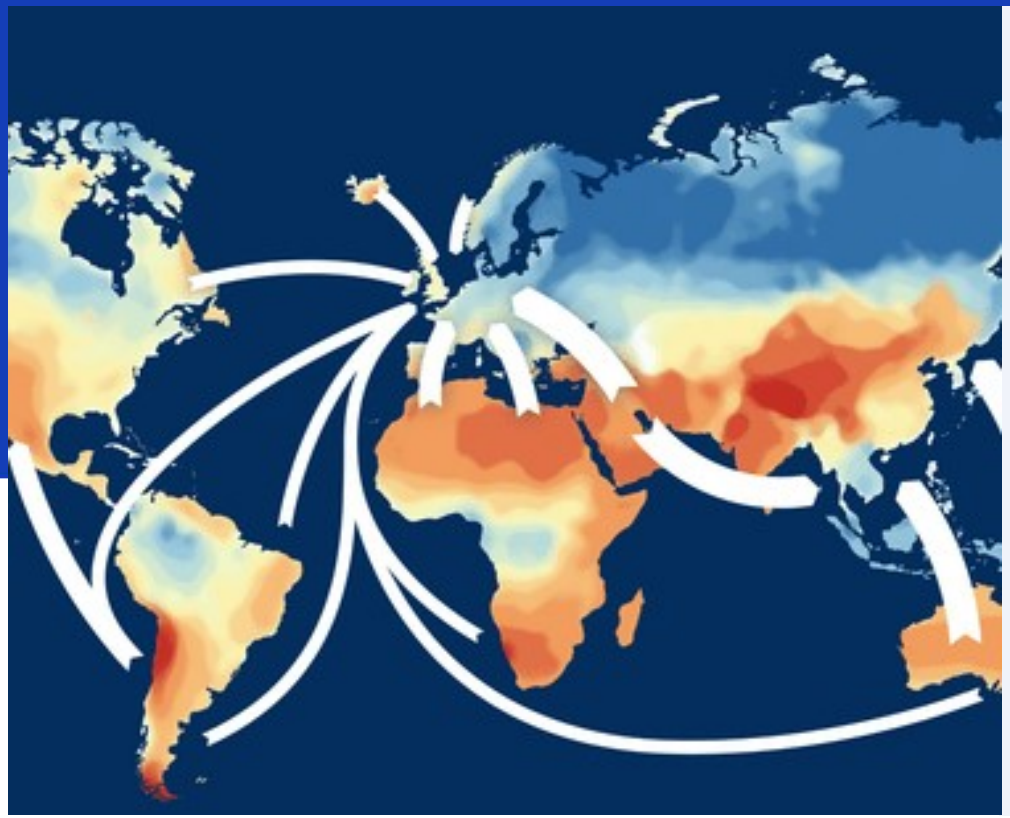
SHIP>NL sessie IX 2024

Drs. M.C.M. Rijkers

Start presentation

TNO innovation for life

Agenda SHIP>NL sessie 16 oktober 2024



1. Welkom
2. Deep dive: RFNBO certification: The role of certification in bringing imported hydrogen to Europe
   David Bolsman | RVO
3. Afsluiting

Huisregels

- Camera aan, microfoon op ‘mute’
- Vragen?
  - Plaats verduidelijkingsvragen in de meeting chat; of
  - Steek je hand op!
- De moderator zorgt ervoor dat je vraag beantwoord wordt (eventueel achteraf).
- De slides worden na de sessie gedeeld. Slides van de andere sessies zijn te vinden op SHIPNL: Sustainable Hydrogen Import Program Netherlands | Nationaal Waterstof Programma

- We bespreken uiteraard geen marktgevoelige zaken.

- Chatham house rules: De besproken informatie mag gedeeld worden, maar zonder de spreker te onthullen.

Meerjarig kennisprogramma met 5 lijnen

- **In deze sessie:**

1 Technisch economisch	2 Beleid	3 Markt	4 Internationaal	5 Omgeving
▪ Inzicht in importketens productie-conversie-transport-opslag-reconversie-gebruik ▪ Vraagontwikkeling, scenario's ▪ Infrastructuur & systeemintegratie: corridors, benutten bestaande infra. ▪ Technology assessments, R&D	▪ Impact van 'Fit for 55', REDII, Delegated acts, ETS/CBAM, etc. ▪ Impact van certificering en CO2 allocatie: emissiefactoren, LCA ketenanalyse, etc. ▪ Financiering en stimulering (EU & NL): IPCEI, PCI, TEN-E, JTF, EIB, Horizon Europe, MOOI, DEI, MIEK, SDE++, etc	▪ Marktmodellen: bilaterale contracten, vrije handel, waterstofbeurs ▪ Internationale handelsstromen: verwachte vraag- en aanbodvolumes en transportstromen ▪ Importtarieven, trade agreements en handelsbeperkingen, WTO, etc.	▪ Samenwerking met omringende EU/niet-EU importlanden om corridors te ontwikkelen ▪ Concurrentie met omringende EU/niet-EU importlanden ▪ Geopolitieke aspecten: strategische voorraden, afhankelijkheid, politieke stabiliteit van exportlanden	▪ Ruimtegebruik van ketenelementen ▪ Veiligheid: brandbaarheid, zorgwekkende stoffen, risicocontouren, etc ▪ Milieu: stikstof, lekkage ▪ Maatschappelijke acceptatie ▪ MVO / samenhang met SDG's in exportlanden

Deep dive:
RFNBO certification:
The role of certification in bringing imported hydrogen to Europe

- David Bolsman| RVO

Netherlands Enterprise Agency

RFNBO certification

The role of certification in bringing imported hydrogen to Europe

October 16

SHIP-NL

>> *Sustainable. Agricultural. Innovative. International.*

Agenda

- Criteria for RFNBOs
  - REDIII and Delegated Regulations
- Voluntary Schemes
- Study – Import of RFNBO hydrogen (NH3 or LH2) from WA via Port of Rotterdam (NL) to Duisburg (Ger)
- Study - Import of RFNBO E-fuels from Uruguay and Chili to the Netherlands
- Conclusions

(Acknowledgement: slides used from Fichtner (study Australia) and Hinicio (study South-America)

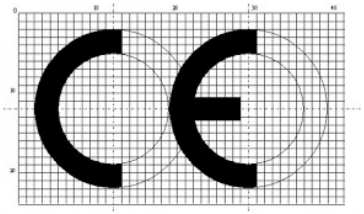
Note: Throughout this presentations, terms like 'RFNBO compliant', 'meeting RFNBO criteria', or similar, are meant to be read as "*RFNBO that meet the requirements as described in RED II/III and Delegated Regulations 2023/1184 and 2023/1185*". There are also RFNBO that do not meet the all these criteria; they may still be called RFNBO but cannot be used to count towards the sector targets set out in RED III.

Certification in the context of European Directives (e.g. CE marking)

- **Objective of European certification requirements is to facilitate the *internal* market**

- European rules are laid down in Directives; these are implemented by the Member States in their legislation
- Various Guidelines refer to Certification
- The certification bodies are designated by the Member States and registered in Brussels (Notified Body (NoBo); Competent Body)
- NoBo certificates and Competent Bodies' reports are accepted throughout the EEA; there is also *mutual recognition*

  - CE marking is essentially 'self-certification': the 'manufacturer' writes and signs the "Declaration of Conformity " (Doc)
  - Certificates of NoBo's (Certificate of Conformity – CoC) are part of the manufacturer's technical file



European legal framework

- EU Treaty (‘constitution’)
  1. Binding legal instruments
  2. Non-binding legal instruments
  3. Legal instrument for implementation

- European Comission is day-to-day policy and operation
- European Council makes the decisions
  - Council of government leaders
  - Council of Ministers
- European Parliament approves/rejects legislation

Binding legal instruments

- Directive:
  - This legally binding act of the European Union establishes a set of objectives which all member states of the European Union must fulfil. The member states are required to implement directives. The member states are free to choose the manner they see fit to fulfil the required objectives.
- Regulation
  - This legally binding act of the European Union is directly applicable in all member states of the European Union. The regulation is similar to national legislation in terms of the impact and direct effect it generates. As such the regulation is the most pervasive of all the legal instruments of the EU.
- Decision
  - A decision is legally binding act in its entirety. Unless explicitly stated otherwise, a decision is binding for the EU as a whole. Decisions can address specific legal entities, in which case a decision is binding only to them. In its current form the decision was introduced with the Lisbon Treaty that came into force December 2009. It replaces various legal instruments introduced by earlier Treaties.

Others:

- Budget
- International agreement
- Interinstitutional agreement
- Treaty
- Act
- Protocol

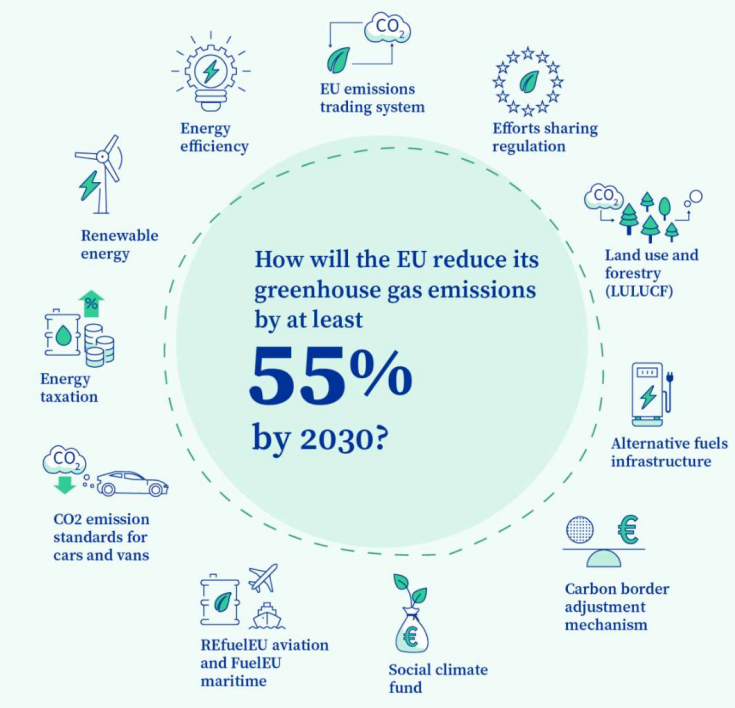
Non-binding legal instruments

- Recommendation
- Opinion
- Guideline
- Communication
- Declaration
- Green paper
- White paper
- Report
- Working paper

Legal instruments for implementation

- Delegated decision
  - This legally binding act of the European Union is directly applicable in all member states of the European Union. Delegated decisions can address specific legal entities, in which case it is binding only to them.
- Delegated directive
  - This legally binding act of the European Union establishes a set of objectives which all member states of the European Union must fulfil. The member states are free to choose the manner they see fit to fulfil the required objectives.
- Delegated regulation
  - This legally binding act of the European Union is directly applicable in all member states of the European Union. The delegated regulation is similar to national legislation in terms of the impact and direct effect it generates.
- Implementing decision
  - This legally binding act of the European Union is directly applicable in all member states of the EU. Implementing decisions can address specific legal entities, in which case it is binding only to them.
- Implementing directive
  - This legally binding act of the European Union establishes a set of objectives which all member states of the European Union must fulfil. The member states are free to choose the manner they see fit to fulfil the required objectives.
- Implementing regulation
  - This legally binding act of the European Union is directly applicable in all member states of the European Union, akin to national legislation. Implementing regulations take precedent over national legislation in case the two contradict one another.

EU LAUNCHED "FIT FOR 55“, AIMING TO REDUCE ITS GHG EMISSIONS BY 55% bY 2030 COMPARED TO 1990 LEVELS AND TO BE NET-ZERO BY 2050



How will the eu translate Its climate goals into legislation?

- In July 2021, the European Commission adopted a package of legislative proposals aimed at **revising and updating existing EU legislation** while introducing new laws.
- Key solutions for decarbonization in this context include renewable energy, clean fuels and H2, used as industrial feedstock, and for mobility applications such as heavy-industry transport, maritime transport, and aviation.
- **Six cross-cutting legislative proposals** are relevant to H_2 and its derivatives:

1. Emission Trading Scheme: **ETS**[1]
2. Imports: Carbon Border Adjustment Mechanism: **CBAM**[2]

Carbon Pricing

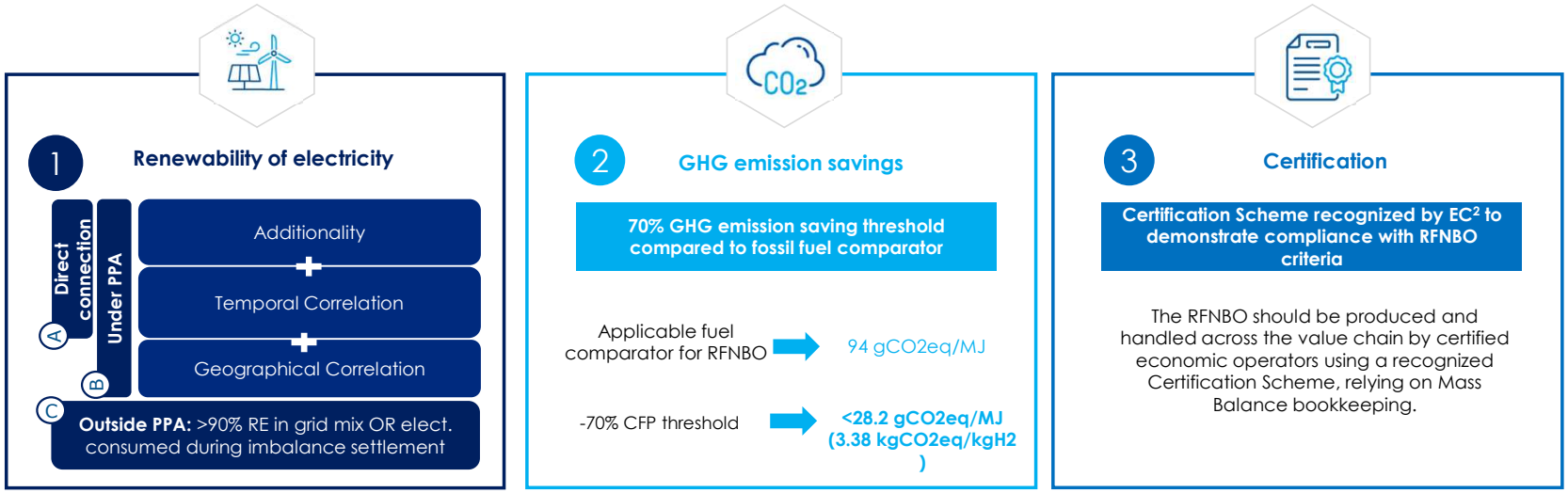
3. Maritime Fuels: **FuelEU Maritime**[2]
4. Aviation Fuels: **ReFuelEU Aviation**[2]
5. Renewable Fuels for Transport: Renewable Fuels of Non-Biological Origin - RFNBO (**RED II & III**)[2]
6. Renewable Raw Material for Industry: RFNBO (**RED III**)[2]

Clean fuels/renewable energies

[1]Law Amendment
[2]New Law Proposal

REQUIREMENTS FOR RENEWABILITY, CFP[1] CALCULATION & CERTIFICATION HAVE BEEN DETAILED IN DELEGATED & IMPLEMENTING REGULTATIONS

To be **RED compliant, an RFNBO** needs to:
- Fulfill the criteria for renewability and GHG emissions reduction compared to fossil fuel-based alternatives
- Be certified under a Voluntary Scheme recognized by the European Commission relying on Mass Balance



[1] CFP = Carbon Footprint
[2] EC = European Commission

Sources; DIRECTIVE (EU) 2018/2001 of the European Parliament and of the Council (2018); DIRECTIVE (EU) 2023/2413 of the European Parliament and of the Council (2023); COMMISSION DELEGATED REGULATION (EU) 2023/1184 (2023).

Certification of Hydrogen

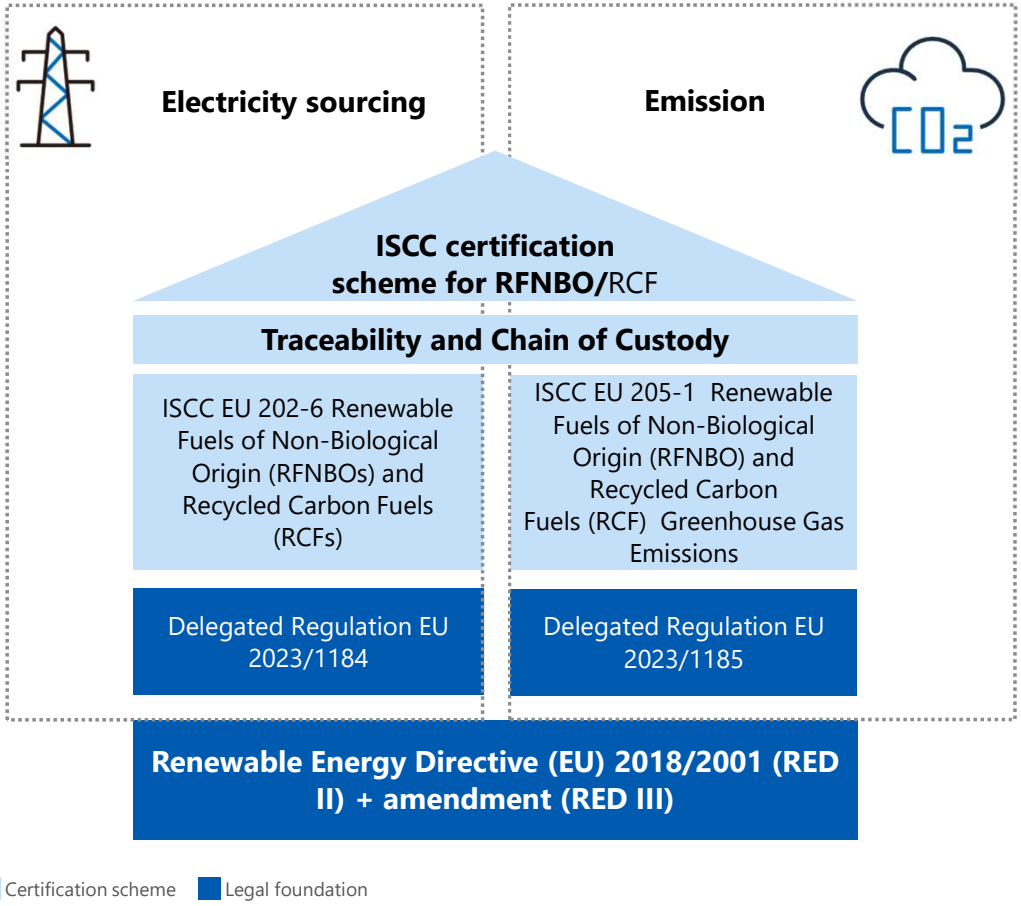
- As with any certification, the first condition is an unambiguous reference, for example a standard or norm.
- A European Norm or Standard (EN) is currently lacking*) , but the RED II/III directive plus both Delegated Regulations do contain unambiguous criteria that can be interpreted as requirements for certification.
- The REDIII directive calls for Voluntary Schemes for the certification of RFNBO hydrogen.
- Various certification scheme owners are working on their own ‘voluntary scheme’.
- 5 have been submitted to the EC for recognition
- 3 have passed the technical review recently and they will be recognised once all 27 member states have agreed
  - ISCC
  - RedCert
  - CertifHy

  The other 2 will likely follow soon

*) Standardization, the process of arriving at a standard, is often quite lengthy and usually lags slightly behind the technical process developments in the market.

Based on RED II and Delegated Acts ISCC provides certification scheme for RFNBO in two main scopes – Electricity sourcing and CO_2 emission

Certification scheme and legal basis



Comments

- **EU's Renewable Energy Directive (RED)** set specific targets on share of RFNBO in each sector – Driving in increasing need for RFNBO projects
- **RED II with amendment** Directive (EU) 2023/2413 **(RED III)** and **two Delegated Regulations** are the **legal foundation** for ISCC certification scheme
- To be **certified as RFNBO,** a minimum of **70% GHG emission savings must be achieved**
- RFNBO should be certified in two main aspects
  - **Electricity sourcing**
  - **Emission**
- **Traceability and Chain of Custody** act as the overarching principle in certification

Source: EC; ISCC; Fichtner

RED III requirements for RFNBO's

What are the key principles?

Additionality	• Hydrogen production should add to the deployment of renewable energy
Temporal correlation	• Renewable hydrogen should be produced when renewable electricity is available
Geographic correlation	• There should be no grid congestions between de place where the renewable electricity is produced and where the renewable hydrogen is produced.
70% CO2 reduction vs. fossil fuel comparator*	• The complete supply chain must be assessed, cradle to grave.

* fossil fuel comparator is grey H2 with SMR, based on natural gas: which is **94 g CO_2eq/MJ**

RED II en III Directives:
European **Renewable Energy Directive**: (EU/2018/2001, amended by EU/2022/759 and EU/2023/2413)

Delegated Regulations:
2023/1184 – RFNBO criteria
2023/1185 – GHG emissions threshold and calculations

Source: Bernd Kuepker, European Commission

Depending on whether the RFNBO production connects to grid, prove of additional requirements is necessary for individual options

Summary eligible “fully renewable” electricity supply

Option 1
Direct Connection

Option 2
Grid Connection

Option 1
No connection to the grid or if connected to the grid only with smart metering system in place

+ **Additionality**

Option 2a
>90% RES-E share in the grid/bidding zone

Option 2b
<18 g CO2eq/MJ GHG intensity in the grid/bidding zone

Option 2c
Electricity taken from the grid reduces temporal grid imbalance

Option 2d
All other grid connections

+ **Additionality**
Temporal correlation
Geographical correlation
PPA concluded

Possible option Requirements not fulfilled

NH4SDVJ5QEZT-1257416149-396669

Source: ISCC; Fichtner

DIFFERENT ELECTRICITY SOURCING OPTIONS ALLOWED, EACH WITH SPECIFIC CONDITIONS TO CLAIM A MOLECULE AS RFNBO

Pathways	Scenario	Electricity supply for H_2 production	Hydrogen type	Percentage of renewable hydrogen	Additional renewability conditions / elements to be considered
A	Direct connection		H	100%	• Additionality • Temporal correlation • 70% GHG emissions saving
B	Grid based with a Power Purchase Agreement (PPA)		H	100% Up to the **power consumption of electrolyzer production that is covered** by the PPA.	• Additionality • Temporal and Geographical correlation • 70% GHG emissions saving
C	Grid-based without PPA but with > 90%* Renewable Energy (RE) in the consumption mix		H	100% To the extent that the **electrolyzer ratio of full load hours does not exceed the share of RE** in the bidding zone gross consumption mix **as per 1 year before production**	(*) RES share of over 90% demonstrated in at least one year within the previous five years in the bidding zone • 70% GHG emissions saving.
	Grid based without PPA with less than 90% RE grid mix		H	X% **X% of RE** in bidding zone **production mix 2 years prior** to production.	• 70% GHG emissions saving.

Renewable energy (RE) production asset (excl. biomass) | Grid | H_2 production asset / electrolyzer | Renewable Fuel of Non-Biological Origin (RFNBO) | Mix of RFNBO H_2 and conventional H_2

[1] PPA: Power Purchase Agreement (PPA not required in case that RE asset is owned by the fuel producer).
[2] GO: Guarantees of Origin (renewable energy certification), hourly data required from 1.1. 2030 onwards.

Sources: DIRECTIVE (EU) 2018/2001 of the European Parliament and of the Council (2018); COMMISSION DELEGATED REGULATION (EU) 2023/1184 (2023).
(*) Article 2, point (65), of Regulation (EU) 2019/943 of the European Parliament and of the Council (2019).

Netherlands Enterprise Agency

Study RFNBO imports from Australia

Fichtner

Engineering & Consulting

For:

Netherlands Enterprise Agency

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Sessie IX 16 oktober 2024

FICHTNER

Conference Brief: RFNBO Study Overview

Alex Dronoff, CEO Australia

Ministry of Economic Affairs and Climate Policy of the Netherlands

Study for: Netherlands Enterprise Agency (RVO)

Renewable Fuels of Non-Biological Origin (RFNBO) certification pilot study on hydrogen derivatives produced in Australia

Federal Ministry for Economic Affairs and Climate Action

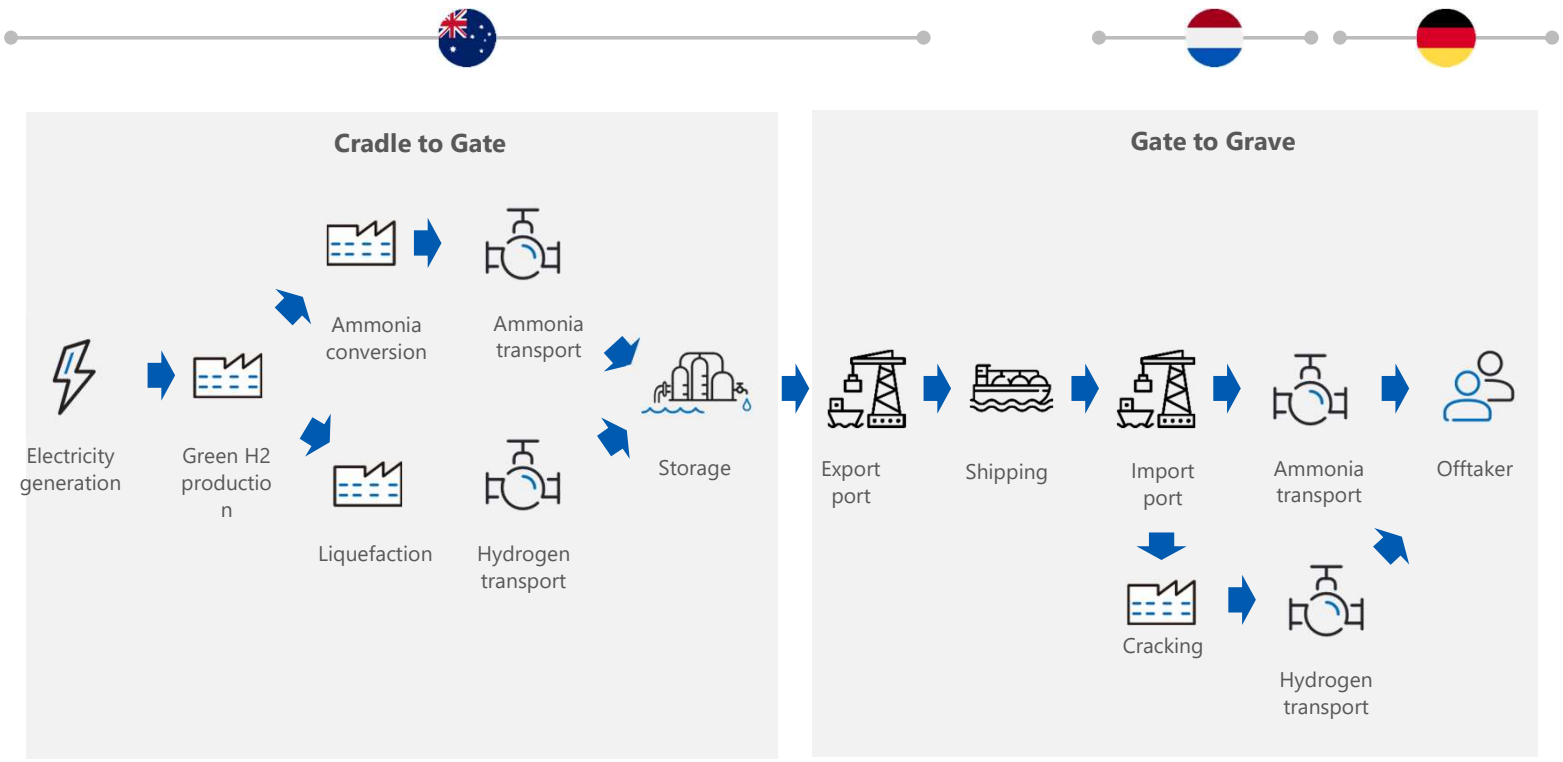
Australian Government
Department of Climate Change, Energy, the Environment and Water

12.09.2024

Agenda

The study will analyse the possibility and circumstances of RFNBO production in Australia with transport to Europe from cradle to grave

Definition of Gate to Grave



Source: Fichtner

Total GHG emissions needs to be calculated to determine the overall GHG emissions savings

Total GHG Emissions Calculations according to 2023/1185

$$\mathbf{E} = e_i + e_p + e_{td} + e_u - e_{ccs}$$

- **Total** emissions from the production and the use of the fuel
- Emission from the **supply of inputs**
- Emission from **processing**
- Emission from **transport and distribution**
- Emission from **fuel in use**
- Emission savings from **carbon capture and geological storage**

GHG emissions savings from RFNBO= $\frac{(E_F - E)}{E_F}$

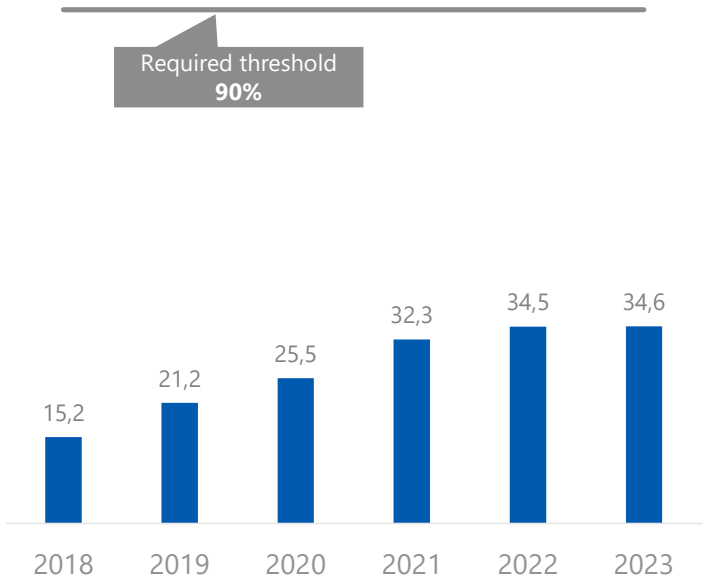
- E_F = fossil fuel comparator, which is **94 g CO_2eq/MJ**
- GHG emissions savings should be more than 70%, i.e., lower the E, bigger the savings
- Until 31st of December 2029, GHG values will need to be calculated monthly and, after 2030, on an hourly basis

Source: ISCC; Fichtner

Due to low share of renewables and high GHG emission in WEM grid, possible options to certify as fully renewable are 2c and 2d for grid connection projects

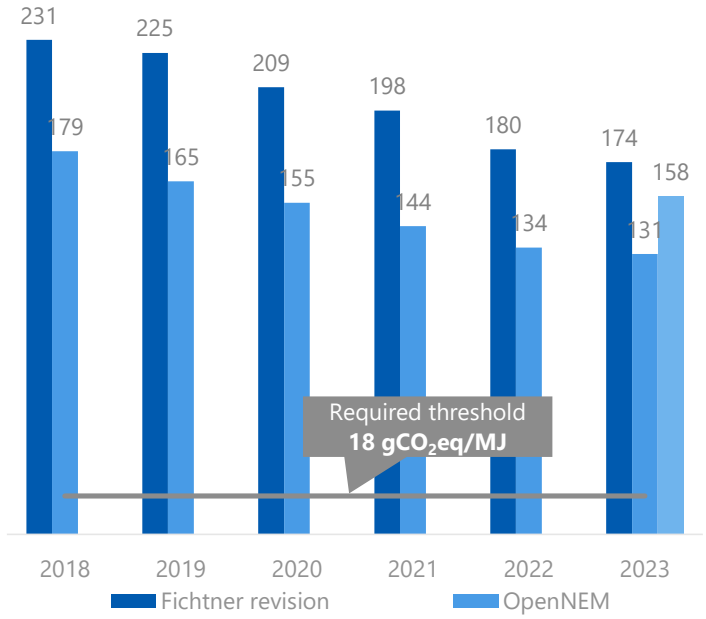
Renewable share and GHG mission in Western Australian (WA) bidding zone, 2018-2023

Renewable share [%]



Renewable share in WA bidding zone[1] (SWIS) is below the required threshold of 90% -> Option 2a is excluded as an option to qualify grid-connected project

GHG emission intensity [gCO_2eq/MJ]



GHG emission intensity in WA bidding zone[1)] (SWIS) is above the required threshold of 18 gCO_2/MJ -> Option 2b is excluded as an option to qualify grid-connected project

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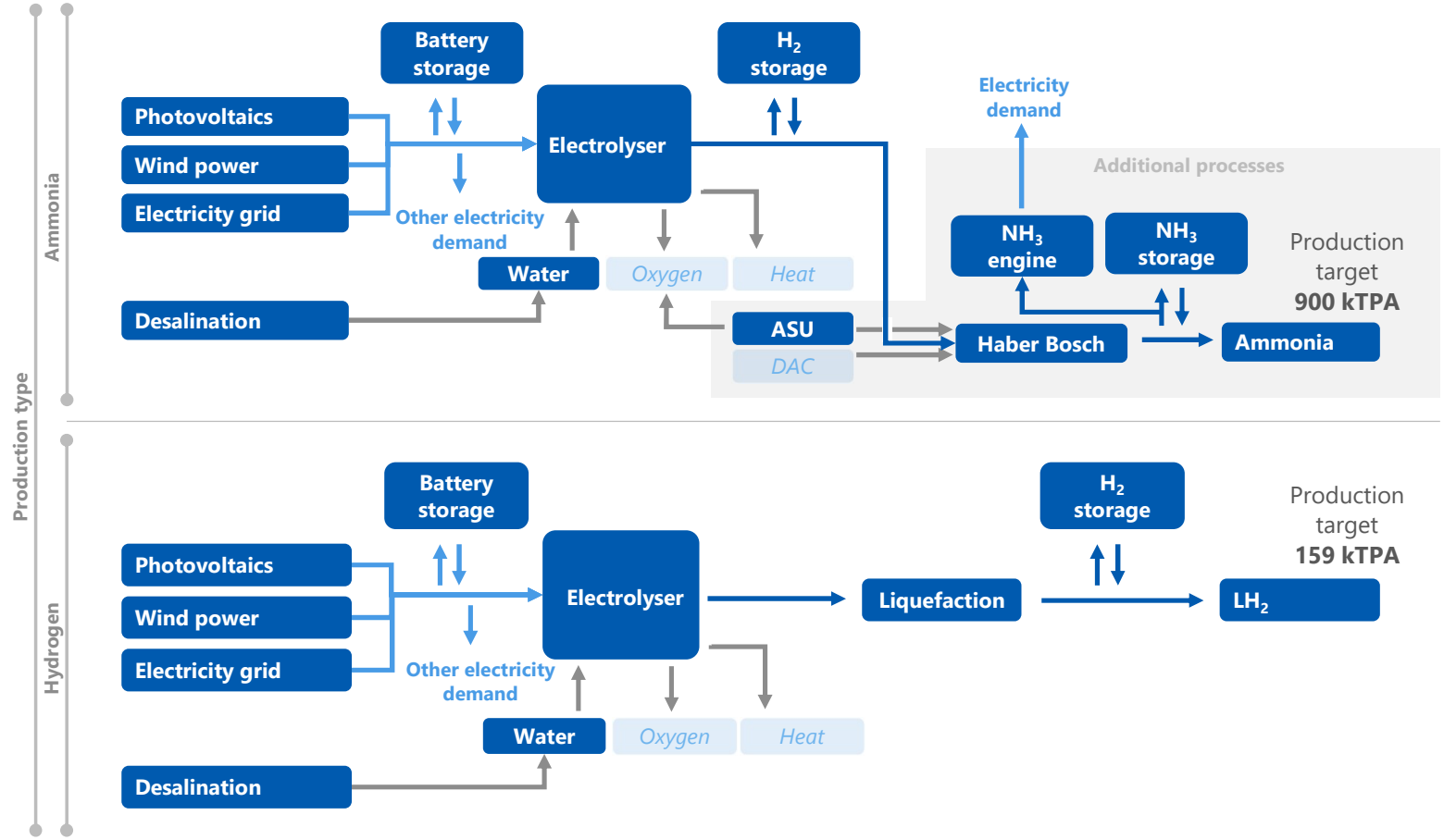
1) WEM is the bidding zone operator; SWIS is the bidding zone

Source: AEMO; NEM; ISCC; Fichtner

Due to lack of information Fichtner H2-Optimizer is used to calculate two configurations of either producing H_2 or NH_3 to gather information

Block diagram of production facility by production type (grid connect scenario)



Source: Fichtner

Only with *more than 90% renewable power* used for electrolyser, it is possible to meet the 70% GHG emission reduction target

NH_3: Sensitivity analysis: share of fully renewable power [gCO_2eq/MJ]

GHG emission **cradle to gate [gCO2eq/MJ]**

Share of fully renewable power for **electrolyzer**[1)]

Share of fully renewable power for **other production facilities**	0%	10%	20%	40%	60%	80%	90%	93%	95%	98%	100%
0%	374.1	339.5	304.9	235.7	166.5	97.3	62.7	54.1	45.4	36.8	28.1
10%	371.3	336.7	302.1	232.9	163.7	94.5	59.9	51.3	42.6	34.0	25.3
20%	368.5	333.9	299.3	230.1	160.9	91.7	57.1	48.5	39.8	31.2	22.5
30%	365.8	331.2	296.6	227.4	158.2	89.0	54.4	45.7	37.1	28.4	19.8
40%	363.0	328.4	293.8	224.6	155.4	86.2	51.6	42.9	34.3	25.6	17.0
50%	360.2	325.6	291.0	221.8	152.6	83.4	48.8	40.1	31.5	22.8	14.2
60%	357.4	322.8	288.2	219.0	149.8	80.6	46.0	37.4	28.7	20.1	11.4
70%	354.6	320.0	285.4	216.2	147.0	77.8	43.2	34.6	25.9	17.3	8.6
80%	351.9	317.3	282.7	213.5	144.3	75.1	40.5	31.8	23.2	14.5	5.9
90%	349.1	314.5	279.9	210.7	141.5	72.3	37.7	29.0	20.4	11.7	3.1
100%	346.3	311.7	277.1	207.9	138.7	69.5	34.9	26.2	17.6	8.9	0.3

Emission below 28.2 gCO2eq/MJ Emission above 28.2 gCO2eq/MJ

Comments

- Electricity used for H_2 production contributes to the low heating value of end product, e.g., ammonia – while other power does not
- Two variables of power sources are chosen for sensitivity analysis
- **Most power demand** of RFNBO (ammonia) production is for **electrolyzer** (more than 90%)
  - The impact of **power source** for **other facilities** is **limited**
- Fully renewability of power for electrolyzer is decisive, not only for the share of product as RFNBO, but contributing to most of GHG emission
- The recommended production case is **fully renewable power input for electrolyzer**
- At 100 % small GHG emission due to assumption that electricity for Desalination and water treatment is always sourced from the grid

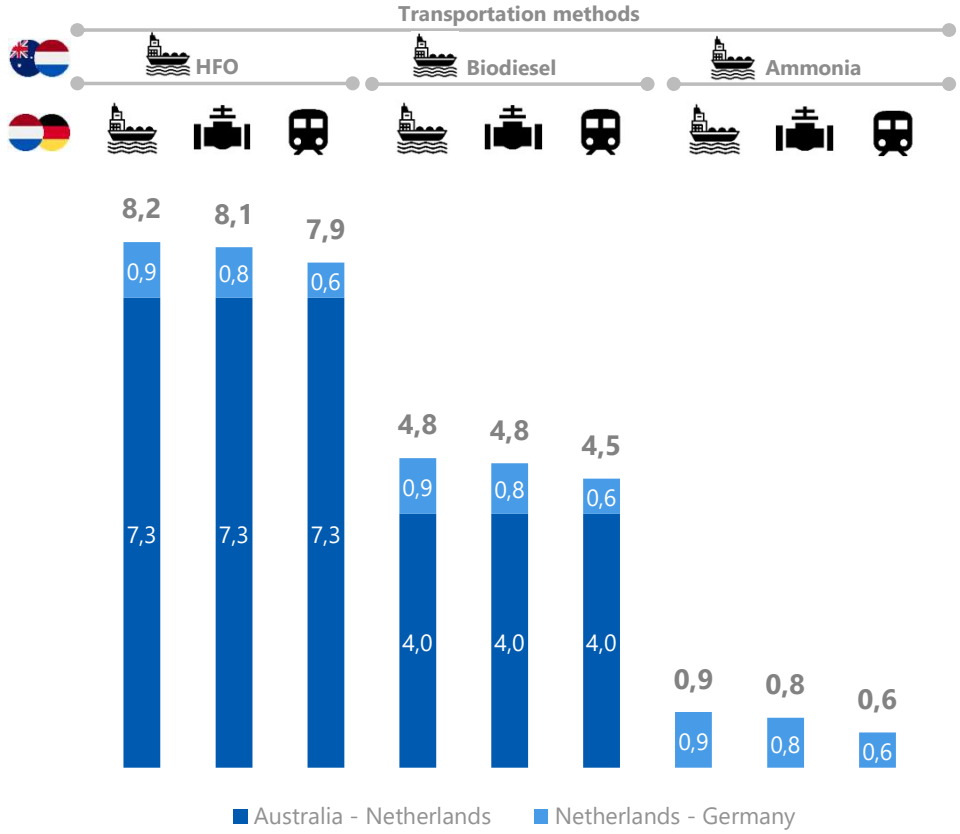
1) Excluding standby load of electrolyzer as it does not contribute to low heating value of end product

Source: Fichtner

Total gate to grave emissions vary from 0.6 to 8.2 gCO2eq/MJ depending on the transportation types

NH_3: GHG emission gate to grave [gCO2eq/MJ]

GHG emission **gate to grave [gCO2eq/MJ]**



Comments

- **Three** options to transport **ammonia** from **Australia to Rotterdam** with **LGC**[1)]
  - **HFO / Biodiesel / Ammonia** fuelled transoceanic tanker
- **3** options to transport ammonia from **Rotterdam to Duisburg**
  - **Barge** tanker transporting **ammonia**
  - **Hydrogen pipeline**, including cracking
  - **Freight train** transporting ammonia
- **Biodiesel reduces 44% of emission of transoceanic tanker**, while using ammonia tanker can save all emission
- Ammonia fuelled tanker consumes produced ammonia as fuel
- The **remaining allowance for ammonia production is between 20.0 to 27.6 gCO2eq/MJ** in order to certify as RFNBO

1) LH_2 transport also considered in the study. Results are available on request

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Source: Fichtner

Transportation is not decisive in qualifying as RFNBO as long as the RFNBO production using fully renewable power for electrolyser only

NH_3: GHG emission cradle to grave [gCO_2eq/MJ] – **Fully renewable power for ELY**

GHG emission **cradle to grave [gCO2eq/MJ]**

Share of fully renewable power for other production facilities	Transportation methods: HFO			Biodiesel			Ammonia		
0%	36.3	36.2	36.0	32.9	32.9	32.6	29.0	28.9	28.7
10%	33.5	33.4	33.2	30.2	30.1	29.8	26.2	26.1	25.9
20%	30.7	30.7	30.4	27.4	27.3	27.1	23.4	23.3	23.1
30%	28.0	27.9	27.6	24.6	24.5	24.3	20.6	20.5	20.3
40%	25.2	25.1	24.9	21.8	21.7	21.5	17.8	17.8	17.5
50%	22.4	22.3	22.1	19.0	19.0	18.7	15.1	15.0	14.7
60%	19.6	19.5	19.3	16.2	16.2	15.9	12.3	12.2	12.0
70%	16.8	16.8	16.5	13.5	13.4	13.1	9.5	9.4	9.2
80%	14.0	14.0	13.7	10.7	10.6	10.4	6.7	6.6	6.4
90%	11.3	11.2	11.0	7.9	7.8	7.6	3.9	3.9	3.6
100%	8.5	8.4	8.2	5.1	5.0	4.8	1.2	1.1	0.8

Emission below 28.2 gCO2eq/MJ Emission above 28.2 gCO2eq/MJ

Comments

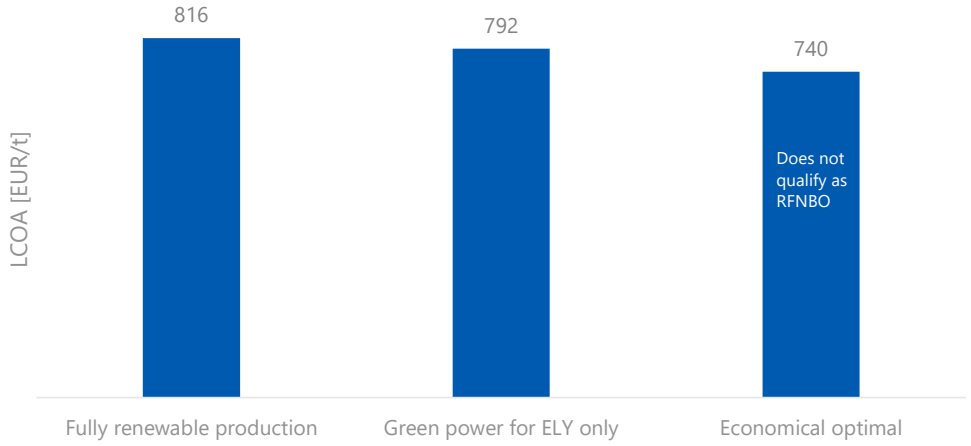
- Assumption, that electricity for electrolyzer is fully renewable
- As long as cradle to gate does not exceed the emission threshold it is quite flexible to combine transportation methods
- Transportation is not decisive in qualifying as RFNBO but rather emission in production
- To make RFNBOs a viable and sustainable alternative, it is **crucial for project developers and policymakers to focus on optimizing the energy mix** used in the production phase.
- This can be achieved by e.g.
  - leveraging locations with **abundant renewable energy resources**
  - investing in technology and infrastructure that increase the proportion of renewable energy.
  - A **higher share of renewables in the Australian Grid** to reduce the GHG emission intensity

Source: Fichtner

Striving for the necessary renewable proportion is causing a rise in the LCOA, driven by increased renewable and storage capacity requirements.

Installed capacity for the main components & power sourcing per scenario

	Unit	Fully renewable production	Green power for ELY only	Economical optimal
LCOA	EUR/t_{NH3}	816	792	740
Renewable Share	**%**	**100**	**95.9**	**73.0**
Capex	bn EUR	6.9	6.4	4.8
Capacity PV	GWp	2.1	2.0	1.4
Capacity wind	GW	2.1	2.0	1.4
BESS	GWh	95	-	-
ELY	GW	1.3	1.3	1.0



Comments

- **Economical optimum** would **not lead to a sufficient share** of renewable to qualify the end product as RFNBO.
- The **strategic options** such as **enhancing renewable generation capacity, aligning generation** with consumption patterns by adding flexibility incorporating **battery storage** or **enlarging the electrolyser** capacity are required.
- **Significant investments are needed** to increase renewable capacity and thereby comply with RFNBO standards.
- The **optimizer** is free to choose when to produce and **aims for the yearly production target**. If a detailed e.g. **hourly production profile is to be met, the cost** for fully renewable production **would further increase**.

Source: Fichtner

Production of RFNBOs (H_2 & NH_3) in Australia is feasible if certain criteria are met, particularly for renewable electricity share.

Key Take-aways

1	**Production of RFNBOs (H_2 & NH_3) in Australia is feasible.**
2	**Fully renewable power contribution for electrolyser is decisive**, not only for the share of product as RFNBO, but contributing to most of GHG emission.
3	Due to low share of renewables and high GHG emissions in the WEM grid, **reasonable options to certify as fully renewable are either with a direct connection or a grid connection including a PPA** and meeting the criteria of additionality, temporal and geographical correlation.
4	If the cradle to gate process is completely powered by renewable energy **any form of large-scale transportation can be utilized** and the criteria for RFNBO will still be met.
5	**Significant investments** compared to the economical optimum[1)] **are needed to increase renewable share in the grid** and thereby comply with RFNBO standards

1) Least cost system configuration for producing hydrogen/ammonia

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ENGINEERING CONSULTING

Netherlands Enterprise Agency

Study RFNBO imports from South-America

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Final Report

RFNBO compliance analysis of products produced from renewable hydrogen and different sources of CO_2 in Uruguay and Chile with the EU's renewable energy directive

Prepared for:

Ministry of Economic Affairs and Climate Policy of the Netherlands

BRUSSELS • PARIS • ROTTERDAM • WASHINGTON D.C. • SANTIAGO • BOGOTA

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CONTENT

DIFFERENT ELECTRICITY SOURCING OPTIONS ALLOWED, EACH WITH SPECIFIC CONDITIONS TO CLAIM A MOLECULE AS RFNBO

Pathways	Scenario	Electricity supply for H_2 production	Hydrogen type	Percentage of renewable hydrogen	Additional renewability conditions / elements to be considered
A	Direct connection		H	100%	• Additionality • Temporal correlation • 70% GHG emissions saving
B	Grid based with a Power Purchase Agreement (PPA)		H	100% Up to the **power consumption of electrolyzer production that is covered** by the PPA.	• Additionality • Temporal and Geographical correlation • 70% GHG emissions saving
C	Grid-based without PPA but with > 90%* Renewable Energy (RE) in the consumption mix		H	100% To the extent that the **electrolyzer ratio of full load hours does not exceed the share of RE** in the bidding zone gross consumption mix **as per 1 year before production**	(*) RES share of over 90% demonstrated in at least one year within the previous five years in the bidding zone • 70% GHG emissions saving.
	Grid based without PPA with less than 90% RE grid mix		H	X% **X% of RE** in bidding zone **production mix 2 years prior** to production.	• 70% GHG emissions saving.

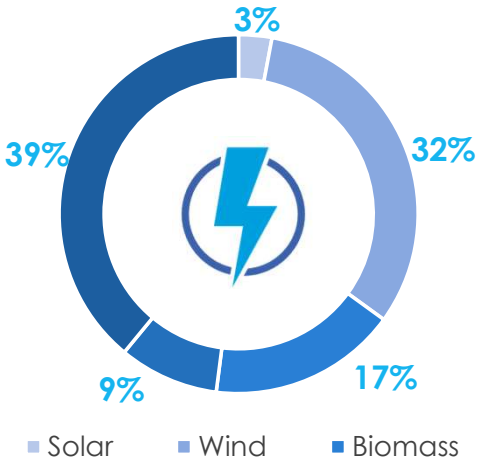
Renewable energy (RE) production asset (excl. biomass) · Grid · H_2 production asset / electrolyzer · Renewable Fuel of Non-Biological Origin (RFNBO) · Mix of RFNBO H_2 and conventional H_2

[1] PPA: Power Purchase Agreement (PPA not required in case that RE asset is owned by the fuel producer).
[2] GO: Guarantees of Origin (renewable energy certification), hourly data required from 1.1. 2030 onwards.

Sources: DIRECTIVE (EU) 2018/2001 of the European Parliament and of the Council (2018); COMMISSION DELEGATED REGULATION (EU) 2023/1184 (2023).
(*) Article 2, point (65), of Regulation (EU) 2019/943 of the European Parliament and of the Council (2019).

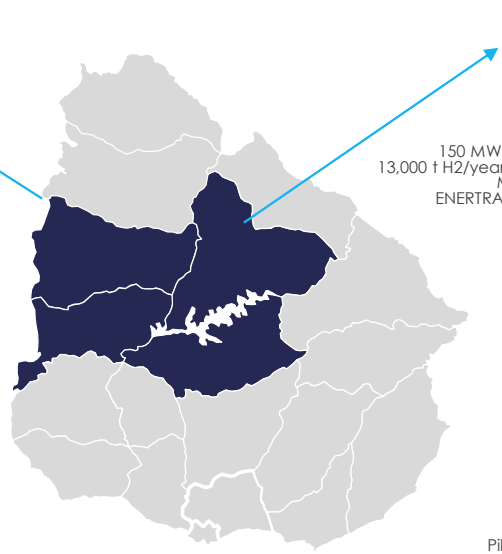
WITH ITS HIGHLY RENEWABLE ENERGY MATRIX, URUGUAY HOLDS SIGNIFICANT POTENTIAL FOR THE DEVELOPMENT OF POWER-TO-X PROJECTS

Electricity generation in Uruguay (2022)



A strong power sector, with 91% RE share, ~5 GW of installed capacity and +300 GW of RE Potential

Renewable hydrogen projects announced in Uruguay



HIF Paysandú

eFuels Facility
1 GW electrolysis
250,000 t/year of eGasoline
700,000 t/year of eMethanol
900,000 t of CO_2 captured/year

Tambor

eMethanol
150 MW electrolysis
13,000 t H2/year or 70,000 t MeOH/year
ENERTRAG and SEG Ingeniería

Kahirós

Heavy Duty Transport
2 MW electrolyzer
Ventus, Fidocar and Fraylog

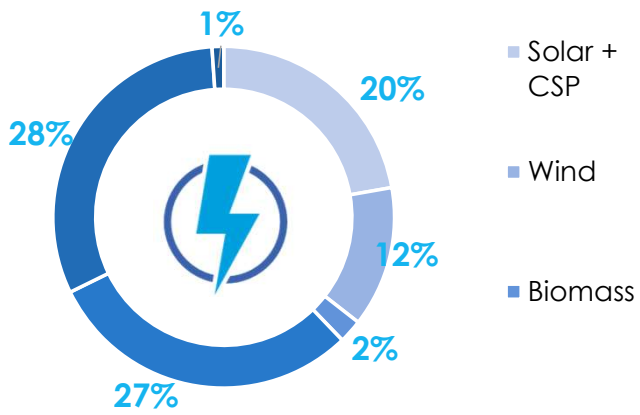
H24U

Pilot Project
Heavy-duty Trucks
Saceem and CIR, with participation of Air Liquide

Source: Uruguay's National Energy Balance (2022); HIF Uruguay; Comunicación de proyecto Belasay S.A (2021); H2LAC

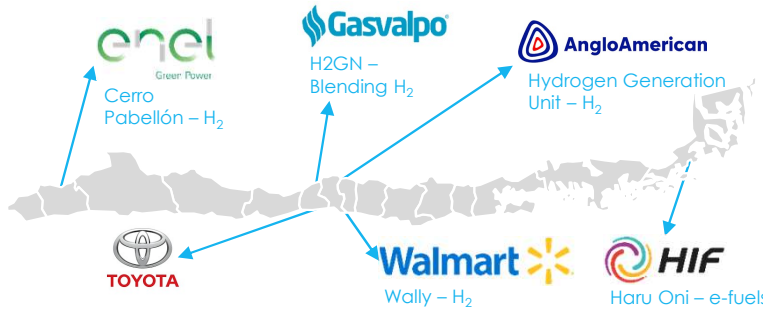
CHILE IS A LONG COUNTRY WITH ABUNDANT RENEWABLE RESOURCES FOR THE PRODUCTION OF RENEWABLE HYDROGEN AND ITS DERIVATES

Electricity generation in Chile (2022)



Until 2022, the electric generation of the SEN was more than 55% renewable. In 2023 it was 64%.

Operational projects in Chile



- Chile is a long country with abundant solar resources in the north and wind resources in the south for renewable energy generation for the production of renewable hydrogen and its derivates.
- To date, 64 projects have been announced, of which 6 are in operation (which are shown in the figure above) and 58 are under development. Of the projects under development, ~45% are for hydrogen production, ~39% are for ammonia production and ~7% are for e-fuels.

Sources: Generadoras de Chile; H2 Chile

TO MEET THE CRITERION OF GEOGRAPHIC CORRELATION, THE EUROPEAN DEFINITION OF BIDDING ZONE NEEDS TO BE TRANSLATED INTO THE LOCAL CONTEXT

Bidding Zone Concept

- To meet the geographic correlation, the electricity injection and withdrawal points need to be within the same/equivalent bidding zone (or an equivalent concept for third countries).
- ***Bidding zone (BZ):*** "largest geographical area within which market participants are able to exchange energy **without capacity allocation** (capability of the interconnected system to accommodate energy transfer between bidding zones) [1]
- In Europe, the term "**copper plate**" is used to refer to a bidding zone, meaning **electricity can be transmitted without any restriction across a determined area.**

Q&A statement for implementation of BD concept

- The Annex "Implementation of bidding zone concept" from the Q&A released by the European Commission states that, **for the implementation of BZ, the following approach should be applied**:
  - "Certifiers should assess whether at the location of the electrolyser, market regulations applied are similar to the rules set out for bidding zones in Regulation (EU) 2019/943. In this context "similar" means that there are rules requiring establishing hourly prices for electricity in a geographical area. If such rules are in place, the geographical area for which the prices are established should be considered as a bidding zone.
  - If the electricity network of the country is integrated and there are no geographically differentiated electricity prices, the whole country may be considered as one bidding zone"

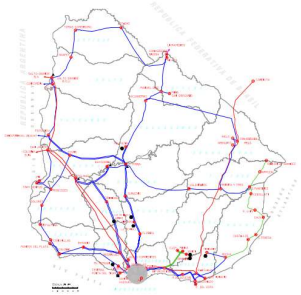
To determine the REDII and REDIII compliant equivalent concept of the European Bidding Zone definition, a technical analysis of the respective country's electricity market and grid is required.

Sources:
[1] Article 2, point (65), of Regulation (EU) 2019/943 of the European Parliament and of the Council (2019); COMMISSION DELEGATED REGULATION (EU) 2023/1184 (2023);
[2] Q&A implementation of hydrogen delegated acts (14/03/2024), European Comission (This report summarises the outcome of those meetings and does not create any enforceable right or expectation … it should be regarded as a 'living tool' open for improvement and its content may be subject to modifications without notice"-

CHILEAN AND URUGUAYAN TRANSMISSION SYSTEMS EXHIBIT RADIAL CHARACTERISTICS AND HAVE MAJOR DIFFERENCES WITH THE EU'S SYSTEM

Bidding zone compliance

Uruguayan transmission System (SIN)



The Uruguayan transmission system currently has **radial characteristics**, but efforts are underway to strengthen and enhance its resilience.

Based on ADME's (Electric Market Administration) information, there is **only one spot price sanctioned hourly** for the entire market.

In general, **the grid capacity exceeds peak demand**, avoiding **congestions of the transmission lines**.

Chilean transmission system (SEN)[1]

The **Chilean** transmission system has **radial characteristics** due to its great length. It links consumption and generation poles by transmission lines which have few interconnection points.

Day-ahead hourly prices are determined by the demand of each node (substation) and generation units are dispatched centrally by the National Electric Coordinator (CNE).

The **grid suffers congestions** due to a lack of enough transmission capacities, specifically in the North where multiple RE plants need to feed-in high electricity amounts which exceed available capacity, leading to curtailment and prices zero.

European interconnected system (ENTSO - E)

The European transmission system is **meshed**, with consumption and generation points evenly distributed throughout.

The pricing methodology within Europe is generally defined by Member States.

This characteristic increases the number of transmission possibilities and helps **prevent congestion**.

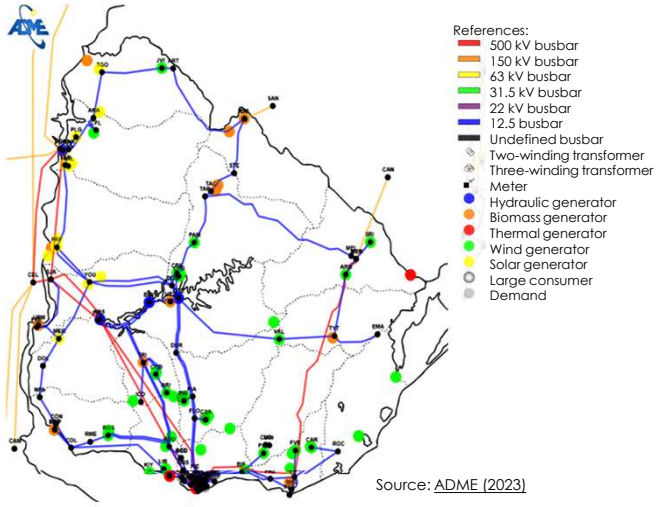
[1] *The Regions of Magallanes (one of Chile's HUBS where several Power-to-X-projects are being developed) and Aysén, in Southern Chile, are not part of the Interconnected Electricity System SEN; they are isolated systems.*

Sources: Uruguay Power System Flexibility Assessment (IRENA, 2018); National Electric Coordinator (CNE).

URUGUAY CAN BE CONSIDERED A SINGLE BIDDING ZONE SINCE, DESPITE NODAL SPOT PRICES, IT SHOWS NO CONGESTION AND A SINGLE HOURLY PRICE

Uruguayan Electrical Power Market

- One public entity, the **UTE (National Administration of Power Plants and Electric Transmissions)**, is **in charge of the transmission and distribution** of the electricity in Uruguay, where any public or private entity can participate. Therefore, the Uruguayan electrical power market operates as a **centralized market**.
- The **ADME** (Electric Market Administration) is **in charge of the administration** of the wholesale electrical market under two main principles:
  1. Allow the execution of contracts freely agreed between the parties.
  2. Dispatch the required demand, considering the optimization of the National Interconnected System, based on the recognition of energy and power prices according to the criteria and values established in the Law 16.832 of the country.
- The **purchase and sale of electricity** in the short-term, concentrated in the Spot Market, is **hourly with nodal spot prices** reflecting the short-term marginal cost.
- According to the information regarding sanctioned spot prices available at ADME's platform, there is **only one spot price sanctioned hourly** for the entire market (same nodal spot prices for all nodes).



Source: ADME (2023)

- When analyzing the technical restrictions of the system, it is observed that Uruguay has a single hourly spot price for the entire system, which at the same time demonstrates that Uruguay's transmission system shows no signs of electrical congestion and that there is not re-dispatch of the generation capacity.
- **For the purposes of this analysis and considering the market's characteristics based on the Q&A information presented by the European Comission, it is concluded that the entire system is very likely to be treated as one single bidding zone since "the country is integrated and there are no geographically differentiated electricity prices".**

Sources: Title III – Spot Market: Reglamento del mercado mayorista de energía eléctrica published in 2002 (Official Information Center); Law N° 16,832 (Official Information Center).

THE SEN SYSTEM COULD BE CONSIDERED A SINGLE BIDDING ZONE; HOWEVER, FURTHER ANALYSIS IS RECOMMENDED DUE TO RE-DISPATCH OF CAPACITY

Chilean Electrical Power Market

- **Day-ahead hourly prices are determined by the demand of each node (substation)** and generation units are dispatched centrally by the National Electric Coordinator (CNE). Therefore, the Chilean electrical power market operates as a **centralized market** under the category "Marginal nodal price or generator nodal price".
- **Merit Order system:** Generating units are **ordered according the marginal cost of production ($/MWh).** Generating units are dispatched from the most economical to the last one required to meet the demand in each of the nodes (substations) of the transmission system. If there are technical constraints that make it impossible to dispatch according to the merit order of the system, a nodal redispatch of the generation units exists ("**digital twin of the electrical system**").
- A 500 kV HVDC transmission line is planned from Antofagasta to the Metropolitan region, which will expand the network's capacity + reduce congestion (start of construction 2025-2026).
- Both the **Magallanes and Aysén systems** are medium centralized markets operated by Edelmag and Edelaysen de Saesa, respectively. This companies are responsible for generation, distribution and transmission. Pricing is done at average cost and has similar values for all nodes of the systems; therefore, it can be concluded that no energy redispatches occur. However, both also have major expansion projects underway to support the scale of projects expected in the region. Thus, it is concluded that the current state of the network is not definitive, and a **detailed analysis of the future or projected grid is required to gather conclusive information on the bidding zones in this area.**

- Chile's electricity market operates on a nodal **day-ahead hourly prices**, categorized as "Marginal nodal price". **Since the SEN system employs a single pricing methodology centralized by the CNE, it can be considered a single bidding zone according to the European Commission's Q&A** ("the geographical area for which the prices are established should be considered a bidding zone.")
- However, technical restrictions reveal re-dispatch of generation capacity and curtailment in many congested nodes, so **further analysis is recommended on this topic. An official statement on this matter, and its approvement by the European Commission, is still required to assume the bidding zone.**

Sources: Generadoras de Chile; Conexión Energía (2023)

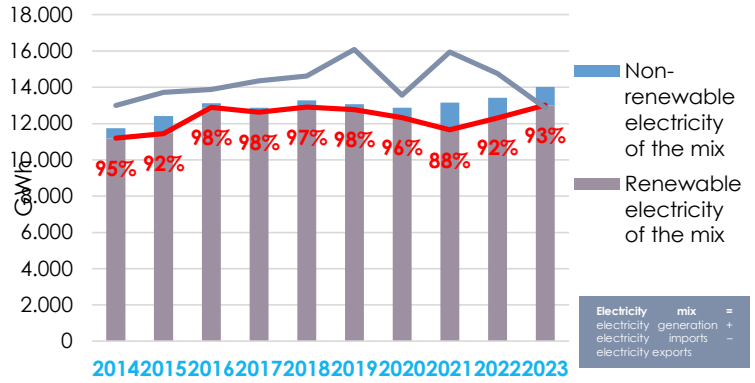
H2 PROJECTS CONNECTED TO THE URUGUAYAN GRID UNDER PATHWAY C[1] COULD CONSIDER 100% OF THEIR CONSUMED ELECTRICITY AS RENEWABLE

Grid renewability compliance

- Uruguay **has a grid with 90% or more of RE generation in at least one of the 5 past years.** In fact, more than three of the last five years meet >90% renewable generation.
- The primary renewable energy source is **hydroelectric generation**, followed by **wind,** and then **biomass[2]**.

  The difference is thermal power generation and import of electricity from neighbour countries, Brazil and Argentina (MIEM, 2024).
- Under this scenario, **all projects located in Uruguay connected to the national interconnected grid (SIN) can be considered as complying with the renewability criteria (100% of their H_2 production is RFNBO compliant)[3]**
- **Uruguay has a National Certification System for Renewable Energy (SCER).** This Guarantees of Origin (GOs) emitted with the power must be bought and cancelled for RFNBO production purpose on the full power consumption scope.

Electricity mix in the Uruguayan grid, 2014-2023



Note: The year **2021** is identified with **low hydraulic generation** and an **increase in exports**. Like Argentina and Brazil, Uruguay suffered the impact of a drought since 2020, resorting to **greater use of fossil** generation to cover national and export demand. This explains the reduced renewability of the electricity mix for the given year.

Uruguay's grid has a slight variation in the RE share over the years. As previously explained, even though RE targets are fulfilled for a period of five years once achieved, the EZ load factor cannot exceed a maximum number of hours relative to the proportion of RE in the bidding zone.

Thus, if the RE share of the grid varies, there will also be an impact on the overall production. In these cases, PPAs can be used to improve EZ utilization rates. However, seeking access to PPAs of varying amounts from year to year may be challenging.

[1] Grid without PPA

[2] 'biomass' means the biodegradable fraction of products, waste and residues from biological origin from agriculture, including vegetal and animal substances, from forestry and related industries, including fisheries and aquaculture, as well as the biodegradable fraction of waste, including industrial and municipal waste of biological origin (Source: Directive (EU) 2018/2001, Art. 2.(24)).

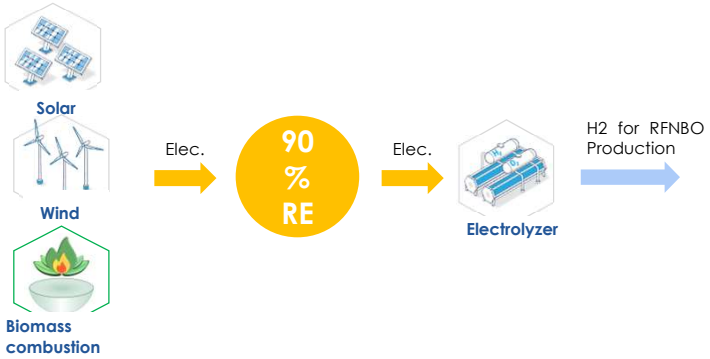
[3] (This is possible as long as the number of full load hours of the electrolyser does not exceed the proportion of renewable electricity in the grid from the previous year (e.g. In 2024 an electrolyser connected to the Uruguay grid can only operate 0.92*8,760=8,059 hours)).

Sources: Generadoras de Chile; Conexión Energía (2023) Source: DIRECTIVE (EU) 2018/2001 of the European Parliament and of the Council (2018); Uruguay's National Energy Balance, MIEM (2024)

WHEN PROVING THAT THE GRID HAS >90% RENEWABILITY FOR RFNBO PRODUCTION, ELECTRICITY FROM BIOMASS COMBUSTION CAN BE INCLUDED

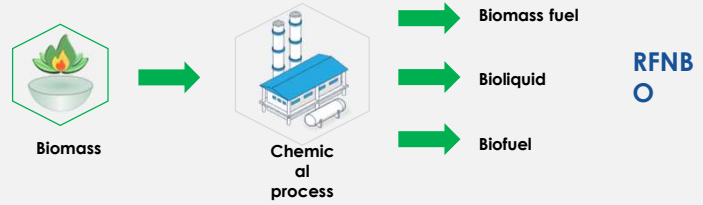
- The use of biomass in the production of RFNBOs is not allowed in most cases, however, a relevant exception is found when electricity from the combustion of biomass is part of the renewable energy share of the national grid.
- In this case, **if an electrolysis plant is connected to the grid without the PPA (Pathway C), the 90% of renewable energy that is required may include electricity from biomass combustion**

Pathway C – Possible renewable energy sources:



- In this context, biomass is defined according to the RED II as the biodegradable fraction of products, waste and residues from biological origin, including bio-based industrial residues.
- Under this definition, common bio-waste from the Uruguayan industrial landscape such as **black liquor from pulp and paper plants, can be accepted as a biomass source for the renewable energy mix of the grid.**

- While the inclusion of biomass-based electricity in the renewable energy mix from the national grid is allowed for RFNBO production in the specific pathway just described, this aspect must not be confused with the contribution to renewable energy targets from biomass fuels, bioliquids and biofuels
- The RED II regulation defines biomass fuels, bioliquids and biofuels as fuels produced from biomass, which depending on the source must go through different chemical conversions and comply with sustainability requirements.



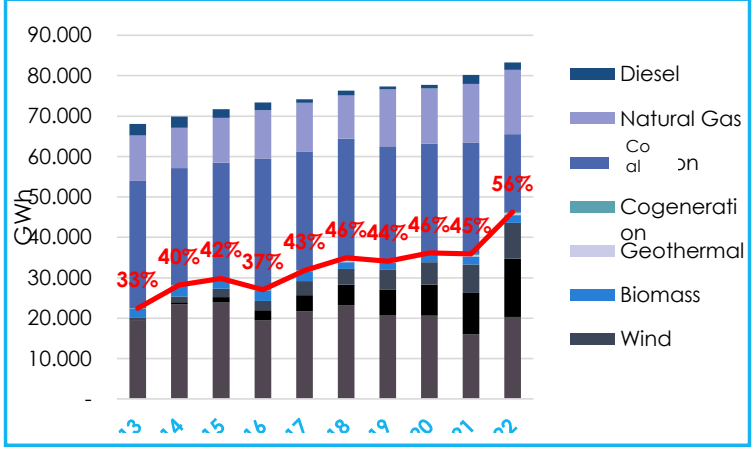
- While industrial waste, such as black liquor, can be used for the production of biofuels, this process must comply with the biofuels production regulation instead, and it can no longer be considered part of an RFNBO value chain.
- Additional sustainability criteria that must be considered for the use of biomass in biofuels production can be found in Article 29. of the RED II regulation. These sustainability requirements mainly affect biomass coming from agricultural and forestry sectors, whereas bio-based waste does not present major environmental requisites.

CHILEAN GRID DOES NOT COMPLY WITH A 90% RE SHARE, SO PATHWAYS A[1] AND B[2] ARE RECOMMENDED FOR PROJECTS IN THE COUNTRY

Grid renewability compliance

- **56% of the electricity generated in 2022** was renewable, corresponding to an 11% increase from the previous year. The remaining 44% primarily consisted of thermal power generation.
- **It does not comply with the requirement of having 90% renewable generation.** For this reason, considering electricity sourcing options A and B (direct connection and grid connected with PPA is recommended.
- However, this should be studied on a node-by-node basis. **If one of this nodes exceeds the 90% renewability, the project could access to pathway C only connecting to the grid in that specific zone. (provided this node could be considered a biding zone)**
- **Chile uses the I-Rec Standard to demonstrate renewable origin of electricity.** In the case of grid connection, this certificate needs to be bought and cancelled to comply with RFNBO criteria.

Electricity mix[3] in national grid (SEN), 2013 - 2022



When considering the SEN, it is far from reaching the necessary renewable share.

However, some regions have high penetration of RES and cold achieve +90% RE generation in the coming years. Renewable Energy Sources (RES) share in Chile keeps growing fast, with huge solar and wind onshore capacities and high plant factors.

[1]Direct Connection
[2] Grid with PPA
[3] Chile does not import electricity. Chile (SEN) has been exporting energy to Argentina since 2022, with the exported amount representing less than 0.2% of the total energy generated in that year.

URUGUAY'S HIGH RE GRID SHARE POTENTIALLY ALLOWS PLANT OPERATORS USING PATHWAYS B* TO SKIP THE ADDITIONALLY CRITERION

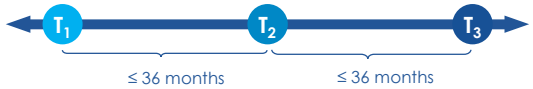
Additionality

- The renewable energy installation must have been operational or upgraded no more than 36 months prior to the electrolyzer's commissioning.
- Any additional production capacity must be added within 36 months of the initial installation becoming operational to be considered part of the same plant. Capacity additions made after 36 months from the commissioning of the electrolyzer must be treated as a new plant, requiring all necessary implications and permits.

T_1: Minimum period for commissioning of an RE plant

T_2: Commissioning of the electrolysis plant

T_3: Maximum deadline to add RE capacity



Sources:
[1] National Electric Coordinator
[2] National Energy Balance, 2021
[3] National Energy Balance, 2022
COMMISSION DELEGATED REGULATION (EU) 2023/1184 (2023).

Uruguay

In 2021, the emissions intensity of the Uruguay grid was ~28 gCO2e/MJ[2](with a renewability of 88% of the electricity mix). In 2022 due to an increased of the renewable share in the grid, the **emissions intensity decreased to ~17 gCO2e/MJ[3].**

Since the emissions factor is bellow **the 18 gCO2e/MJ limit**, the emissions intensity of 2022 would allow to skip the additionality criteria for the subsequent five calendar years for the projects under **Pathway B*** (since it is a small difference, it cannot be guaranteed that this will continue to be fulfilled in future years).

In the case of 2021 it is possible to notice that a 4% difference in the renewability of the grid (compared to 2022), would mean not being able to access this exception because the emissions intensity is 55% higher than the limit.

Therefore, to sustain this condition over time, it's necessary to have at least a significant share of renewable energy in the grid.

Chile

In 2023, the **emissions intensity of SEN was ~66 gCO2e/MJ[1]**, marking a 21% reduction compared to 2022 and a 37% reduction compared to 2021. However, the emissions factor **exceeds the 18 gCO2e/MJ limit**, that if met it would have allowed skipping the additionality criteria for the subsequent five calendar years.

Finally, to reach the emissions factor limit, an increase in the renewable share of the energy matrix is needed.

*Pathway B: Grid with PPA

TEMPORAL CORRELATION[1]: GOS PROVING HOURLY CORRELATION (PATH B) IS IDEAL, WHILE BOTH A AND B PATHS NEED SMART METERING

Temporal correlation

- Electricity must be consumed by the electrolyzer and/or storaged **within the same hour of generation from 01.01.2030 (before: monthly).**
- Additionally, the fuel producer shall provide **reliable information demonstrating that all requirements are complied for each hour**, including amount of electricity used for production and amount of RE generated by installations.

2024	2025	2026	2027	2028	2029	2030	2031
Monthly correlation						Hourly correlation	

Critical point: Given the need to demonstrate information on energy consumption and RE production, two important aspects must be considered:

1. The **electricity consumer** must implement a **Smart Metering system** (as defined in Article 2(23) of Directive (EU) 2019/944). This system is capable of measuring electricity flows fed to the grid or consumed from it on an hourly basis in the RE production process. These **devices must adhere to EU standards** concerning security, communication, and privacy.
2. The **RE generator** must transmit the **energy information to the purchaser with the appropriate temporal granularity**. Therefore, the generator must also achieve this measurement (through **GO's**, or information from the **transmission operator and/or respective generator**, or through **smart metering** implementation).

[1]Criterion applicable to Pathways A (direct connection) and B (Grid with PPA).

Uruguay

1. Until the end of February, **more than 80% of the Uruguayan households have their smart metering system** installed. This demonstrates the existence and implementation of smart metering systems in Uruguay, which could be used for a grid-connected project.
2. **Given that the grid has over 90% RE, it is a favorable option to opt for Pathway C and thus temporal correlation is not required.** However, if this renewability is not met and/or Pathway B is implemented, **hourly correlation should be demonstrated (through hourly based GO's, or requesting** information from the transmission operator and/or respective generator, or verifying it through smart metering)
3. According to the national certification system guidelines, the allocation of **a CER is made considering the consumption within the calendar month with** GOs on an hourly basis. In this way, Uruguay may also comply with the hourly correlation. In case direct connection with the plant, the use of smart metering systems with hourly injection details should be required.

Chile

1. While **smart metering systems are available in the Chilean market,** their widespread use is **limited** because the network is not sufficiently smart, according to the Superintendency of Electricity and Fuels (SEC).
2. Chile implements the I-REC certification system. Although it **currently lacks hourly correlation**, in 2022 The I-REC Standard facilitated a **24/7 matching pilot** with Google in Chile, showcasing efforts towards achieving this. Such correlation could potentially be available by 2030 for the country.
3. In order to comply with hourly correlation while the hourly granularity of I-REC is being developed, **information can be requested** from the Electricity Transmission System Operation (SEN) and/or respective generator, or smart metering can be implemented. The National Electric Coordinator has a National Registry of Renewable Energy (RENOVA), which currently provides monthly information, which has the potential to evolve to allow for the demonstration of hourly correlation.

GEOGRAPHICAL CORRELATION[1] MAY NOT BE A CHALLENGE IN URUGUAY AND CHILE

	Geographical correlation[1]		
	Pathway A (Direct connection)	**Pathway B (Grid with PPA in same bidding zone)**	**Pathway B (Grid with PPA in different bidding zone)**
	The renewable generation plant is connected by a direct line to the production plant.	The renewable generation plant and the electrolyzer are in the **same bidding zone**	The renewable generation plant and the electrolyzer are in a **different bidding zone** and the generation price of an **hourly block is lower or equal in the electrolyzer bidding zone** than in the renewable generation plant.
Uruguay	No critical point are identified for the connection of a dedicated renewable generation plant.	As Uruguay may be considered a single bidding zone, no critical points are identified concerning geographical correlation.	
Chile	The main critical point to consider for a dedicated plant in Chile is that the areas with high potential for renewable generation are located at the extremes of the country. Therefore, for a dedicated grid to be used, the plant should be situated nearby, or it may imply a grid with significant extension (and therefore significant costs).	If the SEN system is considered a single bidding zone, no critical points are identified concerning geographical correlation. The same applies if the Aysén and Magallanes systems are considered independent bidding zones and consumption is carried out within these same bidding zones.	The southern zones (Aysén and Magallanes systems) have hourly spot energy prices lower than the central zone. This suggests that the electrolyser cannot be located in the central zone (SEN system, that could be considered as one bidding zone) and produce with energy from the southern zones (which also have the highest renewable potential). The evolution of the systems in the south should be monitored over time according to their expansion projects to see the effects on the energy prices, and whether or not they can be considered a bidding zone.

REQUIREMENTS FOR RENEWABILITY, CFP[1] CALCULATION & CERTIFICATION HAVE BEEN DETAILED IN DELEGATED & IMPLEMENTING REGULATIONS

To be **RED compliant, a RFNBO** needs to:
- Fulfill the criteria for renewability and GHG emissions reduction compared to fossil.
- **Be certified under a Voluntary Scheme recognized by the European Commission relying on Mass Balance**

1 Renewability of electricity

- Direct connection (A)
- Under PPA (B)
  - Additionality
  - \+ Temporal Correlation
  - \+ Geographical Correlation
- (C) **Outside PPA:** >90% RE in grid mix OR elect. consumed during imbalance settlement

2 GHG emission savings

70% GHG emission saving threshold compared to fossil fuel comparator

Applicable fuel comparator for RFNBO → 94 gCO2eq/MJ

-70% CFP threshold → **<28.2 gCO2eq/MJ (3.38 kgCO2eq/kgH2)**

3 Certification

Certification Scheme recognized by EC[2] to demonstrate compliance with RFNBO criteria

The RFNBO should be produced and handled across the value chain by certified economic operators with a recognized Certification Scheme, relying on Mass balance bookkeeping.

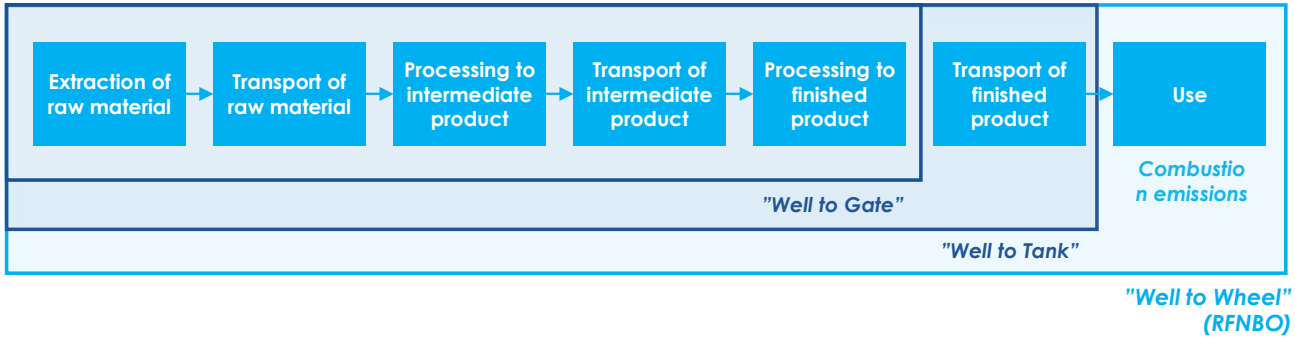
[1] CFP = Carbon Footprint
[2] EC = European Commission

Sources: DIRECTIVE (EU) 2018/2001 of the European Parliament and of the Council (2018); DIRECTIVE (EU) 2023/2413 of the European Parliament and of the Council (2023); COMMISSION DELEGATED REGULATION (EU) 2023/1184 (2023).

THE CFP CALCULATION SCOPE MUST COVER THE ENTIRE SUPPLY CHAIN, INCLUDING THE TRANSPORTATION, UNDER A "WELL-TO-WHEEL" APPROACH

- **"Well to X" footprint of a fuel** = sum of GHG emissions (and removals) over the specified lifecycle scope (until X point), per unit of energy, in gCO2e/MJ.
- Emissions are expressed in CO_2 equivalent (CO_{2eq}) to take into account emissions of all GHG gases.
- The European regulation for RFNBOs require the use of a **Well-to-Wheel scope**, which considers not only the production and processing of the product but also its transportation to the target market. This is crucial for RFNBOs due to the **decoupling of production and consumption value chains**, often involving long-distance transportation, which can **significantly impact the CFP of the final product**.
- **Emissions from the construction of assets are not considered** (conveyed above by reference to "Well" rather than to "Cradle").

Commonly *used scope designations*



As the Carbon Footprint scope is Well-to-Wheel, the **downstream activities will have an impact on the consortium products environmental attributes** and, therefore, in its RED II & III compliance.

Sources; DIRECTIVE (EU) 2023/2413 of the European Parliament and of the Council (2023); COMMISSION DELEGATED REGULATION (EU) 2023/1185 (2023).

RFNBOS NEED TO MEET A 70% GHG EMISSIONS SAVINGS THRESHOLD COMPARED TO REFERENCES FUELS TO BE RED-COMPLIANT

- The equation to calculate the Emissions Savings (ES) from the use of an alternative fuel can be expressed as follows:

$$ES_{AF}\,[\%] = \frac{CF_{RF} - CF_{AF}}{CF_{RF}}$$

ES = emissions savings
CF = carbon footprint
AF = alternative fuel
RF = reference fuel

Carbon footprint (CF) = sum of GHG emissions and removals calculated over whole fuel lifecycle, expressed in (gCO2eq/MJ)

Reference fuel

The value for reference fuel or 'fossil fuel comparator' is set under the Delegated Act as:

For **RFNBOs & RCFs** used in **transport**: **94 gCO_2eq/MJ**

Other values for alternative fuels are set under RED2 as follows:

- Fuels (bioliquids & biomass) used to produce electricity: 183 gCO_2eq/MJ
- Biomass fuels used for heating/cooling: 124 gCO_2eq/MJ
- Bioliquids used for heating/cooling: 80 gCO_2eq/MJ

Alternative fuel

The quantification of the carbon footprint of an alternative fuel follows a "consequential approach". Emissions should be considered as CO_{2eq}:

$$CF_{AF}\left[\frac{gCO_2eq}{MJ}\right] = E = e_i + e_p + e_{td} + e_u - e_{ccs}$$

CF	=	Carbon footprint	**etd**	=	Emissions from transport and distribution
E	=	Total emissions	**eu**	=	Emissions from end-use[1]
ei	=	Emissions from the supply of inputs	**eccs**	=	Emissions savings from carbon capture and storage
ep	=	Emissions from processing			

At least 70% emissions savings from use of alternative fuel → $CF_{AF} \leq 30\%\ CF_{RF}$ = 28.2 gCO_2eq/MJ = 3.38 $kgCO_2eq/kgH_2$

[1] Emissions from combustion of the fuel refer to the total combustion emissions of the fuel in use (considered as equivalent CO_2 emissions).

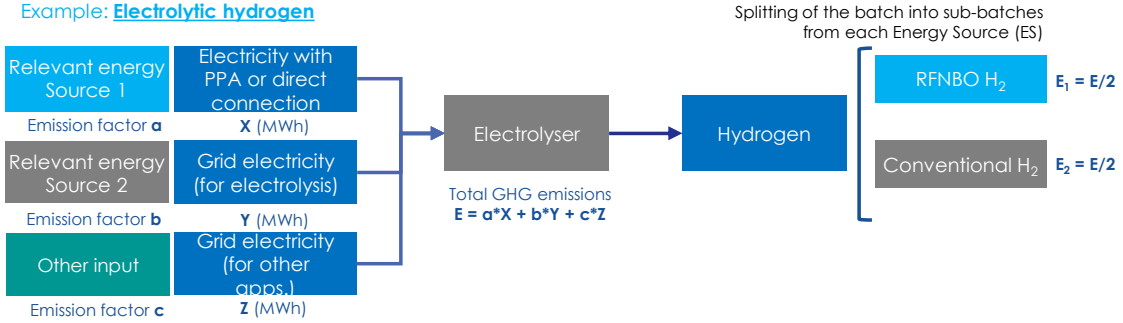
Sources; DIRECTIVE (EU) 2023/2413 of the European Parliament and of the Council (2023); COMMISSION DELEGATED REGULATION (EU) 2023/1185 (2023).

TO PRODUCE RFNBOS ONLY THE RELEVANT ENERGY INPUTS MUST BE RENEWABLE, BUT THE CFP MUST COVER THE ENTIRE PRODUCTION

In RFNBO production, **an energy input is considered relevant when it contributes to the energy content of the product**, other energy inputs (e.g. the required for auxiliary equipment) are only considered to determine the product's CFP. **Only relevant energy inputs must be renewable as per RED II**, other power consumption can be renewable or not, but the impact of non-renewable power on the **RFNBO CFP should be closely monitored**.

- **Share of renewable fuel =** relevant renewable energy input / total relevant energy input
- Relevant energy inputs are defined in different ways whether we are touching upon electricity or material inputs:
  - For electricity, it is defined as the energy enhancing the fuel Lower Heating Value (LHV).
  - For material inputs, it is the defined as the material entering the molecular structure of the fuel.
  - In the case of the production of **renewable electrolytic ammonia**, core energy comes from **the electricity used to produce hydrogen** (other derivatives need to be analysed case by case). In consequence, only this electricity needs to comply with renewability criteria, but the rest should be also considered in the CFP.
- **Coproduced fuels of different origin all have the same CFP**: GHG emissions intensity may be calculated as an average for the entire production of fuels occurring during a period of at most one calendar month. Except when
  - RFNBO/RCF only partially replace conventional input
  - RFNBO/RCF is co-processed with biomass

Example: **Electrolytic hydrogen**



- Product **not 100% renewable** because electricity is not always sourced from fully renewable sources.
- The **share of renewable hydrogen is proportional** to the share of consumed electricity that is using a PPA
- Both hydrogen products have the same CFP

Sources; DIRECTIVE (EU) 2023/2413 of the European Parliament and of the Council (2023); COMMISSION DELEGATED REGULATION (EU) 2023/1185 (2023).

REQUIREMENTS FOR RENEWABILITY, GHG EMISSIONS CALCULATION & CERTIFICATION HAVE BEEN DETAILED IN DELEGATED & IMPLEMENTING ACTS

To be **RED compliant, a RFNBO** needs to:

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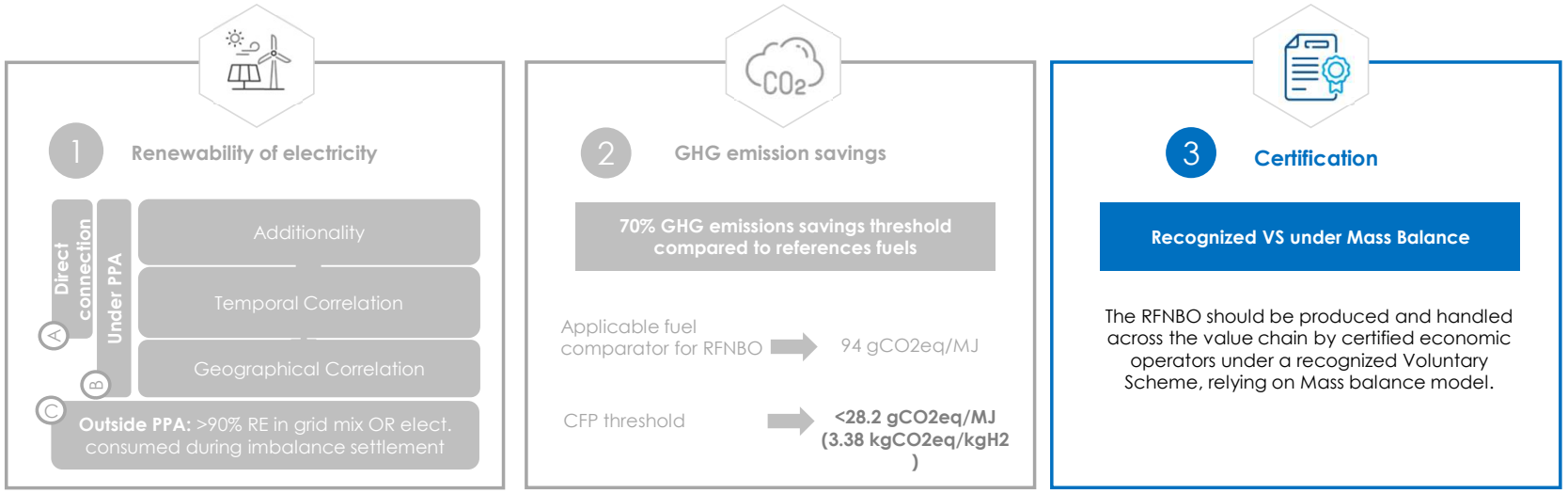


Use of Carbon (CO_2) for RFNBO

- Not included for lack of time and focus on RFNBO certification
- Looking into the sources of CO_2 and how they meet RED III criteria

- Conclusion:
  - with the sources available in Uruguay, synthetic e-fuel or methanol can be produced, shiped to Europe, Rotterdam and onwards (by truck!) to Germany, and still meet RFNBO criteria
  - For Chile, the challenge is that the main sources for biogenic CO2 are in the central, while the most RE is in the extreme North and South of the country.

ANY SOURCE OF CO_2 CAN BE USED FOR RFNBO PRODUCTION; BUT SOME SPECIFIC SOURCES CAN CONTRIBUTE TO THE CFP REDUCTION, DEPENDING ON THEIR ORIGIN

The use of avoided emissions will achieve the required 70% emission reduction; CO_2 shall come from a "currently ongoing activity" that would have been released CO_2 to the atmosphere instead OR that is already releasing CO_2 to the atmosphere, rather than burning sources to generate CO_2 emissions for RFNBO production purpose. The following CO_2 sources are eligible to be considered as avoided emissions:[1]

1	CO_2 capture from an activity listed under Annex I of the EU Directive 2003/87/EC ("industrial emissions" falling under EU ETS generated by production processes like steel, cement, power production)	CO_2 eligibility from this sources/activities for CFP reduction valid until 2036 (CO_2 from power plants) / 2041 otherwise
2	CO_2 captured from the air (DAC)	Only CO_2 source with no regulatory for its use. Still relatively expensive and low efficient.
3	Captured CO_2 stems from the production or the combustion of biofuels, bioliquids or biomass fuels complying with the sustainability and GHG saving criteria[2] and the CO_2 capture did not receive credits for emission savings from CO_2 capture and replacement, set out in Annex V and VI of Directive (EU) 2018/2001	Biogenic CO_2 can be used without any time limit. Using this type of CO_2 source allows maintaining CFP reduction over time, ensuring RFNBO to be RED II compliant.
4	Captured CO_2 stems from the combustion of RED II compliant RFNBOs or RCFs	CO_2 emitted through use of an RFNBO (future), following circular approach; challenging as it would be captured in another place than RFNBO production.
5	Captured CO_2 stems from a geological source of CO_2 with previously naurally released CO_2 (e.g. geysirs, naturally carbonated water)	
X	Captured CO_2 originating from a deliberately combusted fuel for specific purpose of producing CO_2 and its capture	Emissions from a combustion process carried out with the only intention of CO_2 capture are not considered an avoided emission eligible to be deducted from CFP.

[1]More details about the emissions counting methodology for RFNBO fuels can be found in the *Commission Delegated Regulation (EU) 2023/1185*
[2]The sustainability and greenhouse gas saving criteria can be found in Annex 1 – Biomass sustainability requirements

EMISSIONS FROM FOUR GROUPS OF ACTIVITIES ARE ELIGIBLE FOR REDUCING THE CARBON FOOTPRINT OF THE RFNBO

CO_2 capture from an activity listed under Annex I of the EU Directive 2003/87/EC

Energy activities	Production and processing of ferrous metals	Mineral industry	Other activities

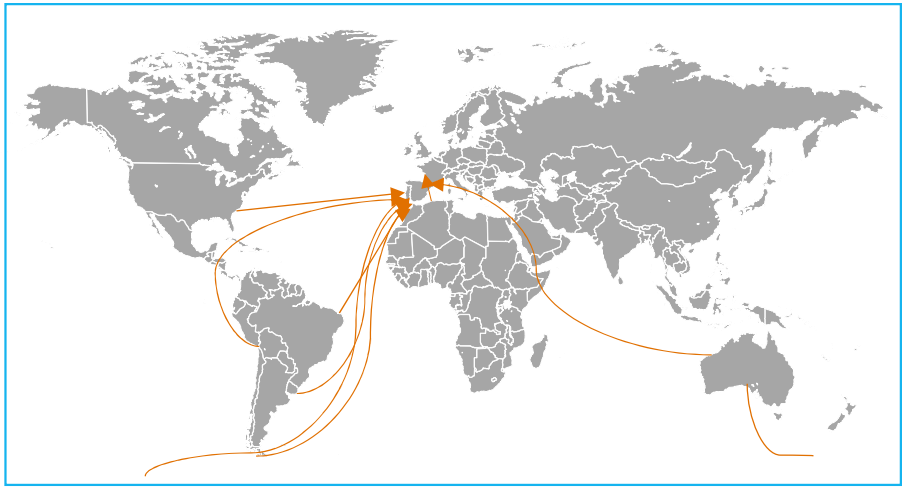
• Combustion installations with a rated thermal input exceeding 20 MW
• Mineral oil refineries
• Coke ovens
	• Metal ore roasting or sintering installations
	• Installations to produce pig iron or steel (with a capacity exceeding 2.5 tones per hour)
		• **Installations to produce cement clinker in rotary kilns (with a capacity exceeding 500 tones per day)**
		• **Installations to produce lime in rotary kilns (with a capacity exceeding 50 tons per day)**
		• Installations to produce other furnaces (with a capacity exceeding 50 tons per day)
		• Installations of manufacture of glass (with a capacity exceeding 20 tones per day)
		• Installations for the manufacture of ceramic by firing (with a capacity exceeding 75 tons per day)
			• Industrial plants to produce:
			  ○ Pulp
			  ○ Paper and board (with a capacity exceeding 20 tons per day)

These activities remain valid only until 2041, except for CO_2 emissions from power generation processes, which are valid until 2036.

For further details on activities eligible for RFNBO's carbon footprint reduction through CO2 capture, Annex I of the EU Directive 2003/87/EC provides comprehensive information.

CASE STUDY: EMISSIONS ASSOCIATED WITH MARITIME TRANSPORT ACCOUNT ABOUT ~10% TO THE E-METHANOL MOLECULES CARBON FOOTPRINT

It is important to note that if this illustrative project were located elsewhere in the world, maintaining all its inputs and technologies, the only emissions that would vary are those related to maritime transport.



$$E = e_i + e_p + e_{td} + e_u - e_{ccs} \quad [gCO_2eq/MJ]$$

e_{td}: Emissions from transport and distribution

Country	Average Distance to Port of Rotterdam (km)	Fuel Oil emissions gCO_2eq/MJ
Uruguay	11,513	~8.2
Morocco	2,560	~1.8
Australia	21,885	~15.6

Assumptions:
- Fuel consumption → 87.9 kg-fuel oil/nautical mile
- Emissions factor → 3.11 $kgCO_2$/kg-fuel
- Vessel capacity → 10,400 t

- According to Hinicio estimates, even when considering a route from Montevideo to Rotterdam, emissions from transport fuels can account up to 10% of the total emissions when considering the whole CFP. Even with the long distances between exporting and importing countries, 70% GHG reduction could be achieved for RFNBO production in Uruguay.
- Emissions associated with road transportation are negligible when compared with maritime transportation emissions. According to Hinicio estimates, the transportation of e-methanol over 400 kilometers in diesel trucks results in emissions of less than 0.8 gCO_2eq/MJ, which represents approximately 1% of the total emissions.

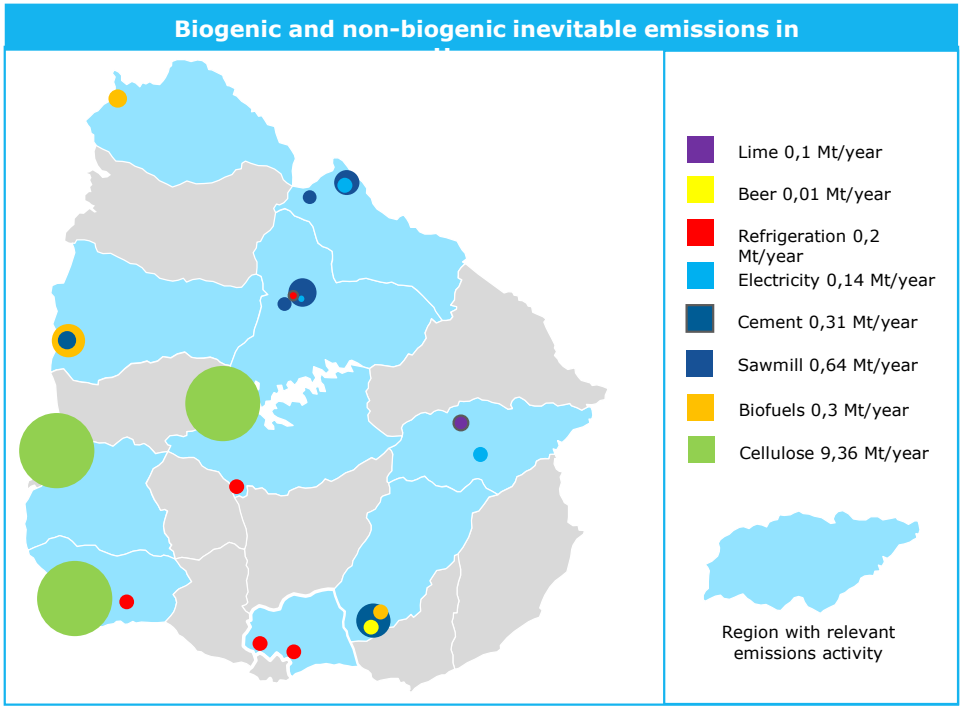
THE AVAILABILITY OF BIOGENIC CO_2 IN URUGUAY CAN CONTRIBUTE TO MEETING THE CARBON FOOTPRINT REDUCTION CRITERIA FOR RFNBO TO ~~ACHIEV~~E RED II COMPLIANCE

During 2022 more than 11 Mt/year of CO_2 inevitable emissions are associated to the industrial operation in the country.

- Cellulose plants are the main source of biogenic CO_2 emissions with more than 9.3 million tons per year of operation, corresponding to nearly the entire available quantity within the country.
- Main sources of biogenic CO_2 are located in the southwest region of Uruguay.

The availability of biogenic CO_2 for RFNBO production could contribute to meet the emissions criteria outlined in RED II. Besides, Uruguay possesses other favorable conditions for emissions reduction, including:

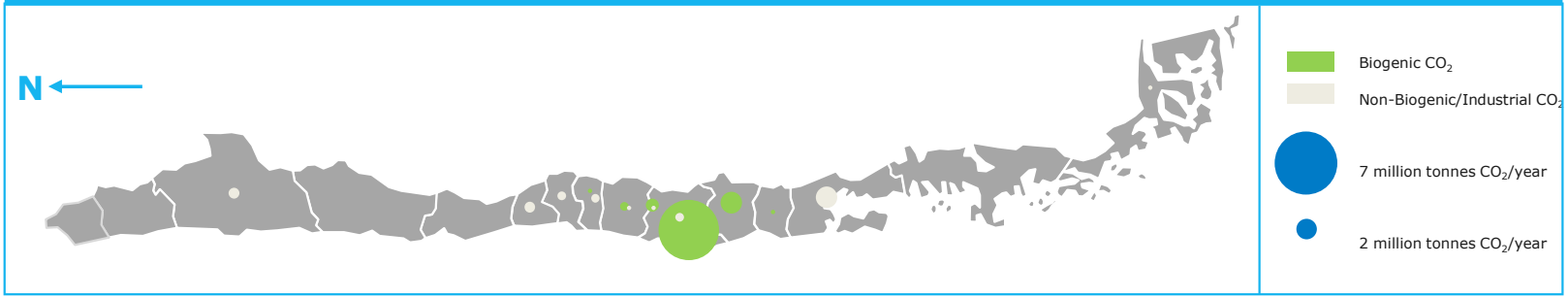
- As Uruguay is a small country, the transportation of biogenic CO_2 to production plants and/or RFNBO to ports shouldn't represent a significant amount of emissions in the RFNBO carbon footprint, as presented in the Case Study. This impact should be evaluated case by case according to the specifications of each project.
- Sources of biogenic CO_2 are near water sources, which could facilitate the commissioning of an RFNBO production plant.



Sources: Análisis de la disponibilidad de CO_2 para la producción de derivados de H_2 verde en Uruguay (GIZ, 2023).

THE AVAILABILITY OF BIOGENIC CO_2 IS EXCLUSIVE TO THE CENTRAL REGIONS OF CHILE, WITH A NOTABLE CONCENTRATION IN THE BIOBIO ~~REGION~~

Availability of biogenic and non-biogenic CO_2 in Chile



- According to the definition of RED II, eligible sources of CO_2 that contribute to reducing emissions are mainly located in Chile's central regions.
- Biogenic sources of CO_2 are concentrated in the Biobío region, with more than 7 million tons registered in 2022. These emissions are mainly from the cellulose industry.
- Besides the biogenic CO_2 there are emissions from another eligible sources available in Chile that can help reduce the product emissions until 2036/2041, associated to industrial activity. These are also concentrated in the regions located in the center of the country.
- Most announced projects and those under development will be located in northern or southern Chile, particularly in regions such as Antofagasta and Magallanes, which are consider major poles for hydrogen development mainly because of the renewable generation potential. Projects can also be developed in the Biobio region, but the potential of the aforementioned regions is higher.
- In this scenario, an option could be to transport the CO_2 captured at the source location to production plants situated in other regions.
- It's crucial to consider that the transportation of biogenic CO_2 from the capture site, in the case of using CO_2 available in the central zone of Chile for production plants located in the extreme zones of the country, entails CO_2 emissions that must be factored into the carbon footprint of the RFNBO.

Sources: Building Value Chains: The market ramp-up of e-Fuels in Chile (INERATEC, 2024); RETC 2022 (Ministry of Environment of Chile).

Conclusions

- Producing RFNBO hydrogen, hydrogen derivatives or e-fuels, and trans-oceanic shipping to Europe, is possible and can still meet RFNBO criteria of RED III and Delegated Regulations
- Some countries may be easier to show compliance, when their electricity system is more similar to the European grid
  - Otherwise, an analysis of the grid and power market may be needed to prove geographical and temporal correlation
- Using close to 100% RE for the electrolysis, allows in most cases for compliance
- If BOP is also powered by RE, all transport modes are possible for transport and still meet 70% carbon reduction criteria
- Playing with power from the grid to optimise the BC can be done for certain transport vectors
- Meeting RFNBO criteria comes at a cost, but can still be done competitively
- Combining CO2 and renewable RFNBO hydrogen to produce carbon-rich H2 derivatives or e-fuel, can also meet RFNBO criteria.

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- Volgende online sessie woensdag 13 november a.s.:
  - Deep Dive: 4-pilaren aanpak HBR - Gasunie – InvestInternational |
    Martijn Coopman, PoR

Datum	
Woe 13 November	Online
Woe 11 december	F2F

SHIP>NL Sessie IX 16 oktober 2024

Hartelijk dank voor uw aandacht

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De slides van alle sessies zijn te vinden op:
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