Focussing Innovation Strategy for Sustainability in Chemical Industry

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Summary
Innovation in a company is as essential for sustainable development as it is for continuing profitability. Much knowledge is available to innovate processes, products and activities. More is still being generated. However use of that knowledge is lagging behind and much is not used at all. There are many causes for this so called 'innovation paradox'. One in particular that the authors have observed in SME's is that there is an insufficiently clear view on where innovation should be aimed for in a specific business. If that is not clear, it is also uncertain which knowledge is needed. Certainly when it concerns innovation in relation to sustainability, the complexity of the issue hampers a clear view on necessary goals and possible approaches.

A practical method is developed therefore to focus on the key issues which form the company's major challenge for sustainability and continuity: FOCISS method: 'Focussing Innovation Strategy for Sustainability'. Its aim is to connect sustainable development with the core business and business continuity in a relatively easy and fast way. It has been developed and tested in cooperation with different industries: electronic, mechanical and various chemical companies, large ones and SME's. The results are promising.

The method involves a stepwise approach, focussing on key sectors and key issues. An inventory is made of knowledge and views in the company on relevant issues and possible options to address these. Preferably other stakeholders, as authorities and NGO's, are involved. Eventually it leads to the selection of innovation options. The stepwise focussing approach, using interviews and workshops, reduces the amount of work. Only those sectors, and subsequently issues and innovations, are worked out in detail, which are considered to be crucial for continuity. Furthermore by bringing together people and their views on these subjects from the various departments, the visions and knowledge of these issues and options are discussed between people throughout the organisation. It leads to better understanding between the people involved and to real commitment for implementation of the necessary steps.

Sustainability, system approach and transitions
A company needs to have insight in the role it has in sustainable development. Because that appears to be a complex issue, most don't even try to find out. Therefore sufficient insight is often lacking confusing discussions about innovation and leading to approaches, which are not optimal or even are ineffective. The right choice for profitable innovations cannot be made without understanding the basic issues and backgrounds.

Sustainable development means essentially 'that we wish for a society with the economic basis, in which it is still pleasant to live, in 20, 30 years and farther ahead'. Without that we will run into innumerable economic, political and socio-cultural problems, such as we already observe increasingly today. The changes that are required, in society and in the economy, are sizable and often quite radical. As an example the efficiency of resource use of our economy must increase with a factor 10 till 20. [1] It is clear that this will not be achieved by improving existing technology or even with radical new technology alone. A different way of using

technology and the way we organise 'fulfilment of our needs' is needed. Society and economy are organised through so-called socio-economic structures: the 'systems' that take care of the needs we have: food, travel, housing, leisure etc. They are made up of many components, technical and organisational ones [2]. How such systems are organised and used is strongly influenced by 'culture', with differences between individuals, groups and nations.

Those systems are continuously changing. When looking back in time, major changes in all systems can be seen, so-called 'transitions'. These are fundamental changes (innovations) in the system implying coherent - and mutually strengthening - developments in technology, economy, culture and organisation. Examples are the introduction of steam power, the change from coal to gas for heating of homes, the introduction of cars for mass transport, the introduction of ICT. During such transitions organisation and culture change fundamentally along with technology: society and economy looked totally different afterwards. As an example consider the cultural changes the new modes of telecommunication recently brought about and the 'shaping of Western society' by electricity and auto mobility.

For sustainable development such transitions are needed too, but not 'just a transition'. Society and the market will have to respond to already existing and foreseeable developments, needs and constraints. 'Sustainable transitions' will need 'focus', for instance leading to production systems that use much more renewable resources and require less transport and to products that enable people to use much less energy in their households and are easy to recycle without much loss of resources. It is a subject of much debate, whether such a focused transition for specific situations will occur spontaneously, due to economic constraints and consumer preferences, or that external regulation is needed, and if these transitions will be easily incorporated or only take place after some 'crises'. That they will occur is certain.

Innovation paradox

To adapt to these changing economic and societal conditions innovation is a must for companies. The need for sustainable development is already a major driving force for research and new developments, certainly also in chemistry and chemical technology. Many new processes, compounds and applications are being developed. Substantial improvement in efficient resource use is possible by means of those new developments. Production installations can be downscaled and production time reduced [1].

This new knowledge in chemistry is essential for innovation in other areas as well. Chemistry is a generic function for the economy. It supplies the compounds, materials and intermediary products for all other economic activities. Sustainable development in other fields is not always possible without development of new compounds, materials and products (figure 1). Innovation in chemistry is essential for and even a driving force for innovation in other economic areas.

However, in order that actual, sustainable innovation takes place, this new knowledge should be used: innovation is not 'developing something', but 'applying something' in a novel way. That often does not seem to happen or at least not as fast as seems possible and necessary.

Of course, the required fundamental changes in systems might need much time. Nevertheless, there appears to exist an 'innovation paradox': it can be done, it is often economically sound, already now, but certainly in the long run, however it doesn't seem to happen or at least not very fast [3]. It seems that companies are not aware of or interested in the options by means of which they can play a role in sustainable development and become more sustainable themselves. There is insufficient investment in time and money for the necessary new approaches to ascertain future continuity and profitability.

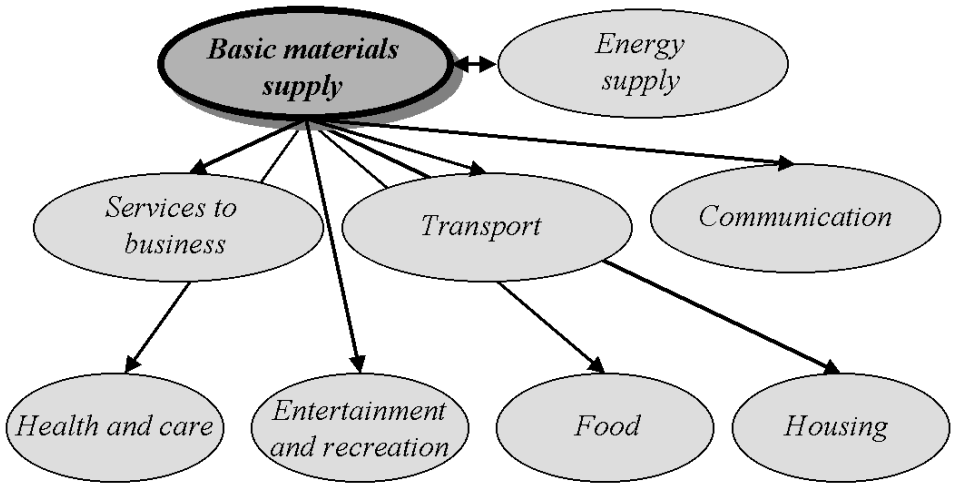

Figure 1 Chemistry as generic function in society

A major cause for this so called 'innovation paradox', is that it seems very complex to determine which innovation options are really feasible or even crucial, certainly for smaller companies. Most companies agree that innovation and sustainable development are important issues for their company. At the same time they indicate that they find it very difficult to determine what it implies for them in practice, certainly when accounting for longer-term developments. Sustainability appears to be a too complex matter involving too many issues and too many different actions at the same time. That system transitions will occur adds to the complexity, of course. They are not able to define how and how much this will change their business strategy, daily operations and ultimately the path they have to choose for staying on a profitable course. As yet, choices for innovations are made rather ad hoc, based on short-term drivers and on short-term profit expectation. Long-term developments are not taken into account. The question is how to change that attitude?

Innovation for a sustainable strategy

Companies play a major role in socio-economic systems. Those systems will change as a result of sustainable development under pressure of the economy and the society as a whole. Therefore a sensible business approach must take into account the changes that will occur in such 'sustainable transitions'. Companies must change course in order to survive: 'sustainable business'!

Transitions take place on three different levels: within the production sector itself, at the production chain level or at the level of society as a whole (figure 2). [3] For the chemical industry that implies the following. On sector level the own production processes must be made as clean and eco-efficient as possible. It concerns also optimising the added value (economic, ecological and social) of the sector and taking advantage of the new business opportunities sustainable development offers. On the chain level chemical industry, in cooperation with suppliers and clients (which are also industries, such as builders, food production, car manufacturing etc., chemistry is a generic function!) should make the material chain, from basic resource till 'waste' as 'lean' and 'eco-efficient' as possible and supply the means so that 'the material chain is closed' by minimising losses and reuse.

On the societal level chemistry faces the challenge to develop and supply the means (materials and products), which can supply in a sustainable manner in the needs people have (energy, transport, food, housing etc.).

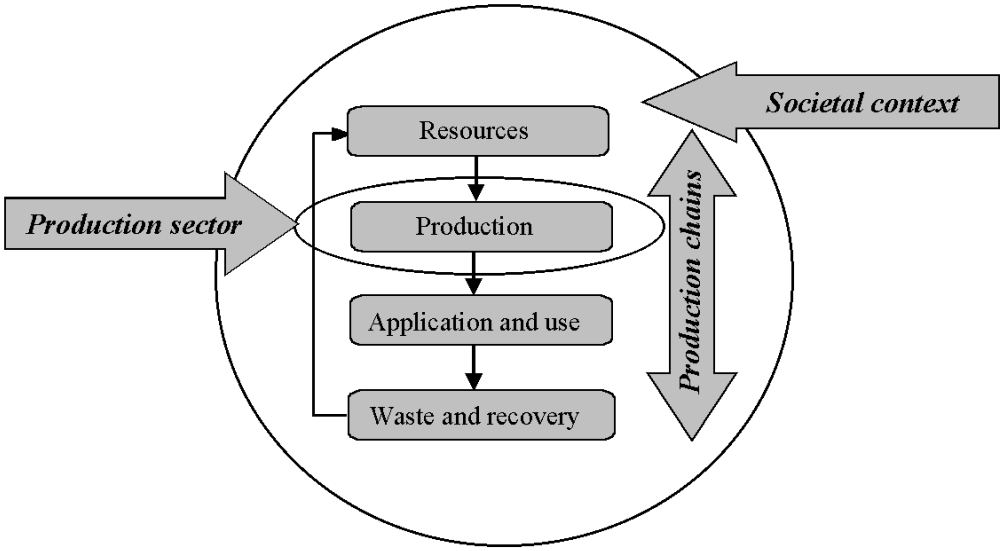

Figure 2: Three levels of transitions within chemistry

Most companies address only the production sector level with 'sustainable business' development. The 'Planet' aspects (environment, resources, ecology) and 'employee' related aspects (labour conditions) are thus emphasized. Many companies, certainly those in the chemical industry, have an environmental management system, have adopted Responsible Care approaches and extend that to sustainable business on this level. Certainly when the role a company plays in chains and systems is considered, that is insufficient. The third level is at least equally important. Here, in particular the 'people' aspects (prosperity, well-being, quality of life etc.) play an important role. Not only the eco-efficiency of chemical industry on sector or chain level is important, but also the relation between production and consumption and the right way (also in societal responsible sense) to respond to the societal needs, locally and globally. It does not concern 'just making products in the right way' but also making the 'right products'.

To integrate that into a general framework for sustainable business management approaches are being developed [4]. But in particular to integrate second and third level considerations, constraints and goals into an integrated management system for sustainability, a coupling must be made to innovation management in order to ascertain the continuity of a company. Because sustainable development and system transitions are rather complex, defining the role and the interests of a company in those structures appears to be hardly possible.
However in practise developing a sustainable business strategy for innovation should be possible. The aspects and issues that are really crucial for a company are limited. It has been proven to be possible by choosing the right focus for the company's strategy and a limited number of key sustainability areas that are specific for that company in view of its character, products, location and ambitions.

Figure 3 depicts the steps a company must take to develop a 'sustainable business strategy'. First it must determine its role and interest in specific socio-economic systems, and how sustainable development might change them e.g. through system transitions that will occur as a result of that. Secondly it must decide which developments concerning the relevant transitions are the most essential for its continuity (opportunities and risks!). Within those developments it must select the 'key issues' it has to face. For each issue it should try to find the best approaches / innovations.

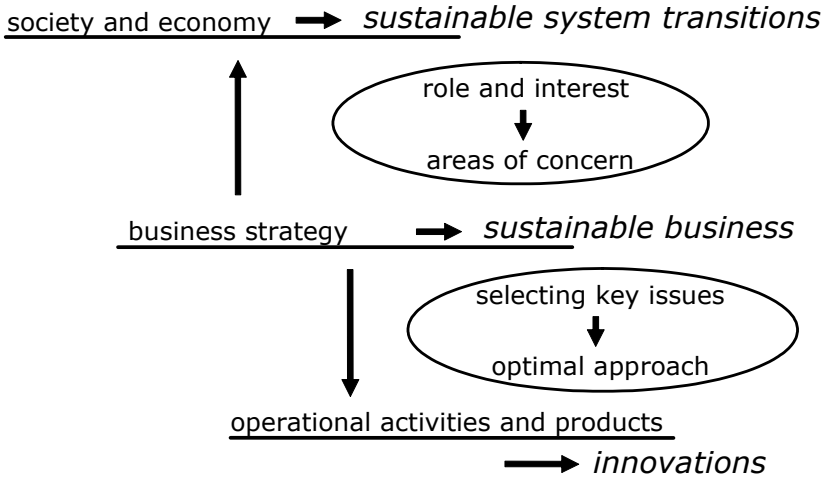

Figure 3 Selecting the innovations that are relevant for a business in a changing system

Description of the FOCISS method

Especially for a small company selecting the key issues in view of sustainable innovation is not an easy task. A method has been developed to assist companies, particularly SME's, in this matter: FOCISS 'Focussing the Innovation Strategy for Sustainability'. The method is developed and tested by TNO, the HAN and the Avans University[1] in the Netherlands. [6]

It is based on two elements:

1. A stepwise focussing approach, by means of selecting at first the major areas of relevance for the company, secondly the major issues within these areas and thirdly the most promising (in view of economics and sustainability). This leads to a significantly reduction in effort and time a company and the advisors involved have to spend.[2] Only those issues that are in essential sectors are worked out in detail. And only for the issues that have been labelled with priority, innovations are sought and evaluated.

2. 'Selection and Reflection tools' designed and adapted for this purpose.
   a. A 'FOCISS matrix' to define the areas that must be discussed. It is made up by investigating the sustainability aspects within the Planet, People and Profit range with respect to the stages in the total production chain a company is part of. Figure 3 shows the basic outline. Each area is duly discussed, somewhat like the HAZOP method.
   b. A rating procedure for opinions concerning the importance of sectors and issues involved and the priority they should be given, is used during interviews and in the selection of key sectors and issues.

[1] Assisting SME's in introducing sustainable business with simple means, is the main objective of the research group Sustainable Business Operation (rgSBO) of the Avans University [5]. In cooperation with TNO (the Netherlands Organisation for Applied Scientific Research) the basic principles of a method to help industry to focus on sustainable innovation were formulated. The practical procedure was developed (under the acronym DOSIT) by TNO and the University for Professional Education Arnhem Nijmegen (HAN) and the rgSBO, with a grant from the Province Gelderland. It was further used in chemical SME's in the Province Brabant by the rgSBO and the Brabant Development Agency.

[2] That would not be the case when complete lists of all sustainability aspects are used. Such lists are very useful when evaluating the sustainability of a company for instance for reporting on performance. An example is the GRI list which is indeed an essential tool for that (www.globalreporting.org). When used to develop a strategy it would result in too many options and priorities to handle.

c. Inventory and translation of the known sustainability developments the specific company is confronted with into concrete issues: a so-called 'sustainability mirror'. For instance the larger issue of climate change is translated in future practical issues for a company, such as levies on CO_2 emission and emission trade, restrictions on energy use in general, options for renewable resources as well as new markets for substances and materials used for other forms of power generation and low weight materials for reduction of energy consumption.

The FOCISS procedure

Four or five key persons are interviewed using the extended sustainability aspects – production stage matrix (see: designing the FOCISS matrix). Those are staff members selected in such way that all of them together represent a good overview of the entire production chain (from cradle to grave) and possible external stakeholders such as customers and NGO's. They fill out all the sections in the matrix with relevant issues. And they have to give a score, based on how crucial the issues in that section might be for the company, with respect to continuity, sustainability and profitability. Issues involve risks and constraints, but also opportunities and new options for better performance. The information is gathered and discussed in a workshop with the staff and other parties involved. Based on this inventory, 3 or 4 key sectors are to be chosen.

In the second stage the issues from those key sectors are described and inventoried in more detail. In a second workshop subsequently 3 or 4 key issues are selected from that.

In the third step the possible innovative approaches to handle those key issues (risk or opportunity!) are being inventoried and described. A first evaluation of their economic effect and their real effect on the sustainability of the business is made. On the basis of that outcome, a choice is made for the most useful innovations in a third and final workshop.

Designing the FOCISS matrix

The matrix was developed to create a clear overview of all aspects that have to be reviewed.

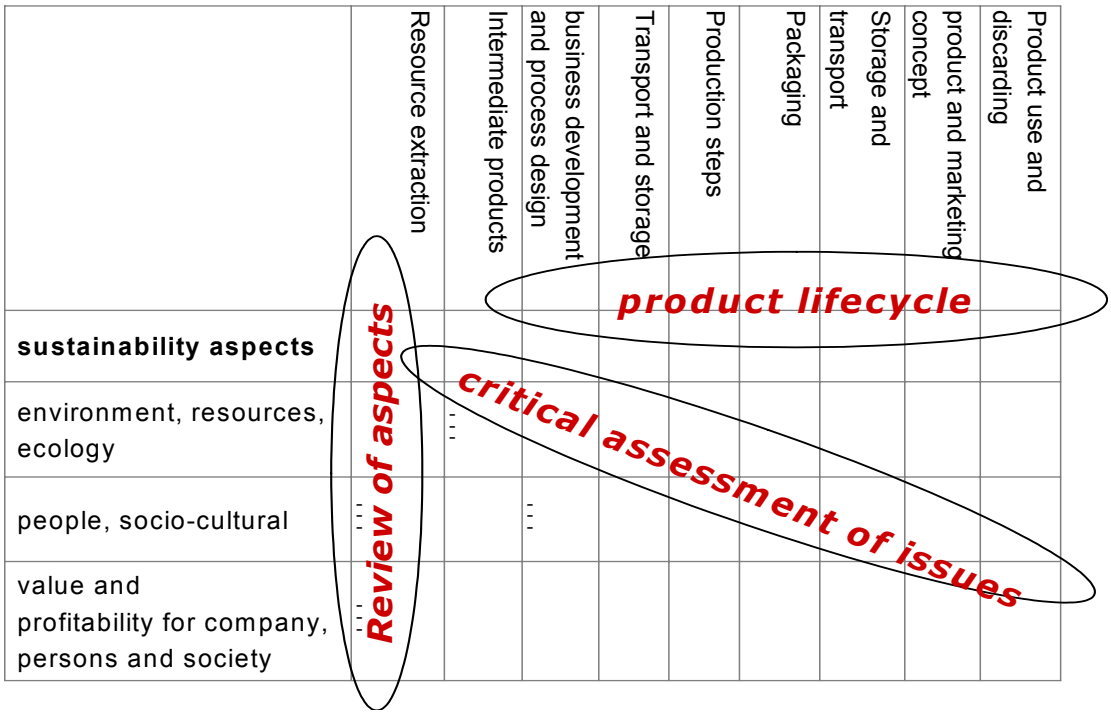

Figure 4 Basic outline of the FOCISS matrix as used in the inventory

In that way an inventory can be performed systematically without the risk to overlook any relevant aspects.[3] Such use of a matrix for environmental issues was proposed by Leopold [6] and applied in various other methods. The matrix has to be customized for a company.

On the horizontal axis are all the stages of the total production chain. Since these can differ from company to company, they have to be adapted for each individual case.

On the vertical axis the various sustainability aspects (from the People, planet, Profit categories) are clustered into about 10 to 12 groups. The standard set-up is normally not changed. It results in 80 till 100 matrix sectors to be inventoried. In practice it requires 2 till 3 hours per individual interview.

The system approach as element in the method

The method includes also other important elements, which makes it different from most other methods. The main difference arise as a result of looking at sustainable development as 'system transitions' in which a company has to find its place and the level of required change.

1. The initial focus is on sustainability prior to innovation. Commonly, at first an area for innovation is chosen on grounds of possible technical progress, costs and markets. However, an innovation that appears to be sustainable on itself, doesn't necessarily have to fit in a sustainable business strategy.

> *Examples:* one can invest in very innovative processes that use less energy that seems to be very sustainable. However when the product produced in that process it not useful in sustainable products, e.g. which use less energy or are easy to maintain or recycle, it is not sustainable in the long run, in the sense that it creates continuity for the company. We observe also that innovation in companies is often directly aimed at energy, for reduction or alternative sources, and on new processes that produce less waste, where the real issues for a company lay elsewhere such as uncertainty of resources and socio economic problems with their products. For instance: TV cook Jamy Oliver brought single handed a whole fast food industry on its knees when promoting good food for school lunches in England. That is also 'sustainability'. There are certainly parallels with chemicals in products e.g. PVC, softeners in plastics, aspartame etc. And more will come!

2. The method attempts to take into account the 'sustainable transitions' that could or will occur within the socio-economic system in which the company operates, and not just changes within the own activities and operations at the plant as frequently happens when discussing 'transition to sustainable business'. In our new approach, each selected innovation might therefore not have a 'sustainable look', but can be much more effective towards sustainability by facilitating a sustainable change in the system as a whole.

> *As example:* it is quite likely that a transition will have to occur in the transport systems as we know them. Changes are needed concerning energy consumption, but also concerning noise, safety etc. New, cleaner fuels and lighter vehicles are needed but insufficient to solve the entire problem. Just new manners of transport are insufficient. Reduction of the need for transport will be needed too, for instance by organizing production in a different way.

3. The level on which innovations have an impact are important. That determines how far-reaching an innovation will be and how complex implementation is. As is said innovations can be categorized according to the impact they have on the various levels of transition

[3] The HAZOP method to determine process safety issues, operates more or less in the same way.

(see figure 2). To assess that a 'simple diagram' was made which characterises the issues and innovations with respect to their impact and their complexity. With a higher level more changes are needed and/or caused in other parts of a chain and economic systems in which the specific company operates. Figure 4 gives such a diagram with some general issues and areas for innovation, which were discussed with the companies that participated in the studies.

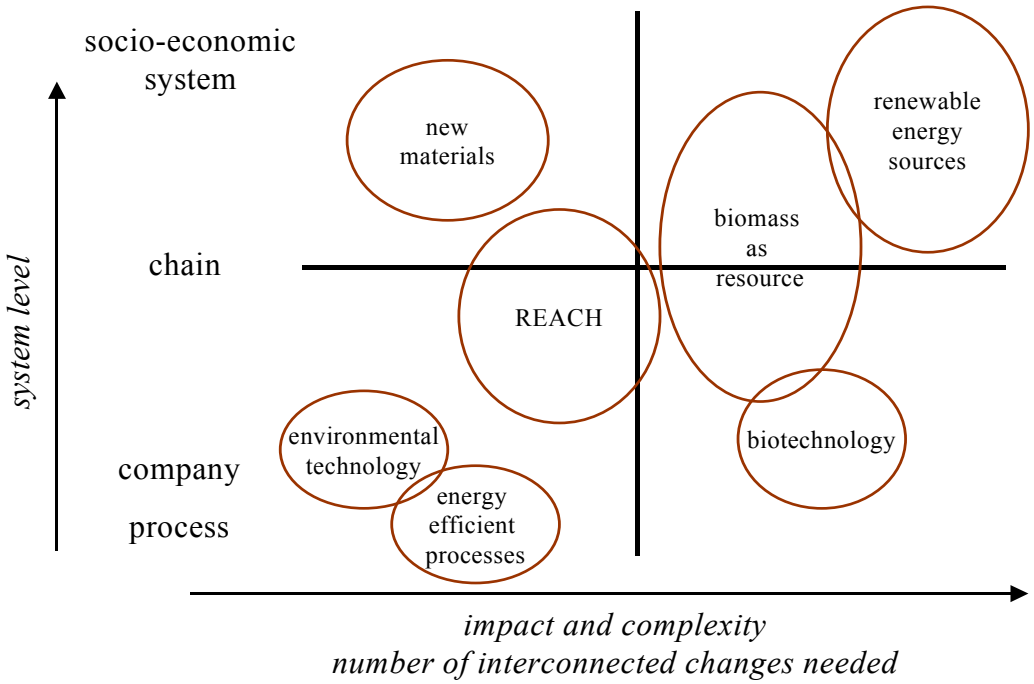

Figure 5 impact and complexity of issues and innovations in chemistry

Creating effective commitment

The method has advantages regarding commitment in the company due to some other factors:

1. application of the available knowledge within the company itself
2. better communication due to workshops
3. innovations based on own choices and decisions

It created active commitment within the company so that the implementation is really supported. Reports and recommendations from outside consultants are to often 'only gathering dust' because people too often do not feel involved and even resent it. Furthermore most companies, even the smaller ones, posses a lot more knowledge and insight in the relevant issues, backgrounds and available options than often recognized. It has not been made accessible before. The procedure and in particular the interviews are aimed to uncover that and make it useful in a structured way.

One of the functions of the workshops that conclude each stage is to share information. Information, problems, unknown aspects, but also possibilities and 'wild ideas' cross the boundaries that often exist in an organisation. Sometimes 'perfect' solutions were found that could not have come up without this mode of communication.

Certainly some additional research might needed for specific items and in particular to draw the 'broader picture' but the main body of information, views and conclusions is felt to be 'own'. As a result there will be a strong commitment to implement the results.

Results

So far, the method has been used in 7 chemical and food companies, SME's of different sizes but also independently operating units of large international companies. These companies produce a wide range of products, including fine chemicals, polymer specialties, modified natural products and fruit juices.

Their incentives to participate in these studies were quite different. Although most managers had to be convinced about the usefulness, all had to admit, mostly half way the procedure, that it proved worth the effort. About half of them indicated that they would directly use the outcome in drafting a strategy or directly by developing one of the innovations selected. The others pointed out that at the least it helped them in their efforts to get sustainable development on the agenda within their company and to motivate their activities in this field to their top management.

On average, per company 3 or 4 key sectors or issues were selected as crucial enough to evaluate in more detail. Of course many sectors that were selected were expected. However about one third of the sectors chosen did not get much or even any attention at all before.
Roughly we can distinguish three types:

- 'Expected sectors': Often the ones, which are already being dealt with in a company, scored high in the interviews. These commonly concerned the own production processes, better efficiency, less energy, reduction of waste. However they proved not always selected as the real top priorities for the future.
- 'To some extent unexpected': In every company one or more sectors, which were hardly considered up till then, received a high score. The main reason was that during the discussions a much better insight evolved concerning the long term consequences of changes in these sectors and the key issues there. One sector that arose for nearly all companies was the availability of essential resources. The issues associated with this subject not only concerned their future physical availability, but also the dependency of availability on uncertain socio-economic developments 'elsewhere'. Commonly such sectors and issues were ranked low played before, because they are not (easily) influenced by the company and are therefore given a low priority.
- 'Totally unexpected': in some cases totally new key sectors of attention emerged that had been overlooked before, because the adjacent issues were not considered to be essential. An example of this is packaging, which, based on the information arising from interviews and workshops, proved to be much more a point of attention for customers then most people in the company where aware of.

Issues and innovations in these of the unexpected sectors will need more time and even cause frictions. Traditional decision procedures and fixed investment programs will have to be changed. Besides, even more drastically, the focus of research must change in some fields and new research started.

The next stage in the method is the selection of key issues within the key sectors. In each sector a number of issues was mentioned in the interviews. Not surprisingly, a lot of issues were not known to all persons involved. As stated before, this can be considered a major advantage of the approach. With the small number of studies performed so far, no statistical analysis is possible about which issues appear to be dominant. Actually, during the studies the range of issues emerging was very wide indeed.
Something else was also Interesting to notice. Initially the fact that the people involved would only focus on issues specific for their own work field was seen as a draw back of the method, creating a strong bias in the result and leading to 'white spots'. In practice many employees

themselves mentioned nearly always all issues that could be thought of by the consultant by means of the 'sustainability mirror's. Apparently, there is a high awareness about the issues that concern the own company, as seen by other parties and stakeholders too. That might be typical for the chemical industry, due to the discussion in society about the risks chemical industry poses and the 'Responsible Care Program' that has been developed because of that.

The innovations selected

The last step in the method is the selection of the most optimal innovations to deal with issues in such a way that the company profits and sustainability is observed. One must distinguish between three types of innovations, regarding the level of impact on one or more sectors and issues. To some extent that parallels the impact the company has with the innovation on the three levels of transitions as described above.

1. changes concerning one specific issue in a key sector have no large impact on other issues or sectors and have an effect on the production level of transitions. (for instance a better separation, a new process, environmental measures)
2. changes in several stages, in the chain, occur and are needed, and lead to changes in the way the chain operates, and to 'integrated innovation'. Examples are: choosing a new resource which leads to new processes and somewhat different products; Attention for socio-economic factors when buying 'cheap materials', which are produced under disputable conditions and could lead to averse reactions with NGO's and in due course with customers.
3. 'revolutionary changes' in the way the company operates, in its products and/or in the way it helps society 'to take care of its needs'. For instance changing from an oil producer to the production of solar cells)

examples from the pilots for the different categories.

1. Recycling of water to reduce the amount of water used. A new process with fewer reaction steps reduces energy use, use of resources and the amount of waste produced. A biodegradable plastic for packaging enabling customers to dispose waste more easily.
2. Options to reduce transport in view of costs, risks, traffic congestion, problems with the living environment of the company etc. That could lead to other ways of production, production on site, other processes involving less or less hazardous chemicals etc. Changing to biomass as raw material instead of oil or gas based resources is possible when changing to bioreactors. At the same time a new range of products is feasible. But many other changes are needed everywhere in the chain. The same is the case when striving for maximal recycling of materials.
3. No examples in this category were selected. However, see the next box for a feasible option that might be picked up in future by the company.

Most innovations that were proposed fall clearly in the first category. These are the easiest to think off, are often already available and relatively simple to implement.

The second category reflects many ideas from companies themselves, but these are not easily selected nor developed further and implemented. Commonly the obstacles and risks are considered to be too many, certainly when it concerns really new technologies or ways of operating. Some innovations that can be considered as examples for this category are clearly selected because of external pressure leaving no choice, for instance the reduction of transport of dangerous materials.

The last category of innovations is of course the most difficult to implement. When a company has a role in a 'system' that is expected to go through a necessary drastic 'transition', as for energy, agriculture, transport, such an innovation will be necessary. That will not ask immediate drastic changes but changes made now will have to fit in a direction that 'third level innovation' will necessary go.

Example of a third category innovation.
A company uses waste from slaughterhouses as resource for their products. The key issues involved are (with high risk potential):
- uncertainty of supply because of changes in agriculture and outbreak of diseases;
- acceptability of materials from animals because of fears for diseases (BSE);
- customers looking for more alternatives suiting their ever changing demands better.

Related issues in other key sectors are:
- processes and reactors are rather specific so it is not easy to change resources or processes;
- operators need to be trained for these processes causing inflexibility in the operations and problems when someone leaves unexpectedly or when production must be increased.
- environmental issues specific for the materials and the processes (smell, waste water, fatty waste)

For all issues specific separate (first category) options for improvement are available. One integrative change emerged, which involved all sectors and applies to many issues: production of the specific product series through biotechnology with modified microorganisms. That would open the possibility of making other commercially interesting products using the same type of processes, in that way increasing flexibility too. Most importantly, it would make the company independent from the 'subsystem cattle raising' within agriculture, which faces a drastic transition in the foreseeable future. Of course, this creates new sectors of attention and issues to be solved. On first sight however it offers much potential. The dilemma here is the size of the company, which makes its involvement in the research and development taking place in this field difficult.

Training as important 'People issue' for chemical industry

A very specific cluster of issues and required innovations, which emerged for nearly all companies, concerned the availability of people with sufficient training. Overall the level of training necessary for operators and other staff in chemical plants is increasing. At the other hand the number of people interested to study chemistry and engineering on all levels of education is dropping. Just moving the production to areas where more trained staff is available is not feasible in most cases. That also will require new processes, requiring less staff, with better work conditions. Besides far-reaching innovation, using new areas of development might make the whole field more challenging and attractive again for young people.

Conclusions and remarks

The companies involved in the first surveys of the FOCISS method agreed that the approach leads to a selection of 'essential sustainability issues and innovation courses' over a broader range of areas than they where used to. Besides, by using this method, sustainable development was translated to something that a company 'recognizes' as vital to its core business. In that way they became much more aware of the crucial importance of sustainability issues for their strategy and future profitability. It was made clear that developing a sustainable business strategy was less complex then it appears at first sight. One can and actually should concentrate on a very small number of issues. That makes it feasible. At the same time the procedure followed created a platform for extensive internal communication about the issues, views and ideas for options. It generates and strengthens the commitment within the company to change course indeed and with a profit.

The method has a message for research and knowledge institutes as well. Companies need to concentrate on a few issues and in result of that they require only specific knowledge and innovation options. Before they start asking for that knowledge or options for innovation, they need to know what is really necessary. Just offering new developments 'because it is

innovative' or 'good for sustainable development' will not work. Research and knowledge centres should take into account the way companies decide to innovate and help them to do so efficiently. Otherwise they have a store full of knowledge, but customers that are unable to make a shopping list.
At the other hand better understanding the 'innovation needs' a specific company has, might lead to another focus or even a totally different scope of research. The question must be, are research time and efforts actually sufficiently spend on what companies need and society requires from those companies, and what is needed in view of the transitions in which companies must play a role?
Better insight and better focus of research in this respect could solve the innovation paradox to some extent.

It is not surprising that chemistry, chemical engineering and chemical industry take the lead in this [1]. The decennia long discussion concerning chemical industry has made the branch quite aware of the issues and the need for continuous improvement and sustainable development. Many chemical companies do have a well-developed care system and take an active role in Responsible Care. It is the best basis for further development of the existing care systems for environment and safety into sustainable management tools by introducing the means for sustainable innovation strategy. Besides, chemistry has to do its share in solving the innovation paradox for sustainability, because it plays an essential role in supplying the new and innovative products and processes other economic activities require: all transitions will need new chemistry in one form or another.

Notes and literature

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