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Competitive sustainability in the Dutch chemicals industry

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1 Introduction

Sustainability and competitiveness have become of fundamental concern for decision-makers around the world. At the same time the process of globalization has created new threats but also new opportunities for the Dutch chemical industry with significant impact on competitiveness in the medium and longer term. Similarly, concerns about increasing energy demand and climate change have risen high on the political agenda, both in the EU and in the Netherlands making the transition to a sustainable energy economy one of the 'grand challenges' of the 21st century. The role of industry and current and future investment and location decisions is hence a crucial one.

For a long time environmental goals and sustainability on the one hand and economic growth on the other hand have been seen as a trade-off. I.e. one was hindering the other. However, this view has changed over the last decade with ground breaking articles such as 'Green and Competitive: ending the stalemate" by Porter and Van der Linden (1995) linking competitiveness of firms with resource productivity and innovation. However, while this change in thinking made it acceptable for business to pursue environmental targets for efficiency reasons, all too often regulation is still needed to stimulate implementation. This has mostly to do with asymmetries in information (firms are not aware of savings potential) and measurement issues (existing accounting systems are not design to easily integrate resource use).

Similarly, at the country level the competitiveness debate receives much attention from politicians and policy-makers. While the same thinking of resource productivity (sustainability) as wealth creator should apply here, old thinking habits frequently return especially in times of crisis.1 However, some traditional strategies followed to boost competitiveness are counterproductive to the goal of resource productivity. A low income strategy and low environmental and social standards result in inefficient labour and resource use. In the long run they make a country hence less not more competitive as it forgoes future wealth creation from higher productivity. A recent example of such thinking is the call by Berlusconi to lower environmental standards to boost Italian competitiveness as the traditional strategy of currency devaluation is unavailable since Italy joined the euro. Such thinking is rooted in old frameworks that rely on narrow definitions of competitiveness without taking into account social and environmental goals.

However, a dramatic change can be seen over the last decade in the chemicals industry. The European High Level Group for the competitiveness of the European chemical industry concluded in early 2009 that "A sustainable chemicals industry is indispensable to address some of the pressing global issues. At the same time, the industry has an important responsibility for the move towards a sustainable use of natural resources, reduction of energy demand, pollution and waste." (HLG, 2009)
The largest global chemical firms, BASF and Dow Chemicals, have defined sustainability goals. BASF for example wants to reduce emissions of greenhouse gases per metric ton of sales product by 25% (BASF, 2009). Dow aims to reduce its energy

[1] Competitiveness at the country level is often discussed in a narrow way related to comparative advantage (trade balances). However, trade balances need to be assessed differently, depending on the strategy followed by which they are reached. Countries can follow a low income strategy, they can devaluate their currency, follow low social and environmental standards or strive for rising incomes and comprehensive social and environmental standards.

intensity by 25% between 2005 and 2015 (Dow, 2008). Nearly all large chemical firms publish annual sustainability reports, and some even link the variable pay of their top executives to the score in the Dow Jones Sustainability Index.

Dutch firms do particularly well in this context. DSM and AkzoNobel have been topping the Dow Jones Sustainability Index already for a number of years focusing on high performance chemicals. AkzoNobel aims at generating 30% of its turnover by 2015 through eco-premium products (Akzo, 2009). Also the sector as a whole has high ambitions aiming to double the chemical sector's contribution to the Dutch Gross National Product until 2016 and halving the chemical sector's use of fossil raw materials until 2030 (Regiegroep Chemie, 2006). However, while many targets are defined total output continuously rises and energy intensive production migrates to the emerging economies. Also more sceptical voices point to the limited potential of renewable feedstocks to simply replace hydrocarbons. This raises the question to how a transition to sustainable production can be achieved without loosing competitiveness. This is what this case study wants to make a first steps towards.

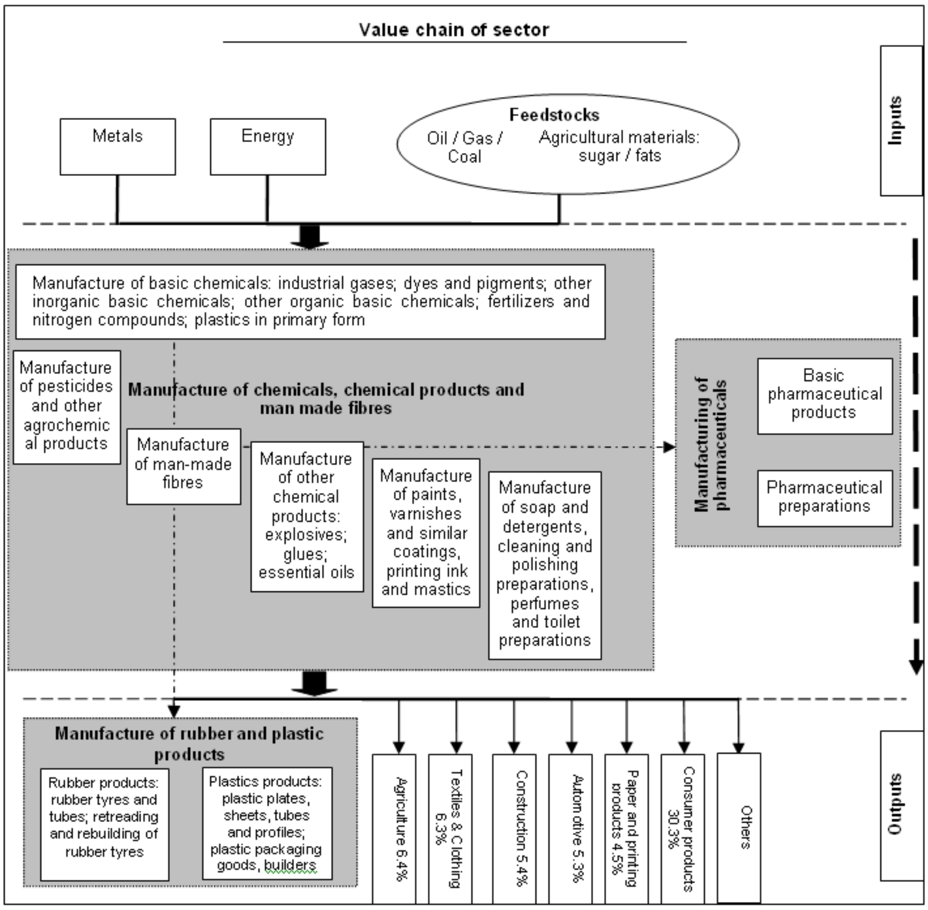
The report consists of following four parts:
1. An overview of the global chemicals sector to place Dutch activities in perspective,
2. Mapping system characteristics of the Dutch chemicals sector
3. Lessons learnt from benchmarking sustainability activities of firms
4. Policy issues and conclusions

The reason to develop such a framework is that for policy makers to implement necessary frameworks conditions in support of competitive sustainability, evidence and measurement is required to guide good decision making.

2 Structural characteristics and changes in global chemicals industry

The chemicals industry converts raw materials such as oil, natural gas, metals, minerals, water and air into more than 70,000 different products. European product output (EU-15) ranges from basic chemicals (37.7% share), through specialty and fine chemicals (26.8%), and pharmaceuticals (23.3%), to consumer chemicals (10.2%) (SusChem, 2005). The wide range of products is supplied to almost all other sectors of the economy. A major share (27%) of primary chemical products is further processed within the industry itself, while only 30% of output is produced for consumer products (SusChem, 2005). Major industrial customers include the rubber and plastic products sector; agriculture; textiles and clothing; construction; automotive; and pulp and paper as displayed in the value chain of the sector. The boundaries of value chain are not fixed, but are moving, as new products, new users and new customers emerge.

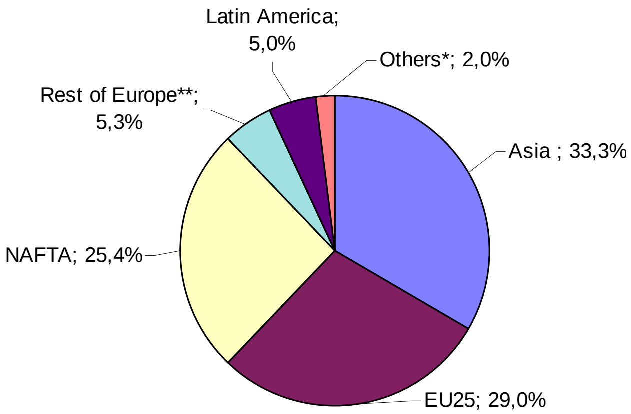
Figure 2.1 The value chain structure of the chemicals industry broadly defined



Source: TNO, 2008, based on CEFIC data. 2008

International competition
In terms of production output, over time Europe has been replaced as the leading chemicals producer by Asia including Japan. Key growth region over the last decade was Asia driven by industrialisation in China, creating structural shifts in global chemicals production (CCIC, 2007).

Figure 2.2 Global chemicals production[2] by region, 2006 (overall €1,641bn)



Source: CEFIC (2007)

But so far Europe has greatly benefitted from the emerging markets as they demanded large parts of the increased production outputs over the last decade. Even if production is shifting to emerging markets this does not mean that European firms do not participate in the economic gains. The table below shows that the chemicals sector globally is still dominated by TRIAD firms with only five companies from the emerging markets breaking into the global top 30 firms. However, one has to acknowledge that his can change over the coming years with Chinese and Middle Eastern firms growing faster than their TRIAD competitors. Furthermore, the relocation of production, while offering the chance to capture economic gains, has more complex repercussions on European employment in this sector.

Table 2.1 Top 30 chemical firms in the world, 2006

Headquarters	Number	Global sales €bn	Share of top 30	Share of global sales
EU	14	260	49%	15.8%
USA	6	138	26%	8.4%
Japan	5	60	11%	3.7%
Other	5	68	13%	4.1%
Total	30	526	100%	32%

Top 10 by name: BASF (GER), Dow Chemical (USA), Exxon Mobil (USA), Bayer* (GER), Shell (NED), Ineos (GBR), Sinopec (PRC), DuPont (USA), Total (FRA), Sabic (KSA). Data based on companies with sales of chemical products greater than $10 billion dollars in fiscal year 2006. For companies with additional activities only the sales relating to chemicals are calculated. Pharmaceutical and Rubber and plastic sector excluded. Global sales 2006 € 1,641 bn.

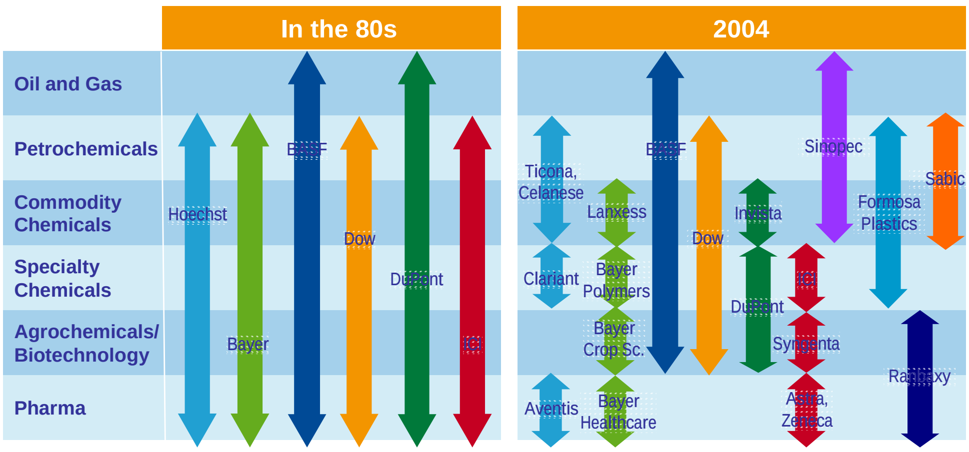
Source: CEFIC (2008). * including pharmaceuticals

[2] Excluding pharmaceuticals; including petrochemicals; Asia including Japan.

Globalisation and trade
The chemical industry is a highly globalised sector with very low tariffs leading to strong international competition. The cornerstone as regards tariffs is the Chemical Tariff Harmonisation Agreement (CTHA), which provides for the reduction of chemicals tariffs to 0%, 5.5% or 6.5% (European Commission, 2008b). The agreement now being applied by 50 WTO members came into force in 1995. As a result tariffs on chemical products are low in the OECD at an 4% average (HLG, 2008a).

Offshoring and restructuring of the industry
In response to globalisation and international competition the structure of the industry has changed considerably over the last decades. Globalisation has fuelled the search for scale efficiencies and new market opportunities, on the one hand leading to further specialisation and consolidation and on the other hand to disintegration of the value chain. Unlike in other sectors relocation of production is not a main driving force for restructuring, however. At the level of the firm, these developments have manifested themselves in the form of a strategic repositioning of firms and a (renewed) search for core competences. The figure below gives a clear illustration of these trends with firms disintegrating along the value chain. European and US firms have tended to exit the oil/gas and petrochemical segments, with new Arabic and Asian players such as Sinopec and Sabic entering these market segments. Overall, the trend of restructuring can therefore be summarised as focusing on specific market segments aiming for scale efficiencies within segments rather than searching for vertical integration efficiencies. The search for segmentation and specialisation by European firms is focused on higher value added sector activities.

Figure 2.3 Restructuring and vertical disintegration of large chemicals firms



Source: BASF

Offshoring, while difficult to measure (for details see Van der Zee *et al.*, 2009), is not a widespread phenomenon in the chemicals sector as large capital investments and high capital intensity prohibit short term relocation of production facilities. However, as user industries have emerged in, and moved to South and East Asia, new production capacities are built up in the emerging markets rather than Europe, leading to a creeping relocation of production capacities. Statistically the share of employment in manu-facturing sectors turns out to be decreasing steadily in comparison with the share of employment in service sectors. With unequal decline between sectors, the most influential factor behind this development appears to be productivity growth and not relocation (Van der Zee et al., 2007). Looking at the high productivity increases in the chemicals industry this indicates future employment decline, also driven by expected slow growth of chemicals demand within Europe.

Commoditisation of specialty chemicals
An important strategy of European firms over the last decade to counteract competitive pressures from South-East Asia and the Middle East was to focus on specialty chemicals. Specialty chemicals are research intensive and provide higher margins. This in turn enables European firms to compete on performance attributes rather than costs, where Europe is at a structurally competitive disadvantage. However, specialty chemicals frequently become commoditized over the product life cycle and hence loose their advantages for European firms. Furthermore, retailers and consumers demand constantly lower prices (CCIC, 2007). This creates a constant pressure for specialty chemical firms to innovate and provide better performing products to sustain the high value added ratios. Additionally, innovation also in specialty chemicals benefits from close interactions along the supply chain. For the future of specialty chemicals the presence of basic chemicals development and production in clusters is therefore perceived of vital importance for the competitiveness of the European chemicals industry.

R&D and innovation as a source for competitiveness
The chemicals industry is a mature industry characterised by large firms. Traditionally key innovations in the sector originate from the research labs of large firms in collaboration with university labs. For the pharmaceuticals industry biotechnology has become a crucial sector, that is driven by smaller, innovative start-ups compared to the chemicals industry. However, the costly clinical trials and economic power of the large firms means that often smaller, innovative firms are bought by the large firms when it comes to the commercialisation of new products. Unlike emerging competitors in the Middle East and South-East Asia, Europe cannot base its future growth on cheap natural resources or abundant cheap labour. Knowledge and a strong research basis are essential to create knowledge-based competitive growth (HLG, 2007a). R&D intensity of the European chemicals industry has slightly decreased over the last ten years, at a level which is considerably lower than in Japan but similar to the US, being close to 2% of sales. According to the European High Level Group one important reason behind the relatively low R&D intensity is the fact that even today bulk chemicals – which require a rather low investment in research per unit output – represent almost 60% of sales of the European chemicals industry. This masks much higher R&D investments in fine chemicals, advanced materials and other higher-tech sub-sectors (HLG, 2007a, p.9). Other sources see the focus on financial performance, frequent restructuring and increasing regulatory costs as limiting R&D spending in the sector (SusChem, 2005).

Importance of biotechnology for future innovation
Consequently, bio- and nano-technology are crucial for the future innovation potential of the chemicals sector. Examples are white and green biotechnology applications, likely to change the chemicals industry structure and output by minimising hazardous materials, waste and emissions and operating at more benign conditions of temperatures, pressures, pH as well as using novel auxiliary materials and solvents. Currently, biotechnology already plays a significant role in the pharmaceuticals sector (red biotechnology), to which statistics on biotechnology normally refer to. For white biotechnology, however, there are fewer examples with most publications referring to the

future potential in the sector (Suschem, 2005). This has to do with large differences between sub-sectors applying biocatalysis in industrial production processes, such as the production of fine and bulk chemicals, detergents, textiles, pulp and paper, and bioethanol. Adoption rates of biocatalysis vary between 100% for individual textile finishing steps and certain fine chemical compounds, and 0.4% for polymer production (Papatryfon, 2008). This also means that aggregated data for the sector is not available. But one of the challenges for implementation is the much slower development of biotechnology than envisaged by experts at the turn of millennium (EMCC, 2005). The frequently cited McKinsey study forecasted a 10-20% penetration of biotechnology processes in the chemicals sector by 2010, with fine chemicals the most important growth sector (up to 60%) (Bachmann, 2002). Today it has become clear that this take longer to be put into practice, but this does not reduce the potential impact of biotechnology on the sector.

2.1 Structural implications for sustainability

The above outlined structure of the global chemicals industry has a number of implications for the successful implementation of sustainable products and production. It should be noted that these structures differ between basic chemicals and fine chemicals providing different backgrounds and potential strategies for these.

The chemicals sector is an extremely globalised sector with low tariffs fostering **high levels of international competition**. Customers, especially in the **bulk segments,** are **extremely price sensitive** providing very low margins. This essentially means that sustainable products and production processes are implemented by firms if they provide a **cost advantage** (i.e. resource / energy savings). This makes **pricing mechanisms** in this sector likely the **most effective policy tool** to support sustainable products and production.

Fine chemicals on the other hand provide more opportunities for sustainable products and production as the **performance characteristics** of products are of **high importance to customers**, which are willing to pay higher margins. This means in addition to cost savings during production, potential cost savings of customers during the life cycle or other added value from product performance are sources for **sustainability strategies**.

However, **fine chemical products** over time **commoditise**, i.e. their performance characteristics become the norm with customers not willing to pay a premium any longer. This means that firms need to continuously invest in upgrading these products to sustain a performance lead or otherwise compete on costs, which is difficult for European firms. Sustainability (regulation) can act as driver to support this continuous strive for higher product performance characteristics.

The sector is largely characterised by large, established firms, having made high capital investments posing substantial economic interests. Smaller and new firms emerge mostly in the fine chemicals segment, where entry barriers are lower and firms compete on product performance characteristics rather than cost and scale factors.

Regulation and standards are an important policy tool for the sector, with many examples where regulation has acted in the past as a stimulus for innovation. However, because of the global nature of the sector, firms lobby very hard against national or European legislation that they perceive as a costly burden and a competitive disadvantage to other production regions. The recently introduced REACH regulation being a good example – and also an example of an regulation that causes relatively high costs of compliance, while stifling innovation as newly developed chemicals face high market entry costs through testing. Regulation hence can be a very effective policy tool to support sustainability in the sector – but as with everything, the way in which it is implemented decides its success.

With few natural resources, **European competitive advantage** needs to be **based on knowledge and R&D**. Advances in **bio- and nanotechnology** provide a key for future competitiveness but especially for sustainable products and production. While in theory many base chemicals based on hydrocarbons could be made from renewable sources, this is economically very inefficient. Rather **alternative processes and new products** need to be developed – however this **requires high investments in R&D**. With the traditional basic products and processes being known for decades and highly optimised, it will take many years until renewable alternatives operate at similar economical levels. This year long experience and optimisation with base chemicals is also of importance for the sustainability debate as many processes are operated close to theoretical optimum with limited future saving potential.

Lastly, the chemicals sector is very high up the industrial value chain. This means that **most products** are **sold to business customers** and comparatively few to end consumers (30%) (Suschem, 2005). Consequently, **strategies influencing norms and values** of individuals for sustainable purchasing behaviour promises **little potential**. Business customers strictly make **economically rational decisions**, purchasing sustainable products when these provide economic advantages. Additionally, chemical products virtually form part of most other end products. End consumers are unable to judge the level of sustainability of the individually used chemicals or production processes. One alternative could be certificates with end products being labelled accordingly, however, this potentially creates high information costs with uncertain effects. Due the sector characteristics **regulation** promises a **more effective tool**.

The hypothesized implications in this section are further substantiated and expanded in sections 3 and 4.

2.2 Ambitions of the Dutch chemicals industry

As in Europe, the chemicals sector is of high economic importance for the Dutch economy generating an annual turnover of €50bn in 2008 with 66.000 employees. The sector provides 10% of employment of Dutch manufacturing jobs being the second largest source of employment after the food and drink sector (VNCI, 2009). The visibility in public focuses on the Dutch firms DSM, AkzoNobel and petrochemical activities of Shell and the foreign operations of Dow and Lyondell-Basell.

In 2006 the sector, through the Regiegroep Chemie, has defined ambitious targets to reconcile future economic prosperity with well being and a sustainable society. The following specific targets where consequently phrased at the time:

- double the chemical sector’s contribution to the Dutch Gross National Product in 10 years,

- halve the chemical sector's use of fossil raw materials within 25 years,
- meet the preconditions for the above by the development of the country's existing technological competences in industrial biotechnology, catalysis, materials and processing technology to a level of global excellence.

(Regiegroep Chemie, 2006)

With these ambitious targets in mind the question arises how these targets can be achieved in practice. In essence these targets require substantial efforts by all actors. However, for Dutch firms to move into the right direction the framework conditions need to be in place. Achieving these targets is not only a question of technology development but at least as much a question of economic incentives for firms to re-allocate capital investment towards sustainable production.

3 Sustainable competitiveness of the Dutch chemical sector

3.1 Introduction

The goal of this section is to presents results on the innovation and sustainability activities of the Dutch chemicals sector. This provides a sectoral overview, while the next section aims at looking at individual firms. The underlying idea is that future competitiveness is largely determined by the innovative capacity of firms. However, technology and innovation is just one necessary factor for sustainable markets to emerge. The demand conditions and hence economic incentives of firms are as much as important. To also map these demand characteristics a framework for a comprehensive system analysis has been developed. This case study is a first application of this framework.

3.1.1 Methodology

For the sector analysis three main sources of information have been used: 1) desk research and publications of individual firms, but also branch organizations and policy document, 2) the European Community Innovation Survey (CIS) data for the Netherlands comprising data on innovation activities of individual firms including economic and environment effects of innovation, and 3) interviews with a select group of industry experts representing the large firms, branch organization and scientific community.

The following table presents the population characteristics of the CIS 2006 data set that has been analysed. Basic and Fine stands for the basic and fine chemicals sector.

Overview of research population						**Relative position* to total economy**		**Relative position* to manufacturing**	
	Total	Serv.	Manuf	Basic*	Fine*	Serv.	Manuf.	Basic	Fine
Population	62,790	41,232	10,855	178	198	-	-	2%	2%
Innovators	15,462	9,257	4,564	125	133	-	-	3%	3%
Share of innovators	25	22	42	70	67	-3%	**+17%**	**+28%**	**+25%**
Firms with new product or service	10,206	5,910	3,438	102	110	-	-	3%	3%
									Share of innovators with …
New methods of production	10	11	9	7	7	1%	-1%	-2%	-2%
New or improved logistics, system	14	15	12	8	11	1%	-2%	-4%	-1%
Large organisational change	46	47	45	49	36	1%	-1%	4%	**-9%**

* Basic and Fine stands for the basic and fine chemicals sector.

****** The relative position is calculated as the difference in percentage points to the compared average. Differences larger than 5 percentage points are highlighted in bold to signal important structural differences.

It shows that the manufacturing sector has a relatively large number of innovating firms, $2/5^{th}$ compared to 1/5 in the total economy and services. The chemicals sector shows an even higher concentration with 70% of the population classified as innovator. Also the share of innovators with a new product or service in the last 3 years is much higher in the basic chemicals (70%) and fine chemicals (67%) sector than the manufacturing average, which again is higher than the average in the services sector and total economy. However, while very strong in product innovation the chemicals sector shows fewer innovation activities in production methods and logistics. Large organizational change is relevant for half of innovators, with the basic chemicals sector above average active in organizational restructuring. This is indicative of high competition and the maturity of the sector.

The following sections present the results of the interviews and substantiate these with data from the 2006 CIS survey where possible.

3.1.2 How do firms define sustainability?

Interviewees were asked “how they would define what sustainability means to their firm” to interpret succeeding questions in light of the definition. Overall, they had difficulties coming up with convincing definitions, giving very mixed responses. This is not surprising as the concept is loosely defined and as there are various perceptions in society what sustainability means.

Most respondents referred to the triple p concept and global challenges, including population growth and expected raw material scarcity, to explain that a transformation is needed. Or more specifically as one respondent phrased “that processes and products need to be designed in a way to ensure that the company is still in business in 2050, knowing that the world is changing due to climate change, population growth and scarce natural resources.” On the other hand this is in parts still perceived as a long term notion, as one product manager stated that so far sustainability has little commercial implications in his segment.

Secondly, half of the respondents explained that sustainability next to the environmental side can also be viewed from the business angle where sustainable growth focusing on brands with a good positioning and learning is of importance. In that context it was further mentioned that firms are there to earn money – and that sustainability costs money. This is interesting, as it highlights that the view of business and the environment acting as two contradicting forces continuous to exist.

In practical terms sustainability is further often described along examples reducing environmental impact of products and production. In that context one interviewee put very bluntly that the chemicals industry has always been busy with environmental aspects of products and production and that for the last 2-3 years this happen under the label of sustainability. This shows that while the concept has gained widespread application, in practical terms it is often reduced to the environmental performance of the firm. This also fits the description of sustainability being a relative rather than an absolute concept. Sustainability hence being defined as a continuous improvement of processes and products to lower environmental and social impact (e.g. best in class, benchmarking).

In terms of implications for business strategy, most firms have defined sustainability goals until 2015/2020. However, due to sector characteristics, in the personal opinion of one interviewee firms should plan more like 30 years ahead as many products and production facilities have a life-cycle of 30-40 years. At the sector level, sustainability is integrated into the former ‘responsible care programme’ that is currently broadened by the sector organization VNCI.

Overall, the concept is not well defined and most people have their own interpretation of it. While this is typical for new emerging ideas that are still in the forming process there lies also a task for the sector to improve transparency and effectiveness of communication. Furthermore, despite difficulties with the concept, sustainability is of very high importance to firms in the chemical sector, also from a level playing field perspective.

3.1.3 Why do firms engage in sustainable activities and environmental innovation?

Sustainable activities

The interviewees were asked why their firm engages in sustainable activities, with examples of social pressures, competitive pressures, market pressures and regulation mentioned. The answers are closely linked to the drivers and barriers to sustainable production as discussed in more detail and with examples under the system characteristics. Overall, interviewees stated that it was a mix of all above mentioned factors but differing in importance.

Regulation was mentioned as the basic factor that firms have to comply with to prevent possible legal and stay in business. But going beyond, also future regulation (e.g. ETS) was mentioned as a driver. With regulatory processes taking years from the making until implementation these are also well to predict. At the same time interviewees frequently stated that there is too much and often counterproductive regulation.[3]

Next to that, competitive pressures are a very effective driver. Firms monitor the actions of competitors and adjust their behaviour accordingly (see section on competitive institutions). This driver works in close relation with market pressures – what customers demand. Market pressures are very important to the chemicals sector as most products are developed in line with customer specifications. These two pressures have been institutionalized through the Dow Jones sustainability index that acts as a positive feedback loop. For example, half of the variable income of top management of one chemical company is linked to the performance of the firm in the Dow Jones sustainability index.

Top management within larger firms further act as an important catalyst as they decide how serious this issue is picked up by the different business units and world regions. If top management does not fully support this, individuals in the organization will follow this behaviour.

Social pressures on the other hand where not perceived as having an impact. This is not surprising as most of the sector output are intermediates and there are few end-consumer products. However, social pressures have indirect influence through regulation. Lastly, norms and values of individuals were also mentioned as important as some people want to be leading the development in sustainability influencing the behaviour of their firm (as employee or owner).

Environmental innovation

Next to the broad question above, interviewees were asked specific questions to what extent their organisation brought out new products and services with goal to reduce

[3] Example of sulphuric acid as waste stream was given by interviewee.

material and energy use, carbon emissions and pollution. The answers further complement the wide general pressures at work as discussed above.

Reduction of material use and substituting hazardous substances were most frequently mentioned (6/6) as a goal for a new product, service, process or organizational innovation. This was followed by reduction of water and soil pollution (5/6). Reduction of energy use and lowering carbon emissions was only mentioned by four respondents – namely in high performance sub-segments energy costs make up a fairly small share of total costs. Lastly half the respondents (3/6) stated that their firm introduced a new product, service, process or organizational innovation with goal of recycling waste, water or materials.

In addition, respondents were asked whether their firm has introduced a new product, service, process or organizational innovation that led to reduced energy use, pollution and improved recycling from the *after sale use* by the customer. Here, 5 of 6 respondents stated that reduction of air, water, soil or noise pollution was a goal, while reducing energy use and improved recycling was a goal according to 4 of 6 respondents. This impressively shows that firms in the chemical sector are not only very conscious about lowering environmental impact of their production, but also in processes of their customers (which are often also active in the chemical sector).

Reduced energy use in customer processes as stimulus for innovation

A large Dutch chemical firm has developed an anti caking agent that prevents salt from getting hard again. The new product means that customers need to use less energy in processing the material, as a whole production process step becomes obsolete. This product has been internally supplied within the chemical firm since 2005. First to a small production plant in Sweden was set up as a test. In a second step a large plant was commissioned in Rotterdam. For a number of months now the product is also available to external customers. Market uptake is difficult so far despite the cost advantage. Customers are afraid of risks (possible unforeseen problems). One reason was that there are issues with transport over longer distances on ships. In response the formula of the product has been adapted to resolve this problem. The product is now in the market for a number of months.

Lastly, respondents were asked whether their firm introduced innovations in response to regulation, subsidies, market demand or voluntary industry codes. Market demand was the most frequently mentioned driver (6/6), followed by voluntary codes of industry (5/6), and existing and future regulation (4/6). Subsidies were only mentioned by half of the respondents (3/6). In addition, all respondents stated that their firm has implemented management systems to identify environmental impact before 2006 and also thereafter.

3.1.4 Comparing interview results to data from the Community Innovation Survey (CIS)

The preceding section has provided very rich information why firms engage in sustainability and innovation. However, the results are based on a small number of interviews for resource constraints. To substantiate the findings of the interviews these are cross-checked in this section with data from the community innovation survey. In addition the data for the chemicals sector is split in basic chemicals and fine chemicals, excluding pharmaceuticals.

By and large the CIS data supports the interview findings. Lowering environmental impact (pollution) and improving health and safety is a key driver for innovation in both basic and fine chemicals. Reduced material and energy use, however, is of high important for basic chemicals, while less important for fine chemicals, where product performance characteristics are key for product success. In contrast, meeting (new) regulations is of very high importance for innovation in fine chemicals, while much less important for basic chemicals. An explanation for this is that basic chemical processes and materials are known already for a long time, with most regulation already in place and few changes to it necessary.

Table 3.1: Drivers of innovation and effect on competitive position

Effect of product, process and organisational innovation						**Relative position to total economy**		**Relative position to manufacturing**	
Share of innovators	Total	Serv.	Manuf.	Basic	Fine	Serv.	Manuf.	Basic	Fine
Reduced material and energy use per unit	30	24	44	54	40	**-6**	**14**	**10**	-4
Reduced environmental impact or health and safety issues	32	24	44	57	65	**-8**	**12**	**13**	**21**
Met regulation	38	34	43	42	67	-4	5	-1	**24**
Improved employee satisfaction	61	63	59	46	40	2	-2	**-13**	**-19**
Increased market share	64	63	73	72	88	-1	**9**	-1	**15**
Improved quality	74	75	79	74	91	1	5	-5	**12**
Reduced labour costs per unit	41	36	49	52	46	-5	**8**	3	-3
% turnover products new to market	10	11	9	7	7	1	-1	-2	-2
% turnover new to firm	14	15	12	8	11	1	-2	-4	-1
% turnover unchanged	76	74	79	85	82	-2	3	**6**	3
Organisational innovation									
Reduced time to market	68	68	67	58	67	0	-1	**-9**	0
Improved quality	73	75	69	71	82	2	-4	2	**13**
Reduced costs per unit	51	50	55	80	59	-1	4	**25**	4

In addition to the interview results the table shows that sustainability characteristics are (sub)sector specific, with differences between bulk and fine chemicals in material use and importance of regulation. Furthermore, the wider comparison between the services sector, the manufacturing sector and the bulk and fine chemicals sector shows that innovation activity correlates with the importance of factors of production (e.g. natural resources are the most important factor of production in bulk chemicals; while this is labour for the services sector). This indicates that price incentives could work very effectively to achieve sustainability goals.

Furthermore, turnover of firms from products younger than three years is low, 12% on average for manufacturing firms, and even lower for basic chemicals (8%) and fine chemicals (11%). However, firms nevertheless state that they innovate to increase market share and improve product quality. This is particularly important for fine chemicals (+15% and +12% points higher than manufacturing average. This discrepancy between statement and facts can be explained with long development times and product life-cycle. This is particularly true for basic chemicals where reduced time to market is no driver for organizational innovation. Lastly, the data also supports the point on factors of production with fine chemicals focusing on improving quality and basic chemicals on reducing costs.

Contrasting evidence:
firms are generally innovating for other reasons than environmental effects

Evidence for the European economy overall shows that in contrast to the chemicals sector environmental effects are not an important driver for innovation and hence competitiveness:

"According to the findings of the Fourth Community Innovation Survey (CIS 4) innovation does not always reduce environmental impacts or the use of raw materials. Indeed, these effects are only two among a number of other effects, and not necessarily the most important. The survey found that the positive environmental effects of innovation actually ranked last, behind the effects on the quality and diversity of goods and services. On a positive note, the importance of reduced environmental impact increases with size class and is higher for manufacturing firms than for total firms. (Eurostat, 2007)

This difference can be explained by structural characteristics as large manufacturing firms can realize larger absolute savings, making reducing environmental impact economically attractive. Furthermore, the CIS-4 survey is already a number of years old (2002-2004), with firms probably having adapted their strategies since.

3.2 System characteristics: barriers and drivers for sustainability and innovation

The respondents were asked during the interview about possible "drivers or barriers to implement sustainability in practice". This open question, which results are presented above, was complemented with a detailed survey structured around the following system characteristics. The physical infrastructure; institutions; interaction; capabilities and market characteristics including demand, barriers to entry, market power, and information transparency. Respondents generally could respond with yes, no or I don't know answers. The scores on the questions are represented in the text between brackets in the order of [yes, no, don't know].Part of the project goal was to test the survey for use on a larger scale in the future.

Infrastructure
In relation to infrastructure interviewees were asked whether the infrastructure for the introduction of sustainable products and production is in place, listing the different types of infrastructure (roads, railways, […] energy, material use and recycling.

Generally, respondents had difficulty answering these questions with 'yes' or 'no'. One respondent highlighted that it is about the quality of infrastructure provision, not whether it is there or not. Furthermore, infrastructure needs to be maintained – this is a continuous process and the requirements change over time. Generally, respondents stated that the physical infrastructure for sustainable production in terms of roads, railways, harbours, pipelines and IT is in place.

Education and research infrastructure: [2/2/2]. The education and infrastructure according to a number of respondents is key for the successful implementation of sustainability. This is not so much because of the knowledge gaps of sustainable technologies, although these partly play a role, but about creating a change in understanding and norms and values of people that is needed for a transformation of the economy. In the view of one respondent is the topic of sustainability not of high interest to many people, or even creates negative associations (eco-resistant). This has to do with misconceptions of sustainability that in public is sometimes associated with organic farming that pose a barrier for market formation.

But also curricula need to be adapted to future knowledge needs and the research infrastructure needs to be adapted to enable 'open innovation' as the sustainability challenge requires interdisciplinary solutions.

Energy infrastructure: [2/1/3]. While the infrastructure for fossil energy is in place it was highlighted by one respondent that the quality of the energy infrastructure needs to be maintained and that costs need to be controlled. On the other hand, the infrastructure for renewable energy is not in place, yet. One respondent stated that it is not possible for the firm to switch completely to green electricity as there is not enough supply.

Material (re)use infrastructure: [2/3/1] Interviewees generally agreed that this infrastructure is not in place. For example it is not possible to simply return products for recycling. Also regulation is sometimes counterproductive. Classification of specific product streams as waste means that regulation acts as incentive to use energy to dry the waste stream (sulphuric acid) to reduce weight, in place of re-using the stream in production processes of customer. Another example is the infrastructure and technologies for second generation bio-fuels. For example the technologies for using agricultural waste stream such as straw in chemicals production are not in place. Surprisingly, infrastructure is generally not seen as a public task [2/4/0] and respondents are in favour of public private partnerships (PPP) [5/1/0]. For example in Zeeland a new pipeline was built to supply CO2 from chemicals production for use in greenhouses. This infrastructure was supported financially by the government but is in private ownership. This attitude towards private infrastructure could be a special case of the chemicals sector that traditionally has a long history of privately owned infrastructure such as pipelines. However, while private initiative in generally is preferable, this could also act as a barrier where infrastructure requires large capital investments and where problems of agency and monopolies arise.

Institutions

Interviewees were asked whether there are sufficient institutions in place to foster sustainable products and production. A list of specific institutions was presented falling in three categories: regulative institutions that act as a coercive pressure, social

institutions that represent normative pressures, and competitive institutions that act as mimetic pressures[4].
Social institutions

Unanimously, respondents agree that norms and values of people act as driver to adopt sustainable practices [6/0/0]. However, at the same time they are of mixed opinion whether norms and values are strong enough to act as market incentives [3/3/0] and they believe that a change in norms and values with all market actors are needed [customers (5/1/0); end consumers (5/1/0); managers (4/2/0); employees (4/2/0); global competitors (4/2/0); investors (4/2/0); government (4/2/0)]. As one interviewee put it, we are on a trajectory of development towards sustainability and the current state of development is not perfect.

This change in cultural norms is necessary for people to make informed consumer decisions and for the pricing mechanism to work effectively. One problem according to an interviewee is that many people do not really understand what sustainability means. Many reduce sustainability to climate change and think that it is enough if they recycle paper and switch off the light when leaving the room. This view is also reflected in a global survey where especially people in highly industrialized countries state that their life-style does not have negative consequences on the environment (for details see introduction). In that sense the social institutions (norms and values) of people need to change for sustainability to be demanded through the market mechanism.

Linked to their belief whether norms and values act as strong enough market incentives, is their view to whether norms and values should instead be reflected in regulation [3/3/0]. However, next to sustainability people have many other norms and values that might stand in conflict. For example, one interviewee pointed out that customers only accept a more environmentally friendly product if there is no difference in product quality and if costs are not higher. Furthermore, the question arises whether social norms and values act as sufficient incentive in an anonymous market place where social pressures do not function very well. Also, while sustainability is a communal value, market incentives influence the behaviour of the individual creating an agency problem.

Also at the firm level a change is needed. Currently, for every product a clear calculation is made to whether it makes economic sense to implement or not. While more and more environmental and social costs are internalized in these calculations, competitive pressures act against this if these are not adopted by the majority of firms.

Competitive institutions

The behaviour of competitors is a crucial factor in adopting sustainable practices, with all respondents being of the opinion that competitor's behaviour influences practices of their own firm (6/0/0). However, this does not mean that firms copy each others strategy – instead competitors' action is more used as a performance benchmark. Leaders in the sector are also leaders in terms of sustainability as benchmarked in the Dow Jones Sustainability Index. Competitive institutions hence act as important pressure for sustainable practice by setting standards and raising the bar. The Dow Jones Sustainability Index plays a key role for the enforcement of this pressure as there are direct economic incentives at work. Furthermore, the benchmark is highly visible in

[4] Mimetic pressures refer to pressures that arise from behaviour of competitors that firms mimic to stay competitive.

public, made by a third party representing an independent and hence trustful instance, and is used for financial decisions of investors. This makes sure that firms have clear economic incentives to improve their score in the Index, with for example half of variable income of top management of one interviewed firm directly linked to the score in the Index.

Regulative institutions

The survey answers further indicate that interviewees believe that there are generally not enough coercive pressures to foster sustainable production, ranging from: standards [1/4/1]; regulation [2/4/0]; and IPR [2/3/1]. One interviewee put it more drastically saying that things only happen if firms are made to change (Dutch: afdwingen). Not because people in the firms do not want to change, but because processes have such strong dynamics that these are not easily changed.

Conservatism of customers as barrier to innovation:
Example of a new waterborne coatings product in the Aerospace sector

A European chemical firm has developed a series of next generation structural waterborne coatings. These substantially reduce chromates (75%), reduce waste, lower paint consumption and hence weight of aircraft. This means that compared to previous products this coating is safer for the environment, contains less organic solvents (VOC) and contains less hazardous materials.

This product line was developed for a large European aircraft manufacturer that needed to reduce its emissions to comply with European regulation. Total development time was 8 years with continuous technology development. Knowledge was transferred from the automotive segment where waterborne coatings have been in use much longer.

First a prototype was developed. It was then presented to the aircraft manufacturer for approval. At the same time the new product was also presented to tier 1 and 2 suppliers but focused on key customers. In the meantime other aerospace manufacturers have followed in their product specifications – whereas a large US competitor has not yet followed.

In principle, the technology development could be sped up but it also takes 5 years for a new product to be taken up by the market. Aircraft manufacturers prefer trusted products and are reluctant to take-on innovative solutions. While it takes time to develop new market uptake, it takes even longer to get old products out of the market. An aircraft has a lifetime of 30 years. Coatings used for maintenance and repair must be made to original (old) product specifications which means that new products take very long to penetrate the whole market.

Now that customers are convinced that the new product (water borne alternative) works, the next step is to convince them to adapt their production (processes). Water borne coatings namely differ substantially in their physical properties to old coatings requiring physical investments and adaptations in production structures of aircraft manufacturers.

Furthermore, interviewees highlight that there are many sustainability initiatives supported by the authorities but often these lead to little. One reason for this is that these initiatives are often based on subsidies with no economic foundation when the subsidies end. However, while regulation can stimulate change, regulations can also act as a barrier.[5]

For that reason it is important acknowledge that it is not so much about whether or not regulation is necessary but how this is implemented. The following box presents the arguments for regulation acting as a stimulant for innovation as presented in a report to the European Commission (Van der Zee *et al.,* 2009).

Box 1: Regulation as stimulant for innovation?

The chemicals sector is exposed to various environmental, safety and security issues and risks. With industrial plants often being located near populated areas, and chemical transports taking place all over Europe, and with chemicals being associated with risk in production and use, the chemicals industry is confronted by extensive regulation. The Consultative Commission on Industrial Change (CCIC) claims that in general, the current EU regulatory environment does not overly support the competitiveness of the EU chemicals industry. The impact and role of regulation on innovation and competitiveness is not clear-cut, however. Where further rules concerning the greening of the industry and innovation may go together (but not necessarily so), other forms of regulation may hamper innovation and competitiveness. Environmental regulation is considered a key factor (driver) for the chemicals industry. Whereas the quality of regulation is important, regulation needs also proper implementation. This applies throughout the EU, with similar degrees of enforcement and effectiveness being applied across Member States, as to maintain a level playing field.

Stifling or supporting innovation and competitiveness?
The High Level Group (HLG) on the competitiveness of the European chemicals industry highlights that regulation has both direct and indirect effects. As a direct effect regulation causes costs of compliance, may delay market introductions but may as well create markets for innovations (e.g. substitutes for CFCs). Regulation also has indirect effects; it may (a) create first mover advantages, (b) provide new competences which can become a competitive advantage (c) lead to relocation to countries with lower environmental standards, but also (d) create trust among the public (HLG, 2007a). Yet opposing views exist on the overall impact of regulation on innovation, especially with regard to SMEs.

Several important regulations are currently affecting the chemicals industry or are about to be implemented with unknown future implications: These include REACH legislation, the environmental liability Directive and several other rules and regulations related to climate change and energy policy. Other regulations related to the chemicals industry are occupational and workplace regulations and parts of other existing environmental and health regulations, notably the legislation on pesticides, biocides, waste, water, climate change and air pollution. An example is the VOC (volatile organic compounds) Directive important for the paint, ink and coatings sub-sector (European Commission, 2006).

Taken from: Van der Zee *et al.,* 2009

[5] Example of sulfuric acid waste stream previously mentioned.

Box 1: Evidence of regulation driving sustainability and innovation

A correlation analysis of Community Innovation Survey variables has been conducted to detect relations between sector characteristics, innovation performance and economic performance of firms. This has been done for the basic and fine chemicals sector and for benchmark comparison also for the manufacturing and services sectors and the total economy.

Two correlation coefficients really stand out across the data set. These are the co-efficients correlating the variable of 'compliance with regulation' with 'reduced material and energy use' on the one hand, and 'improved environmental performance' on the other hand. They are consistently higher than 0.4 in the case of reduced material and energy use and higher than 0,53 in the case of improved environmental performance. This is particularly worth noting in the case of the aggregate sectors, manufacturing, services and total economy, that comprise many correlation coefficients smaller than 0,10. All correlations are significant at the 1% significance level. Only for fine chemicals sector no significant correlation coefficient could be calculated for the reduced material and energy use variable. However, this confirms interview results that material and energy savings is of less importance for innovation in the fine chemicals sector.

The following summary table puts the chemical sector in perspective:

Correlation coefficients for the variable: compliance with regulation

	Basic chemicals	Fine chemicals	Manufact.	Services	Total Economy
Reduced material and energy use	,396(**)	-	,406(**)	,416(**)	,423(**)
Reduced pollution and improved health and safety	,632(**)	,690(**)	,663(**)	,531(**)	,602(**)

** Correlation is significant at the 0.01 level (2-tailed).

This result can be seen as indication of the effectiveness but also need of regulation to implement and reach sustainability goals.

Interaction

Respondents agree that there is a sufficient innovation network for sustainable production in place in the sector and that their innovation network is of high importance for the introduction of sustainable products and production (average 5,8; range 2-7). Furthermore, all respondents stated that their organization collaborates with external parties in the field of sustainable technologies [6/0/0]. Customers, Suppliers, Universities and Consultants were mentioned most frequently [5/1/0]. Competitors and Investors are still mentioned by half (3/2/1). But collaborations with partners outside to the industry are less widespread (2/3/0), which is also reflected in the value how open the network is to outsiders or newcomers (average 4,2; range 1-7).

This describes the chemical sector as most people do – an internally focused sector busy with optimizing processes within the firm and sector. However, as one interviewee noted, to make big steps towards sustainability the whole chain needs to work more and more together (cradle-to-cradle), requiring new skills in knowledge and technology management and 'open innovation'.

Table 3.2: Most important collaboration partner

Collaboration: most important partner of innovators						**Relative position to total**		**Relative position to manufacturing**	
	Total	Serv.	Manuf.	Basic	Fine	Serv.	Manuf.	Basic	Fine
Share of collaborating innovators	36	32	44	73	52	-4	**8**	**29**	**8**
Difficulty finding collaborators	14	12	15	6	8	-2	1	**-9**	**-7**
Within own firm	18	18	19	36	31	0	1	**17**	**12**
Suppliers	43	44	38	21	30	1	-5	**-17**	**-8**
Customers	20	18	24	24	13	-2	4	0	**-11**
Competitors	5	6	3	3	6	1	-2	0	3
Consultants	8	9	9	6	10	1	1	-3	1
Universities	5	4	5	7	10	-1	0	2	5
Public (research) institutes	1	1	1	2	0	0	0	1	-1

Comparing these results to CIS data (table above) supports the results but also indicates slight differences. The share of collaborators is much higher than the manufacturing average for bulk chemicals (+29) and for fine chemicals (+8), indicating indeed that a sufficient network is in place - also the difficulty of finding collaborators is perceived as low. Bulk chemical firms have the highest tendency to collaborate – but this focuses mainly on in-house collaboration. In the interview, respondents were primarily asked about external partners. And the answers indicating a strong preference to collaborate with customers and suppliers is not supported by the data. This can have two reasons, the interviewed firms differ to the overall population, or the importance of 'open innovation' in the last years has led to a change in perception.

Capabilities

Capabilities refer to the technological but also marketing and organizational capabilities of an organization. Interviewees were asked whether they have all the necessary capabilities in-house to introduce sustainable products and production to market. Related to these are the capabilities to manage knowledge and technology, in case the organization does not have the necessary capabilities in-house. This includes sourcing and collaboration.

Technical knowledge

Interviewees stated that their organization has all the technological knowledge and know-how in house to develop sustainable solutions [4/2/0], although the comment was made that it is not always desirable but sometimes more effective to source externally. Also the importance of technological capabilities for the successful introduction of sustainable products and production is perceived as very high [Ø6,5; range 5-7]. Interestingly, the majority stated that the technological requirements for sustainable products do not differ to 'normal' products [2/4/0], however, these are developed in a framework with different characteristics. This essentially means that the technology development process is not different, only the framework conditions are. In case of a lack of technological knowledge most look towards universities (6), public research institutes (5) and other firms (5).

Organisational & marketing knowledge

The picture for organizational and marketing capabilities differs slightly compared to technological capabilities, with [2/1/3] of the opinion that they have all capabilities in-house and a mixed view on whether the capabilities differ to 'normal' products [2/2/2]. Most stated that they look for market specialists if needed (3), followed by universities.
This picture can be further complemented with the CIS data on the most important sources used by innovators. Generally, the view that firms have all technological knowledge in-house is supported with very high levels seeing their own firm as an important or very important source in the innovation process. However, what does not come out of the interviews is the importance of suppliers for the innovation process. Mostly universities and other research institutes were named next to the customers, without which hardly a new product is developed.

Table 3.3: Important and very important sources for innovation

Important and very important information sources for innovators						**Relative position to total economy**		**Relative position to manufacturing**	
	Total	Serv.	Manuf.	Basic	Fine	Serv.	Manuf.	Basic	Fine
Within own firm	76	75	83	88	90	-1	**7**	5	**7**
Suppliers	65	60	72	67	76	-5	**7**	-5	4
Customers	56	54	66	74	77	-2	**10**	**8**	**11**
Competitors	41	40	42	34	60	-1	1	**-8**	**18**
Consultants	19	19	21	16	32	0	2	-5	**11**
Universities	12	11	15	27	14	-1	3	**12**	-1
Public (research) institutes	9	8	11	16	15	-1	2	5	4
Conferences etc	29	27	34	40	50	-2	5	**6**	**16**
Literature	28	28	29	39	56	0	1	**10**	**27**
Branch organisations	27	28	24	23	48	1	-3	-1	**24**

A lack of qualified personnel and information on technology are also not perceived as a particular impediment on capabilities compared to manufacturing and the wider economy overall (see table below). However, the fine chemicals segment perceives it more difficult to collect adequate market information and also has more difficulties than basic chemicals with information on technology. This can be explained with the maturity of the basic chemicals sector that experiences little technological change and has a stable customer base.

Table 3.4: Access to personnel, technology and market information

Capabilities of innovators						**Relative position to total economy**		**Relative position to manufacturing**	
Share of innovators	Total	Serv.	Manuf.	Basic	Fine	Serv.	Manuf.	Basic	Fine
Lack of qualified personnel	41	40	42	37	35	-1	1	-5	**-7**
Lack of information on technology	21	20	24	16	23	-1	3	**-8**	-1
Lack of information on markets	19	18	21	21	28	-1	2	0	**7**

Sources of financing

Generally, about one third of innovating firms find costs of innovation too high and complain about a lack of fund. This is particularly true for the basic chemicals sector that sees particular difficulties to attract internal funding. This is even more dramatic for firms in the basic chemicals sector that do not innovate, although the absolute number of these firms can be assumed to be small.

Financing of innovation						**Relative position to total economy**		**Relative position to manufacturing**	
Share of innovators	Total	Serv.	Manuf.	Basic	Fine	Serv.	Manuf.	Basic	Fine
Lack of external funds	22	21	22	22	25	-1	0	0	3
Lack of internal funds	34	32	38	55	40	-2	4	**17**	2
Innovation costs too high	33	29	39	35	42	-4	**6**	-4	3
Share of non-innovators									
Lack of external funds	30	28	34	40	37	-2	4	**6**	3
Lack of internal funds	43	42	50	92	37	-1	**7**	**42**	**-13**
Innovation costs too high	24	21	34	7	54	-3	**10**	**-27**	**20**

Market characteristics
For a successful transformation to a sustainable economy there needs to be demand for sustainable products and production in the market place. At least the market mechanism is still the most powerful force in society, and most effective in managing change as it is a self-organizing system. Next to that policy intervention is often legitimized on grounds of ‘market failure’. For that reason interviewees were asked a number of questions to understand demand characteristics in the sector, barriers to entry and market power of firms, the role of entrepreneurs for the success of sustainable products, and lastly questions relating to information transparency.

Demand characteristics
Overall, interviewees stated that there is sufficient demand for sustainable products [3/2/1] and production [4/1/1]. However, they also stated that this demand is largely a niche segment (5), although it does not have to be with sustainable substitutes in bulk chemicals. They also highlighted that supply will follow demand if more sustainable products are wanted. When asked whether there are lead customers for sustainable products 5 answered with yes, but did not disclose any names. These lead customers buy sustainable products mostly for image reasons and personal values, less for reasons of regulation.

Barriers to entry and market power
Barriers to entry in the chemicals sector are a widely recognized phenomenon [6/0/0] that can be explained with a long product development cycle (6), large economies of scale (5) and pricing strategies of large players [4/1/1]. However, barriers to entry are specific to market segments, but all barriers mentioned are applicable to the sector somewhere. For example, the segments of industrial enzymes, or salt production are dominated by few players, compared to other segments where many firms are active as for example in powder coating resins and composite resins.

Next to that, buyer-supplier relations are often very long term oriented and require high levels of trust that makes it difficult for newcomers. These tight supplier-buyer

relationships are frequently based on physically intertwined material flows of chemicals production (e.g. pipelines; integrated production). An example of this is the PVC/ chlorine chain. The integration of material flows goes so far that if one firm has to shut down its plant operations, other firms dependent on the production will not be able to function after a short while. All of these aspects make it very difficult for newcomers to break into established markets.
Comparing the interview results to the broader CIS data on innovation characteristics largely confirms the conclusions. However, there are noticeable differences between the firms in the sector that are active innovators and the firms that do not innovate.

Table 3.5: Market characteristics and lock-in

Barriers to innovation						**Relative position to total economy**		**Relative position to manufacturing**	
Share of innovators	Total	Serv.	Manuf.	Basic	Fine	Serv.	Manuf.	Basic	Fine
Market dominated by established players	22	21	24	24	25	-1	2	0	1
No demand due to prior innovations	9	7	9	12	6	-2	0	3	-3
Uncertain demand	24	22	27	25	26	-2	3	-2	-1
No demand	9	8	7	14	9	-1	-2	**7**	2
Share of non-innovators									
Market dominated by established players	14	14	10	25	32	0	-4	**15**	**22**
No demand due to prior innovations	10	10	12	27	18	0	2	**15**	**6**
Uncertain demand	13	11	17	12	31	-2	4	-5	**14**
No demand	19	18	19	30	25	-1	0	**11**	**6**

One quarter of firms innovating perceive dominant players in industry as a barrier for innovation. However, in the chemicals industry this share is not above manufacturing average and only slightly higher than in the services sector and the economy overall. Instead uncertain demand is perceived as the most important barrier for innovation. For firms not innovating, however, the barrier of established players is perceived much higher (basic chemicals +15; fine chemicals +22) than in manufacturing and the services sector on average, while 'no demand' is the most important barrier for non-innovators in basic chemicals sector.

Role of entrepreneurs
The high barriers to entry and market power of existing players gives a special importance to entrepreneurs as stimulants of change. Interviewees rated the importance of entrepreneurs for the commercialization of sustainable products and production with slightly above average (4,8; range from 2-7) in a scale of importance with 7 defined as very important and 1 defined as not important. Again the role and activity of entrepreneurs differs between market segments as the wide range of responses indicates. In segment of aerospace coatings for example, entrepreneurs are seen as completely irrelevant, whereas particularly in the segment of biotechnology they are seen as very important. One interviewee made the very valid comment that entrepreneurs are crucial for sustainability as it requires risk-taking where established players find it too risky to invest. This also fits the comment of another respondent describing entrepreneurs as a 'nice stimulus for other actors to start moving towards sustainability'. This means that policy should focus on stimulating entrepreneurship and lower barriers to entry. One way this is attempted are the Dutch COCIs (Centres for Open Chemical Innovation). These cluster clusters provide entrepreneurs and

employees of onsite firms engaged in spin-out activities, with infrastructure and services. In addition to toll manufacturing, pilot plants and analytical support these services also extend to issues such as intellectual property, finance, legal affairs and marketing. The first COCIs began operations in April 2009 located in Chemelot, supporting six companies. It is hence too early for an evaluation of activities. Two more COCIs are planned.

Information transparency
Information in the sector is not available equally to market participants. According to one interviewee, firms obviously aim to protect their competitive advantage in customer needs and technical knowledge. But compared to other sectors the smaller number of firms active also makes the sector relatively transparent. However, with the chemicals sector placed fairly high up the supply chain, information transparency differs between direct customers and end-consumers. Most chemical products represent only a (small) part of end products making it difficult for end consumer to judge whether they buy a sustainable product and even more difficult how the different product elements have been produced.

This judgment of information is made even more difficult with firms using different standards to report on sustainability. Next to that many calculations require firms to make assumptions as they do not fully monitor actual emissions. This is for example the case with the carbon footprint of firms – in practice this means that results can differ substantially depending on reporting standards and assumptions made, while end-consumers have realistically no fair chance for comparison.

When asked how information transparency for sustainable production could be improved in the sector for (end)consumers, a mixed picture was given. Generally, the respondents had no clear idea. Information campaigns are an option [2/0/4] but in the experience of one respondent have proven ineffective. Certificates are a good idea according to another respondent as it ensures that transparency is ensured with data certified from third parties. Standards are favoured by two respondents to assure that all firms make information available that is comparable for consumers helping the decision-making. Lastly, regulation is favoured by 2, but also with 2 respondents against it, as there is generally too much regulation, and that the implementation of regulation usually results in a compromise that in the end makes no one happy. In conclusion, to increase transparency, certificates are probably the best way to solve this issues, as they are controlled by an independent party. In contrast, regulation is unlikely to produce satisfactory results as the implemented regulation is often a compromise that does not do justice to the original goals.

4 Sustainable competitiveness of Dutch chemical firms

While it is important for policy-makers to monitor overall sector developments, benchmarking individual firms can be a very effective tool to promote best practices and inform decision making.

Complementing the preceding section, this part reports on experiences with benchmarking sustainability activities of individual Dutch chemical firms. It has to be said that no useable results could be generated. Rather the purpose of reporting the results here is to highlight practical issues and necessary steps to enable possible benchmarking in the future.

A number of questions need to be addressed for successful benchmarking:
- Who should be benchmarked?
- Who can be benchmarked?
- What indicators should be used for benchmarking?

4.1 Which firms should be benchmarked, and which firms can be currently benchmarked?

Generally, it would be most effective to benchmark all firms. However, as data collection comes with an administrative cost, which should be minimized, existing data should be exploited and small firms should be exempt from data collection.

The table below gives an overview of the Top 30 chemical firms in the Netherlands. It shows that benchmarking these 30 firms results in covering about 90% of the sector as measured by total turnover. Focusing on these firms would hence be a practical alternative instead of benchmarking all firms.

However, only few of these firms publish annual sustainability reports. These are voluntary and firms use different reporting standards, sometimes certified from third parties, sometimes not. Of the Top thirty, only three chemical firms are listed on the Dutch stock exchange. The rest is a subsidiary of internationally listed chemical firms or privately owned. This makes data availability a key obstacle for benchmarking firms and identifying best practices.

As an alternative and first step, the few large Dutch chemical firms could be benchmarked against international peers. However, this only partly solves the problem, as firms report using different reporting standards, choose benchmarks arbitrarily and make different assumptions about measurements of variables.

Table 4.1 Overview of Top 30 chemical firms in the Netherlands by turnover, 2007

Name	Location	Financial year	Turnover million €	Employees
Akzo Nobel	Amsterdam	2007	10.217	42.600
DSM	Heerlen	2007	8.921	23.254
Invista	Goes	2006	7.710	17.600
SABIC Europe	Sittard	2006	6.059	3.278
Dow Benelux	Terneuzen	2006	2.473	2.142
Huntsman Investments (Netherlands)	Botlek	2005	2.298	3.221
ExxonMobil Chemical Holland	Botlek Rotterdam	2006	2.268	415
Lyondell Chemie International	Rotterdam	2006	1.539	678
SABIC Innovative Plastics	Bergen Op Zoom	2006	1.427	1.380
Eurocil Holding	Amsterdam	2006	1.134	2.576
ADVANSA	Hoofddorp	2005	922	2.510
Ten Cate	Almelo	2007	886	4.020
Reichhold Investments	Rotterdam	2003	699	1.821
Sobel Best	Best	2004	684	4.573
Hexion Specialty Chemicals	Hoogvliet Rotterdam	2006	649	374
Shin-Etsu International Europe	Amsterdam	2005	634	675
Yara Sluiskil	Sluiskil	2006	601	601
FUJIFILM Manufacturing Europe	Tilburg	2007	517	1.040
DuPont de Nemours (Nederland)	Dordrecht	2006	480	857
Thermphos Holding	Ritthem	2006	480	1.142
Promens Group	Zevenaar	2006	462	4.069
Teijin Holdings Netherlands	Amsterdam	2006	438	1.322
Teijin Aramid	Arnhem	2006	416	1.128
Basell Benelux	Zaventem, België	2005	411	128
PolymerLatex Holdings	Luchthaven Schiphol	2004	390	690
SigmaKalon Deco Nederland	Uithoorn	2006	380	1.202
INEOS NOVA European Holding	Breda	2006	349	680
International Flavors & Fragrances I.F.F. (Nederland)	Nilversum	2006	315	769
Stahl Group	Amsterdam Zuidoost	2007	311	1.349
Vibac International	Amsterdam	2006	308	903
Total top 30 firms			**54.381**	**126.997**
Total sector			**60.701**	**171.967**
Share top 30 of total sector			**89,59%**	**73,85%**

Turnover and number of employees for legal entity including foreign operations, as registered with the Dutch commercial chamber (KvK).
Firms publicly listed shaded in dark grey; Firms owned by publicly listed firms shaded in light grey.
Source: TNO / KvK data

4.2 What indicators should be used for benchmarking?

Sustainability reports are based on the triple P approach – planet, people, profits. There have been a number of reporting standards been developed. One of the best known, the GRI (Global Reporting Initiative), has also developed sector specific supplements for reporting. So far no sector supplement for the chemical industry has been developed (GRI, 2009). Following very complex reporting guidelines and a large set of variables, firms can choose to report at six different reporting levels (A+ to C) and let third parties certify their reporting standard. This means that it is even difficult to benchmark the chemical firms choosing to report using the same GRI standard, depending on the reporting choices they make. Next to that the GRI guidelines have specified a large set of indicators, covering economic, environmental, human rights, labour, product responsibility and social indicators. In total this sums up to more than 100 indicators, which makes it difficult to come to useful conclusions.

Furthermore, most importantly, there is no sector benchmark comparison included. Instead, firms normally compare their activities over time. With productivity increases and inflation this leads automatically to positive results over time. For policy-makers to use benchmarking as a way to guide the sector's sustainability activities this is the most important issue to take into account.

Health, Safety and Environmental data reporting: 'Responsible Care'

Currently chemicals firms report health and safety and environmental data to the Dutch authorities, which are also used for the 'responsible care' reporting of the sector. The responsible care programme is globally coordinated by the chemical industry trough the Responsible Care Global charter. Next to the responsible care reporting, many chemical firms have been active in the last few years publishing sustainability reports following diverse guidelines and standards (e.g. GRI). Instead of choosing one of these standards, in 2008, the VNCI chose to broaden the already established responsible care reporting. This new agreement, signed by all VNCI members to increase commitment of firms, was signed by the person carrying responsibility for the firm in the Netherlands instead of individual plant managers. This also reflects an important change in reporting, that in the past focused on production activities (HSE of plant) to firm activities, including economic and market activities. The firm then is itself responsible to let the 'right' people fill in the required information (e.g. plant managers).

The following tables present the results attempting to benchmark two key Dutch firms using a selection of core indicators.

Table 4.2 Sustainability indicators DSM

Category	Variable	Unit	2008	2007
Profit				
Economic	Value Added	€		
	Number of employees			41.440
	Hours worked	h		
	Productivity	€/h		
Financial	Turnover	million euro	9.297	8.757
	Cost of sales	million euro	7.940	7.510
	Labour costs	million euro	1.465	1.389
	Profits	million euro	903	823
	Eco-premium products	% of turnover		

Category	Variable	Unit	2008	2007
Profit				
	Sustainability integrated in business strategy	Yes/No	Yes	Yes
People				
Health and Safety	Fatalities employees	number	1	
	Total reportable injury rate employees		0,72	0,82
	Lost time injury rate employees		0,2	0,26
	Occupational illness rate employees			
	Total illness absence rate employees		2,5	2,4
H&S contractors	Fatalities contractors			
	Total reportable injury rate contractors			
	Lost time injury incidents contractors			
Employability	Training expenditure	€ / turnover		
	Training time	h / employee	21	18
Planet				
Water	Fresh water use	Million m3	230	240
	per ton production	M3/t		
Energy	Total energy consumption	1000 TJ	71	77
	Net energy consumption index	%		
	Zero/low carbon power consumption	%		
	Energy productivity	€/J		
Waste and recycling	Total waste	kt	37,5	46,5
	per ton production	Kg/t		
	Non-reusable waste	kt		
	per ton production	Kg/t		
	Hazardous as % non-reusable waste	%		
	Hazardous (non-reusable) waste	kt	4,1	
	per ton production	Kg/t		
Air quality	Total CO emissions	mt	7,5	9,6
	per ton production	Kg/t		
	Direct CO emissions (Scope 1)	mt		
	per ton production	Kg/t		
	Indirect CO emissions (Scope 2)	mt		
	per ton production	Kg/t		
	COD emissions	kt	7,6	11
	per ton production	Kg/t		
	VOC emissions	kt	8,8	9,2
	per ton production	Kg/t		
Supply chain	Environmental incidents	number	539	540
	Environmental complaints	number	78	96
	Vendor policy signed by suppliers	%		

Table 4.3: Sustainability indicators Akzo Nobel

Category	Variable	Unit	2008	2007
Profit				
Economic	Value Added	€		
	Number of employees			41.440
	Hours worked	h		
	Productivity	€/h		
Financial	Turnover			
	Cost of sales			
	Labour costs			
	Profits	million euro		10.217
	Eco-premium products	% of turnover	18	18
	Sustainability integrated in business strategy	Yes/No	Yes	Yes
People				
Health and Safety	Fatalities employees	number	0	1
	Total reportable injury rate employees		4.6	5.3
	Lost time injury rate employees		1.9	1.9
	Occupational illness rate employees		0.3	0.3
	Total illness absence rate employees		2.2	2.2
H&S contractors	Fatalities contractors		0	1
	Total reportable injury rate contractors		5.2	–
	Lost time injury incidents contractors		–	66
Employability	Training expenditure	€ / turnover		
	Training time	h / employee		
Planet				
Water	Fresh water use	Million m3	297	304
	per ton production	M3/t	15.8	16.0
Energy	Total energy consumption	1000 TJ	115	116
	Net energy consumption index	%	88	87
	Zero/low carbon power consumption	%	73	73
	Energy productivity	€/J	?	?
Waste and recycling	Total waste	kt	285	?
	per ton production	Kg/t	15.1	?
	Non-reusable waste	kt	86	84
	per ton production	Kg/t	4.5	4.4
	Hazardous as % non-reusable waste	%	26	23
	Hazardous (non-reusable) waste	kt	23	19
	per ton production	Kg/t	1.2	1.0
Air quality	Total CO emissions	mt	4.6	4.7
	per ton production	Kg/t	247	249
	Direct CO emissions (Scope 1)	mt	1.6	1.7
	per ton production	Kg/t	85	87
	Indirect CO emissions (Scope 2)	mt	3.0	3.1
	per ton production	Kg/t	161	161
	COD emissions	kt	2.9	3.1
	per ton production	Kg/t	0.15	0.16
	VOC emissions	kt	4.0	4.9
	per ton production	Kg/t	0.22	0.26

Category	**Variable**	**Unit**	**2008**	**2007**
Profit				
Supply chain	Environmental incidents	number		
	Environmental complaints	number		
	Vendor policy signed by suppliers	%	82	81

The indicators falling under the profit section include economic indicators that are normally not reported by firms but are of interest as they are less subject to manipulation, compared to accounting measures such as different types of profits. However, these (e.g. value added[6]) cannot be easily calculated from the financial statements of firms as labour costs are frequently not reported.

The indicators falling under people are mostly available as they largely consist of compulsory measures under the responsible care reporting. However, few firms report total training costs or training hours per employee.

The indicators falling under planet are also largely available as they also consist of compulsory measures of the responsible care reporting. One very useful indicator is energy productivity. It measures the energy input used by a firm for one unit of value added. It is an attractive measure as it directly relates economic output with energy input, being of key importance to monitor effectiveness of energy use. Currently, it is not easily possible to calculate this measure as value added is difficult to calculate.

While the listed indicators here are not comprehensive, the advantage is that they more or less represent data that is already collected but not necessarily publicly reported. If all indicators could be filled in, composite indicators could be constructed to summarise and compare performance of firms. This would enable clear comparisons, rather than the currently more than hundred variables that are reported in sustainability reports, making drawing conclusions challenging.

Next to that it is difficult to interpret these indicators without a clear sector benchmark. However, this could be calculated if reported HSE data of chemical firms to public authorities are used for this purpose.

4.3 Next steps

Benchmarking a selection of key firms in the chemicals sector can be an effective tool to monitor and guide the sector's sustainability activities. Currently, some firms do this voluntarily driven by corporate social responsibility agendas and investment indices such as the Dow Jones Sustainability Index.

However, it is currently difficult to exploit the reporting data to benchmark the sector. Without this sector benchmark an opportunity for best practices in the sector is lost. This could be changed without too much additional efforts.

1) Firms should agree and report according to a single reporting standard to increase transparency and make results comparable. This could be facilitated through the

[6] Value added is calculated as: 1) turnover – operating costs + wages, or 2) sum of labour costs, interest rates and profits.

Dutch industry organization VNCI, and even coordinated internationally coordinated with sister organizations to prevent national solutions. E.g. the Belgian Chemical industry organization for example has chosen to use the GRI as reporting standard. The sustainability index of the American Institute of Chemical engineers (AIChE) is another example of a sector specific sustainability index that could be used as a basis (AIChE, 2009).

2) The currently reported data to the Dutch authorities on health and safety and environmental indicators should be made publicly available at firm, rather than plant level. This allows calculating clear sector benchmarks.
3) The current indicators reported to the Dutch authorities should be revised to reflect developments in sustainability measurement, and possibly complemented with economic indicators. Furthermore, the goal should be to stimulate continuous improvement processes, reflecting technological and economic potential.

5 Conclusion

5.1 Sustainable products and production key for future competitiveness

Overall, there is little disagreement in the sector that innovation and sustainability is of key importance for future competitiveness. Europe cannot compete on costs, with few own raw materials and higher transport costs, and hence can only compete with other regions on productivity and performance. In future resource productivity will supersede labour productivity in importance, with more than 9bn people requiring products and services in 2050 despite a finite resource base. When talking about competitive sustainability we hence talk about the products and services of tomorrow's markets. Leading the path towards these markets is not so much an option for European firms but a necessity to sustain its leading position. This thinking is also reflected in the ambitious goals of the Dutch Regiegroep Chemie. However, the ambition of doubling the chemicals sectors contribution to Dutch GDP within 10 years, while halving fossil raw material use within 25 years seems very far away, despite efficiency increases. Furthermore, also policymakers are disappointed that many sustainability agendas and plans are made but that a transition does not happen.[7]

5.2 Policy-efforts focus largely on technology development (supply side)

One of the reasons that a transition to sustainable products and production is not happening, is that policy efforts focus largely on supporting technology development and consumer information campaigns. While this is certainly an important component, both show limited effect so far. Instead, it is the market framework that decides what products and services are supplied and demanded to the marketplace. However, markets are subject to a much stronger force, globalisation, shaping current products and services. Another issue is that the economic framework so far leaves many choices in relation to sustainability to the individual, rather then regulating these.

5.3 Demand side and framework conditions for new markets to emerge at least as important

However, more and more research shows that the average consumer is far from the assumed 'homo economicus' that makes rational decisions. Instead it seems that there are still behavioural patterns from our ancestors deeply engrained in our psyche. A chimpanzee for example chooses one banana now over 10 bananas offered in 4 hours (). This highlights the short-termism that one can frequently also observe in decision making of humans.

Next to that, although a social animal, people pursue their own interests. The environment being a communal value suffers from this – as individuals benefit from overexploiting natural resources at the expense of others that only get to feel the negative externalities. Currently this is in the form of pollution and - in the future – it

[7] The European Commission has stated this as a reason to call for research proposals researching how jobs need to be adapted and are created in context of a socio-ecological transition (Framework Programme: SSH.2010.2.1-1).

will be in the form of a lack of resources. In other words the interests of the individual do not necessarily match the one's of the community. This factor gets a dangerous dimension with the distorted self-perception of people that also seems to be deeply engrained in people. As the Greendex (2009)[8] study shows, people often do not perceive their own actions as part of the problem. Instead it is the others that should change their behaviour.
For example the lowest values are scored by consumers from the richest countries when asked whether their personal lifestyle is harmful to the environment. Interestingly, the people in developing countries and primarily the BRIC countries, that produce large amounts for the industrialized countries, score much higher (Greendex, 2009, p. 27). Similarly, few people in industrialized countries agree that they feel guilty about the impact they have on the environment (Greendex, 2009, p.61). A good example for how the benefits of resource consumption are separated from the negative externalities, without the polluter being aware of the negative externalities. Furthermore, with few negative consequences felt, there is little incentive for people from industrialized countries to change their behaviour. The survey supports this revealing that North-West Europeans score the lowest values thinking that global warming will worsen their way of life in their life time (Greendex, 2009, p.66).
With that in mind, we can also expect little from politicians as they represent the wishes and needs of the electorate and get punished if taking painful decisions as the social reforms throughout Europe over the last decade impressively show. Europeans are less concerned about climate change, water and air pollution and more concerned about economic issues (Greendex, 2009, p.27). Furthermore, the values of individuals show an addiction to prosperity that leads to overconsumption. Instead, sustainability currently remains a luxury for highly educated people that have time and money to think about the world's problems. As long as these framework and demand conditions prevail, sustainable production and consumption will remain a niche without a large scale transition.

5.4 Effective policy tools and framework conditions

The sector analysis indicates that certain tools have more effects than others. Subsides are useful for stimulating the supply side. Uniform standards help market formation and realize efficiency gains. Compliance with regulation is a strong stimulus for innovation reducing material and energy use as well as pollution. Education and learning are vital for consumers to be able to make informed decisions. Lastly, production and consumption taxes are an effective way of allocating externalities to polluters and consumers. However, these are notoriously difficult to implement. There is hence no golden bullet. Instead, an effective combination of policy tools needs to be used to leverage effects. Three areas are particularly important in this context: provision of infrastructure, use of the price mechanism, and effective regulation and guidance.

Infrastructure
Often new infrastructure is needed for new markets to emerge. For example, second generation biofuels require an infrastructure to collect and process biomass. This is too big a task for single firms to develop and provide without support from the government. However, while government does have support mechanisms, these are often splintered (e.g. EZ, VROM and others) and often too bureaucratic and small scale to have an

[8] The 'Greendex' study is a global consumer survey into sustainable consumption covering 29 countries. It is an annual study financed by National Geographic and executed by GlobeScan.

impact. Next to that support focuses on research. However, rather than more research in the lab, the chemicals sector needs support with the implementation and scaling up of sustainable production processes. Currently, the support that is there in the Netherlands is nice to have but too small and splintered to really have an impact.

Price mechanism
The price mechanism provides an enormous force as it directly effects the underlying economics of decision processes. While it can be an enormous driver, as the high oil prices in 2007 and 2008 have shown, it can also be a barrier to sustainable production and consumption. Namely, if it is not economically attractive for firms to develop more resource effective or environmentally friendly products and processes. Generally, there are many potential alternative products and processes, however, these will only be used on a large scale by firms if economically attractive. Generally, it is possible to steer this mechanism efficiently with production and consumption taxes. However, the products and processes in the chemicals industry are too specific for a practical implementation. An alternative could be set up specific funds supporting investments and innovation in alternative production processes.

Proactive guidance
For public authorities to be able to implement tools using the pricing mechanism, but also support technology development and new infrastructure, high quality information and evidence is needed for decision making. Firms know that only if able to measure sustainability is it possible to successfully integrate it into business strategy. This insight is based on the famous quote of Peter Drucker: “You can only manage what you can measure”. This applies to authorities just as much as to firms. Rather than collecting information to check compliance with health and safety and environmental regulation, authorities should use this information to guide continuous improvement processes in the sector. A sector benchmark would be a first step towards this. In the long term this would also allow to design smart regulation that takes into effect technology advances, economic effects and structural differences between products and production processes within the sector.

Key for successful implementation of policy tools remains their design and effectiveness. The problem is that during the political process, often good ideas are adapted to wishes of interest groups, resulting in ineffective or even counterproductive policy tools. Rather than introducing more and more regulation, less but smarter and better targeted policy tools should be used towards guiding economic activities towards sustainable production and products, while ensuring their competitiveness in a global economic system.

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