experiences, cost structures and CMS contract terms to specific firms.

6. Total chemical costs: the essential first element of the business case

The business case for CMS is based on the manufacturer's understanding of the *total chemical costs* incurred by their operations. Chemical-related costs are incurred at each stage of the in-plant chemical lifecycle (Fig. 4).

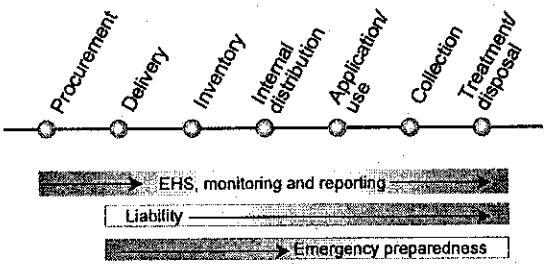

Fig. 4. The chemical lifecycle.

Like any purchased materials, chemicals generate costs associated with procurement, delivery, inspection, and inventory. But, because of the specialized and heavily regulated nature of chemicals, these costs are high relative to other material inputs. Many industrial processes require chemicals with sophisticated properties—such as purity and heat resistance properties—that demand more attention and expertise by procurement staff. Similarly, chemicals typically have special and costly delivery and storage requirements. Transportation is subject to stringent regulations; storage often requires incoming inspection, climate control, shelf-life management, labeling, and safety precautions. Each of these requirements has a cost. And such costs, more often than not, are recorded across a wide array of accounts in the firm or facility.

Unlike most other purchased materials, chemicals also require substantial resources for monitoring, tracking, reporting, training, and disposal, not to mention the less tangible but real costs of liability and, sometimes, public communications and corporate reputation assurance. Even after a chemical has been procured, delivered, and received into inventory, another wave of resources is put into motion as it is drawn from inventory and brought into use. Chemicals require special handling to move them within a facility, and chemical handlers require special training and equipment. Once delivered to the point of use, temporary storage locations scattered throughout the facility (except in plants using materials on a just-in-time basis) may generate many of the same costs as warehouse storage. When the chemical is put into use, the workers must have training and protective equipment. The process continues as some of the chemical is converted into non-product output that must be managed as waste, with all the attendant handling, transport and disposal costs. As the number of storage locations and points of use increases, the resource burden increases as well. Emissions of constituent chemicals, waste management activities, storage of chemicals, and other pieces of information must be routinely gathered for regulatory reporting. Collectively, these requirements place a significant burden on environmental, health and safety (EH&S) staff. For example, procurement systems are only rarely linked to the environmental management systems that contain information needed for reporting. Therefore, determining the volume of any specific chemical component released from a facility requires manual data gathering and manipulation. EH&S managers are all too familiar with the annual deluge of activity that precedes regulatory reporting deadlines.

An obscure layer of costs underlies the more visible EH&S costs. These hidden costs are those that are connected less to specific chemicals than to supporting the facility's overall capacity to manage chemicals. For example, most of the aforementioned activities are supported by information systems. While it is rare that a facility's information systems exist solely to manage chemical information, chemical management may well be a primary function. The development and maintenance of these systems have their own resource requirements. Similarly, facilities using chemicals require emergency response procedures and equipment in case of a chemical spill, explosion, or accident, though such procedures and equipment at the same time may support fuel storage and waste oils.

Chemical use also demands some level of legal expertise and creates various types of liability. From the time the ownership of a chemical is transferred to a company until long past the time it leaves the facility, potential liabilities from both human and environmental exposure must be managed. Finally, the use of chemicals often requires—either by company policy or government regulation—public communication efforts such as meeting with concerned neighbors, talking with the media, negotiating with local authorities, and providing information to shareholders. These demands, too, add to the long list of less tangible costs associated with chemical use.

The results of more than 20 benchmarking studies conducted by CSP indicate that the ratio of chemical management costs to chemical purchase costs is rarely less than 1:1. In other words, at least one additional dollar is spent to manage every dollar of chemical purchased. In some situations, the ratio of management to purchase costs may be as high as 10:1. Estimates by auto manufacturers and the Department of Defense have put the ratio of chemical management costs to chemical purchase costs in the range of 5:1 10:1.[2] [17]. Fig. 5 illustrates a typical distribution of management costs from a CSP total chemical cost baselining exercise (in this case, at a semiconductor facility).

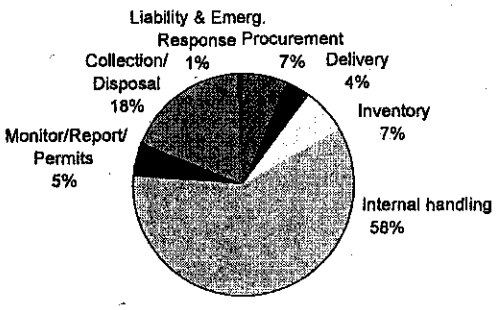

Fig. 5. Distribution of chemical management costs. Source: CSP [18].

Typically, manufacturers have extremely poor understanding of their chemical costs. As implied by the discussion above, chemical costs exist along a 'visibility spectrum' (Fig. 6). Most visible are purchase and disposal costs. As costs move down the spectrum they are less direct and more dispersed throughout a firm's functional groups, making them more difficult to identify and attribute to specific materials or activities. This applies even to firms which have adopted sophisticated enterprise-wide accounting software. The implementation of this software in many cases preserves the problematic overhead accounts and aggregation practices that obscure total chemical costs in the firm's preexisting financial control and accounting mechanisms.

[2] These estimates are based on conversations with representatives from GM and Hughes Electronics during 1996 1997.

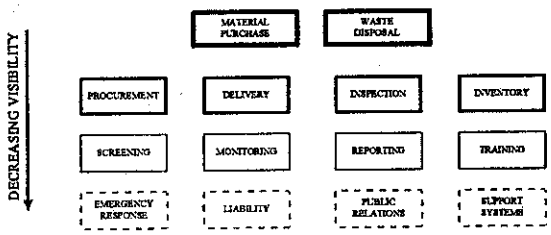

Fig. 6. Visibility of chemical management costs.

If managers look only at their chemical *purchase* costs, it is unlikely that they will be able to properly evaluate the merits of a CMS contract. There is little probability that the CMS provider will be able to provide chemical services (including the provision of the chemical themselves, and at least some aspects of their application or management) for *less* than their existing total purchase costs.

Where chemical management contracts are not based on total chemical costs—that is, where management's only focus is reducing current per-unit chemical purchase costs, the contracts risk becoming merely leveraged purchasing agreements. These may deliver a one-time reduction in chemical purchase costs by consolidating chemical procurement, reducing diversity, and allowing the supplier to realize economies of scale; but they do nothing to fundamentally restructure the perverse incentives in the supplier–customer relationship.

7. The core competency basis for CMS

Even if managers do understand their total chemical costs, a successful business case demands that the chemical service provider accomplish some set of chemical management tasks more cheaply than they can be performed in-house. To understand in general terms why a provider might be able to accomplish this, consider that in most chemical-using manufacturing companies, none of the activities indicated in Fig. 6 are part of the core business. Chemical users are typically focused on maximizing throughput and accelerating a product's time-to-market; these are the activities toward which their resources are rightfully directed. Of course, no company willfully employs an inefficient chemical management system. But because it is outside its core business and because the costs may be perceived to be relatively small, chemical management may not be as carefully managed or continuously upgraded as production processes. Poor visibility leads to deficient management, despite the substantial costs of such practices. Given finite internal resources, this lack of attention may be a rational decision; after all, chemical costs, even if underestimated, may be a small fraction of operating costs.

To illustrate costs resulting from poor management attention, consider the results of a joint CSP–Raytheon chemical cost accounting exercise at a Raytheon (formerly Hughes Electronics) manufacturing facility in Arizona. A cross-functional team conducted materials accounting analyses of printed wiring board production. The analyses revealed that management attention had traditionally been focused on reducing the more hazardous waste streams and did not realize that the facility's general industrial waste stream was of a much higher volume and cost. Following these analyses, significant changes were made to the facility's waste treatment processes resulting in reductions in energy use, treatment chemical use, and hazardous waste generation. Conservative estimates suggest annual operating savings of US$ 400,000.

Beyond lack of management focus, a related reason for poor chemical management is lack of internal expertise in

various aspects of chemical management such as inventory control, chemical tracking, chemical processes, and even chemistry itself. Without knowledge of the availability of, for example, less toxic adhesives or more efficient cleaners, facilities have little chance of making improvements. Similarly, firms with ad hoc ordering processes that require multiple iterations between the user, the buyer, and the supplier, are spending resources on an inefficient system that directly diverts money from the bottom line. When these costs are relatively small it may not make sense to hire procurement experts and full-time chemists. Nonetheless, the need for that type of expertise and the potential benefits remains and its absence is sure to create wasted materials and human resources.

Finally, there are the perverse incentives embodied in the traditional supplier–customer relationship. Again, under a traditional chemical buyer–supplier relationship, the supplier's profitability is a function of volume, which provides an incentive to *increase* the amount of product sold. Meanwhile, the buyer has the opposite incentive—to reduce costs by *reducing* the amount of chemicals purchased. Not surprisingly, internal efforts to reduce chemical use often face a disinterested or reluctant supplier. As long as the supplier increases its profits when chemical use increases, the buyer and supplier face conflicting incentives. This, in turn, is likely to retard chemical management improvements, especially those which lead to chemical use reduction (e.g. process efficiency improvement and systems optimization).

8. When CMS may make sense

Assuming that the manufacturer has a sound appreciation of their total chemical costs, and the provider possesses a set of core competencies related to the manufacturer's needs, there may be a sound business case for CMS.

The business case is determined in large part by two key factors: (1) the transferability of the manufacturer's current, internal costs of chemical management; and (2) the ability of the provider to realize necessary economies of scale.

Chemical-related labor costs—typically the largest part of total chemical costs—vary widely in their transferability to an outside provider. Where dedicated chemical-related staff exist in procurement, receiving, internal distribution or other departments, the labor involved may be transferred to the CMS provider and firm's balance sheet will clearly reflect this transfer. Where chemical management tasks comprise only a fraction of the time of individual staff (e.g. an employee in procurement spends 10% of his or her time procuring chemicals), the transfer of chemical management tasks to the CMS provider is unlikely to reduce the firm's direct costs. That is, while the procurement worker in question may now be able to focus on core tasks much more efficiently, in very few cases will the firm's accounting systems reflect this benefit. In addition, labor contracts and policies can impose strong restrictions on the transfer of labor and labor costs.

In some cases, transferability of labor and other chemical costs is restricted by regulatory requirements. For example, because of the US liability law, some liability associated with using even small volumes of chemicals and the legal staff needed to manage them may be nearly impossible to eliminate regardless of how successful chemical use reduction efforts are.

Despite the admonition that leveraged purchasing agreements do not, by themselves, constitute CMS, chemical volume is important to the viability of CMS contracts. The value of CMS lies largely in bringing focused chemical expertise and

attention to bear on chemical management inside the customer's facility—that is, having employees of the chemical service provider on site. While the contractual mechanisms can vary widely, the CMS provider is able to cover its own labor costs through the savings from its customers total chemical management costs (procurement of chemicals and all associated labor, capital costs, and waste management fees). Insufficient chemical volume thus may not warrant on-site CMS provider staff.

Chemical volume also affects transferability of costs. Large volumes of chemicals are likely to require dedicated staff in procurement, receiving, etc. When chemical volume is small, a number of people will spend some small fraction of their time at chemical-related tasks. As discussed above, the former condition results in a far greater portion of chemical-related being transferable to the CMS provider.

For these reasons, a rule of thumb among most CMS providers is that a `full-service' CMS program generally requires about US$ 1 million in annual chemical sales at any given facility.

If a prospective CMS customer has a sound grasp of their total chemical costs, and if a significant portion of these costs is transferable and basic volume requirements met, then significant potential exists for a CMS program with a provider possessing the appropriate competencies.

9. Range of CMS programs

The form such a CMS program might take varies widely. The compensation model described earlier in our door painting example could probably occur only under a mature, full-service program. In such a program, the CMS provider has substantial responsibility for aspects of production, and costs can be (and are) characterized on a per-unit production basis. Stable production lines and low product diversity greatly facilitate a per-unit compensation mechanism because costs are predictable and are easily tied to production rates.

In practice, the CMS model covers a spectrum of service levels from procurement only to comprehensive coverage across the chemical lifecycle depicted in Fig. 4—and from only certain classes of chemicals to `tier one' procurement of all chemicals. Typical CMS tasks include procurement, receiving and inventory control, delivery to point-of-use, maintenance of working fluids (e.g. coolants, jacket oils and reclaim systems), collection and disposal, and preparation of regulatory reports. CMS is often combined with just-in-time inventory approaches; it is not uncommon for the CMS provider to retain ownership of the chemical up to the point of application. In our experience, the more comprehensive the system, the greater is its potential for realizing mutual financial gains and chemical use reduction.

10. Associated benefits

Thus far, we have focused on chemical use reduction as the primary public or environmental benefit of CMS. And we have likewise focused on direct cost reduction as the primary benefit to manufacturing firms adopting CMS.

Chemical use reduction can occur in a number of ways. To name but a few possibilities, it can occur via efficiency improvements to the process itself; or via improved inventory control (e.g. reduced spoilage); via JIT delivery to point-of-use (e.g. reducing wastage due to inappropriate container size); or via the ability of a supplier to find resale options for unused or unneeded chemicals. In short, opportunities for reduction of chemical use and costs exist, in potentia, at each stage of the chemical lifecycle (Fig. 4). Thus, in our experience, potential for chemical use reduction increases as the provider's

responsibilities for chemical management expand across the chemical lifecycle, and when use reduction incentives are a significant element of overall contract compensation.

However, even a very limited CMS program implementation (e.g. one excluded from production tasks and focused on procurement, inventory control, and perhaps collection and disposal) does have two significant benefits: (1) placing a greater portion of the chemical lifecycle in the hands of professionals; and (2) improving chemical information management and, as a corollary, physical control of the chemicals themselves. An important implication of the environmental and public health concerns raised by chemicals is that their handling should, as a matter of principle, be professionalized to the extent possible. The essence of CMS as a business model is that core competency in chemical management is applied to a firm's chemical operations. Likewise, poor chemical-related data systems in many firms translate into poor physical control of chemicals. Improved chemical data systems improve the quality and consistency of chemical procurement and clearance procedures (such as an approval process for new chemicals or a program aimed at eliminating toxic chemicals) and the accuracy of regulatory reporting. From a business perspective, it provides a better understanding of a firm's true cost structure, an essential foundation for good management.

Because these benefits are difficult to monetize, they are rarely considered by prospective adopters as part of the business case. And while they are likewise difficult to translate into concrete indicators of environmental protection, we nonetheless believe them to be significant benefits to environmental welfare and the effective implementation of the regulatory system.

11. Barriers to the model

The CMS model is timely in many ways, responding as it does to a set of current trends and priorities in business management, including foci on: core competencies, continuous improvement, suppliers as strategic resources, and the environment as a business issue [12 and 13].

However, CMS is a challenging business model. As noted, chemical management is generally not a management priority, in part because chemical purchases are generally a relatively small fraction of operating costs. This attitude is compounded by limited management awareness of the CMS model, as well as poor internal data systems and chemical cost awareness. All of them raise the barriers to serious consideration of CMS adoption.

If CMS adoption is considered, internal proponents face a number of challenges. First, chemical management activities constitute a complex system. Transferring the management of this system to a supplier can be a daunting task because of its many linkages with other management and manufacturing systems such as procurement, material management, production engineering and waste management. Secondly, as with any change process, implementing a CMS program is subject to individual and organizational resistance, system inertia, and risk aversion, especially when potential gains do not directly accrue to the parties essential to implementation. Thirdly, CMS creates increased interdependency between supplier and customer that requires high levels of supplier capability, and customer confidence and trust in these abilities. In contrast to the traditional seller–buyer relationship, CMS requires longer-term, continuous and multi-faceted interaction. Fourthly, CMS, like any form of outsourcing, can evoke resistance immediately from personnel, especially

union personnel who may view CMS as a cause of staffing reductions and dislocation. And again, poor data systems and cost awareness make the task of understanding the CMS model, drafting an RFP and evaluating proposals received very difficult.

With upper management support and a sound communication effort, a thoughtful implementation program can effectively respond to all of these challenges—particularly when no personnel reductions are involved, or when existing staff are hired by the CMS provider. While CMS does require considerable leadership and a receptivity across numerous staff functions, the transition does not have to occur overnight. Roll-out may occur gradually and sequentially in different parts of the facility or company, by incorporating different classes of chemicals, and by phasing in different stages of the lifecycle.

Not all barriers to the CMS model are on the customer side. For traditional chemical suppliers who are primarily or in significant part chemical manufacturers, the prospect of reduced chemical sales under CMS poses an obvious conflict. The performance of chemical manufacturing operations is heavily dependent on volume produced (and sold). For these reasons, the CMS providers who have had the most success in making the service transition are either dedicated providers (i.e. they do not engage in chemical manufacturing at all), or they have built effective firewalls between their manufacturing and service divisions.

In addition, the skills and resources to manage chemicals are not entirely the same as those required to produce and market chemicals. Management of CMS contracts is far more complicated than that of supply contracts, as it typically requires coordination across multiple business units or departments of client firms and a strong information technology component. Other issues relating to corporate strategy, time commitment, and business risk may also give chemical suppliers pause.

12. Compensation mechanisms: critical for business sustainability and environmental benefits

One significant way that CMS contracts differ from typical supplier contracts is their compensation mechanism. CMS contracts can be and are implemented with a wide variety of compensation mechanisms. These include fixed, variable, or volume-driven management fees, intended to pay for the cost (or value) of the services provided; shared cost savings; direct pass-through of chemical purchase costs; flat inclusive unit price per unit produced; and others. Multiple compensation mechanisms are often combined in one contract.

To achieve environmental benefits under CMS, the primary requirement is that supplier profit must be decoupled from chemical volume. A flat per-unit fee is the most obvious mechanism, but it is usually only appropriate under conditions of consistent production volume and low diversity. Gain-sharing mechanisms, in which CMS provider and customer share in the cost savings gained from efficiency or other improvements to the chemical management system, are essential in the absence of non-flat fee compensation mechanisms. Direct pass-through of chemical purchase costs, combined with a volume-based management fee, by contrast, is the compensation scenario *least* likely to result in environmental benefits.

Compensation mechanisms are also essential to the business sustainability of CMS contracts. Taken too far, mandated annual cost reductions quickly turn what should be a strategic partnership into traditional procurement pressure on a supplier's bottom line. Gain-sharing mechanisms whose savings expire too

quickly likewise fail to reward the supplier for the *permanent benefits* of such improvements which accrue to the customer. In these ways, a traditional procurement approach to CMS contracts is probably the most direct threat to their long-term viability.

13. Conclusions and implications

Proven in two US industrial sectors, CMS is a product–service system with significant potential for chemical use reduction and other environmental benefits. The growth of CMS in the US market is driven from the business case. However, realizing the environmental potential of the model depends critically on the scope of the CMS program and the compensation mechanisms employed. Absent gain-sharing or other compensation mechanisms which strongly incentivize chemical use reduction, CMS cannot be expected to result in chemical use reduction. In the presence of such initiatives, CMS is a model which professionalizes significant elements of the chemical lifecycle, and creates a industry whose focus is efficient chemical use, sound chemical information management and regulatory compliance.

Acknowledgements

Major funding for the Chemical Strategies Partnership (CSP), under which this research was conducted, was provided by The Pew Charitable Trusts, The Heinz Endowments, and the US Environmental Protection Agency. CSP is a project of the Canopy Institute. More information on CSP, its sponsors and ongoing projects can be found on the CSP website at http://www.chemicalstrategies.org.

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