

The Green Manifesto

The Journey To Green Process Technology

A declaration of intent of the Dutch Research School in Process Technology
(OSPT¹)

Introduction

Society manifests a growing global awareness of the vulnerability of the planetary ecosystem. Many people interpret issues such as the greenhouse effect and the hole in the ozone layer as signals that limits have been reached in our current economic growth as based on existing technologies of power generation, process industry, mobility and transportation. Worldwide, people call for drastic changes – not only through action groups such as Greenpeace and ‘Milieudefensie’, but also via their government leaders and ministers (*cf.* the Kyoto-Bonn treaty) – to stop adverse trends and thereby guarantee the sustainability of the planet.

Parallel to this, we see an increase in governmental pressure on safety issues, *e.g.* with granting permits for industrial activities or with screening chemical components in consumer products: society is demanding a safer environment.

Prompted by these trends, companies are increasingly willing to include sustainability, the environment and safety as part of their economic policies and business strategies for production and trading. Some companies have already formulated explicit ‘green’ mission statements. The Dutch government is setting up cooperative agreements with branches of industry aimed at realizing long-term ‘green’ goals, *e.g.* related to energy efficiency.

There is a budding global awareness that sustainability is the key to a better world in which not only the needs of the current world population are satisfied, but which also guarantees that future generations inherit a healthy earth. Sustainability can be advanced in a number of ways: by reducing the exhaustion of our finite energy sources and mineral deposits; by designing closed loops in processes and products alike; by reducing the output of waste into the ecosystem.

A ‘great leap forward’ toward reaching the goal of a more sustainable world requires a tremendous effort from the technological world: a large number of power generation and production processes are in need of a fundamental review. This is not only about developing more sustainable process alternatives as such, but also concerns applying them on an industrial scale economically viably over a 10 to 15 year period.

¹ OSPT stands for the Dutch name ‘Onderzoekschool Processtechnologie’

Next to ‘green’ chemistry – either on the basis of biomass or with the help of genetically modified micro-organisms – and ‘green’ energy – on the basis of solar cells and wind turbines – there is room for as well as a need for a third effort on the subject of sustainability: **green process technology**, aimed at breakthroughs in sustainability, environment and safety. These breakthroughs should result in reductions by a factor 2 to 5 in the consumption of energy and raw materials, in production of CO₂ and other environmental loads, in safety risks and in investment and operating costs of plants, and should lead to closed-loop systems and safer processes.

Green process technology relates to manufacturing a wide gamut of products ranging from chips to steel, from whipped cream to polymers, from paint to sugar. Piecewise production of automotive catalysts makes part of the field of expertise of modern chemical engineers, as do the batchwise manufacturing of medicines and speciality chemicals and the large-scale continuous conversion of petroleum into fuel. Further, power generation, too, belongs to the portfolio, whether it occurs in large units in the western world or in small-scale projects in rural communities in developing third-world countries.

The Mission of the OSPT

The OSPT commits itself through the ‘Green Manifesto’ to delivering a considerable contribution to creating a structurally more sustainable technology through

- carrying out scientific **research** on essentially sustainable process alternatives and in the required basic disciplines and skills;
- conducting process **design** studies aimed at realizing considerable gains with regards to sustainability, the environment, safety and process economy;
- developing new **curricula** where sustainability, the environment and safety are the starting points for developing processes for power generation and for the production and recycling of materials and products.

Here it shall, can and must be about research, development and teaching of completely novel process concepts such as pipeless plants, miniature factories (‘micro’-reactors on a chip), systems for distributed power generation, just-in-time on-site production of feedstock and auxiliaries, the extensive use of compact fuel cells, and a wide exploitation of biomass.

The OSPT is confident that nowadays the breakthroughs and innovations mentioned above are really feasible, due to the use of novel technology, encompassing

- advanced analytical and monitoring techniques (*e.g.* miniature sensors, high-throughput screening, laser and radiation diagnostics),
- production techniques (thin layers, *e.g.* for solar cells; *nano*-particles, monoliths; micro-reactors), and
- modelling and simulation techniques (*e.g.* with the intention of extreme control).

This involves, among other things, comprehending the mechanisms of catalysed chemical and biological processes, the functioning and manipulation of micro-organisms, flow and

transport phenomena on the micro-scale, and the creation and behaviour of nano- and micro-particles. It is of utmost importance to understand how all these processes on the smallest scales are interconnected to phenomena and processes on the scale of industrial equipment and plants, as well as how process conditions relate to the eventual product properties. The continued increase in the potential of computer hardware (making parallel computations feasible) and software (a multitude of simulation and design software is available) offers unprecedented possibilities in this regard.

Despite a necessary cooperation with researchers from adjacent fields of study, process technologists are ideally suited for the integration of all the specialist knowledge and the translation of this knowledge into processes and factories. The underlying expertise and techniques can in fact also be applied outside the classical process industry. On the other hand the symbioses with disciplines such as ecology, economy and business management could be profitable.

Research Programmes

In more concrete terms, the OSPT commits itself to strongly innovative research in the following areas:

1. More efficient **energy conversion** processes, such as Fischer-Tropsch and fuel cells: to improve the utilization of conventional and alternative energy carriers;
2. **Combustion** processes: to prevent the creation and emission of undesirable by-products, but also, for reasons of efficiency, combined with chemical processes;
3. **Biomass**: for high-quality 'green' chemistry (*via* metabolic engineering) or for Fischer-Tropsch/fuel cells, with much reduced production of offensive materials;
4. **Product** technology and/or 'structured products': due to better insights in the interplay of process conditions, product structure and product performance, as well as through better control of the functionality of catalysts and local process conditions;
5. Advanced **separation** techniques, including membranes and chiral separations, *e.g.* for application *inside* chemical reactors (to improve yield and selectivity);
6. Bio- and **biomedical** engineering: efficient and reliable medical aids, cures and repair technology for human metabolism, tissue and functioning;
7. The development of alternative process **routes** and process **designs** – mostly for specific products – which would avoid explosive, toxic or otherwise undesirable auxiliaries and/or by- and intermediate products;
8. **Process intensification**: the miniaturization and improvement of processes through combining and reducing the number of process steps, optimising process conditions, improving process control and applying completely new technology (*e.g.*, micro-reactors and pipeless plants);
9. Tools for process **synthesis** and process development combined with techniques of process analysis and process design;
10. Advanced process **control** models and tools leading to a much better on-line control of product properties;

11. Computer **simulation** techniques (Computational Chemistry, Molecular Modelling, Computational Fluid Dynamics);
12. Experimental techniques for **analysing** and **monitoring** local process conditions, *e.g.* for the validation of process simulation results.

With this Green Manifesto, the OSPT declares to strive toward an integrated, innovative approach to our discipline through process technological research with a far time horizon and focused on the key issues of sustainability, environment and safety. Education and new designs must be inundated with innovative thought. Only research, design studies and education for which these three key concepts form the unmistakable guiding principle, will receive active support from the OSPT.

Expectations

The OSPT expects that this green mission will also result in attractive and challenging prospects for future students and in this way help fill the shortages of chemists and technologists that are developing in The Netherlands and in large parts of the Western world. Through this mission, the OSPT hopes to contribute to the preservation of the historically important and economically vital Dutch process industry. The OPST is convinced that we have of a superb starting position in view of the excellent status of Dutch research in the field of process technology. The choice for a challenging mission aimed at developing sustainable production methods while preserving an inhabitable earth, should indeed lure young people to a revived, contemporary study in sustainable process technology.

The OSPT strives for substantial commitment from process industry and for the acquisition of extensive and long-term financial means – also from the government – to be able to realise the green mission.