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# **The methane supply chain, from production to transport and consumption, in the light of the EU strategy**

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# Overview

At the end of 2019, through the **Green Deal**, the European Commission took further steps to make Europe the first climate-neutral continent by 2050 while stimulating the economy.

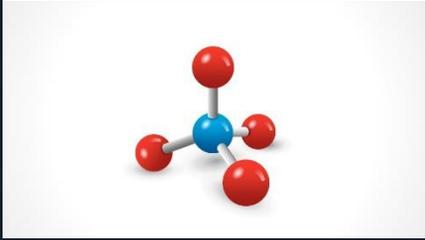
**Cop26 in Glasgow** reached an agreement (Global Methane Pledge), which aims to reduce global methane emissions by (at least) 30% by 2030, compared to 2020 levels.

In this context, the **circular economy** is not just a tool to improve waste management but a valuable tool for addressing the global environmental challenges of our time.

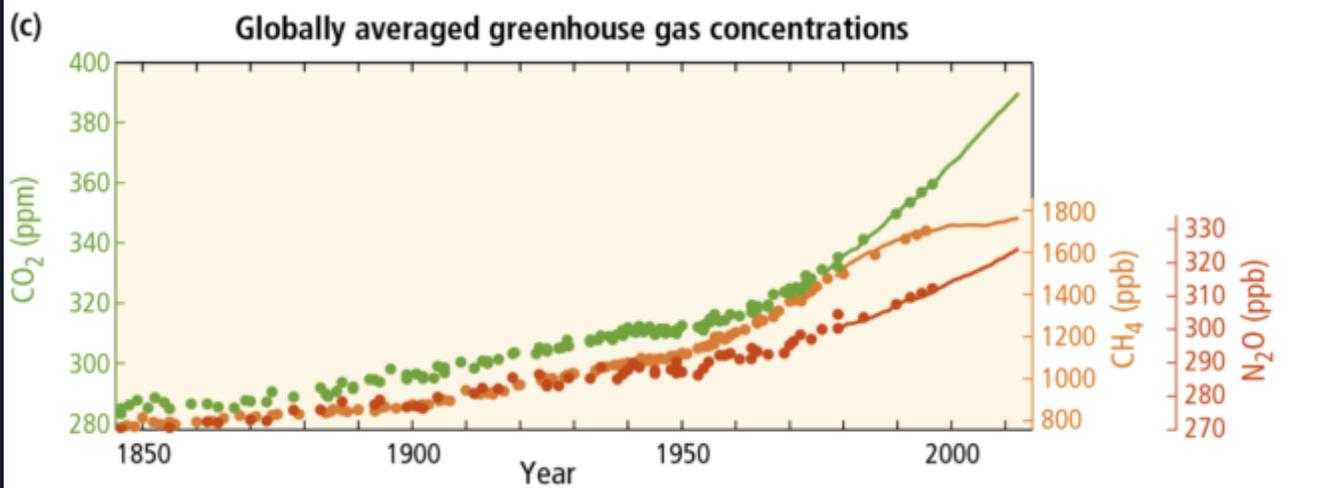
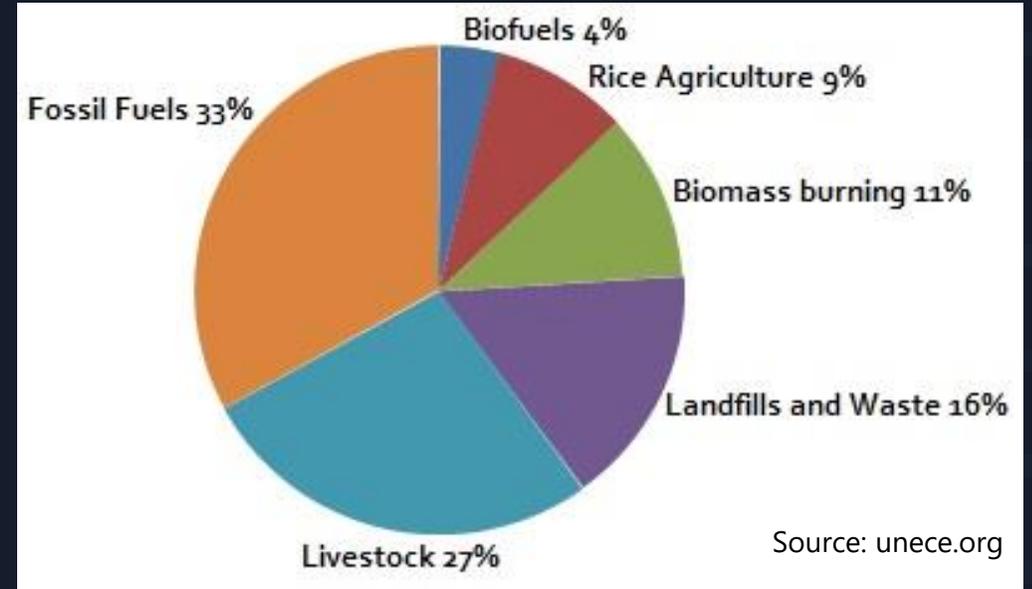
The transition to the circular economy should mobilize 100 billion euros in **investments** in the Italian electricity sector and 700,000 **new qualified jobs** from 2030.



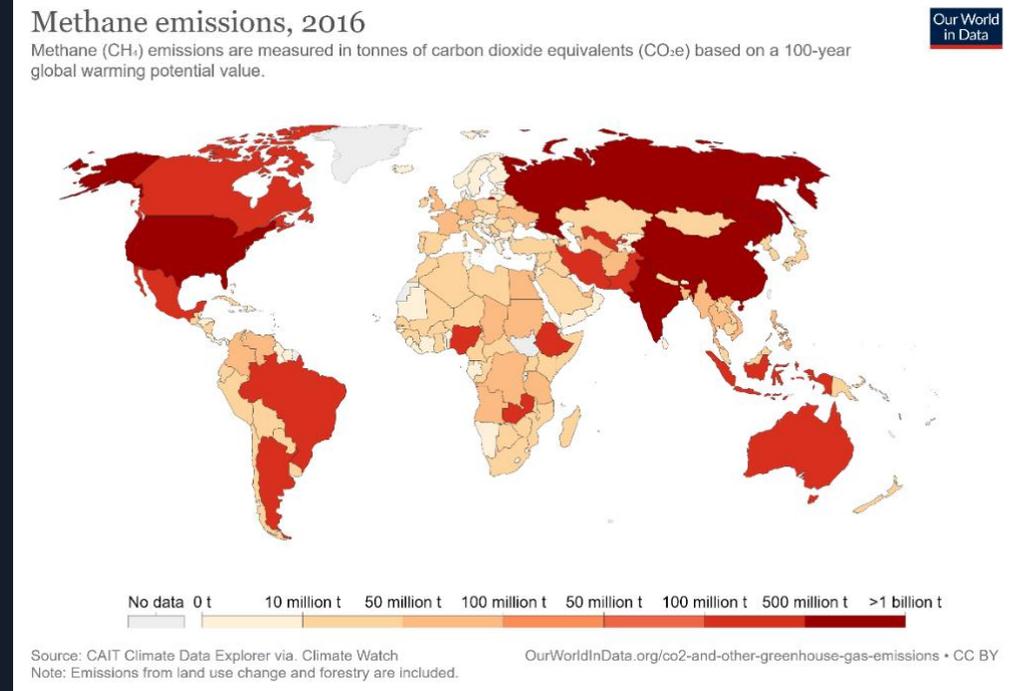
# Introduction



**Methane has a global warming potential about 84 times higher than CO<sub>2</sub> over 20 years. Methane has a more substantial greenhouse effect than CO<sub>2</sub>, even if the permanence of CH<sub>4</sub> in the atmosphere is shorter than that of CO<sub>2</sub> (5 to 200 y).**



IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change



# EU strategy to reduce methane emissions

- Promote **Measurement, reporting, and verification** of detailed national emissions data and information (tier 3) for energy related-sectors to the United Nations Framework Convention on Climate Change (UNFCCC);
- Establish **an international methane emissions observatory** by supporting the UNEP / IEA / CCAC initiatives;
- Exploitation of **satellite-based detection** and monitoring of super emitters through the EU's **Copernicus** programme;
- **Revisions of relevant environmental and climate legislation** (EU Emissions Trading System - ETS, industrial emissions IPPC-IED and European Pollutant Release and Transfer Register - E-PRTR, National Emission Ceilings - NECD);
- **Improvement of the market for biogas** from biogenic sources.
- **Agriculture**: promotion of methane-reducing approaches; best practices and technologies, feed and animal farming changes, and carbon farming to reduce agricultural emissions.
- **Waste and WWTPs**: the main identified sources of methane are uncontrolled emissions of landfill gas in landfill sites, the treatment of sewage sludge and leaks from plants due to poor design or maintenance.
- **Energy** sector: improve methane leak detection and repair (LDAR) programs in fossil gas infrastructure and transmission/distributions systems; preventing and controlling routine venting and flaring.

# EU strategy to reduce methane emissions

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- **Agriculture**: promotion of methane-reducing practices and technologies, feed and changes, and carbon farming to reduce emissions.
- Establishing **an international methane observatory** by supporting the initiatives;
- **Ps**: the main identified sources of controlled emissions of landfill gas in treatment of sewage sludge and leaks poor design or maintenance.
- The exploitation of **satellite-based** monitoring of super emitters through programme;
- **Improve methane leak detection and systems in fossil gas infrastructure and emissions systems; preventing and preventing and flaring.**
- The **revisions of relevant environmental legislation** (EU Emissions Trading emissions IPPC-IED and European Transfer Register - E-PRTR, National NECD);
- **Improvement of the market for biogas** sources.

## 'Fit for 55' package of legislative initiatives:

### ➤ Hydrogen and Decarbonised Gas Market Package.

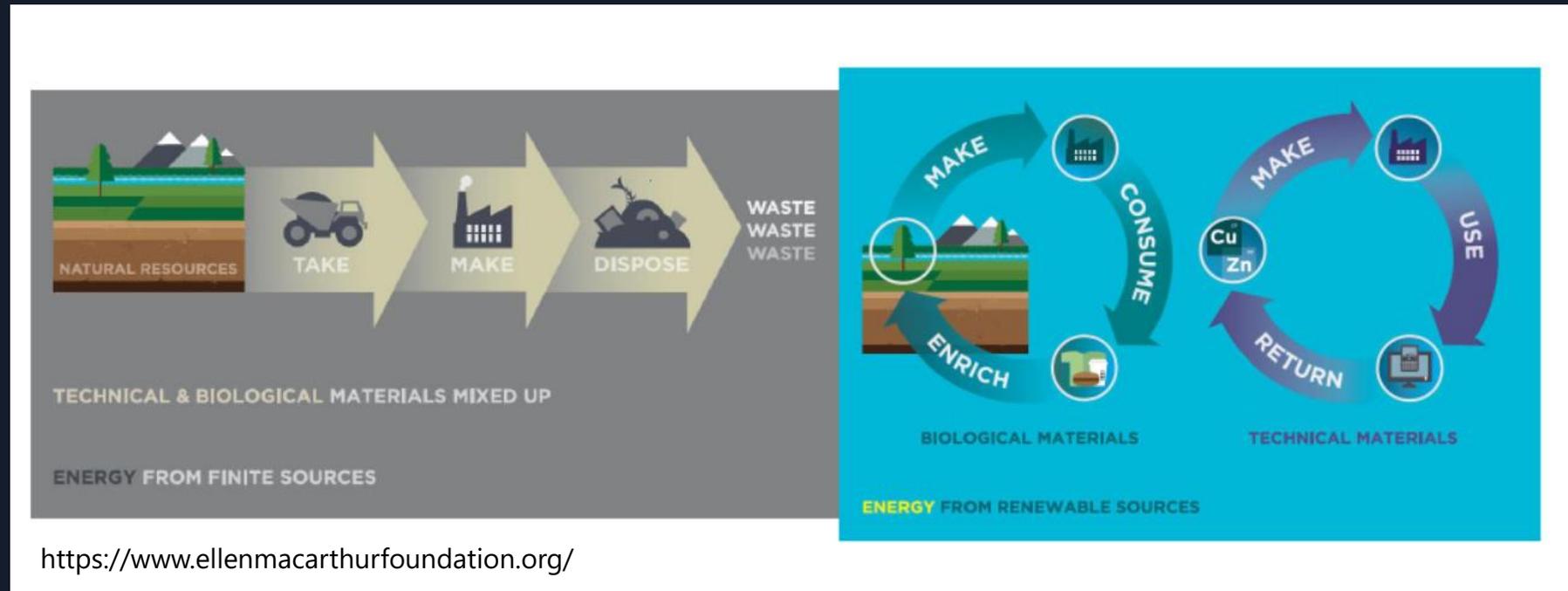
1. Facilitate the access of biomethane and other renewable gases not only to the distribution and transmission level, but also to LNG terminals and storage capacity;
2. Tariff discounts for renewable and low carbon gases to improve their competitive position against natural gas;
3. Ensure that gas quality issues do not hinder cross-border flows.

# Methods

1. The present project work outlines the comprehensive policy framework on the methane supply chain, from production to transport, store, and supply in light of the recent EU strategy.



- Since renewable energy sources' contribution is increasing, and the perspective is to derive **green bio-based feedstock** in a production circular system.



# Methods

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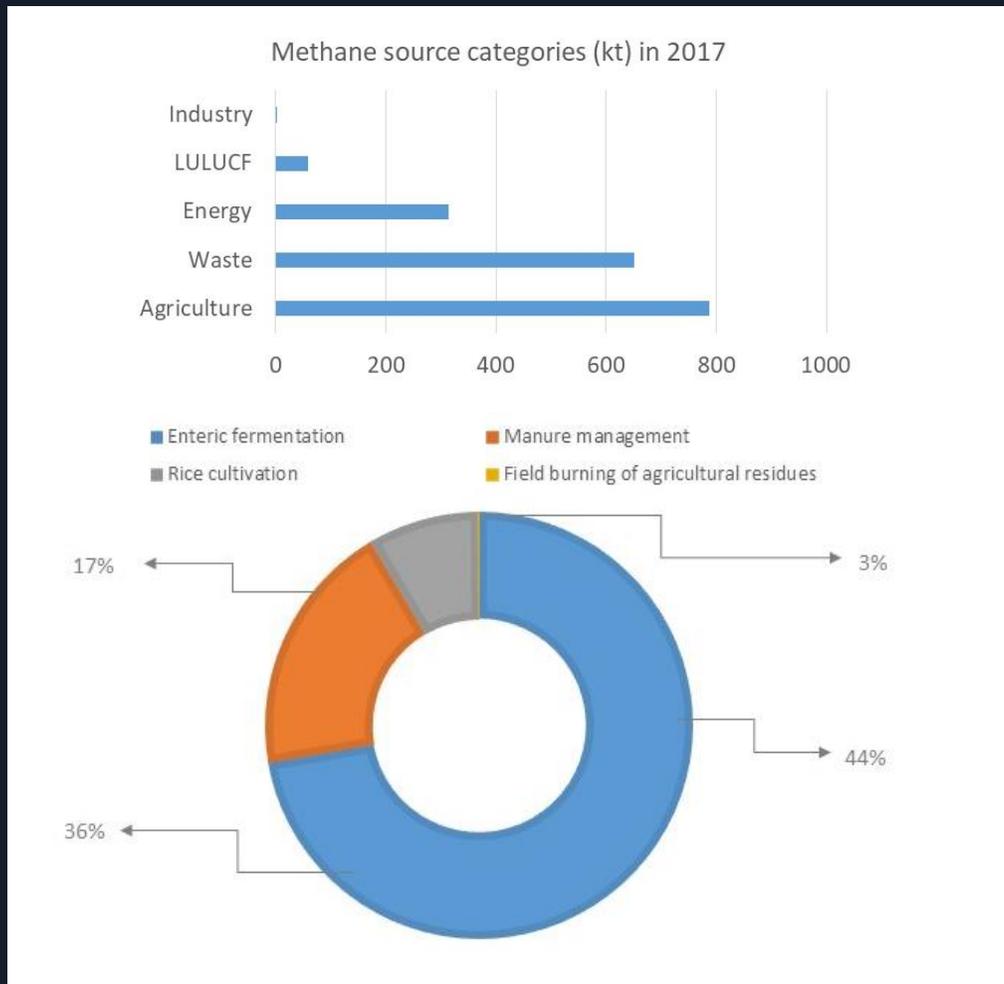
2. In principle, the overall process of **production of biofuel / bio-based products may be considered carbon neutral**. The paper also explores new ways for bioenergy with **carbon capture and storage to achieve negative carbon emissions (BECCS)**.

3. The project work presents a **use case on a Company**, Tonissipower (Ranieri Tonissi S.p.A.), which set up a biogas/biomethane generation system.

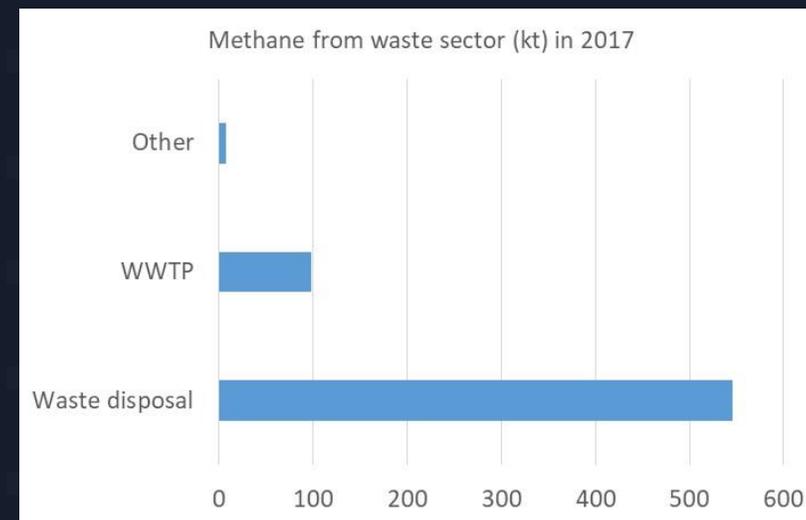
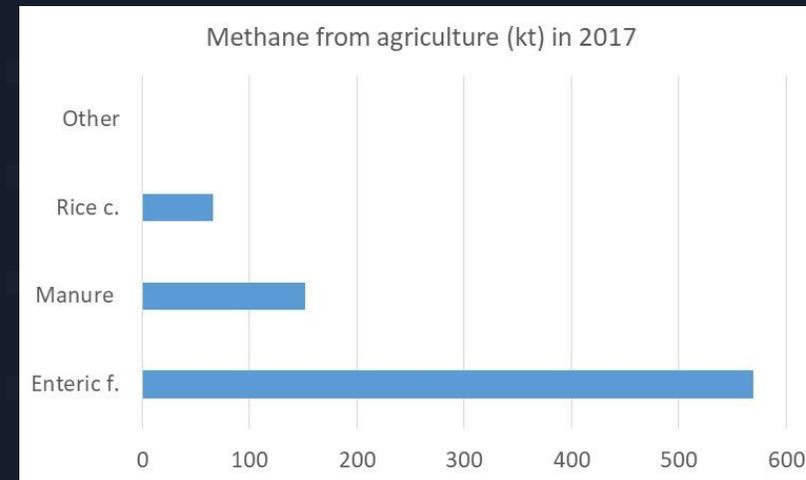


The circular bio-economy allows the exploitation of biological resources' potential preventing the dependence on imports while preserving (and possibly restoring) ecosystems' integrity.

# Current status of national methane emissions



Italian methane emissions per sectors (kt) (Source: Mite (2019) Fourth Biennial Report Italy - UNFCCC)



# Current regulations and best practices - Agriculture

The EU strategy to reduce methane emissions builds on the current cross-sector and sector-specific actions.

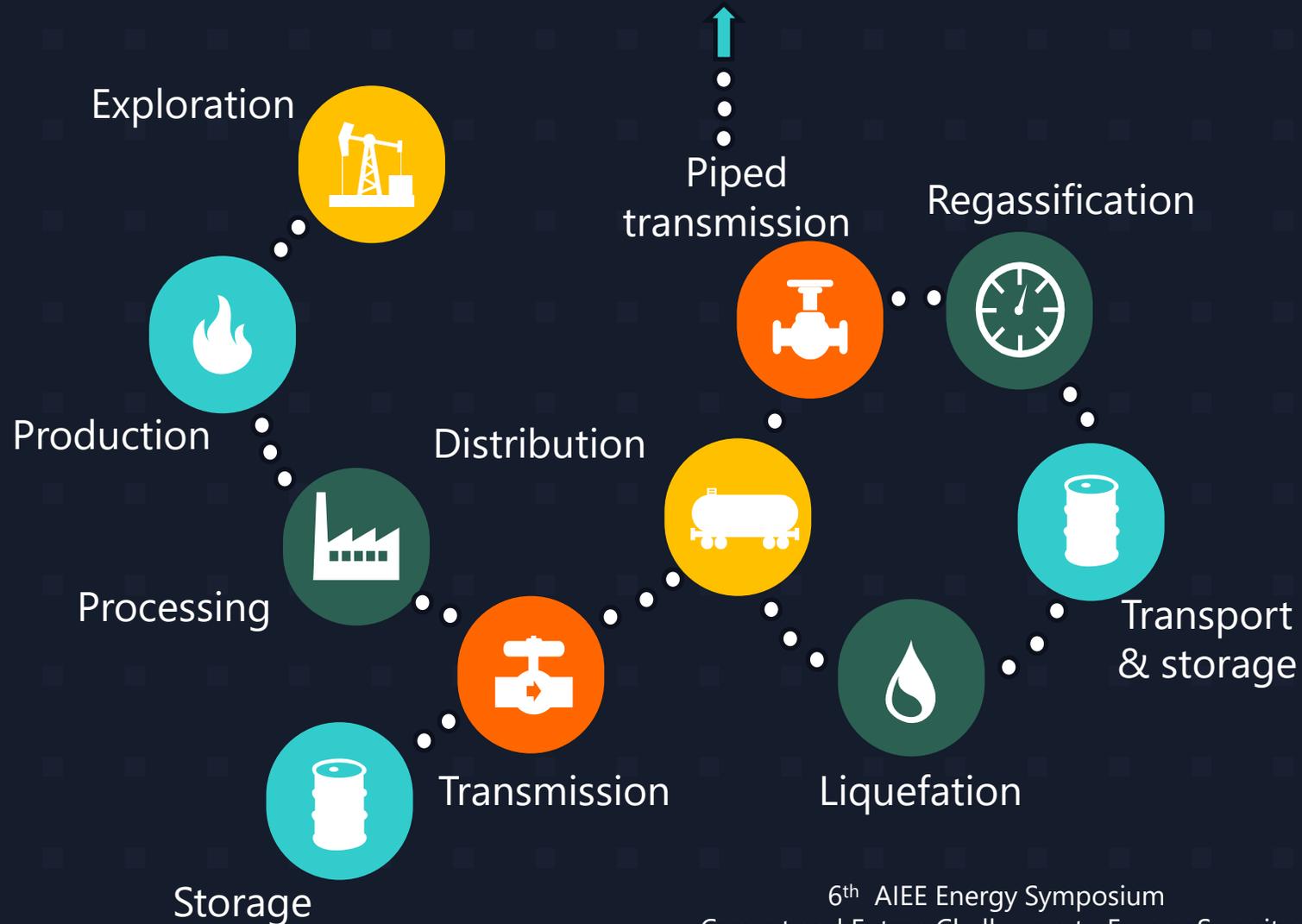
**For some countries, it is possible to achieve encouraging results in the short term through technologies that are not particularly expensive and not particularly complex. Recovering the methane may compensate for these costs.**

- BATs for intensive poultry and pig farming focus on **upstream reduction measures** (sustainable diet and lifestyle) and **downstream** reduction measures (manure/waste management)

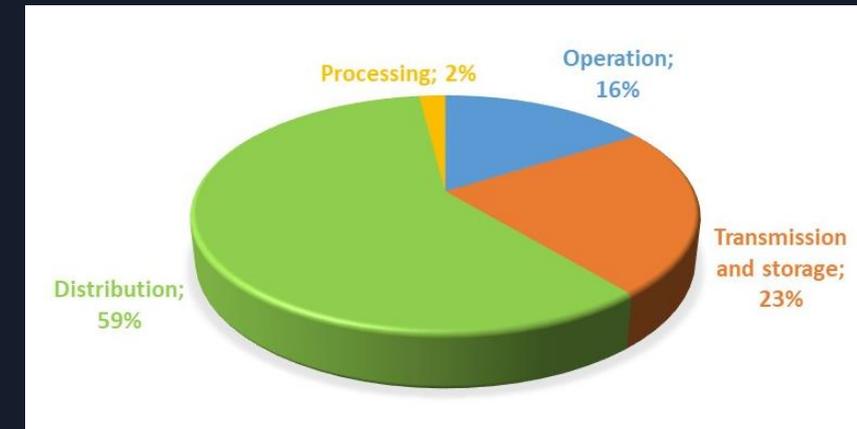
To promote low-carbon livestock, in 2019, FAO proposed the following five practical actions.

1. **Boosting efficiency of livestock production and resource use**
2. **Intensifying recycling efforts and minimizing losses for a circular bioeconomy, including the exploitation and recovery of biogas from agrifood, agricultural and livestock waste**
3. **Capitalizing on nature-based solutions to ramp up carbon offsets**
4. **Striving for healthy, sustainable diets and accounting for protein alternatives**
5. **Developing policy measures to drive change**

# Methane emissions from natural gas operations

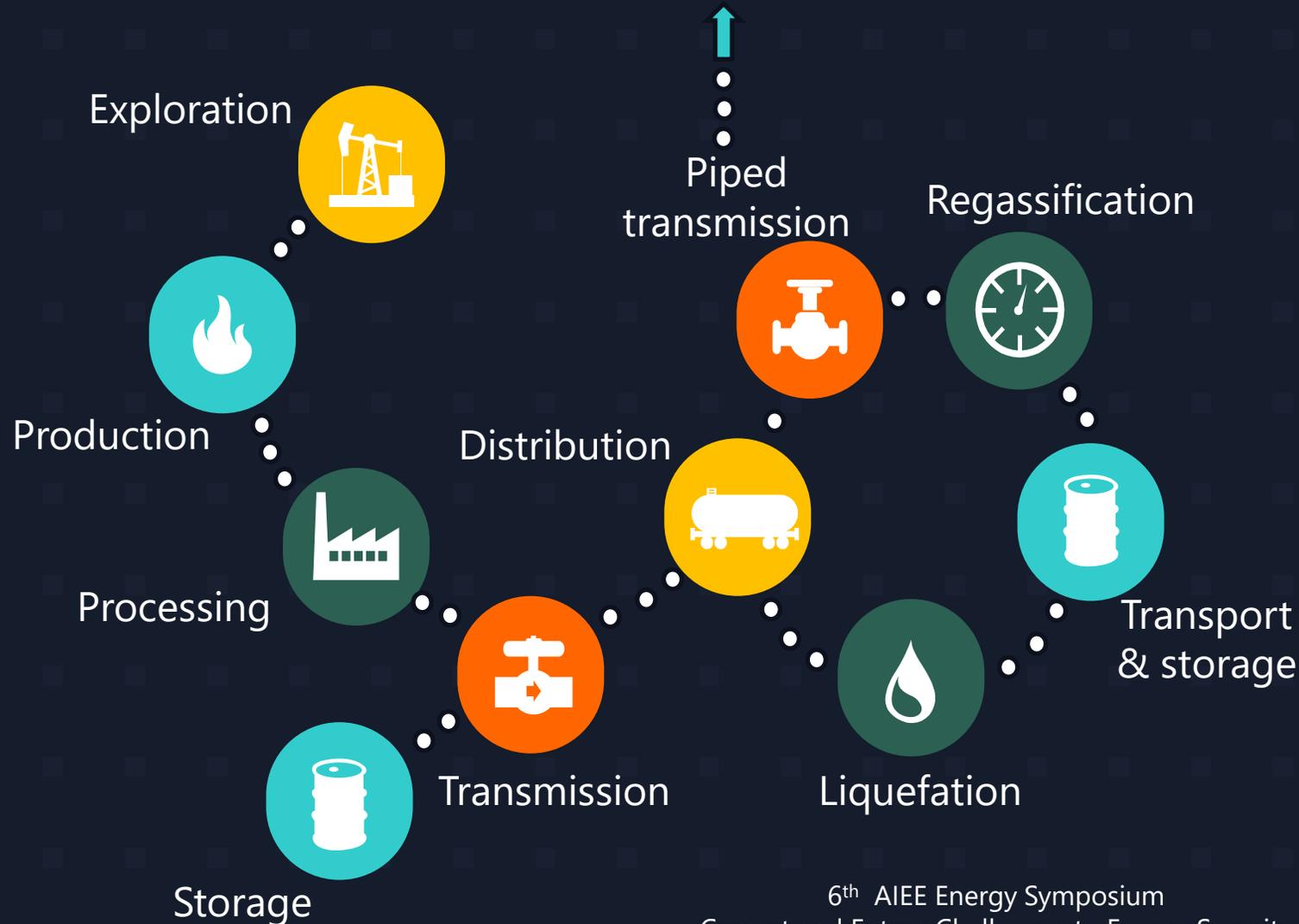


Methane emissions from natural gas operations (source EEA, 2019)



Concerning fugitive emissions, methane emissions for natural gas operation (1.B.2.b) account for **5%** of whole EU emissions. They may occur from venting, fugitive emissions, flaring, and incomplete combustion named methane slip (EEA, 2019).

# Methane emissions from natural gas operations

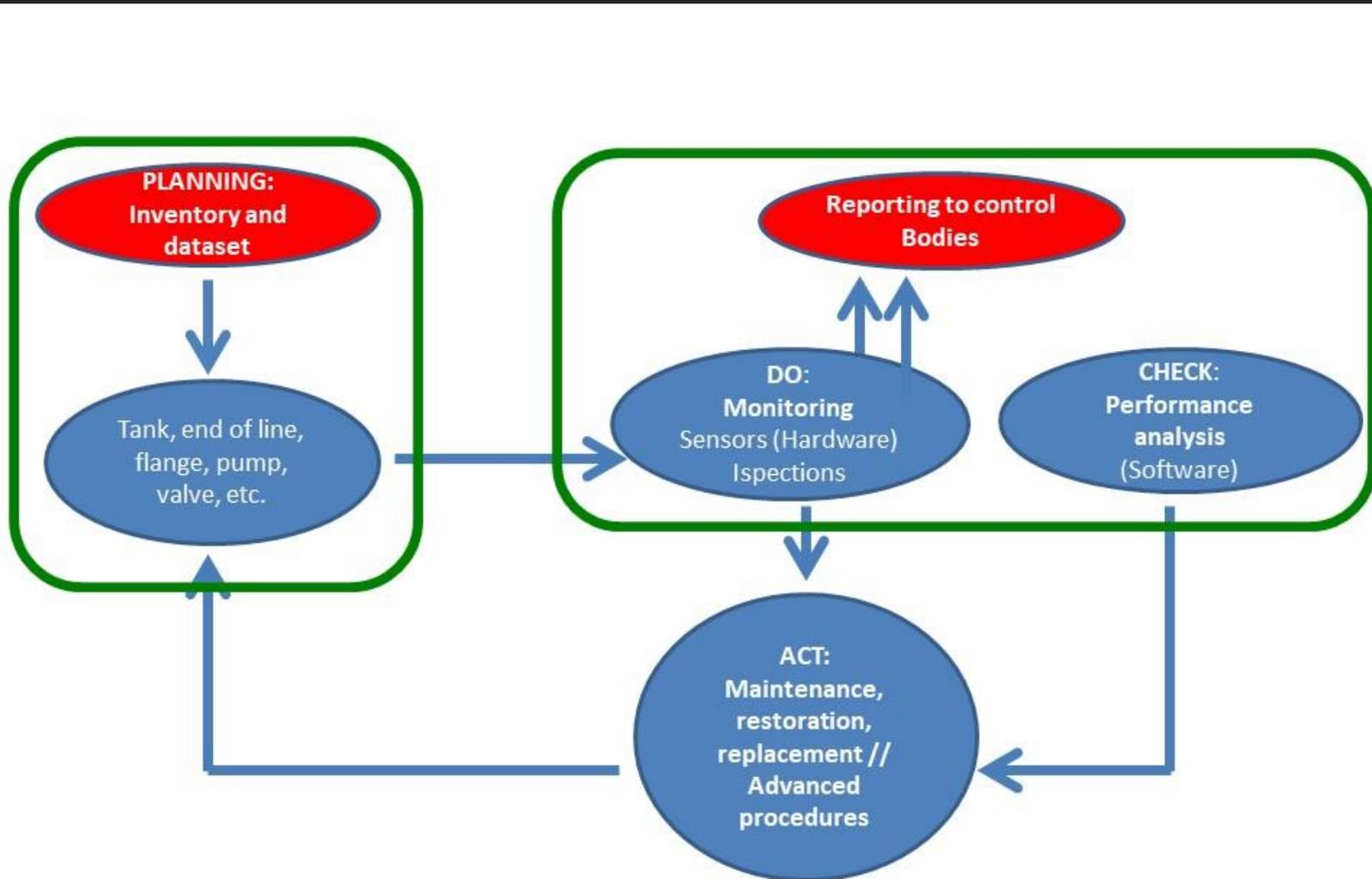


Methane emissions from natural gas operations (source EEA, 2019)

According to ARERA (2020), in the energy sector, the contribution of fugitive methane emissions to the national total is about **1%**. The distribution stage contributes about 80%, followed by transport and storage (17%).

... complete combustion named methane slip (EEA, 2019).

# LDAR - Leak Detection and Repair Programme



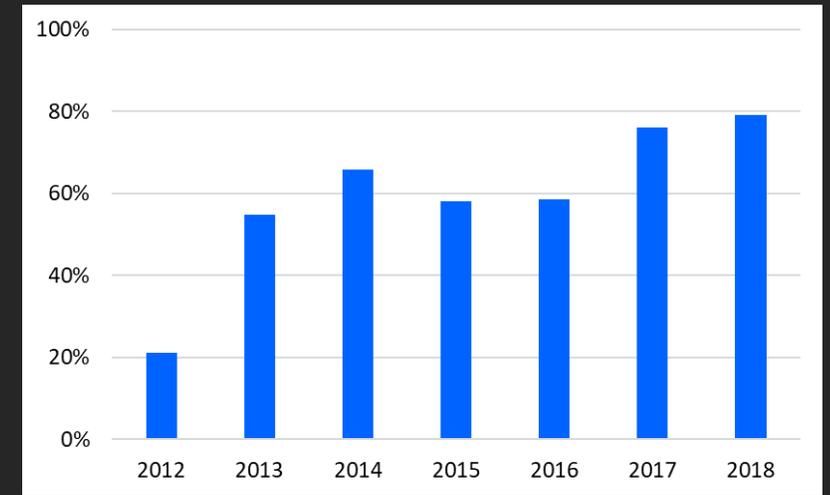
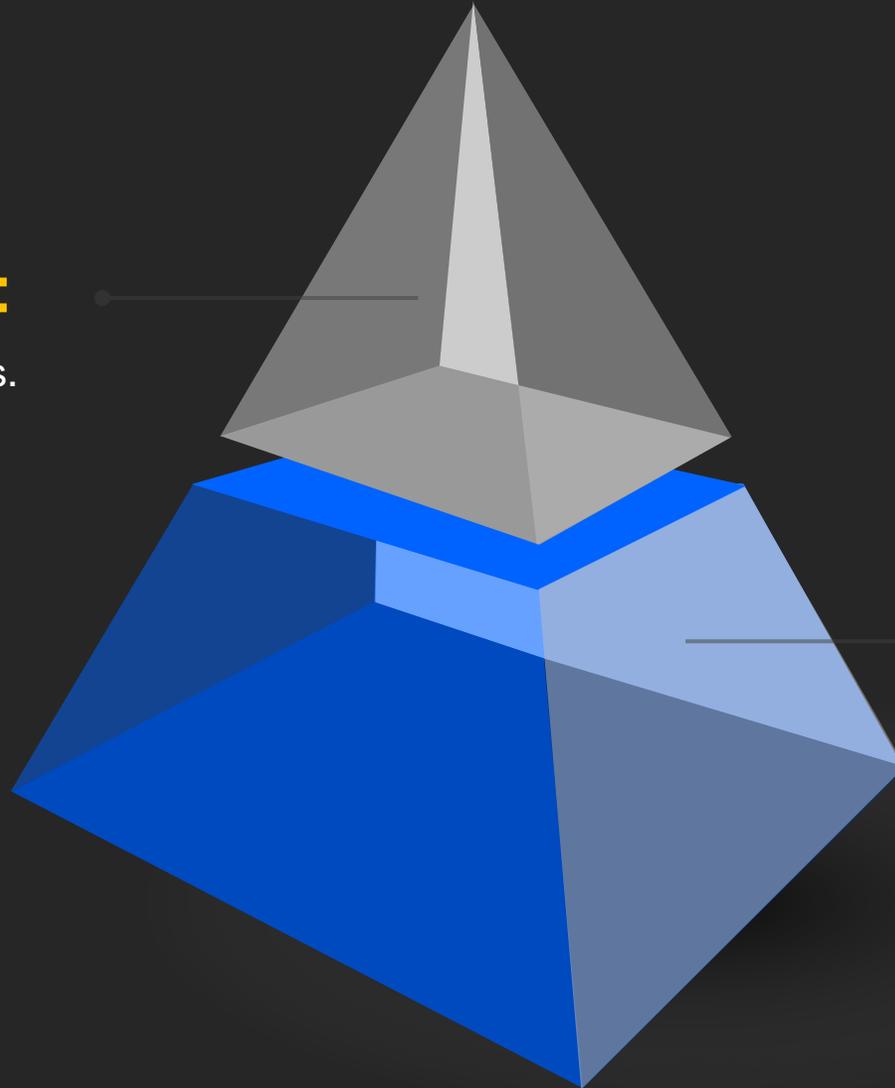
ISO 14001:2015 takes into account, among other things, the following specific aspects:

- The **cost of the sensors** has been significantly reduced;
- Ability to process a significant amount of data (big data) **faster** and faster;
- It is possible to eliminate failure with **predictive maintenance**;
- **Better data storage capacity**;
- Cost-effectiveness of **wireless coverage**.

# Direct and indirect (hidden) COSTS associated with fugitive emissions

## Evident costs:

Not used raw materials.



Increasing trend in the removal efficiencies of annual VOC emissions in a national chemical installation (Source: Mite, 2019).

## Hidden costs:

- Spill repair
- Spill repair material
- Wasted energy
- Plant inefficiency
- Environmental restoration
- Pecuniary sanctions
- Image decline

# Case study

## Overview:

The present use case concerns a company (**Tonissipower with ETW ENERGIETECHNIK GmbH**) designing and producing an upgrading/cogeneration system to exploit waste of a food and drink industry.

## Need:

The food and drink industry generates **wet waste** with a high organic content to be disposed.

## Solution:

The waste produced by the food and drink industry is suitable for anaerobic digestion. Biogas/biomethane resulting from the waste treatments may supply local need of heat, hot water and electricity. Actually, biomethane could also be injected into the gas grid and employed as vehicle fuel.



## What makes the proposed fitting into a context of the circular economy:

The circular economy paradigm is pervasive, and it is possible to give a new direction to how the company does business. Existing assets are examined in a new perspective and re-evaluated to find new business opportunities. It is a systemic vision in which the different aspects are strongly interconnected (resource consumption, waste and pollution, global temperature rise, population growth, food and water shortages, deforestation, and the biodiversity destruction).

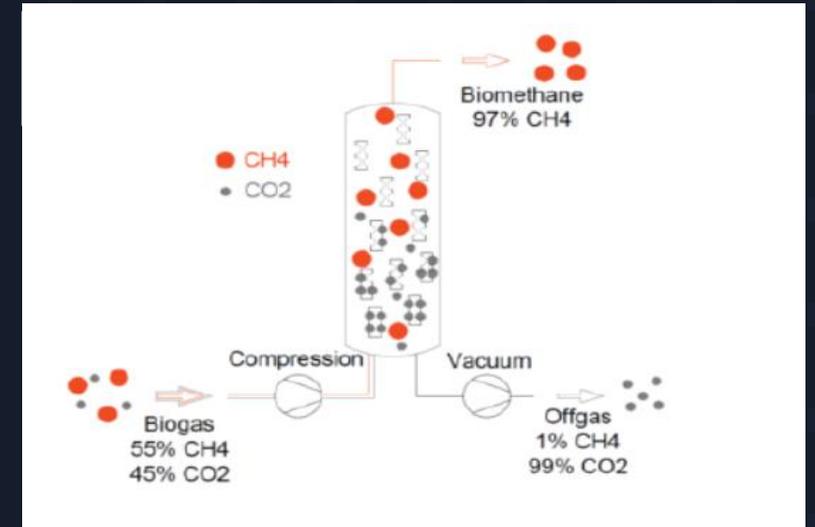
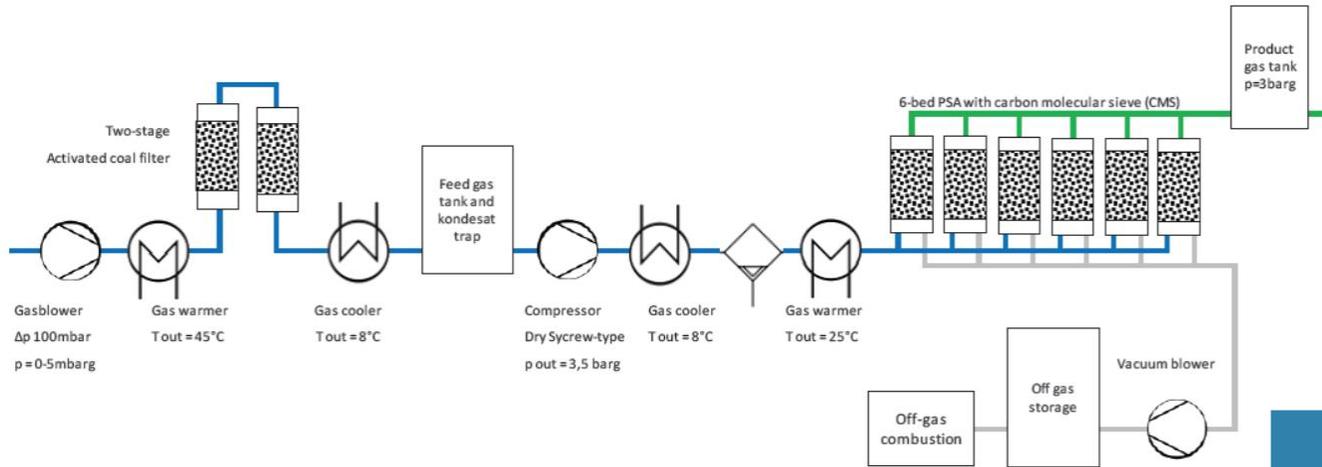
## Benefits:

- **Natural capital regeneration;**
- Creation of a closed-loop system with synergies of resources and skills;
- Use of renewable energy;
- Reduced use of finite fossil fuel.

## Drivers:

- The creation of the **partnership** acts as a driver to create synergies of resources and, possibly, skills.

# Case study

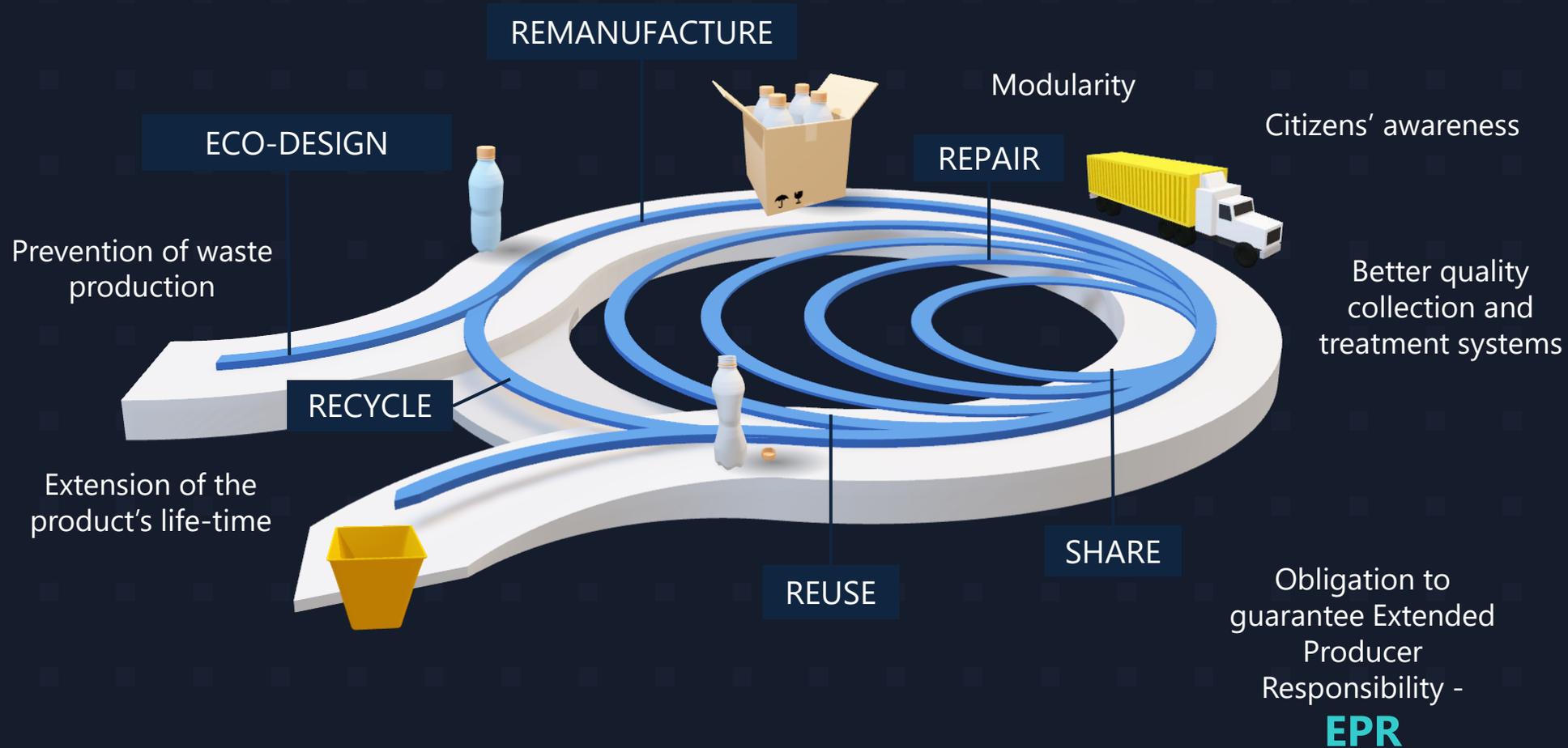


Parameters	Biogas	Biomethane
CH <sub>4</sub>	50 – 70 %	90 – 99 %
CO <sub>2</sub>	30 – 45 %	1 – 5 %
H <sub>2</sub>	< 200 ppm	< 500 ppm
N <sub>2</sub>	0 – 2 %	0 – 2 %
O <sub>2</sub>	0 – 0.5 %	0 – 0.5 %
H <sub>2</sub> S	> 1,000 mg/Nm <sup>3</sup>	< 1 mg/Nm <sup>3</sup>
H <sub>2</sub> O	Saturated with water	Dry

Nominal electrical capacity	800 kWe	
Rated thermal input		
Hot water	452 kWth	
	90/70 °C	20 m <sup>3</sup> /h (small scale)
Vapour	410 kWth	8 bar
	176 °C	617 kg/h

Actions	Strengths in the project
<b>REgenerate</b>	<ul style="list-style-type: none"> <li>• Shift to renewable energy and raw materials;</li> <li>• The business is focused on environmental and social needs;</li> <li>• Return recovered biological resources (digestate) to the biosphere.</li> </ul>
<b>Share</b>	<ul style="list-style-type: none"> <li>• Keep product speed low and maximise their life;</li> <li>• Prolong life through maintenance.</li> </ul>
<b>Optimise</b>	<ul style="list-style-type: none"> <li>• Improved ratio of the output of products to input of raw materials (material efficiency);</li> <li>• Increased energy efficiency of the supply chain and production process;</li> <li>• Reduced waste in the supply chain and in the production process;</li> <li>• Leverage big data and automation.</li> </ul>
<b>Loop</b>	<ul style="list-style-type: none"> <li>• Keep components and materials in closed loops</li> </ul>
<b>Vitualise</b>	<ul style="list-style-type: none"> <li>• Deliver utility virtually (data on upgrading and cogeneration in the cloud for predictive maintenance).</li> </ul>
<b>Exchange</b>	<ul style="list-style-type: none"> <li>• Replace traditional fossil fuels with renewable biofuels;</li> <li>• Apply new technologies with reduced or negligible environmental impact.</li> </ul>

# Case study



# Results

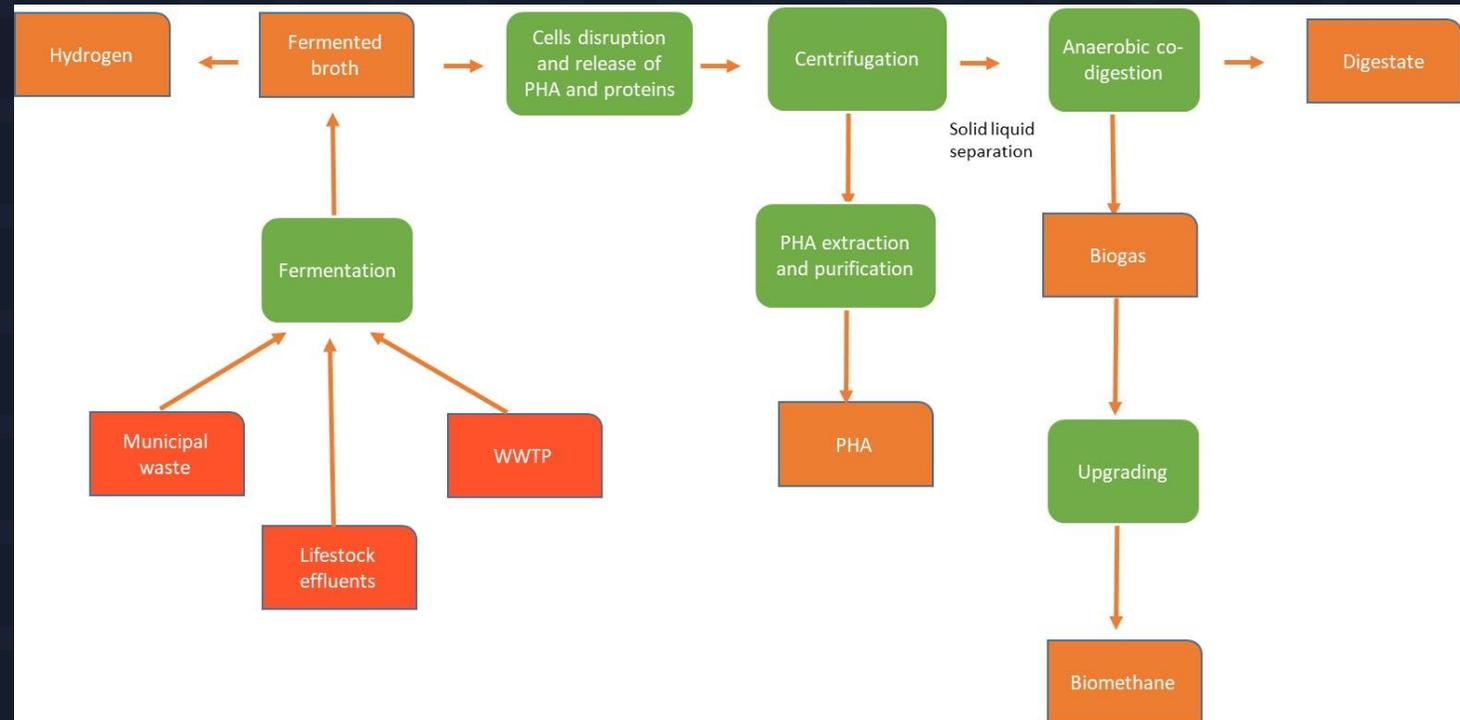
*"Biogas has to adapt to the quality of fossil methane to be injected in the network. Biogas then becomes biomethane. This has extra costs. It is expensive and can even cost 20% of production costs of biomethane. We need therefore to lower the cost of biomethane injection into the grid."*

Speech by  
Commissioner Simson  
at 'Common futures'  
Seminar on biomethane  
(12/07/2021)

Capex	Opex
<b>Anaerobic digestion</b>	
Anaerobic digester	Industrial organic waste or residues, handling and storage.
Installation and commissioning	Operating and maintenance
Decommissioning	Auxiliary energy
	Labour
<b>3-3.5 Mio€</b>	
<b>Upgrading to biomethane (PSA) &amp; Cogenerator</b>	
PSA system	Service and maintenance (200k€)
Installation, piping and commissioning	Auxiliary energy consumption
Data transmission system	
Decommissioning	
<b>2-2.5 Mio€</b>	

# Results

- Several studies investigate methane's use as a feedstock to produce polyhydroxyalkanoates – PHAs.
- Among the PHAs, there is the poly- $\beta$ -hydroxybutyrate (PHB) that is a linear polyesters accumulated as intracellular storage granules in micro-organisms.
- PHB has thermoplastic and mechanical properties similar to conventional plastic.
- Thus, it can be a possible substitute for fossil plastic tools: biomedical and pharmaceutical applications, packaging, textiles are their potential use.



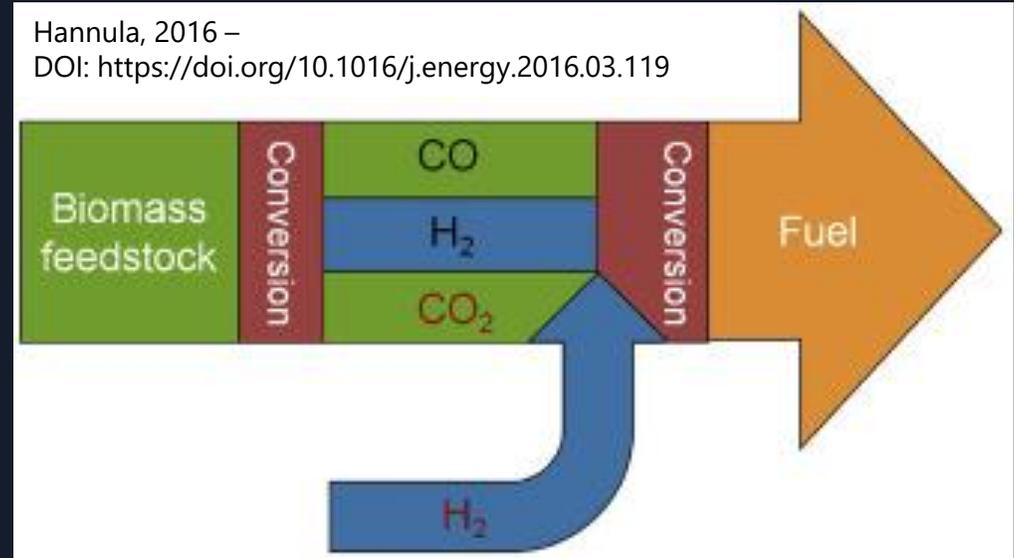
Phases and components in the biorefinery scheme (source: elaboration from Moretto et al. 2020; Yadav et al. 2020)

# Results

## Biomass catalytic gasification and methanisation

Bioenergy with carbon capture and utilization (BECCU), or recycling of the carbon, could also play a role in future emission reductions, especially in an established low-carbon society.

- **There is a potential to increase fuels production from a given amount of biomass (agriculture residues, municipal solid waste and waste oil), by feeding additional hydrogen from a low carbon source to a gasification-based biorefinery.**



Hydrogenation of carbon oxides to methane over nickel catalyst can be described with the following reactions:

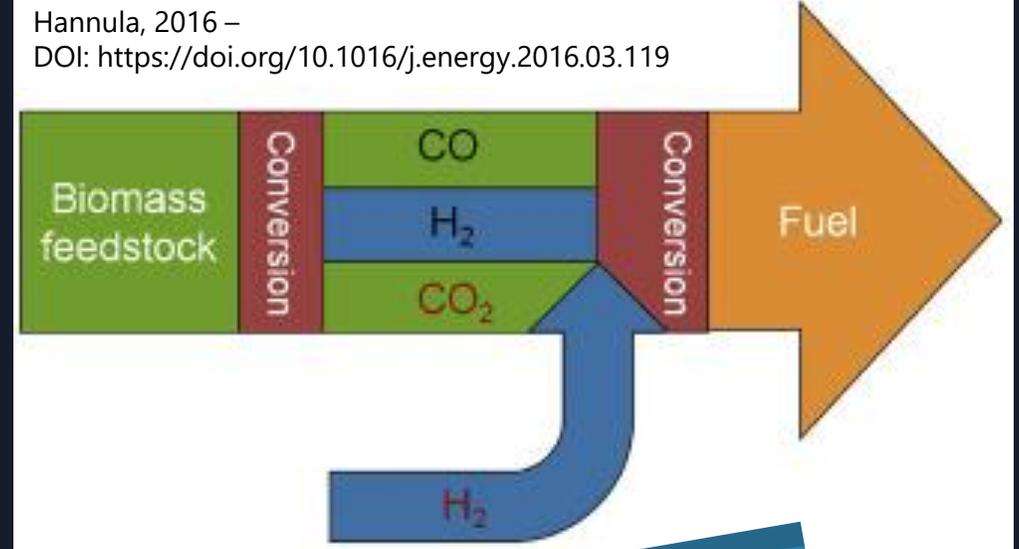


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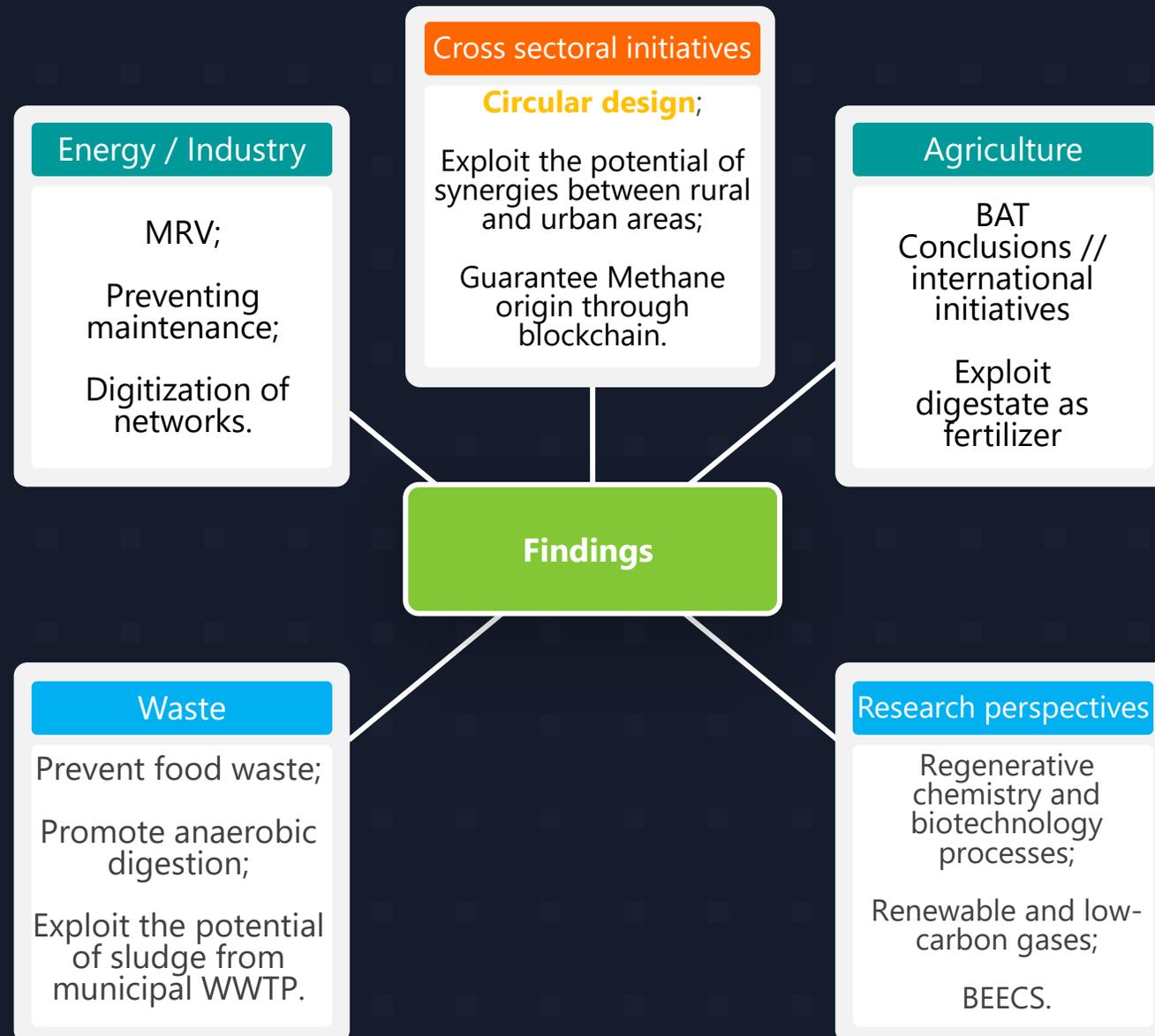
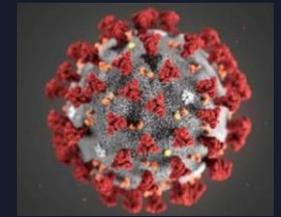


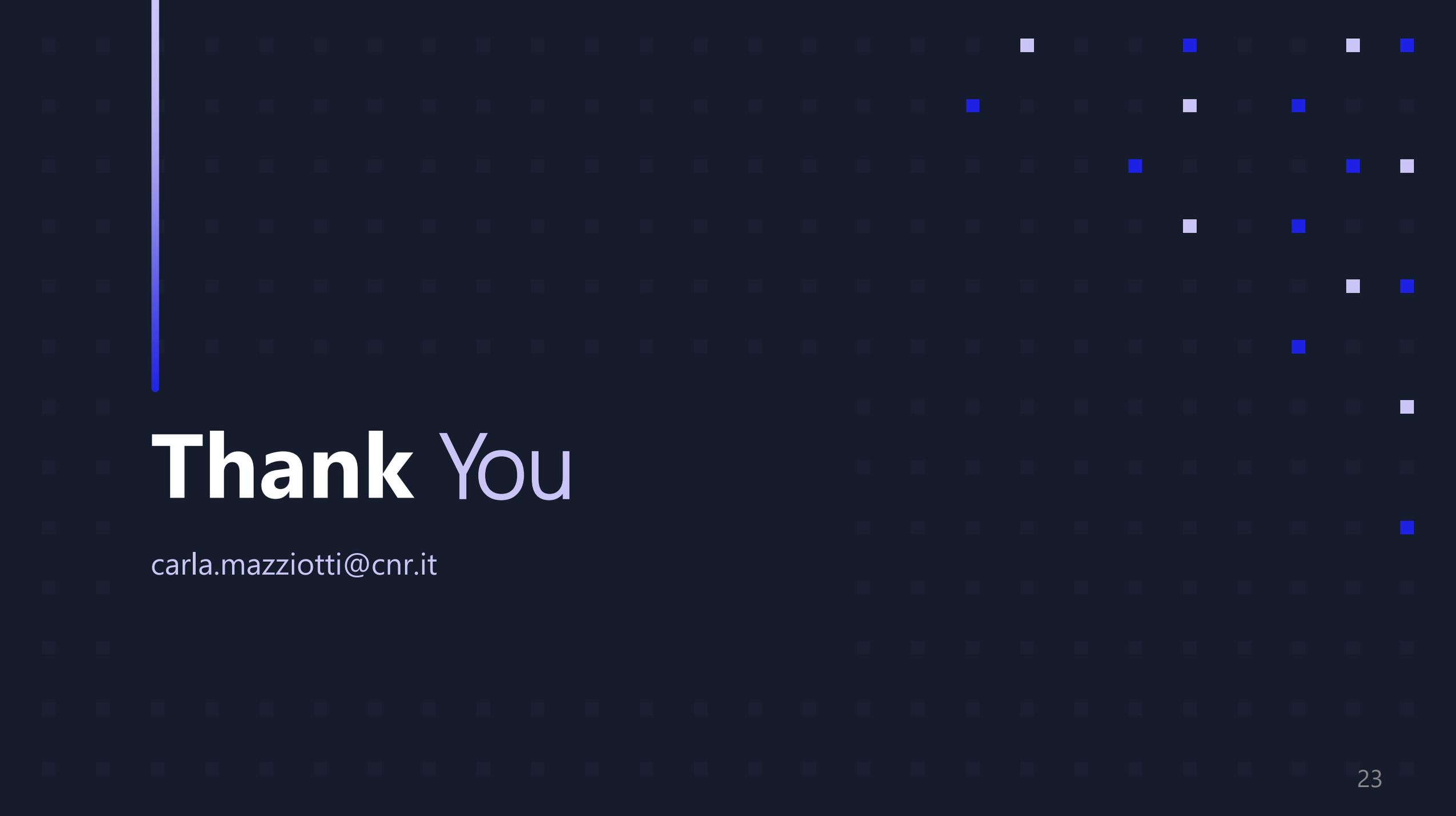
Hydrogenation of carbon monoxide over nickel catalyst can be described by the following reactions:



Other e-fuels production routes (e-hydrogen reacting with captured CO<sub>2</sub>, followed by different conversion routes) can be considered.

# Findings



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# Thank You

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