SubChem
sustainable substitution of hazardous chemicals

public paper

Project results • May 2004

Reducing risks by substitution – tenacious and risky, but necessary

The aim of substituting hazardous substances in products and processes is to limit health and environmental risks at their source.

In the *SubChem* project the substitution of hazardous substances was viewed as an innovative development process. Thus, the following questions relating to the ability to create innovations were the focus of the project:

- How can economic, state and civil society actors successfully interact to bring about innovation?
- How can substitution duties be integrated in the management systems of single enterprises or of corporate networks?
- How can the economic actors involved in the particular economic supply chain achieve greater certainty as to which innovation trend actually does avoid risks and which actions only serve to shift the problem?

Several strategies for more efficient and more effective risk management can be derived from the results of the project:
On the one hand, the framework conditions must continue to be developed to ensure that they encourage self-sustaining competition for best chemical safety as an element of quality related to processes and products. The aim is that innovations are implemented without any prior intervention in the form of regulations or hazardous substance scandals.
On the other hand, it has become evident in the course of the *SubChem* project that innovation and substitution cannot be achieved solely on the basis of reviewed scientific knowledge of (eco)toxicological effects. New management aproaches are required to transform the concept of precaution into reality:

- Models for the development and composition of "intrinsically safe" products and application systems as well as
- an extended system of risk management, which spans supply chains and integrates the issues of occupational safety, environmental protection and consumer protection in the quality management process. In addition, certain drivers are especially suitable for systematically promoting the substitution of hazardous substances:
- The interaction of a critical general public and state regulatory measures is still particularly effective. It is equally important to ascertain the institutions' capacities for action in this area, including consumer and environmental associations, government agencies or product testing laboratories.
- In fact, the interest of companies in chemical safety should have increased more. The reason is that increasing global competition makes brand and company values more vulnerable in view of hazardous substance scandals and claims for compensation. And the effort required to repair a damaged brand image is huge. However, in the course of the *SubChem* project quite a number of case studies indicated that the appropriate precautionary strategies in the economy still have to be developed.
- A universal standard to communicate chemicals risks, which has been adapted to practical conditions, is the prerequisite for improved substance management along the supply chains. This also includes qualifying manufacturers and chemicals users in such a way that they are able to generate and use risk-related information. Both prerequisites have so far not been fulfilled in many instances.
- Small and medium-sized enterprises involving chemicals-intensive processes need to consult with their suppliers. Preparation manufacturers and especially the trade have, however, so far hardly exploited their options to develop relevant information and consultation services.

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Intrinsically safe products are products, which can be used safely even without any special risk management measures.

SMEs: small and medium-sized enterprises.

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Case studies

Substitution in practice

The results of the *SubChem* project were derived from 13 case studies in a work process comprising several steps.

The aim of the case study analysis was to make certain generally applicable statements on innovation processes and innovation systems. For this reason, the cases cover a wide range of substitution conditions: consumer-close and consumer-remote products, product auxiliary materials and process auxiliary materials, SME actors and large-scale industry, issues of environmental, consumer and worker protection, technical and organisational innovations.

13 case studies:

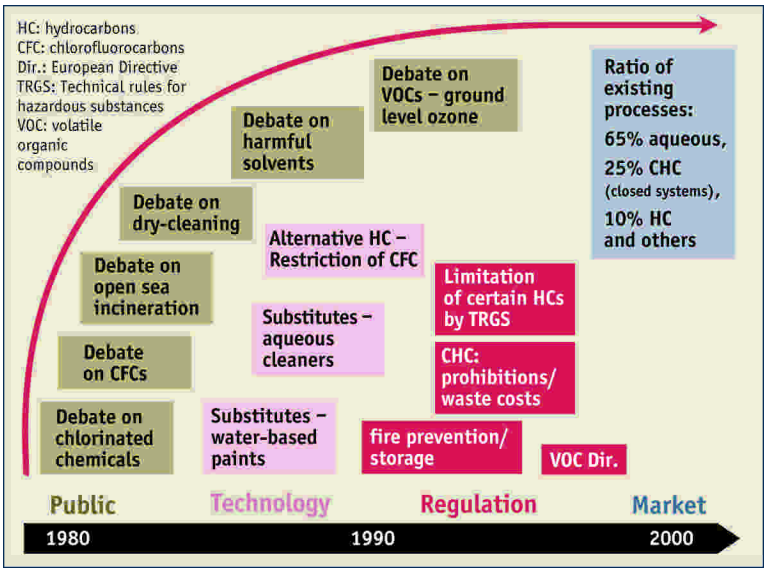
Process auxiliary agents in industrial plants	**Water-based cleaning of metal surfaces**
	Biocide-free cooling lubricants and minimum quantity cooling lubrication
	Biologically degradable concrete separating agents (bio-organic materials)
	More environmentally compatible textile auxiliary agents
Chemical products: usage in industry	**Bio-soluble, artificial mineral fibres in automotive silencers**
	Bio-soluble, artificial mineral fibres in automotive catalytic converters
	Alternatives to hazardous softeners in plastics
	Low-solvent automotive coatings
	UV drying printing inks used in packaging printing
Chemical products: usage in crafts and by do-it-yourselfers	**Low-chromate cement**
	Bio-soluble, artificial mineral fibres in construction products
	Stripping agents not containing methylene dichloride
	Solvent-free decorative paints made of natural primary materials

When hazardous substances remain in the final product, the risk arises that consumers may be directly exposed when using the product (relevant case studies are highlighted).

Evaluation and documentation of the case studies was carried out considering the following criteria:

1	**Advantage and technical function of the substance**
2	**Environment and health-related problem**
3	**Market and actors**
4	**Innovation process**
5	**Driving forces of innovations**
6a	**Certainty regarding direction: assessment of substitution from the standpoint of the market actors**
6b	**Certainty regarding direction: assessment of substitution from a scientific standpoint**
7	**Interpretation for forming hypotheses and developing model of innovation systems**

Substitution of chlorinated hydrocarbons in the cleaning of metal surfaces



The course of one specific innovation process is presented in the illustration on this page using the example of the case study "Cleaning of metallic surfaces". As this was initiated by the intensive public discussion of environmental damage and health injuries caused by chlorinated hydrocarbons in the 1980s, the water-based alternatives already existing in the market were further adapted to new applications. Besides the public debate, this process was also driven by a dramatic increase in related regulations.

Today approximately 65% of all cleaning operations are carried out using water-based systems; the proportion of CHC-based systems declined to 25%, while the use of CHCs decreased by more than 90% between 1986 and 1996.

Initial situation

New chemicals policy required

Competition has become more intensive as a result of globalisation and the saturation of markets. European manufacturers can react basically by creating a differentiation regarding quality, as it is hardly possible to compete on the basis of cost.

In Europe the market dynamics stand face-to-face with a regulatory system for chemicals, which is the result of a historical process and is not in line with the requirements of global supply chains.

As a reaction to accidents involving chemicals, illnesses caused by dangerous substances at workplaces and in consumer products as well as environmental contamination, the European states have over the past decades introduced a system of protection laws. To begin with workers protection was the primary concern, which resulted in certain successes in relation to the safety of plants and installations, working conditions and the substitution of individual hazardous substances. The current regulatory system does, however, have some serious shortcomings:

- Substances, which were marketed after 1981 (new substances), are subject to stringent regulation. Existing substances, which still account for more than 99% of the market volume, are however not subject to any compulsory substance testing and risk assessment before being marketed. The burden to carry out assessments for existing substances is on the authorities. For this reason, many substances are completely devoid of any risk assessment.
- Substance manufacturers, who on their own initiative ensure that hazardous properties in their products are detected and communicated, are systematically placed at a disadvantage. Competitors' products that have not undergone any testing may be marketed without the need to indicate any hazardous substances on the label.
- The numerous and detailed attempts at regulating this area for users of substances that are already on the market have a tendency to overburden the actors. Shortcomings with regard to practical implementation are the consequence. Protective regulations for individual substances also cannot keep up with the market dynamics under the conditions of globalisation.

The *SubChem* project produced (empirically supported) findings, which can be utilised in the discussion of the new European chemicals policy.

The exchange of risk-related information between chemicals manufacturers and chemicals users is inadequate and is not compulsory under chemicals legislation. As a result of this, the uses of many substances are not transparent. So scandals featuring hazardous substances occur, which in turn results in a loss of trust.

Production and usage of chemicals

- Approximately 100,000 substances are registered for the EU market, 30,000 of which are actively used in quantities > 1 t.p.a.
- Of the approximately 23,000 chemicals manufacturers in the EU-15, 95% have less than 250 employees.
- The number of industrial chemicals users in the EU-15 is around 500,000 enterprises.
- As of May 2004 the number of consumers on the EU market will be around 455 million.
- The EU-15 countries presently account for approximately 50% of the global chemicals business, while 30% of exports are destined for non-EU countries.
- The EU foreign trade surplus for chemical products is around 100 billion per annum. The value of imports from Asia and Eastern Europe is 16 billion, and this figure is increasing.
- Since 1930 the volume of organic chemicals produced around the world has increased 400-fold.
- At present about 7000 substances in the EU are officially classified as dangerous. These include not only synthetic organic substances (chemicals), but also some natural materials such as stones (dust or fibres), a range of metals and some plant substances.

Innovation – substitution – risk management

SubChem stands for innovation systems for the *sub*stitution of hazardous *chem*icals. Substitution is comprehended to be the replacement of hazardous substances in open applications by solutions presenting lower risks. This can mean less hazardous substances (substitutes), changes in product design or also improved application systems. The various options for avoiding, limiting or adequately controlling risks are brought together within the scope of the project under the concept of "risk management".

Innovation means that the solution is new and is able to assert its position on the market. Such innovations may be of a substance/technical, organisational or institutional nature. Under normal circumstances various actors from the relevant supply chain are involved in such innovation processes. They in turn depend on the market economic and regulative framework conditions. This is why we refer to innovation systems.

Recommendation: orientation in society

Decision-making in the light of uncertainty – rational ways to deal with a lack of knowledge

Substitution is always linked to the questions as to what alternatives are available for a hazardous substance, what effort is required to modify processes and products and whether the alternatives actually are less hazardous.

Decision-makers in the business sector are faced with a dilemma: if they leave decision-taking until (eco)toxicological hazards are clearly identifiable, innovation processes may be seriously delayed. On the other hand, if decisions are taken very hastily due to the public pressure for action, the solutions may not be adequate. The risk does exist that substances with well understood hazard profile are replaced by substances that have not been adequately assessed (and thus not recognised as being hazardous). Classic examples are the substitution of asbestos, PCB, chlorinated solvents, CFCs or softening agents in plastic by similarly hazardous substitutes (e.g. biostable mineral fibres or fluorohydrocarbons). "Innovation" is thus fast, but may be going into the wrong direction. On the other hand, the implementation of available and significantly lower-risk alternatives frequently appears to be completely absent in areas where there is no public discussion. The substitution of methylene dichloride based paint strippers by lower-risk dibasic esters in the professional painting sector is thus not a subject that gains considerable public attention. The proximity of the market actors to the end consumer appears to be missing here as an important driving force.

What general lessons can be drawn from the cases examined?

- Risk management cannot be based solely on knowledge of toxicological effects. A rational approach to dealing with uncertainties is just as important. More certainty in orientation could create, for example, a national chemicals strategy as exists in Sweden and the Netherlands. The appropriate objectives, time frames and guiding principles have not existed in Germany as yet.
- Guiding principles such as "short-range chemistry" (in relation to time and space), i.e. chemicals with low environmental persistence and spatial range of distribution, or "intrinsically safe products" appear to be suitable to provide orientation for the design of substances and products, without limiting the case by case assessment of risks inadmissibly. However, guiding principles need a risk reference. Otherwise generally accepted, positive guiding principles such as "natural substance" or "water-based product" can cause certain risks to be underestimated (e.g. the toxic effects of natural substances on humans).
- Scandals involving harmful substances or unsafe products that are discussed publicly create learning effects in the broader context, which extend far beyond the enterprise concerned. This means that journalistic interest in chemicals, including specialised or industry journals, and comparative testing of products are important driving mechanisms for innovation. It is thus necessary to ensure a responsible behaviour of dealing with the effective instrument of "public opinion".
- Confidence can be restored by ensuring greater transparency, and the high communication requirements of the current system can be reduced over the long term. This is important especially where the detection and limitation of risks has to be "cut" for pragmatic reasons in view of limited knowledge. The objective is to reach an agreement on transparent rules of procedure in order to lend legitimacy to the substance assessments and the decisions reached on the basis of such assessments.

Short-range chemistry – intrinsically safe products

On the basis of certain guiding principles ideas can be developed as to how an 'ideal solution', an 'ideal substance' and an 'ideal application system' could appear under certain framework conditions. On the other hand, such ideal notions in most instances also contain ideas as to what should be avoided under all circumstances.

The "short-range chemistry" principle (Scheringer) describes chemical products and processes, which are designed so that substances cannot cause undesired long-term effects far away from the place they were employed.

The model of "intrinsically safe products" includes products, which can be handled safely without any special risk management action.

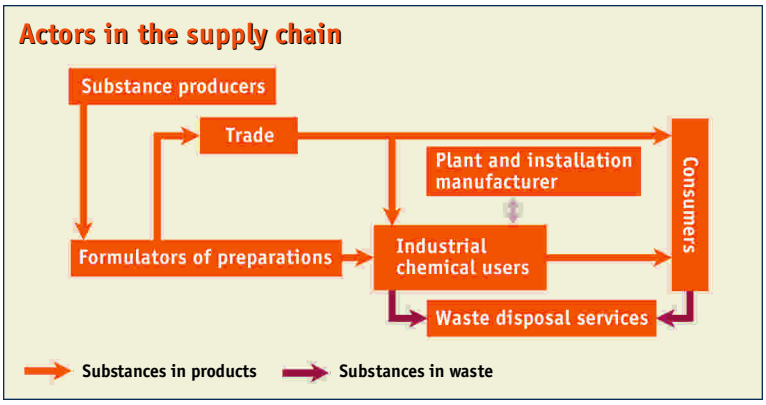
Recommendations for business actors

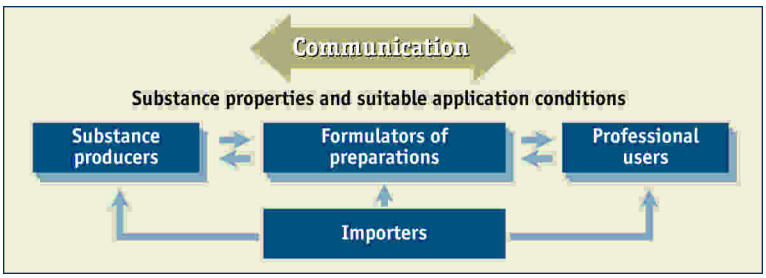
Extended risk management – securing market success

Substitution of hazardous substances is not a special type of innovation, but rather has all the uncertainties and difficulties that other innovation processes also have. Innovation and business risk are inseparable and are entirely normal in commercial matters.

If substitution of hazardous substances is considered to be a normal innovation process, an extended management method for dealing with chemical substances would be the logical consequence:

- Industrial management systems in the areas of environmental protection, workers protection and consumer protection should continue to be integrated in order to avoid shifting of risks and in order to save costs. All areas require reliable, systematic data on substance properties and application-related exposure. Instruments for dialogue along the supply chain and between enterprises and official bodies are also required. In addition, a comparative assessment of chemical products (e.g. in procurement or in product development) can only be carried out in an intelligent way, if all vital risk areas are included in the assessment.
- In the case of private end consumers and also in small and medium-sized companies capacities for high-level risk management are limited. Suppliers of chemical products for these users should thus install the development of "intrinsically safe products" as a guiding principle. Products, which have both good technical performance and which are simple and safe to handle, would for example be innovative.
- It is also important to perceive communication along the supply chain as a chance for more customer-oriented innovation. In particular, the chemicals trading sector and manufacturers of preparations could expand their business by providing information and consultancy services (including more direct contact to clients).
- Both the determination of substance data and also the introduction of harmonised instruments for assessment, communication, documentation and control of chemical risks in the European market can only operate at supra-corporate level. In doing so, the following must be taken into account: if practical workability of such instruments shall be ensured, it cannot be the sole responsibility of authorities to develop these instruments. If costs are to be minimised, enterprises must co-operate with each other to develop common standards, which may include however the exchange of information potentially relevant to competition. This means that enterprises must show courage, if efficient system solutions at a supra-corporate level are to be developed.
- The demands of politicians on the industry to assess the approximately 30,000 existing substances and their applications on the European market under its own responsibility is in line with the Responsible Care commitment undertaken by the chemicals industry. Implementation of this commitment has so far been unsuccessful due to the fact that the users of chemical products had not entered into it. The REACH system, which has now been put forward by the EU Commission, would thus for the first time form a regulatory framework for structuring responsibility and information flows along the supply chain in a binding way. Industry and trade should take up this offer by the state.





Integrated quality management at supply chain level: substance and information flows along the supply chain.

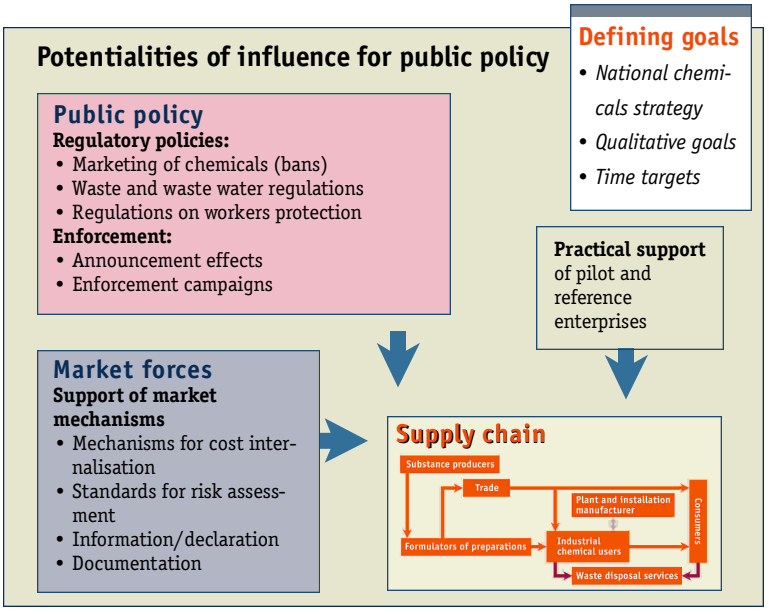
Recommendations for state actors

Utilising the variety of opportunities for state influence

State definition of a framework for determining, assessing, communicating and reducing chemicals-related risks in the supply chains of the European market is crucial.

Internalisation of external costs: as a result of chemicals-related environmental damage, abandoned hazardous sites, disappearance of plant and animal species or damage to consumers' health, costs are generated, which do not occur for the economic actors themselves. By introducing internalisation, these costs (and not just in case of accidents) are to be allocated among the polluters and hence become effective in the market.

The legal obligation for commercial chemicals users to employ lower-risk alternatives is an important factor in specific cases. Substitution seen purely as a regulatory measure, however, does not work. Small and medium-sized users thus hardly transform procedures based on blanket clauses, such as the principle of substitution contained in the German Ordinance on Hazardous Substances, into their own initiative. Comprehensive monitoring by state authorities is also just as unlikely to guarantee the implementation of a general substitution principle. This means that additional driving forces are needed, in particular with regard to assigning the actors clear responsibilities on the individual stages of the supply chain, as well as standardisation of assessment and communication instruments.



Possible strategies for successful state influence are as follows:

- The announcement of new regulations or enforcement initiatives: if users of hazardous substances expect new regulations or monitoring authorities to initiate controls, a market chance exists for innovative products and services. As the *SubChem* studies demonstrate, a clearly perceptible impulse is mostly more effective than universal monitoring on a regular basis.
- Qualification of authorities for consultative tasks, especially in relation to SMEs.
- The establishment of mechanisms to internalise external costs (liability positions and insurance obligations): insurance companies can have an effect on risk management in manufacturing companies. Making insurance coverage subject to minimum standards of risk management (production and product) is an important driving force for innovation with regard to consumer protection. A similar scenario would also be possible for workers protection, if the workers' compensation insurance carriers were to act more like private insurance companies in this area. No mechanisms for internalisation exist, however, in the domain of chemicals-related environmental costs, which are caused by a diffuse and long-term release of hazardous substances. An example of this is the additional expense involved in providing drinking water, disposing of sewage sludge or decontamination of buildings containing harmful substances.
- Development and application of a standard for "good assessment practice". The quality of risk assessments and risk management information could become a competitive element in the global market. To this end a certifiable and, if possible, also internationally acknowledged standard is required.
- State institutions can support pilot and reference enterprises as part of measures to promote innovation. They can promote vertical and also horizontal communication (e.g. sectoral dialogue) and especially provide basic initial services for small and medium-sized enterprises, such as e.g. information free of charge, sector benchmarks or also initiate qualification programmes.
- Focussing public research programmes by guiding principles such as "intrinsic safety of products", "short-range chemistry" or "sustainable chemistry" may also give direction to the innovation efforts in the market.

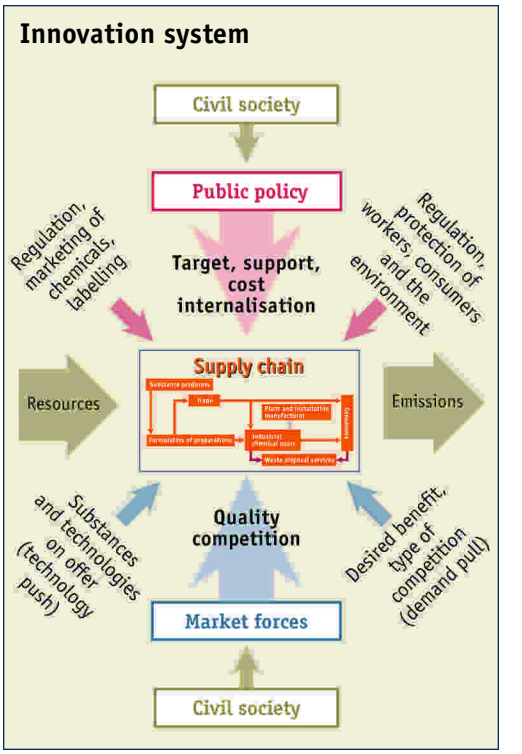
Model and type categorisation

Understanding the innovation system – overcoming inertia

The model of the innovation system demonstrates the systematic linking of framework conditions, influential factors and relations between the actors.

The case studies in the *SubChem* project are organised so that they analyse the architecture and driving forces of the particular innovation system:

- The legislative rules according to which substances can be marketed and regulations on the conditions of use (occupational safety, environmental protection and consumer protection) are important framework conditions established by the state. These also include the legislative measures, which lead to internalisation of external costs and improvement of information flows on the market. They are accompanied by the market-related framework conditions: on the one hand, the structures and activities for investigating and developing new technical options (technology push: new substances, products, processes and applications). On the other hand the demand trends and types of competition, which in Europe are shifting from mass products (with primarily cost competition) towards products of differentiated quality (quality competition, demand pull).
- Publicity and media as well as the civil society actors in the area of occupational health and safety, consumer groups and environmental groups are of special significance.
- The constellation of actors in the supply chain may be comparatively simple and may observe a linear structure, while also being highly networked and complex. The more complex the network of actors becomes and the more far-reaching the particular forthcoming innovation is (level of innovation), the more difficult the innovation process becomes, and the stronger either the external impulses or the intrinsic motivations of actors in the chain must be.



Framework conditions, influential factors and relations of actors in the innovation system

With regard to the COMPLEXITY OF THE INNOVATION SYSTEM two basic system types can be deduced, to which each of the 13 case studies of the *SubChem* project can be assigned. In doing so ideal types are differentiated...

... comparatively straightforward systems, in which the cause-effect relations can be assigned clearly to individual actors and their range of instruments.	**... highly complex and dynamic systems, in which only the interaction of a large number of actors can produce innovations, which no individual actor could have planned or predicted (emergence).**
The cases cement, mineral fibres, concrete separating agents are most in keeping with this type; here it is frequently only a question of substituting a particular substance and thus maintaining the technical performance of the product for the commercial user.	**This type comprises mostly those cases where the perception of future consumer wishes plays an important role, the supply chains are part of a global network, there is no obvious system leader or the chemical products are integrated in complex process chains. One example of this is the textile chain.**

A few words about ourselves

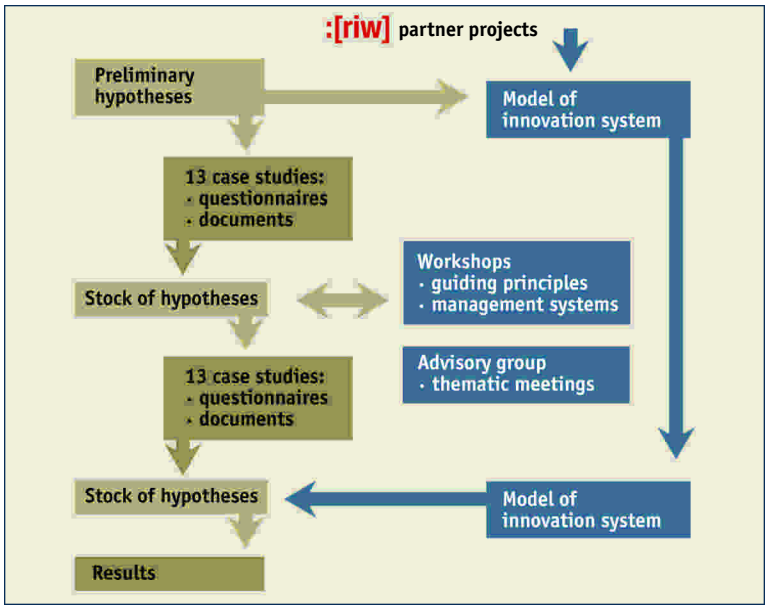
The *SubChem* approach

On the basis of literature and the previous experience of the project group a first set of hypotheses concerning possible success and failure factors in hazardous substance substitution was developed.

Hypotheses were developed as part of an iterative process on the basis of empirical case studies. As a parallel action there was a lively exchange with the :[riw] partner projects and the various stakeholders (workshops, advisory group meetings).

The results summarised in this document are based on the systematic analysis of the case studies, the contributions of participants in several expert workshops as well as literature.

Certain cross-section subjects were dealt with in detail at the meetings of the *SubChem* project advisory group and within the scope of additional workshops: guiding principles as orientation aids, management at supply chain level; differences between business-to-business and business-to-consumer relations; drivers for substance, formulation and application innovation. The *SubChem* project advisory group, which comprises representatives of associations (VCI, TEGEWA, DECHEMA, Consumer Advice Agency , IGBCE), official bodies (BAuA, UBA, Public Health Department of the City of Bremen), scientists (Universities of Augsburg, Oldenburg and ETH Zurich) as well as companies (Henkel KG, Volkswagen AG), also contributed to quality assurance and transfer of results. A good networking of actors as well as an intensive exchange between research and policy makers were also achieved as the result of co-operation in various fora and events as part of the REACH process (since 2001) or in the German Risk Commission (10/2000-12/2003).



Not least of all, networking involving scientific departments also took place. On the one hand, *SubChem* was involved in the program "General framework for innovations for a sustainable economy" :[riw] of the Federal Ministry for Education and Research (BMBF). This included in particular collaboration with two other projects related to chemicals: COIN at the Cologne Center for Public Finance at the University of Cologne and INNOCHEM at the Centre for Environmental Research Leipzig. On the other hand, an intensive exchange took place with the other research projects at the Ökopol Institute and the Co-operation Centre Hamburg; in particular with the EU project "Substitution of Hazardous Chemicals in Products and Processes" (2001-2003), the REACH simulation in North Rhine-Westphalia (2003) and the UBA project "Cost and benefits of the new EU chemicals policy" (2003-2004).

For further information on the *SubChem* project please consult the webpage: www.subchem.de

Book publication: A. Ahrens, A. Braun, A. Effinger, A. von Gleich, K. Heitmann, L. Lißner: Hazardous Chemicals in Products and Processes – Substitution and Beyond (in the series: Sustainability and Innovation, J. Hemmelskamp (ed.) Heidelberg, Berlin (planned publication autumn 2004).

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