

# RECOVERY AND UTILIZATION OF GASEOUS INDUSTRIAL EFFLUENTS IN THE CHEMICAL SECTOR

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**ECOFYS**  
  
A Navigant Company

# INTRODUCTION

- Gaseous industrial effluents (GIEs), currently typically emitted or abated, can potentially be used to produce more sustainable chemicals.
- Ecofys, TNO, Sheffield University and WAAT aim to develop a **Roadmap on the recovery and utilization of gaseous industrial effluents** in which the opportunities in the area of recovery and utilization of GIEs in the European Union will be explored in detail.
- The Roadmap will focus on emissions that are produced in industrial installations, where recovery and utilization could well be possible, and for which in some cases future reduction targets apply.
- Carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), sulphur oxides (SO<sub>x</sub>) and hydrogen (H<sub>2</sub>) are selected to be studied in detail.

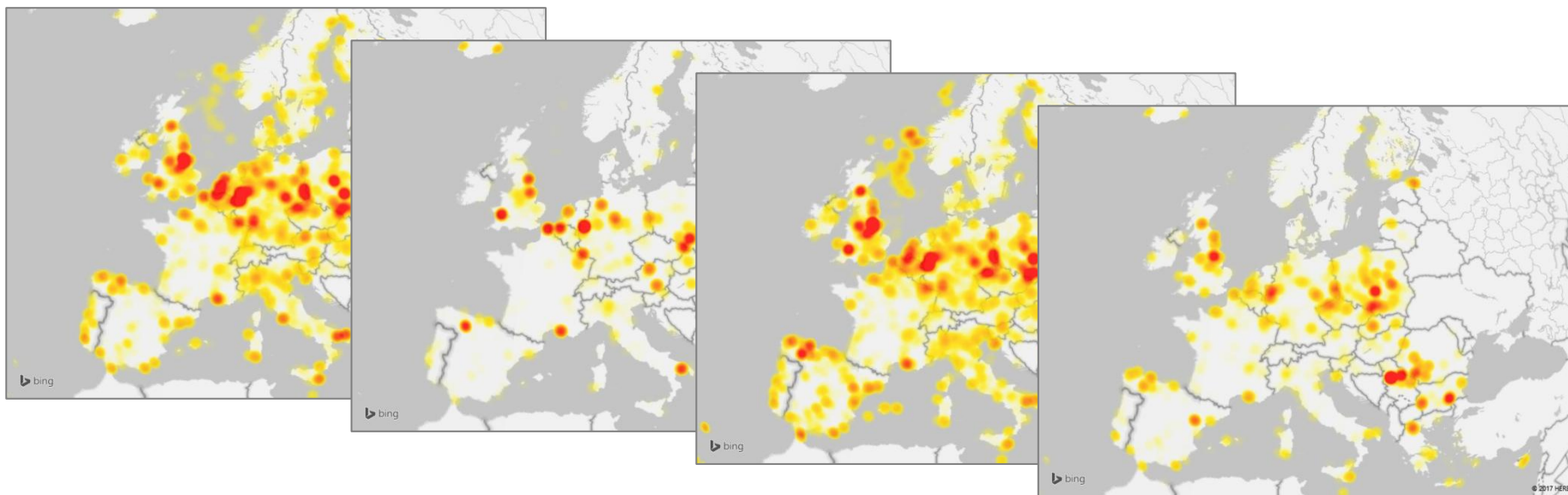
Gaseous industrial effluents are gases that originate from various processes as effluent gas from energy intensive industries, such as power, chemical, steel or cement. These gases represent a large range of substances, from which the ones with the largest volumes are CO<sub>2</sub>, CO, NO<sub>x</sub> and SO<sub>x</sub>.

# PROJECT ACTIVITIES AND PROJECT AIM

- Project activities
  - Mapping of gaseous industrial effluents
  - Assessing recovery and utilization technologies
  - Selecting hotspots
  - Developing Self-Assessment Tool
  - Supporting Model Demonstrator Regions
- Project aim
  - Explore opportunities for recovery and utilizations of gaseous industrial effluents in the European Union
  - Identify measures to stimulate the circularity of gaseous industrial effluents in the chemical sector
  - Support regions in exploring the implementation of the recovery and utilization of gaseous industrial effluents

# MAPPING OF GASEOUS INDUSTRIAL EFFLUENTS

- Mapping of CO<sub>2</sub>, CO, NO<sub>x</sub> and SO<sub>x</sub> emissions based on the E-PRTR and LCP databases
- Mapping of potential H<sub>2</sub> availability based on literature and existence of specific industries



The mapping of gaseous industrial effluents provides insights in the geographical areas and industry sectors where GIE recovery and utilization would be most promising.

# ASSESSMENT OF RECOVERY AND UTILIZATION TECHNOLOGIES

- Techno-economic estimation and environmental impact assessment for various recovery and utilization options

Carbon dioxide (CO <sub>2</sub> )	Carbon monoxide (CO)	Nitrogen oxides (NO <sub>x</sub> )	Sulphur oxides (SO <sub>x</sub> )	Hydrogen (H <sub>2</sub> )
<ul style="list-style-type: none"> <li>• Urea production</li> <li>• Aggregate production</li> <li>• Metal carbonation</li> <li>• Liquid FT fuel production</li> <li>• Accelerated cementation</li> <li>• Methanol production</li> </ul>	<ul style="list-style-type: none"> <li>• Direct use of CO</li> <li>• Ethanol production</li> <li>• Liquid FT fuel production</li> <li>• Methanol production</li> </ul>	<ul style="list-style-type: none"> <li>• Nitric acid production</li> <li>• Metal recovery</li> <li>• Calcium nitrate production</li> </ul>	<ul style="list-style-type: none"> <li>• Direct use of SO<sub>2</sub></li> <li>• Sulphuric acid production</li> <li>• Gypsum production</li> <li>• Sodium bisulphite production</li> <li>• Metals recovery</li> </ul>	<ul style="list-style-type: none"> <li>• Compressed gas</li> <li>• Ammonia production</li> <li>• Liquid FT fuel production</li> <li>• Methanol production</li> </ul>

The assessment of recovery and utilization technologies provide insights for which gasses business cases are most promising and which levers determine the economic and environmental feasibility.

# ASSESSMENT OF RECOVERY AND UTILIZATION TECHNOLOGIES

- Carbon dioxide (CO<sub>2</sub>)
  - Many potential technologies for CO<sub>2</sub> recovery and utilization because of industrial and research focus in recent years
  - Carbon intensity reduction for most options, especially in combination with affordable renewable energy and hydrogen
  - Economic benefits strongly dependent on a variety of factors, like additional benefits from using waste material in aggregate production and the availability of affordable renewable hydrogen for urea, liquid FT fuel and methanol production
- Carbon monoxide (CO)
  - Emissions occur from a limited number of sources, usually at low concentrations because of toxicity
  - Opportunities for recovery and utilization options that replace usage of CO for energetic purposes
  - Economic and environmental benefits at sufficiently high concentrations and availability of hydrogen

# ASSESSMENT OF RECOVERY AND UTILIZATION TECHNOLOGIES

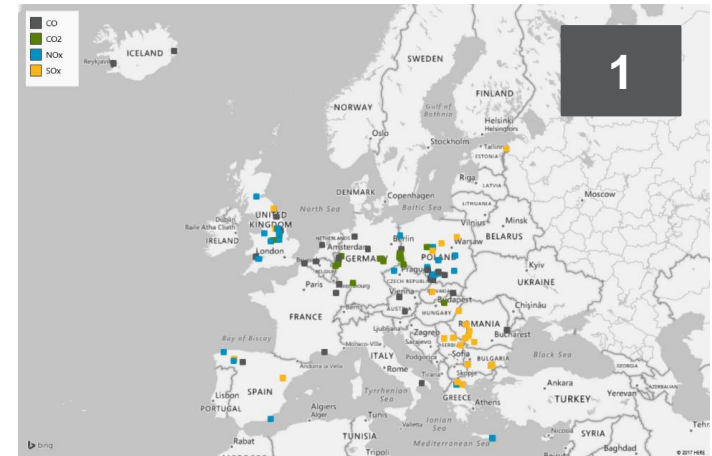
- Nitrogen oxides ( $\text{NO}_x$ )
  - Recovery and utilization of  $\text{NO}_x$  using the LoTOx system uses large amounts of ozone, which results in unfavorable economic and environmental performance.
  - However, when abatement is required anyhow, this technology could provide additional benefits from reusing the  $\text{NO}_x$  to produce chemical products.
- Sulphur oxides ( $\text{SO}_x$ )
  - Recovery and utilization of  $\text{SO}_x$  is only possible with high concentrations and even then substantial energy required, resulting in high costs and high environmental impacts
  - However, when abatement is required anyhow, this technology could provide additional benefits from reusing the  $\text{SO}_x$  to produce chemical products.
- Hydrogen ( $\text{H}_2$ )
  - Various potential utilization with economic and environmental benefits if hydrogen is available at high concentrations and is used in combination with other gases, like  $\text{CO}_2$  and  $\text{CO}$

# SELECTION OF HOTSPOTS

1. **Availability of GIEs** → 100 potential hotspots
2. **Proximity of chemical** → 23 potential hotspots
3. **Potential business cases** → 10 hotspots

- Chemiepark Linz, Austria
- Port of Antwerp, Belgium
- Varna-Devnya, Bulgaria
- Fos-Lavéra-Berre, France
- InfraLeuna, Germany
- Krefeld-Uerdingen, Germany
- Limburg, The Netherlands
- Port of Rotterdam, The Netherlands
- Bełchatów, Poland
- **Sucursala Romag Termo, Romania**

4. **Availability of infrastructure and affordable renewable energy, existence of thriving business community, access to finance and political support** → 4 model demonstrator regions [in progress]

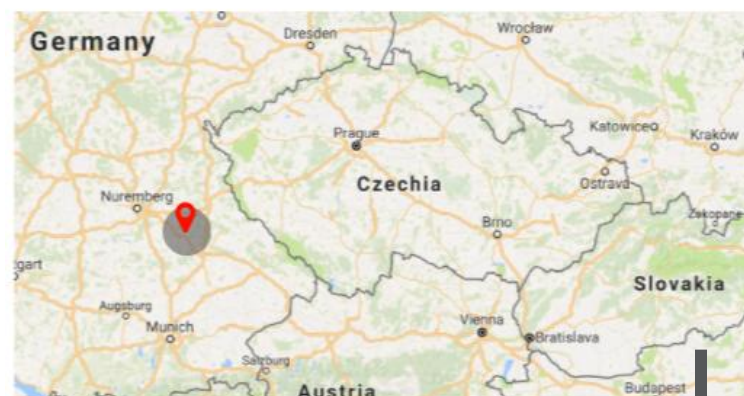




# DEVELOPMENT OF SELF-ASSESSMENT TOOL

- The Self-Assessment Tool (SAT) is an online tool to assess the investment readiness of the region regarding the use of GIEs as feedstock in the chemical industry.
- Questions on 8 key factors:
  1. GIE availability
  2. GIE usage
  3. Infrastructure
  4. Access to finance
  5. Knowledge base
  6. Political support
  7. Thriving business community
  8. Industrial symbiosis
- Evaluation
  - Spider diagram with graphical representation of score in key factors and automated assessment report

On the map below define the location you want to complete the self-assessment for.



Select the distance between the location and the sources for which you would like to see the GIE emissions.

100km

Show results

Plant name	CO <sub>2</sub> emission amount	CO <sub>2</sub> emission concentration	....
Plant A	1.5 Mt	275.000 g/m <sup>3</sup>	
Plant B	0.7 Mt	295.000 g/m <sup>3</sup>	

The SAT enables region to assess the investments readiness for GIE recovery and utilization.



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