Process Technology Networks in the Netherlands

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Marked by a culture of open innovation, the Dutch system of collaboration creates unique opportunities for advances in process technology.

With the world being simultaneously squeezed by stagnating economies, diminishing reserves of raw materials, and climate change, advances in process technology and the chemical sector offer some of the best chances of securing a livable and abundant future. Success, however, will require rapid, targeted innovation.

The Netherlands — in spite of its relatively small size — has produced some of the most promising chemistry research of recent years. This can be attributed, in large part, to a uniquely Dutch approach to collaboration. In this approach, multinational companies from various industry sectors collaborate with small and medium-sized enterprises (SMEs), as well as research institutes and all levels of government, via an array of research platforms. These platforms facilitate and safeguard multiparty R&D collaboration — and create an environment where innovation can flourish.

The polder model for R&D

The Netherlands is home to many large and well-established chemical industry majors, such as AkzoNobel, Shell, DSM, FrieslandCampina, and Unilever, to name a few. These companies have been joined by a host of thriving high-tech start-ups and SMEs. On the academic side, the Netherlands has its own "Ivy League" of chemical engineering and process technology schools, headed by the country's three universities of technology (TUs) in Delft, Eindhoven, and Twente, and by the internationally renowned agricultural university in Wageningen. However, simply having all of these top players together in the same country is not enough; they need to be playing at the same table.

This has not been difficult in the Netherlands, a country whose very existence has for centuries depended on close collaboration among neighbors. In the Middle Ages, when competing cities were often situated close together on the same patch of drained marshland — called a polder — cities had to set aside their differences and work together to keep the land dry, or risk being flooded. Today, the polder model of collaboration — the pooling of resources and sharing of benefits — permeates the country's social and economic life. In the field of chemical technology, the model is clearly reflected in many public-private partnerships (PPPs) — loose consortia of multinational companies, SMEs, universities, and research centers that work together on a particular research agenda.

The PPP concept is based on an open innovation model — that is, a policy of deliberately looking outward for insight and inspiration, and then being ready to collaborate when opportunities arise. There is much talk worldwide about the virtues of this approach. But while most people

Note: All monetary quantities are in U.S. dollars; when this article was written, the exchange rate was 1 € = U.S. $1.32.

The Dutch Chemical Industry by the Numbers*

The Netherlands has an extensive and well-integrated transportation network, and is home to Europe's largest shipping port (Rotterdam) and one of its busiest airports (Amsterdam). As a result, companies based in the Netherlands have easy access to both essential raw materials and European sales markets.

~750	Companies; 93% employ < 250 people
63,000	Jobs
~15,000	Knowledge workers
$17.2 billion	Added value (2.5% of GDP)
$62.1 billion	Sales
20%	Share of Dutch exports
$1.55 billion	R&D investments (2009)

* 2010 figures unless otherwise indicated
Source: The Association of the Dutch Chemical Industry (VCNI)

are talking about it, the Dutch have been formalizing it. In the chemical engineering field alone, a group of organizations has developed mature frameworks for bringing research partners, each with its own focus, together.

The Institute for Sustainable Process Technology: Sharing the costs, the risks, and the benefits

Founded in 2006, the Institute for Sustainable Process Technology (ISPT) is a Netherlands-based PPP dedicated to improving the sustainability of the process industry. The organization facilitates a suite of ongoing research programs that have been shaped by the ISPT member organizations, including major companies like those mentioned earlier. Individual projects are defined and managed by people from industry. As a result, all of the ISPT's research — from fundamental to applied — is driven by long-term business trends and needs. The work is supported by academia, and funded, at least in part, by the government.

The development of new technologies often requires cooperation among various partners, industry sectors, and disciplines. Companies are unlikely to develop very many new solutions if they look no further than the technologies they already have in-house. Large companies in particular are prone to be inward-looking, whereas SMEs are often the developers of the missing pieces. That is why the ISPT focuses on bringing SMEs and larger companies together, with the aim of enabling both sides to locate partners who can help them to further develop their research.

It was this kind of relationship that introduced dairy giant FrieslandCampina to a new technique for separating milk fractions. The company had worked with fairly standard ceramic or polymer membranes. But milk is highly complex, containing proteins, fats, lactose, and micro-components such as vitamins and minerals. Through the ISPT, FrieslandCampina was introduced to a new type of membrane, developed for the oil industry, that is much more selective during separation. As a result, FrieslandCampina has a new way to produce its products that could significantly improve the company's bottom line. Company representatives say that FrieslandCampina would not have risked trying to develop such a new technology in-house from scratch.

As this example shows, PPPs are ideal for helping companies deal with challenges when the risks are too high for them to go it alone. By teaming companies with other players who may have specialized knowledge or accomplishments, all the parties involved share the costs, share the risks, and share the benefits of the PPP collaboration.

BE-Basic: A PPP framework for a bio-based economy

Established in 2004 and funded by the Dutch government, the chemical and energy industries, and academia, BE-Basic (an acronym of Bio-based Ecologically Balanced Sustainable Industrial Chemistry) aims to accelerate the development of a sustainable bio-based economy. One of the largest international PPPs, with a cumulative budget exceeding $260 million, BE-Basic's partners have already developed many new processes for making bio-based fuels, plastics, materials, and antibiotics.

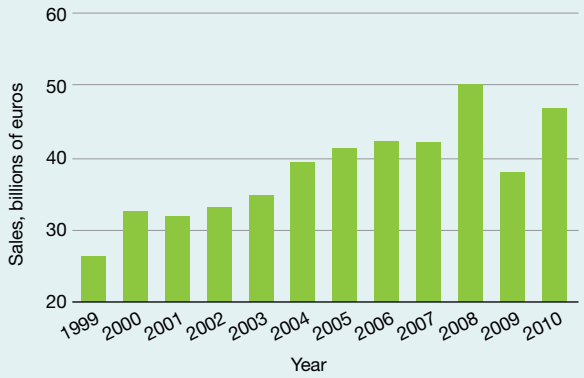
To make biotechnology genuinely sustainable, one must look beyond the impact of the new processes and technologies themselves, and consider the agricultural infrastructure that feeds into the bio-energy and chemicals sectors. To this end, BE-Basic is developing technologies that use agricultural waste streams — rather than food crops — as feedstocks, as well as techniques for improving soil quality and water use.

Expanding on this work, several BE-Basic partners are setting up a new bioprocessing pilot facility at Delft. While there are many biotechnology pilot plants around the world, most are designed to use a specific feedstock. The new pilot plant at Delft, however, has been designed for maximum flexibility — including the ability to test processes with multiple feedstocks. The plant will be open to researchers and students from all over the world, and is being funded by universities, companies, and the European Union (EU), as well as by the national and local governments of the Netherlands. The objective is to create a one-stop shop for biotech R&D, from the lab to the pilot scale, so that all participants can reach their goals — and share the benefits — faster.

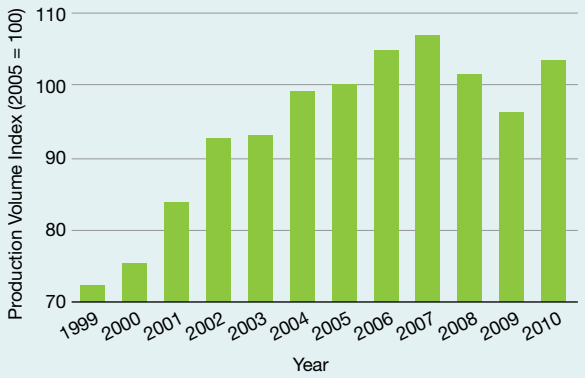
BE-Basic is, in effect, an engine for formal technology

Annual Sales and Production by the Dutch Chemical Industry

Following a sharp decline in 2009, the Dutch chemical industry's annual sales have nearly returned to pre-recession levels. After peaking at $66.1 billion in 2008, its sales in 2010 were $62.1 billion — a 25% increase over 2009 levels (Figure 1). This mirrored the industry's production volumes (Figure 2), which peaked slightly earlier in 2007 and then experienced a sharp dip in 2008–2009. In 2010, the production volume of the chemical industry increased almost 8% over that in 2009.



▲ **Figure 1.** Annual sales for the Dutch chemical industry.



▲ **Figure 2.** Index of production volumes for the Dutch chemical industry.

Source: The Association of the Dutch Chemical Industry (VCNI)

and knowledge transfer with built-in safeguards. SMEs, for example, can work with big partners while retaining their intellectual property (IP) assets. This is seen not so much as a good way of working, but rather as an essential one. R&D requires more than just venture capital. BE-Basic drives R&D by combining the innovative power of SMEs with the financial muscle and human capital of bigger players.

EUROPIC: Knowledge transfer in process intensification

The European Process Intensification Centre (EUROPIC) is an industry-driven platform for knowledge and technology transfer. Headquartered in Delft, EUROPIC was established in 2008 by chemical and pharmaceutical companies in Germany, France, and the Netherlands, and has regional offices in Dortmund (Germany) and Toulouse (France).

Process intensification (PI) can be defined as a set of radically innovative principles for process and equipment design that lead to facilities that are smaller, cleaner, safer, and more sustainable. In the coming decades, PI will become an increasingly important vehicle for tackling the technology issues related to global mega-trends, such as aging populations, climate change, and shortages of energy, food, water, and raw materials.

EUROPIC maintains the world's largest databases in the field of process intensification, and is speeding up the development of PI by bringing that information to the chemical industry. It performs new-technology scouting, benchmarking, and trend analyses; issues technology reports and position papers; and provides its members with consulting services, as well as specialized courses and training.

Collaborative strategy setting

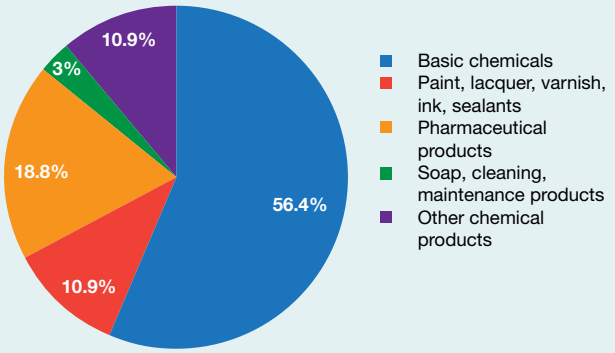
Netherlands-based PPPs are doing more than bringing disparate R&D partners together. They are using their positions in the R&D community to lead the discussion on how research fields and agendas need to be developed.

Many experts agree that process intensification could help the chemical sector to make a leap forward in sustainability — but only as part of a major structural change to the way companies design their plants. That is why Delft Univ. of Technology, the ISPT, and the Dutch Ministry of Economic Affairs, Agriculture, and Innovation brought the PI community together to figure out how to make this happen.

The collaboration took the form of a "backcasting" (as opposed to forecasting) process called the Delft Skylines Debates. Initiated in Dec. 2009, the two-year project drew on concrete science, with the participation and supporting analysis of an international group of more than 75 leading scientists, industrialists, and science managers. The outcome is a 40-year research agenda for PI that would enable the realization of key long-term societal goals concerning the fields of health, transportation, food and agriculture, and overall quality of life. The agenda identifies the research

Chemical Products Made in the Netherlands

More than half of the chemicals produced in the Netherlands are basic chemicals (*e.g.*, caprolactam, polyolefins, urea), followed by pharmaceutical products. The relative size of each market segment is shown in Figure 3.



▲ **Figure 3.** Sales of chemical products by sector in 2010.

Source: The Association of the Dutch Chemical Industry (VCNI)

topics in process technology that must be started in the short term, and key technology milestones that must be reached by 2030, in order to realize these goals by 2050. These technical milestones include:

- efficient technologies for a clean water supply
- highly efficient decentralized electricity generation and high-capacity energy storage
- low-cost, small-scale processing technologies for use in various environments (*e.g.,* mass-production factories)
- design, engineering, and intensified production technologies for recyclable (composite) materials
- intensified fuel-cell-based systems (including biomass)
- full control of the reaction pathways at the molecular level in chemical reactors
- sustainable recovery of scarce elements
- production systems for personalized medicine
- production of artificial organs
- low-energy food production and processing across the supply chain (including energy and materials generation and transport)
- integrated production of chemicals from second-generation bio-based feedstocks
- functioning devices for producing fuels directly from sunlight.

This approach to collaborative strategy setting has been adopted by three other organizations in the Netherlands: SusChemNL, Regiegroep Chemie, and TopSector Chemie.

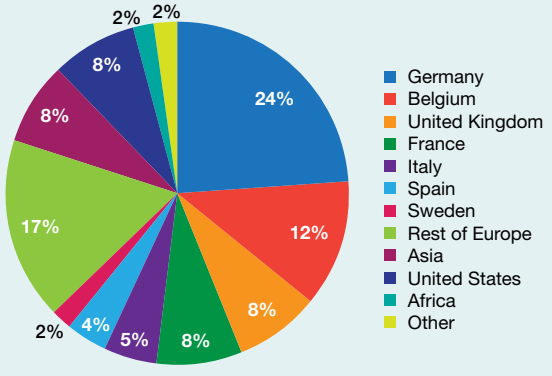
SusChem is the European Technology Platform for Sustainable Chemistry — a pan-EU public-private partnership for the chemistry and process technology fields. Just as the ISPT and EUROPIC connect companies and academic institutes, SusChem builds networks of Europe's many different research platforms, reaching new partners and funding sources from all over the EU. Since it was set up in 2002, SusChem has attracted more than $1 billion in funding.

SusChemNL is the Dutch national SusChem platform, and an essential bridge to the EU-wide SusChem network. It is, in effect, the "Ministry of Foreign Affairs" for the Dutch chemical sector. As the matchmaker between local initiatives and European activities, SusChemNL can identify who elsewhere in Europe is already working on a specific problem or project — or who is missing a particular link in the innovation chain. SusChemNL is then able to connect the loose ends. Just as importantly, it is able to provide crucial updates on the European chemical sector to help in setting the Dutch R&D agenda.

Regiegroep Chemie acts as a steering committee for the Dutch chemical industry. It identifies where the Netherlands can best make a global difference in process technology or in

Where Dutch Chemical Products Go

Dutch exports of chemical products in 2010 had a value of approximately $94 billion — equal to some 20% of all Dutch goods exports. The Netherlands exports approximately 75% of its chemical products, with the largest portion of exports going to other European countries (Figure 4). However, from 2009 to 2010, the proportion of chemical products exported to the United States increased in value by more than 25%. Exports to Asia are also growing, albeit less quickly, with a rise of 10% in the same period.



▲ **Figure 4.** Dutch chemical exports by destination in 2010.

Source: The Association of the Dutch Chemical Industry (VCNI)

Technical Education in the Netherlands

Universities in the Netherlands tend to specialize, which encourages — and necessitates — networking and cooperation. It also avoids duplication of efforts and ensures that available resources in each field are allocated efficiently.

Dutch academic institutes are at the forefront in several fields, including:

• *catalysis engineering*. Delft Univ. of Technology (TU Delft) is a leader in catalysis engineering, with research focused on developing and demonstrating new concepts for sustainable catalysis and reactor engineering. Utrecht Univ. and Eindhoven Univ. of Technology are also breaking new ground, with research groups working in both organic and inorganic chemistry and catalysis.

• *bioprocess technology*. With the bio-based economy gaining ground as the most viable, sustainable alternative to an oil-based economy, Dutch universities, as well as public-private partnerships such as BE-Basic, are developing bio-based solutions for a sustainable society. TU Delft and Wageningen Univ., in particular, are making a mark as world leaders in bioprocess technology.

• *process intensification*. At TU Delft, the Intensified Reaction and Separation Systems research group is exploring the use of alternative energy forms (*e.g.*, microwaves, plasma, lasers) in chemical and biochemical processing, as well as the design of locally controlled, intensified crystallization systems. The group forms part of the newly opened Process Technology Institute, which brings together all the university's process technology research in three strategic areas: process intensification, biochemical process engineering, and process technology for advanced materials. At Eindhoven Univ. of Technology, a Chair in chemical process intensification has been established.

• *flow and transport phenomena*. For decades, Dutch academicians have been leaders in the fields of transport phenomena and chemical reaction engineering. Today, this tradition continues at Eindhoven Univ. of Technology and at TU Delft. Microreactors, multiphase reactors, and computational fluid dynamics (CFD) are among the topics under investigation.

• *process technology for the food industry*. With epidemics of obesity in affluent countries and famines in poorer regions, the way food is produced, processed, and consumed is coming under particular scrutiny. In the Netherlands, Wageningen Univ. is exploring new principles for designing food structure and food ingredients. The university's Laboratory of Food Process Engineering aims to improve the understanding of the dynamics of dispersed fluids and solids, and to translate that insight into food production processes that are significantly more sustainable.

A PhD with an edge

The OnderzoekSchool ProcesTechnologie (OSPT) is the Netherlands' Research School for Process Technology — an interuniversity platform that brings together PhD students from across the fields of chemical engineering and process technology. The OSPT has 10 faculties, 35 research groups, 40 professors, and nearly 250 lecturers, post-docs, PhD students, and research associates. An industrial advisory board steers the OSPT's research programs in the most socially relevant directions.

Dutch research schools echo the collaborative networking approach demonstrated in the Dutch PPPs. Alone, universities could not justify running certain courses because they would attract only a handful of PhD students. However, by working together through the OSPT platform, schools can share their students and run even the most highly specialized courses. This effectively unlocks the entire Dutch academic network for every PhD student in the field.

Additionally, the Netherlands offers a unique qualification in process design: the Professional Doctorate in Engineering (PDEng). A post-MSc education, PDEng courses focus on designing and applying new engineering techniques in a professional environment. Students are expected to take a concept — possibly even without laboratory proof — and develop it through the screening stages to the brink of commercialization. This includes establishing economic feasibility and acceptable safety standards.

The PDEng degree, which is offered by Eindhoven Univ. of Technology and TU Delft, is now highly valued by companies looking for engineers who have the skills to make decisions about budgets, timing, and resources. This is hardly surprising, given that companies increasingly need people who can make tough decisions in multidisciplinary teams — a skill the PDEng gives students a unique opportunity to acquire before they even leave university.

the chemical arena, and then maps out a long-term research agenda. This structured approach allows resources to be aligned to support the most important strategic goals. By connecting with the SusChemNL group, the Regiegroep is able to minimize duplication and maximize productive collaboration.

TopSector Chemie is the Dutch government's own innovation platform for stimulating and funding research in the chemical fields. It is one of the top sectors identified by the government as a target for strategic investment. With its top sectors program, the government is stimulating innovation by stonger involvement of the private sector. The aim is to create a more agile innovation system where stimulation (*e.g.*, by tax breaks) and more generic measures should lead to less bureaucracy, more transparency, and swifter startup of projects in comparison to the current subsidies.

It will also facilitate the work done through PPPs. These are seen as the best vehicles for harnessing the golden triangle of academia, industry, and government. Proof of this can already be seen in the chemical sector, where the financing attracted by PPPs has quadrupled from about $42 million

in 2007 to about $165 million in 2011 — despite the recent worldwide financial crisis.

Ahead of the game

Researchers in the Netherlands are thinking long-term, strategically, and cooperatively about research directions. Companies in the Netherlands tend to be comfortable talking about their research with each other and with universities. It seems that who owns what is not as important as shortening the time to market and gaining access to knowledge. Thanks largely to this mindset, process technology in the Netherlands is ahead of the game when it comes to developing mature, safeguarded, and formal mechanisms for collaborating on research projects. Even the academic world and traditionally conservative multinationals have dismantled their ivory towers. As a result, the Netherlands offers unique opportunities for innovation in the chemical and process technology fields. CEP

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