



NTS Innovation Program Sustainable Carbon Hub Northwest Europe



Institute for Sustainable Process Technology



The transition towards a sustainable carbon chemistry is achieved through collaboration in innovation programs and projects on at least the following two routes:

- 1) The adaptation of existing petrochemicals for the use of sustainable carbon, including mechanical and chemical recycling routes (conversion);
- 2) New chemical and biochemical transformations (new construction).

In a sustainable carbon hub, a large and diverse group of stakeholders are working together on technology development, based on the use of sustainable raw materials and renewable energy, focusing on the future demand for products.

Innovation themes

The transition from using homogeneous, well-defined fossil streams to heterogeneous sustainable carbon streams - which often vary by source and season and contain many impurities for the production of energy carriers and materials - is very challenging. This requires new and intricate, energy-intensive raw material **pretreatment** steps, new and innovative **conversion** processes and new and innovative **downstream processing** (including water purification and -treatment) in order to produce purified feedstocks with low impurities for the production of sustainable chemical materials.

In order to function properly **balanced system integration** is needed. System integration is not only about smartly connecting different energy, material, and value chains so that carbon, molecules, and products are used as efficient and circular as possible (**cascading principle**; new analyses related to the narrative of the Sustainable Carbon Hub will follow). It also requires aligning functions, flows, and decision-making (in many cases influenced by new regulations) so that the overall system becomes more efficient, flexible, and reliable.



Opening

Gert Jan Kramer welcomed the attendees and introduced them to the exhibition location of TRANSIT climate – industry – prosperity, a dialogue between art and science. TRANSIT is an initiative of the Sustainable Industry Lab (SIL). This is a think tank for future visions of the Dutch chemical industry. The exhibition aims to visualize that the energy and industrial transition is not only a technical and economic task, but also requires imagination.

Narrative circular raw materials roundabout Northwest Europe

Jacqueline Vaessen and Marco Waas emphasize the opportunities for the Netherlands to function as a hub for circular raw materials and circular carbon, enabled by smart process technology (AI and digitalization). Jacqueline Vaessen indicates that contributing to earning capacity, resilience, and sustainability is necessary in this context. Marco Waas explains the momentum due to government policy coming together. The National Technology Strategy Action Agenda Process Technology, delivered in January this year, is linked to the broader policy initiative to respond to a changing geopolitical landscape and to strengthen the resilience and earning capacity of the Dutch and European economy, as highlighted in the Wennink Report and related government plans as the six key growth sectors including Innovative Chemistry, the Industry letter Innovative Chemistry and the Cabinet approach chemistry and materials for Defense.

From 2028 onwards, the Ministry of Economic Affairs and Climate will align its innovation instruments, including the PPS-I subsidies, with these developments. Various existing funding options also align well with the narrative of the Circular raw material hub, including sustainable carbon chemistry, critical raw materials and smart process technology.

With that in mind, the NTS-PT-core team organized this event with ChemistryNL, Energy InnovationNL, VNCI, Ministry of Infrastructure and Water Management and ISPT, with the aim of further concretizing the action agenda by facilitating ecosystem, value chain and project development.

The future of pretreatment

Marthien van Eersel from Ortessa introduced us to the future of pretreatment. Use of (vision) AI for both existing and new technologies for collection and sorting, makes it possible to start recognizing objects/products in the heterogeneous mass of waste. By applying new sorting strategies with the ability to easily recognize and classify objects and knowing the composition of a product (with the help of a digital product passport), streams can be separated into homogenous material flows. These flows, ideally with few contaminants, should then be further sorted based on suitability for the different carbon chains. The knowledge on these technologies based on AI should be combined with the knowhow of existing sorting technologies for optimization of pretreatment. Follow-up discussions will take place to explore how the



development of new innovation projects can bring these worlds together, learning from current or former projects.

Water purification & treatment in sustainable carbon routes

With Kees Roest from KWR (the Water Research Institute) we had a perfect speaker to point out the challenges in water purification & treatment for sustainable carbon routes. He pointed out that policy decisions and industry decisions need to consider water treatment as part of their strategy, so synergies can be found with both existing processes and at the design stage of a new process. Safe and sustainable by design means that water must be considered. Historically, there is no incentive/need to do anything other than to treat carbon as a pollutant when in water. This starts to change now because the environment plays a bigger role in industry, under pressure of the EU formulated Kader Richtlijn Water.

The interfaces between water and carbon are for instance related to:

- irrigation for biomass
- energy (raw material H₂, cooling, steam-based processes)
- treatment/cleaning
- industry processes (separation, energy transfer, energy-water trade-offs)

Options to collaborate between carbon chemistry and water industry:

- there is a need for synergy between water reuse and carbon reuse. Both require a lot of energy to achieve reuse, so this is a sweet spot.
- burning sludge consumes a lot of energy and destroys carbon, so this is interesting for cross-sector innovation. I.e. TNO and Torwash have experience in extracting biomass from wastewater in a European context. Here, legislative issues are a hurdle towards industrial application.
- in fermentation processes
- washing in plastic sorting and cleaning in industry

Data & AI for product/process development in sustainable carbon value chains

This relative novel field of expertise was explained towards an industrial application context by Jonah Poort of TNO. He explained how digitalization, AI, and machine learning can improve efficiency and innovation in the sustainable carbon industry. Jonah highlights that AI helps by both solving new problems and accelerating existing processes, where he used examples from areas like bio-polymer design and recycling. Practical examples show how data-driven approaches support the full process cycle from data acquisition to material development and scale-up. The key takeaway is that strong digitalization and high-quality data are essential to effectively leverage AI, alongside balancing domain expertise with data science.

The question from the audience was whether PolySCOUT, besides designing with,



for example, mechanical recycling in mind, can also design with sustainability in mind. Jonah indicated that they have experience with applying Machine Learning in collecting and sorting plastics, where the contaminated plastics were not picked up. This was due to the difference between the perfect data set and the practical data set; indicating the relevance of specific quality of data.

Pitches

Pitches were presented about Methanol Valley Twente, PV Recycling using Direct Carbon Immobilisation, the Gasification Center of Excellence, Process integrated membranes for blue hydrogen and Water as industrial circular commodity through AI (WICCA). The question for the pitchers regarding technology development is what makes the specific technology unique and to what extent lessons are learned from similar technology propositions in the Netherlands and abroad. It is noted that we ideally integrate the presented technologies in a systems approach towards a sustainable carbon hub.

Call to action

1. To concretize the **NTS Action Agenda Process Technology**, we are organizing working sessions on the afternoon of **September 9** regarding the development of:
 - the gasification value chain
 - the syngas to methanol to olefins to polymers value chain
 - AI for sorting/pretreatment for plastic recycling and other routes

Context:

Both the technological innovation and also the development of new, cascading value chains will be addressed. Therefore, there is a need for involving end users/brand owners/retailers and UPV's in this process as well.

When developing value chains, the importance of proximity and the logistical possibilities should also be taken into account. For instance, methanol is easily shipped, waste is not suitable for shipping and ethylene and propylene are currently produced in the chemical industrial conglomerations and not shipped as well. So Methanol to Olefines to Polymers needs to be organized downstream, what offers the Netherlands opportunities for a good position in the value chain.

Please contact us if you want to be involved in the preparation.

2. Follow-up discussions will be held to further develop and concretize synergy concepts for water and carbon reuse.

Please contact us if you have ideas for this.

Recap of the NTS Innovation Program Sustainable Carbon Hub Northwest Europe on May 28



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3. Follow-up discussions will take place on how to develop a WICCA for polluted water related to a pyrolysis or gasification process. The goal is real time monitoring of water quality, use of AI for predicting contamination levels and optimizing treatment and reuse decisions.

Please contact us if you have ideas for this.

4. Visualizations main routes towards a sustainable carbon hub per processing step

Put your carbon route and/or company on the map. Are you still missing in [the visualizations](#)? Let us know.

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