

# Industrial outlook 2050

Emission Changes related to a Transitioning  
Industrial Landscape in Flanders

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## Key questions

- *Effect on air pollutant emissions if current climate scenarios are followed?*
- *If multiple (climate) options, which one is preferred from an air emission perspective*
- *What are the (air) risks of certain climate technologies*

### Client

Flemish administration



VLAAMSE  
MILIEUMAATSCHAPPIJ

### Project team

VITO – Environmental modelling

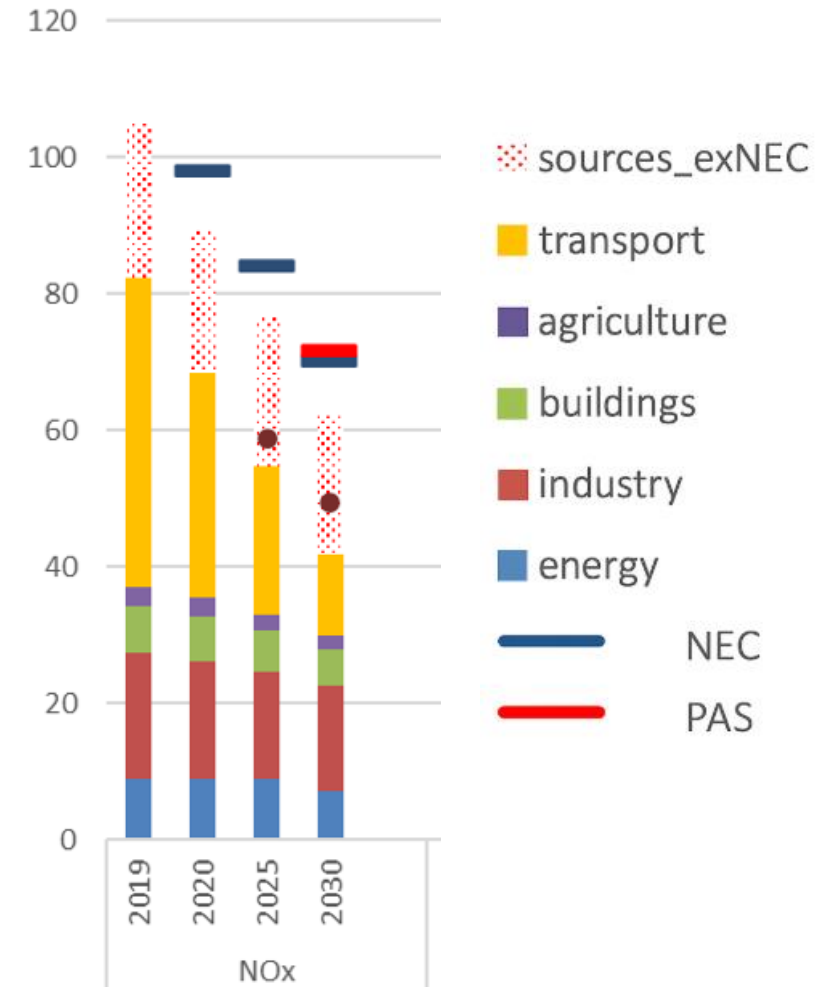
VITO – Energyville

(DNV)



# Context of the question

- Project linked to the Flemish Air Quality Plan (approved 2019)
  - Short term (2030): clear plan with concrete measures per sector
  - Long term (2050): policy to be developed
    - Goal: Below WHO targets by 2050
- Effect of choices made for decarbonization on air pollutant emissions
  - Industry (including energy sector)
  - Focus on **NOx, NH3, PM**
  - 2030-2050
  - **No scenarios but 'rough' estimates and ranges in an impact dashboard**



# Project steps

- Overview technological options
- Impact on emissions
- Technology sheets & Impact dashboard



# Step 1: Overview of technological options

Belgian TIMES scenarios

- Model of the entire energy system matching the official Belgian energy balance
- **Cost-optimization model** to match climate goals while fulfilling all exogenous demands
  - Not a prediction of the future
  - Suggested transition path IF the sole goal would be cost minimization
- Including current and future technological options

# Step 1: Overview of technological options

## Belgian TIMES scenarios

- General drivers
  - Local industrial activity **remains constant**
  - CO2 price increase from 50 to 350 euro/ton over the period of 2020 to 2050
  - Net CO2 emission of 2 Mt in 2050 (remaining technology deficit)
- Scenario specific drivers
  - Electrification scenario: more offshore wind and allowance for SMRs in 2050
  - Molecules scenario: cheaper renewable molecule import and limited CO2 storage potential

## 02 Electrification Scenario Concept



Our fundamental approach for this Electrification Scenario:

What if we walk the road to a carbon neutral Belgium with access to more offshore wind and the option to invest in new nuclear technology?

In a nutshell, these are the Electrification Scenario assumptions we relied on:

Belgium has the possibility to acquire additional access to a large offshore wind zone in the North Sea as of 2030, adding 16GW of offshore wind power. In addition, this scenario allows for investment in a new generation of nuclear Small Modular Reactors (SMRs) operational as of 2050.

For more details on our Electrification Scenario assumptions, visit our more elaborate [Method page](#).

## 03 Clean Molecules Scenario Concept



Our fundamental approach to this Clean Molecules Scenario:

What if we walk the road to a carbon neutral Belgium with the options to import synthetic molecules at lower costs and have a more limited access to cross-border CO<sub>2</sub> storage?

The production cost of synthetic molecules such as green hydrogen and derivatives is highly dependent on the cost of electricity. Under this Clean Molecules scenario, Belgium has the possibility to have access to green hydrogen and other synthetic molecules at a very low cost.

Belgium has no natural locations to store future captured CO<sub>2</sub> emissions, and will therefore need to rely on locations in the North Sea and Norway. Under this Clean Molecules Scenario, Belgium's access to cross-border CO<sub>2</sub> storage is limited to 5 million ton per year.

For more details on our Clean Molecules Scenario assumptions, visit our more elaborate [Method page](#).

# Step 1: Overview of technological options

- Result of step 1: Technology-explicit list for different end products

## technology list HVC

HVC - Naphtha Steam Cracker

HVC - Electric Furnace for Steam Cracker

HVC - Propane Dehydrogenation PDH - Standard (Catofin)

HVC - Methanol Synthesis

HVC - Methanol to Olefins MTO

HVC - Methanol to Aromatics MTA

HVC - Methanol to Propylene MTP

HVC - Ethane Steam Cracker

## Step 2: Impact on emissions

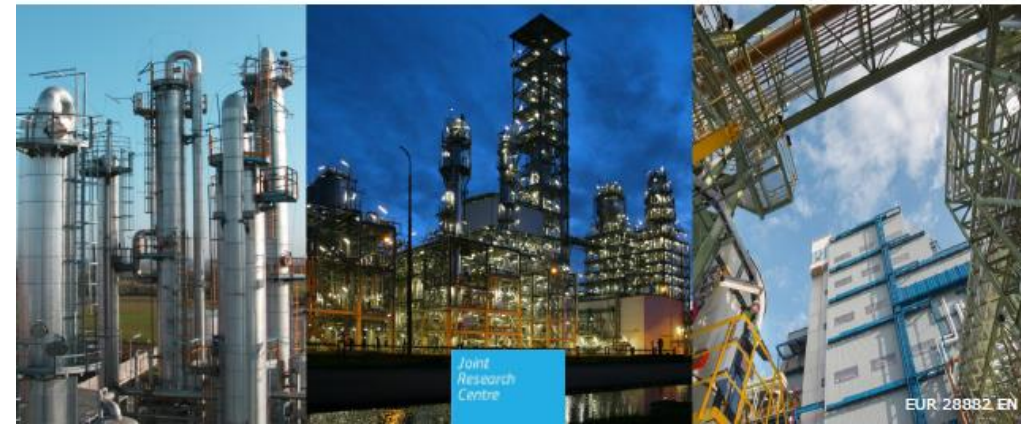
- Result of step 1: Technology-explicit list
- Next: Couple Emission factors to the technologies  
**EF is in kton/UOM**
  1. Demonstrated/Implied emission factors
  2. VLAREM
  3. EMEP/EEA
  4. BREFs
  5. Literature search

## Best Available Techniques (BAT) Reference Document for the Production of Large Volume Organic Chemicals

*Industrial Emissions Directive  
2010/75/EU  
(Integrated Pollution  
Prevention and Control)*

Heino Falcke, Simon Holbrook, Iain Glenahan,  
Alfredo Lopez Carretero, Teoman Sanalan,  
Thomas Brinkmann, Joze Roth, Benoit Zerger  
Serge Roudier, Luis Delgado Sancho

2017



## Step 2: Impact on emissions

- Result of step 2: Normalized table
  - Technology explicit list
  - Complemented with emission factors
  - Added: deployment limits, assumptions, uncertainty score

Group 1	Group 2	reference technology	technology	technology deployment	activity driver	activity driver	UOM	CO2	TSP	PM10	PM25	BC	NOx	NH3	deployment limit	description	relation	assumptions
IronSteel	Furnace	100%	I-IS-FINHTH-00	Steel - Finishing H IISHTH	heat	PJ												
IronSteel	Furnace	0%	I-IS-FINHTHHH2-0	Steel - Finishing H IISHTH	heat	PJ												
IronSteel	Coke Oven Plant	100%	SSDCCOKE00	Cokeoven Plants I COACOK	Cokes	PJ												
IronSteel	Iron pellet Production	0%	I-IS-PELLET-01	Steel - Iron Pellets MISPLT	Iron pellets	Mton												
IronSteel	Oxygen Production	100%	I-IS-OXYSTD-00	Steel - Oxygen production MISOXY	Oxygen	Mton												
IronSteel	Sintering	100%	I-IS-SINTER-00	Steel - Sinter production MISSNT	Sinter	Mton												
IronSteel	Steel finishing	100%	I-IS-FINPRO-00	Steel - Finishing (I) DEMIIS	Finished Steel	?												
IronSteel	Steel finishing	0%	I-IS-FINPRO-01	Steel - Finishing (I) DEMIIS	Finished Steel	?												
IronSteel	Steel Making	68%	I-IS-BLAFUR-00 &	Steel - Blast Furnace MISCPS	Primary steel	Mton										produce iron	cokes and sinter	
IronSteel	Steel Making	0%	I-IS-BLFHH2-01 &	Steel - Blast Furnace MISCPS	Primary steel	Mton												
IronSteel	Steel Making	32%	I-IS-EAFSTD-00	Steel - Electric Arc MISCSS	Secondary steel	Mton												
IronSteel	Steel Making	0%	I-IS-EAFELC-01	Steel - EAF 100% v MISCSS	Secondary steel	Mton												
IronSteel	Steel Making	0%	I-IS-NTGDRI-01 &	Steel - Natural Gas MISCSS	Secondary steel	Mton												
IronSteel	Steel Making	0%	I-IS-HH2DRI-01 &	Steel - Hydrogen MISCSS	Secondary steel	Mton												
IronSteel	Steel Making	0%	I-IS-MOESTD-01	Steel - Molten Oxide MISCPS	Primary steel	Mton												
IronSteel	CO2 Capture	0%	I-IS-AMNCCU-01	Steel - Amine-based IISCO2C	Captured CO2	Kton												
IronSteel	CO2 Capture	0%	I-IS-AMNCCU-02	Steel - Amine-based IISCO2C	Captured CO2	Kton												

*\*Remark on abatement*

## Step 3: Excel tool

- Study new technologies using
  - Technology sheets
  - Impact dashboard
- Basis is normalized table

## Step 3: Excel tool

- Make a sheet for every 'new' technology
- Goal = lower CO2 emission
- Sheet shows effect on other pollutants

HVC - Naphtha Steam Cracker (New) - with electric furnace			
<i>I-CH-HV-NSCSTD-01 &amp; I-CH-HV-NSCELC-01</i>			
Chemicals			
HVC production			
UOM: Mton			
Description of the technology			
Relation with other measures			
Assumptions and boundary conditions			
Deployment limits			
Warnings			
Emission factors			
<i>kton/Mton</i>			
<b>EF reference technology</b>			
TSP		0.028	
PM10		0.019	
PM2.5		0.019	
BC		-	
NOx		0.987	
NH3		0.093	
CO2		1,573.3	
<b>EF current technology</b>		<b>Worst case</b>	<b>Best case</b>
TSP		0.009	0.003
PM10		0.006	0.002
PM2.5		0.006	0.002
BC		NE	NE
NOx		0.300	0.100
NH3		-	-
CO2		192.0	

## Step 3: Excel tool

- Impact dashboard allows to check the effect of a package of measures
  
- User inputs
  - Sectoral evolution
  - Compile list of technologies and relative contribution in the energy mix
  - Adjust general parameters
  - Add possible abatement
  
- Result is visualized

### Impact dashboard - selection of technology packages

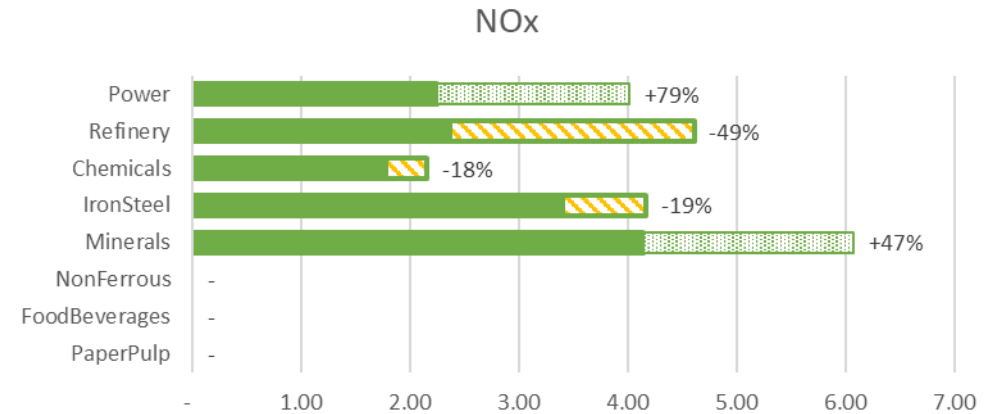
Show results of:

Best/worst Worst case  
 Base year 2014  
 Scenario Central  
 Scenario year 2030

N°.	Technology	2030	2040	2050
1	EEUCGASCCELO	18%	9%	0%
2	EEUCGASOCELO	0%	0%	0%
3	EEUCGASTJELO	0%	0%	0%
4	EEUCNUCSTELO	16%	0%	0%
5	SOLWINOT00	65%	91%	92%
6	E-ELE-AU-TSF-SN-NUC-1	0%	0%	0%
7	EEUCBIOSTELO	0%	0%	0%
8	E-ELE-MA-TSF-GT-HYN-1	0%	0%	8%
9	EEUCGASCCEL1	0%	0%	0%
10	EEUALLAMC1	0%	0%	0%
11	SSCDRFLX00	100%	100%	100%
12	SSCDRFLX01	0%	0%	0%
13	SSCDRFLXELC01	0%	0%	0%
14	I-CH-AM-SMRSTD-00 & I-CH-AM-HBPSTD-00	100%	0%	0%
15	I-CH-AM-ELZALK-01 & I-CH-AM-HBPSTD-01	0%	100%	100%

## Step 3: Excel tool

- Impact dashboard allows to check the effect of a package of measures
  - Sectoral evolution
  - Compile list of technologies and relative contribution in the energy mix
  - Adjust general parameters
  - Add possible abatement
  
- Result is visualized
  - Additional sheets for post-processing
    - Waterfall plot
    - Overview of warnings



### Overview of warnings for selected technologies

Sector	Techn	Technology	Warnings
Chemicals	13	I-CH-HV-PDHSTD-00	Attention is needed to address potential thermal NOx production in this process
IronSteel	19	I-IS-MOESTD-01	Please be aware that the molten oxide electrolysis process is currently at TRL 2, and further research is required to enable its integration into the steelmaking sector.
Power	1	EEUCGASCCELO	Exhaust gas treatment could lead to added ammonia emissions
Power	2	EEUCGASTJELO	Exhaust gas treatment could lead to added ammonia emissions

# Conclusions

- About the project
- About the context
- General conclusions & lessons learnt



# Conclusions

## About the project

- **Shared Resources:** Most sectors can reduce CO<sub>2</sub> and air pollutants, but rely on shared resources (e.g. hydrogen, electricity, carbon storage). Ensuring broad access is critical.
- **Electricity Demand:** All scenarios agree on the need for a major increase in sustainably produced electricity to meet energy needs.
- **Tech Trade-offs:** Some emerging tech (e.g. hydrogen combustion) may raise air pollutant levels (like NO<sub>x</sub>). Ongoing monitoring and policy guidance are essential.
- **Carbon-Negative Tech:** Residual CO<sub>2</sub> must be offset with early-stage, uncertain carbon-negative solutions. Even small pollutant effects could scale quickly.

# Conclusions

## About the context

- Resistance among sector federations
  - Possible solutions: Sounding board, interviews
- Lack of detailed knowledge



# Conclusions & Lessons Learned

Based on multiple related projects

- **Break the 'silo' mindset**
  - Climate and air quality policies must be aligned and developed together
- **Build integrated models**
  - Link energy and air quality models from the start
  - Ensure high detail and consistency across modeling
- **Reduce uncertainties continuously**
  - Address unknowns in emerging technologies and sectors
  - Strengthen abatement data
  - Align with evolving EU strategies and policies

# Questions?

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