KEY FACTORS FOR PROMOTING P2 TECHNOLOGY ADOPTION

"How to" knowledge is the key

Countless workshops, web sites, databases, fact sheets, and case studies have been developed by pollution prevention "change agents" employed by various government agencies. These tools, which generally promote specific P2 practices and technologies, are intended to publicize the applications and advantages of these practices to a wide range of industrial sectors. This strategy is based on the belief that "if we can simply make people aware of the advantages of P2 technologies, the benefits are so obvious that people will rush to adopt these practices." While this strategy has been effective at spreading P2 technology awareness, it has proven to be ineffective for the most part in terms of companies actually adopting P2 technologies.

The heightened level of awareness companies receive from this strategy tends to increase their level of interest in P2 technologies. However, this level of technical assistance usually does not lead to actual technology adoption because simple awareness training does not provide the "how-to" knowledge required for successful implementation. Uncertainty associated with the technology's compatibility, complexity, observability, and trialability frequently keeps companies from adopting P2 technologies even though the technologies offer significant advantages for their operations (Lindsey, 1999). Strategies that provide "how-to" implementation assistance for innovative P2 technologies, along with support on technical principles, could help overcome these barriers.

Because current technical assistance methods are unable to provide the implementation assistance required for adoption, the diffusion of P2

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technologies continues to occur at a disappointingly slow rate (Lindsey, 1998). For example, technologies such as reverse osmosis, ion exchange, conductivity controls, and evaporators have proven to be cost-effective practices for reducing waste and improving efficiency in a variety of metal finishing applications. However, according to Cushnie (1994), these technologies (and a variety of others) have achieved less than 10-percent penetration into metal finishing shops even though they have been commercially available for many years.

What This Article Covers

This article discusses the results of projects undertaken by my organization, the Illinois Waste Management and Research Center (WMRC), to determine what types of technical assistance can be provided to industry to expedite the diffusion of proven innovative P2 technologies.

The first project discussed here involved offering various levels of P2 assistance to 76 different facilities regarding membrane filtration, an innovative P2 technology, and then determining which type of assistance was most effective in encouraging the facilities to adopt the technology. The second project involved developing in-depth case studies of six facilities where WMRC staff conducted pilot trials of the membrane filtration technology.

The focus of the projects described here was a chemical recycling technology commonly referred to as "membrane filtration."

Membrane Filtration Technology

P2 represents a cluster of innovations that may be either "hardware" or "software" in nature. These innovations involve varying degrees of complexity, as well as other factors that can influence their adoption rates in a wide range of industrial processes (Lindsey, 1998).

The focus of the projects described here was a chemical recycling technology commonly referred to as "membrane filtration." Adoption of this technology was examined in the fabricated metals and transportation sectors, where the technology is slowly diffusing into applications that use it to recycle "in-process" aqueous cleaning solutions and metal working fluids. We anticipate that the results from this project can be applied to the diffusion of other P2 technologies in additional industry sectors.

The 76-Facility Project

During the period from 1991 through 1997, WMRC change agents visited hundreds of industrial facilities to identify opportunities within their processes to minimize waste generation, improve raw material use efficiency, and enhance overall competitiveness. In 76 of these facilities, opportunities were identified for implementing membrane filtration to perform in-process recycling of aqueous cleaning solutions and/or metal-working fluids. Based on preliminary evaluations of the P2 opportunities in these applications, WMRC change agents determined that membrane filtration could offer significant advantages in terms of waste reduction and cost savings.

WMRC change agents provided these 76 customers with a combination of "awareness" information, technical "principles" information, and implementation "how-to" assistance, depending on their expressed level of interest in the technology.

Awareness information consisted of verbal explanations of the technology, fact sheets, technical reports, and information on vendor availability. In some instances, this awareness information led the potential adopters to seek more knowledge regarding the technology.

Assistance with technical principles and "how-to" (implementation) information were provided to some of the customers through conducting demonstrations and pilot trials. The demonstrations involved using a small, portable membrane filtration system to process about two to ten gallons of the customer's solution over a one- to three-hour period. These demonstrations exploited the strong

Exhibit 1. Impact of Various Technical Assistance Approaches on Adoption of Membrane Filtration Technology

Change Agent Assistance	Total Companies Receiving Assistance	Customer Response to Change Agent Activity		
		Adopted	Rejected	Evaluating
Promote Awareness Only	47	0	44	3
Awareness & On-Site Demonstration	8	0	4	4
Awareness & Pilot Trial	5	3	2	0
Awareness, Demonstration, & Pilot Trial	16	10	2	4
Totals	76	13	52	11

"observability" characteristics of the technology: Customers could see brown, murky solution entering the system and clear, soapy solution exiting.

The pilot trials consisted of extended in-plant testing that lasted from several weeks to several months. These trials enabled potential adopters to become very familiar with the operation of the technology. They also established precisely what costs and benefits would be associated with permanent implementation of a membrane filtration system. In addition, the trials permitted potential adopters to work through complexity and compatibility issues associated with incorporating the technology into their processes.

P2 Adoption Results

Exhibit 1 summarizes the technical assistance efforts provided to the 76 potential adopters of membrane filtration. It is noteworthy that none of the 47 companies that received only "awareness" information ultimately adopted the technology. However, three of these companies (6 percent) are continuing to evaluate the technology and may adopt it at a future date depending on various factors, such as capital availability, regulatory requirements, and scheduling of a pilot trial.

Similarly, none of the eight companies that received awareness knowledge combined with on-site demonstrations of membrane filtration adopted the technology. However, four of these eight companies have not yet rejected the technology, suggesting that the diffusion process is not complete with respect to these companies. Several of them will likely proceed with pilot trials that could ultimately lead them to adopt the technology.

Five companies did not receive on-site demonstrations of the technology prior to proceeding to an extended pilot trial because WMRC had not yet acquired a portable demonstration system at the time they were contacted. Instead, pilot trials were promoted simply on the basis of the awareness information provided by WMRC change agents. Three of the five companies (60 percent) that conducted these pilot trials proceeded to permanently adopt the technology.

A total of 16 companies received the full complement of WMRC technical assistance with membrane filtration technology evaluation. WMRC provided these companies with awareness information, on-site demonstrations, and extended pilot trials. Ten of these 16 companies (62.5 percent) have adopted the technology to date, and four others (25 percent) are continuing to evaluate it. Several of the "evaluators" will likely implement the technology pending internal budget

Exhibit 2. Summary of Case Study Project Participants

Participant Facility	Participant's Innovation Resources	WMRC Involvement	POTW Involvement	Adoption/Rejection Status
Large Automotive	Extensive	Yes	Yes	Adopted
Large Railroad	Extensive	Yes	No	Partially Adopted
Small Stamping	Limited	Yes	Yes	Adopted
Small Machining	Limited	Yes	Yes	Adopted
Medium Fabrication	Moderate	Yes	No	Rejected
Medium Machining	Moderate	Yes	Yes	Rejected

approval. To date, only two (12.5 percent) have actually rejected the technology.

In total, 21 companies (28 percent of the total 76) that were initially contacted by WMRC regarding membrane filtration technology conducted pilot trials. Thirteen of these companies have adopted the technology, while four others are continuing to evaluate. Based on these results, it appears that, if potential adopters can be encouraged to execute a pilot trial, *there is a 60- to 80-percent likelihood they will ultimately adopt the P2 technology.* This compares to virtually a 0-percent chance of adoption if they are presented with only awareness information or demonstrations.

These data confirm observations by Rogers (1995) that "awareness knowledge alone does not usually provide the necessary information required for adoption." Performing demonstrations and trials of the technology emphasized the technology's positive observability and trialability characteristics and enabled potential adopters to observe the technology's performance in their own unique setting. The trials also helped disseminate the "principles" and "how-to" knowledge that most of these companies needed to facilitate adoption. Extended trials enabled the change agents and adopters to fully evaluate the technology's advantages, while at the same time they reduced uncertainty associated with the technology's complexity and improved compatibility with existing processes and procedures.

Publicly owned treatment works (POTWs) referred 8 of the 76 companies to WMRC for assistance. Four of these eight companies proceeded with demonstrations and pilot trials, and ultimately adopted the technology. This adoption rate is significantly higher than the 17-percent rate (13 adopters out of a total of 76 companies) experienced for the total group. It suggests that the POTWs' involvement may have had some impact on the diffusion of membrane filtration technology.

The Case Study Project

In addition to evaluating the technical assistance efforts provided to the 76 companies, as described above, WMRC developed detailed case studies of six facilities. These case studies were intended to determine the key factors in the companies' decisions to adopt or reject the membrane filtration technology.

WMRC field agents have exposed a large number of companies to membrane filtration technology, and it was not possible to conduct detailed case studies at all of them. Therefore, a sampling of companies was studied. Companies were selected for case studies based on how representative they were of the population at large and on their willingness to actively participate in the case study project. The case study participants are identified by industry type in **Exhibit 2**. Representatives from the participating companies were interviewed in person at their facilities by the WMRC change agents who assisted them.

Case Study Participants

The companies examined in the case studies were willing to work closely with government change agents from WMRC to evaluate the potential of membrane filtration technology at their facilities. In this respect, they were unlike many of their industry peers, which frequently mistrust government representatives too much to partner with them. As a result, the case studies do not reflect a true random sampling of the industry population at large. Instead, they represent a sampling of innovative companies that tend to be at the forefront when it comes to evaluating and adopting new technologies.

·Exhibit 2 provides a summary of the industrial participants that served as case study subjects in this project. As shown, these participants included two large companies with extensive innovation resources—an automotive manufacturer and a railroad. They also included smaller companies with considerably fewer innovation resources—a small stamping plant, a small machining plant, a medium-sized fabrication plant, and a medium-sized machining plant. All but the railroad and the fabrication facility received assistance and/or incentives from their local POTWs. All of the companies except the medium-sized machining and fabrication facilities ultimately adopted the technology.

As mentioned, all of the companies evaluated in the case study process were relatively innovative. They had previously adopted a variety of new technologies in their facilities and were relatively comfortable working with a government agency like WMRC to evaluate membrane filtration. The automotive and railroad facilities both had access to extensive information resources regarding innovation opportunities. The automotive plant's corporate Research and Development group continually monitors innovation developments that can impact their products and processes. The railroad's corporate resources are more limited; they depend predominantly on their trade association for assistance with innovations. The fabrication facility's corporate engineering group keeps abreast of appropriate manufacturing technology developments that are core to their business. The mid-sized machining facility monitors technology developments primarily through their trade association. The small stamping and machining operations try to keep up with innovative technologies primarily by sending staff to conferences and interacting with government change agents. Additionally, all of the facilities monitor their vendors', peers', and competitors' efforts regarding new technology adoption.

As mentioned, all of the companies evaluated in the case study process were relatively innovative.

Selling the Advantages of Membrane Filtration

WMRC personnel attempted, with varying degrees of success, to help the facilities resolve how membrane filtration technology would impact their operations. WMRC change agents expended most of their efforts emphasizing the relative advantages of the technology, which can include reduced water and chemical use, decreased labor costs, and improved compliance with POTW requirements. A summary of the advantages promoted to each of the potential adopters is provided in **Exhibit 3**.

Economic Benefits and Their Effect on Adoption

Proponents of P2 often claim that if substantial cost savings can be demonstrated, adoption of P2 will become virtually automatic. Our case studies do not bear this out, however.

As shown in Exhibit 3, membrane filtration displayed considerable economic advantages in five of the six case studies. Based on reductions in

Exhibit 3. Advantages of Membrane Filtration Technology Communicated by WMRC Change Agents

Company	Economics	Compliance with POTW Ordinances	Wastewater Impacts	Other Advantages
Large Automotive (Adopted)	7-month payback period	Improved compliance with POTW ordinances	Reduction of > 1 million gallons/year	Reduced labor & improved cleaning performance
Large Railroad (Partially Adopted)	12- to 26-month payback period[1]	No compliance issues	Reduction of > 24,000 gallons/year[2]	Reduced labor
Small Stamping (Adopted)	7-month payback period	Compliance achieved previously by finding alternative disposal method	Reduced special waste generation by about 15,000 gallons/year @ cost of $1/gallon	Improved cleaning/ phosphatizing performance
Small Machining (Adopted)	72- to 84-month payback period	Facilitated compliance with pending ordinances	Reduction of 5,000 gallons/year	Reduced oil spotting on cleaned parts
Medium Fabrication (Rejected)	24-month payback period	No compliance issues	Reduction of 8,000 gallons/year	Elimination of wastewater treatment operations
Medium Machining (Rejected)	15-month payback period	Would have brought them into compliance with local POTW ordinances	Reduction in volume of 6,000,000 gallons/year & 90% reduction in BOD	Would significantly improve company's competitiveness

Notes: 1. Payback period is dependent on which of the chemicals in the 17 parts washers the technology would be applied to.
2. Wastewater reductions are based on only the two (out of a total of 17) parts washers where membrane filtration units were installed.

chemical usage and waste generation alone, capital invested in membrane filtration equipment at these facilities would be paid back within 7 to 26 months. Surprisingly, however, two of the five operations that enjoyed strong economic advantages—the fabrication facility (with a payback period of 24 months) and the medium-sized machining facility (with a payback period of 15 months)—chose not to adopt the technology.

In contrast, the small machining facility chose to adopt membrane filtration technology even though its payback period of 72 to 84 months was three times longer than that of any other facility. These data suggest that, while economic advantages are certainly important to technology diffusion, other factors are also important.

The Role of POTWs

Membrane filtration technology was capable of improving compliance with local POTW ordinances in four of the six cases studied. Three of these four (the automotive, stamping, and small machining facilities) needed the technology to help them improve compliance, and they ultimately adopted the technology. Although the medium-sized machining facility did not adopt membrane filtration technology, the need to comply with local wastewater discharge ordinances pushed them into aggressively evaluating a variety of alternatives for reducing their effluent discharges.

POTWs played an additional role as change agent aides in the case of the automotive plant and the medium-sized machining facility. These facilities approached POTWs for assistance with their waste problems because they perceived the POTWs to be experts in waste management issues. When contacted by these companies for information regarding how to best manage their waste problems, the POTWs referred them to WMRC for technical assistance.

The railroad facility chose to adopt membrane filtration technology even though they received no pressure from their local POTW. However, they adopted the technology in only 2 of the 17 locations within their operation that could potentially have used it.

The fabrication facility was not experiencing any compliance problems associated with their wastewater discharges; therefore, the local POTW did not influence their adoption/rejection decision.

Normally, adoption of P2 technologies is an "optional" decision and companies may choose to adopt or reject based on their perception of the technology's characteristics. However, our case studies suggest that POTW enforcement of pretreatment ordinances may add an "authoritative" element to the decision on whether or not to adopt the technology. The fabrication facility may have been more likely to adopt the technology, and the railroad facility might have implemented the technology more widely, if their local POTWs had been pressuring them toward improved compliance.

The Role of Vendors

Vendors of cleaning chemicals played significant roles in two of the six case studies. Chemical suppliers have been shown by Bierma and Waterstraat (1995) to be excellent sources of opinion leadership when trying to diffuse innovative technologies. They tend to have frequent contact with their customers over extended periods and are well positioned to earn customer trust.

At the railroad facility, the chemical supplier worked closely with WMRC scientists to resolve chemistry issues and facilitate implementation of the technology. This chemical supplier saw membrane filtration technology as a potential market opportunity—a service they could offer to customers. This supplier proposed to install and operate the membrane filtration equipment at the railroad facility and to continue supplying chemicals on a monthly fee service basis for basically the same cost that the railroad had previously paid for chemicals only. The vendor determined that it could provide the technology, along with whatever chemicals were needed, and still protect their profit margins. The railroad ultimately rejected the proposal because they believed they could secure more cost savings by implementing the technology themselves.

If the chemical vendor had been allowed to implement membrane filtration technology at the railroad facility, they could have reduced the perceived complexity of the technology and improved its compatibility with existing operating systems. However, purchasing chemicals as a service (instead of a commodity) necessitated a second innovation in the form of a chemical management contract. From the railroad's perspective, this was not compatible with existing systems for purchasing chemicals. In effect, for the railroad to accept the chemical vendor's proposal, they would have had to adopt two innovations (membrane filtration and chemical management contracts), which increased the level of uncertainty that the railroad would have to deal with.

The vendor determined that it could provide the technology, along with whatever chemicals were needed, and still protect their profit margins.

Despite this experience, it is clear that diffusing membrane filtration technology through chemical suppliers still represents an innovative approach for change agents. Instead of working with a single adopter at a time, change agents could encourage chemical suppliers to adopt the technology; these vendors, in turn, could use their status as trusted opinion leaders to promote the technology to their many customers.

It should be noted here that, while the railroad's chemical vendor was a strong proponent of membrane filtration, the sales representative for the fabrication facility was not. In fact, he did everything within his power to discourage the adoption of the technology. He perceived membrane filtration as a competitive substitute for the products he was selling. Consequently, he discredited the concept by falsely claiming that the equipment was not compatible with the chemistry of his products.

Waste Reduction as a Motivator

Anticipated reductions in the quantity of wastewater generated at the case study facilities appeared to have little impact on the decision to adopt. Of the six cases evaluated, three—the automotive plant, the railroad facility, and the medium-sized machining operation—were generating by far the most wastewater. However, only the automotive facility fully implemented the technology.

The improved cleaning performance experienced by the small stamping and machining facilities was certainly an important factor, but it probably did not "make or break" their adoption decision.

On the other hand, the small stamping and machining facilities implemented the technology even though they were generating only a fraction of the wastewater quantities discharged by the larger facilities. This suggests that advantages associated with compliance and economics are regarded as more important by potential adopters than benefits related to the sheer volume of waste reduction.

Impact of Other Membrane Filtration Advantages

It remains unclear whether other advantages offered by membrane filtration impacted the companies' decisions to adopt or reject the technology. The improved cleaning performance experienced by the small stamping and machining facilities was certainly an important factor, but it probably did not "make or break" their adoption decision.

The automotive and railroad facilities anticipated reductions in labor costs associated with draining and recharging chemical tanks, but these costs were lumped with other cost-saving advantages, such as reduced chemical usage and reduced waste treatment costs.

In the case of the fabrication facility, even the potential for eliminating their wastewater treatment system did not provide enough motivation to adopt the technology.

Similarly, in the case of the mid-sized machining company, even the fact that adoption of the technology could have significantly improved the company's market position was not enough to influence them to adopt. However, it is questionable whether this facility's management truly understood the potential impacts of the technology; key personnel responsible for evaluating the technology left the company at an inopportune time, and WMRC failed to establish adequate communication channels with other influential company personnel prior to the company going out of business.

Barriers to Membrane Filtration Adoption

Chemical recycling technologies are not common to most facilities that fabricate and maintain metal parts and machinery. Consequently, virtually all of the facilities examined in the case study project viewed membrane filtration as a relatively complex technology that might not be compatible with their existing processes.

In the four facilities that adopted the technology, WMRC worked effectively with company personnel, chemical suppliers, and equipment vendors to provide them with the "how-to" knowledge they needed to resolve issues associated with chemical and equipment performance. Additionally, the four operations that adopted membrane filtration were able to modify existing processes and procedures to make the technology compatible with their operations. In the two facilities that chose not to adopt the technology, issues regarding complexity and compatibility persisted.

Exhibit 4 shows the relative effectiveness of WMRC change agents in their efforts to address the "innovation" characteristics of membrane filtration. As shown, efforts to demonstrate the technology allowed facility personnel to observe the

Exhibit 4. Results of WMRC Change Agent Efforts to Address Membrane Filtration Innovation Characteristics

Company	Innovation Characteristics*			
	Compatibility Issues	Complexity Issues	Trialability	Observability
Large Automotive (Adopted)	Resolved	Resolved	Successful Pilot	Successful Demonstration
Large Railroad (Partially Adopted)	Resolved in areas tested	Resolved in areas tested	Successful Pilot	Successful Demonstration
Small Stamping (Adopted)	Resolved	Resolved	Successful Pilot	Successful Demonstration
Small Machining (Adopted)	Resolved	Resolved	Successful Pilot	Successful Demonstration
Medium Fabrication (Rejected)	Not compatible with chemical supplier recommendations	Unresolved issues with cleaning chemicals	Pilot terminated early due to equipment problems	Successful Demonstration
Medium Machining (Rejected)	Not compatible with existing chemical management strategy	Unresolved issues with incorporation in plant	Successful Pilot	Successful Demonstration

Note: *Advantage characteristics are addressed in Exhibit 3.

technology's characteristics first-hand in their own operations. Dirty solution was placed in the system and clean solution permeated through the membrane. Virtually all personnel that witnessed these demonstrations and trials were impressed by the technology's ability to remove contaminants from the solution.

The relatively successful pilot trials conducted at the four facilities that ultimately adopted the technology allowed on-site personnel to adequately resolve issues of compatibility and complexity. In the case of the two companies that declined to adopt the technology, however, problems and issues arose that could not be overcome to the satisfaction of the facility. At the fabrication facility, the pilot trial was shortened due to equipment problems associated with overheating. This factor, combined with compatibility and complexity issues brought up by the chemical supplier, ultimately led the company to reject membrane filtration technology. In the mid-sized machining facility, the pilot trials showed that the technology was technically capable of recycling the key chemical. However, some issues regarding how to fully implement the equipment within existing processes were never resolved.

The Importance of Innovation Champions

The factor that appeared to be most significant with respect to encouraging companies to adopt or reject membrane filtration technology was the presence or absence of an effective innovation champion. Each of the four facilities that adopted the technology possessed an effective innovation champion with enough influence and motivation to push the technology into the facility's core business. When issues surfaced regarding the technology's complexity or compatibility, these individuals took it upon themselves to work with personnel from their operations, and with vendors and WMRC personnel, to successfully resolve the problems. The two facilities that rejected the technology did not have effective innovation champions on-site.

This phenomenon raises some important questions about whether innovation champions find problems, or problems find innovation champions.

In other words, do circumstances such as high chemical and waste disposal costs and POTW compliance problems grab the attention of key individuals who become champions in search of innovations that will solve the problems? Or do people who are already innovation champions proactively scan their operations looking for opportunities to implement new technologies? Answers to these questions could significantly influence the development of strategies to diffuse P2 technologies. It is probable that the first scenario occurs more frequently than the latter. Both, however, probably occur regularly.

The importance of individual innovation champions tends to be magnified by the lack of institutionalization of P2. Very few external regulations exist that require pollution prevention planning or implementation at facilities. Additionally, most of the organizations involved in the P2 diffusion process (including end users, equipment vendors, and chemical vendors) have not incorporated P2 into their core business. As a result, the P2 diffusion process remains vulnerable to the preferences, authority, and schedules of key individuals—who cannot be counted upon to maintain their interest for extended periods of time. Moreover, personnel tend to change frequently within industrial operations—as do the economic and other market factors that influence innovation. Consequently, P2 diffusion tends to be inconsistent and unpredictable.

While the economic aspects are important, other factors, such as complexity, compatibility, observability, and trialability, are equally significant.

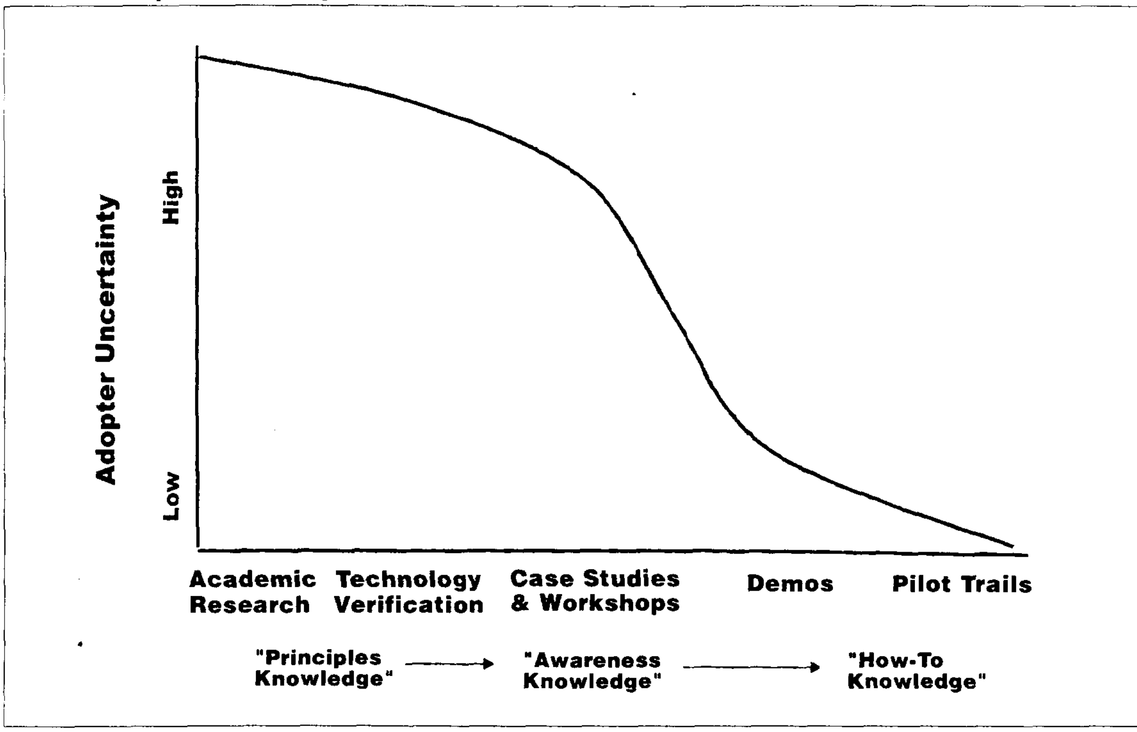
Until P2 can be institutionalized through regulatory requirements and/or incorporation into corporate cultures, its diffusion will likely continue to occur very slowly.

Summary of Key Points

The data collected in the projects reported here reveal some useful points regarding companies' decisions to adopt or reject innovative P2 technologies. A summary of the key points is provided below:

- *Awareness information alone does not lead to P2 adoption.* None of the 47 companies that received only "awareness" information (such as fact sheets, case studies, and workshops) ultimately adopted the technology.
- *Economic advantages may not be enough to "sell" P2.* While the economic aspects are important, other factors, such as complexity, compatibility, observability, and trialability, are equally significant.
- *P2 technologies often are perceived as technically complex and potentially incompatible with existing operations and values.*
- *Pilot trials reduce uncertainty.* Our study results indicate that, through pilot trials, facilities' uncertainty regarding a P2 technology's complexity, compatibility, and economics can be reduced to the point where 60 to 80 percent of the companies will adopt the technology. The "hands-on" experience of working with the technology during pilot trials allows companies to resolve crucial issues and develop a strong understanding of the equipment's operation and capabilities.
- *Innovation champions are extremely important.* Critical to P2 adoption success at any facility is the presence of an innovation champion who has sufficient influence to deal with doubters and address obstacles when they occur. Since P2 has not been institutionalized within most companies, the P2 diffusion process remains dependent on the interest of key individuals who are willing to promote it within their companies. As a result, the diffusion of pollution prevention ideas and technologies remains inconsistent and unpredictable.
- *Regulatory factors can improve P2 adoption rates.* Regulators (including POTWs) can influence P2 adoption by (1) adding an "authoritative"

Exhibit 5. Adopter Uncertainty Reduction



element that creates urgency for companies to take action, and (2) identifying P2 opportunities and referring companies to sources of technical assistance.

- *Chemical vendors can promote or obstruct P2 adoption.* In our case study project, one chemical vendor actually attempted to adopt the technology and provide it to their customers on a service basis, while another vendor effectively discredited the technology because they perceived it to be competition.
- *Vendors provide a unique opportunity for P2 diffusion.* Some P2 technologies are closer to a vendor/supplier's core business than a manufacturer's. Therefore, it may make more sense for some P2 technologies to be provided to manufacturers on a service basis by qualified vendors. This would reduce compatibility/complexity issues associated with the manufacturer's technical uncertainty. The vendors would also be able to optimize technology performance with respect to their specific chemical products. Additionally, this arrangement would allow P2 change agents to more efficiently promote innovative technologies: When these change agents encourage vendors to adopt P2 technologies and provide them to numerous customers on a service basis, the change agents no longer have to promote P2 "one company at a time."

The Role of Government in Pilot Trials

The results of the research reported here suggest that current methods for delivering P2 technical assistance to companies need to be modified to include more emphasis regarding how to implement specific technologies. One way to do this is through effective demonstrations, followed by extended pilot trials performed on-site.

Unfortunately, many of the "pilot trials" available to companies are sponsored by vendors and consultants. They frequently are not effective at promoting innovative P2 technology adoption, for several reasons. First, vendors often are perceived as biased by their customers, who then tend to discount the evidence of the pilot trial. In addition, vendors often lack the technical resources to perform pilot trials that can prove the technology's effectiveness on a site-specific basis.

The pilot trials reduce uncertainty regarding the technology's compatibility with existing operations, and lessen the perceived technical complexity associated with the technology.

Moreover, site-specific pilot trials of technologies tend to be very costly. Vendors try to avoid incurring the cost of extensive technical assistance because they can't be sure their customers will adopt the technology even after it has been successfully demonstrated. End-users try to avoid incurring the cost of extensive technical assistance because they are not sure if the innovation will actually perform at levels that will support vendor claims.

Consultants frequently are not certain that innovative technologies will perform according to a manufacturer's specifications. As a result, they tend to fall back on "time-tested" pollution control technologies.

This type of "market failure" is common to many innovative technologies. When it occurs, government needs to become involved to fill the gaps.

Government P2 assistance providers could benefit from using the "ADOP²T" (accelerated diffusion of pollution prevention technologies) model developed by WMRC and described in a previous issue of this journal (Lindsey, 1999). This model offers mechanisms for addressing many of the deficiencies of other P2 technical assistance models. ADOP²T includes a sequential process for identifying best practices, and for executing both brief demonstrations and extended pilot trials of these practices at the facilities of the sector's opinion leaders. The pilot trials reduce uncertainty regarding the technology's compatibility with existing operations, and lessen the perceived technical complexity associated with the technology. Once the opinion leaders have adopted the technology, their peers must consider implementing the technology to stay competitive. Exhibit 5 illustrates how adopter uncertainty can be decreased through research, demonstrations, and pilot trials that provide the technical details and "how-to" information required for technology adoption.

Conclusion

The "hands on" P2 technical assistance methods proposed in this article may appear new and different compared with most existing models, which rely heavily on the provision of "awareness" information. However, they are really just a new twist on an old adage: Tell me . . . I forget. Show me . . . I remember. Involve me . . . I understand.

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