RSB
Roundtable on
Sustainable Biomaterials
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Power-to-

RSB Handbook

Power-to-X in the sustainable transition

Everything you need to know
about Power-to-X technologies
to make the sustainable transition
to a bio-based and circular economy

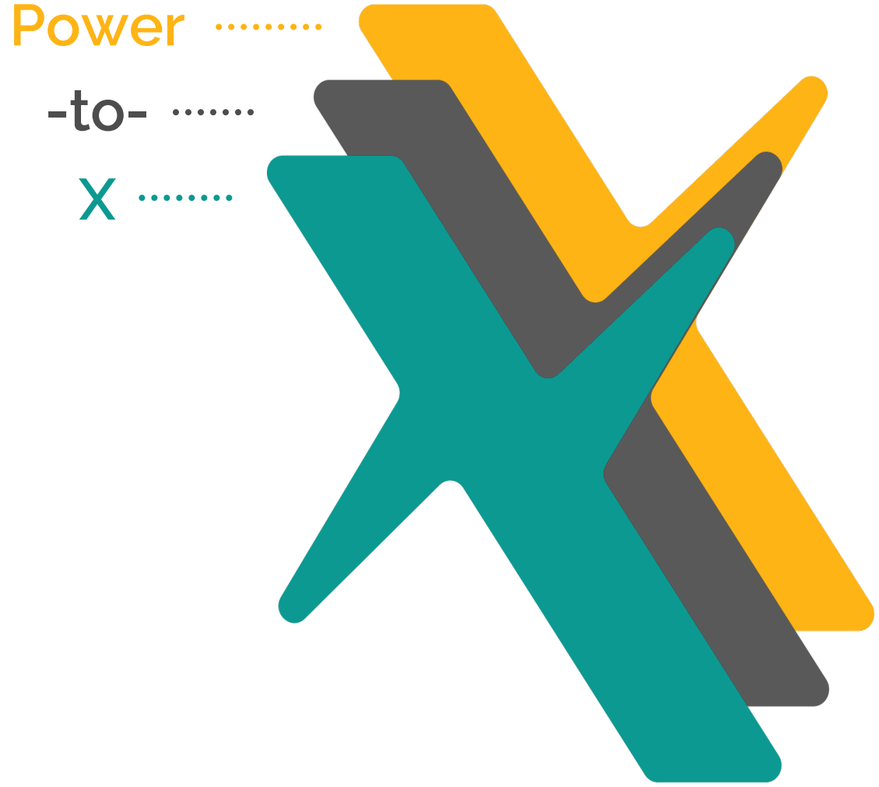
Contents

Part 1

What is Power-to-X?

Our definition

Power-to-X (PtX or P2X) refers to innovative conversion technologies that turn renewable electricity into various synthetic and low-carbon fuels – such as hydrogen, sustainable aviation and maritime fuels, synthetic natural gas, liquid fuels or chemicals – which can be used to decarbonise hard-to-abate sectors, or stored for later use.

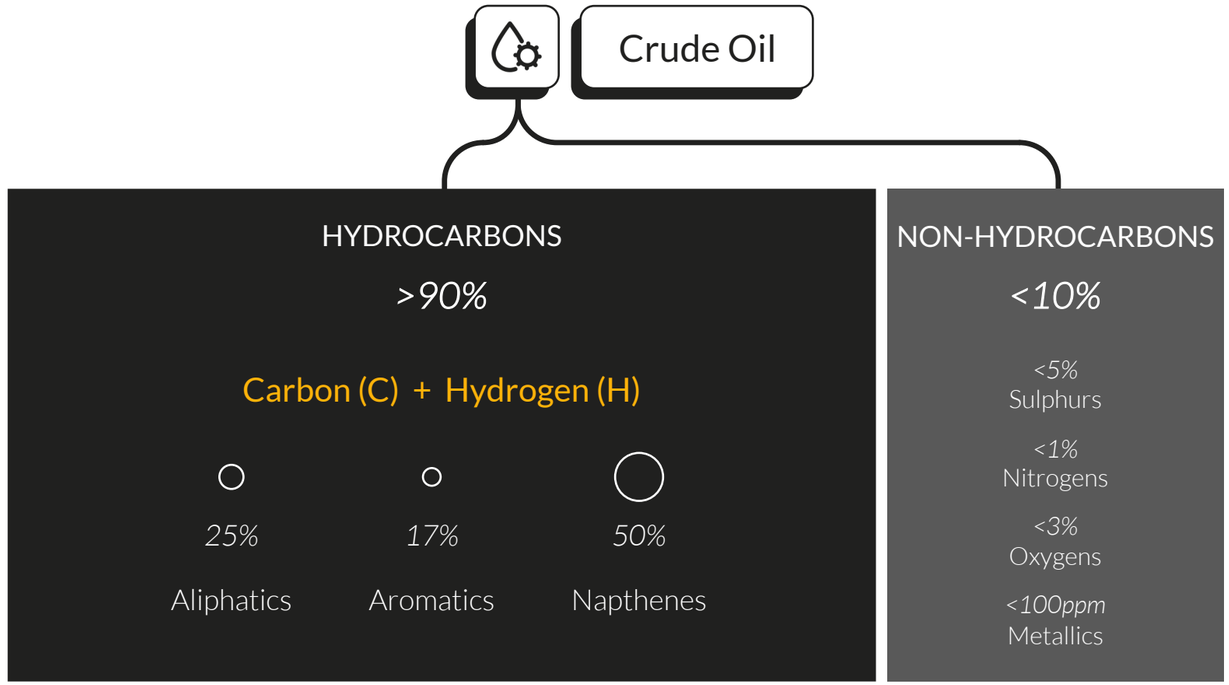


Part 2

The Power-to-X opportunity

Industry is currently powered by fossil fuels

These days, most fuels, plastics and chemicals come from high-energy hydrocarbon molecules found in oil.



But it is not a sustainable energy source

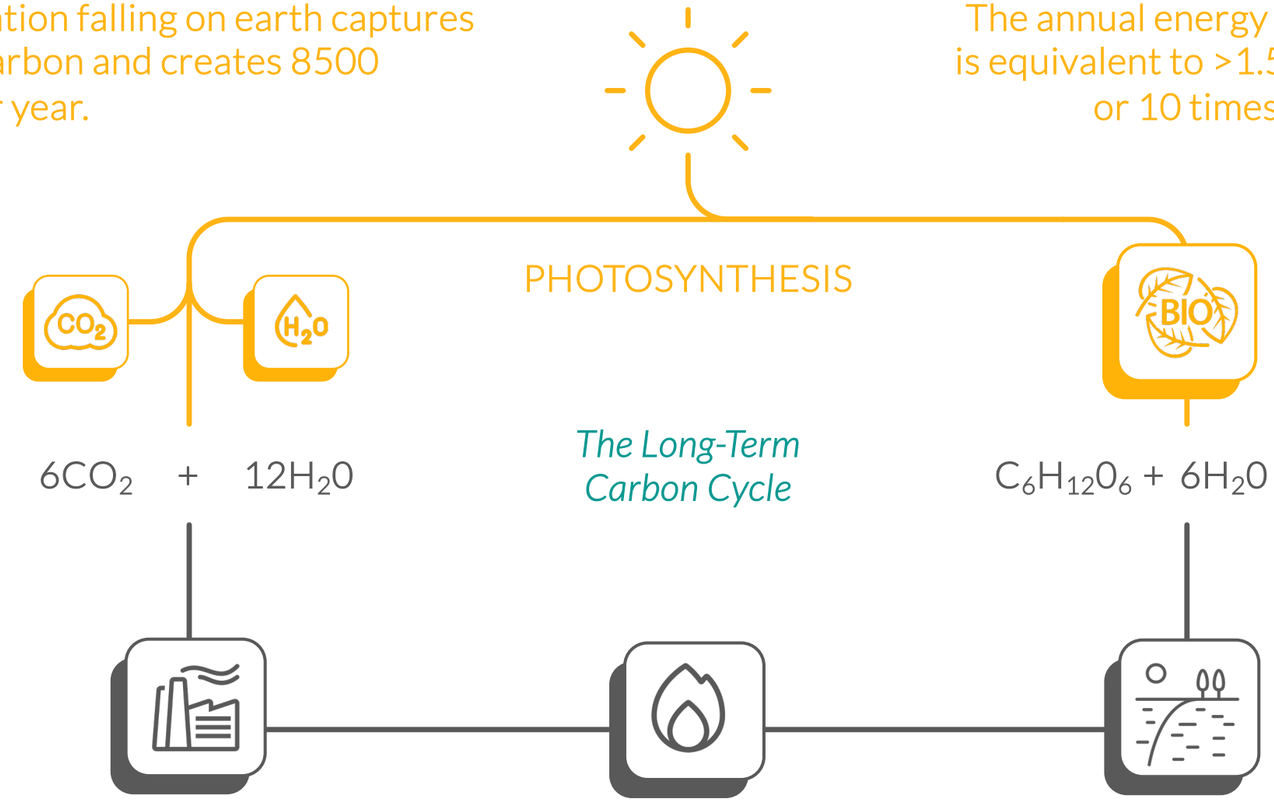
Firstly, oil only forms at 1,500 tons a year, but is being extracted at 4.5 billion tons a year. Secondly, when we burn oil, we release stored CO_2 into the atmosphere, which is changing the climate.

The energy in oil is originally created by photosynthesis

Photosynthesis – a key stage of the carbon cycle – is an efficient chemical process that occurs in plants, algae and types of bacteria, which takes the energy from sunlight to combine water and carbon into energy in the form of glucose (sugars) and oxygen.

Just 0.1% of solar radiation falling on earth captures 220 billion tonnes of carbon and creates 8500 exajoules of energy per year.

The annual energy produced via photosynthesis is equivalent to >1.5 trillion barrels of petroleum or 10 times current world consumption!



Produces glucose, the building block of biomass

COMBUSTION

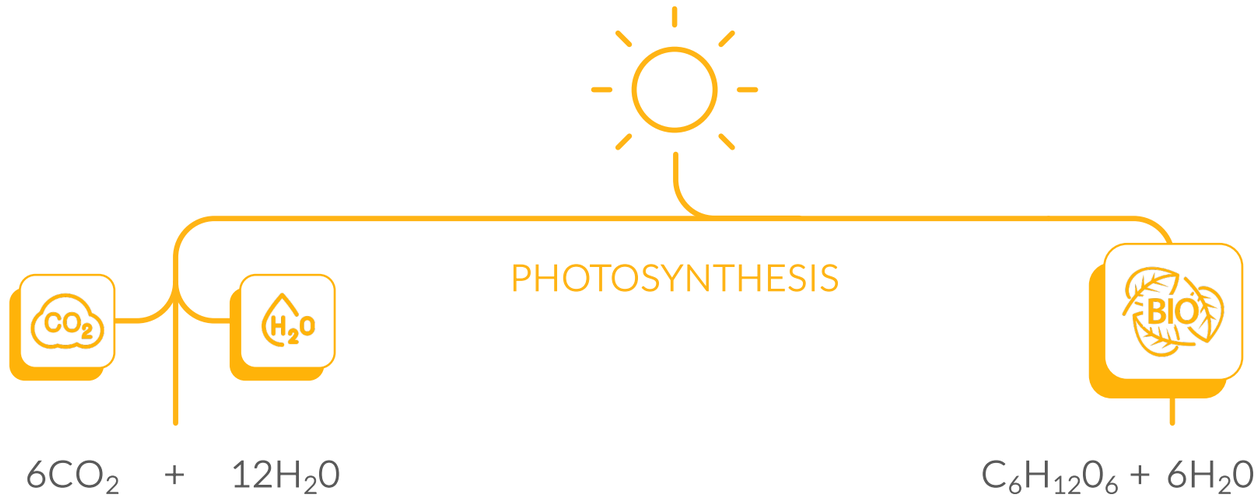
Burning oil releases stored CO_2 into the atmosphere

FORMATION

Oil is created by heat, pressure and time when biomass deposits as sediments on the seabed

The Power-to-X opportunity

What if we could develop a similar technology that can transform and use energy like photosynthesis?



Water and carbon dioxide, and a renewable source of energy — Power-to-X → *Produce high-energy hydrocarbon molecules without using fossil fuels*

Why is this important?

Power-to-X is a 4D technology.

Decarbonising

It can capture and use CO_2 from the atmosphere and waste gases.

Dense

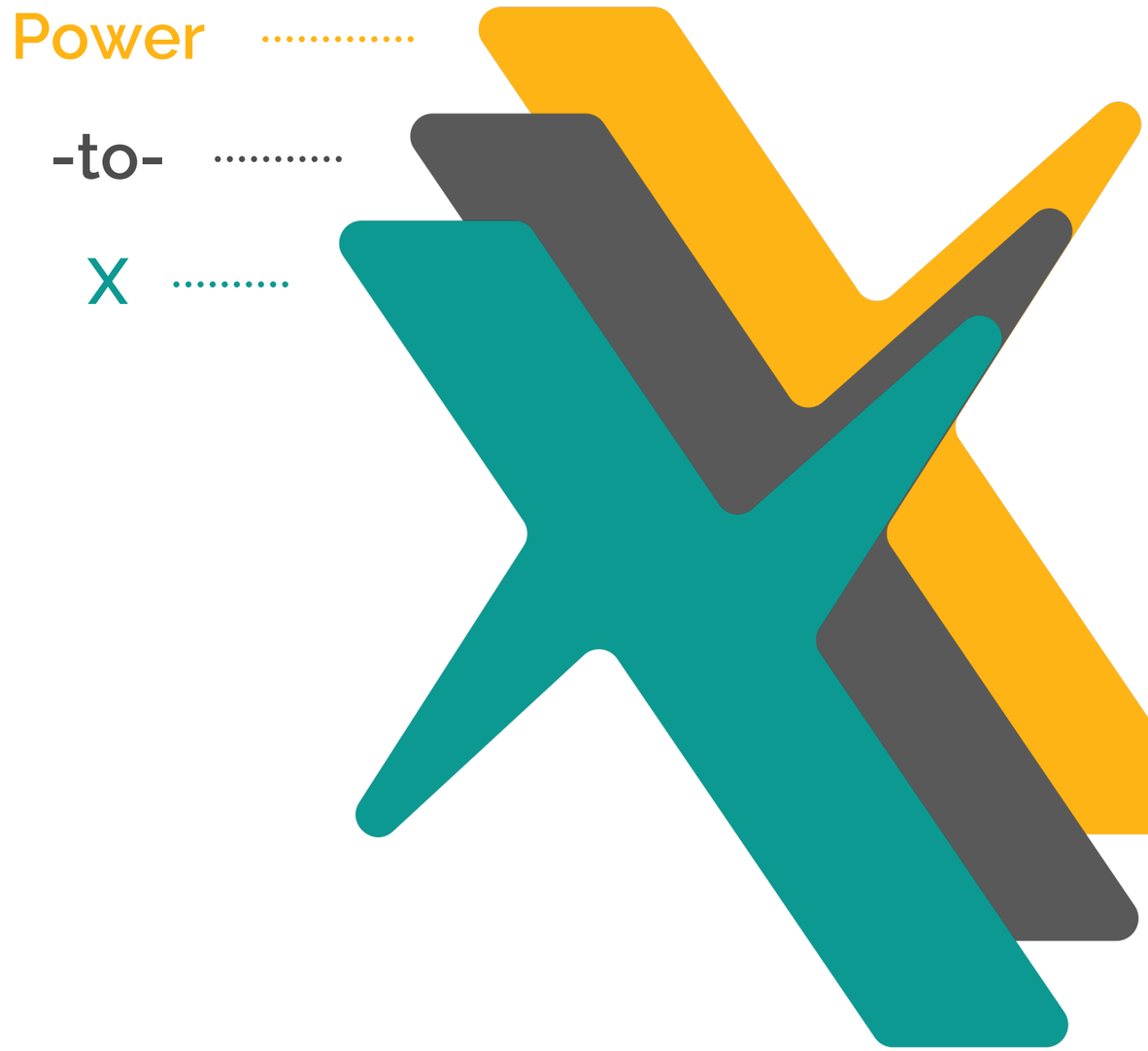
It can be used to produce high energy-density molecules.

Disruptive

It can produce hydrocarbons anywhere in the world.

Diverse

It can produce many different types of fuels and chemicals.



Part 3

How does it work?

3 key stages in the Power-to-X process

Stage 1

Power Generation

Renewable energy is generated from wind, solar, hydro and biomass.

Stage 2

Conversion

Electrolysis converts water into hydrogen, which is either used on its own, or combined with carbon from biogenic or non-biogenic sources, or nitrogen from air separation to create high-energy molecules.

Stage 3

Applications

Renewable hydrogen can be used directly as a fuel to produce electricity or heat, or as a chemical feedstock.

Hydrogen combined with carbon or nitrogen and converted catalytically produces a wide range of fuels, chemical feedstocks, fertilisers etc.

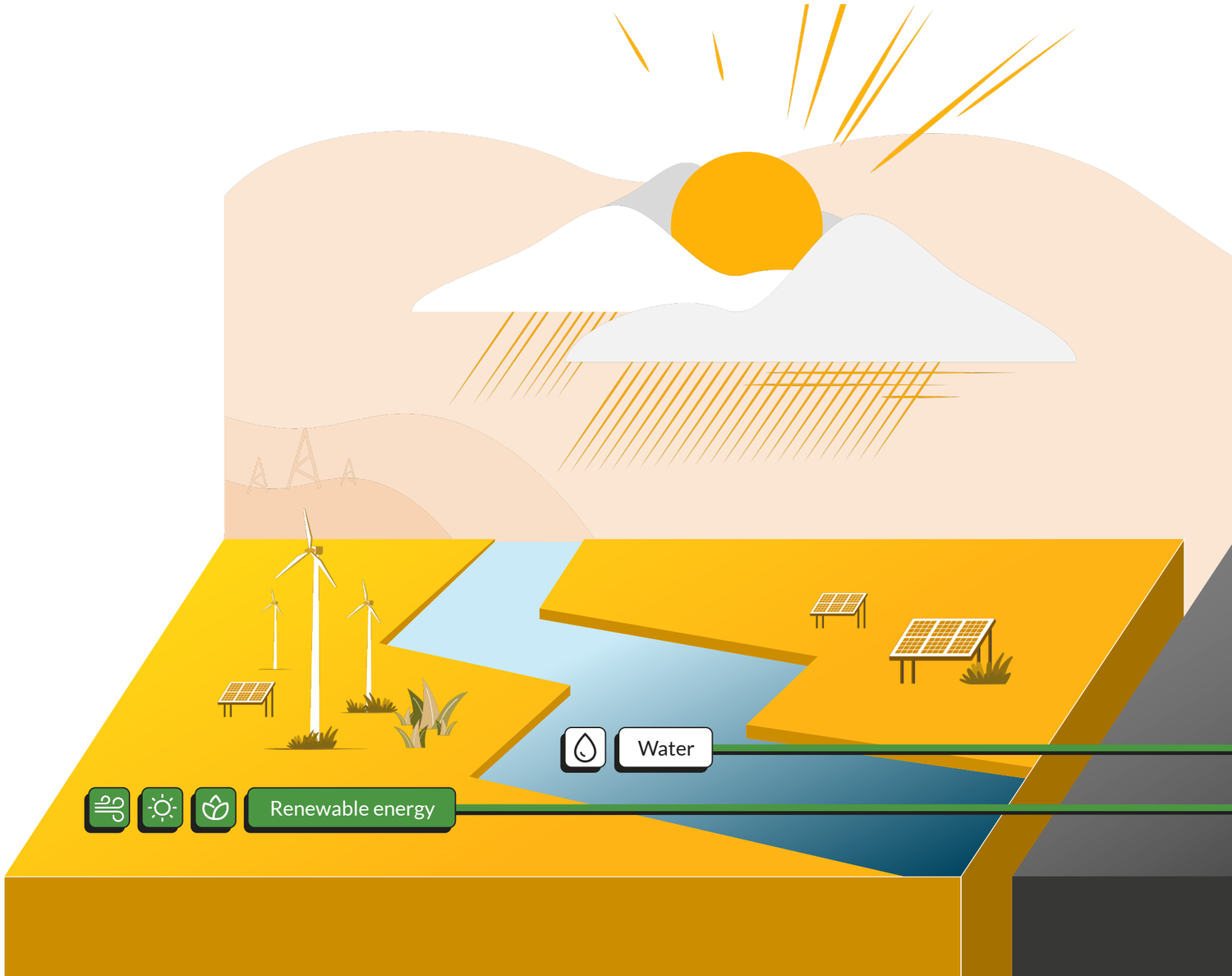
Power -to- X

Stage 1

Power Generation

Renewable energy

Electricity obtained or produced from renewable non-fossil sources, namely wind, solar and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogas.



Water

Purified water is required to produce hydrogen via electrolysis. In general, 9 kg of water is required to produce 1 kg of hydrogen.

Carbon

To produce synthetic hydrocarbons, such as electrofuels or chemicals, a carbon source is needed. Carbon can have biological as well as non-biological origins, or be captured from atmosphere or geological sources.

Electrolysis

This is a method that uses renewable electricity to drive a non-spontaneous chemical reaction, such as the production of hydrogen from water splitting.

Synthesis of molecules

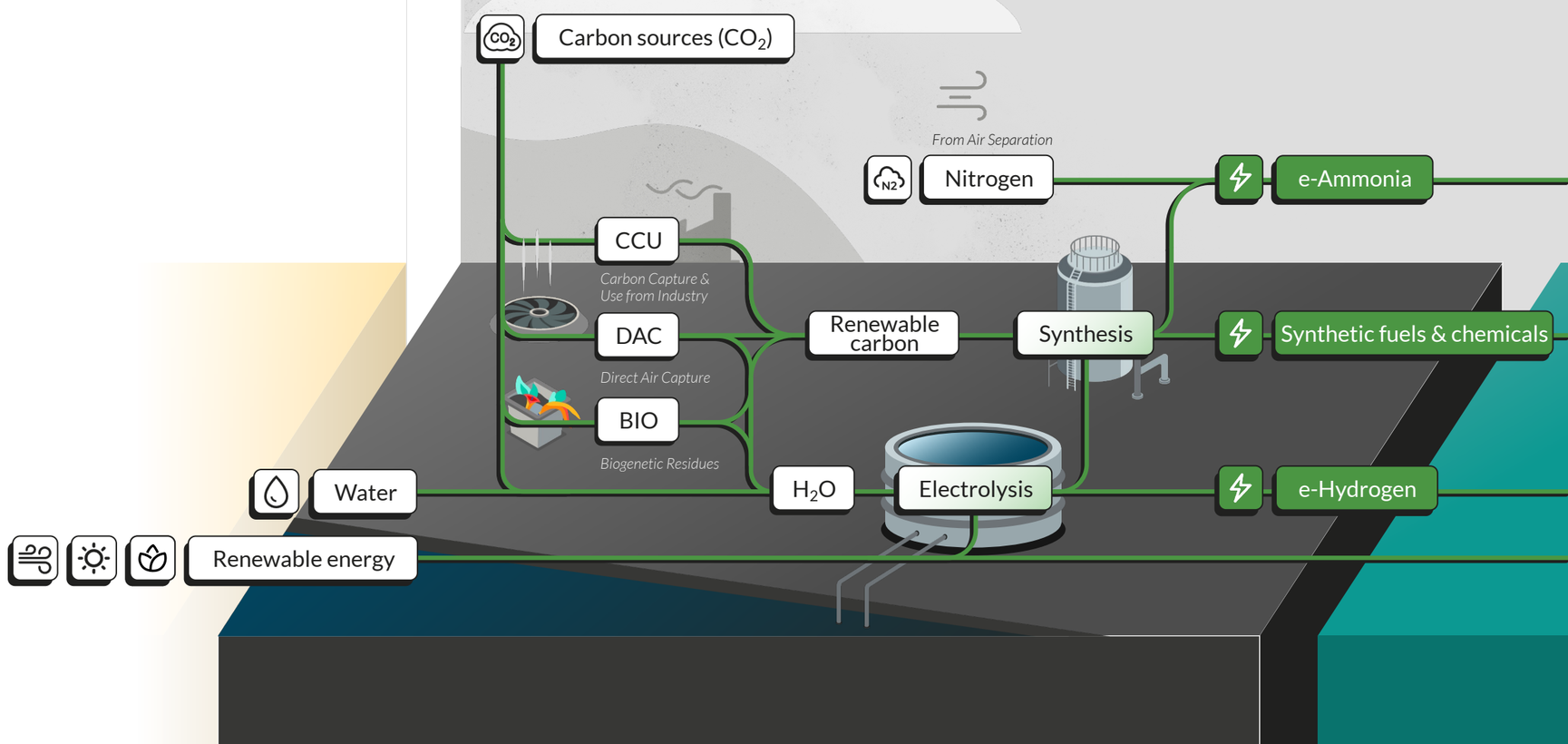
Using chemical and biotechnology processes, synthetic molecules (e.g. hydrocarbons and related compounds, such as alcohols) can be produced by combining hydrogen with a renewable carbon source.

Synthesis of e-ammonia

Hydrogen can be combined with nitrogen (captured from the atmosphere) via a process called Haber-Bosch synthesis, to produce e-ammonia.

Stage 2

Conversion



e-Ammonia

Used to create chemical feedstocks, fertilisers, as a carrier for hydrogen or directly use for energy.

Synthetic fuels and chemicals

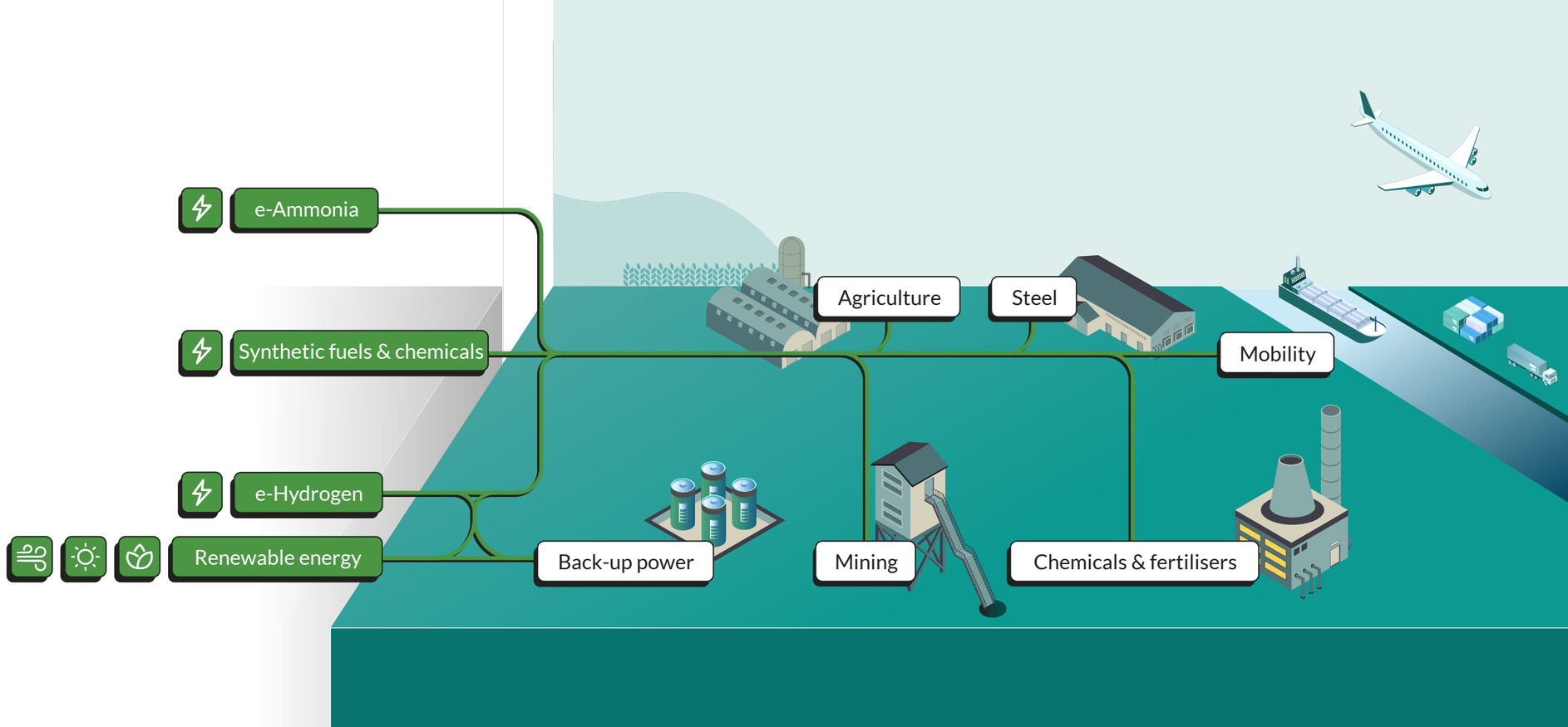
Directly used to create low-carbon fuels e.g. sustainable aviation or maritime fuels, and also used to create chemical feedstocks and electricity.

e-Hydrogen

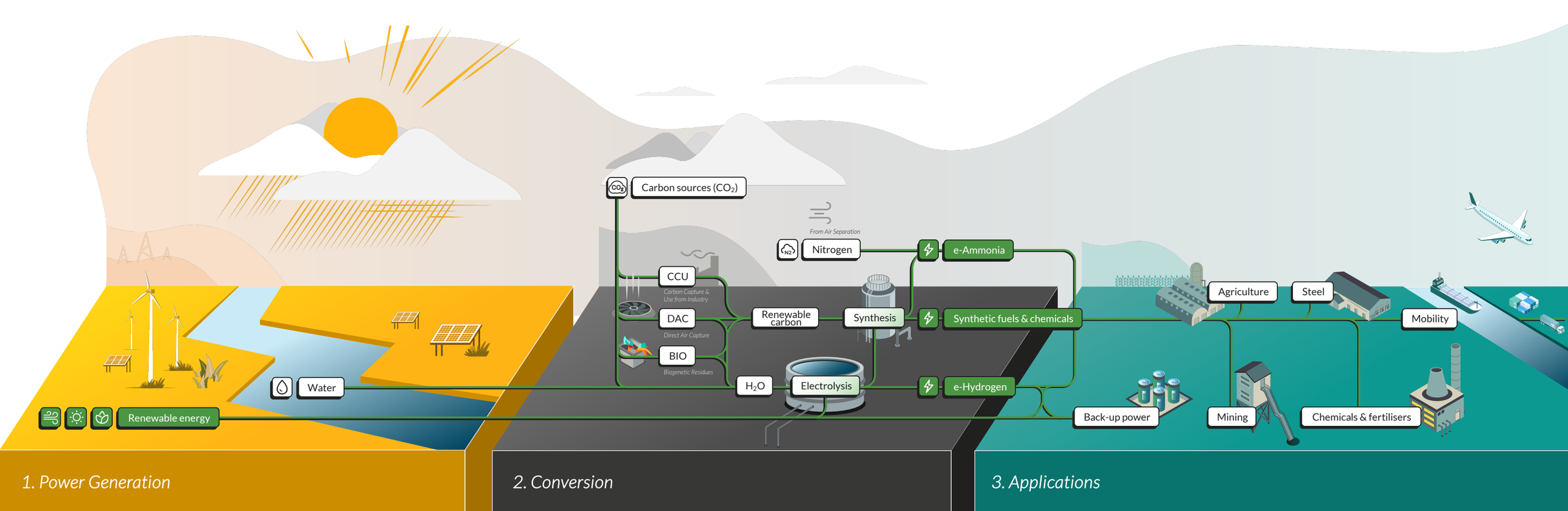
Directly used for mobility, electricity, chemical feedstocks and heat.

Stage 3

Application



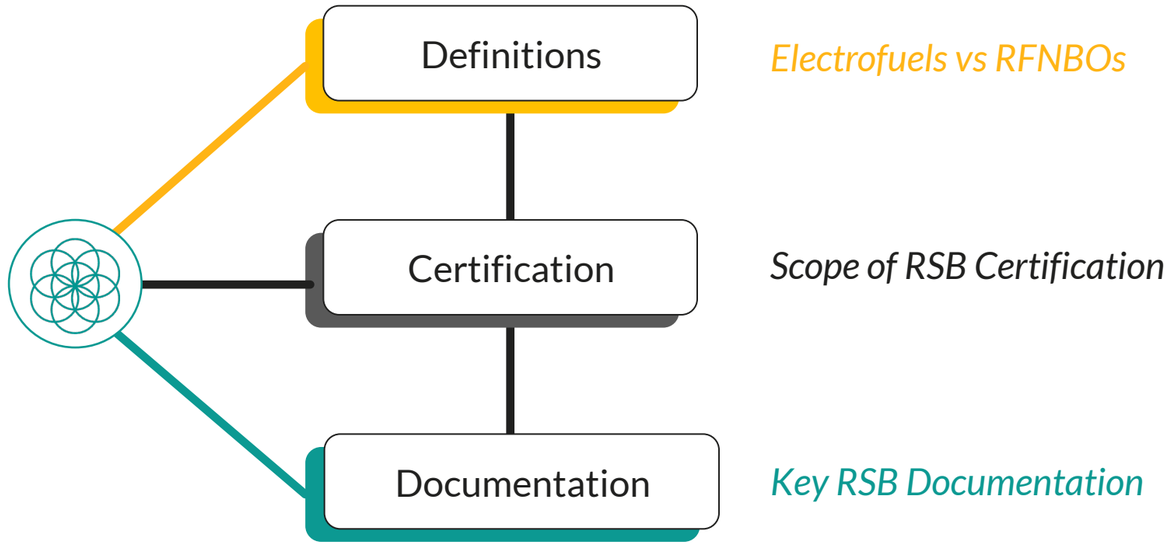
Power-to-X


Carbon sources (CO_2)
From Air Separation
Nitrogen
e-Ammonia
CCU
Carbon Capture & Use from Industry
DAC
Direct Air Capture
BIO
Biogenetic Residues
Renewable carbon
Synthesis
Synthetic fuels & chemicals
Water
H_2O
Electrolysis
e-Hydrogen
Renewable energy
Back-up power
Agriculture
Steel
Mobility
Mining
Chemicals & fertilisers
1. Power Generation
2. Conversion
3. Applications

RSB Power-to-X

Part 4

RSB approach for sustainable PtX production



Key definitions

Electrofuels

Liquid or gaseous fuels and intermediates produced from renewable hydrogen, and combined together with carbon monoxide or carbon dioxide or nitrogen.

Carbon and nitrogen can have biological as well as non-biological origins.

The energy content stems from the hydrogen molecule in the fuel and hydrogen component must be produced in an electrolyser that uses renewable electricity or be obtained from renewable fuels reforming.

Hydrogen from fossil hydrocarbon reforming is not accepted for the production of electrofuels.

RFNBOs (renewable fuels of non-biological origin)

Liquid or gaseous fuels and intermediates whose energy content comes from renewable energy sources other than biomass.

Carbon, hydrogen and electricity which contribute to the energy content of the fuel shall have a non-biological origin.

The hydrogen component must be produced in an electrolyser that uses renewable electricity, excluding biomass and biogas electricity.

Hydrogen from fossil hydrocarbon reforming is not accepted for the production of RFNBOs. Hydrogen from renewable fuel reforming is not accepted under this definition but could be classified as an electrofuel.

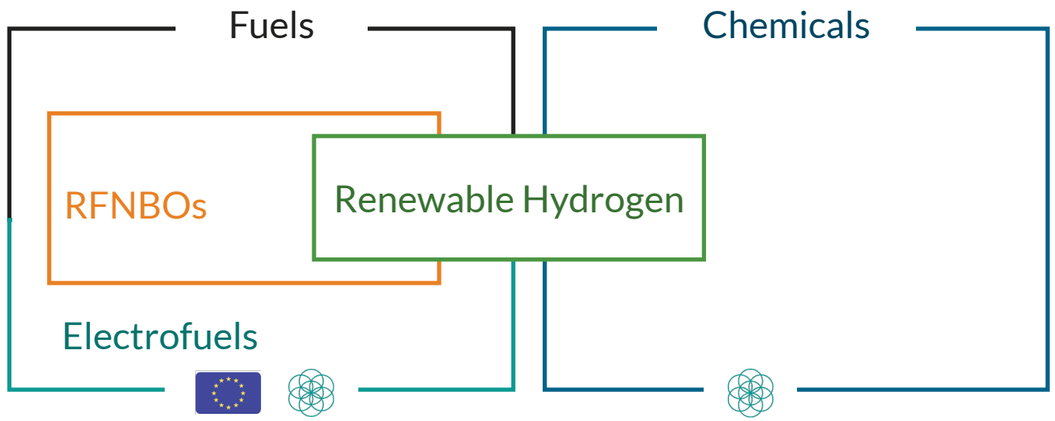
Note:

RFNBOs can also be classified as electrofuels however, the opposite is not true.
A hydrocarbon produced from non-biogenic carbon and hydrogen obtained from water electrolysis using renewable electricity is both an RFNBO and an electrofuel.

Scope of RSB Certification

RSB certification can be applied to:

- electrofuels
- RFNBOs (renewable liquid and gaseous fuels of non-biological origin)
- renewable hydrogen and chemicals



- RSB certifies both fuels and chemicals produced via PtX technologies
- The European Union Renewable Energy Directive (EU RED) is exclusively for fuels, and only RFNBOs/renewable hydrogen produced via PtX technologies

Key RSB documentation

Compliance with public policies and market regulation

RSB EU RED Standards

RSB is still in the process of updating the RSB EU RED Standards with Delegated Acts on RFNBOs.

Global scope with broader social and environmental requirements

RSB Standards for Advanced Fuels and Advanced Products

Robust and transparent chain of custody certification

RSB Chain of Custody Procedure,

RSB Book & Claim Manual

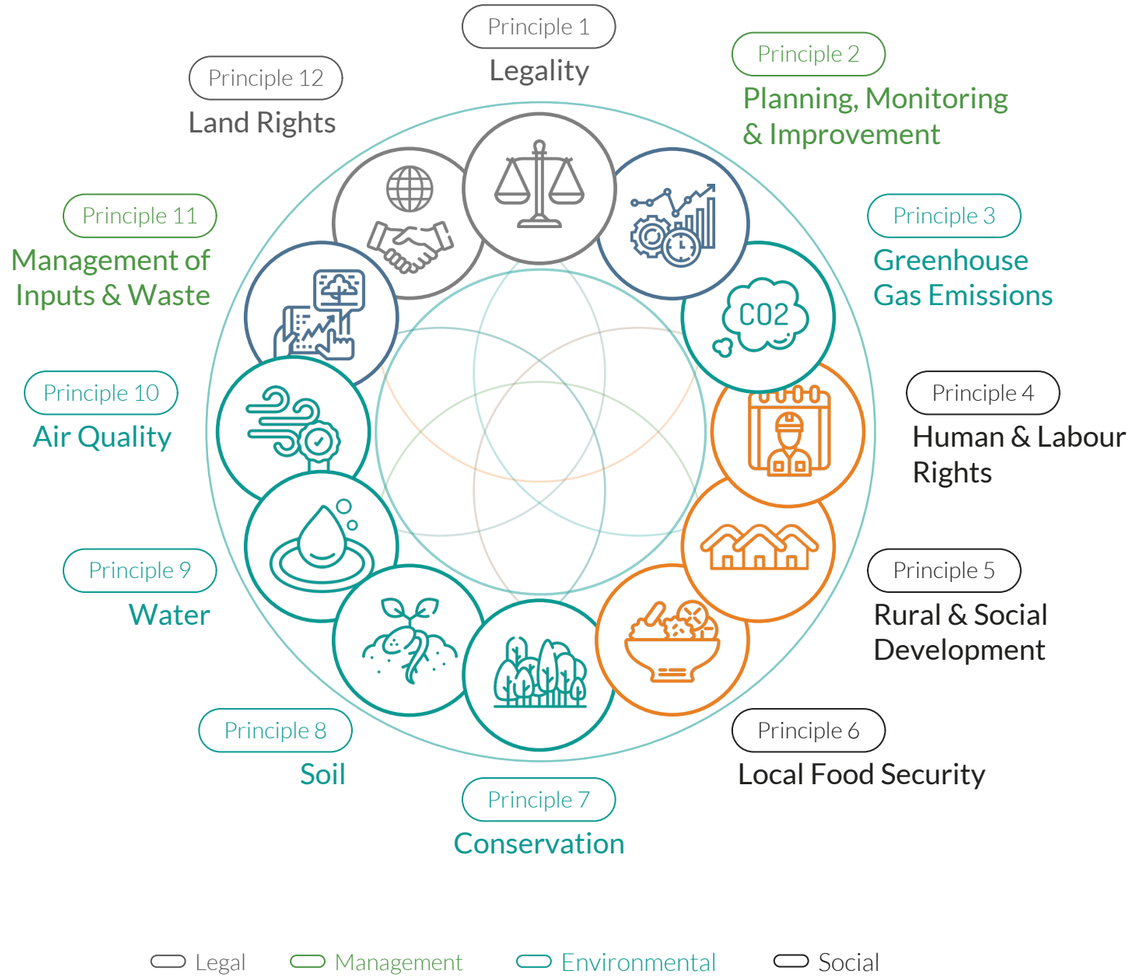
RSB Power-to-X

Part 5

Key requirements to fit with RSB's sustainability framework

12 RSB Principles & Criteria

Ensuring that PtX technology is scaled in an environmentally, socially and economically responsible way.



RSB sustainability requirements

Beyond compliance to the 12 Principles & Criteria, the RSB approach is also aligned to EU RED and includes global scope and generic requirements for all fuel and chemicals producers.

Renewable electricity

a. Specific requirements for renewable electricity (additionality, temporal and geographical correlation);

b. Renewable electricity obtained from biomass, biomass residues or biogas is accepted under the RSB Global certification if the feedstock and industrial process were RSB certified;

c. Areas identified as “no-go areas” and areas that contain identified conservation values, according to Principle 7, must not be used for the production of renewable electricity.

Carbon sources

Feedstock-specific requirements for biogenic, non-biogenic CO2 and precursors contained in waste gas.

Feedstock-specific requirements for CO2 captured from the atmosphere and geological sources.

GHG emissions

Carbon life-cycle assessment of Greenhouses Gas (GHG) emissions using RSB or EU RED GHG methodology.

Water sources

Must meet the requirements of Principle 9 and for water obtained through desalination processes, the desalination plant must use renewable electricity and comply with Principle 11, related to waste management.

RSB convened over a dozen multilateral and bilateral meetings to develop these requirements – including several member consultations with 52 participants from 31 organisations.
The requirements were approved at the RSB Assembly of Delegates on 1st December 2022.

RSB Power-to-X

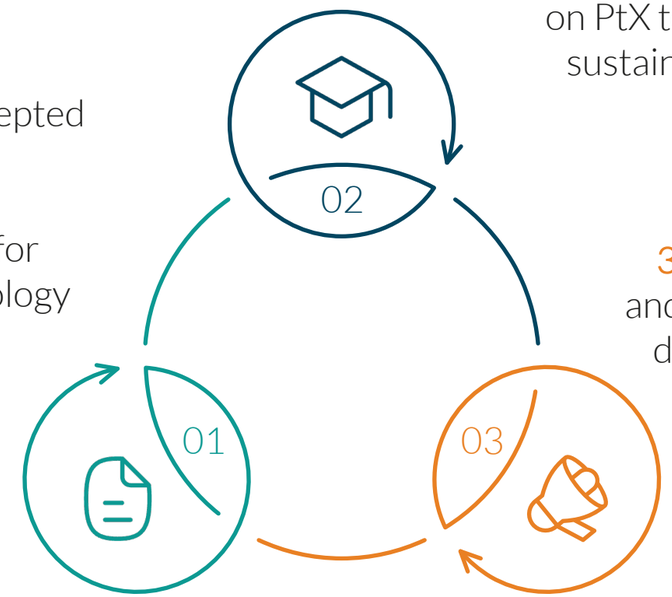
Part 6

Introducing the RSB Power-to-X Platform

A platform to convene stakeholders and experts on PtX technology sustainability

In response to increasing demand and market interest in Power-to-X (PtX) technologies, RSB hosts a platform to convene stakeholders and experts to evaluate and agree on best practices to address and reduce sustainability risks related to PtX technologies, particularly for the aviation and shipping industries.

1. Develop a commonly accepted proposal on sustainability requirements for the PtX technology



2. Deliver learning sessions on PtX technologies and sustainability practices

3. Provide advice and promote wider discussion on key sustainability areas

Find out more by clicking here ↙

Get in touch

The Roundtable on Sustainable Biomaterials (RSB) is a global membership organisation that drives the just and sustainable transition to a bio-based and circular economy.

Our sustainability framework has been developed by our multi-stakeholder membership, and is a uniquely robust and credible foundation for addressing the climate crisis.

We use this foundation to develop projects, guidance and new knowledge and solutions that equip key decision-makers to deliver net-positive impacts for people and the planet.

Contact us

info@rsb.org

www.rsb.org

LinkedIn

The Roundtable on Sustainable Biomaterials
International Environment House 2
Chemin de Balexert 7-9
1219 Châtelaine
Switzerland