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Region prioritization for development of CCU technologies

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eit Climate-KIC

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Introduction

Introduction:

- European Union aim to reduce the levels of the Greenhouse Gas Emissions (GHG) at least by 80-95% below the values from 1990 by 2050 (European Roadmap for 2050);

- Carbon Capture and Utilization (CCU) has been rapidly developing worldwide during the last decade from pilot and demonstration plants to full scale projects;

- CCU can play an important role in the future not only to reduce the CO_2 emissions but also to create valuable products.

Gap:

Necessary to identify and prioritize regions to develop CCU technologies. The last can be done by identifying regions where both CO_2 sources and industries already co-exist.

Methodological framework

CO_2 Availability

- Industrial sites
- Emit > 0.1MtCO_2
- Industry sectors
- Quantities emitted
- Geographic location

CO_2 Utilization

- Technologies selection
- Industrial sectors
- Geographic location
- CO_2 utilization

PRIORITIZE REGIONS FOR CARBON UTILIZATION

Boundaries: European Union 28
Time: 2012

CO_2 Availability

CO_2 Point Sources

Stationary Industries

Fossil fuels

Biogenic

European Pollutant Release and Transfer Register (E-**PRTR**)

- Companies that emit more than 0.1 Mt CO_2
- Covers 90% of all CO_2 the emissions from industrial sources

For each emitter:

Quantity

Location

Sector

Total CO_2 emissions in a region or country

Availability: carbon dioxide emissions

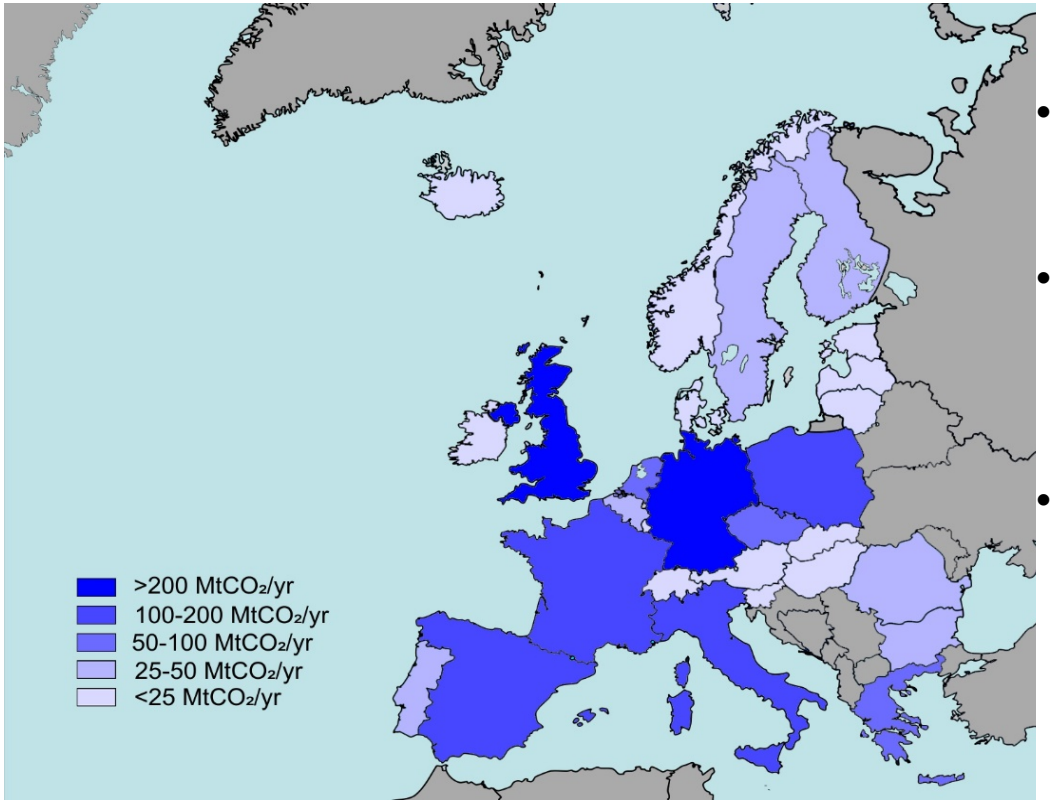
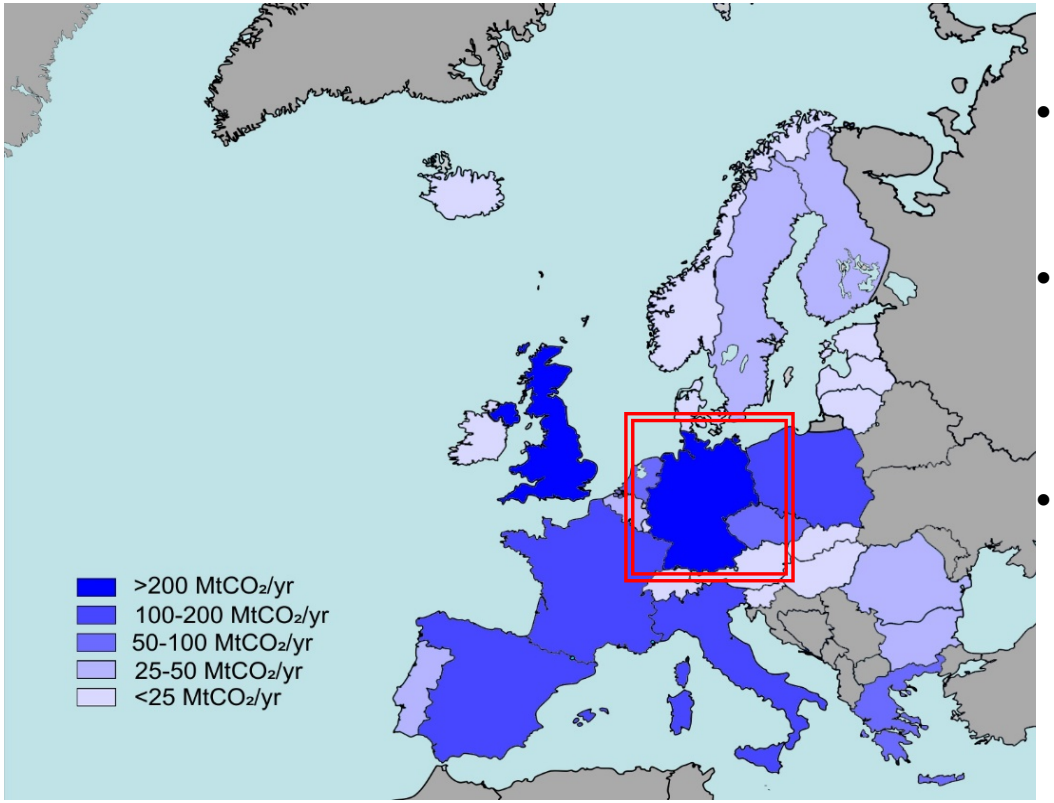


Figure 1: CO_2 availability

- 1,913 Mt CO_2 were emitted in 2012 at a European level by 2,215 stationary industrial sources.
- Thermal power stations (50% weight), oil and gas refineries (7%) and production of pig iron or steel (5%) were the more CO_2 intense sectors.
- The majority of the emissions occurred in Germany (454.6 Mt CO_2), United Kingdom (221.2 Mt CO_2), Poland (192.3 Mt CO_2) and Italy (154.1 Mt CO_2).

Availability: carbon dioxide emissions



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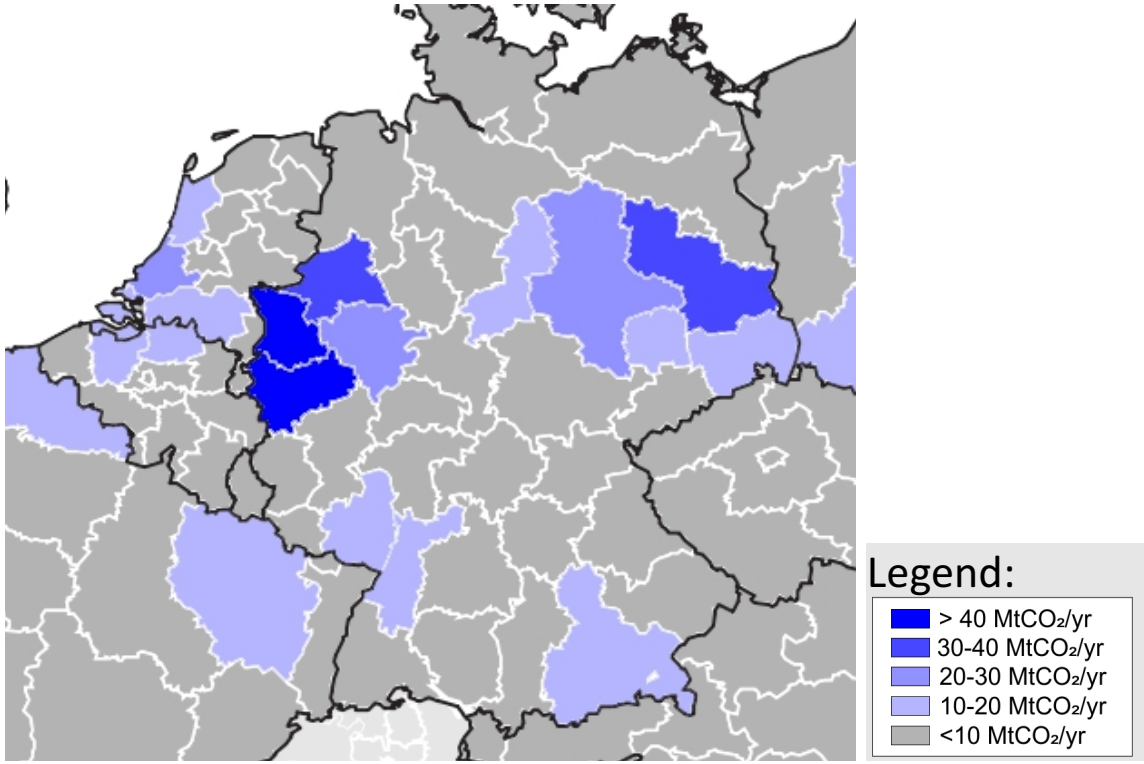
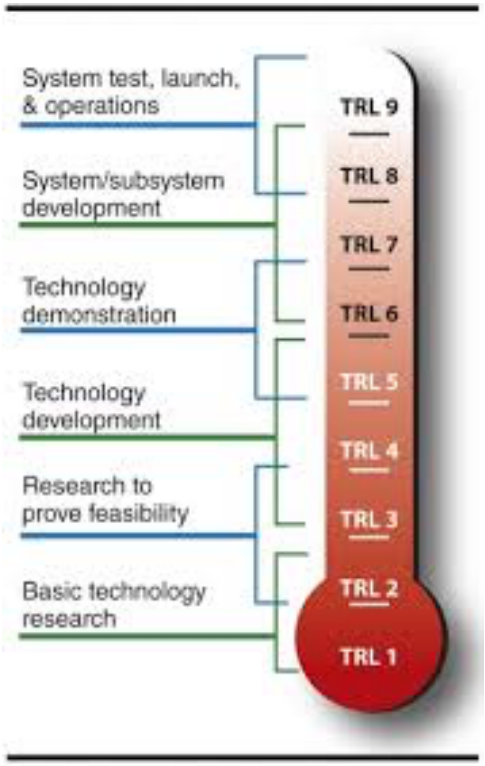


Figure 2: CO_2 availability at regional level

CO_2 Utilization technologies selection

How CCU Technologies were selected?

Technology Readiness Levels (TRL)



Current Industrial Production

Higher Demand

Data availability

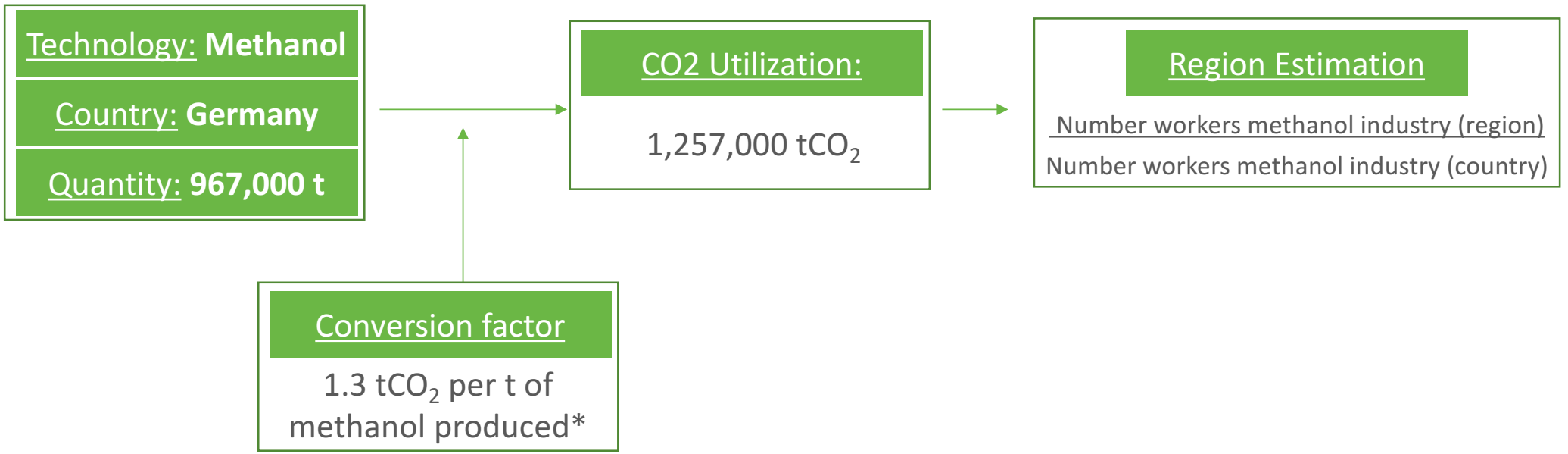
Selected CCU technologies

Nine selected technologies:

Industrial Process	Type of use	TRL	Conversion Factor
Lignin Production	CO_2 used in black Liquor pH regulation	8-9	0.22 tCO_2 per t of lignin produced (Manninen 2010); (Tomani et al. 2011)
Methanol Production	Electrochemical reduction of CO_2.	7-9	1.3 tCO_2 per t of methanol produced (Van-Dal and Bouallou 2012)
Polyurethane Production	CO_2 used as raw material to produce plastics and fibers	7-9	0.1-0.3 tCO2 per t of polyols (Stute, 2015)
Polycarbonate Production	CO_2 used as raw material to produce plastics and fibers	7-9	0.43 tCO_2 per t of PPC produced (Demire 2015)
Concrete Curing (Concrete blocks)	CO_2 used for precast concrete curing	7-8	0.03 tCO_2 per t of block produced 0.12 tCO_2 per t of precast concrete (El-Hassan and Shao 2014)
Mineral Carbonation	CO_2 reacted with calcium or magnesium containing minerals	7-8	0.25 tCO_2 per t of steel slag (Huijgen et al. 2005)
Bauxite Residue Carbonation	CO_2 is used to neutralize bauxite residues	9	0.053 tCO_2 per t of red mud (Yadav et al. 2010)
Horticulture Production	CO2 supplementation on plant growth	9	0.5–0.6 $kgCO_2/hr/100m^2$ (Blom et. al, 2009) 160 tCO_2 per ha (for tomatoes in Sweden) (Jordbruksverket, 2007)
Urea production	Urea production from ammonia and CO_2	9	0.46 tCO_2 per t of precast urea (Hignett 1985)

CCU assessment

Example:



- Industrial production:
- Publicly available data in Eurostat

*Source:Van-Dal and Bouallou 2012

CCU in European Union 28 at country Level

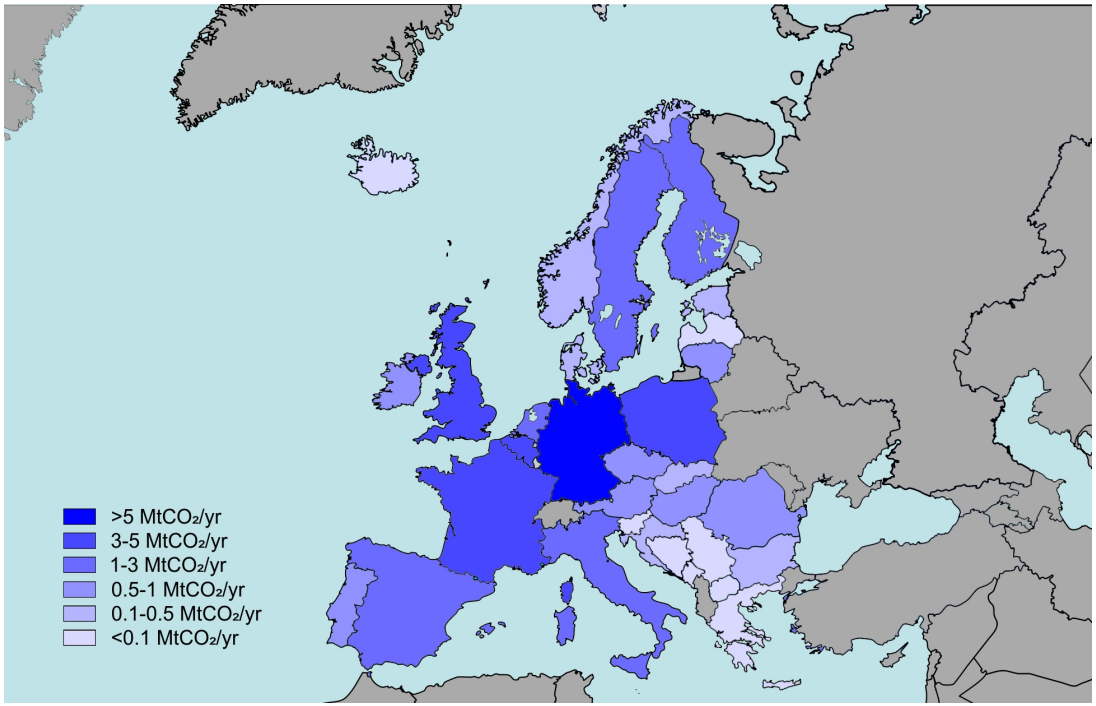


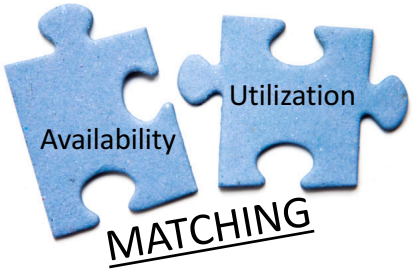
Figure 3: CO_2 utilisation at country level

Industrial Process	CO_2 Utilization (Mtpa)
Concrete curing	22.5
Horticulture production	22.0
Lignin production	8.4
Mineral carbonation	5.3
Polyurethane	4.7
Polycarbonate Production	4.3
Urea	3.9
Methanol	1.5
Bauxite Residue Carbonation	0.2

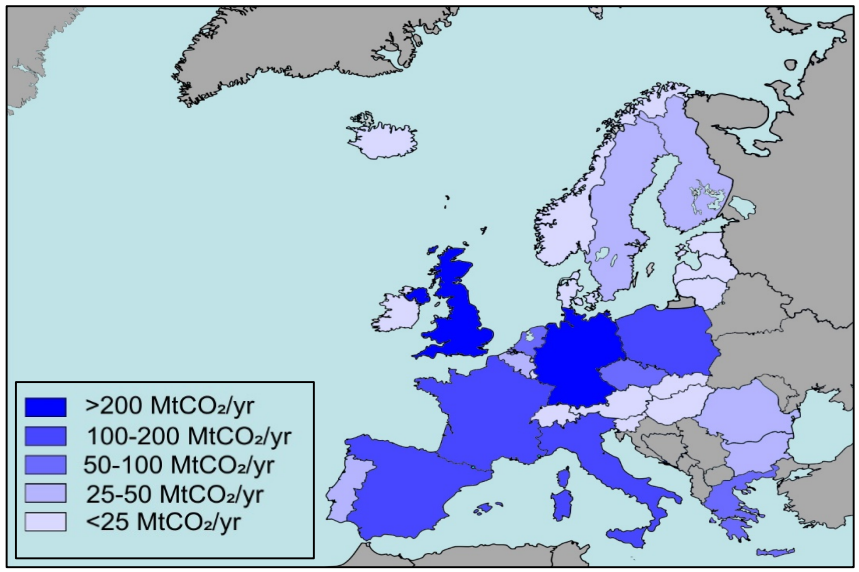
TOTAL: 68.4 $MtCO_2$

3.6% of total CO_2 emissions

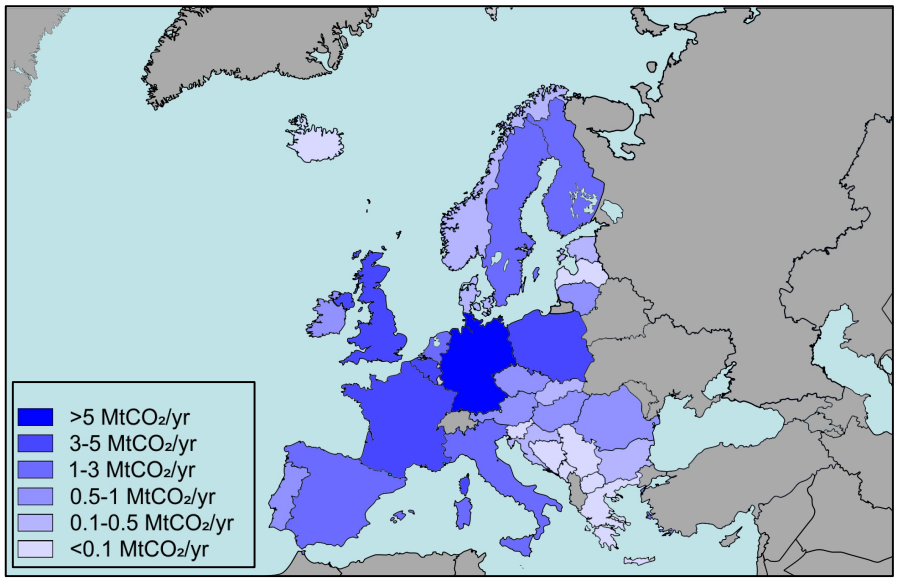
Countries Prioritization:



CO_2 Availability



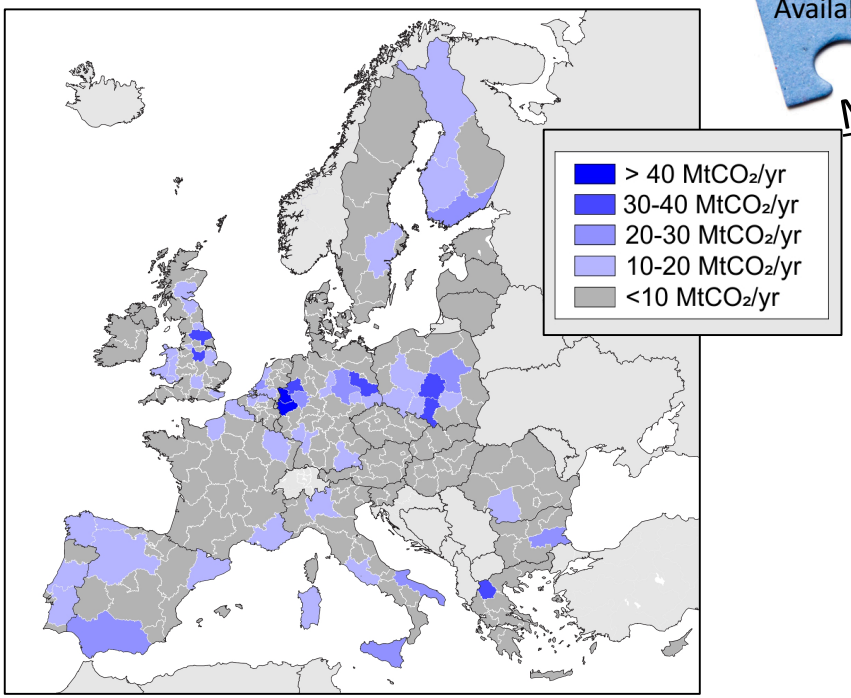
CO_2 Utilization

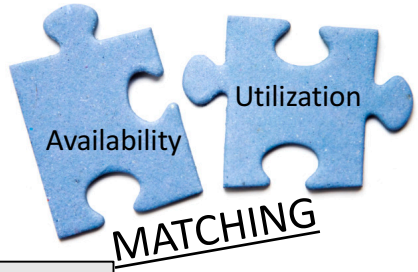


- The amount of available CO_2 is greater than the potential for CO_2 utilization in all countries.
- Germany, UK, France, Belgium, Poland, Italy, Spain, Sweden and Norway are the countries with more potential for the development of CCU partnerships.

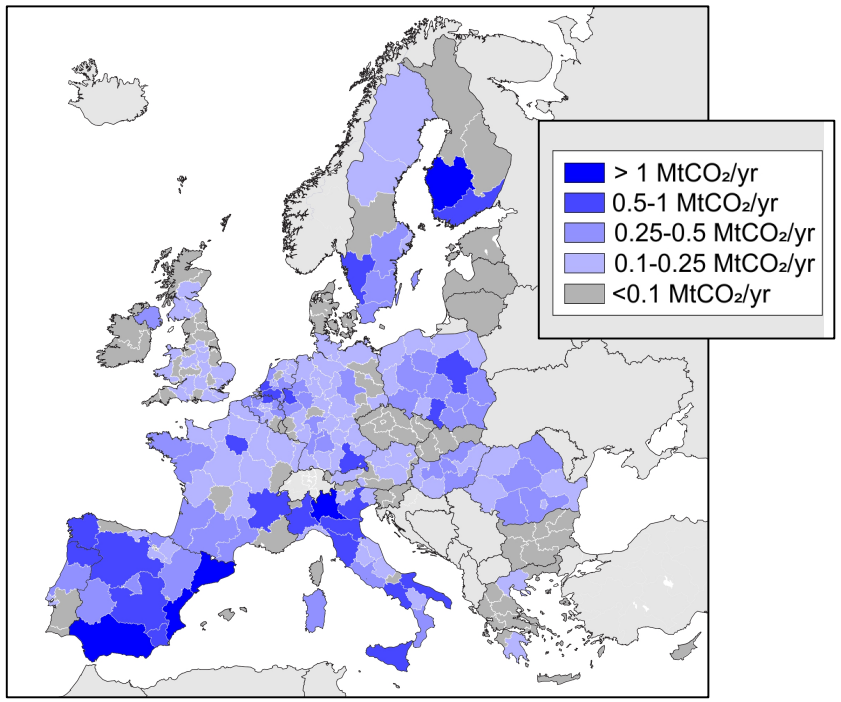
Regions prioritization

CO_2 Availability





CO_2 Utilization



- Six most promising regions: Dusseldorf and Cologne (Germany), Antwerp Province and East Flanders (Belgium), Cataluña (Spain) and Śląskie (Poland).
- Other promising regions: Łódzkie (Poland), Etelä-Suomi and Helsinki-Uusimaa (Finland), Lombardia (Italy) and Södra Sverige (Sweden).

Conclusions

- The annual amount of CO_2 released by industrial sources in Europe was approximately 1,900 $MtCO_2$ while the potential utilization could reach 68 $MtCO_2$, based on nine selected technologies, which represents 3.6% of the total amount of CO_2 available.

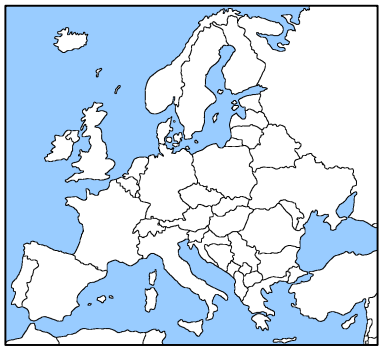
- The study has shown that the countries with the largest emissions also have the highest potential for utilizing the CO_2, with Germany, United Kingdom and France being the most promising followed by Spain, Italy and Poland.

- A more detailed analysis has also revealed several regions where CO_2 reuse schemes could be developed. The majority of them are located in Central Europe (Germany, Belgium and Poland) and Scandinavia (Sweden and Finland).

- These regions may take advantage of the available resources as well as technologies to increase the industrial production and decrease the dependence on fossil fuels based materials while simultaneously decreasing the net CO_2 emissions, by recycling CO_2 in the same region.

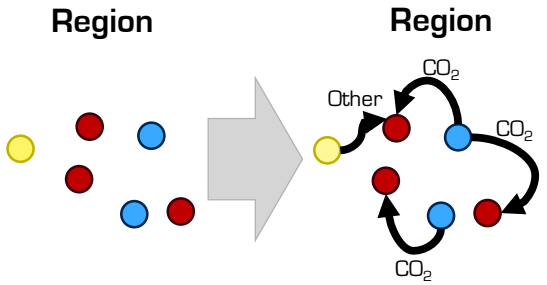
Future work at regional level

Regions Prioritization



- Top down approach
- Statistical Data
- Total amounts

Regions CCU

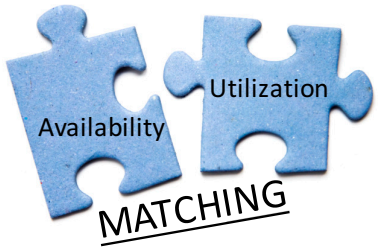


- Top down approach
- Bottom up approach
- Statistical Data
- Auxiliary process
- CCU quantification
- Companies information

Future work at regional level

CO_2 Availability

- Industrial sites
- Industry sectors
- Quantities emitted
- Purity of CO_2
- Other substances in off-gas
- Geographic location



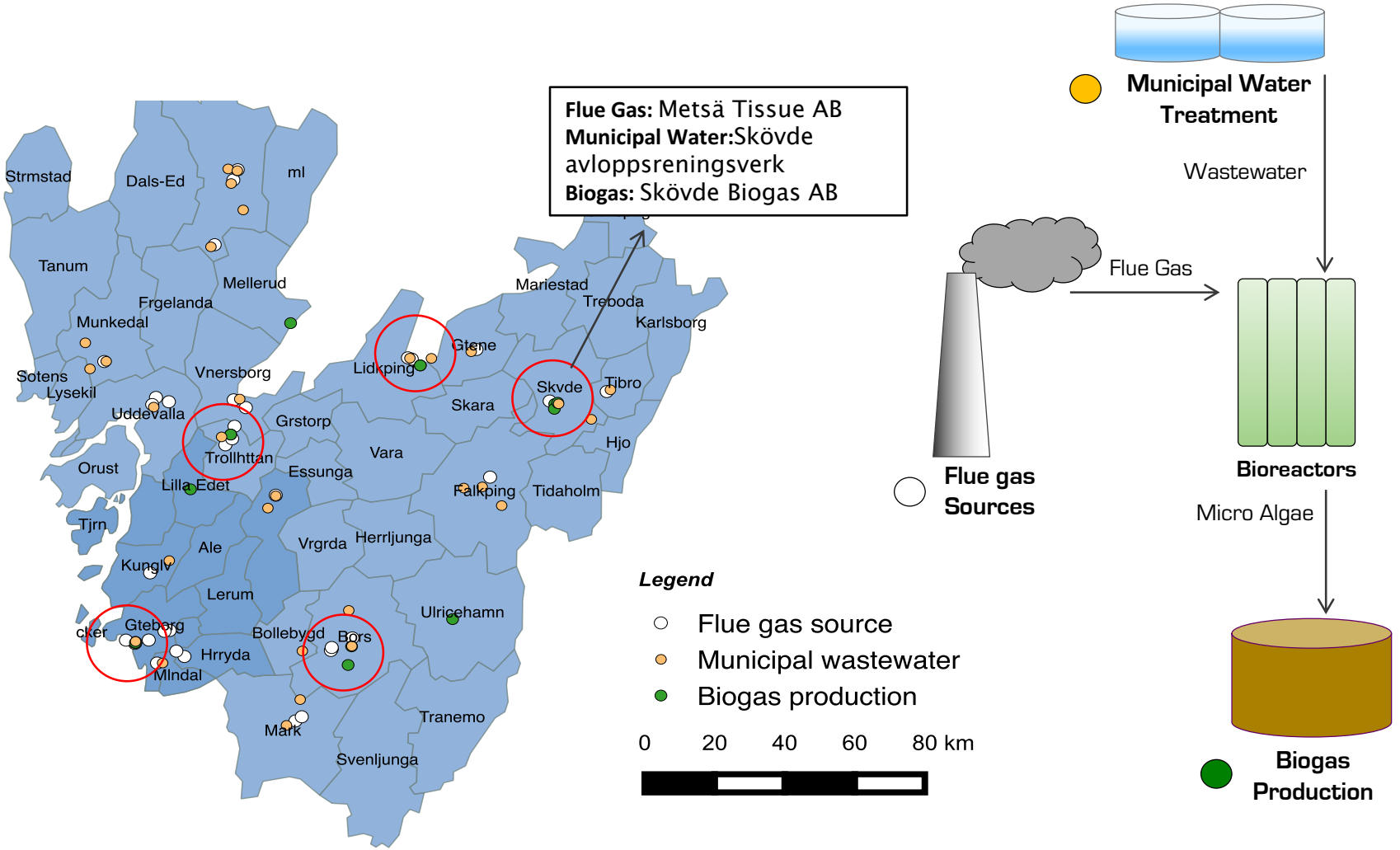
CO_2 Utilization

- Technologies selection
- Industrial sectors
- Geographic location
- Company level
- CO_2 utilization
- Purity of CO_2
- Auxiliary sources
- New business

PRIORITIZE IS FOR CARBON UTILIZATION IN A REGION

Boundaries: Västra Götaland Region - Sweden
Year: 2012

Example – Obtained results Algae production



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