EU Commission

Innovative Business Models with Environmental Benefits

Final report

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1 Executive summary

Greater spread and application of innovation in business models that reduce resource use has the potential to create multi-billion euro markets in the EU and overseas and bring very substantial environmental and economic benefits.

The actual spread of these business models currently covers a very broad range of sectors including industrial production of solid goods, fluids and ingredients as well as transportation, construction and maintenance, agriculture and public services.

But they have been utilised to only limited extent with a very unequal distribution between different countries and industries.

The most promising benefits appear to be realised by different kinds of Product Service Systems (PSS). They are alternatives to the selling of products or services that offer greater profits. If PSS were more widely applied they could lead to greatly reduced consumption of energy and raw materials as well as reduced waste production.

Case studies examined 8 successful business models to distil the factors that make them successful and to understand why such business models are not currently more widespread.

These include chemical management systems, where chemical suppliers take back chemicals they sell – a model more widely applied in the US than in the EU and waste management co-operation where General Motors co-operate with waste specialists to reduce waste production and share savings from effective waste management. There are examples where business model change has led to 20% reductions in waste and 65% increases in recycling – with corresponding financial gain. Some of these types of business models are estimated to have markets worth €5bn or more per year.

The key factor for success is that the company actually have a potential in the form of either product capacity or knowledge that could be captured by diverting into a service market or taking the responsibility of the process related to the product. Key features:

- **Capturing the potential**: PSS projects changes the scope of the supplier. Instead of focusing on the product, the deals focus on the outcome from the combination of product and service. This combination gives the sup-
plier the opportunity to use their specialised knowledge about the use of the product to realise a potential that is not realised in ordinary contracts. This means that the supplier of e.g. chemicals or energy-consuming systems can capitalise the full capability of their product and know-how to improve their business case and reduce prices at the same time.

- **Incentives:** All the cases are based on creating new incentives for the partners. The provider in many cases gains an incentive for a lifetime perspective on investments, and both receiver and provider get an incentive to reduce the use of material or energy in production and use. Both incentives bring down the operating costs. These savings are split through different kinds of contractual regulations to make both partners benefit economically.

- **Risk management:** In many of these models the compensation mechanisms that the contract is based on are decisive for the sharing of risk. It is an additional source of income for the provider in these agreements to be able to handle risk better than the partner could do by himself. This ability to control risk is closely linked with the aforementioned potential and incentives leading to new and better solutions.

The cases show, that the economic results are very positive. Many projects realise annual wins of 20% or more that can be split between the supplier and the customer. Customers can benefit from reduced prices, less hassle and a green image. PSS providers can enter new markets, increase profitability by obtaining a higher position in the value chain, retain customers, sustain a green image and fulfil future legislation.

The spread of PSS is currently limited by several avoidable factors. These mainly relate to lack of knowledge, inertia in ways of working and difficulties in communicating new complicated business cases. Providers of product service systems sometimes need to invest in change whilst facing an uncertain future of policies and regulation that might - or might not - incentivise companies to save resources.

Both business leaders and policy-makers can take action to seize the opportunity these business models offer and speed their spread.

**Business leaders can find opportunities to profit** from PSS models by investigating:

- Existing technical capabilities - or knowledge that is capable of saving resources but which is not utilised by existing business models.
- Possible wins that could be realised and shared in a partnership relation with customers and business partners.
- Opportunities for selling outcomes, rather than products.
- Willingness to pay for intangible value such as e.g. reputation for sustainability.
Policy-makers can support the development of PSS models by:

- Take environmentally-friendly business models seriously as a means to achieve environment and innovation policy goals
- Shaping regulation to give greater incentives for reduced resource use and lower unfair competition from subsidised resource use.
- Checking existing regulation to remove blocks to the delivery of outcomes (rather than products) by businesses.
- Examine the potential in their region, using knowledge of local culture and economic conditions to assess the drivers and barriers.
- Setting up non-profit organisations documenting benefits - commercial and environmental - and spreading knowledge about specific models
- Secure a flow of outcome-based deals to reduce market insecurity, either through public purchases or through regulation of private companies.
- Make existing networks and infrastructure accessible to companies that need them to make their business model operational.

Business associations could break down barriers to uptake through the promotion of knowledge of PSS through business networks.
2 Introduction

This report contains the findings from a study on innovative business models with environmental benefits that COWI has conducted on behalf of the European Commission.

In recent years, resource efficiency has ranged highly on the global business and political agenda. Driven by rising energy and material prices and a limited stock of fossil fuels, climate change and increasing public awareness of environmental issues, reduced resource use is now an issue that is taken seriously by international and national business and by (non-) governmental organisations around the world. This has among other things led to a search for new ways in which energy and resource consumption can be reduced and damaging CO₂ emissions curbed.

This report is first and foremost to investigate for businesses the benefits and availability of innovative, economically viable and environmentally-friendly business models. This report describes a selection of innovative business models that are economically profitable and also have positive environmental effects.

It identifies the promise and pitfalls of the different types of business models leading to policy recommendations that can contribute to the greater spread of this type of business models.

This report can thus be used as an inspiration catalogue for business people, politicians, civil servants, and international profit and non-profit organisations that are interested in implementing or simply learning more about innovative business models that can foster sustainability and enhance competitiveness at the same time.

On the following pages, the reader is introduced to the logic, potential and opportunities of six types of Product Service Systems (PSS) (chapter 4). Based on these descriptions, the next chapters analyse what drives PSS (chapter 5), what the market potential is for PSS (chapter 6) and how PSS and can be realised (chapter 7) leading to the conclusions and recommendations for business and policy-makers who want to promote PSS (chapter 8).

Chapter 9 contains detailed studies of the six types of business models, describing their incentives and barriers. Chapter 10 gives short descriptions of all 85
examples of innovative business models found in the investigation. The ana-
lysed case studies are summed up in the table below.

<table>
<thead>
<tr>
<th>Case Studies</th>
<th>Essentials</th>
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<tbody>
<tr>
<td>Case study I</td>
<td>Energy saving partnership between the provider, TAC Energy Solutions, and the customer, Regionfastigheter, Sweden leading to split savings from of € 1.26 million/year and reduced energy consumption for heating of 30 %</td>
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<tr>
<td>Case study II</td>
<td>Dong Energy and Novo Nordisk have set up an energy partnership. Dong Energy helps Novo Nordisk identifying energy-saving projects on a non-fee basis. The energy savings that are realized through the partnership are committed to purchasing wind power from Dong Energy. The project is expected to reduce CO$_2$ emissions equalling approximately 130,000 tonnes and will make the business case for windmills more attractive.</td>
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<tr>
<td>Case study III</td>
<td>Hampshire County Council, UK, procure the responsibility for building and maintaining the lighting net for a contractually determined sum from a contractor. The contractor gets an incentive to reduce operation and maintenance costs - thereby reducing the use of energy and materials. This optimisation also leads to economic savings realised by both partners.</td>
</tr>
<tr>
<td>Case study IV</td>
<td>PPG industries cooperate with General Motors/Opel on a process and chemical management programme. PPG is obliged to a continuous reduction of the use of chemicals. General Motors realise the savings and rewards PPG for the fulfilment of the agreement. The deal leads to reduced chloride in the wastewater and reduced wastewater sludge.</td>
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<tr>
<td>Case study V</td>
<td>Houghton offers fluid management services based on a fixed price business model, where Houghton takes over the responsibility for the customer's management of lubricants. The customer benefits from reduced downtime of production lines. Houghton benefits from the reducing the amount of chemicals used</td>
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<tr>
<td>Case Study VI</td>
<td>General Motors has outsourced the management of waste - primarily packaging and chemical waste as paint sludge - to a Resource Management Contractor. A gain-sharing mechanism in the contracts gives the contractor incentives to assist GM in eliminating the production of waste and to increase the reuse and recycling of waste.</td>
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<tr>
<td>Case Study VII</td>
<td>ASML provides expensive microlithography systems for the semiconductor industry. When their customers no longer need the system they have acquired from ASML, ASML buys it back and send it back on the market after a sufficient upgrading. The method keeps the price and production time relatively low and increases profit potential for ASML.</td>
</tr>
<tr>
<td>Case Study VIII</td>
<td>Mobility CarSharing Switzerland has 79,000 customers sharing 2,000 vehicles in 400 cities and towns in Switzerland and Liechtenstein. The customers are charged according to hours of use and mileage driven. The costs include fuel, insurance and maintenance. The total annual energy savings from Mobility's private customers in 2005 is estimated to 78.4 TJ (terajoules), which equals approximately 2.5 million litre of gasoline.</td>
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3  Depth and Breadth of the Analysis

The report is based on a comprehensive screening of the business model landscape from around the world. Approximately one hundred experts and/or organisations were contacted to form a case catalogue encompassing over 80 generic as well as substantive business models, which shows the breadth of possibilities.

The study’s sources included:

- Private sector representatives (representatives from firms applying innovative business models).
- Representatives from research institutions (universities, business schools and other research institutions).
- Public sector representatives.
- The case catalogue was also compiled using reviews of academic literature as well as policy reports and other available documents/reports on the subject.

Further analysis of the 8 selected cases was based on more interviews of representatives from the analysed companies as well as an expert workshop with leading scholars in the field of PSS from universities and other research institutions.

3.1  Categorisation of Generic Case Studies

The majority of the business models gathered in the case catalogue are various types of product service systems (PSS). Furthermore many of the most promising business models turned out to be different types of PSS. A handful of generic business models were selected for closer scrutiny/case analysis to investigate promises and barriers for the implementation of various types of PSS.
A PSS can be defined as consisting of "tangible products and intangible services designed and combined so that they are jointly capable of fulfilling specific customer needs" (Tukker 2004, 246). ¹

The key feature of PSS is that there is a shift away from product orientation toward a greater emphasis on delivery of the function of the product combined with relevant service. For example, instead of selling fuel, a company may offer certain levels of heating in a building. Or, instead of selling pesticides, a company may sell a maximum level of harvest loss.

Various types of PSS exist. A conventional classification distinguishes between three main types of PSS (Tukker, 2004). These are:

- **Product-oriented services:** This business model is still geared towards sales of products but extra services are added for instance maintenance contracts, supply of consumables and take-back agreements.

- **User-oriented services:** Traditional products play an important role but the business model is not geared towards selling products; examples are product lease; product renting or sharing and product pooling.

- **Result-oriented services:** The client and the provider agree on a result but there is no pre-determined product; examples are delivery of a functional result as in the two examples mentioned above.

Moving from the first to the latter categories of PSS, the reliance on the product decreases, and the needs of the client are formulated in more abstract terms.

Six generic PSS models were chosen from the case catalogue for a more detailed case analysis. These were:

- Chemical Management Services (CMS)
- Resource Management (RM)
- Energy Service Companies (ESCO)²
- Design Build Finance Operate (DBFO)
- Remanufacturing
- Car-sharing

The first four business models belong to the result-oriented services category of PSS as they all shift the focus from the input to the result. Remanufacturing which is based on altering used products to be ready for resale can be argued to belong to the product-oriented services category. Finally, car-sharing is a method to make more people use the same car and thus a form of user-oriented PSS service.

In the cases analysed here, there is thus a spread in the type of PSS that

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¹ Elsewhere, PSS has also been defined as “a system of products, services, supporting networks and infrastructure that is designed to be: competitive, satisfy customers’ needs and have a lower environmental impact than traditional business models” (Mont 2002, 240).

² Definitions and descriptions of the six business models selected here are available in chapter 4 and 9.
are encompassed by the analysis, nevertheless with the majority of the cases belonging to the result-oriented services category. The reason for this is that function-oriented business models within the result-oriented PSS category have been identified as being particularly promising in environmental terms (Tukker 2004, 259).

The in-depth case analyses evolved around four key parameters:

- Key features of the business model
- Business rationale
- Environmental case
- Possibilities and barriers

We carried out detailed case analysis for each generic business model, with one or two case examples (chapter 9). In total, eight concrete case examples are included.

The cases were analysed to generate general knowledge about the functionality of PSS and how it can be utilised further. On the basis of the case analyses a workshop discussions, a number of findings about the potential, applicability and policy recommendations have been generated, covering the following topics:

- What are the **opportunities** for the successful business models to spill over from one sector/country to others?
- What are the **barriers** to this development in regulation and in the market respectively?
- How can innovative business models with positive environmental impacts be more **widely disseminated** on the market?
- Which **policy changes can support** the development and dissemination of innovative business models?
4 Product Service Systems

The core logic of a Product Service System (PSS) is that the focus shifts away from delivering products or services towards delivering functionality to the customer.

This shift gives companies possibilities to realise economic as well as environmental potentials that are not captured by ordinary business models. Experience shows that PSS can be applied in a very wide range of sectors using different methodologies.

The following sections will describe six different ways of using PSS when doing business. Each description highlights the potential, logic and opportunities of the models. The aim of the descriptions is to give generic input to business case considerations in companies who may consider PSS. Furthermore, each model contains one or two short cases of successful PSSs using the model.

In-depth descriptions of the business models and cases are found in chapter 9. This chapter also contains all the references behind the arguments in these shorter descriptions.

4.1 Energy Service Companies

An energy service company (ESCO) is a company which delivers energy services, assumes financial risk relative to energy projects and further is paid according to the extent of realised energy savings. In an ESCO project the energy provider optimises the consumer's energy consumption through application of more energy-efficient technologies and by optimising the energy consumption, primarily with respect to heating and lighting.

| Application | ESCOs are known in all kinds of buildings and plants including schools, hospitals and production facilities and are considered to be one of the most promising PSS models. The method can be applied in both the public and the private sectors, but the opportunities are most obvious in rundown public facilities. |
| Environmental benefits | The model has the potential of realising 170MJ/m²/year of energy savings leading to substantial reductions in CO₂ emissions. This effect can be even bigger if savings are spent on green energy investments as in the DONG Energy -Novo Nordisk case. If this model was applied in all construction facilities it has been |
estimated to reduce national CO₂ emissions by 10% in Denmark. This figure will probably not be smaller in other countries.

**Project framework**

ESCOs are contractual relations between companies or a company and a public organisation. The typical length of the contracts is 5-10 years, but some contracts are longer to secure that long-term considerations are taken into account.

**What's new?**

This business model differs from traditional business models in the sense that the client no longer contracts for a fixed product/service. The provider is given relatively free hands in bringing about the technical solutions that are necessary to achieve energy savings. The core feature is that the risk of the project is normally transferred to the contractor which means that he/she is incentivised to bringing about as large savings as possible because this is tied to the payments that the contractor receives.

Here, it is important to note the new role of the buyer. He/she has to maintain a more hands-off approach relative to traditional procurement models, and this requires a different type of relationship with the contractor.

The traditional command-and-control approach is not appropriate in this type of project. Instead a partnership approach, in the conventional meaning of the word, is more appropriate. Another core feature is the investment element: i.e. that the ESCO company normally is responsible for or involved in the project finance; e.g. assistance in the arranging of finance by way of the energy saving guarantee.

The new division of risk creates new contracting behaviour and incentivises the buyer and in particular the supplier in new ways. A key benefit of the ESCO model is that it has the potential to realise significant energy savings without constituting a liability for the recipient company. Often, there will be a guaranteed minimum saving, and the savings finance the capital costs.

**Supplier's benefits**

An ESCO gives the supplier the opportunity to capitalise the value that is created by the solution. The business model is particularly attractive to suppliers who can offer a solution that is technically and/or environmentally superior to the competitors'.

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**Case study I: TAC Energy Solutions**

This case concerns an ESCO project between the provider, TAC Energy Solutions, and the customer, Regionfastigheter. Total investments of SEK 109 million (€ 12 million) were made to set up the ESCO project.

The total savings from the cooperation amount to SEK 11.5 million per year (€ 1.26 million) which means a reduction in energy consumption for heating of 30%, the guaranteed annual savings is SEK 10 million (€ 1.1 million).

As both partners gain from the savings the project is an economic success for both.

Further a 30% reduction in heating is a substantial environmental benefit.
A good technical solution will have lower risk of failure and can therefore give better functionality in a performance-based agreement and create better economic results than a traditional sale of products. An ESCO rewards the supplier with the best solution.

The unique DONG Energy - Novo Nordisk cooperation gives further benefits for the supplier as the ESCO-cooperation makes it possible to invest in green energy at lower risk than their competitors.

Customer's benefits For the customer the prime benefit is the ESCO's ability to curb a negative cost trend in an aging estate stock and to support the long-term development of buildings and plants.

The ESCO makes it possible to lower energy consumption, better the coordination within the operational organisation and upgrade technical standards - all bringing about lower costs - without investing scarce capital.

Further the cases show that ESCO can be used to reduce CO₂ emissions in a cost neutral manner and shift to green energy consumption at the same time. For the customer this brings about two benefits. First, it prepares the business for a carbon-constrained future by reducing carbon dependency and curbing rising energy expenses. Second, it realises intangible value in the sense that it signals to the broader community that company cares about the climate.

Case study II: Novo Nordisk and Dong Energy
A Danish energy producer, Dong Energy, and Novo Nordisk, producer of pharmaceuticals have set up an energy partnership. The essence of the partnership is that Dong Energy helps Novo Nordisk with regard to identifying energy-saving projects on a non-fee basis.

Novo Nordisk is committed to convert all the energy savings that are realized through the partnership, into purchasing of wind power from Dong Energy.

By 2014 the partnership is expected to have brought about a reduction in CO₂ emissions equalling approximately 130,000 tonnes. Novo Nordisk's own calculations suggest that should all Danish manufacturers follow the same model then total CO₂ emissions in Denmark could be reduced by 10 % (six million tonnes).

In the EU-15 the manufacturing sector stands for 21.9 % of total greenhouse gas emissions, this equals approximately 901 million tonnes greenhouse gas emissions (Federal Statistical Office 2008, 11 and 15). Thus, when extrapolating to the EU-15 a 10 % reduction in greenhouse gas emissions in the manufacturing sector would equal a cut in the range of 90 million tonnes.

The key precondition is knowledge about the existence of the models. It seems that the market is becoming more aware of ESCOs when energy prices price and there is a general interest in energy efficiency and climate change. Further, aggressive energy saving goals in some countries are pushing the development of the ESCO-sector.
To make ESCO solutions attractive it is essential that the price of energy is not kept low artificially, that there is no legal constraints on investment in energy savings and a general policy that gives incentives for energy savings.

Further, to make a co-operation like the Novo Nordisk - DONG Energy partnership attractive it is essential that it is possible to measure and claim individual companies' investments in green energy.

The European Commission estimates that the marked for ESCOs can develop to a volume in the range of €5-10 billion per annum within a short-term perspective. This gives reasons to believe that there is a large unrealised ESCO potential in Europe.

An estimation of the overall revenue for the US industry in 2006 was $3.6 billion. There was an annual growth in the industry of 20 % in the period 1991-2000. This figure dropped down to 3 % in the period 2000-2004. However, from 2004-2006 this increased drastically again to 22 %. The industry revenue in 2008 is estimated to be around $5.25 billion in US alone. A similar development in Europe is likely to be given the right political backing.

### 4.2 Design, Build, Finance, Operate

The Design Build Finance Operate (DBFO) model is a form of Public-Private Partnership (PPP). A PPP is a contractual relationship between a public authority and a private contractor used for construction projects requiring long-term investments. Significant for the DBFO model is that while the public authority is the owner, it is the private contractor that designs, builds, finances and operates the construction in question.

DBFO is already applied in a long range of sectors including building, infrastructure, transport systems and military equipment. The model is focused on delivering the functional result of a combination of investment, construction and operation to the public sector.

It is yet to be proven that DBFO has significant environmental benefits but the model in its essence gives incentives to minimise operation cost including energy and minimise maintenance.

The environmental potential in DBFOs would be considerably larger if public sector procurers focused more on the environmental side of the projects. The model in itself makes it easy to apply TCO-thinking.

The typical DBFO model covers a period of several decades - typically 30-35 years - some even longer. It is based on comprehensive agreements as a cooperation that long, makes it relevant to regulate a lot of aspects of the cooperation.

Due to these obstacles the model is normally reserved for large contracts.
What's new? The public authority specifies the desired output and it is up to the contractor to deliver this output, and as such it is a form of Performance Based Building. Just like the case with the ESCO model, in a PPP, the buyer assumes a different role relative to traditional procurement models. Again, the contractor must be given the necessary elbowroom to come up with the innovative solutions that bring about the hoped for superior solutions. A partnering approach is thus also important here. The long-term nature of the business relationship emphasises further the importance of a partnering approach.

Normally, in DBFOs the private sector party assumes ownership of the asset for the contract period which typically concerns 30-35 years. After this, the asset is transferred back to public ownership. An interesting detail is that the private party commits to handing back an asset which meets certain minimum maintenance standards. This means that asset maintenance is not neglected during the project period; a problem which is all too well-known in the public sector.

The DBFO model is closely related to the ESCO model and the two models do to some extent share the same logic. In both models, there is a significant move towards delivering function as opposed to products. The provider normally assumes project risk (i.e. the provider commits to certain performance standards – remuneration of provider is contingent on its performance) and the provider normally finances necessary upfront capital investments (in the narrow understanding of the terms).

Supplier's benefits The supplier in a DBFO is secured a long-term, stable income from the project and is incentivised to secure reliability and long-term minimisation of cost.

Further, the large bidding cost is offset by the very large portfolio of assignments that is part of the deal.

Finally, DBFOs' deals are known to be good financial assets as soon as the project is delivered successfully making it attractive for all partners to invest in the deal.

Customer's benefits The same incentives bring about benefits for the customer. As the supplier is incentivised to construct assets that can be efficiently maintained and operated, the cost of operation is brought down. In particular within the public sector a

Case study III: PFI Street lighting
The project builds on an agreement between the Hampshire County council, UK, and a contractor. The contractor holds the responsibility for building and maintaining the lighting net for a contractually determined sum.

The contractor has an incentive to reduce operation and maintenance cost within the 25 years that the contract is running. The contractor will be contractually bound to comply with specified environmental criteria and the contractor has incentives to rationalise the use of materials and maintenance to increase the lifespan and reduce cost for replacements.

Due to contractor finance and profit being at risk, the contractor is incentivised to reduce energy consumption as this is an important income source for the contractor.

Focusing on environmental gains in DBFO is rather new but could have considerable effect.
lack of maintenance of public assets is often a problem and that makes the room for improvement in DBFO deals significant.

The customer is a good situation knowing the price, not just of the product, not just of the service, but of the functionality of the deal. That makes it possible to focus on the TCO of a project and not just one-year budgets.

It is hard to measure the exact economic benefits of DBFO as it is difficult to point out a baseline, but most studies conclude that the possible gains are substantial.

DBFOs are not easily brought about as they challenge several aspects of public regulation including financial management principles, procurement rules and standards, tax and VAT-regulation as well as substantial culturally-based scepticism towards private contractors.

Most countries have dealt with these obstacles by enforcing focused PPP laws (dealing with DBFO) and establishing national organisations promoting DBFO and other forms of PPP.

To realise environmental benefits from DBFO it is essential that the environmental perspective is in focus in the procurement criteria and contract-awarding mechanism. Most important is a shift of focus from the "low bid approach" to an approach focusing on the life cycle cost of the project.

The market for PPP can be considered to be substantial. In the period 2004-2005 alone, about 206 PPP deals were closed worldwide with a value of approximately US$52 billion. In the United Kingdom alone more than 750 PPP projects with a total capital value of £37.6 billion were implemented in the period 1995-2007.

Several other European countries are in a developing stage in DBFO but there is little doubt that the future aggregated European market for DBFO is massive.

4.3 Chemical Management Services

In a traditional chemical supplier-customer relationship, the supplier earns his profit by maximising the volume of sold chemicals. Relative to this, chemical management services (CMS) constitute a shift to a strategic alliance business relationship. Instead of purchasing chemicals (a product), the customer buys chemical management services.

CMS is applied in a very wide range of sectors including production of cars, aerospace and aircrafts, transport, machines and electrical equipment, metal industry, boiler treatment, cooling systems and wastewater treatment.

The management systems handle all kinds of chemicals including solvents, coatings, lubricants, industrial gases, adhesives, water treatment chemicals, tanners and printing ink. This makes it relevant in all kinds of production.
The CMS concept also has a potential within agrochemicals, where contracts can be set up, in which the supplier guaranties the farmer a certain performance for the crop in terms of quantity and quality. The supplier specifies a plan for the application of the product. The concept has been used in the US but has not been applied in Europe yet.

Furthermore, the logic of CMS could in principle be applied to a wide range of other ingredient-suppliers including e.g. medicine, enzymes or active microorganisms.

Environmental benefits

The environmental logic of CMS is that less lubricant is used and wasted if the supplier is incentivised to reduce instead of maximise the volume. This means that less lubricant is used to maintain the machine, less paint is used in the coating of cars or less adhesive is used to assemble a product.

Further a CMS deal makes it possible to incentivise the development and use of environmentally-friendly products by setting up goals to e.g. reduce the chloride concentration in the wastewater or reduce the amount of wastewater sludge.

Project framework

The projects are agreed between commercial partners. They often imply longer contractual relations - e.g. 3-5 years - as a CMS needs some initial investment, the value of which needs to be captured in the contract.

The size of the contract and the organisational interaction can vary a lot from one project to another with contract sums from € 5,000 to 1,000,000 a year.

What's new?

The chemical provider takes a direct role with respect to managing the customer's chemicals throughout the chemical life cycle, including the purchasing, managing and keeping track of chemicals. Thereby a shift takes place in the responsibility for the management of the customer's production processes and the quality of final products. This is expected to lead to a reduction in chemical consumption, in prices on chemicals as well as improved manufacturing processes. As a consequence improved environmental performance is achieved.

Case study IV: PPG Industries

PPG industries cooperate with General Motors (GM)/Opel on a process and chemical management programme at GM's plant in Gliwice, Poland.

All initial investments at the plant were made by GM. PPG is paid by cost per unit and the consumption of chemicals is calculated based on expected use. As a part of the contract PPG is obliged to a continuous reduction of cost per unit.

Only GM gains from the savings and there are thereby no gain-sharing mechanisms in the contract. But PPG is rewarded for the fulfilment of the agreement.

The environmental improvements include reduction in chloride concentration in the wastewater and reduction in the amount of wastewater sludge.

The programme has led to monthly savings in the magnitude of € 10,000.
A typical example of CMS is, for instance, long-term business relations between automakers and paint producers, where, instead of selling paint, the paint producer sells a painting service. The automaker then pays per painted car. This incentivises the paint producer to reduce the consumption of paint and to optimise paint processes.

Supplier's benefits

The supplier gains from the long business relation with the customer securing long-term business. Further it makes it possible for the supplier to realise the business potential in their superior knowledge of the qualities of the chemicals and the correct management of them.

The CMS deal normally gives the supplier massive incentives to realise savings as only very high savings need to be split with the customer. E.g. a typical model is that savings exceeding € 500,000 are shared evenly between Houghton and the customer.

Further applying CMS allows the suppliers to introduce new value-adding products and services that help to maintain growth in the business.

Customer's benefits

By the year of implementation of a CMS the net savings gained are from 5-20% and within the first three years most companies have annual savings of from 6 to 10%. After 5 years the savings are in the magnitude of 0-5% per year. The savings are primarily obtained through reducing the chemical consumption, reducing the prices on chemicals and improving manufacturing processes.

These savings are reflected in the attractive deals with the CMS supplier that can lead to reductions of up to e.g. 50% of costs of lubricants. Further soft savings are obtained by reducing the downtime on the plant and by avoiding additional labour costs.

Essential preconditions

A large barrier to introducing CMS among chemical suppliers is a traditional mindset, where profit depends on the quantity of chemicals they sell. Barriers to the suppliers are also that the customers are not fully aware of the concept and do not have a full understanding of the life cycle costs of chemicals.

Case study V: Houghton

Houghton offers fluid management services based on a fixed price business model, where Houghton takes over the responsibility for the customer’s management of lubricants. The savings gained from fluid management services are due to both hard and soft savings.

Hard savings are gained by considerable reductions in the usage of fluid care products and by reduced disposal cost for discharged lubricants. Soft savings are obtained by reducing the downtime on the plant and by avoiding additional labour costs.

The environmental gains from fluid management services are that less lubricant is used, and therefore less fluid is produced and the volume of fluid lubricant waste is reduced. This entails a reduction of CO₂ emissions.

Houghton benefits from the reduced input of chemicals combined with the fixed price of services.
To promote CMS it has proven a good idea to establish knowledge centers showing the benefits and possibilities to potential suppliers and customers. Further, it might be effectful to make public information campaigns focusing on companies.

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<th>Market opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>From 2000 to 2004 the CMS market in the US has grown about 50 % and made up a market of US$ 1.22 billion. In 2004, CMS has reached the largest market penetration in the US in the automotive industry where 75-80 % of the industry is utilising CMS. Air transportation maintenance (40-50 %), electronics (30-40 %), and aerospace manufacturing (25-30 %) are other sectors with a large market penetration. From 2000 to 2004, CMS had grown from application in 4 to 11 different industrial sectors.</td>
</tr>
</tbody>
</table>

In Europe, CMS is to a wide extent applied within the automotive and aerospace industries. CMS is growing in Europe but is not applied as widespread as in the US. Wider application of CMS constitutes a significant potential.

### 4.4 Resource Management

The idea in resource management (RM) is to set up a contractual arrangement between a waste-producing organisation and a waste contractor with incentives to preventing, recycling and recovering waste. This can be organised by setting up a mutually beneficial business relationships that encourage cost-efficient resource efficiency, recover savings and open up for gain-sharing mechanisms between the customer and the waste contractor.

<table>
<thead>
<tr>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>The model can in principle be applied in all waste producing organisations including both public and private production. The potential is biggest in large organisations as the task of managing the resources becomes more difficult the larger the organisation.</td>
</tr>
</tbody>
</table>

On the other hand, very large companies may find it even more attractive to set up internal resource management programmes to realise all the benefits - given that they have the sufficient knowledge about the resources used and waste produced in their processes.

<table>
<thead>
<tr>
<th>Environmental benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM has led to a reduction in the volume of waste that is sent to landfills and incinerators. This leads to reduction in methane emissions from landfills and reduced CO$_2$ emissions and NO$_X$ emissions from combustion.</td>
</tr>
</tbody>
</table>

A minimisation of the demand for virgin materials entails reduction in the energy consumption to extract process and manufacture products. This reduction in energy consumption leads to reduction of fossil fuel consumption and thus reduction of emissions of CO$_2$ and NO$_X$.

There are examples of RM which have led to a 20 % reduction in overall waste generation and a 65 % increase in recycling.
Innovative Business Models with Environmental Benefits

Project framework
Establishing a RM programme may entail initial investments. The way the investments are split between the waste contractor and the customer must be settled before the programme is set up.

What's new?
Resource Management (RM) is a business model that is based on changing the relationship between waste-generating organisations and their waste contractors. Traditional waste and recycling contracts feature "a profit incentive to contractors to maximise disposal levels (hauls) and/or a limited scope of service with multiple contractors handling separate waste streams or recyclables."

The compensation structure of a RM, on the other hand, can be organised in such a way that the contractor has an incentive to help the customer make continuous improvements in resource efficiency. This can be ensured if the RM contractor's profit margin improves by assisting the customer in decreasing waste generation and increasing reuse and diversion.

This means a significant change of attitude by the contractor: Performance instead of volume, resource efficiency instead of maximising waste and a strategic alliance instead of a minimal interface.

Supplier's benefits
The contract is based on a mutually beneficial business relationships that encourages cost-efficient resource efficiency, recovers savings and opens up for gain-sharing mechanisms.

The main benefit of the supplier is the shared gains. Another benefit is the possibility of building a partnership with the waste producer in a more and more competitive market for waste handling.

Finally, RM gives the waste contractor a better access to the disposal procedures at the waste producing companies which makes it possible to optimise the sorting of the waste and raising the potential for recycling.

Customer's benefits
RM gives the waste contractor incentives to emphasise cost-effective resource efficiency by preventing, recycling and recovering waste and by limiting the hauling and disposal of waste.

When the contractor implements changes that decreases costs on a permanent basis, the contractor gets a share of the savings gained, but the rest of the savings are realised by the customer.

One year after implementing the RM models at several of their production sites, GM realised a 20 % reduction on overall waste generation (30,000 ton) and a 65 % increase in recycling (from 50,000 to over 82,000 tons). In addition to this the com-

Case Study VI: General Motors
General Motors have implemented Resource Management at all of its North American assemble plants.

The waste primarily consists of packaging and chemical waste as paint sludge. All management of waste is outsourced to a Resource Management Contractor.

A gain-sharing mechanism in the contracts gives the contractor incentives to assist GM in eliminating the production of waste and to increase the reuse and recycling of waste.
pany had substantial reductions in the company's waste management costs (the waste management costs were decreased 15-30%).

RM is implemented in all of GM North America's manufacturing facilities, where a single supplier manages all waste at each plant. By 2007 the RM programme has here led to savings in the magnitude of US$ 6 million over the previous three years.

**Essential preconditions**

RM does not need a lot of preconditions as it is a development of an existing market.

The main barrier to RM is lack of knowledge of the opportunities and possible results. In the US this has been dealt with by a non-profit organisation Waste-Wise that promotes RM solutions and has assisted organisations in making feasibility studies of potential savings by application of RM.

**Market opportunities**

Studies of the potential for other US organisations show that the organisations have a large potential for improving their waste minimisation and recycling of waste and reducing their waste management costs.

The same potential is most likely found in Europe which makes RM a promising business model.

### 4.5 Remanufacturing

Remanufacturing is a strategy to bring used products back on the market. The method is applied when a product that is considered "used" by one customer can be made attractive to other customers with a relatively small effort. The idea is to bring the product back to its original specification or modernise and upgrade the product to new specifications.

**Application**

Some of the examples of sectors with successful remanufacturing of consumer durable goods are automotive parts, computers, laser toner cartridges, photocopiers, cleaning equipment, single-use cameras, refrigerators, washing machines, stoves and microwave ovens. This list shows that remanufacturing can be applied to most products given the right setup.

A specific potential is products with failures that are covered by the warranty, products that are harmed during transportation or products that have been leased out.

**Environmental benefits**

Remanufacturing constitutes the potential for achieving environmental advantages both upstream and downstream. Due to the reuse of products, upstream entails less consumption of raw material, and downstream as less waste is produced.

**Project framework**

The frameworks for remanufacturing differ substantially from one product to another. They all include a need for a reverse logistic setup that gives the sup-
plier access to the used goods. Further, an efficient method for disassembling and assessing if the parts are in good condition is needed.

What's new? Remanufacturing constitutes the potential for enhancing the opportunities of recycling to better realise the value in used goods that are not worn out. The business rationale of remanufacturing is to bring the products back to a standard where profit can be made on selling them.

This differs substantially from both other types of production as well from other methods of recycling.

Supplier's benefits Remanufacturing gives the suppliers a possibility to show a green profile ensuring that all value is extracted from their products.

Further, the right setup can deliver very good economic results. In the case of ASML a product that can be sold after refurbishment at €1.2 million is bought back at €400,000. €400,000 is used to bring the system up to the newest specification and €400,000 is the profit ASML makes. By giving a warranty on the remarketed products, ASML takes a risk, but most components are the same with known conditions.

Finally, remanufacturing contains the option of changing the audience of a product, e.g. altering production equipment when they cannot meet the standards of their initial purpose.

Customer's benefits The value proposition of remarketing is simple: When you no longer need the equipment the supplier buys it back at a good price.

Further, remanufacturing can make complicated products (ASML systems) more available and reduce the price of less complicated ones (single-use cameras).

Essential preconditions Remanufacturing is dependent on two preconditions in a company. First, the production and distribution systems must make it possible to find and integrate used products. Second, the incentives of sales persons and marketing efforts must support the sale of remanufactured products.

Case Study VII: ASML
ASML is a world leader in providing microlithography systems for the semiconductor industry. The prices for new systems range from €1.2 million to €45 million.

When their customers no longer need the system they have acquired from ASML, ASML buys the system back. ASML uses five strategies for remarketing their products, Direct-Shipment, Refurbishment, Remanufacturing, Legacy and Conversion.

The strategies are applied in accordance with the potential for reusing the products. The largest risk ASML takes by remanufacturing is the quality of the used systems they buy back. It has only been necessary to make relatively small investments in order to perform remanufacturing.

As the systems ASML makes are so expensive it is feasible to reuse most components and there is not much scrap from the production.
A more structural precondition is the possibility of establishing reverse logistics to make it possible for a company to get the used product back in good shape and at relatively low costs compared to the price of the product.

The case of Fuji Xerox is illustrative: In 1989, 5% of the scrapped machines were remanufactured. In 2005, Fuji Xerox had reached a recovery of 98% of the used products. This gives massive possibilities for reducing production cost and maintaining good relations with costumers.

For many companies the essence of remanufacturing is a platform design making it possible to change specific parts without discarding the entire product.

Electronic waste is growing at an annual rate of 3-5% which is three times larger than the growth of general waste. This can be considered an opportunity rather than a problem.

### 4.6 Car-sharing

Car-sharing is a model of car rental where the car can be rented for a short period of time, often per hour. In many Car-sharing Organisations (CSOs) a membership is a prerequisite for participating. To become a member an entry deposit is paid. Moreover, on a monthly or yearly basis a membership fee is paid, and costs for use of the vehicles are based on amount of time the vehicle has been used and the mileage driven.

Car-sharing is applied to all kinds of cars. Private customers are the main target audience but successful CSOs have spread the market to company cars giving access to a diverse range of deals.

The largest environmental benefits from car-sharing are achieved through shifts in the car-sharing customers' mobility patterns. Car-sharers are far more likely to combine use of a car with public transportation than private car-owners.

According to Swiss Mobility’s own figures the result of their car-sharing are yearly savings of 520,000 litre fuel and a reduction of 1,458 ton CO₂. In 2005, the fuel consumption of Mobility’s vehicles was 25% lower than the average for all Swiss cars.

If similar wins could be realised across Europe the result would be tremendous.

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**Case VIII: Mobility CarSharing**

As of May 2008, Mobility CarSharing Switzerland has 79,000 customers sharing 2,000 vehicles in 400 cities and towns in Switzerland and Liechtenstein.

The customer is charged according to hours of use and mileage driven. The costs include fuel, insurance and maintenance. The customer bears an own risk of a maximum of CHF 2,500 per accident.

Mobility has a strong co-operation with public transport operators in Switzerland. A Swiss study estimates the total annual energy savings from Mobility’s private customers in 2005 to 78.4 TJ (terajoules), which equals approximately 2.5 million litre of gasoline.
Innovative Business Models with Environmental Benefits

Project framework

The contracts are based on paid memberships making the relation more binding than ordinary car rental. The service of the CSO includes fuel, insurance, maintenance and cleaning.

All in all the focus is changed from the actual car to an easily accessible means of transportation.

What's new?

Car-sharing is a model of car rental that fills a hole in the market between ordinary rental and actual ownership. The difference from ownership is that the customer has access to a pool of cars spread across the country/city instead of having one vehicle parked outside the front door. The difference from rental is that access is very easy and that the service is cheaper if the need for a car is more than occasional and not permanent.

Supplier's benefits

Many CSOs are private organisations that would not be in the business if it was not for the environmental profile making the aim purely ideological.

For other CSOs being private rental companies car-sharing is an opportunity to reach a group of customers that wants a green image or has needs that are not met by ordinary ownership, lease or rental.

Customer's benefits

The advantage to the customer of car-sharing is to gain the flexibility of cars in terms of a means of transportation without having the costs and liabilities of owning a car. By having access to a fleet of vehicles the type of vehicle can be adjusted to match the customer's needs.

Successful systems are characterised by car stations which are located near the customer’s residence (every 500 meters in Zurich) and minimal effort is used to book the vehicle or to check in and out.

A “typical” CSO customer that uses public transportation for 75% of her trips and car-sharing for the remaining 25% could, depending on the yearly distance covered, make yearly savings in the magnitude of €3,114 and €1,552.

Essential preconditions

Car-sharing can often with advantage be combined with public transportation. Many CSOs cooperate with public transportation providers, and many car stations (the places where the car is picked up and left) are located in connection with public transportation, i.e. next to railway stations.

Together with access to parking lots the biggest barrier to car-sharing is the popular attitude. In a recent survey only 5% of respondents in a German survey were willing to share cars due to loss of personal status.

These barriers make it relevant for public authorities to help CSOs to establish themselves by giving access to parking space, distributing information and be forerunners in using car-sharing where relevant.

Market opportunities

In Switzerland over 1% of the population is member of Mobility. The potential for car-sharing in Switzerland is estimated at 0.5 million persons. This corresponds to approximately 6.7% of the Swiss population. 1% of the EU27 popul-
lation is approximately 5 million people. Assuming that a similar percentage of the population in the EU27 has the potential for being members of a car-sharing organisation, the car-sharing potential is 33 million EU citizens.

Car transport accounts for a sizable majority of (inland) passenger transport in the EU Member States. This suggests that in principle there is a large potential market for car-sharing but it is unlikely that the general potential is as big as in Switzerland.
5 Drivers for PSS

As the above presentation of the various PSS models suggests they contain promising benefits. Under the right circumstances and when implemented correctly, environmental as well as business benefits can be achieved. In order to gain an overview of the promises of each business model, we can, in general terms, distinguish between environmental benefits, business rationale and political attractiveness.

The models are brought to market by companies who expect commercial gains from the models. The companies are acting in an environment, where both customers and the political demands of the community play a crucial role.

The relation between the customers and the companies is driven by:

- The customers wish to reduce cost and risk and at the same time gain a more comfortable relationship where they can focus on their core competences, further PSS can support a good reputation of doing green business.

- The companies on the other hand wish to enhance their markets into new areas, raise profit by climbing the value chain and reduce their commercial risk - primarily by making longer, broader deals with the customers focusing on output instead of input.

The relation between the companies and the community is driven by:

- The wish of the community to implement green legislation and policy in the most cost-efficient way. PSS offers environmental benefits at no cost for the community.

- The companies wish to secure a good reputation. Environmentally-friendly business models can be a way to take a calculated risk that future legislation will focus even more on environmental issues. This gives the companies who implement new business models a head start.
The figure below sums up these overall drivers.

The table overleaf sums up the drivers behind the cases as described above. Below is an in-depth description of the aggregated drivers and the conclusions for businesses and policy makers on what can be gained from PSS.
### Innovative Business Models with Environmental Benefits

<table>
<thead>
<tr>
<th>Environmental benefits</th>
<th>Business rationale</th>
<th>Political attractiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESCO</td>
<td>Substantial reduction of energy consumption and increased energy efficiency leading to significant reduction of CO₂ emissions[^3]</td>
<td>Project finance and contractor remuneration is brought about by achieved energy savings</td>
</tr>
<tr>
<td>DBFO</td>
<td>More energy efficient assets incl. lower maintenance cost and operation costs due to project life cycle planning[^4]</td>
<td>Value for money is achieved by having provider finance at risk. This brings about innovative technical solutions</td>
</tr>
<tr>
<td>CMS</td>
<td>Reduced consumption of chemicals, less pollution</td>
<td>Smaller amounts of chemicals needed and professional management across business</td>
</tr>
<tr>
<td>Resource management</td>
<td>Less waste, increased recycling of materials</td>
<td>Reduced waste handling expenses and environmental taxes</td>
</tr>
<tr>
<td>Remanufacturing</td>
<td>Reduced use of raw materials, less waste</td>
<td>Cheaper to remanufacture than to produce, fast delivery</td>
</tr>
<tr>
<td>Car-sharing</td>
<td>Reduced energy consumption through shift to collective transport</td>
<td>Optimal use of cars. Professional service and management of fleet</td>
</tr>
<tr>
<td>Aggregated drivers</td>
<td>Reduced use of raw materials and energy and less waste</td>
<td>Incentives for suppliers to reduce consumption and opportunities to capture residual value</td>
</tr>
</tbody>
</table>

[^3]: In a recent study of the US ESCO market, the median electricity and fuel savings were estimated to be 170MJ/m²/year in the investigated projects (Goldman et al. 2005, 394).

[^4]: Little evidence exists relative to the sustainability potential of this business model. However, the incentive structure suggests that the contractor will provide assets that are more easily maintained and operated because this can be a significant revenue resource for the contractor. In turn, this has positive environmental impacts in the sense that cleaning, heating and lighting, for example, become more efficient.
5.1 Environmental benefits

All six models seem to promise positive environmental effects. The different models focus on different sectors but they all build on the same overall rationale: Reduce the input in the form of raw material and energy and reduce the output in the form of waste.

The incentives to change behaviour differ between the models. For ESCO, DBFO and CMS the incentive is handled by the supplier through a contractual setup. ESCO reduces energy use, DBFO optimises lifetime costs and CMS reduces the use of chemicals.

The cases show that ESCO and CMS in particular promise to bring about substantial environmental benefits. ESCOs can reduce energy consumption by 170MJ/m$^2$/year and potentially reduce national CO$_2$ emissions by 10% given the right framework. CMS can halve the use of chemicals and give incentives to reduce harmful ingredients.

In resource management and remanufacturing the incentives rest with both the producer, the waste handling company (sometimes the same) and the customer. The potential is not as clear as in ESCO and CMS, but there are examples of resource management which has led to a 20% reduction in overall waste generation and a 65% increase in recycling.

In car sharing it is the customer who has the incentive to reduce the use of energy and the incentive seems to be effective. Studies show that shared cars consume 25% less fuel and can interact in a successful way with public transportation.

These results show that the environmental perspective in promoting PSS is substantial and can be an essential part of greening the economy of companies as well as countries.

5.2 Business rationale

The business rationale of ESCO, DBFO, CMS and RM is related and the compensation mechanisms for these four business models are similar. The fundamental idea is that a shift in the traditional business relationship between supplier and customer takes place.

Instead of making profit by selling a volume of products the supplier/provider offers a function where they provide the product and manage the application of products more efficiently. There is thus a significant change in incentive structures making it possible for suppliers to create value by using their insight into the functionality of their products.

Further the successful cases show that products often contain an unrealised potential that is only released, when the supplier gets the responsibility of the functional result.
The business models of remanufacturing and car-sharing are fundamentally different. The business rationale behind remanufacturing is to capture the residual value of used products. The business rationale in car-sharing is to organise car-based mobility in a way that meets the needs of customers with a green profile and customers who are not satisfied with owning, leasing or renting cars.

Car-sharing has the special feature that a lot of the operators are small, semi-commercial organisations with more focus on the environment than the business.

Across all the cases four themes are significant:

- **Capturing the potential**: PSS projects changes the scope of the supplier. Instead of focusing on the product, the deals focus on the outcome from the combination of product and service. This combination gives the supplier the opportunity to use their specialised knowledge about the use of the product to realise a potential that is not realised in ordinary contracts. This means that the supplier of e.g. chemicals or energy-consuming systems can capitalise the full capability of their product and know-how to improve their business case and reduce prices at the same time.

- **Incentives**: All the cases are based on creating new incentives for the partners. The provider in many cases gains an incentive for a lifetime perspective on investments, and both receiver and provider get an incentive to reduce the use of material or energy in production and use. Both incentives bring down the operating costs. These savings are split through different kinds of contractual regulations to make both partners benefit economically.

- **Risk management**: In ESCO, DBFO, CMS and RM the compensation mechanisms that the contract is based on are decisive for the sharing of risk. It is an additional source of income for the provider in these agreements to be able to handle risk better than the partner could do by himself. This ability to control risk is closely linked with the aforementioned potential and incentives leading to new and better solutions.

- **Reputation**: Most of the cases are primarily based on ways to make profit, where the environmental advantage is a positive side effect. A better reputation for the partners is only mentioned directly in relation to car-sharing and one of the types of ESCO, whereas the other cases carry the potential of capitalising the reputation of the costumers. The example with the Novo Nordisk - DONG Energy partnership shows that reputation can be a very important driver, potentially leading to massive investments and strong business relations.

The cases show, that the economic results are very positive. Many projects realise annual wins of 20% or more that can be split between the supplier and the customer.
Moreover, the cases show that a successful PSS-supplier can be in a very comfortable position with strong client relations, secure business and opportunities as well as incentives to develop even stronger solutions and concepts.

The decision to invest in PSS is a balance between the need to be in sync with the market - and not in front of it - and still be the one to offer the new and better business models before the competitors.

By changing focus from traditional sale of the product to PSS, the company gives up the power position of knowing more about the product and trades it for a more valuable place in the value chain. This shift is not risk free and should be based on a solid business case.

A major consideration in building such a business case is the development in the political agenda. Will the future be better or worse for the business case of a PSS? And what is the right timing in going to market?

### 5.3 Political attractiveness

As political decisions and agendas are very important to businesses who may consider PSS there is a substantial responsibility in developing PSS which rests with the policy makers.

As shown in section 5.1 PSS can deliver great value in realising environmental goals including:

- Energy efficiency (ESCO, DBFO, Car-sharing)
- Sustainable growth (remanufacturing)
- Total Cost of Operation approach (all models in general and RM in particular)

Policy makers can achieve greater policy results by using policy tools with leverage to get a private effort going. Compared to a national budget the gains for the involved parties in the models are modest and often related to minor parts of a business' operations or the budget of a household. But the aggregated potential of the models is enormous making it possible to reduce CO₂ and NOₓ emissions substantially and reduce the use of raw materials and the production of waste on a scale that can realise national environmental policy.

To reach these opportunities policy makers could implement the following initiatives supporting each of the six models:

- ESCO: Not subsidise energy prices and give public authorities access to energy-saving investment. Further: Make it possible to register and measure individual companies’ investments in green energy.
- DBFO: Put in place legislation that deals with legal barriers relating to procurement, tax and financial management and promote the use of DBFO actively.

- CMS: Spread the knowledge about CMS and make official statistics about the achieved results to make the business case more accessible to companies.

- RM: Spread the knowledge about RM and make official statistics about the achieved results to make the business case more accessible to companies. Raise incentives to RM by making waste production more expensive.

- Remanufacturing: Raise incentives to remanufacture by making waste production more expensive and open up public opportunities for reverse logistics. Be a forerunner in buying remanufactured products.

- Car-sharing: Make parking space accessible in the right places, facilitate cooperation with public transportation agencies and be a forerunner in buying car-sharing services, and provide discounts on road toll and parking fees for car-sharing vehicles.
6 Market possibilities

This chapter is an estimation of the possible market for PSS. For each of the models we ask two questions:

• Does it have potential to spread further in the analysed sector - e.g. to other countries?

• Does it have potential to spread to other sectors?

There is no statistics available about the actual spread of PSS. The reason is that PSS models are not often recognised as such and it is still an area in its early development. Moreover, it is also difficult to acquire statistics on PSS because this label covers a broad variety of different business models. Further the six PSS models reviewed in the table below are also relatively open-ended.

Moreover, it should also be noted that the estimations below are uncertain in the sense that little accurate statistics exist and therefore much relies on estimation and judgements. These methodological caveats should be kept in mind when reading the table below.
Innovative Business Models with Environmental Benefits

<table>
<thead>
<tr>
<th>Spread</th>
<th>Market share</th>
<th>Market potential</th>
<th>Environmental potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESCO</td>
<td>The existing Western European market has been estimated to be € 150 million per annum.(^6)</td>
<td>The total market potential has been estimated to be € 5-10 billion per annum (Bertoldi et al. 2006, 1818).(^7)</td>
<td>The environmental benefits are estimated to be, for example, electricity savings in the range of 23% of the total electric bill baseline (median).</td>
</tr>
<tr>
<td>High intensity: Germany, Austria, The UK, Spain and Hungary. Medium intensity: France, Sweden, Czech Republic and Italy. Low intensity: All others.(^6)</td>
<td>In high intensity countries about 10-15 % of total government investment in public services takes place under PFI.(^8) Number of projects in the UK in 2008: 820.(^9) In Denmark the equivalent number is only 2.</td>
<td>If all countries in the EU had the spread of the high intensity countries the potential would be 10-15 % of total government investment throughout EU; i.e. between € 32 and 48 billions per annum.(^10)</td>
<td>The environmental benefits of the DBFO model have not yet been systematically documented but the model displays promising possibilities due to its incentive structure and sharing/transfer of risk</td>
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\(^5\) Bertoldi et al. 2006, 1822.
\(^6\) Bertoldi et al. 2006, 1818.
\(^7\) Relative to ESCOs a recent international survey indicates that most activity takes place in the commercial, the industrial and the municipal sectors respectively, while relatively low activity was identified in the residential and agricultural sectors (Vine 2005, 700).
\(^8\) HM Treasury 2006, 13. In the Budget 2004 for Ireland, targets for PPP investment as part of total government investment was set to increase from 3 % to 15 % in the period 2004-2008 (Scally 2004).
\(^9\) PartnershipsUK 2007. 3.
\(^10\) Gross fixed capital formation in the EU27 was approximately € 319 billion in 2007. This figure is derived from Eurostat's homepage. Gross fixed capital formation 2007, national accounts, EU27, general government. Date of extraction: Thu, 3 Jul 08 02:49:32.
<table>
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<th>Market potential</th>
<th>Environmental potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMS</td>
<td>High dissemination in automotive and aerospace industries, some application in electric industry.</td>
<td>The value added of the manufacturing of motor vehicles (incl. trailers and semi-trailers) and air- and spacecraft in the EU27 was in 2004 € 159 billion (this is approximately. 90% of the total value added by the transport manufacturing sector. It is not possible to estimate the exact share of CMS in these figures.</td>
<td>CMS has historically led to a reduced use of chemicals by up to 50 %. In 2006, the volume of toxic industrial chemicals produced in the EU25 was 207 million tonnes (Eurostat 2007, 423). The reduction potential could therefore in theory be argued to be 103.5 million tonnes toxic industrial chemicals.</td>
</tr>
</tbody>
</table>

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11 High dissemination means a market penetration in sales that constitutes 30 % or more.

12 The total value added of the EU27's transport equipment manufacturing sector (including motor vehicles, trailers, semi-trailers as well as aircraft and spacecraft) was approximately € 177 billion in 2004. This is approximately 3.5 % of the total value added by the non-financial business economy (which amounts to €5,100 billion) (see Eurostat 2007, p. 10 and p. 197).

13 No estimations of the value of chemical services are available.

14 The total value added of the non-financial business economy in the EU27 in 2004 was € 5,100 billion (Eurostat 2007, 10).

15 Between 1996 and 2006 the total production of chemicals grew by 22 % in the EU15.
### Resource management

The model has been tried in management of household waste in UK and Austria. The market share is very small relative to the European market for waste in which 1300 million tonnes of waste are thrown away each year (Eurostat yearbook 2008, 415). The spread of resource management can in principle reach the market share of the more widely applied models. However, it is impossible to estimate the possible size of a market that immature.

There are examples of overall reduction in waste generation in the range of 20%. When extrapolated to the aggregate EU-level this would imply a 260 million tonnes reduction in waste generation.

### Remanufacturing

Remanufacturing strategies are widely applied for expensive electronic products with a long lifetime. Examples of sectors with a successful remanufacturing of consumable goods are automotive parts, computers, laser toner cartridges, photocopiers, and cleaning equipment (Giuntini and Gaudette 2003; Franke et al. 2006). The kinds of products that are subject to remanufacturing are a very small part of the aggregated electronic market - estimated 1%. The market potential is closely linked to the cost of raw materials and waste handling. Growing scarcity of resources and/or increased taxes on waste production could make more product categories suitable for remanufacturing turning a highly specialised method into a multi-billion market.

As a general rule a prerequisite for most remanufacturable products is that they have high value and relatively long service lives. There are examples where remanufacturing constitutes an important part of a company's competitive advantage and has led to a 98% recovery of used products.

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16 This could for instance be products from enterprises in the machinery and equipment manufacturing sector. This sector alone has been estimated to have generated €171.7 billion of value added across the EU27 in 2004 (Eurostat Yearbook 2008, 159). This points in the direction of a large potential for remanufacturing.
**Innovative Business Models with Environmental Benefits**

<table>
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<th>Market potential</th>
<th>Environmental potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car sharing</td>
<td>The model exists in all of Europe but the popularity varies.</td>
<td>About 1% of the Swiss population are members. In most European countries it is about 0.1%. This market share is very low when considering that in 2004, 82.8% of all inland passenger km were related to passenger cars (Eurostat Yearbook 2008, 380).</td>
<td>If all European countries had a 1% car-sharing this would imply that approximately 5 million EU citizens would be members of a car-sharing arrangement.</td>
</tr>
<tr>
<td>Aggregated evaluation</td>
<td>For most of the PSS models studied here, we see that relative to conventional business models their dissemination is limited with substantial local variation across sectors as well as countries.</td>
<td>The addressed models only constitute a minor part of the market.</td>
<td>Based on the mere size of the general markets and the dissemination in the most successful PSS markets, the analysed business models have a multi-billion Euro market potential.</td>
</tr>
</tbody>
</table>
Even though uncertain the analysis shows that potential for PSS is quite big. Some of the models - ESCO, DBFO and CMS - already show a business potential of several billion Euros each.

Further, some of the less widely applied models - like Resource Management and Remanufacturing - have shown great successes outside Europe that are yet to be learned from.

Finally, car-sharing has a substantial unfulfilled potential that can be accentuated if the market focus shifts from individual cities and smaller regions to large cross-national networks with high intensity in densely populated areas.

The market potential is supported by substantial possibilities of realising environmental savings that can raise the opportunities of realising intangible value from the business models as both suppliers and customers act green when basing the cooperation on a PSS.

To sum up, the analysis of the market potential shows that the opportunities of doing good business and better the environment at the same time are great.
7 Realising PSS

The above chapters showed that the spread of PSS is limited even though the potential market, value generation and environmental benefits are substantial. This makes it relevant to investigate what barriers PSS models face and how the successful models have coped with the barriers.

7.1 Barriers to PSS

The case studies point out eight different barriers that are relevant for all the projects. The eight barriers can be divided into two groups: Five of them are general barriers to innovation that also apply to all kinds of new ideas, three of them are more specific barriers, that are of particular relevance to environmentally-friendly business models.

The five relevant innovation barriers are:

- **Lack of trust between customer and supplier**: A key to innovative cooperation is a good business relationship based on mutual trust. This is a key issue in alliance and partnership research and has also been identified as an issue in a recent report/overview of the ESCO market (EFP 2007).

- **New risk**: New models carry new risks – to which people are often more risk averse than more familiar risks. They are an issue for companies, customers and financial institutions alike. The risks can be different for the three parties but one thing they have in common is that they are unknown. There is no experience with calculating or handling the risks and therefore they might be perceived as bigger than they are. DBFOs are good examples as they involve a large transfer of risk to the supplier raising the question: Can they deliver? The logic of the model is that private finance is a firmer hand than public management, but the insecurity lingers until the project is fully functional.

- **Need of common vision**: Cooperation needs a common vision: What is it good for? A common vision can be hard to reach between partners who used to have clearly separated roles. This is particularly relevant in resource management and CMS which both imply that a subcontractor that is usually quite invisible is suddenly ion the strategic agenda.
Innovative Business Models with Environmental Benefits

- **Inertia:** An often acknowledged barrier to innovation is the inertia in rules, traditions and ways of doing things. A good example is car-sharing which needs a lot of infrastructure of public partners to be successful. Public inertia has been a major obstacle to realising this model.

- **Transaction costs:** It will often be expensive to make the transition from one business model to another. Further, the complexity of the business deals (this is particularly the case vis-à-vis DBFO) also incurs transaction costs.

The three other barriers that are specific to new business models with environmental benefits are:

- **Uncertain incentives:** The models are driven by their functional result, but it can be hard to measure the achievements of the models, and often the incentives are linked to a policy or market price that might change. The rewards of all the models are influenced by public rules for example, the relation is very clear for ESCOs, as the feasibility of the model is closely related to the price of energy which is partly dependent on public regulation. The rewards from environmental savings often depend on the public policy on putting a price on environmental harm.

- **Lack of knowledge:** It is not all companies who know the possibilities open to them and if they do, they know more about the environmental perspectives than the commercial ones. This barrier is of particular relevance because PSS models are quite complex relative to other ways of doing business, so require some knowledge to consider the opportunities.

- **New infrastructure:** Many of these environmentally-friendly models need a new infrastructure to make it possible to do business. This brings up transaction costs at a systemic level. The best example of this barrier is the need for reverse supply chain, disassembly methods and screening procedures in remanufacturing.

### 7.2 Overcoming the barriers

The analysed cases have one thing in common: they have the potential to overcome the barriers. This section will focus on how they did it and what others can learn from their experiences.

The table overleaf sums up the ways the cases have overcome the barriers and are the foundation of a more generic approach to realising PSS.
<table>
<thead>
<tr>
<th>Lack of trust</th>
<th>New risks</th>
<th>Need of common vision</th>
<th>Inertia</th>
<th>Transaction costs</th>
<th>Uncertain incentives</th>
<th>Lack of knowledge</th>
<th>New infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESCO</td>
<td>Guaranteed savings for the customer</td>
<td>Companies perform advisory services as well as installation and management</td>
<td>First step is a visitation that gives a common picture of the possibilities</td>
<td>Changing government policy / showcases that illustrate the economic potential</td>
<td>Internalised in the project. Costs and benefits in one deal</td>
<td>Deals based on objective criteria. Energy prices are perceived as unlikely to fall</td>
<td>Promoted by energy advisors</td>
</tr>
<tr>
<td>DBFO</td>
<td>Outcome-based contracts. Real ownership for the contractor</td>
<td>New insurance products. New financial markets</td>
<td>Public framework, private vision / procurement based on the vision</td>
<td>Public finance push effect</td>
<td>Deal flows that spreads the costs on a series of projects</td>
<td>More certain than in alternative models</td>
<td>Promoted by government offices and advisors</td>
</tr>
<tr>
<td>CMS</td>
<td>Incentives to do right. Environmental responsibility stays with the customer</td>
<td>New risks replace earlier procurement risk. The sum is positive</td>
<td>Break down of the process. The vision is an operational goal</td>
<td>Not more complicated than simple procurement</td>
<td>Compensated by longer deals</td>
<td>Focus on economic incentives rather than environmental</td>
<td>Establishment of non-profit organisations advising and collecting knowledge</td>
</tr>
<tr>
<td>Resource management</td>
<td>Lack of trust</td>
<td>New risks</td>
<td>Need of common vision</td>
<td>Inertia</td>
<td>Transaction costs</td>
<td>Uncertain incentives</td>
<td>Lack of knowledge</td>
</tr>
<tr>
<td>---------------------</td>
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<td>-------------------</td>
</tr>
<tr>
<td></td>
<td>Shared savings or guaranteed reductions for the customer</td>
<td>Service perspective broadened out to capture new risks</td>
<td>Strategic cooperation</td>
<td>Driven by public legislation</td>
<td>Compensated by customer retention</td>
<td>Pressure to reduce waste has to be handled by waste companies</td>
<td>Non-profit organisation providing technical assistance / Market leadership</td>
</tr>
<tr>
<td>Remanufacturing</td>
<td>Leasing instead of buying or guaranteed performance makes the customer sure it works</td>
<td>Focus on the &quot;almost good&quot; products reduces risk</td>
<td>Appeal to green consumers / hide the process</td>
<td>Consumer goods with green appeal or &quot;good as new&quot; = no inertia</td>
<td>Less than construction cost gain</td>
<td>Focus on new products with failing performance / undamaged products reduce risk</td>
<td>Small market / focused dealer net</td>
</tr>
<tr>
<td>Car sharing</td>
<td>Network-based / existing car rental business</td>
<td>Annual fee to secure minimal commitment and cover basic expenses</td>
<td>Clear value proposition - green and flexible</td>
<td>Organic growth</td>
<td>Lower than alternative</td>
<td>Significant economy of scale makes incentives clear</td>
<td>Offers through public transportation providers</td>
</tr>
<tr>
<td>Aggregated ways to overcome the barriers</td>
<td>Guaranties or retained responsibility</td>
<td>Deal with the risk in the deal or replace other risks</td>
<td>Vision process or clear value proposition</td>
<td>Link to general need or policy Keep it simple</td>
<td>Big deals or secured deal flows</td>
<td>Replace bigger insecurities or focus on easy targets</td>
<td>Non-profit promoters or positioning in existing networks</td>
</tr>
</tbody>
</table>
The table shows that for each barrier there are at least two different ways to deal with them. Often these ways are alternative routes, but in some cases they can be applied simultaneously - sometimes by different actors.

The premise for this part of the analysis is that both companies and policymakers can have tasks to fulfil to broaden the road to PSS.

- **Lack of trust:** Customers generally tend to do business with partners they trust or products they know. If you want to sell a new concept - maybe even to a new customer - trust can build by guaranteeing contractually that the promised savings are realised. To be sure to deliver the guaranteed functionality it may be attractive to take on tasks that are normally performed by the customer. These tasks can include operations, management and disposal.

- **New risk:** A related issue is that new concepts carry new risks for both supplier and customer. To make the deals attractive the supplier can choose to take on more risk than in an ordinary deal (see guarantees above) or design the system to replace other more threatening risks for the customer. E.g. a new performance risk "does the supplier have the management expertise needed?" can replace a market risk "is the product available at the right price and quality later on?" Suppliers can compare potential benefits, examine successful models and consider their own risk mitigation strategies.

- **Need of common vision:** The more the business relation is based on a partnership approach, the greater is the need for a common vision. Successful PSS-suppliers either offer a stringent and easily implemented vision process, or have a value proposition that is so clear and obvious that the need for the new business model replace the need for a unique common vision. The latter is the easiest - but not always possible to a sufficient degree.

- **Inertia:** Change takes some time and effort to happen and sometimes involve changed a regulation and/or policy. To shorten the lead time companies can create publicly available business cases or political cases stating how the business model fulfils the needs or policy of customers and policy-makers. Further, it is a successful strategy to start out with a business model as simple as possible - even sacrificing smaller gains that can be realised in later transactions, when the market has got used to the new model.

- **Transaction costs:** Another reason to focus on simplicity is that complex deals are expensive to implement. An extreme case is DBFO where transaction costs make deals smaller than € 20 million unviable. Some complexity is needed in PSS so the companies must focus on setting up big deals with big partners or secure a deal flow through agreements with public or private organisations.

- **Uncertain incentives:** PSS is often heavily linked to political issues as taxes and sector regulation. This makes the incentives uncertain because
policy can change. A successful PSS must structure the system to capture even bigger uncertainties. E.g. it may be uncertain what the exact prices and taxes on waste handling will be in the future, but a long deal reduces uncertainty related to the demand for waste services - and that is an attractive swop. Another way to deal with the uncertain incentives is to go for the easy targets. E.g. many CMS and ESCO deals only capture the short-term wins and not the more uncertain long-term ones.

• **Lack of knowledge:** It is hard to communicate the complex PSS-deals. Companies can create a business case, as described above in relation to inertia, to show the positive effects or to position the PSS-model in existing networks. E.g. ESCOs are promoted by energy advisors, Car-sharing can be promoted by public transportation companies.

• **New infrastructure:** It may need a big change to realise a new way of doing business. To limit investment and risk, successful PSS-companies use existing networks in different ways (e.g. supermarkets collect single-use cameras) or focus on narrow market segments - at least in the beginning (today CMS is almost limited to big companies in big countries).

The figure below sums up the barriers and the way successful PSSs have handled them.
7.3 Integrating PSS in business development

Many companies may see business opportunities in developing PSS solutions as a part of their portfolio. But how can PSS-considerations get implemented in the business development process?

Essentially the companies can start their considerations from three different focus points:

- Focus on internal capabilities for value creation:
  
  - Are the technical capabilities of the product exploited to their full extent? It may be that the customer buys sub-optimal products from a Total Cost Optimisation perspective or that he only delivers a fraction of their potential due to wrong equipment, installation etc.

  - Further it may be that the product still contains some value after the initial customer has used it. It may be useful to others with or without alterations.
- Is the knowledge of the company transferred into value creation? Most times suppliers know more about the products than the customers. This knowledge may constitute a potential to manage the product better in the use, operation or disposal phases.

• Focus on the potential value to be realised in cooperation:

  - Do the customers know something about the use or management of the product that could lead to better value creation if a partnership relation is established?

  - Do (potential) business partners know something about service, equipment or parts related to the product that could lead to better value creation if a partnership relation is established?

• Focus on the intangible value potential of the product:

  - What is the intangible value created by the product today, e.g. reputation, security etc. and what is the potential for creation of intangible value in relation to the aforementioned focus points?

  - What is the willingness to pay for intangible value in the relevant markets?

  - How do policies and regulatory incentives influence the demand for intangible value? E.g. is it possible to document the customers' contribution to CO₂-reduction as in the Novo Nordisk-DONG Energy case?

The company may be able to establish more attractive business models that capture the analysed potential through:

• Partnership agreements with business partners or customers that make it possible to capture and share the value created in cooperation.

• New services and product-service systems that utilise the knowledge and technical capability of the company's products

• Market communication of environmental benefits of the product-service system in the form of business cases that show tangible and intangible value.
8 Conclusion and Recommendations

The potential market for Product Service Systems is estimated in the billions of euros. If exploited fully would yield substantial business, balance of trade and environmental benefits. These benefits include export opportunities, which would also multiply environmental benefits.

It is also clear that the market for PSS is developing slowly and faces several barriers - even compared to other innovative business models. This is particularly true in the more southern countries of the EU, which correspondingly have the greatest potential for benefit. These barriers (described in Chapter 7) are:

- Uncertain rewards
- Lack of knowledge of the potential benefits
- New infrastructure requiring investment

Businesses can do much to capture the potential of these business models and overcome these barriers themselves. The initiatives that suppliers and customers can take to achieve this are described in section 7.3 above.

To profit, individual businesses should:

- Investigate the opportunities for profit in this area – by identifying untapped potential:
  - What technological potential is going untapped?
  - What knowledge could be shared that could unlock potential in a co-operation?
  - What intangible value could be realised?
  - What opportunities could come from selling outcomes, rather than products?

- Understand the barriers and take appropriate steps to overcome them
- Use existing models as inspiration and guidance.
Changes in business models to PSS would be part of the trend in the EU economy towards provision of services as the growth sector.

**Business associations** could have an important role in spreading the benefits of PSS: the barriers to spread are often lack of knowledge of the benefits, familiarity with successes and in lack of co-operation between suppliers and customers. The promotion of PSS through business networks could be significant in overcoming inertia.

**Policy makers** should also facilitate and promote greater spread of PSS.

Policy makers should:

- Take environmentally-friendly business models seriously as a means to achieve environmental goals.

- Include business model innovation within innovation policy and promote the teaching of business model innovation in universities and business schools.

To set up public policy which promotes PSS, policy makers should:

- Examine the areas of potential, using knowledge of local culture and economic conditions to assess the drivers and barriers.

- Audit existing regulation, (for example relating to product standards) and including innovation policy, to remove legal barriers to PSS approaches - as innovation in business models is sometimes unintentionally blocked by regulation designed to facilitate good functioning of existing business models. Greater outcome-based policy allows innovation to thrive.

- Create economic policy that supports growth of these models – internalising environmental externalities. Policy which aligns society's goals with the goals of the businesses is a very important element in relation to influencing market behaviour.\(^{17}\) Tangible as well as intangible benefits (reputation) should accrue from environmentally sustainable behaviour. It should pay off to, for instance, to reduce CO\(_2\) emissions.\(^{18}\) To set up the incentives for change, prices facing companies need to reflect the social costs of business decisions. One way to internalise environmental externalities is by fiscal instruments. If prices of resources (e.g. energy) are right, business will have the right incentives to innovate in these ways. If not, these business models will remain disadvantaged.

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\(^{17}\) The Novo Nordisk-Dong Energy partnership analysed below is a good example of how a number of important framework conditions render a certain business model viable.

\(^{18}\) For instance, in Denmark, energy suppliers are incentivized to reduce customer consumption due to the introduction of a special tariff which is collected from the consumer (Danish Energy Authority 2007). The utility companies are therefore compensated financially for helping consumers to reduce energy consumption.
To spread knowledge about PSS policy makers could:

- Set up non-profit organisations that can solve the problems of knowledge limitation (e.g. associations for innovative business models with the aim of enhancing awareness of such business models, developing tools, best practice examples etc.). This approach has been applied successfully in USA to spread Chemical Management Systems to more sectors.

- Development of tools for measuring environmental benefits and business viability of the identified business models for marketing purposes (both for buyers, suppliers and customers). A lack of developed evaluation tools can constitute an entry barrier. This point is connected to the bullet point above.

To make infrastructure accessible policy makers could:

- Secure deal flows or provide a link for private initiative to make it less risky to invest in new infrastructure. This could be through green public procurement - in extreme cases this could take the form of pre-commercial procurement.

- Make existing networks or hardware available for service providers - for all or through a tendering procedure.

- Help new car-sharing organisations in the start-up phase by public support for establishing the needed infrastructure. The establishment of car stations and special parking lots reserved exclusively for shared cars can boost the initiation of car-sharing. In Switzerland it has taken 20 years to build up Mobility’s infrastructure of car stations.

- More specifically, build a certificate system to make investments in renewable energy visible to give companies a clear incentive to invest in sustainable energy.

It is important to note that the relevance of the various policy recommendations vary from country to country depending on the specific institutional context. Thus, for example, some of the business models require quite strong institutional structures in order to be viable in the first place. While in some context great emphasis must be put on general institution building, in others more attention can be directed towards the business model itself and its implementation.

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19 In a recent international survey of the ESCO industry, it was suggested that one of the most important steps a country can take to promote the ESCO industry is to establish an association of ESCOs (Vine 2005, 693).
9 Case analyses

This section will include six subsections each section dealing with one generic business model. In addition to investigation of the specific cases, the analysis will also draw upon extant knowledge about the generic model itself. Thus the case analyses will, to the extent possible, be infused by already available knowledge about energy service companies, design-build-finance-operate, chemical management systems, resource management, remanufacturing and car-sharing.

The case analyses:

- Describe the business models
- Indicate the Market Potential
- Describe the Barriers to diffusion and how they can be overcome.

9.1 Energy Service Companies

An ESCO can be defined as "a company that provides energy-efficiency-related and other value-added services and for which performance contracting is a core part of its energy-efficiency services business" (Goldman et al 2005). An ESCO typically assumes some extent of performance risk meaning that their profit is tied to the actual amount of energy savings. The projects normally have a relatively large up front capital cost which is typically assumed by the ESCO.

The EU-directive on energy and end-use efficiency defines an ESCO in the following way:

"a natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in so doing. The payment for the services delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria;" (2006/32/EC, Art. 3.1.)

Following from this definition it becomes clear that an ESCO involves two key features. First, that the company assumes some extent of financial risk. Second, that the ESCO's payment is based on the extent of realized energy sav-
ings/improvements. These features create strong incentives for the ESCO to implement optimal energy solutions because the business model is typically based on a 'no cure no pay' basis. Having provider finance at risk in this way can be expected to create strong incentives for innovation and effective energy management.

An ESCO – in the narrow understanding of the term - is effectively a functional result product-service-system (PSS), and is by PSS researchers highlighted as one of the most promising PSS models (Tukker et al 2004). The customer pays the provider for delivering an outcome; e.g. a specific indoor climate or a certain level of heating. The recent rise in interest in ESCOs has among other things been suggested to be rising energy prices, renewed interest in energy efficiency and climate change, aggressive energy saving goals (for US federal agencies) (Hopper et al 2007).

It should be noted that there is a lack of a common and unambiguous definition of the ESCO concept and different stakeholders may define the term differently. For the same reason, international overviews of ESCO markets are somewhat ambiguous as we often do not know exactly what type of models are included in the statistics. In the narrow understanding of the term, a ‘real’ ESCO involves a guaranteed energy saving, finance - or assistance to link financing of the project to the guaranteed energy saving - and the remuneration of the ESCO-company is moreover tied to the extent of energy savings achieved (Bertoldi et al, 2006a).

In the context of this report, we operate with a somewhat broader definition, as we below include a case example which does not involve the finance element (only through overall policy regulation), moreover in that particular case, there are no guaranteed savings. However, the remuneration of the energy company is directly and indirectly tied to the amount of energy savings achieved (see description of the Novo Nordisk and Dong Energy partnership below). Thus although the mentioned partnership does not constitute what some may label ‘a real’ ESCO it has been included in the analysis. This particular partnership is the first of its kind in the world; and entails a very promising and positive environmental impact as well as sound business viability. Last but not least, it is a good example of how careful government regulation together with the environmental programmes of international non-profit organizations lead to innovative business models that perhaps would not have been sustainable without these general framework conditions.

9.1.1 Business rationale

Many estimations of the market for energy services have been elaborated. In 2000, the market for energy efficiency services in Western Europe was estimated to be €150 million per annum. This figure is relatively small compared to the estimation of the market potential to approximately €5-10 billion per annum in 2006, indicating a growth in the assessed market potential (Bertoldi et al 2006a). Other studies assert that the total amount of ESCO activity outside the US was between $560 million and $620 million in 2001, and that this was
only half to one-third of the ESCO revenues for the US for the same year (Vine, 2005).

This gives reasons to believe that there is a large unrealized ESCO potential in Europe. An estimation of the overall revenue for the US industry in 2006 was $3.6 billion. There was an annual growth in the industry of 20 % in the period 1991-2000. This figure dropped down to 3 % in the period 2000-2004. However from 2004-2006 this increased drastically again to 22 %. The industry revenue in 2008 is estimated to be around $5.25 billion in US alone (Hopper et al 2007).

Within Europe, leading ESCO-countries, i.e. countries with the most intensive ESCO activity (in the narrow understanding of the term) are: Germany, Austria, the UK, Spain and Hungary. Countries with medium ESCO activity are France, Sweden, Czech Republic and Italy. All other European countries are placed in a low activity category, including for example The Netherlands and Denmark (Bertoldi et al 2006, 1822). Major differences among EU member states exist not only in relation to development of national ESCO industries but also in terms of type of projects and terms of implementation (Bertoldi et al 2006).

Below follow two case studies illustrating the use of the ESCO model.

**Case study I – TAC Energy Solutions**

The first case concerns an ESCO project between the provider, TAC Energy Solutions and the customer, Regionfastigheter. TAC is an international market leader in the building automation industry (TAC 2008c). Regionfastigheter is, on the other hand, one of the largest building administrators in Sweden with a real estate portfolio of approximately 1,400,000 m² in Skåne, a region in the south-most part of Sweden. Regionfastigheter acts as a strategic partner for its largest tenant, which is the public health sector in Skåne, and employs 370 people (TAC 2008b).

The content of the ESCO project is energy efficiency, retrofits and refurbishments projects within three hospital areas in the Skåne region (PU Benefs, 2005). The project involves 11 buildings (1 university hospital, 5 hospitals and 5 office buildings). Additionally, the project also involves training and capacity building of staff. However, Regionfastigheter was not interested in outsourcing of operational and maintenance work. The project comprises the following works (PU Benefs, 2005):

- air handling retrofit,
- installation of heat recovery,
- rebuilding of heating and cooling systems,
- updated control systems and water saving efforts,
- new metering, energy statistics, follow up structure, and
- targeted training of administrative and managerial staff.

Total savings amount to SEK 11.5 million per year which means a reduction in energy consumption for heating of 30 %; the guaranteed savings are however
SEK 10 million. The table below presents an overview of the key indicators of the agreement.

Case I – An overview

<table>
<thead>
<tr>
<th>Case</th>
<th>No. of m² involved in the project</th>
<th>Capital investment</th>
<th>Pay back time</th>
<th>Contract period</th>
<th>Guaranteed savings/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regionfastigheter and TAC Energy Solutions, Sweden</td>
<td>443,215</td>
<td>108.8 million Swedish Kroner (SEK)</td>
<td>9.5 years</td>
<td>7.5 years</td>
<td>Approx. 10 million SEK</td>
</tr>
</tbody>
</table>

Source: TAC 2008a and TAC 2008b

The principal idea behind this project is that a large part of the investment is financed via realized energy savings TAC 2008b. TAC guarantees a certain extent of savings, here approximately SEK 10 million. Thus this project model comes close to what some scholars have labelled a ‘real’ ESCO (cf. above). In this particular case, the investment potential of the customer (Regionfastigheter) was limited due to budget restraints and public spending restraints. Regionfastigheter was therefore not able to implement already identified saving potential in energy and operational costs by itself. It needed a provider or a partner that could carry the responsibility for detailed energy analysis, project implementation, provision and development of financial means, and finally also provide a savings guarantee (PU Benefs, 2005). The energy service company TAC Energy Solutions could provide this.

This indicates that the use of the ESCO model did contribute to accomplish energy savings that would have been postponed or not fulfilled due to budget restraints without the utilisation of the ESCO model. Cooperation between authorities and the ESCO, TAC, has however in other cases been hampered by budgetary restraints. In Denmark a contract was signed with the Municipality of Middelfart, but could not be realised due to budgetary restraints on the amount available for renovation (DR, 2008). The renovation cost needed for the implementation exceeded the maximum spending for renovation set out in the national budget. The Danish Government did not allow the municipality to get an exemption and the cooperation was terminated without the achievement of the environmental benefits that the renovations would entail (Danish Society for Nature Conservation, 2008). This emphasises the importance of having a policy framework that facilitates energy savings and that there are currently policy barriers to implementation of ESCOs. This is reverted to in section 9.1.3 below.

Motivation and results

There were several rationales behind the implementation of the Regionfastigheter project. First, there was a desire by Regionfastigheter to curb a negative cost trend in an aging estate stock and to support the long-term development of the estate. It was considered important to increase coordination and agreement within the operational organisation and to strengthen an underdeveloped measurement structure (TAC 2008a).
The project started in 2004/2005 and the results are positive so far. The early training and optimizing efforts have delivered more savings than expected (PU Benefs, 2005). This ESCO has resulted in lower energy consumption, clearer coordination within the operational organization, upgrading of technical standards and new products simplifying operation work, and simple and unitary solutions which bring about lower costs. The project may moreover serve as a flagship case for others in the whole Skåne Region, higher operational reliability, and finally increased in-house competence (TAC 2008a).

Experience has shown that the planning and purchasing process is time consuming in a project of this size, and that there is a need to set up an internal team with complementary competences that can manage the tendering process and contractual work. Another lesson is that internal preparation was vital to avoid internal opposition. A subsequent analysis of the project states that a key part of the success is to anchor the project among internal stakeholders before approaching the market (PU Benefs 2005). Another important policy-related lesson is that there was a lack of knowledge and interpretation capacity among public branch organizations concerning financial, accounting and contractual aspects of energy service contracting and third party financing (PU Benefs 2005). This may work as a barrier for the implementation of ESCOs. Barriers to the ESCOs will be reverted to in section 9.1.3.

**Key findings from case study I**

The case indicates that cooperation with an ESCO, in this case TAC, can lead to significant savings in energy consumption at a limited cost to the customer, which is particularly important for public authorities operating under strong budget restraints. It does, however, also indicate that budget restraints may be a barrier to the implementation of an agreement with an ESCO as seen in Middelfart municipality where a project that was both economically and environmentally viable was blocked due to politically inflicted budgetary barriers.

**Case example II - partnership between Novo Nordisk and Dong Energy**

In May 2007 the energy producer Dong Energy and Novo Nordisk, producer of pharmaceuticals, signed a partnership agreement. The essence of the partnership is that Dong Energy helps Novo Nordisk in identifying energy-saving projects (on a non-fee basis). In addition to giving energy advice, Dong Energy is committed to disseminate best practice between different parts of the Novo Nordisk group, and to produce fact sheets and guidelines for best practice. Novo Nordisk, on the other hand, commits to convert all the energy savings that are realized through the partnership into purchasing of new green electricity from Dong Energy. This is a groundbreaking partnership on wind power as it creates a unique win-win situation were Novo Nordisk in a cost neutral manner can reduce CO\textsubscript{2} emissions and shift to green energy consumption at the same time. For Dong Energy, on the other hand, the partnership with Novo Nordisk is an effective means to achieve the energy savings that it has committed itself to achieve in an agreement with the Danish Government. In 2006, Danish energy companies committed to create documentable savings in their customers’ energy consumption. And Novo Nordisk's shift into green energy consumption contributes to create a market and secure the investment in a new
windmill park at Horns Rev II – an investment that without this partnership would involve a considerably higher risk.

The partnership between Dong Energy and Novo Nordisk runs until 2020. Originally, Novo Nordisk contemplated to establish its own wind farm as an important means to realize its climate goals (Børsen, 2008a). However, realizing that this was not a part of its core business, Novo Nordisk decided instead to enter into negotiations with Dong Energy. These negotiations lasted about a year and resulted in the innovative partnership described above. Dong is currently negotiating with other Danish business corporations to establish similar partnerships (Børsen, 2008a).

External drivers

In the Novo Nordisk/Dong Energy partnership external framework conditions are significant drivers for this innovative partnership. In 2006, Novo Nordisk, signed a voluntary climate saver agreement with the World Wide Fund for Nature (WWF) and became a part of the latter organization's 'Climate Savers' programme. This programme currently involves 14 multinational corporations and in total these companies will, by 2010, have cut carbon emissions by approximately 13 million tons annually. This is equivalent of taking more than 3 million cars off the road every year (WWF, 2008a). In the agreement with WWF, Novo Nordisk has committed to reduce its total carbon dioxide emissions from production by 10% below 2004 levels by 2014. When taking into account the average growth of Novo Nordisk in the same period, this means that the company has committed to a 65% relative reduction of its CO₂ emissions in the mentioned period. (Børsen, 2008a)

Here, the climate agreement with WWF is an important driver for Novo Nordisk's overall climate strategy. The climate strategy is global and has the following three main components:

- cLEAN®: a lean programme (the Novo version of the LEAN philosophy)
- Energy Savings (projects to optimise energy consumption).
- Green energy (renewable energy)

It is by way of the above three levers that Novo Nordisk will achieve the target reduction agreed with WWF in 2006. Two thirds of the emission reductions will be reached by the company’s cLEAN® programme while the vast part of the remaining third will be realized through the Novo Nordisk – Dong Energy partnership. By 2014 the partnership is thus expected to have brought about a reduction in CO₂ emissions equalling approximately 130,000 tonnes (Vibeke Burchard, 25 April 2008). The partnership covers only the Danish Novo Nordisk premises, because the Danish production facilities account for 85% of the company’s global emissions (Vibeke Burchard, 25 April, 2008).

General concerns about the climate have led to agreements between Novo Nordisk and WWF on the one hand, and between the Danish Government and the Danish energy companies on the other hand. These are important frame-

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20 Read more about WWF’s ‘Climate Savers Programme’ here: http://www.worldwildlifefund.org/climate/projects/climatesavers/companies.cfm
work conditions that make this business model a viable business model. Dong is bound by its Public Service Obligations (PSOs). PSOs are obligations put on Danish collective electricity suppliers and concerns i.e. support to production of renewable energy hereunder wind energy. The PSO is collected from consumers as a tariff (Danish Energy Authority, 2007) and constitutes support to the production of renewable energy.

Hence, by entering this partnership, Novo Nordisk achieves two important things. First, it prepares the business for a carbon-constrained future by reducing carbon dependency and curbing rising energy expenses. Second, it realizes intangible value in the sense that it signals to the broader community that Novo Nordisk cares about the climate. According to Dong Energy, the desire to improve the image of the company is essential for engaging in green projects, and it is important to be able to show and materialise the effort in the branding process. Having a visible, tangible output of the greening process is according to Dong Energy pivotal in getting commitments from the business community and here the Danish system with renewable energy certificates is important (Christian S. Berthelsen 18 May 2008). The certificates provide a guarantee that the energy derives from a renewable energy source in accordance with the Directive on the promotion of electricity produced from renewable energy sources in the internal electricity market (2001/77/EC).

Currently, almost 300 energy saving projects are in the pipeline within the Novo group. These projects cover all areas of energy supply - including ventilation, cooling, compressed air, water treatment, boilers, illumination etc. In particular, a substantial potential has been identified in optimisation of the ventilation & cooling systems. One of the projects – concerning the optimisation of cooling water supply in Kalundborg – gave a saving corresponding to five million kWh in 2007. Also, small adjustments like not ventilating during nights and weekends in administrative areas have shown a large energy-saving potential. (Vibeke Burchard, 25 April, 2008) As Novo Nordisk was already working on energy-saving projects before its cooperation with Dong Energy (implemented in May 2007) it is difficult to distinguish between which projects are a part of the Novo Nordisk /Dong Energy partnership, and which are implemented outside the auspices of the partnership.

The energy-saving efforts are financed by the PSO-tariff paid by consumers, mentioned above. For Dong Energy the agreement with the Government means an average reduction in consumer consumption of energy in the range of 144 gWh in the period 2006-2013 (Dong energy, 2008b).

An important aspect of this deal is that the supply of green electricity is conditioned to come from new windmills. In effect this means that the Novo Nordisk and Dong Energy partnership is paving the way for a new wind farm (Horns Rev II) that Dong Energy is establishing in the North Sea. The expectation is that by 2010, Novo Nordisk will absorb 30 % of the capacity of that windmill park. Thus in this particular business model a unique link is created between energy savings and greening of energy supply.
However, Novo Nordisk is not obliged to absorb 30% of the wind park capacity under the contract. This percentage is calculated based on the expected energy consumption of Novo Nordisk relative to the capacity of the new windmill park on Horns Rev II. Nevertheless, the extent of capacity absorbed by Novo Nordisk is variable depending on the energy savings achieved. There is the theoretical chance that Novo Nordisk will reduce its own energy consumption so much that the demand for energy will be lower. In other words, the partnership can be undermined by its own success. However, according to Dong Energy, the risk related to this aspect is minimal (Christian S. Berthelsen 16 May, 2008).

According to calculations from Novo Nordisk, if all Danish production companies would do the same as Novo Nordisk then CO₂ emissions in Denmark would altogether be reduced by six million tonnes. This amounts to approximately 10% of the total emissions in Denmark (Vibeke Burchard, 25 April, 2008).

The cooperation

The Novo Nordisk and Dong Energy representatives appear to work together very effectively. Both companies stress the importance of working towards a common goal and mutual commitment in the partnership. According to Dong Energy initiating projects like these is a cumbersome process and commitment anchored in top management is a necessity (Christian S. Berthelsen 16 May 2008).

The Novo Nordisk/Dong Energy partnership is organized in the following way. First, there is a project group, which manages the day-to-day implementation and operation of the partnership. Then there is a steering group, which manages issues of more strategic character. Finally, there is a partnership committee at the senior vice president level. Each of the three levels involves representatives from both partners (see table below). The boundaries between the three levels are fluid as there is overlap between the different levels of organization.

Structure of the Novo Nordisk and Dong Energy Partnership

- **Partnership Committee**
  - Senior vice president level

- **Steering Group**
  - Corporate vice president level

- **Project Group**
  - Project manager level
Dong Energy holds the responsibility of designing and building the new wind park. Should Dong Energy fail to do so, they are entitled to assign a new supplier to Novo Nordisk. The Novo Nordisk and Dong Energy partnership is not, as already noted earlier, an ESCO in the traditional sense of the term because it does not involve guaranteed energy savings and finance\textsuperscript{21}.

**Key findings from case study II**

This cooperation offers a mutually beneficial situation for both companies – it offers the opportunity for implementing environmental projects with high effect at a low cost and with limited risk. Moreover, the cooperation offers positive publicity and contributes to greening the image of both companies. The case indicates that external drivers are important in motivating such partnerships and that tangible results to use in the branding process are valuable.

Certificates of green energy are important as they make the effort of the company tangible. This is important to make the efforts visible in terms of image and branding.

### 9.1.2 Environmental case

The ESCO model represents a possibility for gaining environmental effects and reducing emissions. A report from the US suggests that the median ESCO project saves approximately 170MJ/m\textsuperscript{2}/year of energy, and further that the median annual electricity saving in 'lighting only' projects is 23 % of utility bill baseline (Goldman et al 2005, 394). The model opens up for a range of agreements that can be used both for international conglomerates and growing SMEs.

The above-mentioned two cases illustrate the possibilities for mutual gain and how the use of this model can serve as a driver for greening the energy consumption. As is seen in the case of Novo Nordisk and Dong Energy, the agreement reduces overall consumption and shifts the remaining energy consumption into relying on renewable energy, hence contributing to creating the basis for development of a new windmill park.

In Novo Nordisk, small adjustments have made significant reductions. Energy saving projects implemented in the period 2005-2007 are estimated to have reduced CO\textsubscript{2} emissions by 12,000 tonnes. In 2007 alone, Novo Nordisk implemented 50 energy saving projects, out of which 26 had a pay back period of less than 1 year. 13 of these projects were "just do its"; i.e. there was no investment needed (Vibeke Burchard, 25 April, 2008).

If all Danish corporations would follow Novo Nordisk’s example it would require over 10 new wind parks with the size of Horns Rev II. Horns Rev consists today of 80 windmills with a total production capacity of 160 MW. This equals approximately the electricity consumption of 150,000 Danish households (Dong Energy/Vattenfall, 2008). Horns Rev II is expected to consist of 95 new mills with a total production of 218.5 MW. It will further include three large test mills with a total effect of max 15 MW. The project will cover an area of

\textsuperscript{21} Cf. the definition of Bertoldi, et al 2006
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35 km² (Danish Energy Authority, 2008). Extrapolated to the European Union there is room for significant reductions.

### 9.1.3 Possibilities and barriers

**Possibilities**

As also mentioned above in section 9.1.1, it is estimated that there is a market for ESCO in Europe. The European Commission estimates that the market for ESCOs can develop to a volume in the range of €5-10 billion per annum within a short-term perspective (Dansk Energi 2008) and the Commission has currently registered 150 energy service companies within the European Union (Dansk Energi 2008).

The differences among the European countries are, however, substantial as also mentioned above. And there are different barriers in the countries indicating that the challenges to be overcome in the countries vary.

However, as indicated in the Novo Nordisk case, changes can be done with only minimum input, without there being major structural barriers – as many changes are - as Novo Nordisk categorises it - "just do its". An ESCO here constitutes a possibility to create awareness of changes needed at minimum cost. There is a potential for substantial reductions if it is managed to get private companies and public authorities committed to this and if the framework conditions are tuned to this and barriers reduced.

**Barriers**

Numerous barriers have been identified in the scholarly literature concerning the development of an ESCO industry. And there are several cases of failed cooperation. Among these is the cooperation between Middelfart municipality and TAC, as indicated in section 9.1.1. Another case is from Sweden where, according to a representative from the Danish ESCO market, about ten years ago Vattenfall attempted to implement ESCOs. This effort failed.

From one of the case interviews emerges the finding that the quality of the business relations is important. A project representative from the provider organization points out "good relationships, flexibility and a common vision are decisive for a successful project. We want to work together with the customer, not against the customer". Another interviewee correspondingly notes that the partnership between the involved partners is important. Initiating a project without a common understanding and good relations between the parties might constitute a barrier to the success of the partnership. These statements from the stakeholders generally correspond with academic research on business alliances where increasingly alliance scholars stress the importance of non-tangible aspects of cooperation such as relational quality and trust, and suggest that such factors of cooperation are important performance antecedents. Therefore, management attention should be directed towards this aspect of cooperation. As noted above legal and administrative barriers have been identified.

The tables below list key barriers for industry, end users and policy. It should be noted that barriers may not be the same throughout the Union and different Member States may encounter different barriers.
**Key Industry barriers**

- Lack of information and understanding of the opportunities that energy efficiency offer
- Lack of culture for project financing
- Public procurement rules that inhibit the use of ESCOs
- Low price of electricity
- Safety and reliability concerns (which prevent the use of new technology)
- Burdensome administrative procedures (which render small projects unattractive)
- Financial institutions have a limited understanding of energy efficiency and performance contracting
- Energy-efficiency projects compete with traditional investments for scarce capital
- Energy-efficiency projects are perceived to be more risky because they often are non-asset based
- Many projects are too small to attract attention from large multilateral financial institutions
- Legal and regulatory frameworks are not compatible with energy-efficiency investments (particularly measurement and verification protocols are poorly understood)
- Few in-country financial institutions have experience from financing energy-efficiency projects
- Utility companies tend to have a negative response to ESCO due to fears of decreased revenues (in Denmark, for instance, this problem is somewhat avoided because PSO-tariffs have been introduced and the utility companies thus get compensated financially for helping consumers to reduce energy consumption)
- Lack of government support for energy performance contracting

Key barriers to end users

- Financing challenges have been identified as a major stumbling block in the development of ESCOs (e.g. lack of access to capital, financing and credit; and unclear accounting and treatment of energy performance contracting, see page 695).
- Risk perceptions (e.g. need for risk management and business plan; short-term view of investment; and conservative behaviour of customers and banking industry)
- Lack of information/awareness (lack of both understanding and interest in energy performance contracting)
- Lack of access to expertise (e.g. technical, financial, and education)
- Shortage of access to energy efficiency equipment and technology
- Administrative barriers (transaction costs are high)
- Concerns about reliability of equipment
- Trust/credibility (lack of confidence in ESCO services and solutions)


Key Policy barriers

- Lack of governmental policy and leadership
- Low cost of electricity
- Lack of budgeting and standardized procurement rules and guidelines for ESCO services
- Economic and political uncertainty and conflicts with other government policies (little attention paid to energy efficiency)
- Unfavourable tax regimes (discourage energy efficiency)
- No legal framework protecting the interests of energy performance contract participants


9.2 Design, Build, Finance, Operate

The Design Build Finance Operate (DBFO) model is a form of Public Private Partnership (PPP). PPP constitutes a partnership between a public authority and a private contractor used for construction projects requiring long-term investments (Danish Enterprise and Construction authority, 2008). Significant for the DBFO model is that while the public authority is the owner, it is the private contractor that designs, builds, finances and operates the construction in question. The public authority specifies the desired output and it is up to the contractor to deliver this output, and as such it is a form of Performance Based Building (PBB) (Jasuja, year unknown). The terminology in this field lacks a clear definition and there are several overlaps of notions that cover similar forms of cooperation between public and private actors. The key is however that a private operator is contracted to perform a certain output for a public authority.
The DBFO model is closely related to the ESCO model. The two models do to some extent share the same logic as indicated in the table below. In both models, there is a significant move towards delivering services as opposed to products. The provider normally assumes project risk (i.e. the provider commits to certain performance standards – remuneration of provider is contingent on its performance) and the provider normally finances necessary up front capital investments (in the narrow understanding of the terms).

The key difference between ESCOs and DBFOs is that the latter typically includes a large construction element while the former is normally limited to technological installations in buildings. Moreover, the DBFO model covers a period of several decades (typically 30-35 years) while the ESCO model typically covers a five to ten years period (Vine 2005). There is thus a difference in length and the elements included in the two models. Another aspect is the capital intensity of DBFO models. These projects often involve multi digit figures while the capital intensity of ESCO project is significantly lower.

*Similarities and differences between the ESCO and the DBFO-models*

<table>
<thead>
<tr>
<th></th>
<th>ESCO</th>
<th>DBFO</th>
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</thead>
<tbody>
<tr>
<td><strong>Key emphasis</strong></td>
<td>Energy services</td>
<td>Infrastructure associated services</td>
</tr>
<tr>
<td><strong>Finance by provider</strong></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Transfer of risk to provider</strong></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Capital investment</strong></td>
<td>Medium</td>
<td>Very high</td>
</tr>
<tr>
<td><strong>Project elements</strong></td>
<td>Finance, service and maintenance</td>
<td>Construction, finance service and maintenance</td>
</tr>
</tbody>
</table>

*Note that there are variations of both models. For instance, the ESCO model does not always include provider finance, and risk is moreover not always transferred to the provider. In this table, the models are depicted in their most pure form.*

In the DBFO model, the provider (typically called a special purpose vehicle (SPV)) is incentivised to construct assets that can be efficiently maintained and operated. This is due to the fact that there is private finance at risk. In DBFO projects it is normally the SPV that holds the commercial risk (Gruneberg and Hughes, 2006) The SPV normally assumes the responsibility not only for constructing the building but also for operating it afterwards. It is therefore in the provider’s best interest to build or construct assets that can be maintained in an efficient manner (e.g. lower heating and electricity consumption, longer lasting materials, easier to clean etc.). This is sometimes referred to as the innovation potential of DBFO. The risk transferred to the SPV incentivises the company to be innovative and come up with solutions that are better in the long run. In more traditional projects, a construction company will normally only be interested in building or constructing the asset as quickly as possible and then move on to the next project. In the DBFO model however, this has changed. SPVs are not looking to hit and run but are interested in how their delivery functions in the long run.
Another related advantage with the DBFO model is that during the contracted period buildings and other assets are maintained properly. In particular within the public sector, a lack of maintenance of public assets is often a problem. For instance, in Denmark, municipalities alone are estimated to have a lack of maintenance in the range of DKK 3.4 billion by the end of year 2009 (COWI 2008). This is also a key driver for the street lighting case from the UK presented below.

It should be noted that the innovation potential, including energy efficiency, of DBFO is not documented sufficiently in literature. Moreover, the general performance of this type of projects is difficult to determine for various reasons (for instance, Hodge and Greve 2007). Current knowledge about the innovation potential therefore tends to be case-based and anecdotal (Smith, 2007). This is also the case in relation to PFI street lighting project, which is used as a case study in this report. Street lighting projects were chosen because these were highlighted by one of the experts that we consulted as having an interesting environmental aspect. PFI, Private Finance Initiative, constitutes a means to funding major capital investments without immediate recourse to the public budget. The PFI was launched by the UK Government in the early 1990s. A private partner, usually a consortium, is contracted to design, build, and in some cases manage new projects. It is thus a variant of PPP and the DBFO model described above. Contracts typically last for 30 years, during which time the public authority tends to lease the construction in question (DH, 2008). In the street lighting case the street lighting network is not leased, but can be considered as a stewardship agreement where the public authority owns, but the SPV is the steward of the lighting system.

9.2.1 Business rationale

The business rationale of the model is anchored in transferring certain tasks to a private contractor, the SPV, which is expected to be able to carry out the project at a lower cost. In the UK for instance, in assessing where PFI is appropriate, the Government's approach is based on its commitment to efficiency, equity and accountability and on the Prime Minister's principles of public sector reform. PFI is only used where it can meet these requirements and deliver clear value for money without sacrificing the terms and conditions of staff (DH, 2008).

The SPV on the other hand is secured a long-term stable income from the project and is incentivised to secure reliability and long-term minimization of cost. In the UK, much interest in PFI derives from cutbacks in government capital expenditure, which influence the turnover of many construction companies (Ezulike et al 1997). According to Ezulike, capital expenditure using PFI is increasingly used as a substitute for public sector expenditure (Ezulike et al 1997).

Case example I - PFI Street lighting

The first scheme was signed in December 1998 and The UK Department for Transport or Government Office London has now approved PFI funding for 35 English local authority street lighting projects. In 2007, sixteen of these projects
were in operation, four were in procurement and 15 are preparing Outline Business Cases (PFI/PPP Issue 7, January 24, 2007). The motivating factor behind the UK street lighting projects was to enhance the quality of life of the citizens, by reducing the number of accidents and local crime (Wallis, 18 April 2008). The environmental agenda in relation to street lighting only appeared on the agenda a few years back. Driving down energy consumption was not a key rationale behind most of the first PFI street lighting projects. This has only surfaced as a topic retrospectively.

The South Coast Street lighting PFI is still in the making. The project builds on an agreement between the Hampshire County council and a contractor. The contractor is not finally identified at this point and the contractual negotiations are ongoing. It is expected to have a final bidder early 2009 and to reach financial close in 2009 (Trevor Wallis, 18 April 2008). The agreement between the council and the contractor will be a stewardship, where the contractor holds the responsibility for building and maintaining the lighting net for a contractually determined sum (Trevor Wallis 19 May 2008). The concept implies that the authorities, here Hampshire County council, specify the output, and select the contractor that they consider the best suited to fulfil the requirements set out. It is thus up to the contractor to choose how to deliver the output.

Objectives

Street lighting in the UK has not been given the proper maintenance and substantial parts of the network are old and needs replacement (Trevor Wallis, 19 May 2008). The investment needed to replace the systems is considerable (OBC, 2007 annex 8). A key objective behind entering a PFI project is that the contractor is responsible for the maintenance within the contract period, which is planned to be 25 years.

It is expected that the project will lead to the following improvements:

- building safe and strong communities,
- stewardship of the environment,
- improving services,
- improving levels of performance,
- improving sustainability,
- more cost effective use of capital and revenue resources,
- improving crime reduction,
- reducing traffic accidents,
- embracing new technologies, and
- innovation.

Investment and risk

All investments in the new lighting networks are to be in place within five years after signing the contract. The contractor is, as specified above, responsible for delivering the requested output. The council pays the contractor a unit fee charge. This charge covers two elements. First, the repayment of the loan to cover the investment and second the fixed amount agreed to cover the cost of maintenance. This entails that if cost of maintenance is lower than the agreed amount this is of benefit to the contractor. However, the contractor also holds the risk if maintenance cost exceeds the fixed amount. Hence there is an incentive to reduce maintenance cost on the one hand, however, within the perspec-
tive that the contractor has the responsibility for operation within the 25 years that the contract is running. Neglecting maintenance to increase short-term gain is thus not a viable long-term solution to the contractor.

The risk of changes in energy prices is held by the Council, whereas the risk of changes in the volume is held by the contractor. A volume range is specified in the contract and the contractor is required to pay the extra cost if consumption exceeds the specified range. This implies that there is an incentive for the contractor to reduce consumption, or at least avoid that consumption increases.

Environmental considerations are one of the objectives of the cooperation. Particularly the objective of improved sustainability is important for getting a positive environmental effect. This entails examination of "all aspects of sustainability and ensuring that development proposals of bidders comply with sustainable principles" particularly the following:

- recycling the vast majority of the waste,
- use of recycled, recyclable and durable products,
- use of energy efficient technologies,
- consideration of energy efficient operational practices (e.g. part night lighting), and
- sustainability of communities themselves.

The project will use SMART\textsuperscript{22} objectives "to maximize the benefits and monitor the delivery of this aspect of the service" (OBC, 2007). This indicates that the project is designed to lead to more efficient use of resources hereunder energy consumption and waste.

In most of the lighting projects in the UK, environmental requirements have not been part of the contract specifications and this has on several occasions led to increased energy consumption. In order to achieve an environmental benefit the procurer, here the Council, must be conscious of this fact in outlining the specifications.

9.2.2 Environmental case

The environmental gain derives from two key factors. First of all, in specifying the procurement criteria when selecting a contractor the public authorities may include environmental requirements that the contractor must comply with, i.e. green public procurement. In doing so, the contractor will be contractually bound to comply with the specified environmental criteria. Second, in DBFO, the contractor has the full responsibility of the contracted item in question, this being a building or a lighting network etc. This provides the contractor with an incentive to rationalise the use of materials and maintenance to increase the lifespan and reduce cost for replacements. This is likely to reduce waste.

\textsuperscript{22} specific, measurable, agreed, realistic and timely
As the contractor is also responsible for the operation, it is rational to reduce cost of operation hereunder cost of energy consumption. It is therefore likely that the rational contractor will use an energy solution that minimises consumption.

Using the DBFO model it is thus likely that an economically rational actor will strive to increase the lifespan of the building, reduce waste and minimise energy consumption and in that way earn his profits.

9.2.3 Possibilities and barriers

The market for PPP can be considered to be substantial. In the period 2004-2005 alone, about 206 PPP deals were closed worldwide with a value of approximately US$52 billion (PricewaterhouseCoopers 2005, 37). In the United Kingdom alone, more than 750 PPP projects with a total capital value of £37.6 billion were implemented in the period 1995-2007 (Partnerships UK 2007, 3). In Australia the Government has estimated the market to be some 18 billion Australian dollars (National PPPforum, 2008). In using a DBFO model, the SPV provides a solution that caters for quality, efficiency and effectiveness of the service provision is selected. According to a report from the Serco Institute by Briony Smith, the SPV will try to balance the capital expenditure with the best design to produce the cheapest whole life cost and drive innovation forward.

The academic literature on PPP is however fragmented and there are only a limited number of studies focussing on the barriers to this form of procurement. There are possible barriers to PPP both within the public and private sectors.

Barriers in the public sector vary from country to country as to a large degree they depend on the legal setup of the country. Moreover the traditional perception of the role of the state and involvement of the private sector may have an influence. In a report to the US Congress on PPP, impediments to the formation of PPP were identified (US Dept. of Transportation, 2004). The report indicates that barriers i.e. derive from (US Dept. of Transportation, 2004):

- State laws and policies
  Public procurement laws and procedures may impede or actually prohibit the use of DBFO. An example is if the main focus is on the "low bid approach", often this does not cover a life cycle cost approach

- Local opposition
  Particularly in projects concerning roads and road pricing for financing a project rather than tax income local opposition may be substantial.

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This number does not include the Buildings Schools for the Future Program (BSF), the Local Improvement Finance Trust programme (LIFT) and the London Underground PPPs which taken together add several billion pounds to the above figure.
• Shared responsibilities
  Barriers may occur due to the national setup for sharing of responsibilities. An example from US transport is that it is the state or local governments that own and operate roads, while a substantial amount of the funding is the responsibility of the federal government which sets out specific requirements that must be fulfilled in any project.

• Financing concerns
  Restrictions on financing may constitute a barrier to PPP. Returning to the example from the transport sector, this can be in the form of limitations to e.g. road pricing limiting the contractor's ability to earn an income. It may also be different tax codes for government and private bonds for infrastructure projects or credit policies.

There are also barriers on the part of the private partner. The construction industry can be characterised as a complex industry with relatively low barriers to entry and exit (Ezulike 1997). However, projects that are relevant for PPP or DBFO are often long-term capital intensive projects that have high requirements for the SPV. This is one of the reasons why contracts are often awarded to consortia.

In a study carried out by Ezulike in 1997, contractors were asked to identify the main barriers to entry that hinders their involvement in the PFI market, which includes the DBFO. The main barriers identified were:

• Lack of appropriate skills
  DBFO requires involvement through the whole life cycle of the project and not only the construction phase. Many skills that are traditionally outside the scope of a contractor are needed and both management capabilities, technical and financial ability must be present (Ezulike 1997).

• High participation cost
  The cost of participating in bidding for projects is considered a substantial barrier to entry. A consortium that is bidding for a project has to deal with a variety of issues even before knowing if the contract is awarded to them, hereunder contracts, construction, design, finance, legal frameworks etc. that all involve cost at the bidding stage (Ezulike 1997).

• High project values
  The DBFO projects are often capital intensive and require a large investment. The consortium must be geared for this cost (Ezulike 1997).

• Risk
  The private contractor holds the risk of the project hereunder risks relating to design and construction, commissioning and operation, demand, residual value, technology and financing (Ezulike 1997).

• Credibility and contacts and demands on management time
  PFI and DBFO projects are mainly awarded to a consortium. This involves that the contractor must gather partners from outside into a partnership for
the project. This requires both contacts and the ability to build a viable consortium for the duration of the project and it also requires time input from management.

9.3 Chemical Management Services

In the traditional relationship between chemical suppliers and their customer, the supplier makes profit by maximising the volume of sold chemicals. Chemical management services (CMS) constitute a shift from such a traditional supplier relationship to a strategic alliance between the chemical supplier and its customer. Instead of purchasing chemicals the customer buys chemical management services. The chemical provider takes a direct role with respect to managing the customer's chemicals throughout the chemical life cycle, including the purchasing, managing and keeping track of chemicals (CSP, 2004). Thereby a shift takes place in the responsibility for management of the customer's production processes and the quality of final products.

Definition CMS can be defined as a business model "in which a customer engages with a service provider in a strategic, long-term contract to supply and manage the customer's chemicals and related services" (Stoughton & Votta, 2003). The management of chemicals is outsourced to the chemical supplier. The chemical service provider is specialised in managing chemicals and outsourcing the management of chemicals allows the company to focus on its core business activities. The chemical service provider assists the company in making economic savings on chemical management.

In traditional chemical management the chemical user purchases the chemicals from a range of different chemical suppliers, known as tier I suppliers. In CMS the chemical service provider becomes the tier I supplier of the chemical user, and the chemical provider purchases chemicals from a range of sub-suppliers, known as tier II suppliers.

Chemical Strategy Partnership Chemical Strategy Partnerships (CSP) is a non-profit organisation that since 1996 has advised manufacturing companies on how they can implement CMS. In 2000 and 2004 CSP has conducted comparable studies of the CMS industry's structure, conduct and performance in the US. Moreover, CSP has made an array of case studies of US companies that have introduced CMS. From 2000 to 2004 the CMS market in the US has grown about 50 % and made up a market of US$ 1.22 billion. In 2004, CMS has reached the largest market penetration in the US in the automotive industry where 75-80 % of the industries are utilizing CMS. Air transportation maintenance (40-50 %), electronics (30-40 %), and aerospace manufacturing (25-30 %) are other sectors with a large market penetration. From 2000 to 2004 CMS had grown from application in 4 to 11 different industrial sectors (CSP, 2004). In Europe CMS is to a wide extent applied within the automotive and aerospace industries. CMS is growing in Europe but is not applied as widespread as in the US (Oldham & Votta, 2003).
More than half of the US companies that use CMS are large companies with a sale of more than US$ 1 billion annually and more than 10,000 employees (CSP, 2004).

In a study from 2006, Kortman et al. investigate the dissemination of CMS in EU. In the study the terminology Chemical Product Services (CPS) is used for CMS. The study distinguishes between two kinds of CPS. In CPS-I the chemicals are still sold by volume and extra service is sold on an itemised basis or a cost incorporated in the chemical prices. In CPS II the supplier is paid based on the performance of the service sold. CPS II is similar to CMS. There is not always differentiated between findings regarding CPS I and CPS II business models. The industrial groups where CMS is most widely applied are in services connected with solvents and coatings followed by lubricants, industrial gases, adhesives, water treatment chemicals, tanners and printing ink (Kortman et al., 2006: 24).

**Solvents**

It is estimated that the market share of solvents used for cleaning/degreasing purposes is 'high'\(^24\) in the car and transport equipment industry and the metal product industry, and 'low to medium' in the machine and electrical equipment industry and in the metal products industry.

**Paints/coatings**

The application of CPS for painting and coating has a high market penetration in the car industry. In the automotive industry, from 40 to 70% of painting processes are serviced and from 30 to 45% of the companies in the aerospace and aircraft industry are using CPS for painting and coating their products.

**Lubricants**

CPS-based models with service of lubricants are used in the automotive sector and in the metal industry. It is estimated that the application of CPS within lubricants has a 'medium' dissemination.

**Water treatment chemicals**

Chemicals are used in boiler treatment, cooling systems treatment and wastewater treatment. The use of CPS in this sector is estimated as 'low'.

**Industrial gases**

Industrial gases are used in the process of manufacturing products. A low share of the contracts is CMS (Kortman et al., 2006).

The industries where CPS are most widely applied are the car and transportation industries, metal products manufacturing, and machine and electrical equipment industries. Only in the car industry is the application of CMS contracts widely applied.

\(^{24}\) The dissemination of the CPS is 'high' if the estimated market penetration in sales constitutes 30% or more, 'medium' refers to an estimated market penetration of 1-20% and 'low' is a market share below 10%.
The application of CMS within adhesives and inks (printing) and tanners is unsure. The CMS concept also has a potential within agrochemicals, where contracts can be set up, in which the supplier guaranties the farmer a certain performance for the crop in terms of quantity and quality. The supplier specifies a plan for the application of the product. The concept has been used in the US but has not been applied in Europe.

The character of the chemical compounds is decisive for the potential of setting up CMS. Base chemicals include petrochemicals and derivates and basic inorganics. The application of these products does not require a high level of technical support, and it is therefore concluded that basic chemicals offer little opportunities for suppliers and customers to develop CMS. Fine chemicals are chemical compounds that are made in relatively small amounts in a pure state. The products are used to formulate other products. The application of fine chemicals is considered not suitable for setting up CMS (Kortman et al., 2006).

### 9.3.2 Business rationale

The business model entails a shift in the way the chemical provider gains profit. Instead of making profit on the volume of sold chemicals the chemical provider is paid according to the service it provides, i.e. the management of chemicals. Contracts for CMS can be designed in various ways.

<table>
<thead>
<tr>
<th>Compensation mechanisms</th>
<th>Performance based contracts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Here the chemical provider is paid a fixed cost per unit of production. This model can be applied where the production unit is well defined and constant, an example is coating of car parts in the automobile industry. Here the chemical producer has an incentive to reduce the consumption of chemicals. (Mont et al., 2006; CSP, 2004)</td>
</tr>
</tbody>
</table>

Shared savings contracts

- The chemical supplier and the customer agree on a chemical budget. Savings on chemicals that entail a chemical consumption below the agreed chemical budget are shared between the chemical provider and its customer. This contractual model gives the provider an incentive to improve process efficiency and to reduce the consumption of chemicals (Mont et al., 2006).

Cost base-line based contracts

- The purchase cost of chemicals is based on the pattern of use of chemicals. The purchase costs of chemicals are limited and the chemical supplier is guaranteeing a certain reduction of chemical consumption over the time of the contract. (Mont et al., 2006).
Other compensation measures are also used, and the contracts are set up by combining different compensation measures. Usually it is the customer who decides the combination of compensation measures (CSP, 2004).

In the year of implementation of a CMS the net savings gained are from 5-20 % and within the first three years most companies have annual savings of from 6 and 10 %. After 5 years the savings are in the magnitude of 0-0.5 % per year. The savings are primarily obtained through reducing the chemical consumption, reducing the prices of chemicals and improving manufacturing processes (CSP, 2004).

Case example: PPG Industries

Background
PPG Industries is a worldwide supplier of paints and coating, chemicals, glass and fibre glass and optical products. PPG takes part in the manufacturing processes in a broad range of industries, where the company offers both products and services. In the automotive industry the services offered are chemical management, process management, industrial services and special services customised for the customer (http://corportal.ppg.com).

PPG industries cooperate with General Motors (GM)/Opel on a process and chemical management programme at GM's plant in Gliwice, Poland. The plant was built in 1997 and from 1998 production with CMS was initiated. The management of anticorrosion treatment, water treatment, wastewater treatment and waste management is delegated to PPG. PPG's CMS programme includes direct materials, process management, mix room, logistics, storage, quality control, maintenance, cleaning, indirect materials, consumables and chemical management systems. PPG's personnel at the plant are fully integrated in GM's processes (Oldham & Votta, 2003, Barbara Mucha, 24 April 2008). The basic idea is that by outsourcing part of the production GM can focus on their core business. From the beginning PPG had to comply with the requirements that GM set up. In terms of the anticorrosion treatment PPG had to fulfil specific process requirements. These requirements specified what chemical product should be used and how the processes should be performed. Other requirements were set up as general requirements, e.g. the waste water had to comply with specification for the pH level. (Barbara Mucha, 24 April 2008)

It is possible to distinguish between chemicals that are used directly and chemicals that are used indirectly in the processing. Directly used chemicals are applied directly to the products, e.g. car doors. The products that are used indirectly are all the products that not are applied directly, e.g. solvents or cleaning products. PPG is responsible for the purchase of all chemicals used at the plant. The chemicals used indirectly may be change without asking GM, whereas GM has to approve the substitution of direct chemicals. This reduces the risks for both GM and PGG as GM is in charge of the products used and the risks of errors are reduced. (Barbara Mucha, 24 April 2008).

Investments
All initial investments at the plant were made by GM.

Contract
The contract between PPG and GM is cost-line based. PPG is paid by cost per unit and the consumption of chemicals is calculated based on expected use. In
the anticorrosion processing PPG orders an amount of chemicals equal to the expected consumption, and PPG's payment is settled on a half yearly basis based on the actual chemical consumption. Spillage at the plant that PPG is not responsible for is paid by GM. This mechanism ensures that both PPG and GM have incentives to reduce spillages and errors. PPG has taken a risk by setting up a fixed price per unit. There is, however, some flexibility in the contract between PPG and GM to adjust price mechanisms. (Barbara Mucha, 24 April 2008).

Continuous improvements

As a part of the contract PPG is obliged to continuously reduce the cost per unit (CPU). The reduction of CPU is gained by various initiatives, among others reduction in the use of chemicals. Only GM gains from the savings and there are no gain-sharing mechanisms in the contract. The continuous improvements are developed in cooperation between PPG and GM. On a monthly basis meetings are set up where the potential savings and improvements are discussed, and PPG is required to come up with suggestions for process and quality improvements. Improvements have to be implemented on a yearly basis. (Barbara Mucha, 24 April 2008).

Environmental impact

The environmental improvements gained are in terms of reduction in use of chemicals, reduction in water and energy use and substitution of chemicals with less toxic chemicals. The environmental improvements include reduction in chloride concentration in wastewater and reduction in the amount of wastewater sludge. The savings gained by the programme have led to monthly savings in the magnitude of €10,000 (data from 2003). The plant complies with the local environmental standards, and PPG assists GM in being capable of meeting future environmental regulations (Oldham & Votta, 2003; Barbara Mucha, 24 April 2008).

The compensation mechanisms in the chemical management services that PPG provides for GM/Opel are based on fixed price contracts without gain-sharing mechanisms. Agreements about continuous improvements are included in the contracts.

The environmental impact of PPG’s business model is a reduction in chemicals used and improved waste management.

Case example: Houghton

Houghton is one of the world's largest suppliers of specialist industrial production lubricants and fluid management services. Houghton serves industries within aerospace, aluminium, automotive, bearing, defence, food and beverage, machinery fabrication, medical devices, metal finishing, offshore and steel (http://www.houghtonintl.com).

Houghton's fluid management services are based on a fixed price business model, where Houghton takes over the responsibility for the customer's management of lubricants. In the fluid management services Houghton supplies and manages the fluids at the customer's site. The fluid management services are designed to match the customers' demand. The activities included in the man-
Management services vary from periodical visits to operators based permanently at the customer's production site. The range of involvement at the site depends on the contract that is set up. The contracts vary from €5,000 to €1,000,000 a year. In order to be feasible for Houghton to have technicians employed permanently in the customer's plant the yearly sale of services must be around €100,000 (Declan Grant, 9 May 2008).

The lubricants are used to maintain the customer's machines. In the automotive industry a part of the engine manufacturing process is the drilling of holes in an aluminium board where the engine components are later assembled. The machine that drills the holes is maintained with coolants. Through use of the machine the coolants become dirty and in the end the coolants have to be substituted with clean fluids. Fluid management services are based on Houghton having a better understanding of the fluids. Houghton's technicians are able to provide a more efficient management of the fluids through continuous monitoring of the condition of the fluid, e.g. with respect to bacteria and pH, and by applying recycling equipment to clean and reuse the fluids. In this way the lifetime of the fluids are considerably prolonged. In a worst case scenario of bad fluid management, it may be necessary to change the fluids every week. By improving the fluid management, Houghton is capable of extending the lifetime of the fluids to 6 months. The savings gained from fluid management services are due to both hard and soft savings. Hard savings are gained by considerable reductions in the use of fluids and by reduced disposal cost of discharged lubricants. The fluid waste can be reduced by 90%, which in large plants can entail reduction in disposal costs corresponding to €90,000 annually. Soft savings are obtained by reducing the downtime on the plant and by avoiding additional labour costs (Declan Grant, 9 May 2008).

One of Houghton UK's customers is Visteon. Visteon is a worldwide supplier of integrated systems to automobile manufactures. The contract with Houghton was set up in 2003. Until then Visteon had purchased the lubricants from their former supplier and was in charge of applying the products. Based on a tendering process Houghton offered Visteon fluid care services. The contract includes four of Visteon's plants. Only at Visteon's plant in Belfast is the application of lubricants entirely outsourced to Houghton. The first contract ran for three years, where Houghton guarantied a 6% yearly saving during the contract. As part of the contract a gain-sharing mechanism was in place where savings exceeding the annual 6% would be shared between Houghton and Visteon. Visteon's background for setting up the gain-sharing mechanism was to give Houghton an incentive to make additional savings. The gain-sharing mechanism has only been used to a limited extent. After the first three years, the contract was renewed. As most of the easily achievable savings were achieved, the new contract has lower targets for annual savings. Houghton made the initial investments that were needed to set up the cooperation. This includes feasibility studies and establishment of recycling equipment at some of Visteon's plants. The annual costs of lubricants at the four plants are about £400,000. In comparison the annual use of lubricants was £700,000-800,000 when the contract was initiated. A part of these savings is due to reduction in the volume of production at the plants. Visteon had no problem in establishing the cooperation with Houghton. At one of their plants some of the employees were suspicious.
about the cooperation. But it turned out that Houghton's employees had sufficient capacities to carry out the work. The former lubricant supplier had not made any attempt to assist Visteon in reducing the chemical consumption, and this left plenty of opportunities for Houghton to make savings (James Mortimer, 9 June 2008).

Contract
The contracts Houghton set up run for a minimum of 3 years. Some contracts are set up with gain-sharing mechanism. If Houghton is capable of achieving savings above an agreed level, the additional savings are shared. A typical model is that savings exceeding € 500,000 are shared evenly between Houghton and the customer. It depends on the customer whether the contract contains agreements on gain-sharing. Houghton often aims at continuous improvement, but this is normally not mentioned in the contracts. The achievement of continuous improvements improves the relationship with the customer (Declan Grant, 9 May 2008).

Investments
The implementation of fluid management services demands investments at the customer's site. Such investment ranges from € 20,000 to € 100,000. In many cases Houghton makes these investments. Houghton, however, only makes the investments if it is economically feasible. If the sale of fluid care products is too low, there is a lack of incentive for Houghton to engage in a profound cooperation. The large companies that have implemented fluid management services with Houghton technicians situated at the plant are located in the larger European countries such as Spain, Italy and UK. The market penetration for fluid management services in smaller countries such as Ireland, Switzerland and Denmark is limited (Declan Grant, 9 May 2008).

The advantage to Houghton in engaging in fluid management services is business security. The customer is obliged to buy Houghton's services as long as the contract runs. This ensures a certain market share to Houghton. Further, the business model improves the relationship between Houghton and the customer. Trust between Houghton and the customer is an important prerequisite for setting up the business model. New customers are primarily obtained through references and a good reputation. Most customers accept that they are not experts in fluid care management and are therefore willing to outsource the management of lubricants (Declan Grant, 9 May 2008).

Environmental impact
The environmental gains from fluid management services are that less lubricant is used, and therefore less fluid is produced and the volume of fluid lubricant waste is reduced. This entails a reduction in CO₂ emissions. Most of Houghton's customers have an ISO 14001 certification. By managing the customer's lubricants, Houghton helps the customers to improve their environmental performance in accordance with the ISO 14001. Houghton UK has no calculations of the environmental savings gained from implementing their business model.

Risks
The contracts are based on fixed prices, so if it turns out that the consumption of lubricants is higher than estimated, Houghton will have to suffer from the losses. Therefore it is crucial for Houghton to make accurate calculations of the consumption of chemicals. If there should be production losses caused by downtime due to mismanagement of the production facility, it would be a dis-
cussion between Houghton and the customer who bears the responsibility (Declan Grant, 9 May 2008).

The compensation mechanisms in Houghton’s fluid management services are based on fixed price contracts. Some of the contracts include gain-sharing mechanisms.

The environmental impact of the Houghton’s business model is a reduction of chemicals used and improved waste management.

A prerequisite for extensive application of fluid management services is that the customers company has a high demand for fluid care products.

Grundfos is a large Danish manufacturer of pump solutions. The company is situated in Bjerringbro, Denmark. 2,800 persons are employed in the production of pumping equipment. The production takes place at 8 plants. 6 of the plants are situated within a radius of 2 km. At the 8 sites a total of 3½ persons are employed full-time to maintain the production equipment with lubricants and managing the use of fluid care products. Preventive maintenance and management of the production equipment are crucial to Grundfos in order to increase the lifespan of the equipment and to reduce failures of the production line. The use of lubricants constitutes significant costs, but compared to large companies, e.g. within the automotive industry, the application of fluid care products at Grundfos does not have a major impact on the overall cost situation.

3 years ago a benchmark was performed to compare whether the current situation could be improved through outsourcing. The cost-benefit analysis showed no significant improvement therefore the company decided to follow the existing in-house process.

Grundfos has not set up targets for reduction of the consumption of lubricants. This is due to the relatively low economic significance of the use of lubricants and because the benchmark showed that the internal process is quite competitive to what was used by a similar manufacturer who had outsourced the process. Moreover, Grundfos buys their fluid care products at a competitive price (Jørgen Hejlesen, 22 May 2008).

9.3.3 Environmental case

CMS constitutes a potential win-win situation for the involved companies and the environment. In the 2004 study of the CMS industry’s performance the chemical providers were asked how they help their customers to reduce sources of emission. 54 % of the providers stated that they assisted their customers to reduce emissions by reducing the amount of chemicals being used, and 46 % reduce the emissions by establishing reuse or recycle alternatives. More than 30 % of the providers stated that they helped their customers to reduce emissions through chemical substitution and the same percentage of providers held that
their customers’ environmental performance was improved by establishing other types of process efficiencies\(^{25}\).

The customers of chemical products emphasise continuous improvements. CMS providers are using three strategies to make such improvements: through internal development, by using their sub-suppliers (tier II) and by using third party consultants, academics, etc. (CSP, 2004). In the CMS industry report from 2000, 80 % of the customers indicated that environmental benefits were achieved through chemical optimization, 47 % stated that environmental benefits were achieved through elimination of hazardous materials from their operations (Stoughton & Votta, 2003).

The results from various Chemical Management Services

<table>
<thead>
<tr>
<th>Company</th>
<th>Results from CMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GM Oshawa &amp; Haas Corp.</td>
<td>30% reduction of costs, 54% reduction in quantity of purge solvent, 77% reduction in quantity of paint stripper, 80% reduction in quantity of solvent masking and 75% reduction of emissions of VOC</td>
</tr>
<tr>
<td>Nortel</td>
<td>$120,000/yr from chemical substitution, 50% reduction in quantity of annual chemical consumption, reduction of hazardous waste 8% in 2 yr = $ 24,000/yr</td>
</tr>
<tr>
<td>Raytheon Systems Company/Radian International LLC</td>
<td>10–20% net savings in costs first 2 yr, reduction in scrap rates by 250%, 71% reduction in paint waste</td>
</tr>
<tr>
<td>Navistar engine plant/Castrol Industrial North America</td>
<td>Up to $10,000 per year as rebates for reduced chemical use, coolant use reduction by &gt;50% of quantity, coolant waste reduction by 90%</td>
</tr>
<tr>
<td>General Motors Truck and Bus Plant/BetzDearborn</td>
<td>Over $1 million in savings, 8% decrease in chemical costs per vehicle, 50% reduction in quantity of paint use, 78% reduction in paint inventory</td>
</tr>
<tr>
<td>Delta Air Lines and Interface LLC</td>
<td>Net savings in excess of $2.5 million, 30% reduction in chemical costs, eliminated inventory waste, generating $250,000 annual savings, shelf-life-related losses reduced by 75%</td>
</tr>
<tr>
<td>Ford-DuPont CPU program</td>
<td>35–40% reduction of chemical quantity in finishing operation, reduction of VOC emissions by 50%</td>
</tr>
<tr>
<td>Chrysler Neon assembly plant/PPG</td>
<td>7.5% reduction in deionised water costs</td>
</tr>
<tr>
<td>Ford Taurus assembly plant/PPG/Chemfil</td>
<td>&gt;$50,000/year from reduction of wastewater sludge generation by 27%, reduction of VOC emissions by 57% in 18 months</td>
</tr>
<tr>
<td>GM/Opel-PPG</td>
<td>Cost savings of $12,700/month and reduction of chloride concentration in wastewater and of wastewater sludge</td>
</tr>
</tbody>
</table>

\(^{25}\) The interviewed chemical providers had the opportunity to indicate two ways that influence their customers’ environmental performance positively (CSP, 2004).

Source Mont et al. (2006). (The results have been gathered from various studies)
The table above shows the results of CMS from a range of programmes. The results origin from various studies and have been gathered by Mont et al. (2006). The results include large economic savings, gained among other by reduction in the consumption of chemicals.

### 9.3.4 Possibilities and barriers

In 2003 a study was conducted on CMS among a range of European companies connected to the chemical industry. Based on the study various drivers and barriers for CMS in Europe was identified (Mont et al., 2006). The chemical suppliers and the customers had different views on the barriers and drivers for CMS.

**Drivers**

Due to an increased competition and declining margin on the traditional market for chemical products, CMS improves the competitive position of the chemical suppliers. Applying CMS allows the suppliers to introduce new value adding products and services that help to maintain growth in the business. CMS can constitute an alternative for the chemical suppliers to price underbidding by their competitors (Mont et al., 2006).

CMS helps to improve the relationship between the chemical supplier and the customer and to create mutual trust. This may lead to enhanced customer loyalty and long-term contracts. (Mont et al., 2006) Depending on the kind of contracts that are set up, CMS can allow the supplier to profit from gain-sharing with the customer (Mont et al., 2006).

By outsourcing the chemical management the customer can focus on his core activities. The customer gains cost savings from CMS through a reduction in the consumption of chemicals, through lower chemical prices and by reducing the number of accidents and associated risks. As the supplier in some cases purchase chemicals for customers, they can negotiate a discount that the company could not do himself. Applying CMS can lead to continuous improvements in the company's environmental performance (Mont et al., 2006).

The EU regulation on Registration, Evaluation and Authorizat (REACH) came into force in June 2007. The purpose of the regulation is to improve the protection of human health and the environment by an earlier and better identification of the properties of chemical substances. The directive calls for substitution of the most dangerous chemicals where alternatives are available. The providers and suppliers of chemicals will have to provide information on the properties of their substances. (http://www.chemicalstrategies.org). The directive constitutes a driver for chemical users to subsidise environmentally hazardous chemicals with environmental friendlier products.

**Barriers**

A large barrier to introducing CMS among chemical suppliers is a traditional mindset, where profit depends on the quantity of chemicals they sell. Barriers to the suppliers are also that the customers are not fully aware of the concept and do not have a full understanding of the life-cycle costs of chemicals. Some customers are reluctant to apply CMS as they lack trust in the chemical pro-
provider's capacities to take care of their chemical management. For CMS to be feasible a certain amount of services has to be sold (Mont et al., 2006).

It is crucial for the customers that CMS does not constitute a threat to the efficiency of their processes and the quality of their products - which in the end will affect the competitiveness of the company.

For CMS to be financially feasible for a company the company has to be of a certain magnitude, otherwise they will not be able to outsource all of the process. Transaction costs are connected to making a baseline of the chemical management costs, to review the existing production line and to go thorough a bidding process. These transaction costs may constitute a problem to the implementation of CMS (Oldham & Votta, 2003).

The chemical user may not see the use of chemicals as a priority. The cost of chemical use is often calculated to comprise less than 1% of the company's operating costs. These calculations do not often include the actual life cycle cost of chemical usage. Lack of cost awareness of chemical use and poor data management lead to difficulties in showing the potential benefits to the management (Oldham & Votta, 2003; CSP, 2004).

The chemical customers indicate that there is a lack of CMS providers and that they have difficulties in understanding the market of CMS, what services the different suppliers really offer. If a company has to change supplier in order to engage in cooperation on CMS, the company has to build up a trust relationship with the new supplier (Mont et al., 2006). Trust between supplier and customer is crucial for CMS to succeed, and the lack of trust can present a large cultural barrier to CMS (Oldham & Votta, 2003).

If the chemical provider's payment is based on a pay per unit contract, the provider may have a lack of incentive to replace chemicals with alternative chemicals that are better for the environment but more expensive (Mont et al., 2006).

### 9.4 Resource Management

**Definition**

Resource Management (RM) is a business model that is based on changing the relationship between waste-generating organisations and their waste contractors. Traditional waste and recycling contracts feature "a profit incentive to contractors to maximize disposal levels (hauls) and/or a limited scope of service with multiple contractors handling separate waste streams or recyclables" (US EPA, Year unknown).

RM gives the waste contractor incentives to emphasize cost-effective resource efficiency by preventing, recycling and recovering waste and by limiting the hauling and disposal of waste (Ligon et al., 2001).

The differences between traditional hauling and disposal contracts and RM contracts are shown in the table below. RM contracts give an incentive for the contractor to minimize the production of waste.
RM contracts are based on three premises:

- That there exist opportunities to cost effectively reduce waste and improve recycling.
- That contractors will try to achieve such gains if they are offered proper financial incentives.
- The financial incentives are supported through cost-effective improvements to the current waste/recycling system (US EPA, Year unknown).

RM may include external as well as internal handling of waste. The external handling includes monitoring/reporting and recovery services. The internal handling of waste can be optimised by more efficient material use, better storage and ordering. The waste stream can thus also be minimised by changing the product or process design (US EPA, 2001). RM can be said to be an approach to move waste management up the reduce - reuse - recycle hierarchy.

The type of RM services stretch from external changes in the waste handling to taking over all of the customer's waste management and making continuous improvements through changes in product and process handling.
Distinguishing Features of Waste Hauling/Disposal vs. RM Contracts

<table>
<thead>
<tr>
<th>Features</th>
<th>Traditional Hauling and Disposal Contracts</th>
<th>RM Contracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractor Compensation</td>
<td>Unit price based on waste volume or number of pick-ups.</td>
<td>Capped fee for waste hauling/disposal service. Performance bonuses (or liquidated damages) based on value of resource efficiency savings.</td>
</tr>
<tr>
<td>Incentive Structure</td>
<td>Contractor has a profit incentive to maximize waste service and volume.</td>
<td>Contractor seeks profitable resource efficiency innovation.</td>
</tr>
<tr>
<td>Waste Generator-Contractor Relationship</td>
<td>Minimal generator-contractor interface</td>
<td>Strategic alliance: waste generator and contractor work together to derive value from resource efficiency.</td>
</tr>
<tr>
<td>Scope of service</td>
<td>Container rental and maintenance, hauling, and disposal or processing. Contractor responsibility begins at the dumpster and end at the landfill or processing site</td>
<td>Services addressed in traditional hauling and disposal contracts plus services that uniform and influence waste generation (i.e., product/process design, material purchase, internal storage, material use, material handling, data management, reporting).</td>
</tr>
</tbody>
</table>

Source: US EPA (2001)

The concept of RM has been promoted by the US EPA. In a voluntary programme called WasteWise, free technical assistance to businesses, governments and institutions is provided on how to set up RM. The programme emphasises the opportunities in implementing RM in waste management of domestic waste (US EPA, Year unknown).

9.4.1 Business rationale

The idea of RM is to set up a contractual arrangement between a waste producing organisation and a waste contractor where there are incentives preventing recycling and recovering waste. These can be organised by setting up a mutually beneficial business relationship that encourage cost-efficient resource efficiency, recover savings and open up for gain-sharing mechanisms between the customer and the waste contractor. The compensation structure can with advantage be organised in such a way that the RM contractor has an incentive to help the customer make continuous improvements in resource efficiency. This can be ensured if the RM contractor's profit margin improves by assisting the cus-
Innovative Business Models with Environmental Benefits

Compensation mechanisms

Pass-Through of Service Costs with 'Shared Savings' and Performance Bonus. In one model the contractors provide the requested waste services e.g. in terms of tip fees, hauling fees, container rental on a 'Pass-Through of Service Costs' basis. The cost pass through is based on biddings for taking over the existing waste services. When the contractor implements changes that on a permanent basis decreases costs, the contractor gets a share of the savings gained. The kinds of improvements that the contractor can implement include over-all reduction of waste generation, waste diverting more materials, making handling and hauling procedures more efficient, 'right-sizing containers' in order to make cost savings and make behavioural changes. The gain-sharing mechanisms can be designed so that the savings are split between the waste contractor and the customer (e.g. after a 50/50 % sharing model), or that the savings gained above a predetermined level are shared (e.g. after a 70/30 % model in favour of the waste contractor).

Fixed Cost with Guaranteed Cost Reduction. The second model is based on the waste contractor taking over the existing waste services at a predefined annual cost. The costs are calculated based on the previous year's total cost and include guarantees for cost reduction. The cost reduction could be of 5 % annually. If the contractor is confident that savings larger than 5 % can be realised and that there is a potential for continuous improvements. This model gives the contractor an incentive to provide the waste services in an efficient way as the company gains profit directly by this (US EPA, Year unknown).

Establishing a RM programme may entail initial investments. The way the investments are split between the waste contractor and the customer must be settled before the programme is set up.

Case study: General Motors

Background
The concept of RM is coined by GM. In 1997 GM realised that the existing hauling and disposal contracts were inadequate to produce resource efficiency across GM's 70 North American facilities. The first site where RM was implemented was in Lake Orion Facility Assemble Plant. An audit of the site's waste management showed a potential for considerable improvements.

Waste management
In such assemble plants thousands of components are assembled to final vehicles. All these components, e.g. instrumental panels, window driers, small electronic parts, are packed in wooden boxes, cardboard, paper and plastic. Many components come on pallets. Some of these package material is return-able other are not. If the components are manufactured overseas, e.g. in China, it does not make sense to return the package material e.g. wooden boxes and pallets. One challenge was to minimise the amount of package waste. Another source of waste generations originates from coating of car parts. The paint used for coating is extremely expensive. Even in the best plants it is only possible to get 60-70 % of the used paint on the car parts. The rest of the volatile paint has to be captured and disposed. A water recycling process is used as method for
capturing the paint. The paint is very sticky. It has to be made less sticky and removed from the water. This waste product is called paint sludge. If the moisture content of the paint sludge can be reduced it is more suitable as a fuel. Other types of waste chemicals, e.g. oil products, also have to be disposed correctly.

Inspired by the CMS system GM already had implemented at their sites a waste management system was developed. Million of dollars were used to haul and dispose waste. The idea was to consider waste as a resource and to minimise the amount of hauled and disposed waste. GM needed to bring together a team of people that had incentives to eliminate the production of waste and to encourage reuse, recycling and correct disposal of waste. GM made a review of costs associated with the waste handling and the kind of waste services that they wanted to outsource. Potential tenders were invited to the plant to identify where savings could be made. If the Resource Management Contractor (RMC) was able to eliminate the production of waste or show GM how to reuse or recycle material, the costs for hauling and disposal of waste would be reduced and thereby the contractor could make a profit.

The amount of paint sludge that is generated depends on the number of vehicles produced at the plant. The need for heating of the plant is independent on the size of the production, and ashes from burning coal are therefore fixed. The contracts set up with the contractor takes into account whether the amount of waste is fixed or variable.

Instead of having an array of tyre I waste contractors, all waste management is outsourced to one contractor, the RMC. The RMC is responsible for developing a resource management programme on how to eliminate, reduce and reuse waste. This includes a total system analysis and a source operation programme where the closest recycling centre is identified. The RMC has employees situated fulltime on GM’s plant. The services covered by the RMC include traditional hauling and disposal of waste and consultancy on how to recycle and re-use material, and advises on what type of container to use in order to reduce costs. Moreover, the RMC advise GM on how to handle waste correctly, e.g. in order to prevent leakages. The RMC are responsible for making the environmental reports and material safety data sheets.

The contracts are set up for a three year period. The first year the contract runs, the RMW contractor gets 30 % of the savings that are achieved. The second and third years GM get 100 % of the savings. The contracts require continues improvements throughout the time period that the contract runs. When the contract ends, the contract are renegotiated, and if the contractor is able to improve the waste management further, gain sharing mechanisms are included in the new contracts. To increase the incentive for the RSC further, it is considered to increase the contractor’s share of savings from 30 to 50 %. This is, however, not yet implemented.

The RMC is assuming all risks associated with the waste management. If the contract states that the plant has to be landfill free, the contractor is liable of ensuring this. If for instance the facility that receives the paint sludge is closing
down, the contractor is responsible for proper handling of the paint sludge even if this entails increased costs for transportation. Retooling of the assemble plant in order to manufacture a new vehicle entails a total stop of the production line - and thereby a dramatic reduction in the amount of produced waste. The variable costs for waste are thereby zero. In the past GM has continued to pay the RMC the costs of having employees situated at the plant. In some cases the production line has been closed down in up to 2 months. In connection with future retooling of the production line the RMC might have to bear the risk of paying the salary of the on-side employees themselves.

Most of GM's costs associated with implementing Resource Management are related to making cost books of past and present costs connected with waste management and to identify the waste services that the RMC should take over. Some investments can be associated with acquiring new containers and/or to bring in new compactors.

The integration between a RM and a CMS system is crucial. Proper handling of waste in the CMS system impacts directly on the RM system. Clay is for instance very suitable for capturing paint. The problem is, however, that this method entails very huge amounts of paint sludge that is not suitable for reuse of incineration.

Results

The result from the RM has among other things been improved processing of paint sludge which has entailed higher solid content of paint making the sludge more attractive as a fuel. Opportunities for using paint sludge to development of new - but inferior paint - are also being investigated. 50 % (ca. 23 plants) of the North American plants where RM is implemented are planned to be zero landfill plants by 2010 (Warren Underwood, 22 July 2008).

One year after implementing the RM models at several of their production sites, GM realised a 20 % reduction on overall waste generation (30,000 ton) and a 65 % increase in recycling (from 50,000 to over 82,000 tons). In addition to this the company had substantial reductions in the company's waste management costs (the waste management costs were decreased about 15-30 %). RM is implemented in all of GM North America's manufacturing facilities, where a single supplier manages all waste at each plant. By 2007 the RM programme has here led to savings in the magnitude of US$ 6 million over the previous three years (GM, 2007). Similar waste management systems are implemented in most of the automotive industry. Some of the larger of GM's suppliers and a large company as BASF are using similar systems (Warren Underwood, 22 July 2008).
9.4.2 Environmental case

Successful RM entails reduction of the consumption of resources and increases waste diversion. The US EPA points at three ways that RM contributes positively to reducing emission of greenhouse gases.

- Reduction in the volume of waste that is sent to landfills and incinerators. This leads to reduction in methane emissions from landfills and reduced CO$_2$ emissions and NO$_X$ emissions from combustion.

- A minimisation of the demand for virgin materials entails reduction in the energy consumption to extract process and manufacture products. This reduction in energy consumption leads to reduction of fossil fuel consumption and thus reduction of emissions of CO$_2$ and NO$_X$.

- By slowing down the logging of trees, the CO$_2$ storage capacity of forests is maintained (US EPA, Year unknown).

Studies of the potential for other US organisations show that the organisations have a large potential for improving their waste minimisation and recycling of waste and reducing their waste management costs. Massachusetts Pilot Project involves, for instance, a range of case studies on the potential of RM (Ligon et al., 2001, http://www.mass.gov).

9.4.3 Possibilities and barriers

Reducing disposal volume is an obstacle to companies that normally make profit through disposal volume. The skills necessary for taking care of RM are different from those that are required for providing hauling and disposal services (US EPA, 2001). The companies have to change the value of the services they gain profit from. The types of companies are also different such as e.g. engineering firms and management consultants (US EPA, 2001).

In an US survey, waste service providers indicated opportunities and barriers to performance contracting of waste management (see table below).
9.5 Remanufacturing

Remanufacturing is one approach to remarketing. The US EPA has defined remanufacturing as "the standard term for the process of restoring used, durable products to a 'like new' condition" (US EPA 1997).

Remanufacturing constitutes the potential for achieving environmental advantages both upstream and downstream. Due to the reusing of products upstream entails less consumption of raw material and downstream as less waste is produced.

In terms of companies that perform remanufacturing, it is possible to differentiate between companies that only remanufacture their own products (closed-loop remanufacturing) and third party companies that remanufacture products originally manufactured by other companies (open-loop remanufacturing). The kind of incentives companies have to engage in remanufacturing - and the kind of barriers they may encounter - may differ according to whether they remanufacture own products or not. The Dutch company ASML is an example of a company that uses an array of strategies to remanufacture their own products.

9.5.1 Business rationale

The business rationale of remarketing is to bring the products back to a standard where profit can be made on selling them. The type of remarketing which is emphasised most on here is remanufacturing. Remanufacturing is an ap-
proach to remanufacturing where the used products are brought back to a state where the products are 'as new'.

Some of the examples of sectors with a successful remanufacturing of consumer durable goods are automotive parts, computers, laser toner cartridges, photocopiers, cleaning equipment, and single-use cameras (Giuntini & Gaudette, 2003; Franke et al., 2006).

Original equipment manufactures (OEMs) as General Electric, Boeing, Caterpillar, Deere, Navistar, Xerox, Electrolux and Pitney Bowes have developed business models were remanufacturing of their products is an integrated part. Eastman Kodak and Fuji Photo Film remanufacture their single-use cameras. The cameras are reused up to 10 times after being returned to the film processing.

Fuji Xerox is an example of a company that has integrated remanufacturing as a part of their business model. In 1987, Xerox started a programme called 'asset recovery'. The purpose was originally to remove old copy machines from the waste streams and to reuse the machines for resale. In 1989, 5 % of the scrapped machines were remanufactured. In 2005, Fuji Xerox had reached a recovery of 98 % of the used products. In 2000, Fuji Xerox was the first Japanese company to reach zero landfill of used products. Fuji Xerox leases their copy machines for 3 years, and then they remanufacture the machines and lease them out again. Fuji Xerox performs the same kind of services on their machines whether they are made of 100 % virgin parts or they are remanufactured. The remanufacturing business model constitutes a significant competitive advantage for Fuji Xerox (Nagler, 1999; Fuji Xerox, 2005; King & Burges, 2005).

Electrolux has remanufactured household appliances since 1998. Environmental concerns were the initial driver for remanufacturing products as the profit from the start was very uncertain. The products that are remanufactured are appliances that it has been impossible to repair on site. The remanufactured products are mostly newly manufactured products with failures that are covered by the warranty, products that are harmed during transportation or products that have been leased out. The kinds of products that are remanufactured include refrigerators, washing machines, stoves and microwave ovens (Sundin & Bras, 2005).

**Case example: ASML**

ASML is a world leader in providing microlithography systems for the semiconductor industry. The advanced technology systems are leading edge technology that is critical for production of integrated circuits or microchips. These chips power a wide range of electronic, communication and information technology products. ASML designs, develops and manufactures equipment that is used to transfer circuit patterns onto wafers. The customers include many of the global semiconductor manufactures. (http://www.asml.com) The prices for new systems range from € 1.2 million to € 45 million (Boudewijn Sluijk, 9 May 2008). When their customers no longer need the system they have acquired from ASML, ASML buys the systems back. ASML uses five strategies...
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for remanufacturing their products, Direct-Shipment, Refurbishment, Remanufacturing, Legacy and Conversion. The strategies are applied in accordance with the potential for reusing the products. The remanufacturing strategies that ASML applies are an interesting example of different ways to bring products back on the market. The Direct-Shipment is not a remanufacturing strategy, however, it is described to give an overall understanding of when and how different remanufacturing strategies are used.

**Direct-Shipment**

ASML facilitates Direct-Shipment of systems, where the systems are reorganised from one location to another without passing through the factory. These systems are in such a good shape that they can be made fully functional on-site with minimal effort. These systems are remarked as second hand systems (http://www.asml.com; Arnout Meester, 28 April 2008).

As a remanufacturing strategy, reusing - or Direct-Shipment as it is called in ASML - is the cheapest and fastest solution, where the products are in such good condition that they can easily be reused without too much change. The advantages are that there is no need for new materials and the product does not have to be altered. This implies that the amount of waste entering the waste streams is reduced and there is little demand for man-hours to make the product ready for sale. (Vrij et al. 2006) The services included in Direct-Shipment that ASML performs are auditing (ensuring the quality of the product) relocation of the product, qualification (setting up the system and training the users) and upgrading the product. The products are thereby upgraded to a higher standard than the original product.

**Refurbishment**

ASML systems that need more repair in order to be remarked go through a refurbishment process. The process takes place at ASML sites, where the machines are repaired and the system performance is brought up to the specifications of the newest products. The components that are broken and are likely to cause problems are substituted, and the system is upgraded with the newest components and software. The result is better performance in terms of quality and productivity. The products are sold with full specifications and warranty.

**Risk**

A product that can be sold after refurbishment for € 1.2 million is bought back for € 400,000. € 400,000 is used to bring the system up to the newest specification and € 400,000 is the profit ASML makes. By giving a warranty on the remarked products ASML takes a risk.

Refurbishment only involves minor changes in the product design. Most components are the same and the small adjustments do not change the functionality of the product. However, some of the components are changed which results in some amount of waste (Vrij et al. 2006).

**Remanufacturing**

In remanufacturing the old machines are taken apart and rebuilt. This results in machines that perform almost as products built on virgin components only. The machines are sold with the specifications of the latest products. The products are sold with a warranty and at an attractive price (http://www.asml.com; Vrij et al., 2006).
Remanufacturing is a complicated process, where the original product is rebuilt into a new product. The main differences between refurbishment and remanufacturing are the number of actions that are required to bring the product back to an as-new state.

Remanufacturing constitutes advantages in cases where the product is highly complex and the product’s lead time therefore is long or where component costs are extremely high. Building new lenses for ASML’s machines requires for instance up to a year\(^{26}\), and also remanufacturing lenses can take several months, as the lenses have to be polished and realigned. By means of buffers, ASML has reduced the lead time for remanufactured products in the range of 2-3 months (Vrij et al., 2006; Boudewijn Sluijk, 9 May 2008).

**Legacy**

Some machines are in such a condition that remanufacturing is still possible but no longer economically feasible. The cost of bringing the machines to the original specifications is too high so it is cheaper to purchase a new or a refurbished/ remanufactured system. ASML makes an audit of the performance of the products. Based on the audit the customers can chose between a portfolio of possible updates. The machines are brought into a shape were they work, but do not meet the original specifications. The products are sold with a very limited warranty. The machines that are remarke ted as legacy systems are often 15 years old. The products are still quite expensive, around 40 - 50 % of the price of the original product. ASML is on a market where the technologies develop very fast. The customers that purchase legacy systems do not demand the latest technology. This can be because the customer has to substitute the existing system to continue the production, the customer wants to add capacity to the existing production or because the customers apply the system on a new market. An example of the later is production of airbags. Integrated sensors for airbags can be made with the type of machines that was used to make top of the line semiconductors 10-15 years ago (Boudewijn Sluijk, 9 May 2008).

**Conversion**

The machines that no longer work and essentially are scrap still holds a value. ASML buys such systems back at a price corresponding to 5 % of the new price for the system. ASML's systems are built on a platform base. The same platform is used for different products, whereupon specific components as the optics are added. Formerly, ASML made both lamp and laser-based optic systems. The laser-based technology is no longer in demand. ASML can convert a laser-based system to a lamp-based by substituting the optics. In this way ASML can reuse the platform from systems that are no longer in use.

Originally the systems were not designed with the purpose of remanufacturing. ASML started to perform remanufacturing when the used systems became available and a market for the remarke ted systems emerged. It turned out that the platform design was an advantage with respect to remanufacturing the systems. The systems were originally designed on a common platform because it was a more efficient design.

\(^{26}\) ASML has a buffer capacity. This ensures that their customers can receive their systems within 6 month from ordering (Boudewijn Sluijk, 9 May 2008).
The largest risk ASML takes by remanufacturing is by buying the used systems back. An audit is performed before the systems are bought back to determine what condition the system is in. The risk is primarily associated with investing in and repairing the used machines as it is unclear when the systems can be sold. The used machines are sold on a continuous basis and the risk is therefore not very high. The remanufacturing of products (except Direct-Shipment) is a non-standard project individually designed for each machine. This makes it problematic to guarantee the quality of the system. If refurbished or remanufactured products are on the market most customers are interested in buying these machines instead of new as they are cheaper.

_Vrij et al. (2006)_ have set up a model for the extent of failures of a product and the need for remanufacturing. When a product is launched, for a period of time it fulfils its requirement. After some time the requirement changes. In the beginning the changes in requirement are small but eventually the changes will be so large that the product does not fulfil the requirements at all, and the product arrives at End of Live (EOL).

Where there are small changes in requirement the Direct-Shipment strategy can be applied to products to remanufacture them. This is shown in figure 5.1 as phase 2. Systems sold as Direct-Shipment are normally between 4 and 7 years old. Where there are medium changes to the requirements, refurbishment can be applied as a strategy to remanufacturing the product (shown in the figure as phase 3). Where large changes in requirements take place, remanufacturing may be used as a strategy to remarketing of the product (phase 4). Where the changes to the requirements are very large (the systems are 10-15 years or more), legacy or conversion may be strategies to remarketing.

It has only been necessary to make relatively small investments in order to perform remanufacturing. The skills needed to refurbish and remanufacture the products are the same as the ones that the employees had from the original production process. The refurbishment is made on the product facilities that are used for maintenance of the systems, and remanufacturing is performed on the original production line.

ASML performs remanufacturing because it is a way to make profit. ASML has not made specific calculations of the environmental advantage of applying their remanufacturing strategies. Because the systems ASML makes are so expen-
sive it is feasible to reuse most components and there is not much scrap from
the production. ASML's strategy is an efficient approach to waste minimisation.
The amount of original components in each remarketed product varies from
system to system. In Direct-Shipment all original components are reused. In the
other remanufacturing strategies the amount of components that is substituted
depend on the condition of the system and the specification that the system
shall meet.

Design of products at Philips

Philips manufactures a broad range of products e.g. household appliances, per-
sonal care products, TV-sets, monitors, audio and video products, etc. The ex-
pected lifetime of Philips' products is typically 7 years or more. The products
are designed to be repaired, but are not designed to be remanufactured.

The products are for household application and most products do not have ex-
pensive components (exception LCD panels). It is not economically feasible to
reuse components from worn out products that are 7 years or more. The technol-
ogical development of most products is very fast, and the residual value of old,
used products is low. It will therefore be more expensive to organise reverse-
logistic and remanufacture products than it will be to manufacture new prod-
ucts.

The recycling potential for Philips' products is high and most of the materials
from used products can be, and will be recycled more and more (Ton van Veen,
26 May 2008).

9.5.2 Environmental case

The environmental problem of electric parts is that they contain substances that
have a damaging impact on the environment when they are disposed of either
by landfill are incineration. Further, electronic waste is growing at an annual
rate from 3-5% which is three times larger than the growth of general waste.
To cope with these problems, EU has implemented the directive on waste and
electrical and electronic equipment (WEEE), where the original equipment
manufacturer is made responsible for the treatment and disposal of post-
consumer products (King & Burges, 2005). While a strategy to ensure recycling
would meet the producer's obligation, many manufactures see recycling as an
additional cost as the recycling makes up little or no financial benefit - this is
due to the scrap value being lower than recycling costs. The interest in repair-
ing or remanufacturing products is "increasing because the potential profits
from these smaller loops will be the most 'value-adding' way to discharge ex-
tended producer responsibility" (King & Burges, 2005).

A way to estimate the sustainability in environmental terms is the ratio of recy-
cled/reused material compared to the total supply of virgin recycled/reused ma-
terial (King & Burges, 2005). The example of ASML's management of remanu-
facturing their products entails that most components are reused. This means
that the environmental impact from scrap from the used machines is reduced to
a minimum.
9.5.3 Possibilities and barriers

A prerequisite for most remanufacturable products is that they have a high value and relatively long service lives. An exception to this is single-use cameras and toner cartridges. Smaller appliances like electric shavers and hair dryers are almost never refurbished as they are inexpensive and their lifetime is only a few years (Nagler, 1999).

King and Burges (2005) point at four technical barriers to remanufacturing of electrical devices and electronic equipment: reverse logistics, disassembly, component inspection and customer demand.

Reverse logistic

Reverse logistic is about bringing the used appliances to the remanufacturing company. The problem with reverse logistics is the costs associated with transportation of the items, space requirements needed to store the returned products, the availability of the used products (many customers lack incentives to return the products as there is often little financial rewards), the identification and handling of returned products can be difficult as there is a huge variety of products being returned.

Disassembly

When the products are returned to a manufacturer for potential remanufacturing the products have to be disassembled. Many products are not designed for remanufacturing. Certain components may be designed to be removed by maintenance but the majority is not. The poor condition of the products can make it difficult to disassemble the products because they are damaged or corroded. Many products are produced in the Far East and assemble logic and sequence information is therefore not available to the remanufacturer. It can be a significant barrier if the remanufacturer has to disassemble a high number of products to learn the best sequence.

Component inspection

After the products have been disassembled, an audit of the quality of the products has to be made to assess which parts are suitable for remanufacturing. The remaining parts can be used for recycling or may be disposed of as scrap. This process can be a barrier to remanufacturing as many parts will not be remanufactured, and it can therefore be time consuming and costly to identify the parts suitable for remanufacturing. In order to assess whether a component is distorted or worn an original component has to be available, so that the used component can be compared with an original. Otherwise it might be difficult to evaluate the level of remanufacturing needed. The inspection of complex assemblies can be difficult, costly and time consuming. It is therefore necessary to develop efficient inspection procedures.

Customer demand

It is crucial to have a credible and stable demand for remanufactured products. If the remanufactured products do not represent the latest generation of technology, styling and functionality they may have difficulties in competing with new products. It can be difficult to persuade customers to buy cheaper old products if cheaper new products are available. Many customers associate remanufactured products with 'second hand' products of an inferior quality. It is difficult to change such an understanding of remanufactured products. Remanufacturing products can constitute a threat to some brands - both in terms of im-
age and sales. Such brands will therefore be reluctant to introduce remanufacturing of their products.

Remanufactured products can be divided into capital goods and consumer durable goods. The capital goods are often remanufactured as the products are expensive and have a long lifespan. The problem with remanufacturing of consumer goods is that the process costs of remanufacturing goods often exceed the price of new products (Giuntini & Gaudette; 2003).

Giuntini and Gaudette (2003) point at some further obstacles to remanufacturing: The salespeople are often not given an incentive to handle the sale of remanufactured products to the customer. The product marketing managers often do not put remanufactured products into their strategic selling plan, and remanufacturing is only performed on individual customer request. Remanufacturing of products can be difficult as the primarily supply of spare parts comes from the used products. Not until the used products are disassembled, inspected and tested is it known which parts can be reused and which have to be substituted. Further, the disassembling process, testing, inspection and to some extent reassembling require different skills and equipment than the original manufacturing process. A further barrier is the shortage of skilled technicians.

The designing of products on a platform basis is essential for manufacturing products that are easily remanufactured. The ASML case shows that a platform basis allows the company to convert systems that are no longer in use into working systems. The idea of platform-based designs is to develop a platform that is the base for a range of derivative products. Platform-based design is used for instance by Volkswagen, Black & Decker, Rolls-Royce Aero-engines and Nippondenso Meters. The challenge of designing such a platform is to find a balance between a high component-sharing strategy with limited variability and a high component variability strategy with limited sharing. The difference between the strategies is to what degree the design of the product makes it easier to produce with respect to reduced time, cost and stock levels, and to what degree the products are designed to increase market coverage and fit customer choice. It is difficult to include both (King & Burges, 2005).

### 9.6 Car-sharing

**Definition**

Car-sharing is a model of car rental where the car can be rented for a short period of time often per hour. Car-sharing can be defined as "sharing vehicle services amongst members, thereby giving them access to a fleet of vehicles" (Loose et al., 2006).

The kind of car-sharing dealt with here is formally organised by companies, clubs or associations. The organisation owns a fleet of vehicles that can be used through advance booking. In many Car-Sharing Organisations (CSOs) a membership is a prerequisite for participating. To become a member an entry deposit is paid. Moreover, on a monthly or yearly basis a membership fee is paid, and costs for use of the vehicles are based on amount of time the vehicle has been used and the mileage driven.
Background

Worldwide car-sharing has become increasingly popular within the last 20 years. In Europe car-sharing has reached a relatively large dissemination in Switzerland, Austria, Germany and Holland, and has some popularity in for instance Sweden, Denmark and Italy. In the US 18 car-sharing programmes have a total number of about 234,500 members sharing 5,261 cars and in Canada 13 car-sharing programmes involve about 33,900 members sharing 1,499 vehicles (data from January 2008) (http://www.carsharing.net). This corresponds to 0.08 % of the US population and 0.1 % of the Canadian population being members of a CSOs (http://www.census.gov; http://www.statcan.ca).

Car-sharing has had a large growth in Switzerland over the last 15-20 year, and Switzerland has become an international leader in organised car-sharing. In 2008, 1.03 % cent of the Swiss population was car-sharing customers (www.bfs.admin.ch, 2008; Peter Muheim, 2 May 2008) In 2008; in comparison 0.18 of the population in Austria were car-sharing customers (www.statistik.at, 2008; Mobility, 2008).

9.6.1 Business rationale

The advantage for the customer of car-sharing is to gain the flexibility of cars in terms of a means of transportation without having the costs and liabilities of owning a car. By having access to a fleet of vehicles the type of vehicle can be adjusted to match the customer's needs.

Using car-sharing is one means of transportation that should be combined with other kinds of transportation. The optimum means of transportation is chosen based on the degree of flexibility and distance to cover. Car-sharing can often with advantage be combined with public transportation. Many CSOs cooperate with public transportation providers, and many car stations (the places where the car is picked up and left) are located in connection with public transportation, i.e. next to railway stations.

To be an attractive alternative to private car ownership, the shared cars have to be easily accessible. The car stations have to be located near the customer’s residence and minimal effort should be used to book the vehicle or to check in and out.

Case: Mobility CarSharing Switzerland

Mobility CarSharing Switzerland\(^\text{27}\) is Europe’s largest CSO. Mobility was established in 1997 by merging the two Swiss CSOs ATG•AutoTeilet Genossenschaft (in English: CarSharing Cooperative) and ShareCom. Both cooperatives were originally founded in 1987 (Mobility, 2007). Mobility is based on providing means of environmentally sound personal transportation (Mobility's constitution, article 2) (Mobility, 1997). Of May 2008, the company has 79,000 customers sharing 2,000 vehicles located at 1,050 car stations in 400 cities and towns in Switzerland and Liechtenstein. Mobility offers car-sharing in all Swiss cities with 10,000 or more inhabitants and in many with less than

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\(^{27}\) Mobility CarSharing Switzerland is from hereon referred to as ‘Mobility’.
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10,000 inhabitants. 10% of the customers are business customers. Mobility is now the only CSO in Switzerland. Since the 1st of January 2008, the Mobility Cooperative and Wolfgang DENZEL AG are offering car-sharing in Austria in the Joint Venture “Denzel Mobility car sharing GmbH”, where 15,000 customers share 200 vehicles (Peter Muheim, 2 May 2008; Mobility, 2008).

Mobility’s fleet of vehicles range from micro cars with space for only 2 persons (e.g. Smart Passion) to minivans with space for 7 persons and large luggage compartments (e.g. Peugeot 807) and transporters (e.g. Mercedes Vito). The fleet includes 10 different types of cars, which gives the customer the opportunity to match the type of vehicle with her actual needs.

Membership

Mobility organises car-sharing for both private and business customers. Private customers can either subscribe for a basic membership or they can become cooperative members. The cooperative members pay CHF 1,000 for their cooperative share which they can recover if they leave the cooperative and a one-off administration fee of CHF 250. The basic membership customers pay for an annual subscription, where the fee is a maximum of CHF 290\(^{28}\). Business customers can choose between an array of products (Basic, Plus, Master and Exclusive), see figure 5.2. Depending on the kind of product, the business customers can get a higher degree of exclusive user rights to the vehicles. Basic, plus and master are types of car-sharing, whereas ‘exclusive’ entitles a firm to be the exclusive user of vehicles even with the firm’s own logo. Thereby ‘exclusive’ is, in addition to the sharing of Mobility’s vehicle fleet, more similar to ordinary car rental. But the reservation management and the whole car management is sourced out to Mobility.

The vehicles are booked by phone or internet. If the vehicle is free it can be booked directly before use. Each vehicle is fixed to a car station, where the vehicle has to be picked up and handed over. All vehicles are equipped with an on-board computer that registers the hours driven and the mileage covered. The customers are charged according to hours of use and mileage driven. The prices vary according to what kind of product the customer subscribes to, the time of day where the vehicle is used (it is cheaper to drive at night and more expensive for business customers to drive during weekends) and the mileage driven (a discount is given for each kilometre driven that exceeds the first 100 km).

Risk

The costs include fuel, insurance and maintenance - for instance the cleaning of the vehicles. The customer has an own risk of a maximum of CHF 2,500 per accident\(^{29}\) (www.mobility.ch).

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\(^{28}\) Mobility offers various reductions depending on membership of organisations that cooperate with Mobility, e.g. reductions are for instance given if the customers have an annual subscription for the Swiss Federal Railways (SBB).

\(^{29}\) By paying a fixed additional fee, the customers’ liability can be reduced to a maximum of CHF 300 per accident. The magnitude of the fee varies from CHF 125 to 375, depending on whether the customer is a private or business customer and whether the membership covers one or more persons. (www.mobility.ch)
The demand for shared cars peaks during weekends, and the size of the fleet of cars is designed to match the demand for transportation during the weekends. The capacity of cars is therefore too high during the working days. Business customers primarily use the vehicles on working days, which improve the overall efficiency of the system. The average private Mobility customer makes 16-17 annual trips with an average distance of 42 km per trip and the average business customer makes 33 yearly trips and covers an average distance of 55 km per trip (Haefeli et al., 2006; Peter Muheim, 2 May 2008).

During holidays the demand for car-sharing is above average and in summer the demand is higher than in winter. The vehicles are in the fleet for 3-4 years. The size of the vehicle fleet can be adjusted to changes in seasonal demand by selling the old vehicles in winter and purchasing new cars in the spring. Mobility cooperates with car rental companies (Avis/Hertz), where Mobility’s customers get lucrative offers on car rental. The car rental companies often have excess capacity at weekends and during holidays, where the demand for shared cars peaks. Customers that have a demand for high mileage or long rental periods can use these offers with advantage (Peter Muheim, 2 May 2008).

Mobility has a strong cooperation with 17 different public transport operators in Switzerland. The most comprehensive cooperation is with the Swiss Federal Railways (SBB). Mobility customers with an annual subscription for SBB get a discount on car-sharing. Mobility and SBB cooperate on a Click and Drive concept. Basically, the idea is that the train passengers have easy access to a car...
at all railway stations and car-sharers to trains. Mobility and SBB mutually advertise for the counterpart's products.

**Infrastructure**

The access to parking lots has been decisive for establishing the countrywide car-sharing organisation. Mobility is the single largest renter of parking lots from SBB. Nearly 900 parking lots at 320 railway stations are located next to the stations and are clearly visible. Official pictograms at the railway station signals where Mobility’s cars are situated. The visibility at the railway stations is an important source for Mobility to set focus on their concept.

There has been only little support to Mobility, which also has meant that there are no public parking lots reserved for car-sharing. All parking lots for Mobility’s fleet of vehicles are therefore privately rented. Many of the parking lots that are not located at railway stations are situated in backyards where they are not easily recognised (Peter Muheim, 2 May 2008).

The average distance in terms of time to nearest shared vehicle is 5-10 minutes for most Mobility customers. In larger cities such as Zürich, Mobility has vehicles dispersed in the city so the distance between the cars is within 500 meters.

When car-sharing was first launched in Switzerland in 1987, there were no experiences from other countries to draw upon. From the beginning the domestic car-sharing organisations cooperated, so it was possible for customers from one CSO to use the other CSO’s vehicles. In Germany there are around 100 CSOs but there is a low extent of cooperation and integration between the car-sharing providers. In Germany it is therefore often difficult for a member of one CSO to use another CSO's vehicles (Peter Muheim, 2 May 2008).

Public transportation in Switzerland is very well developed. Mobility’s fleet of vehicles is spread all over Switzerland and the customers can easily combine car-sharing with public transportation. There has proven to be a certain degree of maturity of the Swiss market for car-sharing. A relatively high number of the population has been willing to substitute the private ownership with shared use of cars (Peter Muheim, 2 May 2008).

Mobility Support AG offers help to start up car-sharing organisations; this covers everything from help in the initial phases to developing business plans and setting up complete systems with the newest car-sharing technologies. Last year Mobility developed the Mobility License System giving the licensee access to the know-how and system platform, to the Mobility brand, to hosting and operating services (i.e. billing and 24h call centre) and to the Mobility academy and support. This complete service package is first used by the Denzel Mobility CarSharing GmbH in Austria (Peter Muheim, 2 May 2008).

**Economic gain**

Mobility drives a sound economic business. In 2007 the company had a turnover on CHF 50.6 million (Mobility, Geschäftsbericht 2007). The same year, the profits before interests and taxes were CHF 1.07 million (Mobility, 2008b).
The customers' savings by using car-sharing depend highly on the demand for transportation in terms of means of transportation and mileage. According to a Swiss investigation of the economic savings of car-sharing, a “typical” CSO customer that uses public transportation for 75 % of the trips and car-sharing for the remaining 25 % could, depending on the yearly distance covered, make yearly savings in the amount of € 3,114 to € 1,552 (Jacobsson, 2002).

Mobility’s model of car-sharing has proven to be economically feasible for both Mobility and their customers. In terms of mobility the advantage to the customer is a high degree of flexibility without having the liabilities and costs connected with private car-ownership.

The major environmental improvement achieved by the Swiss car-sharing model is a change of the car-sharing customers' mobility pattern. The car-sharing customers increase their usages of more environmentally sustainable transportation systems, i.e. public transportation, walking and biking, after joining the CSO.

CSOs in Denmark

In Denmark all CSOs except Hertz Car-sharing (Hertz Delebilen) are non-profit organisations. These CSOs are based on ideological roots, where the purpose of establishing car-sharing is primarily to reduce car transportation in cramped inner-cities and to gain environmental advantages (Villads Hansen, 8 May 2008). The nine largest CSOs are members of the Danish umbrella organisation for CSOs Danish Car-sharing (Danske Delebiler). On January 2008, these CSOs had 227 cars and a total number of 5,037 members. This corresponds to 0.09 % of the Danish population. Hertz Car-sharing is the single largest provider of shared cars in Denmark with 102 cars and 3,900 members (Statistics of shared cars, 2008; www.danmarksstatistik.dk). The CSOs are located within Greater Copenhagen and in some of the largest Danish provincial towns were the population density is high. The first Danish CSOs emerged in the late 1990s, and Copenhagen Car-sharing (CCS) was founded in 2004. CCS has a fleet of 49 vehicles and about 600 members.

There are three CSOs located in Copenhagen. The Copenhagen municipalities support the CSO by providing special parking lots reserved only for shared cars. Each of the Copenhagen CSOs has been allotted a number of these parking lots. The parking lots are, however, not reserved for specific cars, but a gentleman agreement between the CSOs states that the parking lots should not be used by other shared cars. The CSOs try to get these special parking lots located next to city train stations and bus terminals. The Copenhagen municipality, moreover, supports CSO by giving very cheap parking permits to the shared cars. The Danish non-profit CSOs have set up a cooperation that allows the members to use the other CSOs' vehicles. The cooperation is not effective yet, as a shared booking system is being developed at present (Villads Hansen, 8 May 2008).

30 The municipalities of Copenhagen and Frederiksberg.
31 2/3 of CCS's vehicle fleet is located at these 'car stations'. The last third of the vehicles also have car stations, but are parked at normal parking lots.
Innovative Business Models with Environmental Benefits

Car-sharing has been in place in Switzerland for a far longer period than in Denmark, and this may to some extent explain the differences in the share of the population using the system. Increased cooperation with the public transportation providers would be beneficial for the Danish CSOs. In Copenhagen there has been a certain degree of cooperation between the CSOs and MOVIA, a public transportation provider. MOVIA has advertised for the CSOs and the CSOs on their side have offered a discount for new customers. A more formal and integrated cooperation with public transportation providers would help the CSOs to establish themselves as an alternative to private car ownership. The taxes on Danish cars are very high and a tax reduction on shared cars would make car-sharing cheaper, which would be a strong incentive to join the CSOs. The Copenhagen system with special parking lots reserved only for shared cars could be improved, if the parking lots were more unambiguously accentuated as special parking lots. At present, it is a large problem that non-shared cars are parked on these special parking lots. A clearer marking of the parking lots would also help to put more focus on car-sharing. The upcoming cooperation between the Danish non-profit CSOs allows their customers to use shared cars in various Danish regions. This will be an advantage for the flexibility of using shared cars (Villads Hansen, 8 May 2008).

9.6.2 Environmental case

In 1998 Peter Muheim made an evaluation of the environmental advantage of car-sharing in Switzerland and in 2006 the Swiss Federal Office of Energy (SFOE) made an evaluation of the environmental advantage from Mobility’s car-sharing. The later study was based on interviews with private customers in 520 households (constituting a total of 1,404 persons) and business customers (a total of 144 companies).

In a study conducted for Oikos Sustainability Case Writing Competition from 2003, Dr. Kai Hockerts identifies two ways in which car-sharing leads directly to increased efficiency in car use.

First, by reducing the number of cars, the need for parking lots is reduced. This is especially an advantage in cramped inner-cities. Mobility serves 77,000 customers with 2,000 cars which gives a ratio of 38.5 customers per car. In 2002, 2.2 Swiss citizens shared a car. Taking into consideration that some Mobility customers live in households with private cars the ratio of users per car was in 2002 estimated to 1 to 11. The average shared car in Switzerland in 2002 was thus shared by a factor 5 compared to privately owned cars (Hockerts, 2003).

Secondly, by choosing the most efficient vehicle type, car-sharing constitutes a more energy efficient alternative to private car ownership. Mobility’s fleet of vehicles is more environmentally friendly than the average for new cars in Switzerland. The average fuel consumption for Mobility’s vehicles is 7.19 litre per 100 km compared to an average of 7.62 for new vehicles in Switzerland. According to Mobility’s fleet specifications from the manufactures the fuel consumption is 6.8 litre per 100 km. 7.2 litre per 100 km reflects the actual fuel consumption. The 7.62 litre per 100 km is the average of new vehicles in Switzerland according to the manufactur-
According to Mobility’s own figures the result of their car-sharing is yearly savings of 520,000 litres of fuel and a reduction of 1,458 ton CO₂ (www.mobility.ch). In 2005, the fuel consumption of Mobility’s vehicles was 25 % lower than the average for all Swiss cars (Haefeli et al., 2006). The performance in terms of fuel consumption per mileage has been quite constant since the Swiss CSOs started at the end of the 1980s (Peter Muheim, 2 May 2008). As fuel consumption is included in Mobility’s prices, Mobility has a strong incentive to optimize the energy efficiency of its fleet of vehicles. The fleet includes hybrid cars and natural gas fuel cars. Mobility has experimented with using electric cars. The use of electric cars have, however, turned out not to be feasible, as there are unsolved problems with respect to limited range and recharging of batteries (Peter Muheim, 2 May 2008).

A third direct advantage of car-sharing is the need for a smaller production of cars. A study of the energy consumption of cars in terms of life cycle analysis shows, however, that by far the largest energy consumption is connected with the operation of the vehicle. A calculation of the energy spent by driving 150,000 km in a car shows that 10 % of the energy is used for manufacturing the car, 10 % on refining the fuel and 80 % on fuel consumption (Jacobsson, 2002).

The largest environmental benefits from car-sharing are achieved indirectly through shifts in the car-sharing users’ mobility patterns. In the study from 1998, Peter Muheim compared the mobility patterns of car-sharing customers with persons that did not use car-sharing. The study showed that private car owners used their car as the preferred means of transportation (Muheim, 1998). Car owners tend to evaluate the costs of public transportation against the variable costs of using their car, i.e. the fuel costs, and not the total costs (Hockerts, 2003). Car-sharers were far more liable to combine the use of a car with public transportation (Muheim, 1998). The SFOE study from 2006 showed that 73 % of the interviewed households owned “a General Pass for the Swiss Federal Railways, an annual subscription with the Swiss Federal Railways for a specific route, or an annual ticket for the services of a regional public transport operator” (Haefeli et al., 2006). Furthermore, it was concluded that the households reduce car ownership after joining Mobility. Mobility’s customers did not change their total demand for transportation in terms of kilometre travelled. In contrast to private customers, business customers did not decrease the mileage driven by car after joining Mobility and there was no change in person-kilometres travelled by public transportation (Haefeli et al., 2006).

The SFOE study estimates the total annual energy savings from Mobility’s private customers in 2005 to 78.4 TJ (terajoules), which equals approximately 2.5 million litre of gasoline. The energy savings corresponded to a reduction of 290 kg CO₂ emission per active car-sharing customer. For business customers the energy savings are estimated in the range from 3.0 to 28.4 TJ per year (Haefeli et al., 2006).

ers’ specifications, the actual fuel consumption might therefore be even higher for the average new Swiss car. (Peter Muheim, 2 May 2008).
The potential for car-sharing customers in Switzerland is estimated to 500,000 persons. This potential can only be achieved in partnership with the public transportation system, and a growth rate of 2-3 % is seen as realistic (Haefeli et al., 2006).

### 9.6.3 Possibilities and barriers

**Possibilities**

In Switzerland over 1 % of the population is a member of Mobility. The potential for car-sharing in Switzerland is estimated at 0.5 million persons (Haefeli et al., 2006). This corresponds to approximately 6.7 % of the Swiss population. 1 % of the EU27 population is approximately 5 million people. Assuming that a similar percentage of the population in the EU27 is a potential for membership of a car-sharing organisation, the car-sharing potential is 33 million EU citizens. (http://www.eurostat.ec.europa.eu). This number is properly a far too high estimate as not al EU countries have as well developed a public transportation system as Switzerland.

In a study of German CSOs from 2004 the potential for car-sharing was estimated at 1.1-1.4 million customers. In a similar study from 1994 the potential was then estimated to 2.45 million. The 2004 study raised the question why only 70,000 persons had joined German CSOs at that time.

**Barriers**

The German study showed that:

- The respondents had an insufficient understanding of what the concept of car-sharing was.
- The majority of the respondents were unaware of the presence of local car-sharing offers.
- The majority of respondents saw car-sharing as an innovative service but very few could imagine using car-sharing themselves.
- 75 % of the respondents would prefer to use their own car instead of sharing a car with others. Changing people's attitude towards private car-ownership is the largest barrier to car-sharing.
- 75 % of the participants stated that they were the main user of a car and had access to a car at any time.
- 88 % of the respondents stated that they used a car on a daily basis or several times every week. On the other hand, the share of the respondents that used public transportation or biked was low (26 % for bicycles and 24 % for public transportation).

33 1,000 German-speaking residents above the age of 18 took part in the study. The participants were representative for the population in cities with 20,000 inhabitants or more. 100 German CSOs were invited to take part in the study, 65 of these answered the questionnaire (Loose et al., 2006).
• Only 5% of the respondents were willing to use a car-sharing offer (Loose et al., 2006).

For some persons the personal status of owning a car is very important, and they are not easily targeted by car-sharing. Car-sharing has to be a convenient alternative to private car ownership. The cars have to be easily accessible which constitutes a problem in areas that are sparsely populated. The Swiss model does not allow for customers to pick up the vehicle in one location and deliver it elsewhere. The logistic challenge would be immense, as the vehicles would have to be redistributed eventually.

Lack of public support has been a challenge to developing car-sharing in Switzerland, where especially the lack of parking lots has been a barrier. Mobility has, however, succeeded in providing the necessary parking lots from private stakeholders.

The major obstacle to further development of car-sharing in Switzerland is to stand out as an alternative to private car-ownership. A prerequisite is to become more visible and Mobility is therefore going to launch a commercial campaign on national TV (Peter Muheim, 2 May 2008).

Loose et al. (2006) recommend that CSO gets a better profile and becomes more known to the public. CSOs have to be more aware of their potential customers and they have to adapt better to the needs of business customers in order to get them as customers. The technical application offered to the customers has to be easy to use. Setting up alliances between CSOs will help them grow.

In a study from 2002, Jacobsson investigated constraints to further development of car-sharing in Sweden. He concluded that lack of cooperation with public transportation operators was a big problem. There was a lack of understanding of car-sharing among various actors and there needed to be a change in the mindset of key actors. Moreover, there was a need for more support from the Swedish media to put emphasis on car-sharing as an alternative to private car-ownership (Jacobsson, 2002).
10 Case catalogue

<table>
<thead>
<tr>
<th>Name</th>
<th>Brief description</th>
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| **Product Service System (PSS)** | PSS = a pre-designed system of products, services, supporting infrastructures and necessary networks that:  
- fulfil a consumer's needs on the market  
- have a smaller environmental impact than separate product and services with the same function fulfilment  
- are self learning |
| PSS | Carpet producers sell a carpet-service. The carpet is sold with maintenance of the carpet, i.e. the cleaning with special products and the replacement of damaged parts of the carpet. After 2-3 years the producer takes the carpet back and takes care of reuse/end disposal. Environmental benefit is a more efficient maintenance and end disposal. |
| PSS | Computer manufactures sell a computer service instead of a product. The manufacture takes the old computers back. Computer parts are primarily reused - secondarily recycled. This has implication for the design of computers where parts shall be reusable. |
| PSS | Reallocation of furniture in buildings. Companies offer a furniture-service to companies. As all employees are not at work at the same time, companies can do with less furniture, if the use of the furniture is properly planned. |
| PSS | Rolls Royce has changed from selling an engine-product (engines for the aircraft industry) to selling engine power as output measured as power/hour. RR is now responsible for the maintenance of the engines. From a life-cycle perspective the largest environmental impacts are due to the operation of the engine, i.e. fuel consumption. Rolls Royce has an incentive to produce more efficient engines that use less fuel and fewer spare parts. This is the environmental potential of the product-service system. |
| PSS | Danfoss, a Danish producer of valves, has run an experiment with a product-service system. Instead of only selling valves for a cooling system, Danfoss sold cooling of refrigerators to Tesco (an English Department Store chain). The product was cooling to 3 degree Celsius. The energy savings was split between Danfoss and Tesco. Emerson has made similar experiences in making energy savings with remote monitoring equipment. |
| PSS | - eco-efficiency oriented leasing and renting services  
e.g. renting bridges instead of selling them to municipalities |
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<tr>
<td><strong>PSS</strong></td>
<td>Grundfos, a Danish producer of pumps, has changed from selling pumps to selling pumping-service, where the customer pays for amount of removed water.</td>
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<td><strong>Besch 2005</strong></td>
<td>The environmental problems associated with office furniture consumption call for a more efficient use of office furniture that can decrease emissions and volume of waste. The author discusses the opportunities and barriers for the implementation of a PSS for office furniture.</td>
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<tr>
<td><strong>PSS</strong></td>
<td>Sharing services from car sharing to laundries to libraries for books and tools etc. Here it depends a lot on the organization and design if they are successful and if they are sustainable.</td>
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<tr>
<td><strong>PSS</strong></td>
<td>Most radical and with highest sustainability potential (if well organized and designed) are result oriented services such as - Koppert pest management in NL, where the companies sell pest free fields instead of selling pesticides.</td>
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<tr>
<td><strong>Performance-based Pest Management Services (PSS)</strong></td>
<td>A pest management services provider commits to achieve a certain standard or level of pest control, instead of being compensated for a particular treatment or application. Thus, the pest provider has an incentive to reduce the amount of used pesticides, as pesticides become a cost of service provision rather than a source of profit.</td>
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<tr>
<td><strong>Electrolux, Sweden - functional sales of washing (PSS)</strong></td>
<td>This is pilot project called Pay-per-Wash, at the Gotland Island in Sweden. The island was chosen because it was the only place in the world at that time with intelligent electrical meters installed in 7000 households, which allows for remote reading. The pilot was introduced into 50 households on the island. Instead of charging customers to buy a washing machine, the customer borrows a new washing machine for and pays SEK 495 as a fee to Electrolux that covers the cost of installation. In return customers are provided with Electrolux’s ‘intelligent’ energy efficient washing machine. The washing machine connects to a household electricity meter that is connected via the Internet to a central database that tracks the energy consumption of the product. Customers pay for the function of washing alone. (<a href="http://www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
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<tr>
<td><strong>Gispen, The Netherlands - furniture services (PSS)</strong></td>
<td>Gispen is a designer and producer of Office furnishings. Gispen provides a leasing package to its customers. It also provides a consultancy service for product specification in specific situations. Once the furniture is installed they also assist the customer in moving, updating and reconfiguring the office furniture for new office plans. They become a partner and facility manager for the customer. (<a href="http://www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
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<tr>
<td><strong>Videoconferencing systems (PSS)</strong></td>
<td>Videoconferencing provides a voice and video link between geographically separated parties, allowing “virtual” meetings. Videoconferencing systems require both equipment (products) and transmission bandwidth (service), but the service and product are often provided by unrelated vendors (For example, internet video calls). High-end video conference services are usually different; product and service are closely linked. For example, in December 2006, Hewlett Packard (HP) announced the Halo videoconferencing system, which utilizes specially constructed videoconferencing rooms, life-size high resolution video, and other features. The system en-</td>
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Innovative Business Models with Environmental Benefits

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<tr>
<th>Business Model</th>
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<tr>
<td>Millicare, USA – carpet maintenance (PSS)</td>
<td>Millicare started out as a cleaning system and developed an environmental services system for office carpets and business clients. They also offer maintenance services for carpets for reconditioning and reinstalling old carpet in other areas. (<a href="http://www.cfds.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfds.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
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<tr>
<td>Mobility, Switzerland - car sharing (PSS)</td>
<td>Car-sharing provide the user with a clear cost per unit price for a mobility service. The car itself is the product and mobility the service. Car sharing offers a more efficient use of cars compared to individual ownership. Car sharing differs from car rental by offering car mobility for a short time period - from 15 min. to a few hours. Car sharing is common in a range of countries, i.e. Switzerland, Germany, Holland, Spain, Sweden, Denmark, etc. (<a href="http://www.cfds.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfds.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
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<td>StatAuto, Germany – car sharing (PSS)</td>
<td>This is another car-sharing scheme based in Berlin that employs the membership system. It has signed up over 200 corporate customers through a discount scheme in order to help profits and improve the car range available to its traditional base of weekend drivers. (<a href="http://www.cfds.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfds.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
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<tr>
<td>Xerox International – photocopy re-manufacturing (PSS)</td>
<td>Xerox Corporation originally only produced photocopiers, but has developed into a document company. They now offer a range of services including document translation, software, consulting services and outsourcing services. They also have developed their asset management programme, where products are sold or leased under contract, guaranteeing customer satisfaction through functioning machines as a fixed price per copy. Products and processes are designed for re-manufacturing. (<a href="http://www.cfds.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfds.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
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<td>Electric car battery unit (a kind of PSS)</td>
<td>Instead of selling battery units to electric cars, a new business model has been developed, where the battery belongs to a energy provider. The customer then buys the output charged battery with a maintenance agreement. The model is used in a Norwegian model, where the battery unit for the car model “Think City” is rented on a monthly basis. Shai Agassi an Israeli businessman has developed a similar concept, where the battery units for electric cars are rented instead of bought. His company recharges the battery units with cheap excess power e.g. from wind turbines.</td>
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<td>Cradle-to-cradle (a kind of PSS)</td>
<td>Ecologically intelligent design. Book from 2002. System of life-cycle development. Nature inspired design principles. Description (<a href="http://en.wikipedia.org/wiki/Cradle_to_Cradle">http://en.wikipedia.org/wiki/Cradle_to_Cradle</a>) Cradle to Cradle is a phrase coined by Walter R. Stahel in the 1970s and popularized by William McDonough and Michael Braungart in their 2002 book Cradle to Cradle: Remaking the Way We Make Things. This framework seeks to create production techniques that are not just efficient but are essentially waste free. In cradle to cradle production all material inputs and outputs are seen either as technical or biological nutrients. Technical nutrients can be recycled or reused with no loss of quality and biological nutrients composted or consumed. By contrast cradle to grave refers to a com-</td>
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<td>The idea of remanufacturing is about restoration and resale of used products. The remanufacturing may be done by the original manufacturer (closed loop) or a third party (open loop). The idea is that refurbishing may be cheaper than creating new products from scratch. Remanufacturing is pointed out as an area of high environmental potential in USA. The savings are often passed down to the customer that can acquire products at a much lower price than the price of a similar new product. (Stoughton et al. 2007 - draft paper).</td>
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<td>Resource Management is a performance-based approach to waste management. It is built on innovative contractual partnership between waste-generating organizations and a qualified waste contractor that changes &quot;business as usual&quot; compensation structures and supports and incentivizes waste minimization and recycling. Resource Management is based on 3 premises: 1) significant cost-effective opportunities to reduce waste and boost recycling. 2) Contractors will use the opportunities if offered proper financial incentives. 3) Significant financial incentives to the contractor can be financed from the savings generated through cost-effective improvements to a waste producer's current waste/recycling system (Stoughton et al. 2007 - draft paper).</td>
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<td>&quot;Recycle Bank&quot; a recycling company that partners with local governments in USA to operate municipal solid waste recycling programs in communities does employ the sharing of cost savings in some of their contract operations. (<a href="http://www.recyclebank.com/">http://www.recyclebank.com/</a>)</td>
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<td>Sten &amp; Metal - company in Göteborg (Sweden) - cooperate with among other hospitals about recycling waste, after a win-win model.</td>
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<td>Revalorisation Services in the German Automobile Industry. The secondary car part network operated by Renet works as a virtual interface between different branches and sectors (see Figure F.1). The second-hand automobile components are &quot;produced&quot; by the car recycling industry collecting and dismantling scrap and accident vehicles. Renet serves as a kind of &quot;prolongation of their counter&quot; by re-marketing the used and refurbished components preponderantly to the professional and (to a smaller extent) private vehicle repair sector and also into the automotive aftermarket where car parts dealers start to expand their ranges towards secondary parts. Simultaneously, automobile industry plays a triple role by supplying increasingly reliable cars requiring less repair and maintenance, by profiting considerably from sale of car parts through their dealership workshops and, finally, by increasingly entering the large-volume automotive repair sector (Zaring (ed.) 2001).</td>
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<td>Third-party logistics (3PL), also referred to as logistics outsourcing or contract logistics, focuses on improving resource utilization and process efficiency in order to reduce costs and improve service. PL providers deliver comprehensive logistics-related services, including delivery, storage, inventory, customer service, cargo handling, supply/distribution information systems, etc. 3PL providers are usually not specifically focused on improving environmental performance, but on improving logistics efficiency. Reductions in environmental loads are often achieved as by-products of the effi-</td>
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<tr>
<td>Chemical management services (CMS)</td>
<td>Chemical Management Services (CMS), an application of Product Service Systems (PSS) in the chemical sector, attempts to optimise the chemical consumption patterns. CMS works by changing the fundamental relationship between chemical suppliers and chemical customers and providing incentives to both sides to reduce the quantity of chemicals used. CMS is gaining increasing popularity as a tool for cost savings and reducing the chemical load on the environment. CMS has a high penetration in USA, especially in the automobile and semiconductor industry but the extent till which it is being used in Europe is still not well established (Pranshu, 2004).</td>
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<tr>
<td>Chemical Strategies Partnership (CMS)</td>
<td>The Chemical Strategies Partnership (CSP) seeks to reduce chemical use, waste, risks, and cost through the transformation of the chemical supply chain by redefining the way chemicals are used and sold. CSP works with manufacturing companies to help redefine the way they purchase and manage their chemicals. In this new model, manufacturers shift away from a traditional supplier relationship to a strategic alliance with a chemical service provider. Instead of purchasing chemicals, the manufacturer purchases chemical services: assistance in purchasing, managing, and tracking chemicals. This shift to chemical services directly aligns the incentives of the service provider and manufacturer to reduce chemical use and costs (<a href="http://www.chemicalstrategies.org">www.chemicalstrategies.org</a>).</td>
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<td>Mont et al. 2006 provides in an article an overview of the existing advantages and barriers for CMS providers and customers in the European context, identifies conflicts of interest between them, and highlights important lessons regarding the role of CMS in shaping these markets. It reports on findings from interviews with European chemical producers and other stakeholders of chemical management services and is directed toward industry professionals interested in chemical management services.</td>
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<tr>
<td>CMS</td>
<td>DuPont is a paint producer. DuPont used to sell paint to Fort. Now DuPont are selling coating of the cars, where they are paid per coated car. The coating has to fulfill certain quality standards regarding thickness of paint etc. DuPont therefore has an interest in reducing the consumption of paint. The consumption of paint is regulated through development of new paint technology, through more efficient technology, e.g. valves that spray the paint in a more efficient way, and through avoiding spills and coating errors. The result is improved environmental performance in terms of lowering the resource consumption.</td>
</tr>
<tr>
<td>Ashland Inc, USA (CMS)</td>
<td>Ashland Inc is a Chemical company that is a supplier of both specialty chemicals and the distribution processes for those chemicals. Ashland has developed an entire management service programme around procurement, use training, regulatory compliance, waste management, disposal/recycling and energy services. This service package helps the customer in reducing operating costs, as well as better managing risk. Contractual arrangements with customers allow for unit pricing structures, reducing chemical use and keeping the management of materials with the supplier.</td>
</tr>
<tr>
<td>Company</td>
<td>Description</td>
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<td>-------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Castrol Inc, North America</td>
<td>Castrol is a supplier of professional lubricants and associated services. They offer lubricant service packages that provide the customer with more than just the product. These include needs assessment, site surveys, analysing costs and productivity indicators, training, and performance assessment for opportunities in reducing lubricant consumption. They develop profit from cost savings given to customer, rather than just the volume of chemicals they sell. (<a href="http://www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
</tr>
<tr>
<td>Dow Chemicals and SafeChem,</td>
<td>Dow chemicals developed the Safetainer system in response to German regulations on the handling of chlorinated solvents (required Chemicals manufacturers to limit evaporation and make take-back obligatory for these solvents). SafeChem, a Dow subsidiary in Germany, developed has developed a closed loop system of delivery and take-back of the used solvents using Safetainers, to recycle the solvents back to customers. (<a href="http://www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
</tr>
<tr>
<td>Germany – CMS</td>
<td></td>
</tr>
<tr>
<td>DuPont, USA – carpet leasing</td>
<td>DuPont manufactures carpets and fibres. It has introduced a product-service solution by leasing carpets to consumers. It also offers a service package for maintenance and carpet cleaning. They recycle old carpets through a carpet reclamation scheme. (<a href="http://www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
</tr>
<tr>
<td>CMS</td>
<td>CMS Volvo has changed from painting their cars them self to let the paint-producers make the painting. Volvo then pays per painted car. This implies environmental savings.</td>
</tr>
<tr>
<td>ESCO</td>
<td>Energy Service Companies (ESCO) are companies providing energy services to final energy users, including the supply and installation of energy-efficient equipment, the supply of energy, and/or building refurbishment, maintenance and operation, facility management, and the supply of energy (including heat) (Bertoldi, 2005).</td>
</tr>
<tr>
<td>ESCO</td>
<td>In providing the service Vattenfall takes over the responsibility for the customer's functional need of heating, cooling, climate control, compressed air or electricity. The necessary fuel or its equivalent (concerning heating), financing and maintenance of the equipment are the components needed for the service innovation are also provided by Vattenfall. The customer buys the function, and does not need to be concerned about anything concerning the necessary equipment, its maintenance, environmental issues, new investments etc. Instead the idea is that the customer can then focus on its core business. Each service contract is unique, and is elaborated in co-operation with the customers according to their needs and wishes. In the pre-contract phase expertise is needed to estimate investments and to make an appropriate offer to the customer. If new equipment is needed to provide the service, project management is of vital importance. Vattenfall has an customer management organisation, which is responsible for the delivery to the customer, and a maintenance organisation that maintains the equipment physically (Zaring (ed.) 2001).</td>
</tr>
<tr>
<td>ESCO</td>
<td>Scottish Power has installed an energy management system for Barnet Borough Council. This scheme went operational in December 1997. It involved a £400,000 upgrade to an existing district heating scheme in the London suburb of</td>
</tr>
</tbody>
</table>
Hendon. The scheme serves over 1,000 homes as well as community buildings such as schools, libraries and swimming pools with around 1000kW of thermal and 60kW of electrical power. The upgrade involved installation by Scottish Power of a new 800kW gas-fired CHP unit, which has replaced an older oil/gas boiler (which was supplemented by costly electricity from the grid). The Council originally approached the company with a view to installing a small, supplementary, CHP unit to eliminate the need for particularly expensive electricity in peak periods. However, Scottish Power suggested installation of a larger unit to replace both the existing boiler and electricity purchases, and also generate surplus electricity for sale to the grid. They also offered to provide project financing, in the form of loans and a government grant of £85,000 (distributed by the Combined Heat and Power Association). This was accepted and a 10-year contract was signed between the parties. This guarantees Barnet at least 90% availability from the unit at a price which compares favourably with the costs of self-generation. The council also receives a proportion of the revenues from export of electricity to the grid. The new unit is also more than twice as efficient in terms of energy generation as the plant it replaced, resulting in a reduction of approximately 1,500 tons per annum of carbon dioxide emissions (Zaring (ed.) 2001).

| TAC/Middelfart (ESCO) | Middelfart Municipality has made a contract with TAC an (ESCO) about setting up a energy savings systems for the municipality's buildings (ca. 100 buildings with a total of 170,000 m2. The contract includes primarily heat and energy (and partially water). The project entails DKK 35-30 mill. investments in new technology and the setting up of an energy management system with external monitoring. The project should lead to savings within a time frame of 7 years. The ESCO has 2 years to demonstrate that savings take place. It is a no-cure-no-pay agreement. The economic gain from the savings will be split between the municipality and the ESCO. During the spring 2008 the ESCO will finish its investigations of the potential savings. Hereafter the ESCO has 4 years to install the needed technical solutions. The municipality became aware of the project from the municipalities of Örebro, Sweden, where TAC has set up a similar successful project. Middelfart is the first Danish municipality to set up contractual arrangement with an ESCO for energy management of most of its buildings. The project is closely followed by other Danish municipalities. |
| ESCO Modstrøm | Modstrøm: a new power provider on the Danish energy market that assist costumer with counselling about energy savings. |
| Eastern Energy, UK – ESCO | Eastern Energy is one of the energy service providers in the UK that provide more than just energy to their customers. They have a business development team that offer services to their business customers that help in monitoring and saving energy. Services include sub-metering, energy management data through load consumption and profiling, process monitoring, as well as training in utility awareness and post training facilitation. (www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html) |
| ESCO Berliner Energiagentur | Berliner Energiagentur has participated in a range of projects in Berlin. One example is an energy management system set up for Bartel & Sohn. The company Bartel & Sohn (a glass machining company with about 100 employees) assigned Berliner Energieagentur GmbH the heat supply and |
the introduction of an energy management system. The installation of the energy management system is intended to reduce the energy demand and is composed of the central electronic energy input control system, partially in connection with the production facilities. Economisation potentials are analysed and evaluated. Furthermore, measures to reduce the demand of compressed air and effluents are implemented.

- supplied total area: ca. 10,000 m²
- natural gas condensing boiler unit: 200 kWh
- restoration of the existing oil boiler: 800 kWh
- commencement of supply: 2004

Berliner Energieagentur participates in the resulting savings. www.berliner-e-agentur.de

### Deconstruction (PPS)

Deconstruction is a concept for selective dismantling or removal of materials from building before or instead of demolition. The idea is to reuse as much of old buildings as possible. The concept is evaluated as having a high potential of environmental improvements in USA. In the US 'business as usual' (BAU) is a low degree of reuse/recycle of materials from old buildings. In many cases deconstruction is an economically viable option, as it often is cheaper to dismantle a building and selling the salvaged materials than it is to demolish the building and pay for the disposal of wreckage. Companies are specializing in offering deconstruction services.

### Industrial Symbiosis - (IS) Kalundborg

A symbiotic relationship between to or more companies where waste products from one company are either disposed of for free to the other company(ies) or bought on marked terms. In case of the industrial symbioses in Kalundborg, Denmark, there are seven firms involved in the project and 20 different projects. This symbiosis has had significant environmental as well as business benefits (www.symbiosis.dk).

### IS - Avedøreværket (Christian Hansen). Alternatively TEP/COWI

Example of Industrial symbiosis in Avedøre, Denmark.

### IS


### IS

Examples of Industrial Symbiosis:
Austrian province of Styria, the Ruhr region of Germany, the Jyväskyla region of Finland and the petrochemical complexes of Los Angeles, Houston and Sarnia (Canada). Desrochers (2002).

### IS

Cases of Industrial Symbiosis in England. Mirata (2004) reviews the factors influencing the development and sustained operation of regional industrial symbiosis (IS) networks and discusses the roles a coordination body can play to alter these factors so as to catalyse the development and functioning of such networks.

### Green Supply

Is a concept, where a company controls the performance of companies up-
<table>
<thead>
<tr>
<th><strong>Chain Management</strong></th>
<th>or downstream to improve in an environmentally friendly way. This concept is relevant when the environmental improvements are followed by economic savings.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Green Supply Chain Management</strong></td>
<td>Applied in some of the companies of the Nordic Partnership. Hartmann, Coloplast, Novozymes and Flygt have succeeded in putting pressure on their suppliers to produce more environmentally friendly. The suppliers have gained from this economically by getting long-term contracts.</td>
</tr>
<tr>
<td><strong>Eco-efficient Services (ESS)</strong></td>
<td>All kinds of commercial market that offers aiming at fulfilling customers needs by selling the utilisation of a product (system) instead of providing just the product. ESS are services, relating to any kind of product, in which some of the property rights are kept by the producer. An eco-efficient producer service is one which improves the eco-efficiency of customer activities. This can be done directly (by replacing an alternative product-service mix) or indirectly (by influencing customer activities to become more eco-efficient).</td>
</tr>
<tr>
<td><strong>Mobility care sharing</strong></td>
<td>This is very common in Switzerland but not Germany for instance. Probably depends on the public transport infrastructure.</td>
</tr>
<tr>
<td><strong>Business models for building-integrated solar energy</strong></td>
<td>«Solarsiedlung am Schlierberg» is an award-winning solar housing estate in the city of Freiburg im Breisgau (Germany). Rolf Disch, an architect with a longstanding experience in low-energy architecture, has driven the project through a 10-year period that started with the planning of the first buildings in 1997 and resulted in construction and completion of 50 single-family homes and a commercial building complex between 2000 and 2006. Today, 180 people are living in the solar housing estate, and the related commercial building provides office space for an additional 240 people. While low energy architecture has recently become more and more popular in various European countries, this project is unique in that the buildings generate more energy than they consume, which is why Rolf Disch has coined the term &quot;plus-energy houses&quot;. This has become possible by combining the latest insights about energy efficiency in buildings (such as high-performance transparent insulation, heat recovery) with replacing traditional roof structures by large-scale photovoltaic panels (Wüstenhagen, 2008).</td>
</tr>
<tr>
<td><strong>EPR (extended producer responsibility)</strong></td>
<td>Extended Producer Responsibility (EPR) is a strategy designed to promote the integration of environmental costs associated with products throughout their life cycles into the market price of the products (OECD 1999). Extended producer responsibility imposes accountability over the entire life cycle of products and packaging introduced on the market. This means that firms, which manufacture, import and/or sell products and packaging, are required to be financially or physically responsible for such products after their useful life. They must either take back spent products and manage them through reuse, recycling or in energy production, or delegate this responsibility to a third party, a so-called producer responsibility organization.</td>
</tr>
</tbody>
</table>
Innovative Business Models with Environmental Benefits

(PRO), which is paid by the producer for spent-product management. In this way, EPR shifts responsibility for waste from government to private industry, obliging producers, importers and/or sellers to internalise waste management costs in their product prices (Hanisch, 2000).

| PPPs (public-private partnerships) | Private finance, design, build, operation and maintenance of public infrastructure over a sustained period of time which ushers in new governance practices [currently awaiting examples from Building Schools for the Future (BSF)] |
| Exploitation of waste heat | LEGO and Billund Municipality concerning waste water. Joint project aimed at solving problems with getting rid of waste water in the area. |
| Win-Win transportation solutions | Win-Win transportation solutions help solve transportation problems by removing market distortions that encourage inefficient travel behaviour and help to increase consumer choice. These solutions are cost effective and technically feasible reforms based on market principles. |
| CSA (community supported agriculture) | Community supported production-consumption concepts where the consumers become co-designer and co-producer in the system. Especially available in the area of food/organic food production at the moment. Community supported agriculture (CSA) is a new idea in farming, one that has been gaining momentum since its introduction to the United States from Europe in the mid-1980s. The CSA concept originated in the 1960s in Switzerland and Japan, where consumers interested in safe food and farmers seeking stable markets for their crops joined together in economic partnerships (http://www.nal.usda.gov/afsic/pubs/csa/csadef.shtml). |
| Design offices | In the consulting business there are very interesting design offices coming up, that analyze where environmental problems are and design a solution for the existing problem, then approach the company/organization which has the problem and sells them the solution for license fees. After a period of high investments these consultancies then can live from license fees that are generated as long as the client companies apply their solutions. |
| Micro factory retailing (MFR) | With micro-factory retailing the terms of competition are changed. Rather than seeking to match the high-volume, low unit cost approach of traditional manufacturing and distribution, micro factory retailing (MFR) refutes that logic by placing small factories within the markets they serve - and so eliminates the distinction between production and retailing. Rather than having one large plant producing, say 250,000 cars per annum the MFR approach would involve 50 plants, each assembling 5,000 cars per annum (i.e. 250,000 in total). There would be no separate distribution channels or sales outlets: the factory is also the sales, maintenance, service and repair location. Power train components and other generic items could be centrally produced in conveniently located highly automated facilities for distribution to the decentralised assembly plants, thus benefiting from economies of scale. Ironically this would conform to the early Ford dictum of "Manufacturing near the source of supply and assembling near the point of distribution". |
| THE ECO-ROVER CONCEPT: AN ALTERNATIVE COMMUNITY | The eco-rover is a concept developed by Bill Tubbs, an entrepreneur based in Canada. In brief, his idea has two main elements:  
  - A fleet of cars is owned, operated and maintained by a third-party transport provider who serves a range of transportation needs in a community; |
Transportation Scheme

- The fleet uses existing vehicles (i.e. buys in used cars) that are continuously ‘refreshed’ in order to reduce and potentially eliminate depreciation.

New Climate Model (Dong and Novo)

A business model changes energy savings to new wind turbines. DONG - a Danish energy provider - cooperates with Novo - a Danish medical company. The economic gains provided by energy savings in Novo is used to build wind turbines in a new of shore wind turbine park ‘Horns Rev II’ established by DONG. Very significant levels of energy savings have been recorded.

Success History about Ecological Milk Production

Holm et al. (ed.) "Økologisk modernisering på dansk - Brud og bevægelser i miljøindsatsen", Frydenlund 2008. (see kap. 11, 13 og 14 for historierne om historien bag økologisk mælk og nye passive huse).

Success History about Passive Housing

Holm et al. (ed.) "Økologisk modernisering på dansk - Brud og bevægelser i miljøindsatsen", Frydenlund 2008. (see kap. 11, 13 og 14 for historierne om historien bag økologisk mælk og nye passive huse).

Just-in-time

Just-in-time (JIT) is a manufacturing and inventory management technique, initially developed by the Toyota Motor Corporation, which has been widely adopted around the world. It is often considered to be synonymous with lean production, and has been hailed for its efficiency, customer service, and cost savings. This paper seeks to inventory and analyze the environmental effects of switching from traditional management to JIT. After outlining the many environmental impacts, it further seeks to address the impacts from supplier transportation, which have not been extensively addressed by previous researchers (Nathan, 2007).

Cookson Group, UK – Specialist Engineering Leasing.

Cookson Group supplies engineering products for the steel, glass and ceramics sectors. One of its services is to rent refractory furnace liners to steel companies in order to help them avoid refractory disposal and stocking problems. They also provide consultancy to their customers in order to lower customer’s production costs with project management services. (www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html)

Greenstar Community Centre, USA – E-commerce Services

The Greenstar community centre is essentially a group of products that deliver e-commerce service capabilities to virtually any place within the world. The centre is a unified hardware system, which is highly portable. The community enclosure includes a segmented room enclosing a medical clinic with basic equipment and tele-medicine connections, a classroom, an e-commerce and computer workstation, all powered by a commercial-grade photo-voltaic solar power array, and connected to the Web through a satellite dish or digital cellular modem for high-speed telecommunications. The Greenstar Corporation works with a community to develop products of cultural value, and to translate that into market value using the community centre. (www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html)

Mobile Dishwashing, Germany

The German Federation for Environment and Nature Protection has been using a mobile dishwashing service system at outdoor festivals and mar-
<table>
<thead>
<tr>
<th>Business Model</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Innovative Business Models with Environmental Benefits</strong></td>
<td></td>
</tr>
<tr>
<td><strong>many – domestic services</strong></td>
<td>It reduces plastic waste by washing porcelain and stainless steel, using environmentally friendly cleaning products. (<a href="http://www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
</tr>
<tr>
<td><strong>Oce, The Netherlands – photocopier and printer re-manufacture</strong></td>
<td>Oce produces Photocopiers and Printers and has a commitment to the environment and eco-design and has been involved with various projects in the Netherlands. Oce design products for a long lifetime and since 1990 they have taken back their products with components re-used back into the market or recycled back into raw materials. (<a href="http://www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
</tr>
<tr>
<td><strong>Odin Organic Vegetables, Netherlands – subscription food</strong></td>
<td>Odin supplies a service of organically grown fruit and vegetables direct to consumers from Farmers. The consumer receives the produce by paying a fixed subscription fee. All produce is supplied to Odin by growers on a fixed price contract, without using third parties such as wholesalers or auctions. Odin also offers its growers advice on agricultural and horticultural matters by experts as part of the supply relationship. (<a href="http://www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
</tr>
<tr>
<td><strong>Philips Omnidiagnost – medical systems</strong></td>
<td>The OmniDiagnost is a Radiography and Fluoroscopy (RF) system designed for patient examinations within hospitals. Maintenance and further technical support for the system can be offered remotely and these functions are available through service contracts. Philips also offers full training in its operation under clinical conditions using purpose-built facilities. Philips also offers the option of leasing the product over purchasing. (<a href="http://www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
</tr>
<tr>
<td><strong>Renew Inc., USA – furniture re-manufacture</strong></td>
<td>Renew Inc. re-manufactures previously owned Steelcase® office furniture systems to “as new” condition employing environmentally responsible refinishing techniques. Renew offers four services programs that maximize the value of your existing furniture assets. These services programs can be used to purchase either remanufactured Renew or new Steelcase furniture. (<a href="http://www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
</tr>
<tr>
<td><strong>Wilkhahn, Germany - furniture services</strong></td>
<td>This company offers a range of furniture products to the consumer that environmentally design conscious. Products are made for easy repair and maintenance, disassembly and reuse. They also sell a maintenance subscription to the sold furniture. This service annually replaces parts of the furniture that are worn out. (<a href="http://www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html">www.cfsd.org.uk/events/tspd6/tspd6_3s_cases.html</a>)</td>
</tr>
<tr>
<td><strong>Osaka Eco town</strong></td>
<td>The program aims at creating a national scale model of a sound material-cycle society in Osaka metropolitan area. In order to reinvigorate industries in Osaka through vitalizing environmental businesses, the program includes the construction of innovative private recycling facilities on a vacant lot of demolished final disposal site combined with nature restoration.</td>
</tr>
<tr>
<td><strong>Saraya</strong></td>
<td>A cosmetics/detergent company, actively participating in several initiatives to improve the environment, hereunder The Kansai Sustainability Network (KSN) – an experimental facility that converts organic waste into charcoal for carbon sequestration, agriculture and commercial purposes. Since 2003, the KSN has been exploring this green technology as a means of offsetting the effects of greenhouse emissions.</td>
</tr>
<tr>
<td><strong>Metabolix</strong></td>
<td>Founded in 1992, Metabolix is an innovation-driven bioscience company providing sustainable, clean solutions to the world’s needs for plastics, fuels</td>
</tr>
</tbody>
</table>
Innovative Business Models with Environmental Benefits

| Solvay sustainable development | Solvay has changed radically in recent years, into a group focused on competitiveness, leadership and high added value activities, aimed at sustained and profitable growth and led by a passion for innovation. A range of initiatives to profit from environmental initiatives e.g. concerning eco-efficiency and reducing hazardous waste. |
| ECOVER | ECOVER built the world’s first ecological factory in Malle, Belgium. Today, Belgium’s Minister of Environmental Affairs and Pensions, Bruno Tobback, is opening ECOVER’s second ecological factory in France. The new factory is situated in Landacres Park, a business park that limits entry to companies showing respect for nature as an extremely important aspect of running their business. |
| Transportation Management Associations | Transportation Management Associations (TMAs) are non-profit, member-controlled organizations that provide transportation services in a particular area, such as a commercial district, mall, medical centre or industrial park. They are generally public-private partnerships, consisting primarily of area businesses with local government support. Transportation Management Coordinators (TMC) are professionals who work for TMAs or individual employers. TMAs provide an institutional framework for TDM Programs and services. They are usually more cost effective than programs managed by individual businesses. TMAs allow small employers to provide Commute Trip Reduction services comparable to those offered by large companies. They avoid problems that may be associated with government-run TDM programs, since they are controlled by members. Transportation Management Associations can provide a variety of services that encourage more efficient use of transportation and parking resources. (http://www.vtpi.org/tdm/tdm44.htm). |
| Product-life cycle management (and information tracking using smart embedded systems) | In the actual globally changing business environment, companies are seeking new ways of providing additional value to customers and gain a competitive edge over their competitors. Past initiatives aimed solely at product cost, quality, or time-to-market are no longer sufficient to gain market advantage. The focus today is on innovation: products that differentiate themselves from others while also being affordable, reliable, and early to market. Total management of the product lifecycle is critical to innovatively meet customer needs throughout its entire life cycle without driving up costs, sacrificing quality, or delaying product delivery. The ability of industry to provide such holistic products and supporting services is currently limited by the information gap in the products life cycle (i.e. the flow of information between the design/production phase and middle and end of life phase of the products life cycle). PROMISE (ed.: an EU-funded international research project) offers the following business proposition to the Product Lifecycle stakeholders: to create value by transforming information to knowledge at all phases of the product lifecycle and thus improve product and service quality, efficiency and sustainability. www.promise.no |
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http://www.bygningsenergi.dk/fundanemt/files/Delrapport_1_041007.pdf


Information, 13 June 2006 (Jens Holstien, DI)


Mobility (1997): Statuetten der Mobility Genossenschaft. www.mobility.ch


TAC (2008a): One page project summary sheet provided by TAC

Legislation
Directive 2006/32/EC of 5 April 2006, Chapter 1, Article 3, point 1. Directive on energy end-use efficiency and energy services


EC 1907/2006 European Community Regulation on chemicals and their safe use.

11.2 List of case interviews

<table>
<thead>
<tr>
<th>Company</th>
<th>Name and position</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novo Nordisk</td>
<td>Vibeke Burchard, project manager for the climate strategy</td>
<td>25 April 2008</td>
</tr>
<tr>
<td>ASML</td>
<td>Boudewijn Sluij, Director of Product Marketing</td>
<td>9 May 2008</td>
</tr>
</tbody>
</table>
11.3 Internet

<table>
<thead>
<tr>
<th>Host</th>
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<tbody>
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<td>ASML</td>
<td><a href="http://www.asml.com">http://www.asml.com</a></td>
<td>29 April 2008</td>
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<td>Canada's National Statistic Agency</td>
<td><a href="http://www.statcan.ca/English/edu/clock/population.htm">http://www.statcan.ca/English/edu/clock/population.htm</a></td>
<td>17 May 2008</td>
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<td>Dong Energy /Vattenfall</td>
<td><a href="http://www.hornsrev.dk/">http://www.hornsrev.dk/</a></td>
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<td>DR</td>
<td><a href="http://www.dr.dk/Regioner/Fyn/Nyheder/Middelfart/2008/04/29/074311.htm">http://www.dr.dk/Regioner/Fyn/Nyheder/Middelfart/2008/04/29/074311.htm</a></td>
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<td>Statistics Denmark</td>
<td><a href="http://www.danmarksstatistik.dk">www.danmarksstatistik.dk</a></td>
<td>17 May 2008</td>
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<td>Swiss Statistics</td>
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<td>TAC</td>
<td><a href="http://www.tac.com/dk/navigate?node=4610&amp;printfriendly=true">www.tac.com/dk/navigate?node=4610&amp;printfriendly=true</a></td>
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<td>Veolia</td>
<td><a href="http://www.veolia.com/">http://www.veolia.com/</a></td>
<td>5 May 2008</td>
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