Managing with the aim of sustainable development

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Abstract

Recycling and waste treatment solutions in the fine chemicals industry are described in this article. Conceptual strategy, facts and empirical conclusions are discussed. Data are provided both on the qualitative evolution of effluent quality and on the volumes and costs involved in an industrial-scale recycling solution. Recycling is clearly a key component of environmental protection, and a cost-effective one. Although recycling is fundamental to sustainable development, industry will only invest in it if raw material costs are high or are perceived to be rising.

Résumé

Cet article présente des solutions de recyclage et de traitement des déchets à l'oeuvre dans l'industrie chimique. L'examen, qui porte aussi bien sur les conceptions stratégiques que sur les faits et les résultats empiriques, cite des données relatives à l'évolution de la qualité des eaux usées, et chiffre les volumes et les coûts impliqués dans la mise en oeuvre d'une solution de recyclage à l'échelle industrielle. Il est désormais acquis que les techniques de recyclage sont un instrument privilégié - et rentable - pour la protection de l'environnement. Cependant, aujourd'hui encore, c'est moins le rôle capital qu'assume le recyclage dans le projet d'un développement durable que l'augmentation effective ou escomptée du prix des matières premières qui incite les entreprises à y investir.

Resumen

En este artículo se describen soluciones para el reciclado y el tratamiento de desechos en la industria de productos químicos refinados, y se explican la estrategia conceptual, los hechos y las conclusiones empíricas. Se proporcionan también datos, tanto sobre la evolución de la calidad de los vertidos, como sobre los volúmenes y costes que conlleva una solución medioambiental a escala industrial. El reciclado es sin duda un componente clave y rentable de la protección del medio ambiente. Sin embargo, a pesar de que el reciclado es fundamental para un desarrollo sostenible, la industria sólo invertirá en el reciclado si los costes de las materias primas son altos o si se espera que aumenten.

Hovione is a manufacturer of active ingredients for the pharmaceutical industry. Our chemical synthesis processes are developed in-house, and we supply the most highly regulated and quality conscious markets in the world. We have two plants, one located in Portugal and the other in Macao.

In the mid 1980s Hovione's Board of Directors felt that mere waste treatment was not a long-term solution. A fundamentally different approach was necessary if we were to aim towards sustainable development. In our industry the ratio of liquid process waste to final product is never less than a multiple of 10. These waste waters are often harmful to the environment (mostly organic solvents) but valuable (say, >$US 0.5/kg). Clearly the correct solution was a comprehensive recycling programme.

Within six years, this strategy was implemented into a successful industrial reality. Fully integrated recycling and waste treatment solutions were in operation in 1991.

The industrial realities of such an implementation are often ignored or misunderstood by many managers, legislators and pressure groups. Hovione's experience shows that the absence of certain mechanisms explains both the complacency and inability of industry to do better in terms of sustainable development. The second part of this article examines Hovione's results in the area of recycling economics and waste treatment options.

Industry's efforts on the environmental front are today geared towards waste treatment. The focus is on emissions. Why then did Hovione worry about reducing its raw material consumption?

Industrial waste problems have complex technological solutions that only R&D-rich companies can solve. These are mostly large companies in which ownership and management are today quite separate. The Boards of Directors of the billion-dollar companies must deliver competitive dividends to their shareholders (impersonal pension funds and insurance companies) or be sacked. They therefore maximize profits within a "level playing field" set by legislators who define environmental laws that are today essentially emission-based. There is no actual market mechanism to encourage management towards sustainable development.

In the case of Hovione, ownership and management are the same – most of the shares are owned by the employees. We do not have the excuse of anonymous shareholder pressure! On the contrary, a strong family business culture, a traditional role of community leader, and a sense of duty instil a feeling of wanting to do the right thing, not just the bare minimum imposed by law.

F1/F2 and the Greencycle Technologies

Hovione's strategy is based on two concepts:, F1/F2 and the Greencycle Technologies.

Technology can go some way towards reducing the volume of wastes in proportion to final product quantity. However, if process optimization has its limits, it is possible to develop technologies to recycle waste back into the production process. The Greencycle Technologies developed by Hovione are improvements that enable the successful production of quality products with less and/or with recycled raw materials, as well as new processes to recover otherwise unusable raw materials from waste streams.

In order to implement these technologies in an industrial-scale recycling programme, we had to find innovative cost-effective solutions of industrial organization. Wastes are produced in batch, but the recycling processes are continuous. We must not forget that the business must still deliver product for sale according to customers' wishes; waste treatment operations must be organized so as not to constrain commercial operations.

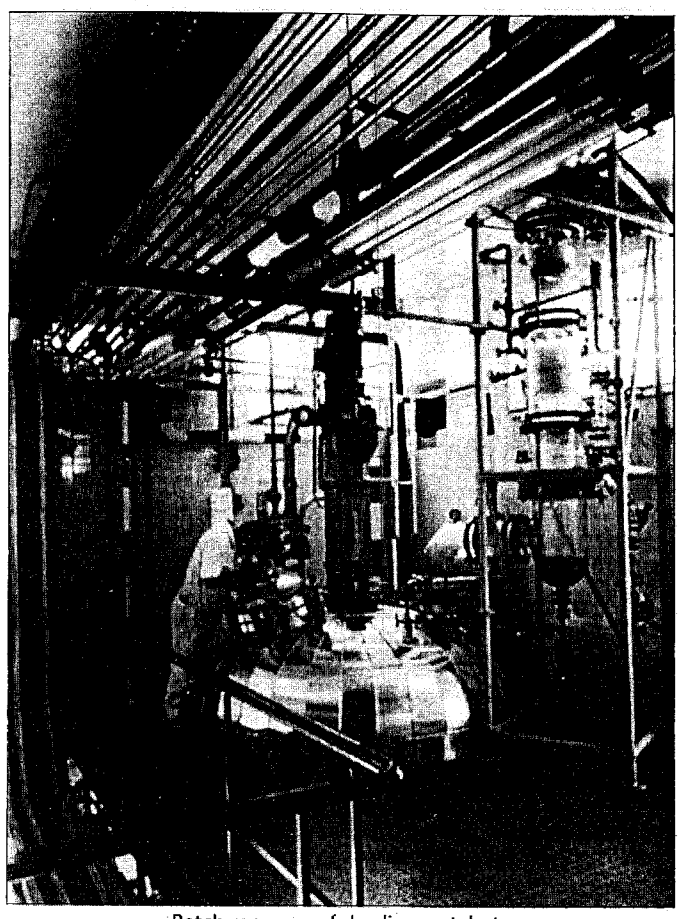
The solution was an F1/F2 arrangement. Factory 1 (F1) produces product for sale, and F1's waste is accepted by Factory 2 (F2). Dedicated pipelines connect F1 to F2, and wastes are never mixed. F2's tank farm solves the F1/F2 interface. F2 has several production lines which separate each waste stream into its original components – the processes used to achieve this aim at obtaining as high purity as possible. An incinerator recovers the thermal energy of non-recyclable residues, and the resulting steam is used both in F2's distillation columns and in F1.

The management of F2 is advised of F1's production programme weekly, and must accommodate the waste streams. F2 does not impose

constraints on F1; similarly F2 must supply recycled raw materials to F1 on demand. See **Table 1**.

This approach minimizes emissions and saves on waste treatment plant. Since consumption is drastically reduced (in some instances by a factor of 20), the capacity required for waste treatment is very greatly reduced.

We also considered that it was not enough to change the approach to waste in our industrial process. The new approach had to apply to everything Hovione people do: from driving cars to creating waste in the office and laboratory. Paper, plastic, glass, etc. – all is now sorted by the individual user and sent for recycling. The income generated is donated to the Lisbon Zoo. Company cars use unleaded petrol. Some employees bring their old newspapers to the office, as a public paper recycling system is not widely available in Portugal. Open days for factory visits by schools, neighbours, and employees' families have become a routine.



Batch recovery of rhodium catalyst.

A classic fallacy is to believe that a central waste treatment plant solves all problems. We have found that there is no miracle solution: overall results come from a series of many small changes to processes and systematic evaluation of options, with a constant concern for the best environmental solution. This process is not achievable by an outsider – say a consultant. Only an intimate knowledge of the process and a thorough understanding of the chemistry involved enables the development of a Greencycle Technology. This is not static, but a continuous dynamic process. It takes time and resources. Hovione's six-year effort in this area explains why our new product launches suffered in the late 1980s! Our scientists were busy dealing with rubbish.

Legislators need to consider that technologies (especially cost-effective ones) are not available off-the-shelf. They take time to develop. End-of-pipe solutions are the most expensive ones, and are probably not faster either. What is lacking is proper planning: if industrialists were provided with reliable data on the limits of emissions levels and corresponding fines over the next ten years, they would time their R&D and plant investments for the best deal. *Ipso facto* regulations do not address the issues, they merely close down plants.

Quality systems are key tools for implementing an F1/F2 system. Hovione has had an ISO 9000 type management system since 1981. In addition, because our products are used to treat humans, the manufacturing process is the object of extensive analytical controls. This profound knowledge of raw material quality implications in the synthesis of pharmaceuticals permits us to know what purity levels the recycled raw materials need to have to be reusable in the manufacture of antibiotics or steroids. Furthermore, any change to our production processes – such as using recycled solvents – must be authorized by the health authorities, whom we must satisfy that the quality of the end product remains unchanged. The validation programme of F2's recycling processes lasted six months and established the best quality/efficiency balance. Three months' accelerated stability studies on trial batches of the pharmaceutical final product had to be performed. The United States Food and Drug Administration approved these changes surprisingly promptly – an indication that efforts to protect the environment get special treatment!

There are two relevant factors here. First, a quality system enables easy identification of waste producing points and provides a climate of accuracy and thoroughness: analytical specifications, process parameters, etc., all factors which contribute to reliable information on the process used and thus an understanding of where and what wastes are produced, how we can recycle them, what recycling process is required, and what it must achieve. Second, if it is possible to successfully implement a comprehensive recycling programme in a very quality-critical industry such as pharmaceuticals, then other industries should also find it possible.

Recycling and waste treatment are two different options for dealing with emissions. Recycling typically requires a greater fixed asset investment and more technology. Waste treatment does not save resources. However, irrespective of the option chosen, it is relevant to remember that cleaning up the first 90 per cent can be done at an acceptable cost while the next 5 per cent is very expensive and the last 1 per cent is simply not cost-effective. The law usually sets 98 per cent levels and then fails to carry out enforcement equally. The level playing field disappears: note how imports from LDCs may be more competitive because they are produced with lower costs for environmental protection.

Hovione's F2 plant works 24 hours a day, seven days a week, and employs a staff of eleven. From a financial point of view, our recycling programme transformed variable costs (purchase of raw materials) into fixed costs (salaries, depreciation and loan interest). Whilst this is favourable as long as sales of the products grow, should these drop the company is unable to contain the F2 fixed costs. Another issue is the fact that the F2 is designed and has equipment dedicated to recycling specific waste streams for current products. New products require new production processes and probably new recycling solutions. The F2 amounts to further vertical integration of a production process: a worsening of the return on assets ratio, a reduction in flexibility – altogether a worse position in terms of industrial versatility and strength.

The "bottom line" is an inescapable test. Cost minimization and the pursuit of profit are the limiting factors. Hovione's experience shows that it is possible to solve environmental problems through a major recycling programme. Recycling avoids waste and so contributes to sustainable development. One key question remains: is recycling more economically efficient than waste treatment?

Implementation of the F1/F2 concept in Macao

Hovione's F1/F2 concept was first implemented in our plant in Macao. This is a territory in South China where, in the mid 1980s, environmental protection legislation and/or monitoring was virtually non-existent but, equally, licensing delays were unheard of. From its start-up in 1986 we had in place an end-of-pipe waste treatment plant (pH control, sedimentation, aeration) as well as a solvent recycling plant. Dedicated to a simple production process, the distillation column saved 475 tonnes of organic solvents in 1993. The original investment of $US 100,000 was paid back in under a year. The system has annual running costs of $US 35,000, achieves savings of $US 300,000 a year, and avoids disposing of liquid effluent containing 475 tonnes of organic solvents.

The Macao Government's Urban Plan includes very significant investments in the field

of environmental protection. A state-of-the-art municipal waste incinerator has been in operation since 1992. An industrial liquid waste incinerator is due to enter into operation well before the 1999 handover date. When these facilities become available, we expect our Macao operations to be as respectful of the environment as any in Europe.

Implementation in Portugal

In Portugal, bureaucratic problems exist! Our liquid waste incinerator was delivered in 1987. All types of licensing issues caused its start-up to be delayed until 1991. The main delay was the absence of a licensing procedure for industrial incinerators.

The F2 plant in Portugal is an investment of $US 5 million, an amount equal to 20 per cent of our sales. The quality of the effluent improved very significantly, and it is now compliant with the municipality emission quality limits. BOD5 levels before and after F2 have been improved by a factor of 5.

F2 carries out the recycling of organic solvents and the recovery of phosphine reagents and catalysts. The profit and loss for F2 in 1993 can be found in **Table 2**. This leads to an interesting discussion. F2 includes an incineration facility. The cost of incineration of the waste we cannot recover is – to Hovione – marginally irrelevant. The main direct cost is the diesel (4 per cent of costs); the high costs are the depreciation of the equipment and the intangible cost of having an "incinerating license". These are sunk costs, so we incur them whether or not F2 operates. Yet were we to be forced to buy incineration service from a professional third party, the cost would be $US 1,273,000 for the amount burnt in 1993. Without F2, we would have an additional 922,000 litres of solvent in our waste streams; this we would have to incinerate at an extra incineration cost of $US 1,108,000. F2 also provides us with additional savings resulting from the recovered raw materials that F1's production consumes and which we do not have to buy ($US 239,000 from recovered solvents and $US 465,000 worth of rhodium).

This totals $US 3,085,000 of notional savings, which must be set against total costs of $US 1,425,000 ($US 757,000 of running costs and $US 668,000 of depreciation).

The above figures seem to indicate that F2 shows a profit of $US 1,660,000, or a 50 per cent margin. This is not so: this amount is the saving that the in-house F2 affords Hovione, as it is not obliged to buy incineration or other services from third parties to comply with regulations. But the real net margin is indeed negative: the cash income is only $US 704,000 (i.e. the value of recovered solvents and rhodium), which is almost enough to pay for the direct operating costs of F2 ($US 757,000) but certainly does not cover the plant's depreciation.

These calculations are further complicated by the fact that the EC and the Portuguese state provided Hovione with a non-refundable grant of $US 1,000,000 for the F2 project.

Put simply, we can conclude that in its second year of operation our F2 plant provides Hovione with a recycling income which pays for the total waste treatment costs of the company, but not for depreciation. This we consider a notable achievement. We consider that this depreciation charge is a necessary cost to "remain in business". Without it, strict application of the law would cause Hovione to be closed down.

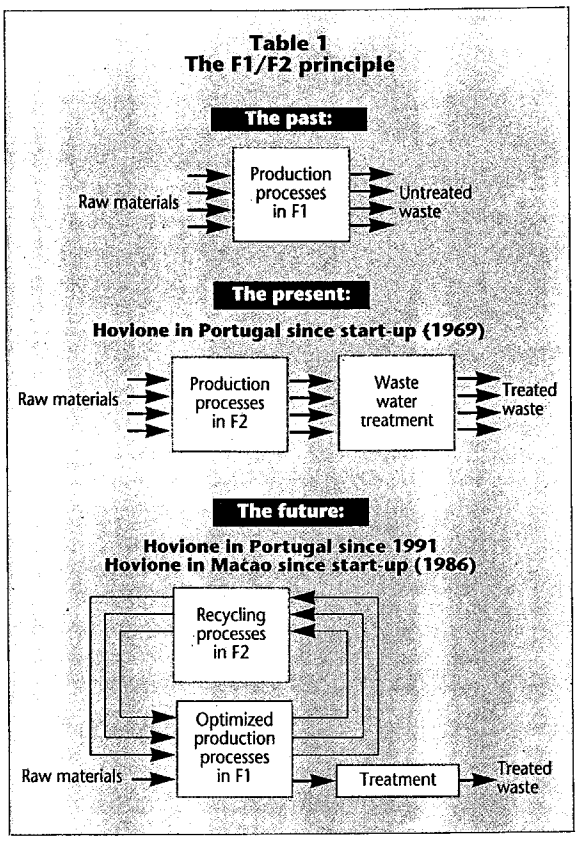
What are the alternatives to having an F2? An F1 without any in-house environmental protection facilities would require the purchase of third party incineration services worth $US 2,381,000! Clearly this is wishful thinking for two reasons: first, no company would accept waste treatment costs equal to 10 per cent of sales; and second, in Portugal there is not a single company competent to accept our liquid waste and treat it correctly.

EC legislation prohibits waste to cross borders. This policy aims at waste being dealt with at the local level: ideal in principle, but of difficult short-term implementation. The harsh reality is that the alternative solution, practised by so many companies, is to dump the waste discreetly – one often hears that "the solution to pollution is dilution".

Strictly speaking, if Hovione were to speak to any bank about loans to finance our F2 to the tune of $US 4 million, there would be no takers, considering that competitive options exist and are far more cost-effective: zero cost plus a guilty conscience. Fortunately, there are family-owned and family-run banks such as the Espirito Santo Bank in Portugal that see further than their quarterly reports.

These figures could be presented in many ways in a spread sheet. We have tried to present them as simply and as close to the reality as possible. One scenario, however, is pertinent. When the decision to invest in F2 was taken, rhodium cost six times more than the value shown in the Table 2 1993 accounts. This

Table 1
The F1/F2 principle



F2 recycling and waste treatment plant.

means that the whole F2 would have been made viable by rhodium recovery alone, as this would have provided an income of over $US 2.5 million per year.

It is important to note that the magnitude of the investment was only authorized because the rhodium saving was estimated then to be very significant. Today the recession has caused this noble metal, so critical for the car industry (it is used in the catalysts), to sell at one sixth of the 1989 price.

This decision-making process, based on commodity prices, well illustrates that it is of paramount importance to sustainable development that commodities be expensive or be perceived to increase in price steeply. Whether through real shortage or through tax – which simulates shortage through price increase – it is the increase in raw material cost that will drive industry to seek savings in recycling solutions. We believe that it is the market and the perception of market trends that drive entrepreneurs' decisions.

Sustainable development is achieved by a reduction in consumption, which inevitably results in less waste. As with Hovione in the case of rhodium, and with the world in the case of the 1973 oil shock, crisis situations drive key decisions such as building an F2 or developing fuel-efficient cars. Today oil and petrol at the pump are – in real terms – cheaper than in 1973, so "miles per gallon" does not rank high in car advertising. It was the doubling of heating bills in 1973 that caused the drive to double-glazing and home thermal insulation.

Table 2
Profit and loss for F2 (Hovione's recycling and waste treatment plant in Portugal) in 1993

	US$	%
Income		
Actual savings		
• Solvents recovered	238,620	12
• Rhodium recovered	464,713	24
Costs avoided		
• Incineration	1,273,053	64
Total income	1,976,386	100
Expenses		
Personnel F2 process	131,260	17
Personnel F2 quality control	30,620	4
Maintenance	79,307	10
Utilities		
• electricity	36,593	5
• gas	49,580	7
• diesel	31,633	4
• water	40,920	5
• nitrogen	36,413	5
Analytical control	74,167	10
Process raw materials	217,346	29
Consumables	28,893	4
Total expenses	756,733	100
"Profit" before depreciation	1,219,654	
"Depreciation"	668,427	
"Profit"	551,227	
Notional cost of incinerating the solvent waste streams if they were not recovered and reused:	1,108,000	
Total F2 net "profit"	1,659,227	

When our municipality changed its pricing from a solid waste removal flat fee to a "per container" price, our quantity of waste was cut to a third. The water supply charge is based on consumption, and soon the price per cubic metre is to include an extra amount to pay for the municipal liquid waste treatment plant. It seems simple and obvious that costs previously called "externalities" and not accounted for must henceforth be "internalized"; users must start to pay for what was once free, and at that point the market will bring efficiency to resource allocation. In Germany, the price paid for plastic containers by bottling companies already includes the costs of the collection and recycling schemes.

In Hovione's experience, recycling is a viable proposition. The saving in the purchase of fresh raw materials covers F2's running costs. If we add in the notional cost of avoiding third party incineration services, then F2 even pays back the capital investment. Hovione is committed to its recycling programme and to sustainable development. Yet to survive in the market we must compete, although sometimes this is made difficult because irresponsible firms are able to avoid environmental costs. We need governments to enforce a level playing field. More discerning legislation, internalization, truer pricing, eco-accounting and eco-audits should help towards market-driven sustainable development.

To us, the green tax on a barrel of oil, the gradual substitution for income tax of an environmental tax is music to our ears. We are also sure that our choice is the correct long-term choice – but are we too early? Will "green" companies still be around to inherit the earth? ◆