Carbon Transition Model for Dutch industry

Final report

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Partners

Kalavasta Climate Neutral Strategies

ArcelorMittal

Dow

OCI

CIEP

TATA STEEL

ebn

Nouryon

urgenda SAMEN SNELLER DUURZAAM

Utrecht University

Final report

1. Summary

We believe that the dialogue between government, energy sector, industry and society on possible pathways towards a circular and carbon neutral process industry in The Netherlands can only be successful when everybody has access to the same information.

Therefore, the Carbon Transition Model initiative was started to develop a transparent, fact based, open source model to facilitate just that. The Model can be used to explore different scenario's together, whereby the consequence of certain choices become clear and a mutual and coherent understanding of the (combination of) various transition options towards 2030 and 2050 evolves.

The Carbon Transition Model will facilitate the process to make the right fundamental choices, at the right time and in a cooperative way.

In this project, version 1.0 (a working prototype) of the Carbon Transition Model has been developed.

2. Introduction

In order to achieve the challenging CO_2 emissions reduction targets as agreed in the Paris agreement and in the Dutch climate agreement, fundamental changes and radical transitions are needed.

For the Dutch, fossil intensive industry, in particular the petrochemical and process industries (the 'basisindustrie' which is a major pillar of the Dutch economy), the energy transition and the transition from a fossil-driven, linear economy to a net-zero emission, circular economy are two major, systemic transitions. These transitions interlock and will fundamentally change the economic logic and logistical interconnectedness of the industry. This dual transition will disrupt and reorganize current value chains.

Currently, (sub)sectors, companies and industry clusters individually try to develop strategic plans on how and at what costs they could reduce carbon emissions. Most of these plans have included a limited scope and focus on a small part of a large, interconnected and clustered industrial system.

There is a need to put the plans and specific technology development in the perspective of a large, interconnected and clustered industrial system by assessing these plans and developments for their impact on national, (EU regional and global) physical flows of carbon. Combined with the need for mutual understanding of the associated constraints, dependencies and opportunities of the dual transition. Only in such a system-in-transition context we can get a better grip on what emissions are produced and how they can be reduced. For that purpose, we propose to build an integral Carbon Transition Model, where carbon flows take center stage.

Motivation

The Dutch, fossil intense industrial sector is for geographic and historic reasons relatively large compared to other countries. Dutch emission reduction is therefore to a large extent dependent on the changes that can be made to the industrial sector. And there are many ways to achieve emission reductions in industry but each option has its own (dis)advantages.

Hence, the industry is facing major uncertainty, which is even more prominent under the common circumstances (Covid-19). Various stakeholders keep an eye on each other and wait for or expect the other to act first, resulting in inactivity amongst all stakeholders.

The consortium partners strongly believe that the Carbon Transition Model holds the promise to reduce uncertainty by facilitating cooperation and integration of expertise, experience and individual visions on potential transition options. The resulting new relations and connections across sectors will re-activate stakeholders to start acting together on the challenges that are staring us in the face.

In other words, the consortium aspires to contribute to the acceleration of the CO_2 emission reduction and the deployment of (new) circular carbon value chains in the Netherlands.

3. Objective(s)

In this project we have built a first version (prototype) of the Carbon Transition Model (CTM) that should allow the user to explore not only what emission reduction options exists, but also understand how they interact and see their impact on the greater Dutch industrial system, taking into account import and export of both energy, feedstock, intermediate and final products.

The Carbon Transition Model is designed to:

1. allow structured analysis of transition pathways;
2. let users experience how certain transition options have an effect on the industrial system and carbon flows within, and vice versa;
3. allow for mutual learnings and shared experience to create actionable insights on a level that individual organizations or (sub)sector at their individual level do not have;
4. support multi-stakeholder informed decision making;
5. identify new value chains and sector coupling aimed at reducing carbon emissions;
6. lead to new knowledge and insights to be used for further development and scale up of CCU-technologies;

The development of CTM is a joint effort with input from universities, knowledge institutes, consultants, civil society organizations and industry. Together they have defined the pathways that need to be taken into account in version one of the CTM. Data has been collected with regards to historic emissions and energy, feedstock and product flows. These data have been integrated in a model that allow the user to change the historic (validated) base year into a future year with old and new pathways. For every change the user makes, the model provides instant feedback on key parameters like emissions, volumes and costs. The integrated model has been tested and validated by all consortium partners. The final deliverable of this project is a prototype the Carbon Transition Model, incl. a User Guide, Conceptual Design and Technical Documentation.

4. Project execution

a. Work breakdown structure

The project is structured in four work packages, whereby work package 1-2 were executed sequentially and work package 3 and 4 in parallel to 1 and 2:

1. WP1 - Scope, Data Inventory, base model historic year - scope setting for model setup, collection and harmonisation of data to build a national model and model development for base year (back-end of the model)

2. WP2 - Base model development for future years, additional data gathering for future years and addition of new pathways to carbon neutrality including new cluster connections (back-end of the model) and user interface development (front-end of the model)

3. WP3 - Multi-stakeholder validation, verification and analysis - going stepwise over the use-case levels the models will be explored

4. WP4 - Substantive technical supervision - coordination and supervision of work progress

b. Planning

Table 1 Overall project Gantt chart

	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March
WP 1.1									
WP 1.2									
WP 2.1									
WP 2.2									
WP 3									
WP 4									

c. (Justifications for) relevant changes with respect to project plan

There have been no substantive changes to the project plan, except that more time was taken for the Multi-stakeholder validation, verification and analysis exercise and the demo and exploration sessions. These sessions have resulted in the need for further development of the CTM.

5. Budget

a. Budget and realized costs

Table 2 Overall project Gantt chart

	BEGROTING				REALISATIE			
Partners	**kosten**	**financiering**			**kosten**	**financiering**		
		TKI	cash	in kind		TKI	cash	in kind
ISPT	93.400	42.360	51.040		94.000	42.360	51.040	600
OCI Nitrogen	6.000	3.000		3.000	6.000	3.000		3.000
DOW	6.000	3.000		3.000	6.000	3.000		3.000
Nouryon	3.000	1.500		1.500	5.040	1.500		3.540
Arcelor Mittal	6.000	0		6.000	6.000	0		6.000
Tata Steel	4.800	2.400		2.400	4.800	2.400		2.400
EBN	6.000	0		6.000	6.000	0		6.000
Urgenda	4.800	2.400		2.400	4.800	2.400		2.400
CIEP	4.800	2.400		2.400	4.800	2.400		2.400
Universiteit Utrecht	30.000	24.000		6.000	30.625	24.000		6.625
Totaal	**164.800**	**81.060**	**51.040**	**32.700**	**168.065**	**81.060**	**51.040**	**35.965**

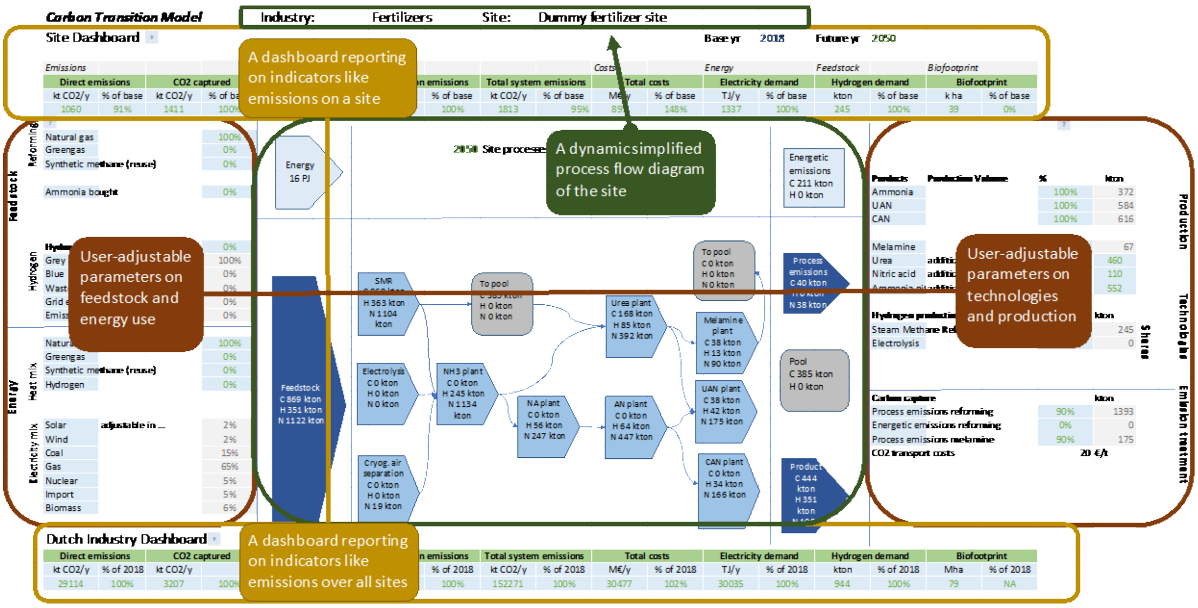
6. Results

a. Carbon Transition Model tool

The Carbon Transition Model has been developed as an MS Excel based tool for this phase. It has been designed as a series of tabs with all data, including a full material and energy balance for every process modelled. In addition, an interface has been build that allows the user to explore various scenario's.

In version 1.0 of the Carbon Transition Model, the production sites of the 12 (+1) large emitters in the Dutch (Belgian) Industry have been modelled. Each industrial site that is contained in the model can be approached by its own interface. The interface consists of several panes, such as a dynamic simplified process flow diagram of the site and two user-adjustable parameter boxes. One for feedstock & energy use and one for technologies & production. Finally, it contains a two dashboards: one to report on indicators at a site-level and one to report on indicators at industry / national level.

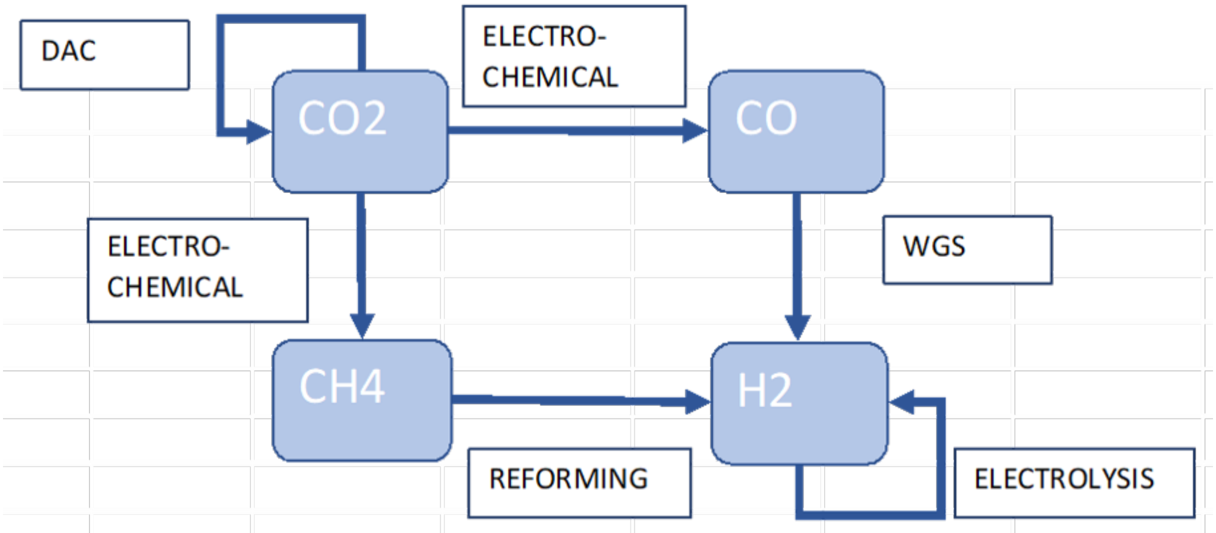
A screenshot of the interface for a fertilizer site is presented below.



b. Feedstock pools

During the model development and the validation / exploration sessions, the idea originated to keep track of the by-products that were resulting from certain processes and/or the implementation of a new technology for that process. This resulted in the incorporation of the concept of feedstock pools, allowing material exchange between industrial sites in analogy to the 'copper plate' principle for electricity. This allows the user to explore not just how to reduce emissions on a site in isolation, but also on a system level through integration and synergies. For version 1.0 of CTM, the supply, demand and exchange of CO_2, CO, CH_4 and H_2 are tracked.

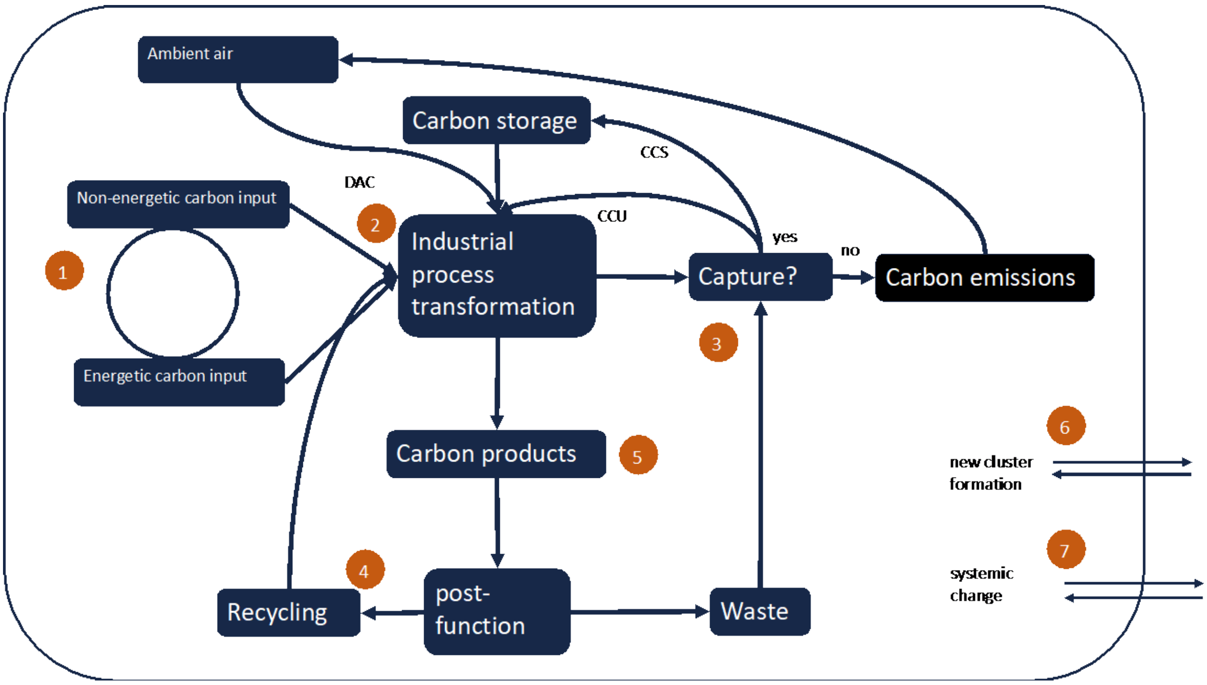
Here below, the feedstock pool concept is illustrated. Note that it is also possible to perform conversions across pools; e.g. take methane from the methane pool to supply hydrogen to the hydrogen pool through steam methane reforming.



c. Seven routes for CO_2 emission reduction

There are various routes for industrial sites to reduce their emissions and provide feedstock to other sites from their "new" waste gases. The large industrial emitters have seven base routes to reduce their emissions. Each of these routes can reduce emissions to zero. Some routes can be mutual exclusive, while others can be complementary. Depending on the route, industries start to emit different "waste" products (often gases). These "waste" gases, if available in a "feedstock pool", can be input for other industries, where they can replace fossil feedstock.

Seven base routes to emission reduction for large fossil based industrial sites are distinguished:



Each node 1-7 is further described below:

1. A different energy carrier and or a different feedstock, both can be NL sourced or imported
2. A change in industrial process

3. Capture of any greenhouse gas emissions from a site and possible storage and/or reuse and/or direct air capture
4. Recycling of products containing carbon at the end of their life, either thermal of mechanical
5. Volume reduction of the production of products containing carbon and/or removal of the carbon in the end product
6. A consequence of changes in 1-5 might be that a site has “new waste gasses that can be used by another industry to replace fossil fuels
7. As time goes by CO_2 intensity of electricity consumed by a site will go down if taken from the grid

All results and explanations can be found in the *“Carbon Transition Model (CTM) Version 1.0 - User Guide, Conceptual Design and Technical Documentation”*

7. Discussion

a. Results

While each emission reduction route leads to new demands on infrastructure, there is no proper overview of the best routes available. Each route places different demands on the infrastructure that is needed. Each addition and subtraction from the “feedstock pool” places different demands on the infrastructure and there is no proper quantitative overview of what all the routes mean in terms of volume and costs. There is no consensus on what the best choices are, although it is certain that they will differ per site.

In a planned follow-up of the Carbon Transition Model initiative, the results acquired in this project will be further aligned in cooperation with the grid operators. Therewith, CTM can reduce strategic uncertainty in infrastructure investments, with regards to industry choices to reduce emissions between now and 2050.

In addition, it is intended to further improve and expand the Carbon Transition Model and making a connection with the Energy Transition Model (ETM). This includes improvement of the User Interface and preparation of the model for open source publication. Which developments will be carried out exactly, will be decided upon jointly with the CTM partners.

b. Technical and organizational issues

Successful cooperation between the process industry, academia and societal organizations was realized. An “open source” environment was created, where public data was used, mitigating confidentiality issues and ensuring a transparent process. Collectively, basic assumptions and parameters were determined.

c. Lessons learned

The CTM is met with enthusiasm and it is recognized that such a tool does not yet exist, but is highly important for the energy transition (in industry).

8. Conclusions and recommendations

a. Findings

As described in this report, the objectives of the project have been achieved. At the same time, it is recognized that the CTM needs further development in order to serve it’s ambition.

b. Possibilities for further activities, research and/or spin off

In a planned follow-up of the Carbon Transition Model initiative, the grid operators (GasUnie, TenneT, Netbeheer NL) and several companies, such as Shell and SABIC have committed themselves to further development of CTM. Several other organisations have indicated their interest to join the CTM initiative from phase 2 onwards. These organisations include e.g. RWE, Albermarle, Twence, BP, Clariant, BASF, Vopak, Yara, Air Liquide, Air Products, VNCI, VNO-NCW and more.

In the second phase, we will focus on improving and expanding the model and making a connection with the ETM. Which developments will be carried out, will be decided upon jointly with project partners. Possible developments include infrastructure, waste balance connection, additional sites, feedstock pool expansion and detailing, heat integration.

Worth mentioning is that output from CTM version 1 is currently being used by Urgenda, Shell, VNO/NCW and various political parties in determining how to accelerate the transition in the industry (moonshot projects)

9. Communication / dissemination

a. Activities and Public references

The project was kicked-off with all project consortium partners on 8th September 2020.

Over ten demonstration and initial exploration sessions leading to directions for further development were held with partners and interested organizations (e.g. RWE, SABIC, VNPI, ZR, RvO, EZK, ABN AMRO, TNO, etc.)

A user-guide of the 1.0 version of the Carbon Transition Model is available for all project partners. Other activities and/or public references include the following:

- Publication in NPT magazine (nov 2020);
- News items on ISPT website & LinkedIn Posts
- Project poster (https://ispt.eu/media/Project-poster_CTM_2020.pdf)
- Project website (https://ispt.eu/projects/carbon-transition-model/)
- Master Thesis Paco Rutten: “Mapping carbon of the Dutch industry today and how this can evolve towards circularity”
- Sustainable Industry Lab (SIL), initiative by CTM member Gert-Jan Kramer, focused on improving the quality of the societal and political debate to reach a carbon neutral Dutch industry by 2050, making use of visualizations as much as possible (https://www.sustainableindustrylab.nl/)

10. Acknowledgement

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