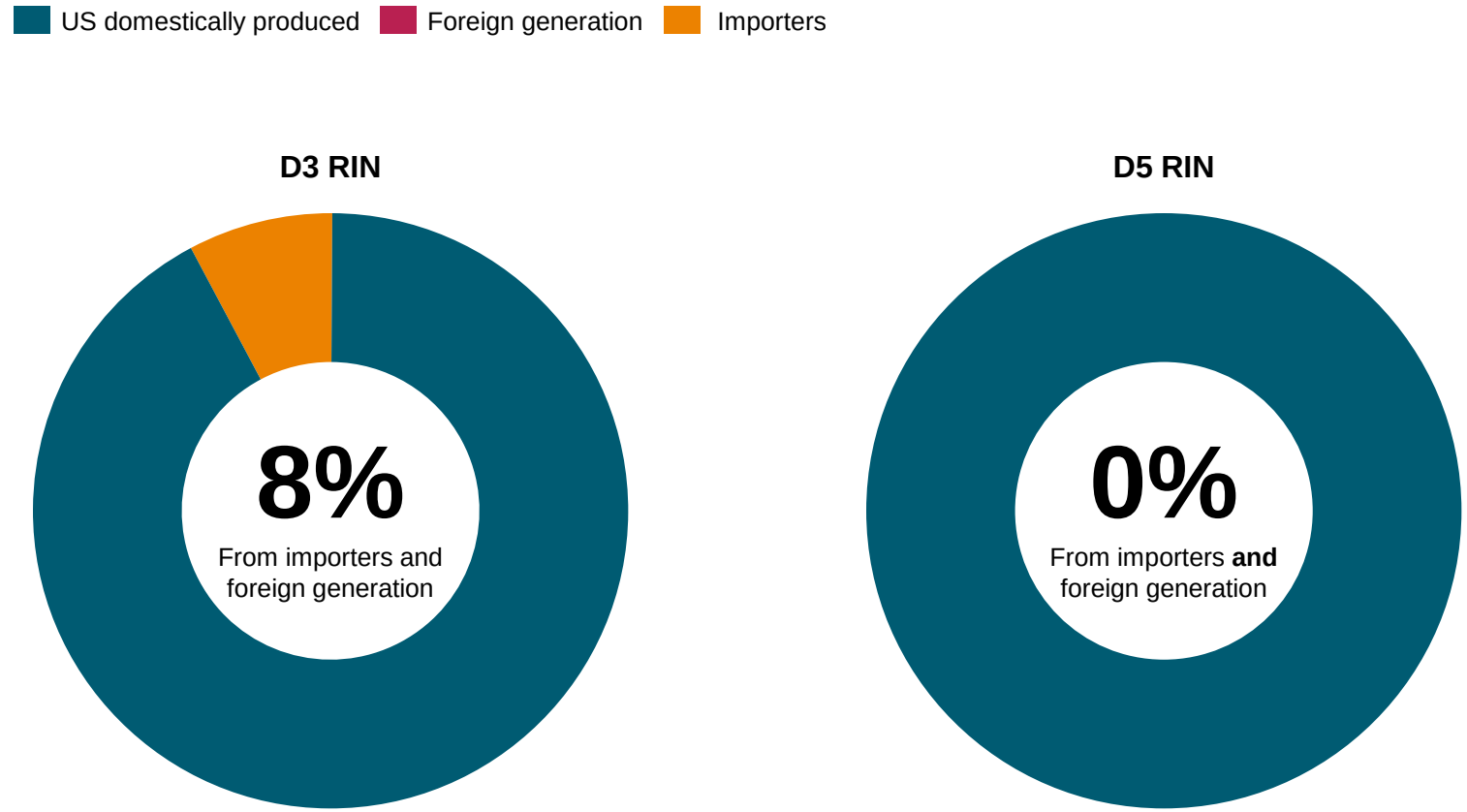
Estimated number of new RFS-certified landfill gas and manure RNG facilities in the US since 2015[1]

60+

Source: EPA RFS data, Argonne National Laboratory - Renewable Natural Gas Database
Note: (1) This estimate only includes new facilities with approved RFS pathways; during this period, more than 210 new RNG facilities came online in the US

Given additional requirements for foreign producers, only a small percentage of RNG D3 is generated outside the US, incentivising localised production of alternative fuels

2011-2023 cumulative RNG volume production by location

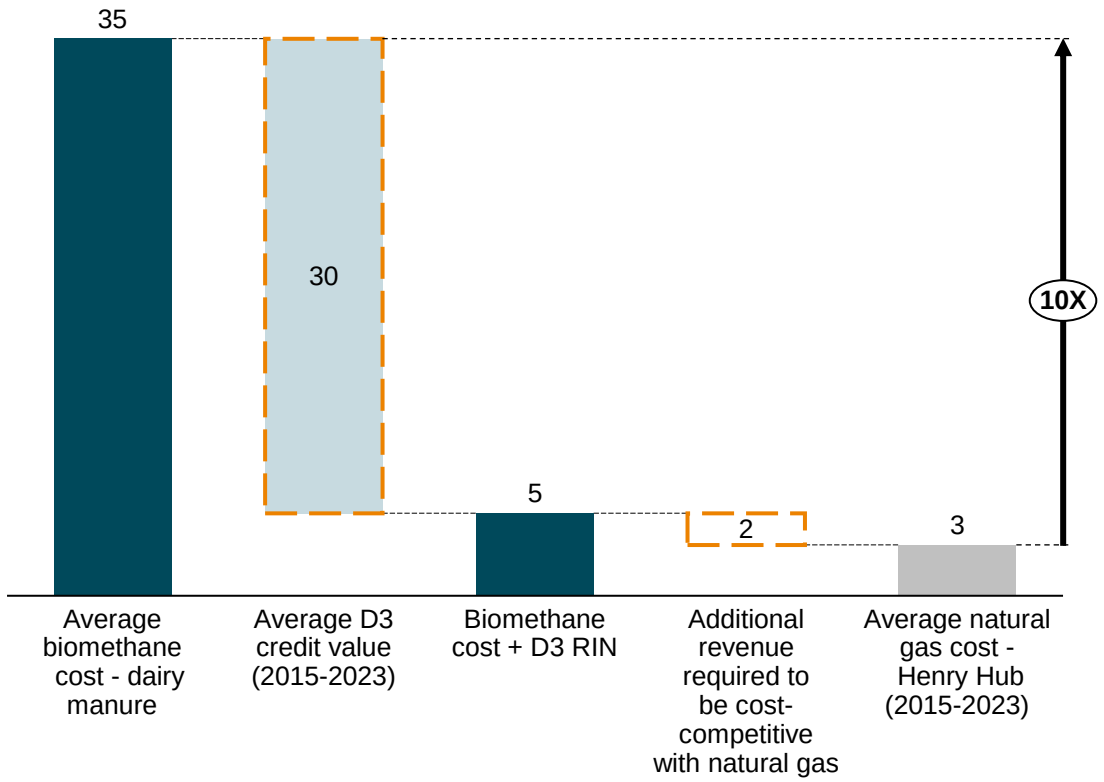


- Foreign renewable fuel producers and importers located outside the US are required to comply with additional regulatory and inspection requirements (e.g., conducting a third-party engineering review, posting a bond, allowing the EPA to conduct inspection of foreign facilities)
- In the case of RNG production in the D3 and D5 RIN categories, demand is already covered by domestic production, with limited production volume for foreign generators
- The US market is attractive to foreign producers in specific fuel categories where domestic supply is not enough to meet domestic demand and to comply with RFS volume mandates (e.g., ethanol)

Source: EPA RFS RINs generated transactions

Given that RNG is costlier to produce than fossil natural gas, RINs provide an additional revenue stream and enable RNG facilities to be more cost-competitive

Illustrative analysis – cost-competitiveness: US RNG cost – dairy manure vs. natural gas
$/MMBtu



Source: S&P Global; EPA historical RIN trades and price information
Cost of $/MMBtu was calculated: RIN using a conversion factor of 0.077 MMBtu per gallon of ethanol

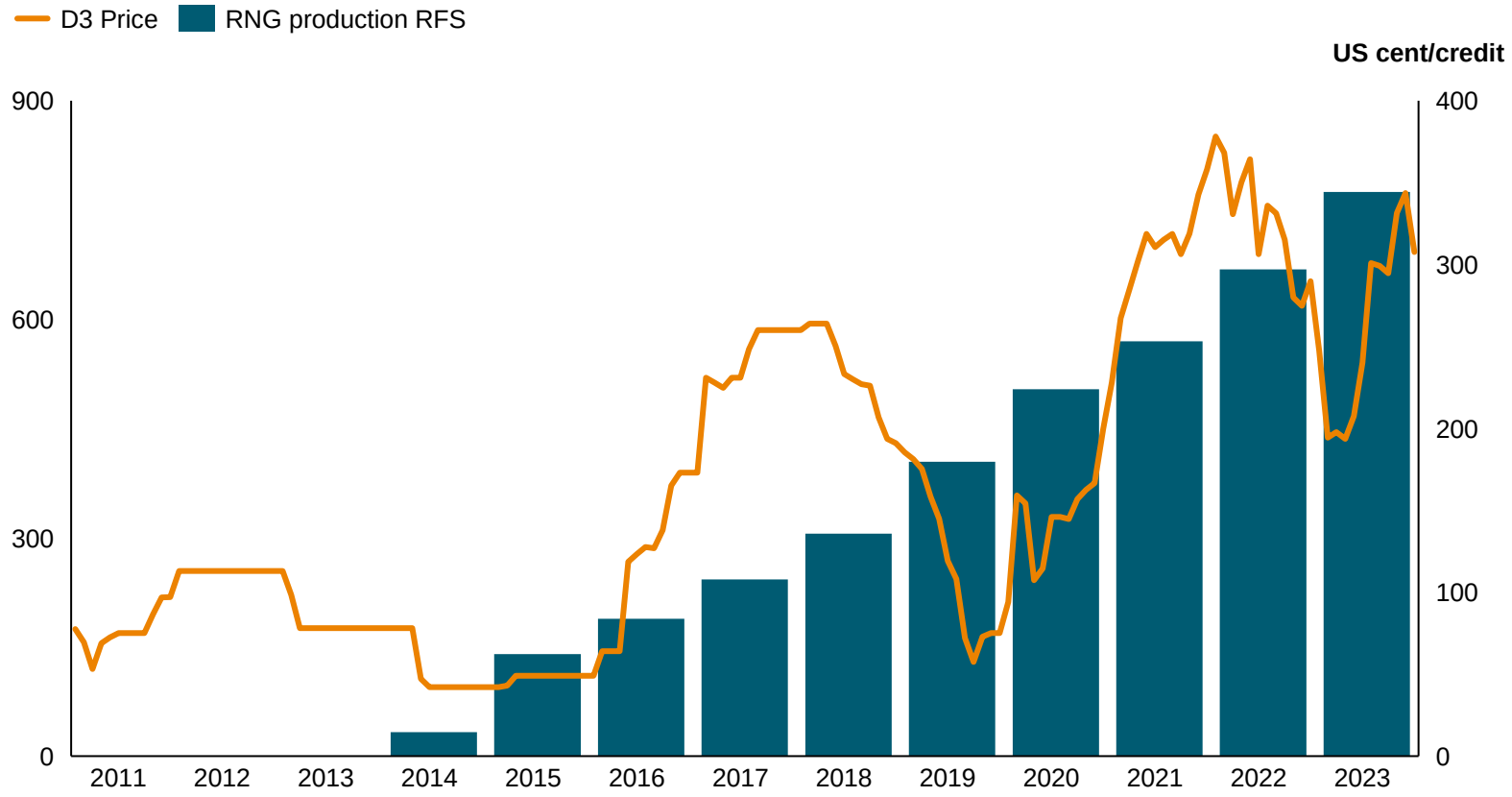
To be cost competitive, RNG suppliers would need to consider and access various sources of revenue streams

- **State LCFS:** LCFS credits can be generated if the lifecycle emissions intensity of the proposed low carbon fuel alternative (e.g., RNG) is lower than the carbon intensity standard for the existing fossil fuel (e.g., gasoline and diesel). The credit value would depend on the carbon intensity and feedstock
- **US RFS:** Under the RFS program, RNG is eligible to generate RIN credits (D3 or D5 RIN). The value of the credit will depend on the type of feedstock
- **Other state and federal grant programs:** For example, USDA Rural Energy For America program and Washington "Promoting Renewable Natural Gas" tax incentives for anaerobic digesters
- **Utility cost-recovery mechanisms:** Some states (e.g., Nevada, Ohio) allow gas utilities to recover cost of RNG investment or purchases
- **Voluntary offtake agreements:** Some RNG companies are looking to secure offtake agreements with industrial players

Historically, the book and claim chain of custody model has helped broaden RNG suppliers' access to these revenue streams by lowering cost of implementation and unlocking additional offtake markets

The rapid increase in D3 RIN prices between 2020 and 2023 created a strong market signal for RNG producers, driving an increase in RNG production in recent years

2011-2023 D3 RIN prices and US RNG annual production volume
Million gallons



- The spike in D3 RIN prices to over $3.00 per RIN by mid-2023 created strong financial incentives for RNG producers
- Attractive D3 RIN prices led to a significant increase in RNG production, with the RNG industry growing at a 25% annual rate through 2025
- The regulatory environment, including higher RFS mandates and the elimination of cellulosic waiver credits (CWCs), pushed obligated parties to increase cellulosic biofuel blending, driving up D3 RIN prices and boosting RNG production

Source: S&P Global and EPA

RIN credit prices are driven by the balance of demand/supply, market stabilisation mechanisms (e.g., CWC), and Bean Oil-Heating Oil (BOHO) spread

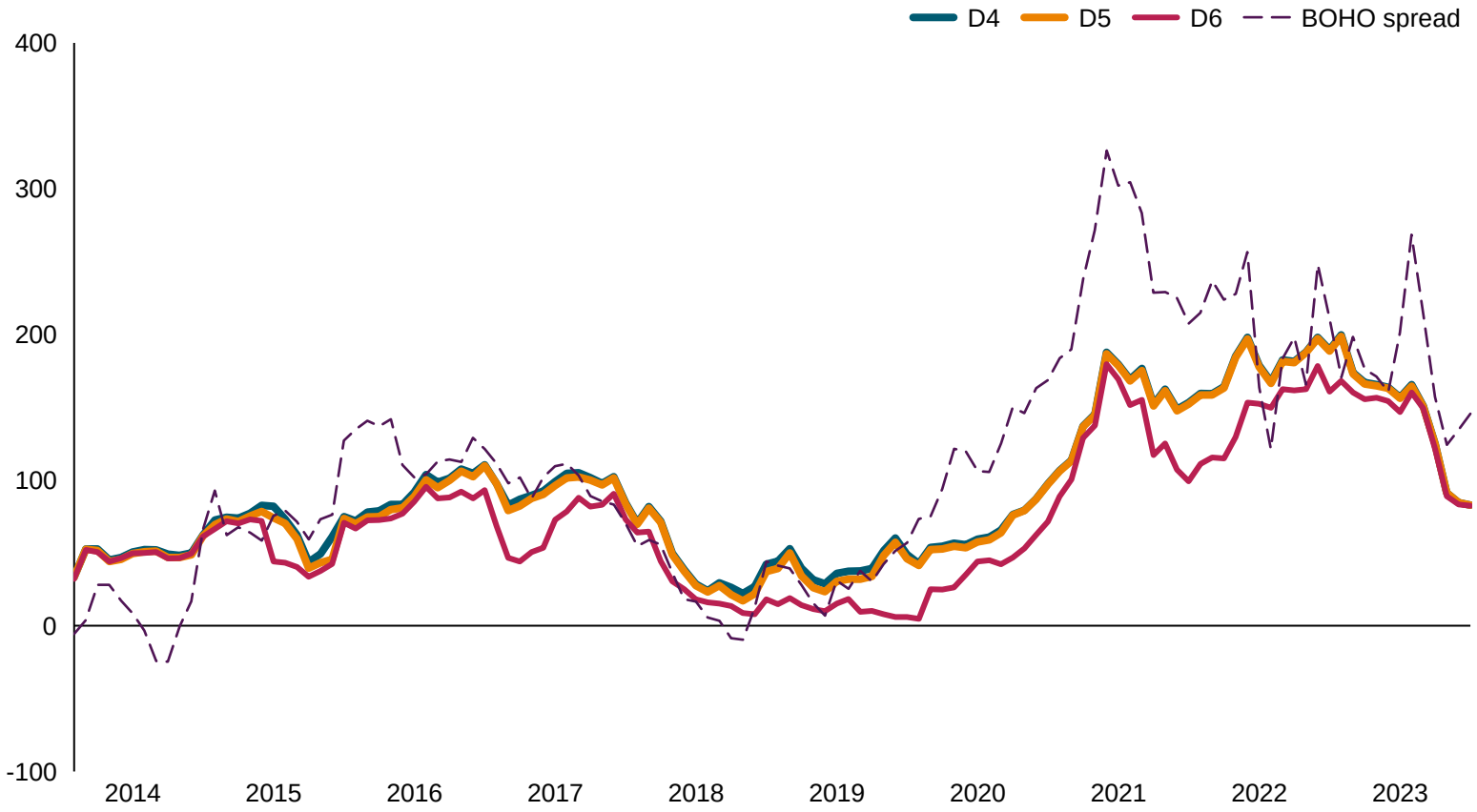
High ● ◕ ◑ ◔ ○ Low

Factors impacting RIN prices	Level of impact
Supply of RIN credits: The balance between the supply of RIN credits (generated by low-carbon fuel producers) and the demand (from fuel providers needing to comply with the RFS requirements) is a crucial determinant.	●
RFS mandates and rules: The EPA sets annual RFS RVOs for refiners, importers and blenders of fuel. The stringency and targets of these mandates directly affect the demand for RINs. The EPA also sets rules for each obligation period which could impact the program requirements for various fuel types and eligible production pathways.	●
Bean Oil - Heating Oil (BOHO) Spread: The BOHO spread describes the relationship between soybean oil feedstock price (cost) and price for heating oil prices (the market's willingness to pay for biofuel). This is used as a metric to assess profitability for biofuel production.	◔
Compliance Waiver Credits (CWCs): To account for the potential discrepancy between the RVO and the actual D3 RIN production capacity, the EPA has the authority to issue CWCs, which could be used in combination with D5 RIN credits to meet the D3 RIN RVO. When the market is short, CWC + D5 defines the price ceiling for D3 RIN.	◔
Price ceiling: By capping the price, the ceiling prevents the cost of credits from exceeding a predetermined level, thereby providing a predictable cost environment for fuel suppliers.	◔
Trading, banking and borrowing: The ability of regulated entities to bank excess credits, trade, or borrow against future compliance can affect credit supply and demand dynamics.	◔
Other RNG markets (non-transportation, voluntary): Interest in other RNG markets is rising, with companies securing long-term agreements that reduce exposure to RIN/LCFS volatility. Growth of the non-transportation and voluntary RNG markets for other uses (e.g., utility RNG targets and hard-to-abate sectors) could provide an alternative market for RNG over the longer term. Other RNG market alternatives could help rebalance supply and reduce price compression in the event of an oversupply of RNG in the transportation compliance market.	◔

Source: S&P Global

Biofuel-related RIN (D4, D5, D6) prices are driven by the BOHO spread, which measures profitability of biofuel production using soybean oil feedstock

BOHO spread vs. biofuel-related RIN prices (D4, D5, D6)
US cent/gallon (BOHO); US cent/credit (RIN)



- The BOHO spread describes the relationship between soybean oil feedstock price (cost) and price for heating oil prices (the market's willingness to pay for biofuel). This is used as a metric to assess profitability for biofuel production
- In a balanced supply and demand market
  - A ***higher BOHO*** spread indicates lower margins, driven by higher feedstock cost or lower heating prices. RIN prices will need to rise to compensate biofuel producers for margin compression
  - A ***lower BOHO*** spread indicates higher margins, driven by lower feedstock cost or higher heating prices. RIN prices tend to fall as less incentives are required given the margin expansion
- However, the recent downward pressure on biofuel-related RIN prices is largely due to the increase of renewable diesel production and oversupply of D4 RINs

Source: S&P Global and EPA

D3 RIN pricing dynamics are driven by the EPA's ability to accurately predict volume production for the RVO and bounded by D5 RIN and CWC prices

Given that cellulosic biofuel (D3 RIN) is an emerging pathway and less developed, it is often **difficult for the EPA to accurately predict production** volume to set the RVO.

To account for the potential discrepancy between the RVO and the actual D3 RIN production capacity, the EPA has the authority to issue **CWCs,** which could be used in combination with D5 RIN credits to meet the D3 RIN RVO.

Liquid market

In a functioning D3 RIN market with well-balanced demand and supply, the D3-D5 spread is determined by the **marginal cost of production of the marginal cellulosic RIN producer.**

Price floor

When the D3 RIN supply *exceeds* the RVO, the D3 RIN price declines to the theorical price floor set by the D5 RIN price.

Price ceiling

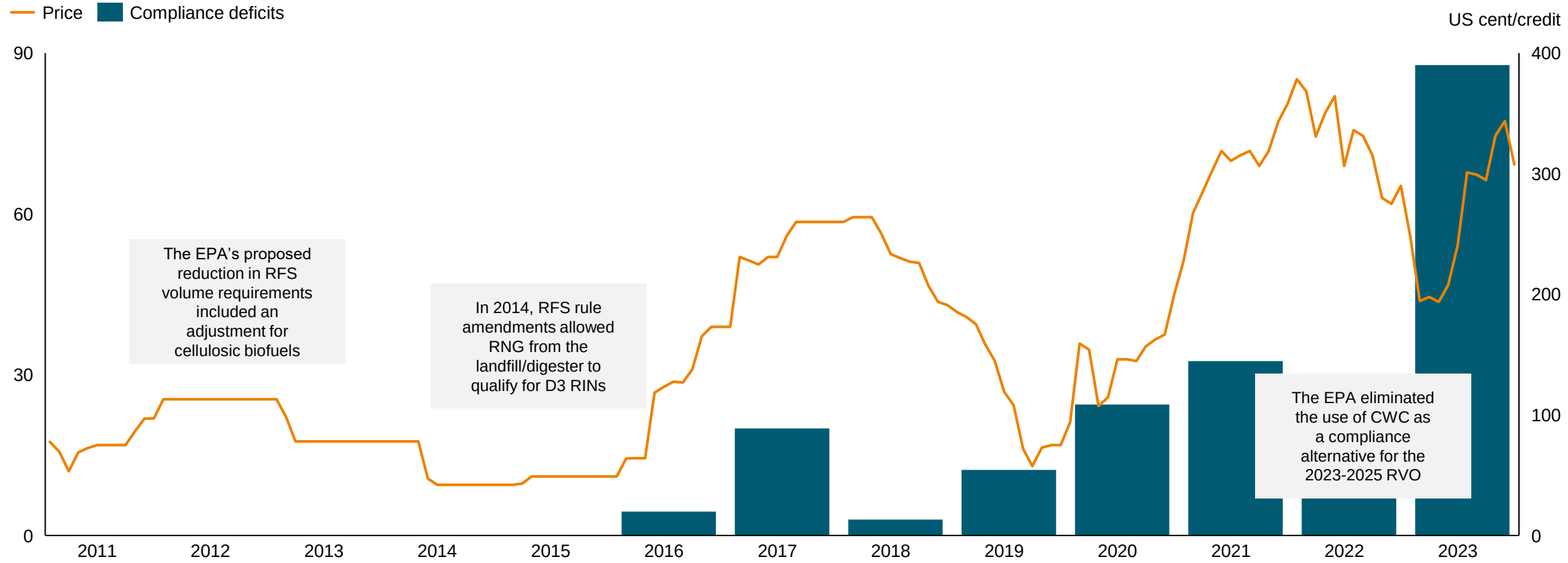
When the D3 RIN production *falls short of* the RVO, the EPA could issue CWCs to make up the difference and the price would be traded at D5 price + CWC (e.g., price celling)

The CWC price is equal to the greater of $0.25 or $3.00 minus the average wholesale price of gasoline over the past 12 months, adjusted for inflation.

Sources: EPA

Even with many RNG-based fuels qualifying for D3 RIN RVO in recent years and access to CWCs, the current supply of D3 RIN falls short of the RVO, resulting in price increase

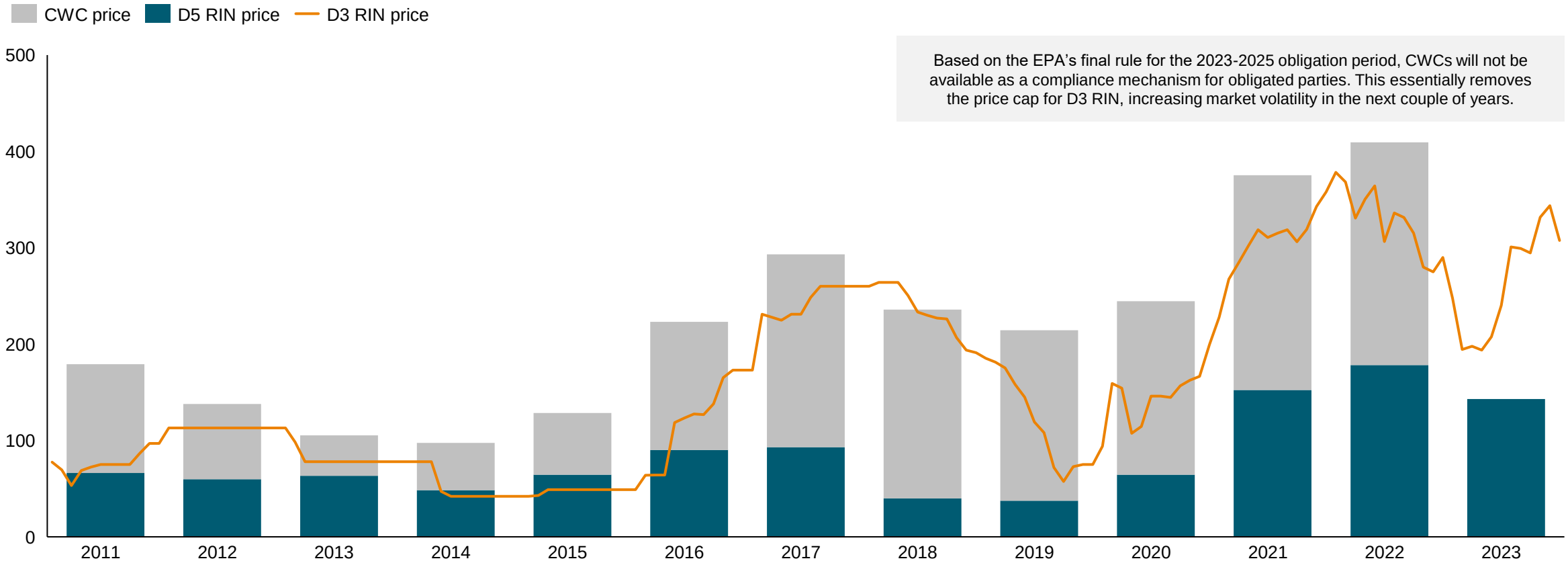
2011-2023 D3 RIN prices and volumes
Million gallons



Source: S&P Global and EPA

Given shortage of D3 RIN in the market over the past decade, D3 RIN price is driven by D5 + CWC price, but this is likely to change as CWCs are no longer available for 2023-25

2011-2023 D5, D3 and CWC prices
US cent/credit



Based on the EPA's final rule for the 2023-2025 obligation period, CWCs will not be available as a compliance mechanism for obligated parties. This essentially removes the price cap for D3 RIN, increasing market volatility in the next couple of years.

Source: S&P Global and EPA

EPA’s final RFS 2023-25 rules outline key provisions that may impact D3 RIN markets

Highlights of key provisions of EPA final RFS 2023-25 rules

Volume targets increase

The EPA set new volume targets for cellulosic biofuel, which includes RNG. The targets for D3 were increased to 0.84 billion gallon in 2023, 1.09 billion gallons in 2024 and 1.38 billion gallons in 2025.

Elimination of CWCs

CWCs will not be available as a compliance mechanism for obligated parties for the 2023-25 RFS compliance period. This will likely drive increase demand for D3 RIN credits.

eRIN programme uncertainty

The latest EPA ruling did not include eRIN as a potential pathway for RIN generation (i.e., eRIN provisions would have allowed EV OEMs to use biofuel for electricity generation to generate RIN credits). However, the EPA did not shut down the possibility of implementing this programme in the next obligation period.

More stringent provisions for RNG pathways

Registration and reporting requirements

New pathways registered after July 1, 2024 must comply immediately with the updated RFS rule. This includes mandatory registration of biogas producers, such as landfills and digesters, with the EPA. Additionally, there are new reporting requirements for biogas quantities and quality.

Enhanced third-party oversight provisions

The new RFS rule includes strengthened third-party oversight provisions. This covers enhanced requirements for third-party verification and reporting to ensure compliance and accuracy in RIN generation and reporting. The changes aim to improve the integrity and transparency of the RFS programme.

RIN generation process changes

RINs will now be generated upon pipeline injection and separated by the CNG dispenser, rather than at the point of immediate separation. This may require contractual changes between RNG producers and offtake partners.

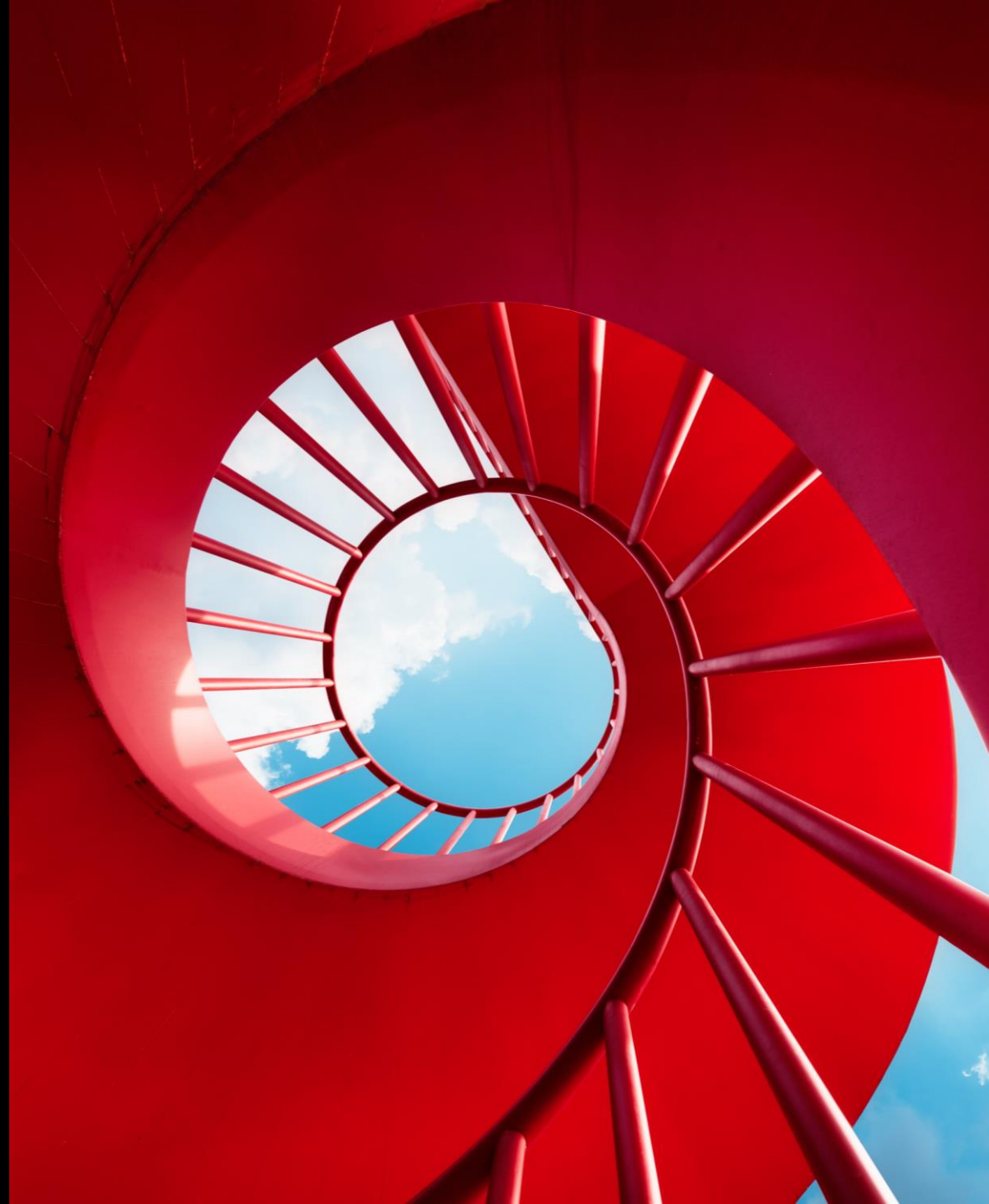
Given EPA's final RFS 2023-25 rules and growth in voluntary RNG market, D3 RIN prices will likely continue to experience upward pressure, especially in the near to medium term

Emerging trends		Impact on D3 RIN Market		
		Demand	Supply	Price
RFS programme	**Increased RVO obligations**: This provides a demand signal for RIN credits and could potentially drive up the prices if the market is short.	↑	—	↑
	Elimination of CWCs: Given the market is currently short, the removal of CWCs will likely provide a demand signal and could drive up D3 RIN prices.	↑	—	↑
	eRIN programme uncertainty: If this provision gets implemented in the future, it could provide additional pathways to generate RIN credits, increasing the supply of credits in LCFS markets.	—	↑ Long term	↓
	More stringent RNG provisions: This additional requirements for RNG-related pathways could make participating in the RFS - D3 RIN programme less attractive for RNG producers, reducing the supply of D3 RIN credits.	—	↓	↑
Other market trends	**Growing other RNG markets (non-transportation, voluntary):** The growth of the non-transportation and voluntary RNG market for other uses (e.g., utility RNG targets, hard-to-abate sectors) could provide an alternative market for RNG over the longer term. Other market alternatives could help rebalance supply and reduce price compression in a saturated RNG transportation compliance market.	—	Long term ↓	↑

Source: S&P Global & CARB

Contents

5. Emerging RNG markets in Europe and the US

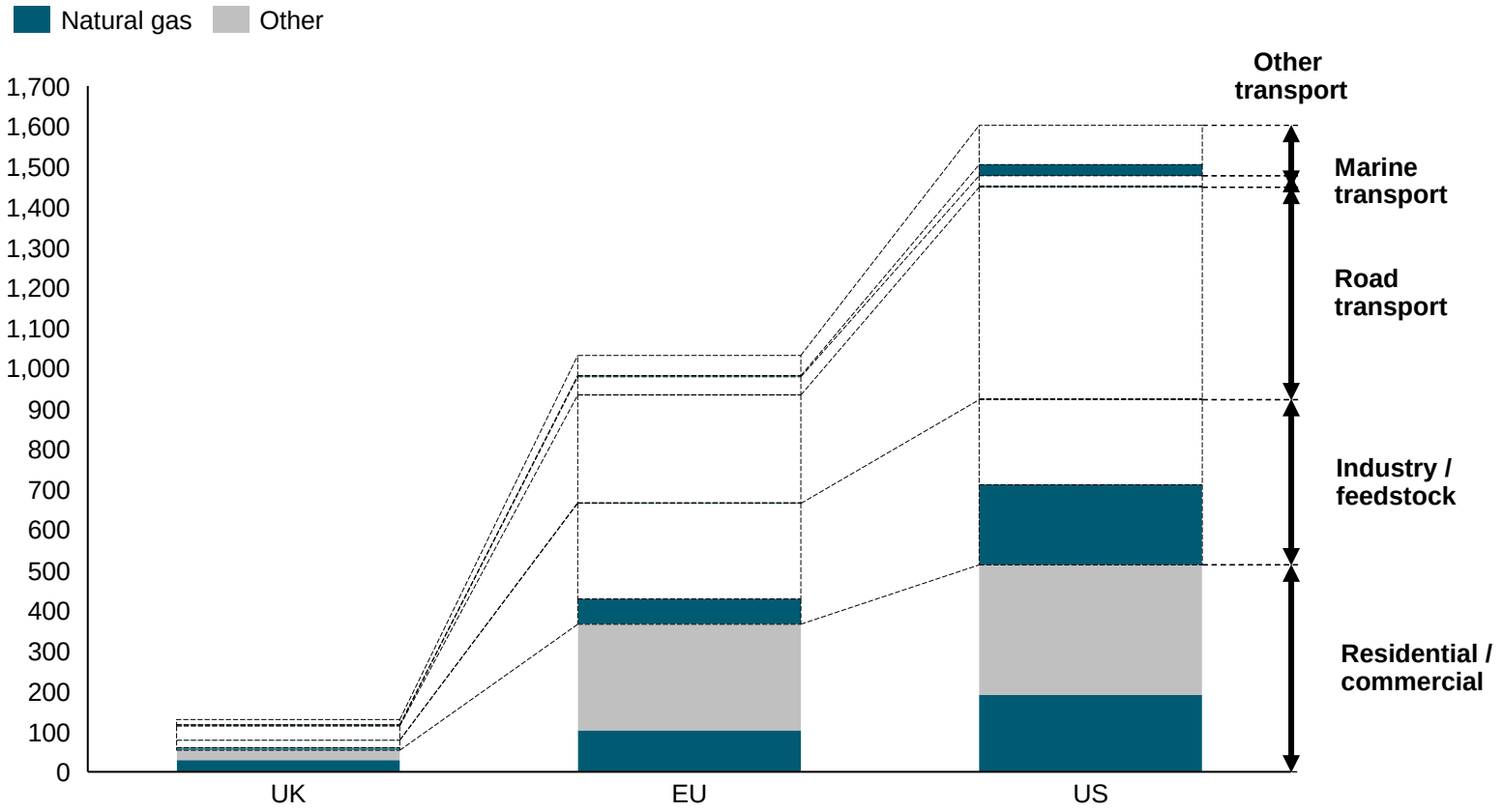


Overview: Emerging RNG markets in Europe and the US

- **Globally,** grid-injected RNG provides an attractive tool to reduce emissions from hard-to-decarbonise existing gas demand, utilising existing gas distribution infrastructure. RNG can benefit from circa 2.2 million km and 4.8 million km in the EU+UK and the US, respectively
  - RNG is complementary with other forms of renewables and can provide a means to support the role out of other renewable forms such as solar and wind, balancing volatility in power generation. Natural gas currently accounted for 26% and 16% of final energy consumption in the US and EU, respectively, in 2023 highlighting the ample addressable demand and potential to reduce current emissions from natural gas consumption
- In the **US,** RNG for transport accounts for the bulk of RNG demand and continues to grow strongly, with the revenue associated with LCFS and RIN certificates being a key driver of new RNG plant economics. RNG for road transport increased from circa 0.09 Bcf/d in 2019 to an estimated 0.16 Bcf/d in 2023
  - In the long term, however, the non-transport sector, in particular thermal heating, is expected to drive growth in RNG demand. If state and utility targets for RNG's share in thermal sector natural gas demand are attained, RNG demand for this sector would reach close to 0.6 Bcf/d by 2030-35 compared with just circa 0.06 Bcfd in 2023
  - Multiple schemes are emerging regarding RNG tracking and value creation in the US thermal sector. These include Oregon's SB 98, which allows utilities to recover RNG procurement costs through tariffs on specific customer segments and M-RETS Renewable Thermal Certificates and the Vermont Clean Heat Standard, where fossil fuel providers are obligated to retire Clean Heat Credits that can support RNG investments
- There are also **nascent RNG demand sectors** such as **maritime bunker** fuels where the EU is likely to take the lead in terms of maritime shipping emission reductions with regulations such as Fuel EU Maritime. Given the impact of these regulations on global shipping, there is a potential for the currently highly regionalised RNG markets to have a more global dimension, requiring RNG tracking and certification to cover a more global scope as well

Grid-injected RNG provides attractive option to cut emissions from hard-to-decarbonise existing gas demand, utilising existing gas distribution infrastructure

Final energy use by region and fuel 2023
MMToe



Source: SPGCI Energy and Climate Scenarios
Note1: Other - Final energy includes oil, coal, hydrogen, electricity (including from gas fired power generation), modern and traditional biomass, district heating)
Note2: Other transport includes natural gas consumption for pipeline transport

RNG as a low-carbon solution

- RNG, injected into existing gas grids, offers a proven and cost-effective means to reduce carbon emissions. This is given compatibility with existing infrastructure, industrial equipment, power generation capacity and end-user appliances

Natural gas's critical role in the current energy mix and potential to replace it with RNG

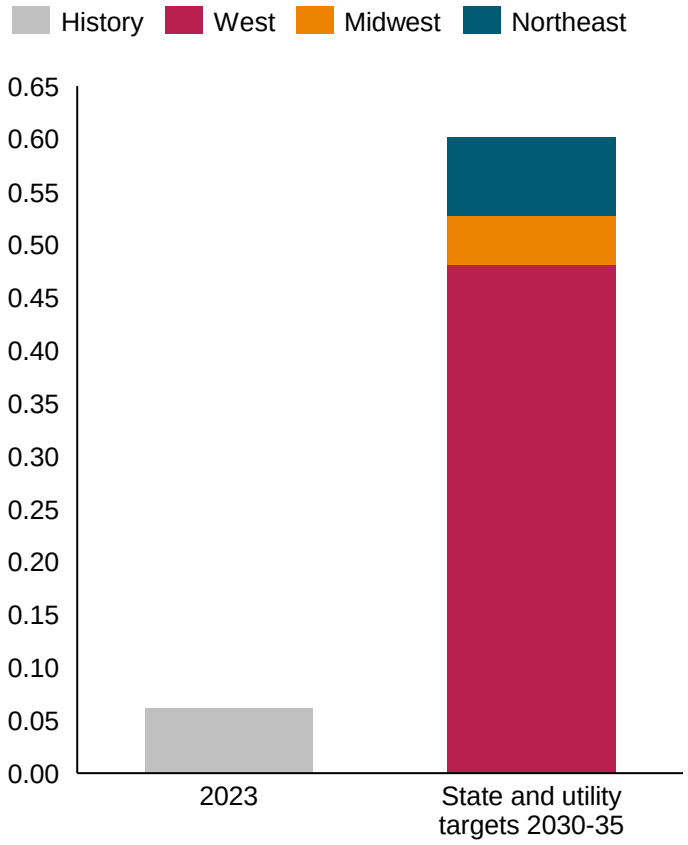
- Natural gas plays a critical role in today's energy mix for residential, commercial and industrial sectors, along with limitations in the speed of demand electrification and the need for natural gas in challenging-to-electrify industrial processes. RNG is essential for accelerating emissions reductions. Additionally, carbon-based molecules will remain necessary in the chemical and materials sectors and will need pathways (e.g., RNG) to decarbonise

Sectors with potential for natural gas demand growth, addressable by RNG

- While the consumption of natural gas as final energy and in power generation is expected to decline in the long term due to growing renewable power generation capacities and demand electrification, natural gas and liquefied natural gas demand is expected to grow in other sectors with substantial potential for use of RNG and bio-LNG

If state and utility targets for RNG's share in thermal sector natural gas demand are reached, RNG demand for this sector would likely reach close to 0.6 Bcf/d by 2030-35

US lower 48 states and utility RNG targets for the thermal sector by region of consumption
Bcf/d

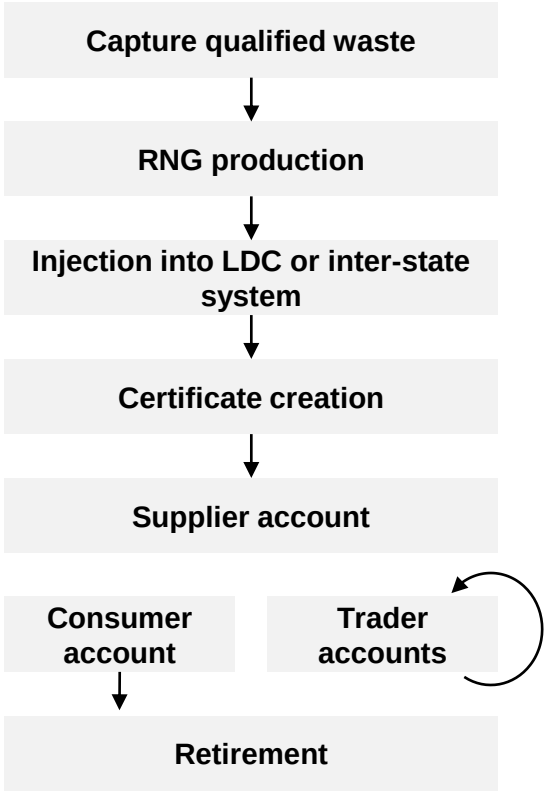


- A multitude of state and utility RNG targets with focus on thermal sector natural gas demand (local distribution company natural gas demand) have been announced and implemented since 2019
- Achievement of utility and state targets could result in thermal sector RNG demand of ~0.6 Bcf/d by 2030-45, up from ~0.07 Bcf/d in 2023. 85% of these targets are related to RNG consumption in the US West Coast; 10% cover the Northeast
- Key state RNG targets include:
  - California's SB 1440 mandates 12.2% RNG delivery by 2030 for core customers
  - Oregon's SB 98 sets voluntary RNG procurement targets: 5% (2020-2024), rising to 30% (2045-2050)
  - Nevada's SB 154 targets 3% RNG share of natural gas by 2035
  - The above targets focus on investor-owned utilities; utilities are allowed to partially recoup investment and operational costs related to achieving these targets from specific customer segments through tariffs, also known as rate-based investments
- Key utility RNG targets include:
  - SoCalGas targets 20% RNG share by 2030; Pacific Gas targets 10-20%
  - Dominion aims for net-zero emissions by 2045; RNG demand equivalent to ~6% of current residential, commercial and industrial natural gas demand is implied
  - National Grid in the Northeast targets 15% RNG share of current natural gas demand by 2030
  - Vermont Gas System plans to increase RNG's share in the supply mix to retail customers to 20% by 2030. Furthermore, in Vermont, the Clean Heat Standard is intended as the mechanism to facilitate thermal sector greenhouse gas emissions reduction by creating a market incentive comparable with the LCFS scheme in California

Source: Corporate websites, government announcements, S&P Global analysis

US thermal markets: RNG tracking certificates play a critical role in tracking the process of RNG targets such as Oregon SB 98

Simple M-RETS renewable thermal certificate life cycle



Renewable thermal certificate structure

Certificate details
Serial number
Account
Project
Thermal resource
Feedstock
Vintage
Location
Quantity
Carbon pathway (carbon intensity)
IRE (independent reporting entity)

Overview

- Oregon SB 98, enacted in 2019, establishes targets for the use of RNG by Oregon's natural gas utilities
- The law directs the Oregon Public Utility Commission (OPUC) to develop mechanisms for utilities to recover their investments in RNG projects
- The targets increase gradually from 5% in 2020-24 to 30% by 2045-50, providing strong incentives for investment in RNG projects

RNG investment and monetisation

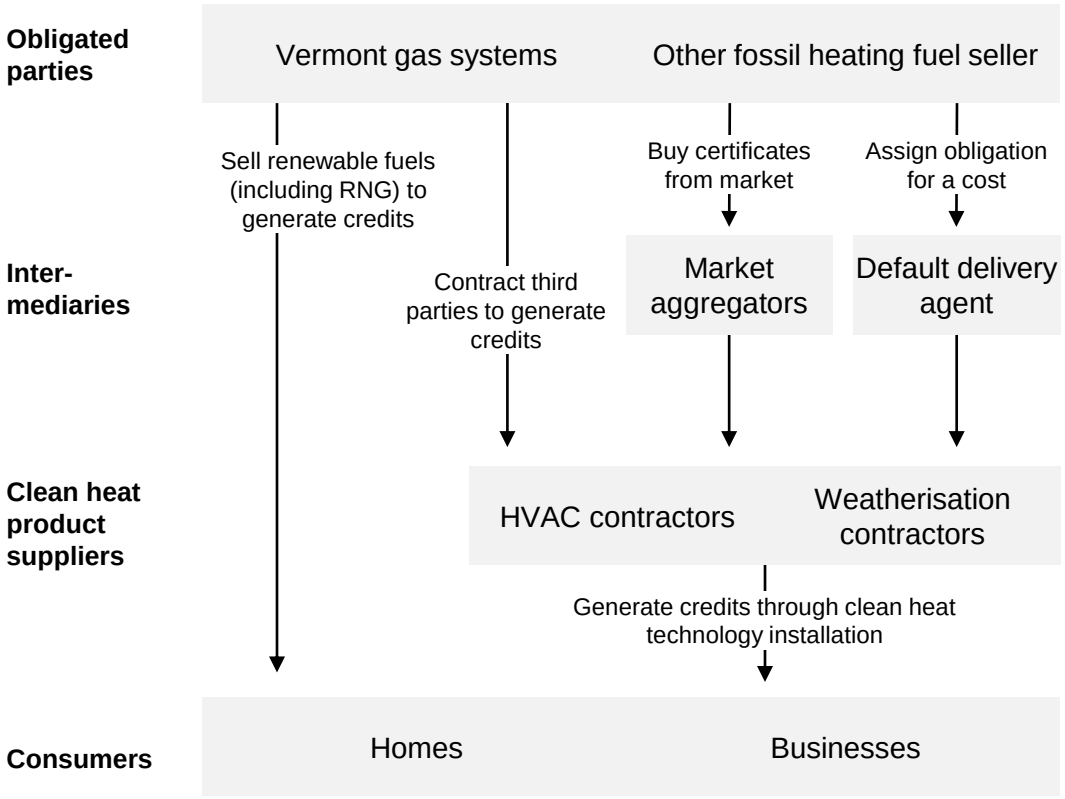
- Utilities can recover costs related to RNG production investment, as well as expenses for procuring RNG from third parties through tariffs
- SB 98 allows utilities to procure RNG from within and outside the state through the purchase of Renewable Thermal Certificates (RTC) managed on the M-RETS platform
- Importantly, the use of a book and claim system such as M-RETS allows utilities to acquire RNG without the need for a physical connection between the source of RNG consumption and the point of consumption, providing greater flexibility in RNG investment and consumption
- To date, carbon intensity variations in RNG supplies are not considered in the SB 98 RNG targets. However, carbon intensity is recorded on RTCs and may affect the value in the future
- RTC certificates are tradable; while there is no public information of their value, it is understood they can play a significant role in the economics of new RNG production for the thermal sector
- It needs to be noted that investments in RNG and the share of RNG in the supply mix needs to be approved by the OPUC, with the impact of carbon emissions reduction and cost assumed to be key criteria

Sources: S&P Global, National Law Review, NW Natural, M-RET

*M-RETS is a nonprofit operating the environmental attribute tracking platform in support of voluntary carbon emissions reductions schemes but is also the designated platform for obligatory schemes such at the California Clean Fuel Standard

US thermal markets: Vermont Clean Heat Standard incentivises RNG and other clean heat investments by obligating fossil fuel importers to retire clean heat credits

Vermont Clean Heat Standard Clean Heat Credit generation



Overview

- The Vermont Clean Heat Standard (CHS), passed into law in 2023, aims to reduce greenhouse gas emissions from the thermal sector, which includes heating and hot water for buildings, in line with the Global Warming Solutions Act of 2020
- Fossil fuel wholesalers and dealers, including the main gas utility Vermont Gas Systems, who sell or import fuel into Vermont must reduce emissions by retiring Clean Heat Credits (from 2025 onwards). These credits can be generated by switching to lower-emitting renewable energy sources or installing equipment that avoids emissions
- Clean Heat Credits are earned through approved actions called clean heat measures, such as switching from natural gas to RNG or installing cold climate heat pumps. Obligated entities can either implement these measures themselves or pay a statewide default provider to do so
- Implementation and compliance: The Vermont Public Utility Commission is responsible for designing the rules for credit valuation, setting obligations and verifying compliance

RNG investment and monetisation

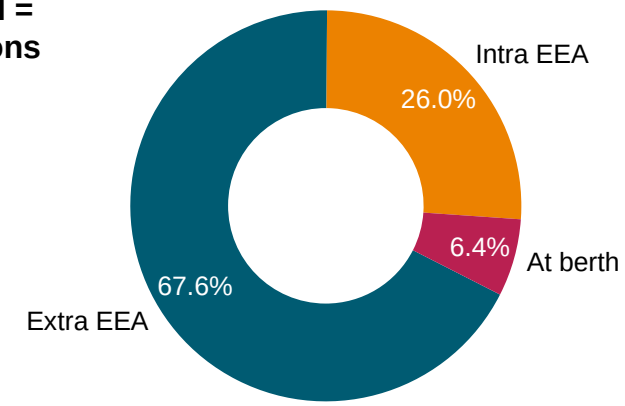
- CHS is likely to stimulate RNG production and consumption in Vermont, although there will be strong competition with alternative emissions reductions options such a heat pump installation
- It is not clear if the carbon intensity of specific RNG production sources will impact Clean Heat Credit generation, but it is understood that associated level of carbon intensity for RNG production eligible for the credits will gradually decrease over time, from 80 gCO_2eq/MJ in 2025 to below 20 gCO_2eq/MJ in 2050. The need for physical connection between point of production and consumption, in the form of pipeline capacity bookings, will likely add some limitations to RNG imports from out of state, despite economies of scale and carbon intensity of feedstock being more favourable
- It is understood that platforms that would abolish the need for a physical connection between RNG production and consumption are being considered

Sources: Vermont PUC, Vermont Gas Systems, Regulatory Assistance Project

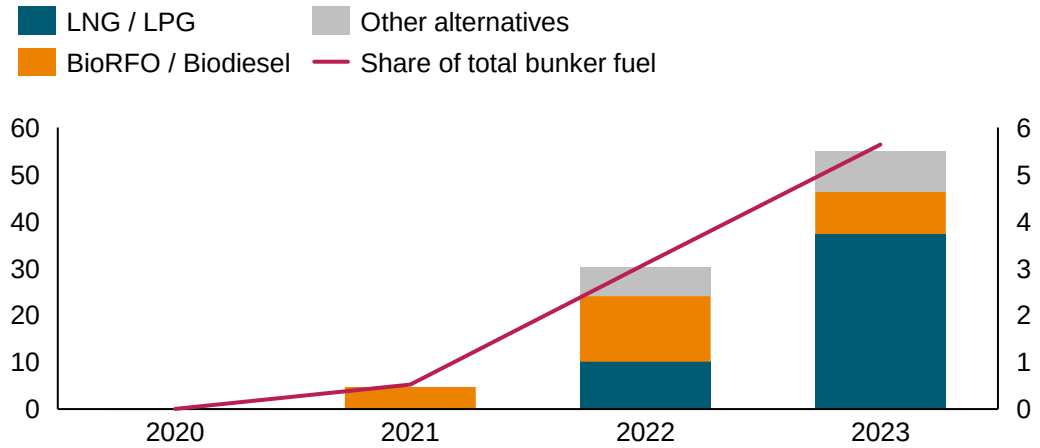
EU carbon pricing and regulations cover a significant proportion of global shipping, providing opportunity for RNG-derived bunker fuels

2021 EU MRV [1] CO_2 emissions by voyage type
Million tons CO_2eq

EU MRV Total = 124 million tons



Alternative European bunker fuel demand by type
Thousand barrels of oil eq. per day[2] %



- EU ETS, which is currently extending European carbon pricing to the maritime sector, and FuelEU Maritime, a regulation set to reduce the emissions intensity of European shipping, are expected to have a strong impact on the rise of low carbon fuels in shipping. This includes providing an opportunity for RNG-derived bunker fuels, such as bio-LNG and bio-methanol
- Alternative lower carbon bunker fuels (including LNG / LPG, liquid biofuels, methanol, ammonia and batteries) have strongly increased their market share in Europe in recent years (from 1% in 2021 to 6% in 2023); they are expected to increase market share further to c. 20% by 2030
- EU ETS and FuelEU Maritime will not only cover intra-EU voyages, but also partially cover (50%) emissions for voyages to and from ports outside of the EU, leading to a coverage of close to 15% of total global shipping emissions (2021)
- Industry participants and commentators have stated to S&P Global Commodity Insights that clarity in the certification of biofuels and RNG is key to increase uptake, particularly considering biofuel and RNG production and supply outside the EU required for compliance with FuelEU Maritime and EU ETS

Source: European Commission, SPGCI Freight Markets Bunker Forecast (July 2024)
1 MRV = Monitoring , Reporting and Verification = emissions covered under EU ETS and FuelEU.
2 One thousand barrels of Oil Eq. per day = 0.65 TWh/a

EU ETS, FuelEU Maritime and corporate targets are likely to support the value and need for RNG production and certificates

Demand driver	Impacted market	Key parameters	Implied value GHG reductions	Certification requirements
EU ETS in shipping	• Starting from 2024 (gradual implementation period to 2027) • Covers c. 125 million tons of CO_2 emissions based on EU MRV fleet reporting • Covers all emissions from vessels with < 5,000 gross tonnage for voyages	• 100% of emissions for voyages between EU ports • 50% of voyage emission for voyages to and from EU ports • Emissions covered: Carbon and NOx (from 2024) and CH_4 (from 2026)	• EU ETS Carbon prices traded on average at c. 83 €/tCO_2eq in 2023 and could rise to above 200 €/tCO_2eq by 2050 in real terms	• Compliance with EU MRV required • Compulsory use of Union Database as traceability tool required • Selected accredited certification bodies: – ISCC EU1 – REDcert
FuelEU Maritime	• Starting from 2025 • Same vessel and voyage coverage as EU ETS	• FuelEU Maritime requires fleet operators to achieve relative emissions intensity reductions for the covered fleet of 2% by 2025, 6% (2030), 14.5% (2035), 31% (2040), 60% (2045) and 80% (2050) • Reductions to be made against a fuel carbon intensity reference value of 91.16 gCO_2eq/MJ	• Penalties of €2,400 per ton Very Low Sulphur Fuel Oil (VLSFO) energy equivalent, or about €58.50 per GJ of non-compliant energy use imply non-compliance costs of c. €640/tCO_2eq • Negative CI from bio-LNG or bio-methanol can be counted towards FuelEU Maritime regulation emissions reductions requirements, driving uptake in RNG demand and the need for certification	• Compliance with EU MRV required • Certification follows RED requirements • Compulsory use of Union Database as traceability tool required • Selected accredited certification bodies: – ISCC EU* – REDcert
Corporate targets	• Key European shipping companies are already increasing or have stated their intention to increase the use of bio-LNG and bio-methanol, supporting their net-zero emissions strategies	• The top three container ship operators are already sourcing or have committed to source RNG-based shipping fuels, including bio-methanol and bio-LNG	• Shipping companies are already offering low carbon shipping solutions to their clients, which are backed by RNG, acquired through GO schemes, going beyond the requirements of FuelEU Maritime regulations	• ISCC is assumed to offer certification for RNG-derived marine bunker fuels • Container shipping companies have referred to GO purchases

Sources: European Commission , DNV, European Commission Voluntary Schemes
1 GATE (NL) and Zeebrugge (BE) LNG regasification terminals received ISCC certification for Bio-LNG supply in 2021

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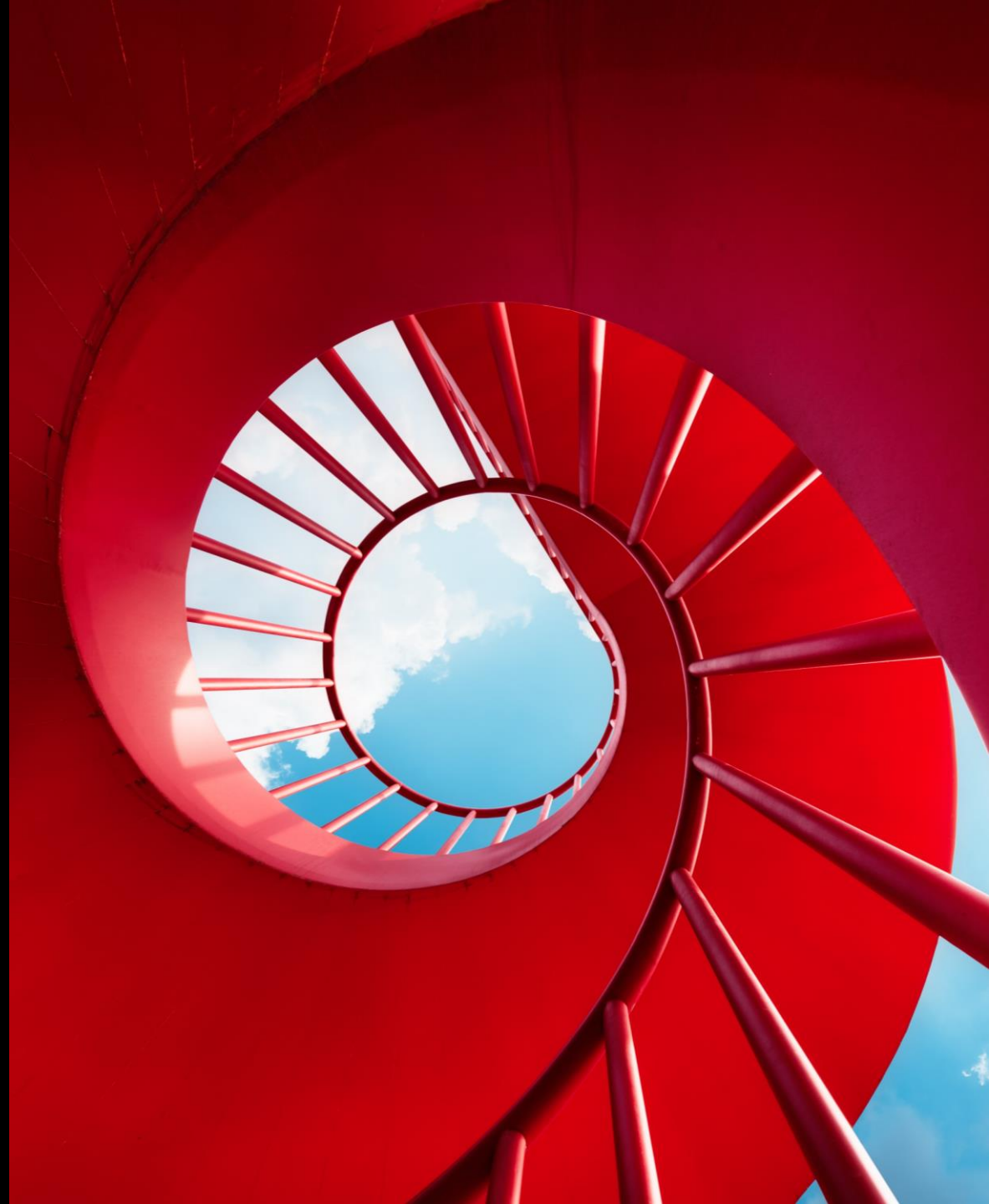

Abbreviations

Abbreviation	Meaning	Abbreviation	Meaning
Bcm/a	Billion cubic metres per annum	**GJ**	Gigajoule
BPC	Biogas Production Certificates	**HVAC**	Heating, ventilation and air conditioning
CARB	California Air Resources Board	**LCFS**	Low Carbon Fuel Standard
CHP	Combined heat and power	**LNG**	Liquefied natural gas
CI	Carbon intensity	**MJ**	Megajoule
CNG	Compressed natural gas	**PoS**	Proof of Sustainability
DDV	Default emission value	**RED**	European Union Renewable Energy Directive
EPA	Environmental Protection Agency	**RFS**	Renewable Fuel Standard
ESG	Environmental, social and governance	**RHI**	Renewable Heat Initiative
ETS / ETS-2	EU Emissions Trading System	**RIN**	Renewable Identification Number
Fit-for-55	EU Climate Target Plan	**RNG**	Renewable Natural Gas (biomethane)
GGSS	Green Gas Support Scheme	**RTFO**	Renewable Transport Fuel Obligation
GHG	Greenhouse gas	**SAF**	Sustainable Aviation Fuel
GHGP	Greenhouse Gas Protocol	**Ton(s)**	Metric ton(s)
GO / GOs	Guarantee(s) of Origin	**UDB**	Union Database for Biofuels

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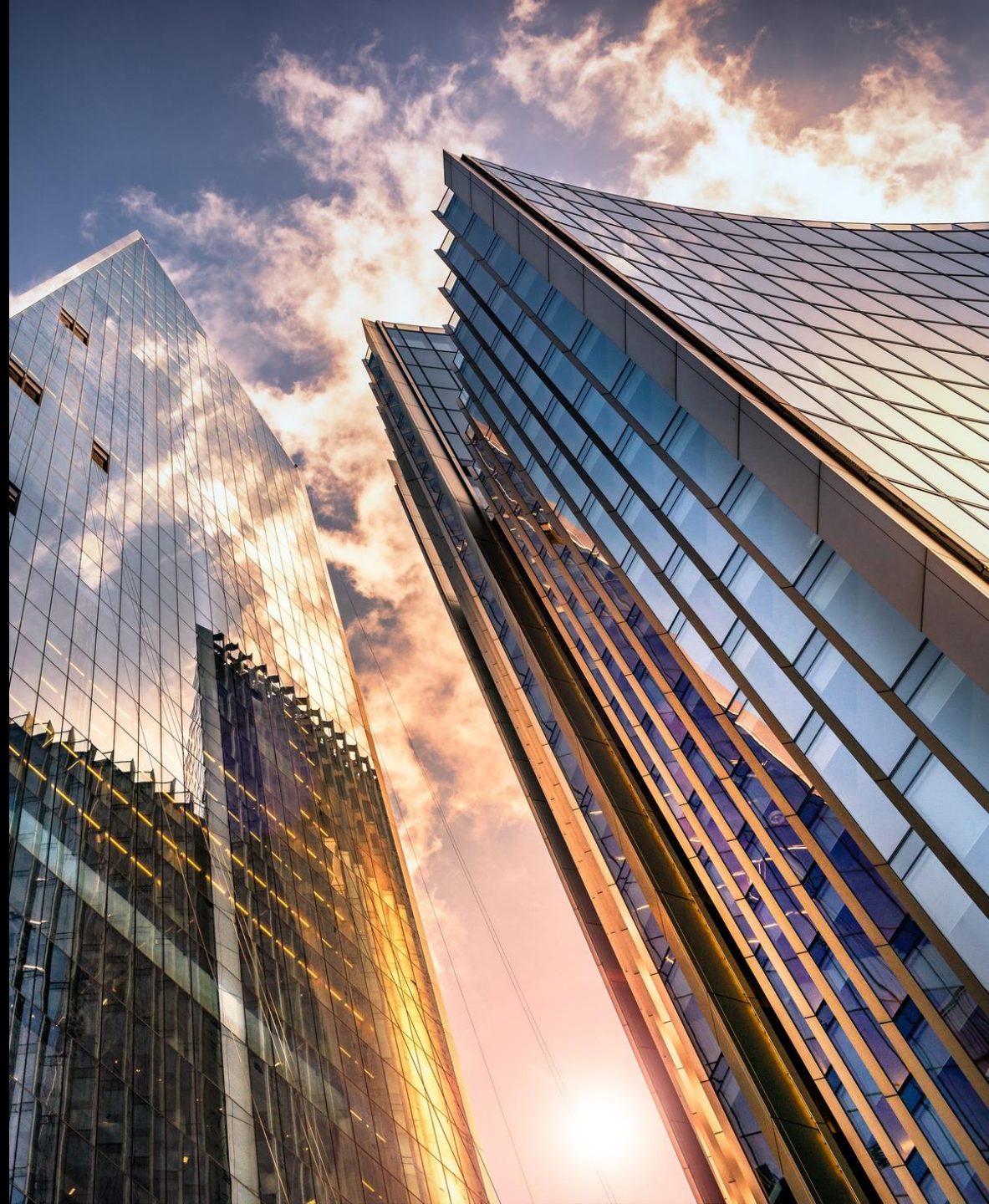

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