HELMHOLTZ
ZENTRUM FÜR
UMWELTFORSCHUNG
UFZ

UFZ-Diskussionspapiere

Department of Economics

2/2007

Chemical Leasing Business Models – A Contribution to Effectively Manage the Risk of Chemical Substances?

Cornelia Ohl[a], Frank Moser[b]

February 2007

[a] Cornelia Ohl
Helmholtz-Centre for Environmental Research – UFZ
Department of Economics
Permoserstr. 15, 04318 Leipzig, Germany
e-mail: cornelia.ohl@ufz.de

[b] Frank Moser
United Nations Environment Programme
Chemicals Branch, DTIE
11-13, Chemin des Anémones
CH-1219 Châtelaine - Geneva , Switzerland
e-mail: fmoser@chemicals.unep.ch

ISSN 1436-140X

Herausgeber:
Helmholtz-Zentrum für Umweltforschung GmbH – UFZ
Permoserstraße 15, 04318 Leipzig

Executive Summary

Chemicals undisputedly contribute to a large extent to the wellbeing of modern societies. Apart from such benefits, chemicals, if released, may pose serious threats to human health and the environment. Therefore the European Commission proposed a regulatory framework for the Registration, Evaluation and Authorization of Chemicals (REACH) that requires companies using chemicals to invest in the gathering of information on the properties of their substances. In this paper we argue that the gathering of information may critically depend on a transfer of knowledge from the producer to the user of a chemical, which may be particularly true if application of chemicals is not part of the user's core competency and point out that the traditional sales concept provides no incentives for transferring this knowledge. The reason is that an increased knowledge most likely raises the efficiency of the application. This, in turn, lowers the amount of sold chemicals, which is expected to directly decrease the profits of the producer of a chemical. We show that a possible strategy to overcome this shortcoming is the introduction of chemical leasing business models. By introducing two models (model A differs the least and model B the most from the traditional sales concept) we demonstrate that chemical leasing business models are capable to reach the goal of REACH: to effectively manage the risk of chemicals, by reducing the total quantity of used chemicals either by a transfer of knowledge from the lesser to the lessee (model A) or by posing incentives for efficient application on the side of the lesser (model B).

Key Words: Chemical leasing business models, selling versus leasing of chemicals, economic incentives for the implementation of chemical leasing models

Chemical Leasing Business Models – A Contribution to Effectively Manage the Risk of Chemical Substances?

I. Introduction

On October 29, 2003, the European Commission proposed a new European Union (EU) regulatory framework for the Registration, Evaluation and Authorization of Chemicals (REACH). The proposal is based on a white paper, which was adopted by the European Commission on February 13, 2001 [1]. The overarching goal of REACH is to ensure sustainable development in the EU by improving the protection of human health and the environment through the better and earlier identification of the properties of chemical substances, while, at the same time, ensuring the efficient functioning of the internal market and stimulating innovation and competitiveness in the chemical industry.

With a global production of chemicals of currently 400 million tons per year, there are about 100,000 different substances registered in the EU, of which 10,000 are marketed in volumes of more than 10 tons, and a further 20,000 are marketed at volumes ranging from 1 to 10 tons. In 1998, the EU chemical industry was the world's largest chemical industry and also Europe's third largest manufacturing industry: It generated a trade surplus of 41 billion Euros, employed 1.7 million people directly and up to 3 million indirectly. The European chemical industry comprises several multinational companies and about 36,000 small and medium enterprises (SMEs), whereas the latter represent 96% of the total number of enterprises and account for 28% of chemical production. By generating employment and fostering trade, chemicals undisputedly contribute to a large extend to the economic and social wellbeing of the citizens of the EU, who are strongly dependent on the use and consumption of chemicals in various sectors, such as the food and feed, the pharmaceutical, the agricultural, textile, and automobile sector.

Notwithstanding these benefits, there is justified concern that certain chemicals cause various adverse effects to human health and the environment, such as cancer, allergies, and the disruption of reproductive and endocrine systems [2]. At the same time as the impact of many chemicals is not fully understood, there is a lack of public awareness of those negative effects of chemicals released to the environment [1]. Therefore the EU REACH proposal aims at a better and earlier identification of the properties of chemical substances by shifting the responsibility to manage the risks from chemicals and to provide safety information on the substances to industry. Producers, importers, as well as companies that use chemicals in volumes of 1 ton and more per year are required to gather information on the properties of the chemical substances they use under the REACH initiative.

In the paper at hand, we argue that especially for enterprises for which the use of chemicals is not part of their core competencies (in particular to expect within SMEs), the gathering of information may critically depend on a transfer of knowledge from the producer to the user of a chemical. We further maintain that the traditional sales concept falls short of providing incentives for transferring this knowledge. Instead, we show that a possible strategy to overcome this shortcoming is the introduction of chemical leasing business models that are capable to effectively manage the risk of chemicals.

In *section II* we first illustrate the problems at stake by a case study from the metal working sector. In *section III* we introduce the traditional sales concept that serves as baseline for the analysis of chemical leasing business models in *section IV*. *Section V* closes with a summary and discussion of results.

II. Case Study

As outlined above, chemicals play a vital role in various sectors in a modern society. In this paper, we particularly focus on industrial sectors like the automobile and the metal working sector. Within these sectors, chemicals are often used in applications such as the degreasing of metal parts with organic solvents. This goes along with a potential risk of polluting the environment through spillages and accidents [3].

II.1. Toxicity of selected chlorinated solvents

The most common chlorinated solvents used in degreasing procedures include trichloroethylene, methylene chloride, and perchloroethylene [4]. All of these substances show negative side effects as illustrated by trichloroethylene [5]:

> *Effects of short-term exposure* - The substance is irritating to the eyes and the skin. Swallowing the liquid may cause aspiration into the lungs with the risk of chemical pneumonitis. The substance may cause effects on the central nervous system, resulting in respiratory failure. Exposure could cause lowering of consciousness.

Effects of long-term or repeated exposure - Repeated or prolonged contact with skin may cause dermatitis. The substance may have effects on the central nervous system, resulting in loss of memory. The substance may have effects on the liver and kidneys. This substance is probably carcinogenic to humans. It is considered a suspect carcinogen by the International Agency for Research on Cancer (IARC). It can cause CNS depression, can affect kidneys, liver, and lungs, and can cause rapid and irregular heartbeat that may cause death. It causes skin, eye, and mucous membrane irritation. Toxic effects are increased when combined with alcohol, caffeine, and other drugs. It has been used extensively in vapor degreasers.

Due to the negative side effects of chemical substances the producer as well as the user is forced to take measures that assure the safe handling of chemicals. In general, the implementation of such measures entails costs.

II.2 Costs of measures for a safe handling of chemicals

For the *producer* of a chemical, the safe handling of chemicals includes costs for research and development to e.g. avoid claims and litigation that follow a violation of product liability rules. Costs also arise for the safe handling of chemicals during production and delivery in order to avoid claims and litigation that follow a violation of liability rules covering damages to persons and goods. This includes providing a safe working environment, such as safety equipment for workers, appropriate storage sites, regular maintenance of machines and equipment that are connected to the production of the chemical as well as training and outreach measures for workers. This also includes measures to avoid personal injury or property damage caused by chemicals in connection with their sale, e.g. at the transport to the user. The sum of the costs connected with the above-mentioned measures and the production costs, which include costs related to research and development, raw materials, energy, staff time, represent the costs of producing chemicals.

For *the user*, the costs of safe handling the chemical include providing a safe working environment, such as safety equipment for workers, appropriate storage sites, regular maintenance of machines and equipment that are connected to the use of the chemical, safety training for workers, and the costs for the recycling or proper disposal of the chemical. The sum of the costs connected with above-mentioned measures and the costs related to the acquisition and consumption, for example energy costs, represents the costs of using chemicals. Some of these costs may be difficult to identify, as some of them are contained in the overhead.

The safe handling of chemicals falls in the core business of the producer of a chemical. This may not be the case for a user so that the producer may have comparative advantages in handling and storing the chemical under consideration. Above that she may have facilities for an effective recycling of the chemical substances.

II.3. Recycling potential of organic chlorinated solvents

Some of the organic chlorinated solvents show potential of recycling. With regard to degreasing procedures, the most common method of recovering for reuse chlorinated organic solvents is distillation[i]. Due to their chemical stability, non-flammability, and low latent heat of vaporization[ii], this recycling procedure can be easily performed on-site by an uncomplicated separation of the chlorinated solvent from the waste oils received during the degreasing operation [6].

Although the distillation delivers purified chlorinated solvents that can be reused, the effectiveness of the solvent recovery can vary. The effectiveness of the solvent recovery, in general, much depends on the level of contamination with impurities of these waste oils, such as greases and other contaminant materials (e.g. resins, polymers, pigments, paints, waxes, oils, etc.). The higher the concentration of impurities is, the more solvent will remain in the residue after the distillation, which normally is disposed of as hazardous waste. Such losses may compose up to 30 % of the total solvent losses [6].

A method to minimize the amount of solvent lost in hazardous waste is the segregation of solvents. If two or more different types of solvents (chlorinated and/or non-chlorinated) are used in the degreasing process, the blending of these solvents after their usage should be carefully avoided. This is because mixtures of two or more solvents may form azeotropes[iii], which are generally difficult to separate. Another method is the application of micro-filtration systems. This allows the removal of solid impurities from the solvent prior to its distillation, which in most cases increases the effectiveness of the solvent recovery.

The effectiveness of recycling thus critically depends on a proper segregation of solvents. It is therefore very likely that the recycling of chemicals becomes ineffective if enterprises have a deficit in knowledge regarding the proper handling of the chemical.

II.4. A company within the metal working sector

A lack of knowledge regarding the appropriate handling and/or efficient application of chemicals is in particular to expect if the use of chemicals is not a core activity of a company. For example within the metal working sector enterprises are found that use chemicals as part of their production process; the use of the chemical however is of minor importance regarding the whole chain of production.

Our model company of the metal working sector (the user) is classified as SME and uses a chlorinated organic solvent to degrease metal parts that are used in the production process. The solvent, which the company purchases from the producer of the chemical, is the only chemical substances the company applies in larger quantities. The metal parts have minor importance in the overall production process so that the application of the solvent is not part of the company's core competencies. This hampers the company to internally conduct research and development (R&D) regarding the risks and efficient application of the chemicals. The costs for the company to conduct R&D-activities are prohibitively high. The producer is thus the only source of information for the user and consequently has a head start in terms of knowledge on the effective and efficient application as well as on the proper handling and secure storage of the solvent.

This results in over-consumption of the chemical which raises the application costs of the company compared to the efficient use of the solvent. Furthermore, the disposal of the chemical through a disposal company also adds to the costs of applying it. Since the solvent is applied in a suboptimal manner, disposal costs are increased as well. Additionally, dependent on the rules of liability, the company may have to cope with higher liability claims; esp. if the level of chemical consumption is positively correlated with the risk of adverse side effects that are detrimental to human health and the environment. Above that the improper handling of the solvent reduces the potential for recycling the chemical, which in turn increases the amount of chemical waste as well as the need for further chemical production.

This may change with the implementation of REACH. A stringent implementation of REACH may force our model company to gather information on the chemicals in use. If, however, the costs of conducting R&D-activities are prohibitively high and the producer is unwilling to transfer his knowledge the improper handling of the chemical remains. This might even be the case if the producer is forced by the institutional setting to transfer his knowledge to the user. Reasons for example are that the model company's infrastructure does not support the optimal handling of the solvent. The provision of appropriate storage room for chemicals may, for example, be insufficient. Workers may not be adequately trained in the proper handling of the chemicals and may not be fully aware of the adverse effects of the solvent, which may foster a careless association with the chemical at hand. As the metal parts play a minor role in the company's production process, the costs of updating the infrastructure and/or educating the workers may be so high that there are no internal incentives for the company to change the current situation.

III. Traditional Sales Concept

Traditionally, most of the produced chemicals are sold to users. If a chemical is sold and the sale contract gains legal validity the proprietorship of the chemical passes from the producer of the chemical to the user. This usually comes up with a transfer of the ownership and the passing of risk regarding the chemical under consideration. This can be at the time of delivery on the premises of the applier, but may also be subject to the place of performance as specified in the contract. We here assume that the risk passes over at the time of delivery on the premises of the applier.

Above that producers, and all others in the product distribution chain, can be held liable for personal injury or property damage caused by a defective product. This can happen if the producer neglects its obligations concerning the appropriate design (design defects), manufacture (manufacturing defects), and instructions (warning defects). With regard to the operation of chemicals, the liability rules include obligations for the producer concerning the proper labelling and handling of dangerous goods. Moreover producer and user of a chemical can be liable for personal injury or property damage caused by the improper application or handling of a chemical. This includes liability for damages to persons, goods, and sites. In order to keep things simple, we presuppose the producer to manufacture, operate, and sell chemicals in such a way that liability in negligence can be excluded; for the user of a chemical liability in negligence is excluded as well.

Given this setting it is very suggestive that the selling of more chemicals increases the gains of the producers. Under the traditional sales concept the producer consequently has no incentives to transfer his knowledge regarding the properties of the chemical if this enables the user to apply the chemical more efficiently and subsequently to reduce the amount of chemicals ordered in the sales contract. It is consequently most likely that the traditional sales concept fails to solve the problems of our model company and that over-consumption of chemicals is not avoided, increasing the amount of hazardous waste and the risk of damages to humans and the environment.

IV. Chemical Leasing Business Models

The traditional sales concept – as introduced above - serves as a baseline for the analysis of chemical leasing business models. Generally, this concept provides no incentives to prevent over-consumption of goods, here, of chemicals with adverse side effects, related to the quantity of chemicals in use. The reason is that the selling of more chemicals increases the gains of the producers so that there are no incentives to transfer knowledge regarding the efficient application of the chemical substances. This may also hamper an effective re-use of the solvent due to e.g., the blending of solvents after their usage.

One possibility to avoid these shortcomings of the traditional sales concept is that the producer – instead of the user – applies the chemical; a second one, favoured by REACH, is that the producer transfers his head start in knowledge to the side of the users. Below we question whether business leasing models can be designed in a way that meets these requirements.

IV.1. Design of leasing contracts

Business leasing models have in common that the chemical is owned by the supplier and not – in contrast to the traditional sale contract - by the user. Options of contract design are:

1. ***Location of the application/ownership of the chemical:*** The chemical can be applied both on the site of the supplier and the user. This affects the ownership of a chemical.
2. ***Proprietorship of the equipment:*** The equipment can be owned either by the supplier, by the user, or by a third party provider of equipment.
3. ***Application of the chemical:*** In leasing contracts the application of the chemical can fall under the responsibility of the supplier, the user, or a third party.
4. ***Operation of the equipment*****:** The operation of the equipment may either fall under the responsibility of the lesser or the lessee.
5. ***Recycling:*** The user, supplier, or a third party provider of the recycling service can be responsible for the recycling or final disposal of the chemical.

Design options one to five may be chosen in accordance with the nature of a chemical, i.e. dependent on whether the risk arising from the application of the chemical is high or low. Anyhow in order to diminish negative side effects from an over-consumption of chemicals these options should be combined such that the leasing model increases the efficiency of the application either by a transfer of knowledge from the producer of the chemical to the user or, by specifying the contract in a way that the supplier applies the chemical himself either on his own or the user's (the lessee's) site.

Regarding the first option, knowledge transfer has to be designed such that it constitutes a service that becomes part of the leasing contract. Since the solvent itself is not sold anymore to the user, but leased, the desired transfer of knowledge takes place (is part of the contract) as soon as any inefficient application, e.g. spillages and other losses, diminish the profits of the producer. This is to expect especially if inefficient use diminishes the quantity of the solvent that can be re-used after recycling (design option five). Given this case, the producer has a strong incentive to transfer his knowledge on the properties of the solvent to the user in order to ensure the efficient application of the chemical substances.

Regarding the second option the producer of the chemical can either offer to apply the chemical on his own premises or the premises of the lessee (see design options one and three) by operating the own or the lessee's equipment (design options two and four). In this case knowledge transfer from the producer to the user will *not* take place. Nevertheless (as will be shown below) chances increase that the chemical will be applied efficiently. So that in both cases chemical business leasing models lower the quantities of the chemicals in use which in turn is expected to result in fewer accidents and spillages as well as less damage to humans and environment.

IV.2 Incentives for switching from the traditional sales concept to chemical business leasing models

Chemical business leasing models compared to traditional sales contracts show advantages regarding chemicals' risk reduction if the risk posed by a chemical is positively correlated with the quantity of chemicals in use. So the critical questions are: Under which conditions are producers of chemicals willing to offer leasing, instead of sales contracts? And: In which cases are traditional user companies willing to accept leasing, instead of sale contracts?

In reality, a broad variety of different chemical business leasing models may be applied. In order to analyze the incentives for a shift from the traditional selling to the leasing of chemicals we concentrate on two models: *Chemical leasing model A* which differs the least and *chemical leasing model B* which differs the most from the traditional sales concept.

Chemical Leasing Model A

The design of chemical business leasing model A differs from the traditional sale concept (as any other design does) with respect to the proprietorship of the chemical. Above that a further distinguishing feature is that, in accordance with design option five, the responsibility of disposal respectively recycling is shifted from the user's (the lessee's) side to the producer's (the lesser's) side. Comparing model A with the traditional sales concept, there are two changes on the side of the user. First, he does not become the proprietor of the chemical and second, he is not responsible for the disposal respectively recycling of the chemical. While in the traditional sales concept the producer has an interest in the over-consumption of the chemical by the user - as this directly increases his profits - this may change under the condition of the leasing contract.

The user – as in the traditional sales concept - applies the chemical herself while the producer stays proprietor and has to take care of the disposal respectively recycling of the chemical (in order to reuse it). However, different from the traditional sales concept, the producer now has incentives to transfer his knowledge on the efficient application of the chemical, if this allows decreasing the costs of disposing respectively recycling the chemical. Assuming profit maximizing behaviour of the producer, the decrease of costs has to outweigh the gains from an over-consumption of the chemical if knowledge is not transferred to the user.

The producer is willing to switch from selling the chemical to a leasing offer with knowledge transfer if (and only if) the gains from this leasing contract [$GL(A_{KT})$] are higher than the gains from the sales contract (GS) respectively a leasing contract with no knowledge transfer [$GL(A_{NT})$]. Given leasing model A, he will transfer his knowledge if the price per unit of leased chemical, P_C, times the (efficient) quantity, X_e, plus the price of the service offered (either for disposing or recycling the chemical), $P_{DP}(X_e)$, is higher than the gains from the sales contract which is unit price, P_C, times the (inefficient) quantity, X_i, i.e.:[iv]

$$GL(A_{KT}) = P_c{*}X_e + P_{DP}(X_e) > GS = P_c{*}X_i \qquad (1)$$

Additionally, it is to assure that profits from leasing model A with knowledge transfer are higher than without knowledge transfer. It is very suggestive that without transfer of knowledge the level of over-consumption in case of leasing equals the level of over-consumption in case of selling the chemical. We therefore call for:

$$GL(A_{KT}) = P_c*X_e + P_{DP}(X_e) > GL(A_{NT}) = P_c*X_i + P_{DP}(X_i) \qquad (2)$$

It is obvious that inequality (2) includes inequality (1). Moreover, since $P_c*X_e < P_c*X_i$ it is straight forward that:

$$P_{DP}(X_e) > P_{DP}(X_i) \qquad (3)$$

has to hold in order to deliver incentives for the producer to switch from selling the chemical to a leasing offer with knowledge transfer. The fulfilment of inequality (3) presupposes that the disposing service is not charged per unit of chemicals in use (since otherwise there would be no incentives for transferring knowledge on the efficient use of the chemical). Above that, reformulating (2), we find:

$$P_{DP}(X_e) > P_c*(X_i-X_e) + P_{DP}(X_i) \qquad (4)$$

Inequality (4) delivers the necessary and sufficient condition for an offer of A_{KT}. Given (4) holds the traditional sales concept may be completely substituted by chemical leasing model A_{KT} (dependant on the competitive situation of the market). The user of the chemical would thus have no choice between selling and leasing the chemical. However in reality this case might not be found. We therefore analyze in which cases the user of the chemical is willing to switch from buying to leasing the chemical.

Regarding leasing contract A with knowledge transfer, the quantity of chemicals used in the production process of the user will be reduced due to the transfer of information on the efficient application of the chemical. This quantity reduction lowers the user's application costs depending on the quantity of chemicals in use. Given that the lessee maximizes his profits, he will choose leasing model A if (and only if) he is at least not worse off than under the traditional sales concept, i.e. if:

$$CL(A_{KT}) = P_c*X_e + P_{DP}(X_e) < CS = P_c*X_i + P_{DU}(X_i) \qquad (5)$$

$CL(A_{KT})$ specifies the cost of leasing model A with knowledge transfer and CS the costs under the traditional sales concept when the user is responsible for the disposal of the chemical, which costs him $P_{DU}(X_i)$. Reformulating (5) we derive at:

$$P_{DP}(X_e) < P_{DU}(X_i) + Pc(X_i-X_e) \qquad (6)$$

Given that both, the lesser and the lessee, have to be better off under chemical leasing model A_{KT} than under the traditional sales concept, we have to take (4) and (6) simultaneously into account to derive at the critical condition for offering and taking leasing model A_{KT}, i.e.:

$$P_{DP}(X_i) < P_{DP}(X_e) - P_c*(X_i-X_e) < P_{DU}(X_i) \quad (7)$$

Inequality (7) implies that: $P_{DP}(X_i) < P_{DU}(X_i)$ has to hold in order to foster the offer of leasing model A_{KT}. A head start in knowledge on the side of the producer, which enables him to dispose respectively recycling the chemical in a more efficient way than the user, is thus a presupposition for the introduction of leasing model A_{KT}. Only in this case the producer is given the possibility to offer a price $P_{DP}(X_i)$ that is lower than the user's cost of recycling, $P_{DU}(X_i)$ but that is still able to close the difference in profit between leasing model A_{KT} and A_{NT} due to the quantity reduction $[P_c*(X_i-X_e)]$; it is a presupposition to compensate the difference by charging a price for the disposal service, $P_{DP}(X_e)$ with $P_{DP}(X_e) > P_{DP}(X_i)$, so that both: the lesser and the lessee, are better off compared to the traditional sales concept (and with respect to the producer also compared to the leasing model without knowledge transfer).

Chemical Leasing Model B

The design of chemical leasing model B differs most from the traditional sales concept. In model B, the producer is responsible for the application of the chemical, the application of the equipment as well as for the recycling respectively disposal of the chemical. In addition (as in any other chemical business leasing model) the producer remains the proprietor and the owner of the chemical.

If the leasing contract is signed and gains validity, the responsibility for the application of the chemicals and the operation of the equipment passes over to the producer. In this case the probability to be held liable for damages to persons and goods is significantly reduced on the side of the user. Above that the costs of handling the chemical, such as costs related to the provision of a safe working environment, is reduced to zero. While the outsourcing of the application avoids such costs entirely on the side of the user it poses negative effects on the producer's cost structure that have to be covered by the price of leasing model B.

Like for model A and contrary to the traditional sales concept, sub-optimal application of the chemical is avoided for at least two reasons: First, efficient application reduces the producer's (the lesser's) costs for disposing and recycling the chemical. Second, the producer can be held liable for damages to persons and goods due to taking over the responsibility for the application of the chemicals and the operation of the equipment. This delivers incentives for efficient use of the chemical as the probability of adverse side effects is said to increase with the quantity of chemicals in use.

Given profit maximization behaviour of the lesser, he will be willing to apply model B and make use of his head start in knowledge if (and only if) the price for applying, $P_{AP}(X_e)$, and disposing/recycling the chemical, $P_{DP}(X_e)$, plus the product of unit price of chemicals, P_C, and (efficient) quantity, (X_e), is higher than the unit price charged in the traditional sales concept, P_C, times the (inefficient) quantity, (X_i), i.e. if:

$$GL(B_{KT}) = P_c*X_e + P_{AP}(X_e) + P_{DP}(X_e) > GS = P_c*X_i \quad (8)$$

Above that the gains from using her knowledge $[GL(B_{KT})]$ have to outweigh her gains from applying the chemical in the same inefficient manner than the user $[GL(B_{NT})]$.[v] We therefore call for:

$$GL(B_{KT})=P_c*X_e + P_{AP}(X_e) + P_{DP}(X_e) > GL(B_{NT})=P_c*X_i + P_{AP}(X_i) + P_{DP}(X_i) \quad (9)$$

It is obvious that inequality (9) includes inequality (8). So, if the lesser is willing to apply the chemical efficiently she is also willing to switch from the traditional sales concept to chemical leasing business model B. Since $P_c*X_e < P_c*X_i$ inequality (9) is only fulfilled if $P_{AP}(X_e) + P_{DP}(X_e)$ is sufficiently higher than $P_{AP}(X_i) + P_{DP}(X_i)$. This (as in case of leasing model A) implies that the service charges should not be specified per units of chemicals in use. Additionally inequality (8) clearly shows that the price of chemical leasing model B has to comprise a compensation for the additional services offered by the producer (including an increased producer's liability). Consequently, the price of leasing model B will clearly exceed the price of the traditional sales contract. In analogy to model A, the price increase will be accepted by the user if (and only if) he is at least not worse off than in case of buying the chemical. This is to expect if the cost savings of the lessee due to shifting the responsibility of applying and disposing the chemical (including reductions in the user's liability expectation) exceed the price increase of the leasing contract.

Since we are interested in an efficient use of the chemical, we directly focus on the costs of a leasing contract that makes use of the producer's head start in knowledge. In this case we have to call for:

$$CL(B) = P_c*X_e + P_{AP}(X_e) + P_{DP}(X_e) < CS = P_c*X_i + P_{AU}(X_i) + P_{DU}(X_i) \quad (10)$$

$P_{AU}(X_i)$ specifies the costs of the user for applying the chemical and $P_{DU}(X_i)$ for disposing it.

Given that both: the lesser and the lessee have to be better off under leasing model B_{KT} than under the traditional sales contract (respectively model B_{NT} with respect to the producer) a shift from selling respectively buying to leasing the chemical is expected, if we take (9) and (10) simultaneously into account:

$$P_{AU}(X_i) + P_{DU}(X_i) > P_{AP}(X_e) + P_{DP}(X_e) - P_c^*(X_i - X_e) + > + P_{AP}(X_i) + P_{DP}(X_i) \qquad (11)$$

Inequality (11) points out that if the lesser is as ineffective in applying and deposing the chemical than the lessee, i.e., if: $P_{AU}(X_i) + P_{DU}(X_i) = P_{AP}(X_i) + P_{DP}(X_i)$, inequalities (9) and (10) are simultaneously not fulfilled. Hence leasing model B is only chosen if the lesser makes use of his head start in knowledge and applies the chemical efficiently. Only in this case, gains from over-consumption (either on side of the producer or the user) can be outweighed by service charges that the lessee is willing to pay.

All in all, we find that both leasing models are supported first, if the service charge is specified independent of the amount of chemicals applied respectively disposed and second, if the producer of a chemical has a head start in knowledge regarding the efficient application of the chemical so, that gains from an efficient use of the chemical can be realized by switching from traditional sales contracts to chemical business leasing models.

V. Summary and Discussion

REACH requires companies that use chemicals to invest in the gathering of information on the properties of their substances. For small and medium enterprises as well as companies for which the dealing with chemicals is not a core competency the costs of gathering information might be prohibitively high so that the producer of a chemical is the only source the user is able to get knowledge from. In the traditional sales concept, however, the producer does not benefit from a knowledge transfer if this enables the user to apply the chemical more efficiently. The reason is that efficient application lowers the amount of sold chemicals, which is expected to directly decrease the profits of the user. Regarding a chemical leasing business model, one of the key features is that a service related to the good (here: a chemical) – instead of the good itself – is offered to the customer. Since the kind of the service can be freely chosen, it may, for example, consist of a transfer of knowledge on the properties of the leased chemical. Since producers in general have extensive knowledge on their products, it will be possible for them to offer such information to customers as an added service.

We have shown that the service charge of the lesser (per unit of leased chemical: GL/X) has to clearly exceed the costs of the lessee (per unit of chemical) if he rejects the service offer and accepts a sales contract instead (CS/X). In order to pose incentives for the acceptance of a leasing contract the lessee thus has to be compensated by cost savings due to quantity reductions. The implementation of chemical leasing business models is thus feasible if first, the lesser transfers his knowledge regarding the efficient use of the chemical to the lessee (leasing model A) or second, efficiently applies the chemical herself (leasing model B). With it the goal of REACH: to effectively manage the risk of chemical substances is fostered, either by a transfer of knowledge or by leaving the responsibility of applying and disposing the chemical in the hand of the producer. In both cases chemical leasing business models compared to the traditional sales concept have the advantage of avoiding chemicals' over-consumption. They are therefore able to ensure efficient application of chemicals. Above that, if the level of chemicals in use is positively correlated with the probability of adverse side effects, chemical leasing business models, at the same time, decrease the risk of negative effects on human health and the environment and are therefore a convincing alternative to the traditional concept of selling chemical substances. Above that model B shows comparative advantages to A if the infrastructure and the training of workers remains insufficient after knowledge transfer (see section II.4).

Up to now chemical leasing business models have been successfully applied in Austria [7, 8]. Moreover the idea of chemical leasing business models is picked up by the United Nations Industrial Development Organization (UNIDO). Within UNIDO's program "Sustainable Industrial Resource Management (SIRM) chemical leasing projects are applied in Egypt, Mexico and Russia. In all these settings chemical leasing business models have proven to significantly reduce emissions [9]. It is thus promising to concentrate future research on the analysis of factors and institutional settings that foster the shift from the traditional selling of chemicals to the implementation of chemical leasing business models. The results of our analysis suggest that shifting is especially to expect if the design of service charges in leasing contracts is independent of the quantity of chemicals in use. Further stimulations are expected if the risk of liability is left on the side of the lessee even if the responsibility of application shifts to the side of the lesser. Further analysis has to clarify these points in order to support the innovative approach of chemical leasing business models as instruments to implement the goals of REACH: to effectively manage the risk of chemical substances.

References:

[1] COM (2001) 88 final, Commission of the European Communities, Strategy for a Future Chemicals Policy, Brussels, 27 February 2001.

[2] Royal Commission on Environmental Pollution (2003), The Long Term Effects of Chemicals in the Environment, Twenty-fourth Report: Chemicals in Products - Safeguarding the Environment and Human Health, London, June 2003.

[3] Austrian Federal Environment Agency, Altlast O 55 Eumig, Upper Austria, Kirchdorf an der Krems, http://www.umweltbundesamt.at/umweltschutz/altlasten/altlasteninfo/altlasten3/oberoesterreich1/o55/.

[4] Glossary of chlorine and other chemical related terms – entries for trichloroethylene, methylene chloride, and perchloroethylene; http://www.eurochlor.org/ mainglossary.

[5] International Chemical Safety Card (ICSC) No. 0081 prepared in the context of cooperation between the International Programme on Chemical Safety (IPCS) and the Commission of the European Communities (CEC) 2004.

[6] Center for Emissions Control (CEC), Solvent Cleaning (Degreasing), An Assessment of Emission Control Options, November 1992, Washington D.C..

[7] Jakl, T., Joas, R., Nolte, R., Schott, R., Windsperger, A. (2004), Chemical Leasing: An Intelligent and Integrated Business Model with a View to Sustainable Development in Materials Management, Springer Verlag, Wien.

[8] Perthen-Palmisano, B., Jakl, T. (2005), Chemical Leasing - Cooperative business models for sustainable chemicals management - Summary of research projects commissioned by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management, ESPR, 12, 1, 49-53.

[9] Schwager, P., Moser, F. (2006) The Application of Chemical Leasing Business Models in Mexico, ESPR, 13, 2, 131-137.

Notes

---

i Distillation is a method of separation of pure liquids or a mixture of different liquids, which is based on differences in the volatilities of the pure liquid or each single component of the mixture. In order to perform the separation process, vapor is generated by the application of heat to the solution that is to be distilled. The so generated vapor has a composition determined by the chemical properties of each component of the solution. A necessary precondition for a successful separation is that each component must have a higher concentration in the vapor than in the solution.

ii The specific latent heat of vaporization is the amount of heat required to convert unit mass of a liquid into the vapor without a change in temperature.

iii An azeotrope is a liquid mixture of two or more substances that retains the same composition in the vapor state as in the liquid state when distilled or partially evaporated under a certain pressure. It can be difficult to separate the components of an azeotropic solution by distillation.

iv If the chemical can be re-used by the producer he may also take the gains from re-using the chemical into account. We neglect this aspect for simplicity reasons. Above that we assume that P_D covers all costs that arise with the recycling respectively disposal of the chemical (i.e., e.g. expected increases in liability claims on the side of the producer due to taking over the responsibility of disposal).

v If the user (the lessee) is unable to observe the level of chemicals in use, the producer – even if he would charge the inefficient amount of chemicals - has strong incentives to apply the chemical efficiently since this would reduce his overall costs.