

Integration of Innovative Technologies to Different Energy Intensive Industries

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TNO Energy Transition

TNO Energy Transition unit



Towards a CO₂-neutral **INDUSTRY**

GOALS 2050

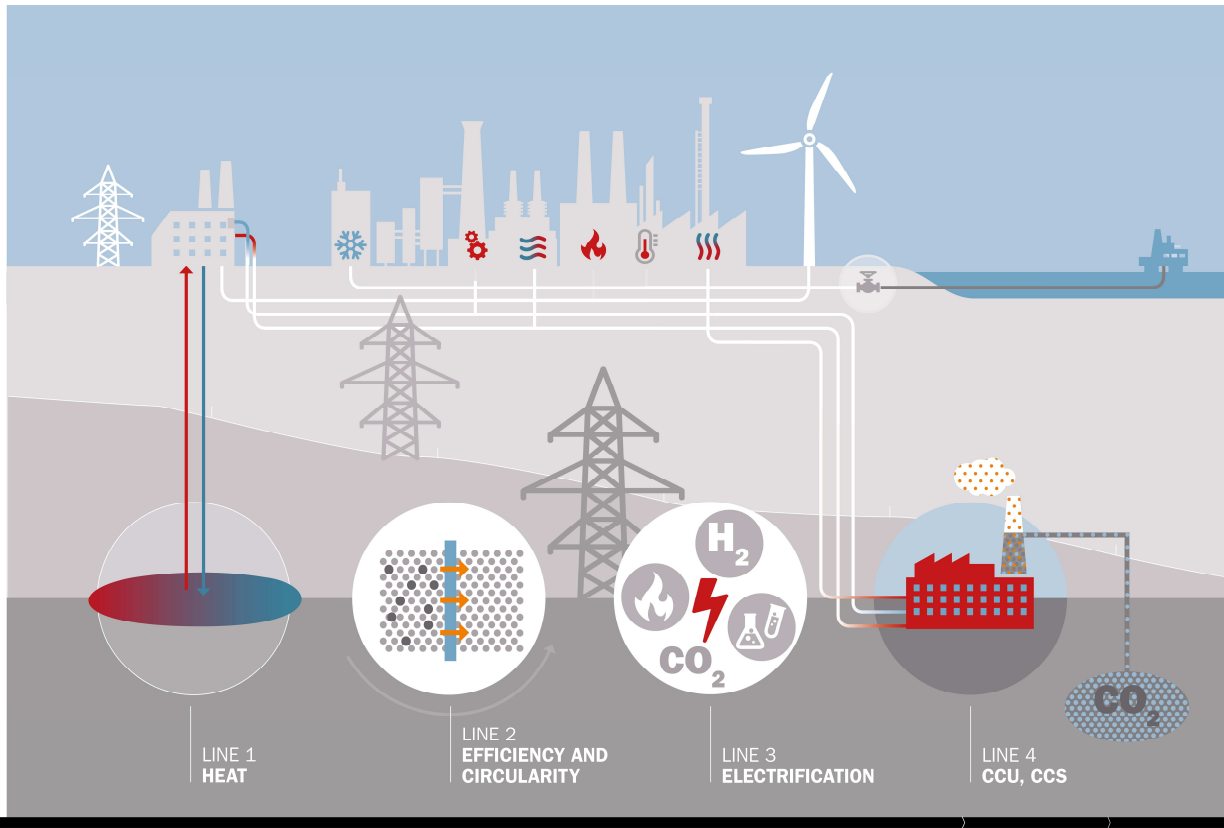
ALL INDUSTRY HAS A **ZERO NET CO₂ EMISSION**

SUSTAINABLE SUPPLY AND (RE-)USE OF INDUSTRIAL HEAT

> 40% PROCESS EFFICIENCY IMPROVEMENT

COMPLETE ELECTRIFICATION

CO₂ CAPTURE CONVERSION AND STORAGE



CONVERGE

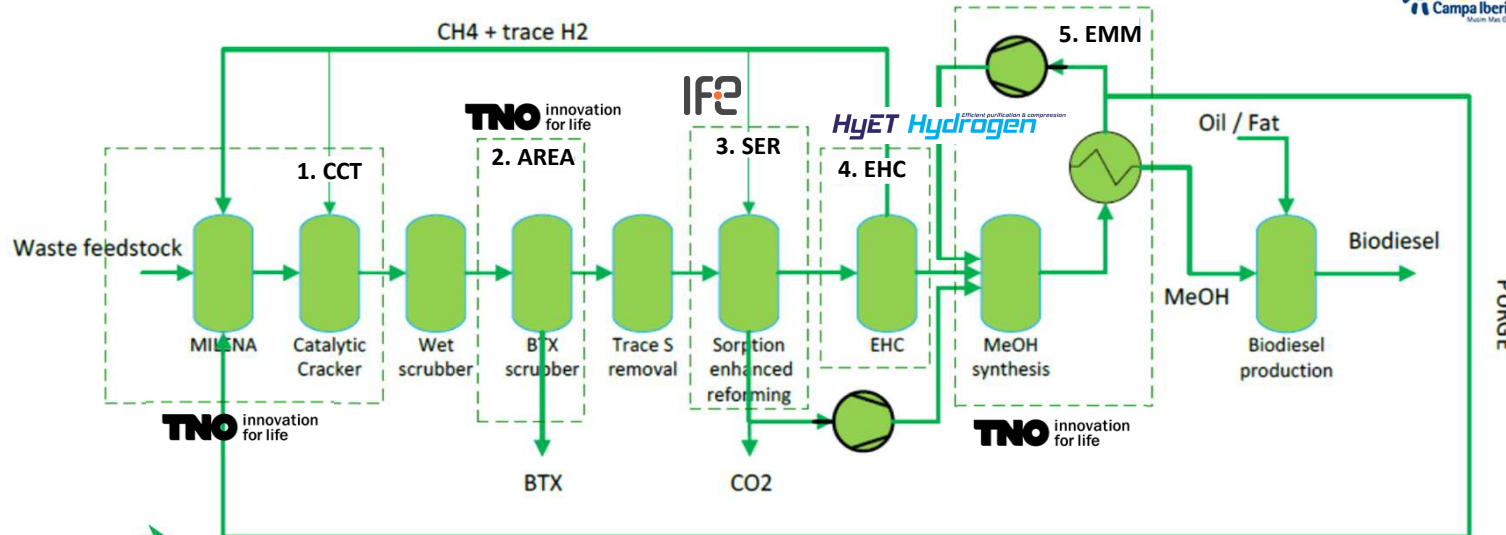
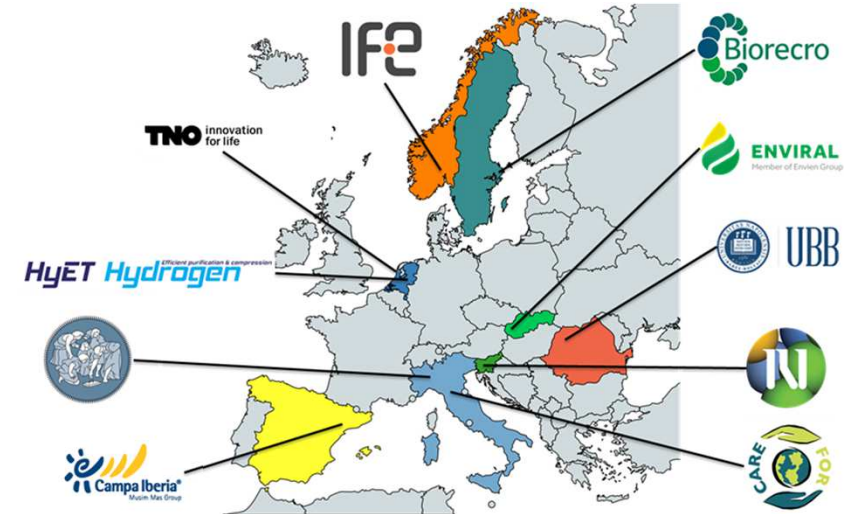
CarbON Valorisation in Energy-efficient Green fuels

The CONVERGE Process

The H2020 - CONVERGE project aims to validate a state-of-the-art multi-step configuration for **advanced biodiesel** production from gasification.

Five innovative technologies are combined...

1. **CCT**: Catalytic Cracking of Tar
2. **AREA**: Aromatics Recovery Apparatus (BTX-scrubber)
3. **SER**: Sorption-Enhanced Reformer
4. **EHC**: Electrochemical Hydrogen Compressor
5. **EMM**: Enhanced Methanol Membrane



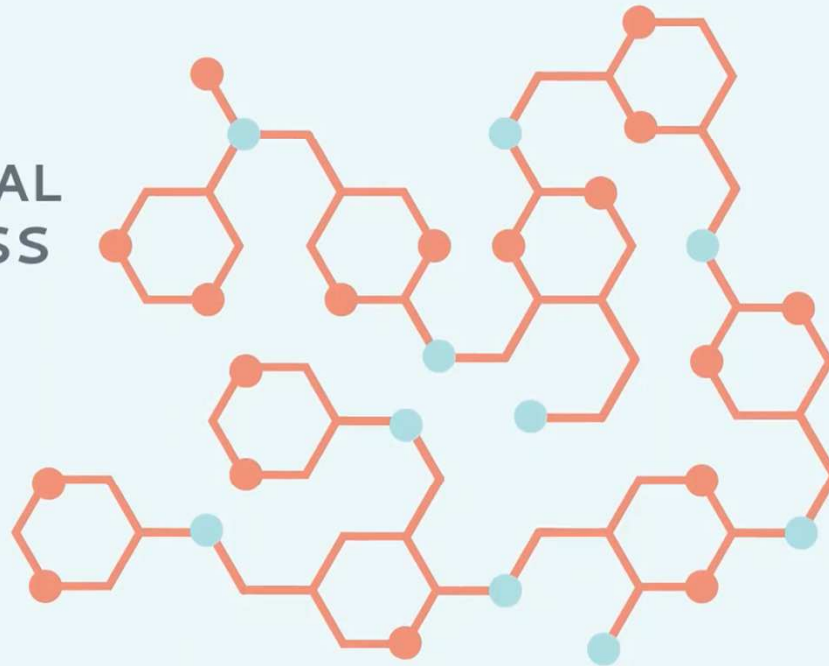
...but can also be used separately.

CONVERGE

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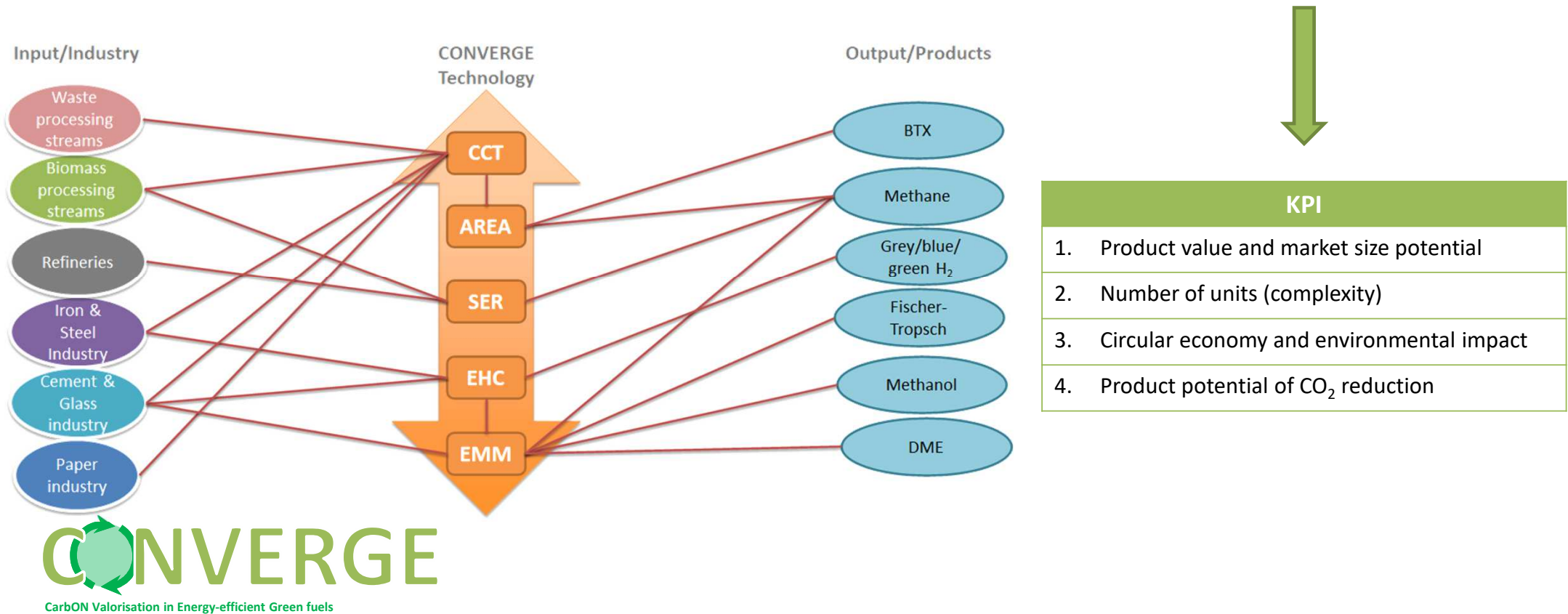
The CONVERGE Process

RESIDUAL BIOMASS



Methodology: Implementation in Different Industries

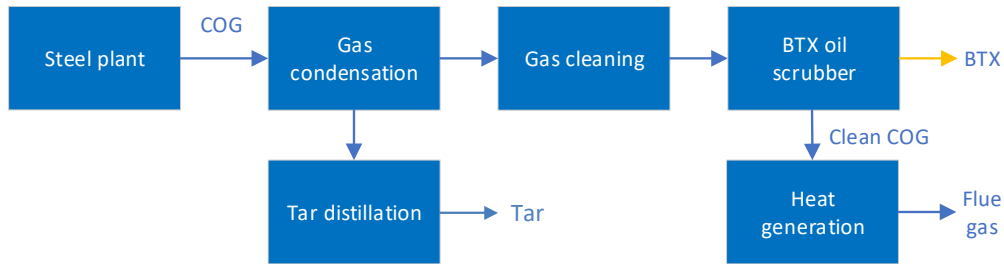
- 16 cases have been selected for **different industrial sectors**, where the 5 CONVERGE technologies (CCT/AREA/EHC/EMM/SER) are implemented.
- Cases are compared to the conventional plant/industrial process.
- 4 Key Performance Indicators (KPI's) have been defined to rank the different cases (based on multicriteria approach).
- KPI's are based on the European market.



2 Selected Cases

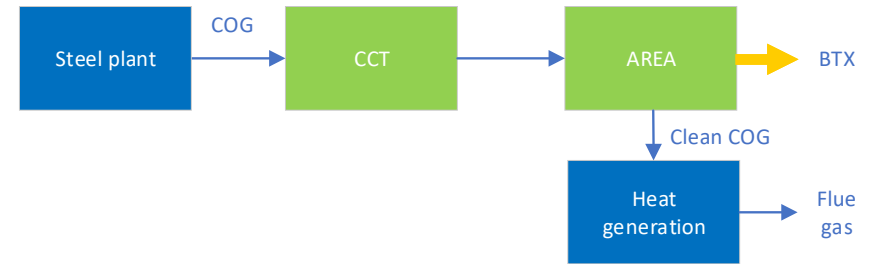
Conventional process

Steel industry



CONVERGE technologies integration

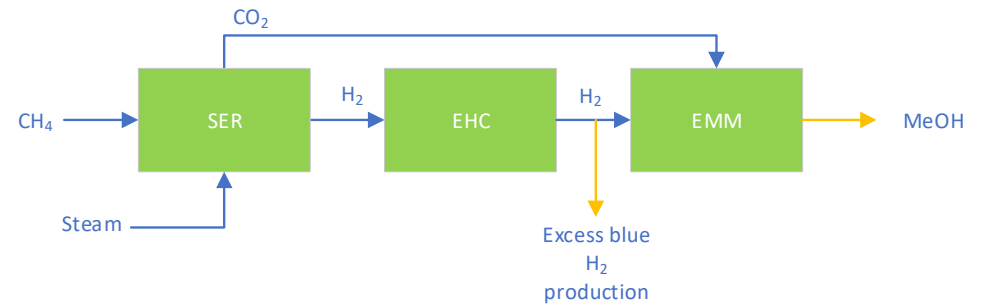
Steel industry CCT/AREA



Refinery: methane by-product

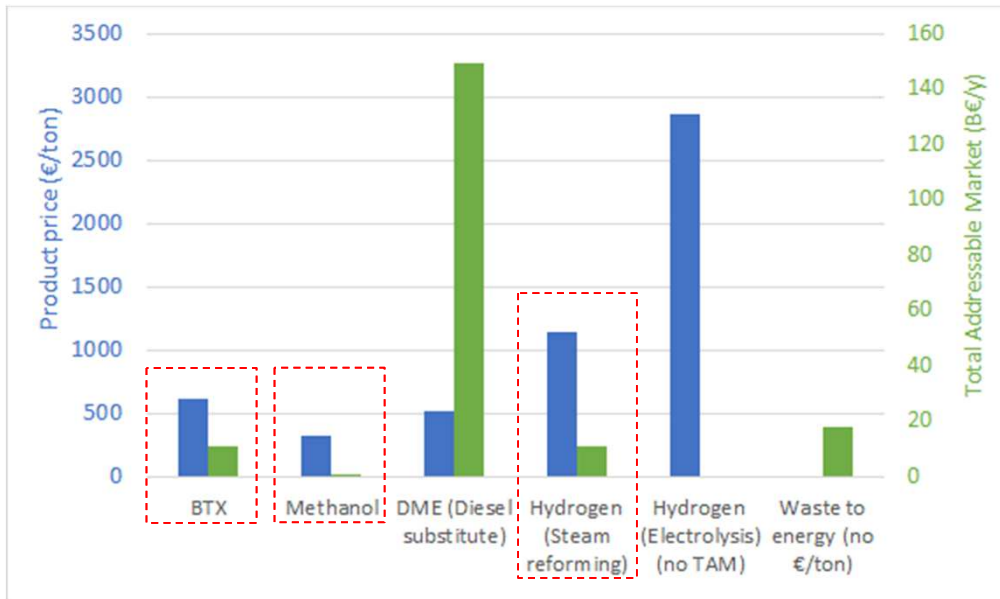


Refinery: methane by-product utilization SER/EMM/EHC

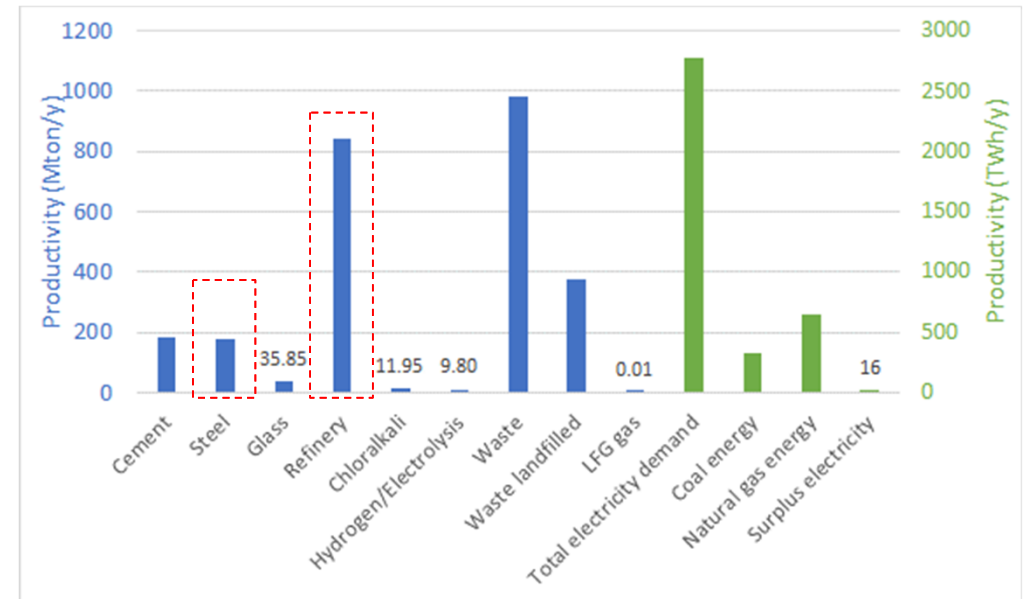


KPI1 Product Value and Market Size Potential

1. Product price and Total addressable Market



2. Size of the industry targeted



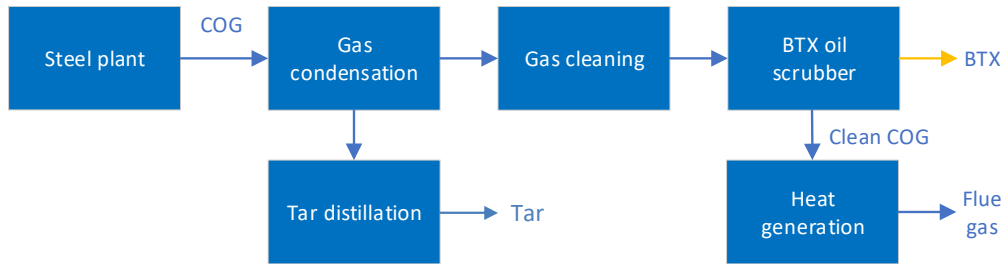
3. Upgrading and valorizing products

Products	KPI score
No change	0
Upgrade	2-4.5
New stream	5

KPI1 Product Value and Market Size Potential

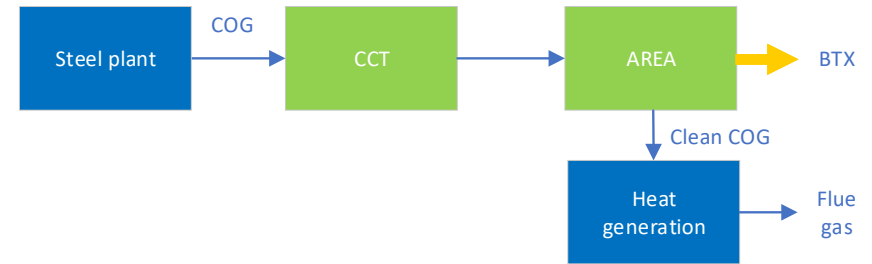
Conventional process

Steel industry



CONVERGE technologies integration

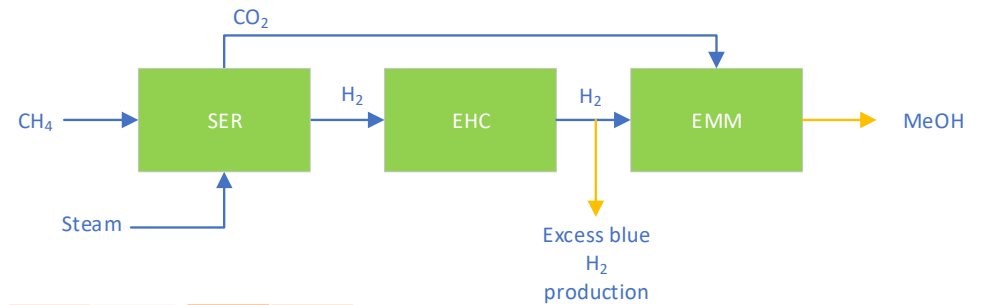
Steel industry CCT/AREA



Refinery: methane by-product



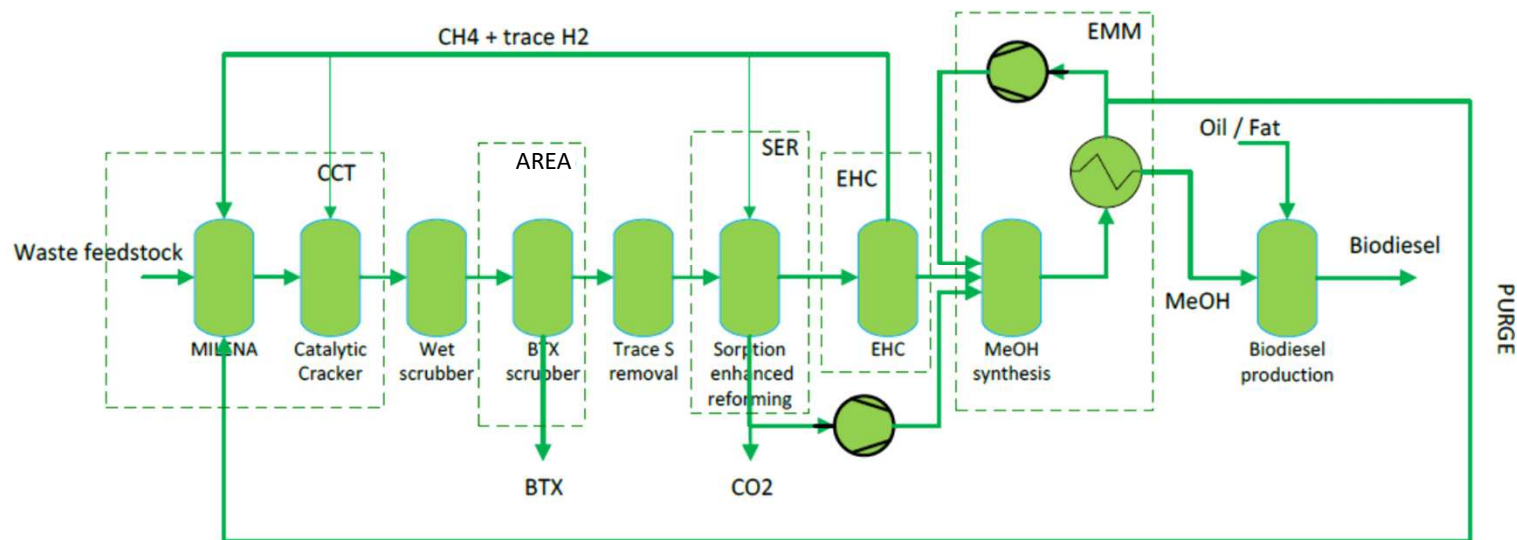
Refinery: methane by-product utilization SER/EMM/EHC



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KPI2 Number of Units (Complexity)

- The complexity of each technology is expressed in number of units (higher complexity = lower KPI score)
- Carbon Capture and Storage (CCS) is assumed for all conventional cases



Technology	Number of units
CCT	1
AREA	2
SER	3
EHC	1
EMM	2
CCS	2



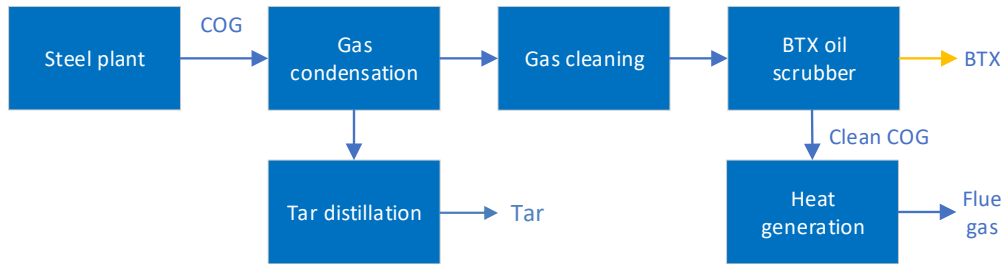
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NM(6) Add cut out units from CONVERGE process slides
Nordby, M.W. (Mads); 04.04.2022

KPI2 Number of Units (Complexity)

Conventional process

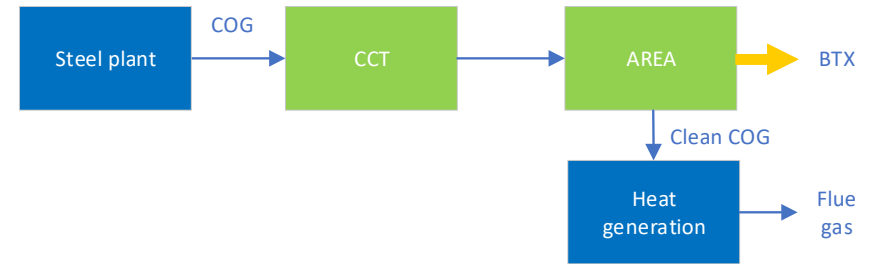
Steel industry



KPI1	5.0	KPI2	5.0	KPI3		KPI4	
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CONVERGE technologies integration

Steel industry CCT/AREA



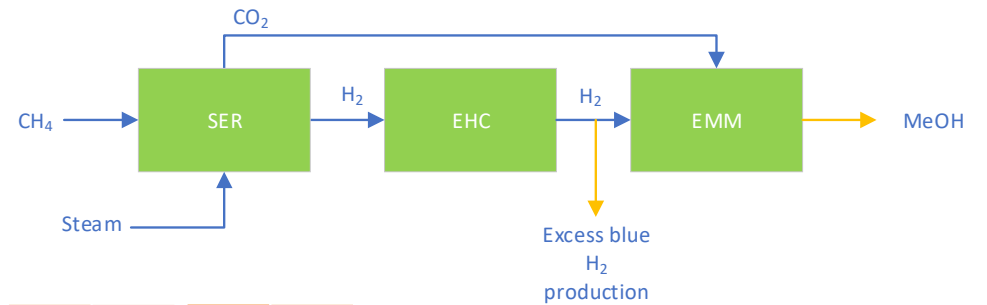
KPI1	6.0	KPI2	7.0	KPI3		KPI4	
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Refinery: methane by-product



KPI1	3.3	KPI2	9.0	KPI3		KPI4	
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Refinery: methane by-product utilization SER/EMM/EHC



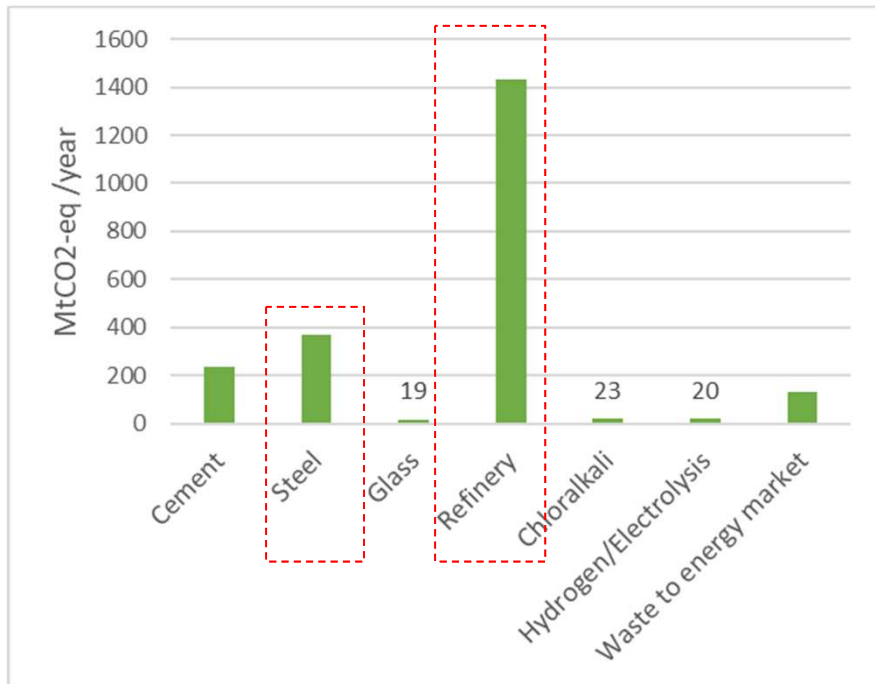
KPI1	8.3	KPI2	3.0	KPI3		KPI4	
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KPI3 Circular Economy and Environmental Impact

1. Industry footprint (that will be improved with CONVERGE technologies)



2. Scale of emissions/energy usage of CONVERGE units compared to total plant. (Higher impact = lower KPI score)
Based on energy balances/LCA studies and best estimates.

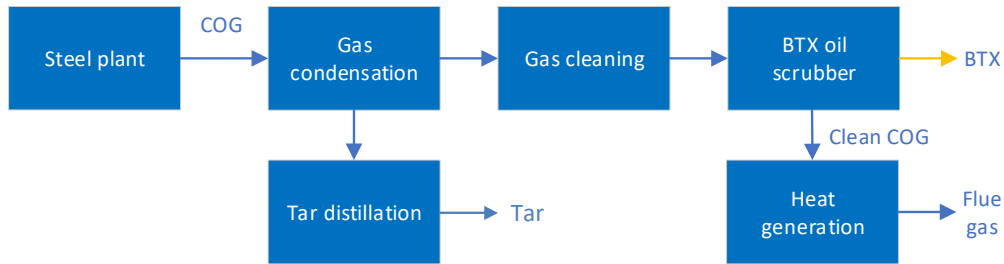
3. Impact on environment (non-GHG) based on the LCA analysis. (Higher impact = lower KPI score)

Technology	non-GHG LCA Impact
EHC	3.5
SER + CO ₂ Compression	2.2
SER	1.0
EMM	0.8
CCT/AREA	0.1

KPI3 Circular Economy and Environmental Impact

Conventional process

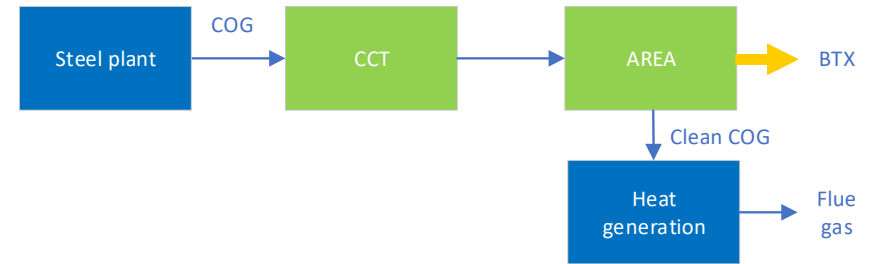
Steel industry



KPI1	5.0	KPI2	5.0	KPI3	5.4	KPI4	
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CONVERGE technologies integration

Steel industry CCT/AREA



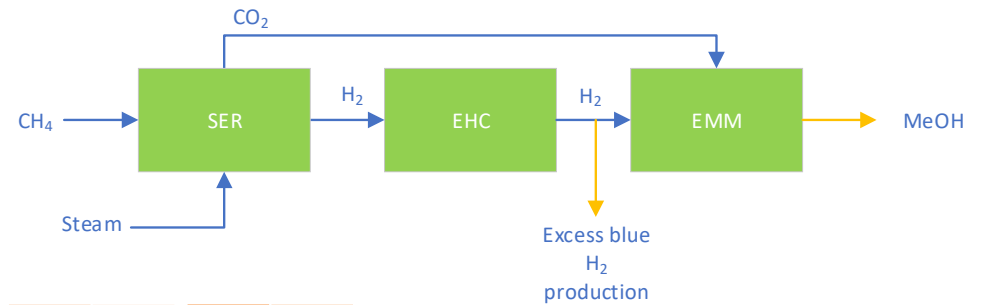
KPI1	6.0	KPI2	7.0	KPI3	8.3	KPI4	
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Refinery: methane by-product



KPI1	3.3	KPI2	9.0	KPI3	6.1	KPI4	
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Refinery: methane by-product utilization SER/EMM/EHC

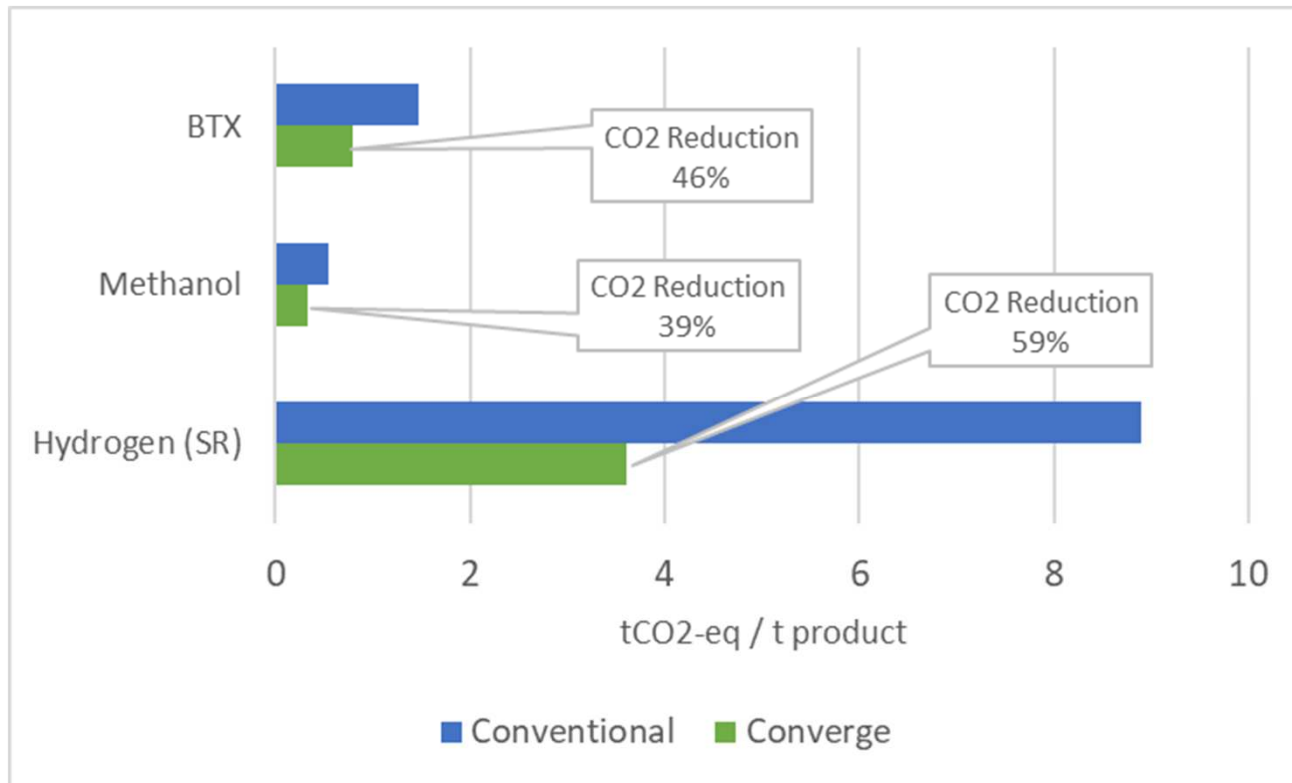


KPI1	8.3	KPI2	3.0	KPI3	7.2	KPI4	
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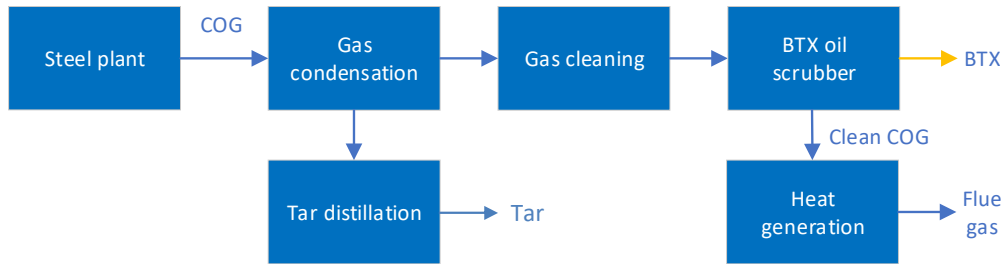
KPI4 Product Potential of CO₂ Reduction



KPI4 Product Potential of CO₂ Reduction

Conventional process

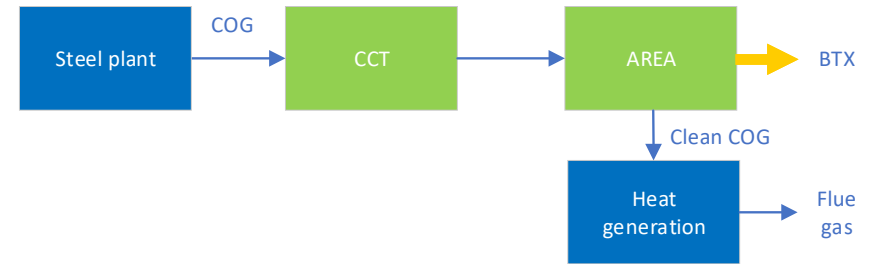
Steel industry



KPI1	5.0	KPI2	5.0	KPI3	5.4	KPI4	1.0
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CONVERGE technologies integration

Steel industry CCT/AREA



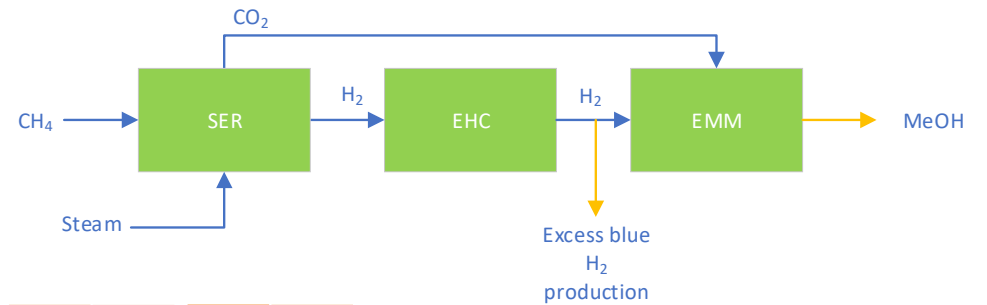
KPI1	6.0	KPI2	7.0	KPI3	8.3	KPI4	6.1
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Refinery: methane by-product



KPI1	3.3	KPI2	9.0	KPI3	6.1	KPI4	1.0
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Refinery: methane by-product utilization SER/EMM/EHC

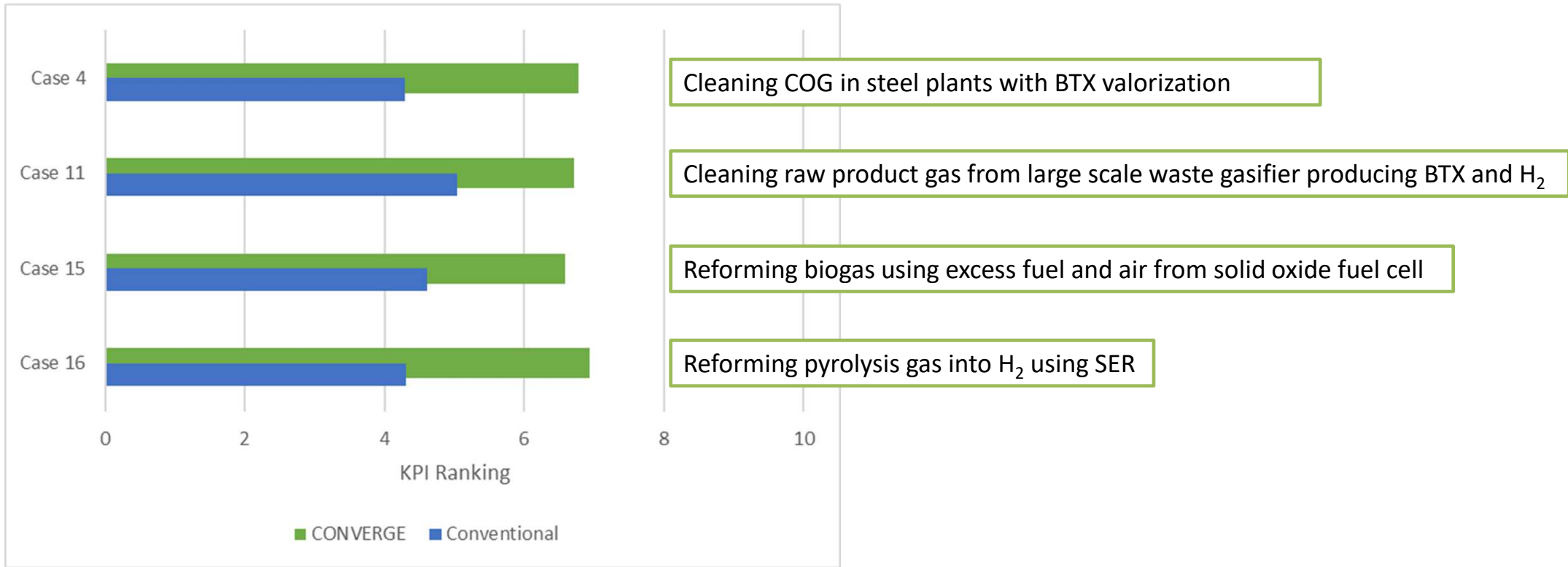


KPI1	8.3	KPI2	3.0	KPI3	7.2	KPI4	5.7
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Cases with the highest KPI ranking



Conclusions

- The application of **innovative technologies** in 8 different industry sectors was considered, resulting in 16 cases.
- A **tool** was developed, based on a **multicriteria approach**, that can be applied in different industries and for other technologies.
- In all cases CONVERGE cases ranked higher than their respective conventional case, proving that the technologies can improve the performance and efficiency of each process. In terms of:

- | |
|---|
| 1. Valorization of new product stream with high value application |
| 2. Complexity of the process |
| 3. Circular economy and environmental impact |
| 4. Product potential of CO ₂ reduction |

- 4 best cases have been selected for more detailed techno-economic analysis.

Register now for our Workshop!

Interested in biofuels?

You are welcome to visit our facilities in Petten

Draft program:

9:30 - 10:45 - CONVERGE Project presentations
11:10 - 12:30 - Gasification based biofuels
12:30 - 14:30 - Laboratories tour
14:30 - 15:30 - Renewable fuels
15:50 - 16:30 - Round table and discussion
17:00 - 18:00 - Closure drinks

[Scan to register](#)



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CONVERGE workshop & TNO lab tour

INNOVATIONS IN ADVANCED BIOFUELS PRODUCTION

18 May 2022 | 9:30 CET | Hybrid: Petten, Netherlands & Microsoft Teams

TNO innovation
for life



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Acknowledgements

Integration of Innovative Technologies to Different Energy Intensive Industries

Thank you!
QUESTIONS?

[Scan to register](#)

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The CONVERGE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 818135



KPI's explanation - Graphs

Instead of the previous slide, use here graphs for the relevant KPI. e.g. for KPI 1:

- 1. Graph of value (€/ton) for BTX, methanol, DME, etc. Product value, i.e. what is the market value of a ton of BTX or MeOH*
- 2. Graph or table about: New streams being valorized or existing streams being upgraded*
- 3. Graph of: Total addressable market (TAM) of the products in M€ per year*
- 4. Graph of size and value of the industry targeted in M tonnes of product or TWh per year*



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KPI's explanation - Graphs

KPI 1 – Product Value and Market Size Potential

Evaluates the economic potential of implementing the CONVERGE technology in each case.

1. Product value, i.e. what is the market value of a ton of BTX or MeOH
2. Are new streams being valorized or existing streams being upgraded
3. Total addressable market (TAM) of the products in M€ per year
4. Size and value of the industry targeted in M tonnes of product or TWh per year

KPI 2 – Number of Units (Complexity)

How many units are subtracted or added when implementing the CONVERGE technologies.

- When a conventional unit is replaced, the added/subtracted complexity is estimated
- Complexity is inversely proportional to the KPI score.
- The reference conventional solutions generally score higher in this KPI, as they are often less complex.
- For flue-gas (and similar) streams, CO₂ capture is assumed to be baseline even though it is not industry standard yet.

KPI 3 – Circular Economy and Environmental Impact

Deals with the potential for positively impacting the circular economy and environment, when implementing the CONVERGE technology.

1. Industry footprint
2. Scale of emissions/energy usage of CONVERGE units compared to total plant. Lower contribution to overall plant is better
3. Impact on environment (non-GHG). Based on the LCA analysis of the CONVERGE process, electricity usage is a significant factor

KPI 4 – Product Potential of CO₂ Reduction

Carbon emissions from conventional production methods are compared with production using CONVERGE technologies.

The KPI is the net carbon reduction percentage from this comparison.



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