TNO innovation for life

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TNO report

0100173227

Speurwerkprogramma 2015-2018 Theme Sustainable Chemical Industry Program 2015

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Sponsor	Ministry of Economic Affairs Topsector Chemical Industry
Number of pages	20 (incl. appendices)

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1 Introduction

This report describes the context, ambition, content and governance of the TNO program for the chemical industry for the period 2015 – 2018. That program is the successor of the first TNO innovation program that was specifically established for the chemical industry. TNO started the program sustainable chemical industry in 2011 in response, at the time, to the business plan for the chemical industry (2007). Shortly after the start of that TNO Program, the key area chemical industry was transformed to the Dutch Topsector Chemical Industry and the business plan was updated in the first innovation contract (2011) of the sector. TNO's contribution in this contract was the sustainable chemical industry program.

The program described here is, to a large extent, the continuation and extension of the ambitions and activities of TNO in the period 2011 – 2014. Still there are some significant changes, both in the content of the program and in the governance. Compared to the period 2011 – 2014, this program puts even more emphasis on the development and production of high value added specialty chemicals. Although it was clear already in 2011 that the industry in Europe had to shift from bulk commodities to high value added product and (material) systems, this need has become much more pressing over the past four years. The competitive position of bulk chemicals production in Europe has steadily deteriorated and it is unlikely that this tide will turn in the coming decade.
The governance of this program has also changed. The period 2011 – 2014 was a period of transition between one form of industry governance over the program to another. Before the advent of the top sectors in The Netherlands, TNO was organising regular formal meetings with industry (knowledge arenas) to ensure alignment between the TNO program and the priorities of the Dutch industry. All other publicly funded innovation programs did the same.
One of the central ideas of the Topsectors is to bundle this debate across all publicly funded programs for one sector. This not only reduces the number of meetings required, it also allows for a better coordination between all publicly funded innovation for the sector. This cooperation and coordination was gradually developed in the period 2011 – 2014 and has recently been concluded by establishing one TKI for the chemical industry in The Netherlands. Starting in 2015, the program will therefore be governed, together with the efforts of NWO, DLO and ECN by the "TKI Chemie", a new coordinating foundation that develops and maintains the industry roadmap for the Dutch chemical industry.

1.1 A word on semantics

The term "program" can be confusing since there are multiple rograms at various levels. In order to understand this description of TNO activities we must be able to distinguish between these various levels.
There is the level of the overall ambition of the sector, the multi-annual goals and aspirations of the industry. In this report we will refer to that by the word roadmap. A roadmap is typically made and owned by a program council of the TKI Chemie (cf. page 20 and beyond). It describes the desired changes in time the sector wants to achieve and the associated development of new products, business models and technologies.
TNO has resources available to assist the sector to execute its roadmaps. These resources are allocated according to a plan. This plan is referred to here as program and it is the subject of this report. The TNO program typically has two

types of goals: to realize tangible innovations that contribute to the roadmaps and to build new skills and competences in which new knowledge is retained within TNO. TNO does not work on these innovations in isolation. All activities in the program are part of a broader cooperation with other RTOs, universities, industry and governments. These consortia are called Public Private Partnerships (PPPs) here. Two special types of PPPs are Centres of Innovation, national PPPs that are formed to execute the sector roadmaps and European PPPs like SPIRE and BBI. PPPs will also cooperate. Thus one single project can be part of several PPPs. For example, a centre of innovation can submit a project proposal to a European PPP. All of these levels tend to describe themselves as “programs”. This report will use the semantics described above to try and limit the confusion.

The size of this program can also be defined in various ways. By size of the program this report refers to the total effort in all of the PPPs in which the program participates. The size is composed of various components: the government funding of TNO, referred to as SMO[1], the contribution of industry, referred to as industry in-kind and in-cash and funding from other public means, referred to as public funding. The latter can be a variety of funding such as EU, regions, NWO and contributions by other RTOs (ECN, DLO, Fraunhofer etc.) that are funded by governments. Only a fraction of the total size of the program is turnover at TNO. This is referred to as the TNO effort in the program.

1.2 Outline of this report

This report will start with a short summary of the main challenges and innovation needs and ambitions of the European chemical sector. The ambitions of this program are derived from those European sector ambitions and are described in Chapter 3. Subsequently the content of Program is described in general terms. Special attention is paid to the activities in 2015. The way in which the TNO activities are embedded in PPPs and how cooperation between knowledge institutes is organized is described in Chapter 5. Finally, the governance of the program is described in the last chapter.

[1] Dutch acronym meaning “means for cooperation in research”

2 European innovation agenda of the sector

2.1 A vital industry under pressure

The chemical industry has been at the root of the European industry for almost 200 years. The industry has always enabled the production of high-end products by developing and producing new materials and chemicals. A vital and innovative chemicals sector is one of the essential conditions for a vital industry in Europe. At this moment the chemical industry in Europe is facing a number of structural changes to its competitive environment:

- The prices of energy and ethylene are likely to be much higher in Europe than in Asia, The Middle East and the US for the coming decades.
- Refinery capacity and with it the supply of naphtha will decline in Europe the coming decades.
- Demand for chemicals will remain more or less constant in Europe and grow in Asia and Africa.

Chemical companies need capital to invest in expansion in Asia and Africa. Investing in Europe is unattractive due to structurally higher costs, also compared to the US. As a result, it is expected that Europe will attract very little investments from the chemical industry in the coming decades. Even though the industry is today still profitable, the innovative power and the possibility of the industry to enable new innovations downstream in the value chain might be severely diminished in Europe. Already, some production facilities are closing in Europe and at the sites concerned, staff is reduced and critical mass for RD&I is gradually fading.

The 2020's to 2050's will be characterized by a fundamentally different competitive position for the European chemical industry compared to the 20th century. In Europe the industry will likely have a structural cost disadvantage for the production of bulk chemicals. Oil and gas based raw materials will be more expensive than elsewhere and so will heat. Electricity might be very cheap as a result of the emergence of solar power. As mobility in Europe is gradually more electrified, the domestic supply of base chemicals will gradually reduce and the industry will become more dependent on imports of base chemicals.

2.2 Innovation response

Even though the picture painted above is grim. The structure of the chemical industry in Europe is still very good. The industry has a strong network and competences and the cooperation with other innovative sectors is very good. Europe has very little options to dial back the clock. There are little oil and gas reserves left and shale gas will take long to develop and meets strong opposition. Instead of trying to recreate favourable conditions for the traditional bulk chemical industry, Europe could better focus on creating new competitive advantages by inventing the chemical industry of the future.

Many ideas on the future chemical industry were already developed in projects like F^3 factory, Coriac and the Delft Skyline Debates. A number of key elements of this future chemical industry are:

- Highly customized, even personalized, production of chemicals and materials
- Zero or near zero emissions and residues.
- Use of exclusively renewable materials such as waste recycling, biomass or CO_2.

- Localized, small scale production, possibly even at the consumer.
- Using light assets with shorter design lifespan.
- Tight integration between product development and production.
- Electricity or electromagnetism (including light) as the primary energy carriers, instead of heat.
- Extremely precise process control at the molecular level.

Europe can build a structural competitive advantage in this area because there is a unique ecosystem in Europe of very good universities and knowledge institutes, a very able and strong network of equipment suppliers and engineering firms and a strong and integrated installed base where companies are also working closely together. In short: Europe can be structurally more innovative and build this future chemical industry faster and better than the rest of the world. However, it will not happen unless there is concerted action of this ecosystem to make the transition from emphasis on traditional bulk chemicals production toward emphasis high-tech and high-end chemicals and materials.

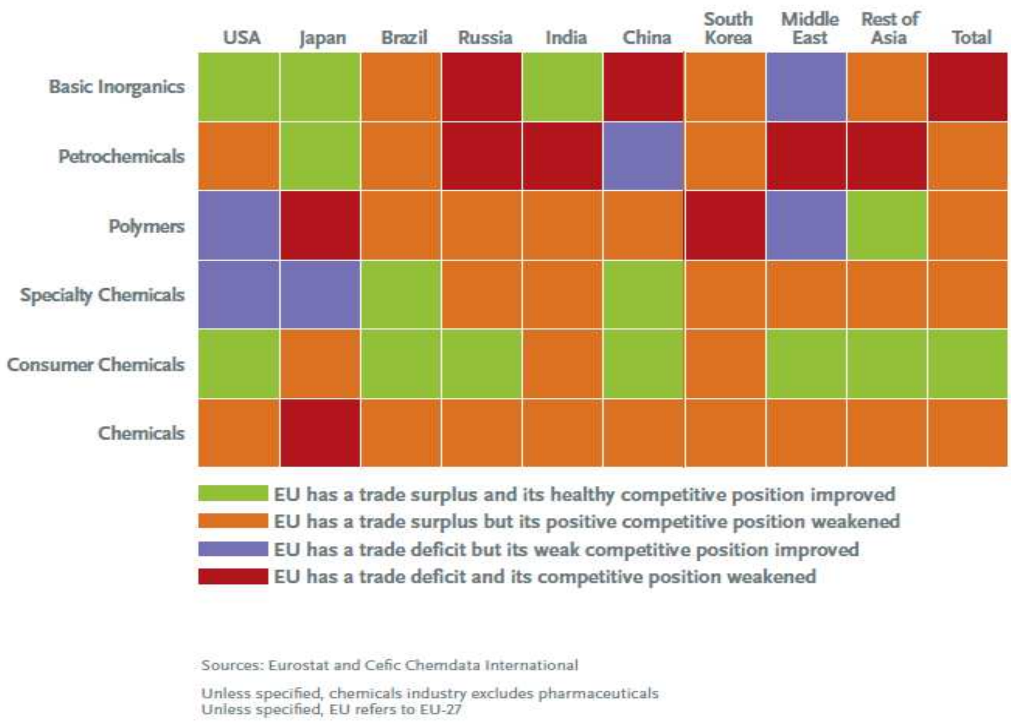

Figure 1: The competitive position of the European chemical industry is improving on consumer chemicals and specialty chemicals. In other areas the industry in Europe is losing ground. The challenge is to benefit from a strong position on consumer chemicals and to integrate with client sector on specialty chemicals and polymers to improve that competitive position.

2.3 The innovation challenge

This vison on the future of the chemical industry has been formulated in various white papers and documents of the industry, such as the Spire roadmap, the BBI strategic innovation and research agenda and the innovation contract and the transition plan of the Topsector. All of these programs show an innovation challenge for the industry on three horizons. In the short term, the existing network and installed base of the industry in the ARRR[2] cluster must be reinforced in order to preserve the industry's critical mass and ability to innovate. On medium term, the installed base must gradually switch to more sustainable feedstock like biomass and CO_2.In the long term the cluster must transform in a flexible production network that can process waste, biomass and CO2 into a variety of highly specialized (smart) materials. Such a cluster is at the heart of the urban ecosystem, providing vital materials, energy and waste processing capacity. Innovation in this cluster is highly integrated in the value chain where the chemical knowledge enables the development of new products by providing new functionality in materials and materials systems.

One could summarize these horizons as three consecutive and overlapping innovation waves that need simultaneous attention.

1. Increasing competitiveness of the current installed base through improving efficiency, better control and more efficient maintenance. This also prepares the way for the second wave by adding abstraction layers and increasing agility and flexibility of the system.
2. Enabling the production of smaller quantities of highly customized chemicals and materials, while at the same time introducing renewable feedstock.
3. Introducing local, small scale and competitive production facilities with integrated product innovation in the value chain.

There are many ways to structure the proposed transition differently. In this report we will refer to these three waves to identify the phase in the overall transition.

2.4 Changing skill base and knowledge base

The industry is quite capable to achieve the innovation needed in the first wave. The industry is in charge of its own installed base and has the knowledge and means to optimize performance. On the second and third wave, the industry needs new skills and contacts to achieve the transition. Some of the new skills include:

1. Electrochemistry and photo chemistry need to be developed much further.
2. The product development cycle must become faster and cheaper to cater for smaller markets, this includes:
    a. Better decision support in the product development process
    b. Shorter time between benchscale and pilotscale production
    c. Faster and more gradual scale-up of production facilities
3. Knowledge on new feedstock such as biomass or CO_2 must be increased.
4. A robust way to assess the societal impact of new products and technology, such as sustainability, during product development.
5. System engineering skills form modular process design to facilitate small scale production that defies the economy of scale.
6. Better understanding of biomass processing to extract both high value components and cheap bulk feedstock.
7. Skills to understand and optimize complex interactions in energy and material flows in large chemical clusters.

[2] Antwerp Rotterdam Rhein Ruhr, the Northern European integrated chemical cluster

3 Ambition of the TNO program

3.1 Achievements of the previous program

The TNO program for the period 2011 – 2014 formulated the following ambitions:
a. TNO wants to be part of the top 3 RTOs in Europe in the area of process and product development for the chemical industry by 2014.
b. In the period 2011 – 2014, TNO will demonstrate at least three new technologies on pilot scale.
c. TNO will introduce new methods with regulators and industry to improve safety, efficiency and sustainability.
d. By 2014, TNO wants to be an important partner of two centers of innovation of the sector, including the ISPT.

Near the end of the period, one may conclude that most of these ambitions have been achieved. TNO plays and important role in several key European projects and is among the top 3 RTOs with Fraunhofer and VTT in the area of the chemical industry. TNO realized five new pilot or demo units:

- A production facility for phosphoric acid based on hydraulic wash column technology at Solvay in Bernburg.
- A NOx reduction installation in the production facility of Almatis in Rotterdam.
- Two continuous flow pilot skids in the Coriac project.
- The Valorie pilot plant for algae processing.

The reason for this ambition in the program was to make the switch from mostly research to actually implementing new technology. The pipeline of new opportunities for pilots or demos is filled and we should be able to continue to build on average one new pilot each year.
TNO introduced sustainability portfolio management tools in industry and a quick scan for safety culture in industry and with regulators.
The final ambition has not been achieved. The reason behind that ambition was to increase coordination and cooperation between TNO and other knowledge institutes and universities. Due to various changes in the way PPPs are organized, the cooperation through and with ISPT has not been achieved. Still, the cooperation between DLO, ECN and TNO has improved much and the cooperation with universities is starting to take shape.

Figure 2: Solvay's management: Dr. Thomas Müller and Dr. Matthias Dabrunz at the official transfer of the TNO Hydraulic Wash Column to Solvay. They are holding a glass sheet with an image of the installation printed on the glass.

3.2 Ambition of the current program

The achievements of the past period will largely be retained in the current program. Thus we will continue to strive for a minimum of one pilot installation each year, even though it is no longer an explicit ambition of the current program. The ambition of this program is expressed in the desired impact of the program in 2018 and in new skills and facilities that TNO must acquire through the program.

3.2.1 Desired impact of the program

The desired pact of the program is:

- Accelerating chemical product development: enabling the industry to serve smaller, niche markets.
- Increasing scalability of production technology: cost factors (n^a) should approach a=1.
- Providing a sound basis for innovation decision taking: a common view within industry and society on sustainability.
- Proven economically viable chemical building blocks from renewable resources (CO_2 and biomass).
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3.2.2 Desired competence development in TNO

TNO wants to improve and develop its competences in the following areas:

1. Photo and electrochemistry
2. Process system engineering
3. Biomass utilization
4. Sustainability management
5. Innovation decision support
6. Synthesis and formulation technology

In these areas TNO should have an outstanding position in Europe, expressed by an audit score of 7 or 8.

The program starts with a strong knowledge base. The main challenge is to integrate these know-how-bases into the more integrative, multi-disciplinary competences listed above.

Table 1: List of current know-how-bases with their audit rating

Know-how-base (KHB)	Rating
High Performance Energetics	8
Innovative Materials	7.5
Separation Technology	7
Process Modeling & Control	7
Instrumentation	n/a.
Materials Performance	8
Climate, Air and Sustainability	8
Functional Ingredients	7
Microbiology and Systems Biology	7
Human Performance	8.5

4 Content of the program

4.1 Division in program lines

The new TKI Chemie will develop four roadmaps: advanced materials, chemistry of life, synthesis and process technology and chemical micro and nano devices. These roadmaps are not yet available because the program councils have not yet started. This program can be divided in four coherent clusters of projects: program lines. These program lines do not coincide completely with the four proposed roadmaps. For each program line, the main characteristics will be listed here including the possible relevance to each of the roadmaps. More detailed plans on the project level exist, but these often contain confidential information from partners, so they cannot be shared here.
Once the roadmaps are available, it may be necessary to structure the projects differently. This will be discussed with the roadmap council at that time.
The stated size of the program line is the actual committed size of the line in all projects since the start of this line. The overview lists the current partners in the various program lines. All of these lines are open for new partners to enter.

4.2 Line 1: electrochemistry development and CO_2 utilization

Size: 7,9 M€
TNO effort: 2,3 M€
SMO in 2015: 280 k€ plus 500k€ from the transition plan (excluding SMO that is spent at ECN)
Started: 2013
Partners: ECN, Sintef, Feyecon, CRI, University of Newcastle, RWTH Aachen, University of Twente, University of York, Evonik
Relevant roadmaps: Synthesis and process technology, chemical micro and nano devices.

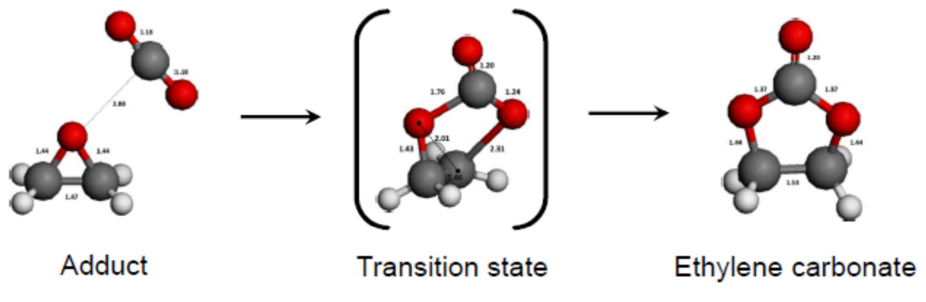

Figure 3: One of the synthesis routes under development for the use of CO_2

Goal:
Develop innovative technology to use CO_2 and electricity as feedstock for the chemical industry.
Since rewenable energy is, to a large extent electrical, it is useful to investigate how electricity can be used to drive chemical processes rather than for instance natural gas. In this program line, new technology is developed to achieve electrochemical conversions in the chemical industry and to use CO_2 as feedstock, either in

combination with electrochemistry or in “normal” thermocatalytic reactions. The development aims primarily at the production of drop-in replacements for existing components such as glycerol carbonate from CO_2 and ethylene oxide by electrochemistry. The reason is that this allows us to focus on the production technology rather than material development. The knowledge generated in these projects should be used later to develop production of more high value components.

Projects:
Currently the line comprises two projects: CyclicCO2R, an EU FP7 project and the project “*Towards the use of sustainable electricity and modular processes in the chemical industry”* which is part of the transition plan of the Topsector.

4.3 Line 2: Provide! Flow chemistry development

Size: 18 M€
TNO effort: 6.3 M€
SMO in 2015: 600 k€ (budgeted)
Started: 2011
Partners: Bayer, BASF, Solvay, DSM, Huntsman, Jansen Pharma, P&G, Arkema, TU Dortmund, Clariant, BAM, Invite, Krohne, Coatex, Atlan-tec, University of Cagliari, Inno TSD, Bronkhorst High Tech, ESK, Chemtrix, Synthon, Brocolor
Relevant roadmaps: Synthesis and process technology, chemical micro and nano devices.

Figure 4: One of the two skids of the Coriac project

Goal:
To develop small scale process technology for the production of high added value components and or hazardous chemistry. The purpose is to enable a faster scale-up of production from laboratory to commercial production by introducing reactor and separation concepts that provide higher selectivity (less down-stream processing) and are less sensitive to economy of scale effects. In this way, the pilot production facility can easily be transformed into commercial production facility by numbering up.
One of the essential issues is the commercial availability of flow chemistry equipment. This program line brings asset owners and equipment suppliers

together to develop this new technology. Usually asset owners need specific solutions that equipment suppliers are unable to develop for one single client. The challenge is therefore to identify and develop generic components or modules that allow equipment suppliers to quickly make customized solutions while still maintaining a generic product portfolio. This program lines creates both the generic hardware and the modelling tools and design methods to quickly design customized solutions based on the generic components.

Projects:
The program line comprises a number of projects. The most important and largest ones are Coriac and CONSENS. The latter is an EU Horizon 2020 project, part of SPIRE.

4.4 Line 3: Biomass processing and biorefinery

Size: 8,5 M€
TNO effort: 2,1 M€
SMO in 2015: 700 k€ (budgeted) plus possibly additional SMO from the transition plan AgroFood
Started: 2012.
Partners: DLO, AF&F, Van Wijhe verf, De Wit oils, Bühler, RHDHV, Avebe, Celsius, Indugras, SABIC, VTT, VITO, Sintef, Fraunhofer, CEA, Tecnalia, SP
Relevant roadmaps: Synthesis and process technology, Chemistry of life, Biobased economy (TKI).

Goal:
This program line is a joint effort with the TNO program for the AgroFood Topsector. The goal is to develop technology that allows the optimal extraction of components from biomass so that high value components can be separated first and cheap feedstock for chemicals production becomes available. The line can be divided in two parts: the processing of lignocellulosic feedstock and the processing of biomass with little or no lignin.
The processing of lignocellulosic biomass focuses on the development of super-heated steam treatment of biomass to produce fibres, cattle feed, furans and sugers (C5 and C6).
The processing of non-lignin-containing biomass focusses on cell disruption to extract high value components like specific oils and proteins and subsequently processing the remaining material through fermentation or thermochemical conversion. We use algae as a model feedstock in this development but it can equally well be applied to leaves and sea-weed.

Projects:
The main projects in this line are GAIA (Getting Algae Ingredients Applied), the SHS development and AERTOS BBE. The latter is a consortium of the main eight European RTOs active in the field of Biobased economy. These parties (CEA, Fraunhofer, VITO, Tecnalia, SP, VTT, Sintef and TNO) have joined forces in a joint development plan where each party contributes 500 k€. The joint development allows sharing of knowledge and facilities and accelerates the development. TNO can for example use the facility of Fraunhofer in Leuna to produce Lignin.

Figure 5: The Valorie container pilot plant for algae processing is an important facility for the activities in Program line 3

4.5 Line 4: Performance materials from renewable sources

Size: 36 M€
TNO effort: 7.5 M€
SMO in 2015: 900 k€ (budgeted)
Started: 2012
Partners: VITO, Fraunhofer, VTT, Archer Daniels Midland, Evonik, ATA, Novamont, Poyry, Proviron, Solvay, Clariant, Taminko, Applikon, Arquebio, CLEA, Designer energy, Dracosa, Eucodis bioscience, GTVT, QNorm, Tygron, Weastra, Zena, Fluor, Ingenza, Lucite, Biochemize, AVA Biochem, ADM Research, Lubrizol, Mater Biotech, Cargill, MI-Plast, Nova institute, Rewin, SABIC, Avantium, DLO
Relevant roadmaps: Advanced materials, Biobased economy (TKI).

Goal:
This program line wants to develop monomers for biobased materials and the subsequent functional polymers that can be produced from these monomers. Both drop-in replacements for current polymers and new biobased building blocks for new materials are in scope. The focus is however on developing new materials with new functionality based on particular properties of biomass and derived monomers. Special attention is paid to sugar and sugar derivatives as a platform (comparable to nafta for fossil petrochemistry). Both biotechnological conversion and catalytic chemical conversion is considered. The program line aims to build pilot and demonstration units for the production of these new materials.

Projects:
The main projects in this line are BioConsept, Bio-QED and Biorizon. The former two projects are EU FP7 projects that expect to build pilots and demonstration units of the production of di-acids and other Biobased building blocks. Biorizon focuses on the production of aromats from both sugar and lignin.

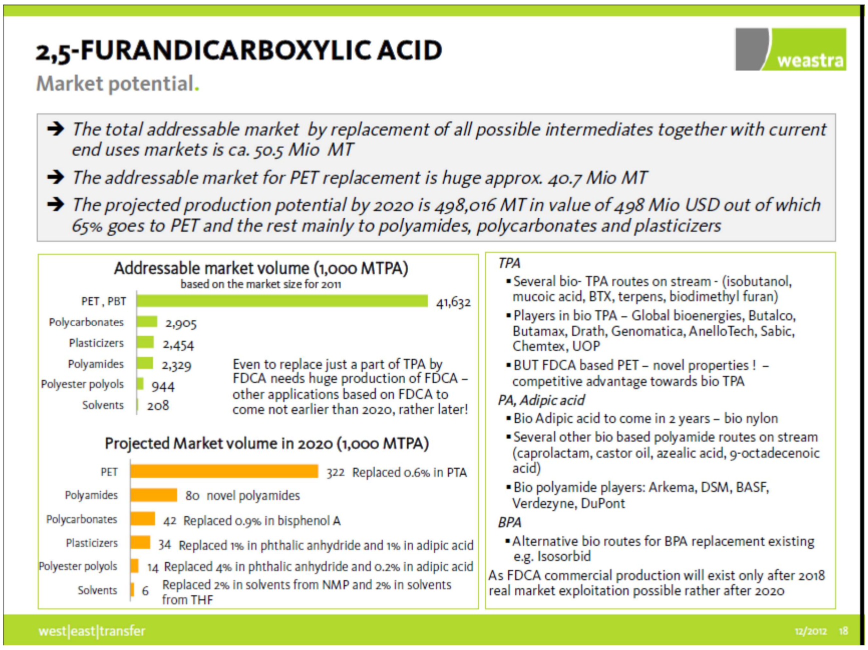

Figure 6: Example of one of the documents in BioConsept that guide the discussion on which pilot installations should be built by the consortium.

4.6 Line 5: Sustainability management

Size: 16 M€
TNO effort: 1.5 M€
SMO in 2015: 400 k€ (budgeted)
Started: 2012
Partners: AIMPLAS, Instituto Nacional de Tecnologia Industrial Argentina, Logoplaste Innovation lab, Citricos y refrescantes, Vanguardia Honduras, Mega Empack, Omniform, European fruit juice association, Sivel, Business region Goeteborg, Van Gansewinkel, CEFIC, VNCI, BAYER, Chalmers, REWIN, Forschungzentrum Jülich, Avans, TU Dortmund, Cogvis, Optoeletronica, Optisort, Indumetal recycling, Relight, Coolrec, Technical Reunidas, Ondeo industrial solutions, Francisco Albero, TU Wien, Österreichisch Gesellschaft für System- and Automatiseringstechnik, Solvay
Relevant roadmaps: Advanced materials, Biobased economy (TKI), Chemistry of Life, Chemical Micro and Nano devices.

Goal:
This program line wants to provide an agreed upon methodology for assessing long term effects of new products and technology. It provides a quantifiable way of assessing sustainability risks and benefits of new developments. In this way, new developments can be ranked and compared to existing solutions. The methodology must not only be scientifically sound, it must also be built on a consensus between industry, NGOs and governments to provide a robust base for decision taking.

Projects:
The portfolio consists of two specific developments of sustainable technology that act as case studies and one overarching development of the methodology.
The two cases are PHBottle, development of sustainable fruit juice packaging out of fruit waste and Reclaim, technology to facilitate the recovery of rare earth metals

from display waste. The overarching project is a joint industry project where TNO involves NGOs and industry in the development of the methodology.

4.7 Line 6: Innovation decision support

Size: 11.8 M€
TNO effort: 1.2 M€
SMO in 2015: 300 k€ (budgeted)
Started: 2012
Partners: PNO, Dechema, Nova Institute, Clever Consult, Chemistry innovation, AIA, Poyry, Ciaotech, CEFIC, Europabio, KIT, Centre for research and technology Hellas, Chimar Hellas, Energie Baden-Würtemberg, Grace, Syncom, DSM, Universität Stuttgart, AVA-CO2 Forschung, Neste Oil, FH OO
Relevant roadmaps: All.

Goal:
This program line focuses on tools to assist in planning and implementing innovations. One might consider this part of social innovation. The tools include roadmapping, value chain analysis and economic appraisal of new technology.

Projects:
The main projects in this line are Bio-Tic, European roadmapping for Biobased economy developments and Bioboost, value chain analysis.

4.8 Development of the program 2015 - 2018

As shown above, the program starts in 2015 with six program lines that already have many activities. In the period 2015 – 2018, the program will evolve to achieve the ambition stated in Chapter 3.

4.8.1 Activities to be ended

Besides these six program lines the program also still contains some projects in the field of industrial safety. These activities should not be part of this program, since innovation of industrial is not a priority of the Topsector agenda. It is however an important topic for the Dutch industry. In 2015 these activities will be continued pending a discussion with regulators and regional and national government on the continuation of these activities in a separate program. After 2015 the program will no longer have any activities on industrial safety.

4.8.2 Overall development of the program

Currently the program has an average size of approximately 20 M€ per year, while the TNO effort is approximately 6 M€ per year and the funding from Dutch government to TNO (SMO) is 3.6 M€. This may develop along two possible scenarios.
The most realistic scenario is that the SMO funding will decrease in the coming years, following the general decrease of government funding to TNO. In order to achieve the goals of the program, the TNO effort should increase to at least 8 M€ annually. This paradox can be resolved by including “TKI toeslag” funding. At the moment this type of funding is not used in the program. In the coming period, the TNO effort should increase from 6 to more than 8 M€ annually by increasing TKI toeslag funding to 2 M€ per year and increasing the industrial contribution to the

TNO effort to at least 3 M€ per year. The SMO funding in this scenario is expected to decrease to 3 M€ per year in 2018. In this scenario the program size can increase to 25 M€ with a TNO effort of 8 M€.
A more optimistic scenario is that the industry contribution to the TNO effort increases to much more than 3 M€ per year. In that case, TNO could reconsider its priorities in SMO distribution over the top sectors and the SMO funding will increase. That will also result in increasing opportunities for European funding (since more matching is available). In that case the program might grow to 40 M€ per year in 2018 with a TNO effort of at least 14 M€ and 5 M€ SMO funding.

The development of the program is thus a dynamic process in the coming years and much will depend on the interaction with the TKI Chemie.

At this moment it is difficult to predict the changes of the priorities within the program for the coming period. The priorities for 2015 have been implied already in the overview above. At this moment, program lines 1 and 4 (electrochemistry and performance materials) are regarded as the main growth areas of the program. However, the program now has little to offer to the roadmaps Chemistry of Life and Chemical Micro and Nano devices. A discussion with the roadmap councils on the priorities of the program is much needed to decide on the longer term course of the program.

Still, the ambition of the program is clear and this has been derived from the overall ambition of the Topsector. An overview of the contribution of each of the lines to both the impact ambition and the build-up of competences is given below

Table 2: Contribution of the program lines to the impact ambition

Impact	*Line 1*	*Line 2*	*Line 3*	*Line 4*	*Line 5*	*Line 6*
Accelerating chemical product development	+	+	0	++	0	++
Increasing scalability of production technology	++	++	+	+	0	0
Providing a sound basis for innovation decision taking	0	0	+	0	++	++
Proven economically viable chemical building blocks from renewable resources	0	+	++	++	+	+

Table 3: Contribution of the program lines to the competence development

Competence	*Line 1*	*Line 2*	*Line 3*	*Line 4*	*Line 5*	*Line 6*
Photo and electrochemistry	++	0	0	0	0	+
Process system engineering	+	++	+	+	0	+
Biomass utilization	0	+	++	+	+	+
Synthesis and	+	+	0	++	0	+

formulation technology						
Sustainability management	+	0	0	+	++	+
Innovation decision support	+	+	+	+	+	++

5 Implementation: way of working

In order to achieve the full ambition of the program, it must not only contain the right content. It must also form the right partnerships in order to establish new value chains and organise actual investments in new (pilot) production. This means that the right public private partnerships must be established between TNO, DLO, ECN, NWO, European RTOs and universities and Horizon 2020. Furthermore regional networks are becoming increasing important in facilitating investments in (pilot) production.

The need to cooperate on so many levels with so many different partners that have different funding and boundary conditions makes it very challenging to keep focus and result orientation in the program lines. Each program line consists of a number of projects with different partners, goals and funding according to coincidental boundary conditions imposed by the funding instrument. Sharing results and information between the projects might be difficult or even prohibited depending on the composition of the consortia involved. Still the success of the program line depends on a coherent project portfolio where one can build on previous results. Special attention and a special way of working is required to ensure that we can use all opportunities to fund the program while maintaining a coherent portfolio.

The way this is done in this program is to compose a core for each program line. The core of a program is a combination of partners (knowledge institutes and industry), a regional network and specific agreement with NWO on aspects of the research. For example, the core of program line 4 (Performance materials from renewable resources) is formed by a formal cooperation between TNO, DLO, VITO and VTT (Fraunhofer might be added later), Sabic and Avantium as industrial partners (Cosun might join later) and a clear focus on the Biobased Delta region for implementation. If this is supplemented with agreement with NWO on the associated university research, then the core of this line is set. This core will form the basis for all subsequent initiatives such as submitting EU projects and acquiring funding for facilities, so that the parties in this core at least possess all information and results of the activities in the program line and are thus able to use all results to achieve the overall goals.
The members of the core consortium also coordinate their input for Horizon 2020 to increase the likelihood of relevant calls in the various European Programs (SPIRE, BBI, NMP etc.).

Such a core is very similar to what is called a centre of innovation in the transition plan of the Topsector. One of the priorities for 2015 will be to form a stable core or centre of innovation for each of the ambitions of the program. Not each program line needs its own centre of innovation. Some centres may combine the content of several program lines. This will be done in close collaboration with the program councils.

6 Governance and the Topsector

This program is based on the innovation agenda of the Topsector chemical industry in The Netherlands. Governance of the program takes place on various levels. On the level of the program line and the projects within the program line, the activities are governed by the partners of the particular program line or project. They are the ones that are actually contributing money and effort to that program line or project and they determine what will happen within the scope of that activity.
The distribution of TNO effort over the various program lines and the decision to start new program lines or activities is governed through the roadmaps of the TKIs. There are two TKIs that have a stake in this program: the TKI Chemie and the TKI Biobased economy.
At this moment the TKI Chemie is still in the process of starting. It is therefore very difficult to predict how this TKI will cooperate with the TKI Biobased economy and how the governance of this program will be organized. Several options exist:

1. The program lines could get targets from each of the program councils of the TKI Chemie and the TKI Biobased economy. In that case each program line would report integrally to all program councils and the discussion would be whether or not the program line is contributing sufficiently to the roadmap of each particular program council. The distribution of TNO effort over the program lines would be the outcome of that discussion.
2. The program lines could be allocated to a “primary” program council that would take into account the interests of the other roadmaps while governing the program line. The distribution of TNO effort over the program lines would then equal a distribution of TNO effort over program councils and would have to be decided by the management of the TKI. This leaves the question of distribution between the two TKIs since there is now no obvious place where this is decided.

The program councils will start in October 2014 and their first priority is to draft the roadmaps. The TKI Biobased economy has recently started to draft its roadmap. The matter of governance can only be decided once the roadmaps have been written. After all, one must know what one wants to achieve before one can discuss how to achieve this.
Another aspect to take into account is that it is desirable to take a coherent approach to coordinating activities of TNO, DLO, ECN and NWO.
Therefore TO2, NWO and the two TKIs must agree early 2015 on the way to govern this program and the programs at NWO and other TO2 institutes. This report cannot yet present any definitive structure for the governance.