Economic and Environmental Analysis of GIE Re-utilisation

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Methodology

LCA and TEA type thinking was applied to various scenarios for each GIE to assess the economic feasibility and environmental impact of use

A comparison was made between GIE & “reference” production routes on both economic & environmental outcomes

Ideal products would have a large, Europe-wide market to allow for localised sales.

Ideal scenarios would result in a net reduction of environmental impact with a lower or comparable production expenditure

What are LCA and TEA?

Techno Economic Assessment:

TEA is the analysis of the economic feasibility of a production process. By analysing the CAPEX and OPEX of a process limitations, and economic bottlenecks/ hotspots can be identified.

Life Cycle Assessment:

LCA is a systematic analysis of the inputs and outputs of a technology in a specified scenario to identify the environmental impact of the process.

To apply TEA and LCA type thinking some conditions must be assumed to develop a scenario for comparison of the GIE and reference pathways – eliminating the ability to consider a "general case".

Local conditions (e.g. GIE concentration) have a significant impact on feasibility of utilisation

GIE and Product Overview

CO_2

- Aggregates
- Cement
- Urea
- Methanol
- FT fuel
- Metal Carbonates

CO

- Methanol
- FT fuel
- Ethanol
- Purification (Direct Use)

H_2

- Methanol
- FT fuel
- Ammonia
- Purification (Direct Use)

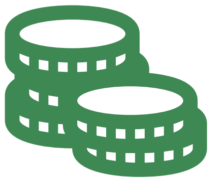
NO_2

- Nitric Acid
- Calcium Nitrate
- Metals Recovery
- Purification (Direct Use)

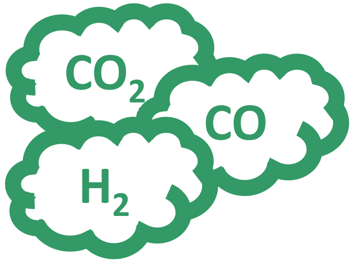
SO_2

- Sulfuric Acid
- Gypsum
- Metals Recovery
- Bisulfites
- Purification (Direct Use)

Key findings: CO_2, CO and H_2



- Economics is typically the driving factor in the feasibility of utilization
- Separation is costly and not preferential for utilization
- The economic viability of separation and utilization depends on flue gas conditions, emission sources with high purity streams should be seen as most immediately valuable
- H_2 production is expensive so has more capacity for recovery from dilute GIE streams



- Many products require the production of "syngas" (H_2 and CO gas mix) – due to this co-utilization of GIE H_2 with GIE CO and/or GIE CO_2 is viable – this makes co-emitting streams of these gases of interest
- Currently many sources of mixed GIE CO and H_2 are used as fuel or flared – many of these sources can be economically viable as feedstocks for utilization. A significant problem is the CAPEX required for change.
- If no GIE H_2 is available - fossil-derived H_2 is typically more affordable than renewable H_2 from electrolysis but its use typically results in a net negative impact on the environment

There is a clear need to develop the availability and affordability of renewable H_2

Key findings: CO_2, CO and H_2

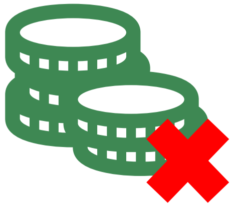
Emission sources with most potential for viable utilization:

- CO_2: Fertilizer plants (high purity), fermentation plants (high purity)
- CO: Iron & steel production (co-utilization with H_2)
- H_2: Chlor-Alkali plants (high purity), Iron & steel production (co-utilization with CO)

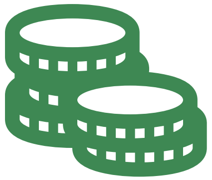
Products with most potential for viable utilization:

- CO_2: Aggregates, Cementation, Metal Carbonation
- CO: Ethanol, Methanol, FT fuels
- H_2: Methanol, Ammonia, FT fuels

Key findings: SO_2 and NO_2



- Traditionally utilization of SO_2 and removal of NO_x has been driven by regulatory compliance – not economic benefit.
- In most cases this is likely to remain consistent however GIE utilization offers a chance to recover some of those costs. When exploring how to further reduce SO_x and NO_x emissions, the option(s) to re-use GIE's should be explored too.



Emission sources with most potential for viable utilization:

- SO_2: Fossil-fuel powered generation plants, Metal smelters
- NO_2: Fossil powered generation plants (highest concentrations)

Products with most potential for viable utilization:

- SO_2: Gypsum, Sulfuric acid (particularly in sources with 3% vol SO_2 in the flue gas)
- NO_2: Nitric acid

Summary

The general findings from the economic and environmental analysis are as follows:

- Utilization of GIEs “in-situ” typically offers greater benefits both economically and environmentally
  The continued development of increasingly robust catalysts capable for in-situ utilization to minimize the need for GIE separation and for flue gas cleaning should be a priority
- Co-utilization of mixed GIE streams (of CO, CO_2 and H_2 in particular) typically produces positive outcomes environmentally whilst remaining economically competitive in some cases
- Many promising GIE feedstocks are utilized as fuel or flared, *capital incentivization may help change this*.
- H_2 derived from renewable sources is preferred over fossil-derived H_2 due to the negative environmental impact of the latter, however without incentivization electrolysis-H_2 is economically unfeasible,
  Incentivization may help change this (Capital incentivization for localized renewables construction, reduced electricity costs)
- Regulatory compliance may drive the need for NOx and SOx removal but utilization of these materials as feedstocks rather than wastes allows for the opportunity to recover some of the associated cost. This is well-established for SOx but the development of technologies such as LoTOx for NOx capture offers potential for utilization over destruction.

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