

The Introduction of Postconsumer Recycled Material into TYVEK®

Production, Marketing, and Organizational Challenges

Mark Sharfman, Rex T. Ellington, and Mark Meo

Keywords

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Summary

In the late 1980s, with the advent of increased consumer environmental awareness, DuPont faced a challenge with its TYVEK® family of nonwoven polyethylene textile products. TYVEK is used in a wide variety of applications ranging from house wrap to medical packaging. One of the most visible portions of the business is envelopes used by FedEx (previously known as Federal Express), the well-known courier and delivery service and by the U.S. Postal Service. As early as 1988, end users began asking questions about the environmental characteristics of TYVEK envelopes. As these questions increased, DuPont began to address the concerns directly. In response to the market's concern and because of the increased availability of postconsumer-recycled (PCR) polyethylene, DuPont decided to put PCR polyethylene into TYVEK, beginning with the envelope business. Further, DuPont developed a recycling infrastructure for TYVEK because, although TYVEK consists entirely of high-density polyethylene, which is highly recyclable, no infrastructure was in place to recycle the material. These decisions produced a wide variety of technical and organizational challenges the firm had to overcome. This case study examines how DuPont made these choices and overcame the difficulties created by implementing needed changes. Whereas the envelope market for TYVEK embraced PCR polyethylene, other product markets resisted the innovation. The article closes with a discussion of the lessons learned from DuPont's experience.

Address correspondence to:

Mark Sharfman
Michael F. Price College of Business
Division of Management
University of Oklahoma
307 W. Brooks, Room 206
Norman, OK 73019-0450, USA
Msharfman@ou.edu
<http://www.ou.edu/spp>

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Introduction

As early as 1988, DuPont began to get questions from its end users regarding the environmental characteristics of TYVEK® its family of nonwoven polyethylene textiles. These questions ranged from “Is it biodegradable?” to “Is it recyclable?” At the time, the company had never been asked these questions and, consequently, had never developed any responses.

In the early 1990s, the rate of environmental questions to DuPont increased because the U.S. Postal Service (USPS), one of DuPont’s largest end users¹ of TYVEK, began to pose them as well. The USPS increased its interest in the environmental characteristics of TYVEK because of the U.S. Environmental Protection Agency’s (U.S. EPA’s) purchasing guidelines at the time on material reduction, reuse, and recycling. TYVEK use allowed the USPS to reduce energy costs because the use of the material in envelopes meant lighter envelopes than comparable designs using competing materials. Lighter envelopes meant less fuel costs to transport the mail. These guidelines, however, also pushed the USPS to look at the recyclability of TYVEK. If TYVEK did not meet the U.S. EPA guidelines, the USPS would be forced to consider alternative envelope material.

FedEx (previously known as Federal Express), the prominent courier and delivery service, is another major end user of TYVEK. Although not under the stricture of federal government purchasing guidelines, as early as 1990, FedEx was getting pressure from its customers regarding the environmental characteristics of its packaging materials. FedEx, in turn, made it clear to DuPont that unless the product changed, they might well take their business elsewhere (e.g., to other spun-bonded products made from polyethylene, such as the envelopes used by the competing courier service Airborne). The combined threat from the USPS and FedEx got DuPont’s attention because the two were among the TYVEK business unit’s largest end users.

Because TYVEK is essentially pure polyethylene, one might think it would have been easy to accommodate these customers, given the massive volume of postconsumer polyethylene in the recycling stream. Unfortunately, it was not. In the remainder of this case study we describe

the processes by which DuPont introduced postconsumer-recycled (PCR) polyethylene into TYVEK. We also discuss the recycling infrastructure DuPont developed for TYVEK. First, we describe TYVEK and its applications. We then give an overview of DuPont’s recent corporate environmental history and policies. These policies provided the context within which the TYVEK decisions were made. Next, we discuss the specific context within which the TYVEK business unit operated and discuss how PCR polyethylene was introduced into TYVEK envelope stock. We then examine the dynamics of trying to introduce PCR polyethylene into other TYVEK product lines and the process by which DuPont developed the TYVEK recycling infrastructure. We conclude with a discussion of the challenges facing the TYVEK business unit and the lessons we learned from our study.

What Is TYVEK?²

TYVEK has been manufactured and converted into industrial or consumer products since 1967. It is a continuous-fiber form of high-density polyethylene (HDPE, the plastic in most milk bottles), which is composed of carbon and hydrogen, and is called a spun-bonded olefin. The polymer contains typical polyolefin processing additives, each of which is present at a weight concentration of less than 1.0%. Using heat and pressure only, the polymer is pressed into a continuous roll format that DuPont distributes to various customers for processing into TYVEK products. Some types of TYVEK are coated with an antistatic agent for use in printing applications. Because TYVEK, according to DuPont’s proprietary data, is essentially pure polyethylene, it can be recycled along with other polyethylenes (e.g., milk bottles) or be safely disposed of by incineration insofar as the products of complete combustion are carbon dioxide and water. Burning TYVEK completely is rather simple because it has a relatively low ignition point and essentially the same heating value as the hydrocarbons used to make it. During combustion, any additives are completely incinerated, according to DuPont’s proprietary test data.

Postindustrial TYVEK scrap or postconsumer TYVEK can be recycled for extruded applica-

tions such as plastic lumber if the TYVEK has not been contaminated with any toxic material and has been shredded or ground into pellets (pelletized). As a nonwoven textile, virgin TYVEK is used in a wide variety of products such as envelopes of various sizes and uses, topographic maps, banners, fabrics (e.g., apparel and covers for a range of activities from nonhazardous, dirty jobs to hazardous, dry-particulate protection), protective house wrap, and as packaging material for medical products.

The Environmental Context at DuPont

Given that the impetus behind this case was the environmental characteristics of TYVEK, understanding how the environment fits into decision making at DuPont will help the reader understand the choices we are about to discuss. Environmental stewardship currently provides a pervasive context for decision making at DuPont. Chad Holliday, the company's current chief executive officer, was quoted as saying, "In five years' time, people will not see DuPont as a chemical company but as an environmental company" (Goodman 1998, 19). Over the years, the role of the environment in corporate decision making at DuPont had gone through a pronounced evolution. As Goodman (1998, 18) suggested, the environmental perception of DuPont by the public "has swung over the decades from green pariah to eco-hero." On one side, the company has been the target of scathing attacks on its environmental performance (e.g., Friends of the Earth 1989) and named one of the country's most dangerous polluters (e.g., Montage 1990). In addition, throughout the early 1990s, the company was regularly listed as the nation's largest emitter of U.S. EPA Toxic Release Inventory (TRI) chemicals. The high volume of TRI emissions colored the public's perception of DuPont's environmental efforts. By some accounts, the firm's sheer volume of emissions overshadowed the fact that the low relative toxicity of these emissions should have placed DuPont much lower on the top polluters list (cf. Horvath et al. 1995) than their TRI ranking would suggest. On the other hand, DuPont regularly receives awards for its environmental ef-

forts. Following are some recent examples of such awards:

- 1998 Keep America Beautiful Vision for America: Automotive. DuPont was presented with a merit award recognizing their initiation of the Carpets to Car Parts recycling program that annually turns 27 million feet of used commercial carpeting into resin for air cleaners.
- 1998 Most Valuable Player: Corporate. The National Pollution Prevention Roundtable awarded DuPont's pollution prevention manager, Ed Mongan, their MVP award for building relationships between business groups and the National Pollution Prevention Roundtable.
- 1998 Texas Natural Resource Conservation Commission Clean Texas 2000 Award. DuPont's LaPorte, Texas, plant won this environmental excellence award for the most significant contribution to reducing toxic emissions among large industries in the state.
- 1997 Industrial Energy Technology Conference Award. This award was given to DuPont's corporate energy leadership team.
- 1996 Keystone Center Award. DuPont was recognized for its ambitious environmental goal of zero wastes and emissions.
- 1996 Arthur Page Society Merit Award. DuPont received this award for its communications program to educate about the phaseout of chlorofluorocarbons.
- 1995 U.S. EPA/McGraw-Hill 33/50 Environmental Champions Award. DuPont was recognized as an "environmental champion" by the U.S. EPA and the McGraw-Hill Company because of its voluntary reductions of waste and chemical releases.

Despite the company's huge effort to reduce the impact of the negative publicity it has received, it faces an ongoing public relations battle. As such, decision making at DuPont has been shaped by both the firm's internal environmental policies and the perceptions of the company's environmental performance.

DuPont traces its formal corporate commitment to the environment to Edgar Woolard's first

public speech after becoming chief executive office in 1989. In this speech, which he delivered to the American Chamber of Commerce in London, England, Woolard made a corporate "commitment to cut production of hazardous waste and to give pay raises to managers who show awareness of environmental matters" (DuPont in environmental move 1989, 26). Woolard also said "chemical groups might sometimes have to sacrifice costs in the drive to show better environmental performance" (DuPont in environmental move 1989, 26). Prior to 1989, although DuPont had always been committed to efficient production, environmental considerations had not been a formal part of the company's planning process.

The following statement from DuPont's annual environmental report clearly spells out the firm's commitment. This statement has appeared in every DuPont environmental progress report since 1994.

We affirm to all our stakeholders, including our employees, customers, shareholders and the public, that we will conduct our business with respect and care for the environment. We will implement those strategies that build successful businesses and achieve the greatest benefit for all our stakeholders without compromising the ability of future generations to meet their needs. (DuPont 1999a)

Goal of Zero Waste and Emissions

The firm's environmental commitment is underscored by the goal of zero waste and emissions.

We will drive toward zero waste generation at the source. Materials will be re-used and recycled to minimize the need for treatment or disposal and to conserve resources. Where waste is generated, it will be handled and disposed of safely and responsibly. We will drive toward zero emissions, giving priority to those that may present the greatest potential risk to health or the environment. Where past practices have created condi-

tions that require correction, we will responsibly correct them. (DuPont 1999a)

For DuPont, the commitment to zero waste and emissions is manifested through concrete steps. Chad Holliday described examples of those steps in the 1999 DuPont Environmental Progress Report:

Our environmental progress continues in most areas. Global air toxics are down 64 percent and global air carcinogens are down 87 percent from a base year of 1987. Greenhouse gas emissions (on a carbon dioxide equivalent basis) are down 39 percent since 1990 and we completed our first sale of emission reduction credits in Canada. Global hazardous waste has been reduced by over 30 percent since 1990 during a period when total production increased by over 28 percent. In the United States, the numbers we report to the U.S. Environmental Protection Agency for the Toxics Release Inventory (TRI) are down on an "as released" basis by 67 percent since 1991 but were only slightly lower than last year. However, we expect additional reductions in the next few years as we complete several large projects in Texas. (DuPont 1999b)

Tables 1–5 detail the specifics of these reductions.

In summary, DuPont faces a difficult challenge. Historically, the company has been a major emitter of TRI chemicals, sometimes the country's largest. This dubious distinction created the perception of the firm as a major polluter in the minds of many consumers. From another perspective, however, one sees in DuPont a firm that is working toward a companywide commitment of zero emissions. Among the many factors that drove this choice were market forces, costs of pollution, publicity concerns, and a growing sense at the highest levels of the firm that better environmental performance was simply the right thing to do. The application of the companywide commitment varies, as one would predict in one of the world's largest firms. Nevertheless, the

Table 1 DuPont worldwide greenhouse gas emissions*

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Carbon dioxide	38	36.4	34.8	35.6	37.2	38	44.5	37.2	37.2
Nitrous oxide	112.5	110.6	106.8	85.9	95.5	97	100.8	64.5	57.5
HFCs, PFCs	41.3	47.7	45.3	46.9	66.4	56.6	73.6	56.6	60.7
Other (includes CFCs, HCFCs)	76	72.8	53.4	50.2	40.5	30.8	17.8	14.6	8.9
Total	267.8	267.5	240.3	218.6	239.6	222.4	236.7	172.9	164.3
Total, Kyoto basis	191.8	194.7	186.9	168.4	208.8	191.6	218.9	158.3	155.4

Source: DuPont (1999c). Used with permission.

*Figures are billions of pounds of carbon dioxide equivalents, includes CFCs.

Table 2 DuPont worldwide global air toxics and carcinogenic air emissions*

	1987	1991	1992	1993	1994	1995	1996	1997	1998
Air toxics	68	53	41	29	32	32	29	26	24.5
Air carcinogens	9.1	5.7	4.7	3.6	3	2	2.2	1.6	1.2

Source: DuPont (1999c). Used with permission.

*Figures are in tons.

Table 3 DuPont worldwide hazardous waste generation*

	1990	1995	1996	1997	1998
Canada	5.1	1.8	1.8	2	2.7
Europe	120	50	48	49	33
Mexico	197	198	141	179	252
South America	7.7	6.9	0.9	1.2	0.9
Asia/Pacific	6.8	1.1	1.2	6.1	24.3
United States	2,414	2,024	2,051	2,027	1,596
Total, all regions	2,750.6	2,281.8	2,243.9	2,264.3	1,908.9

Source: DuPont (1999c). Used with permission.

*Figures are in millions of pounds.

data clearly indicate that the firm has made major strides toward its environmental goals and is attempting to take an environmental leadership role in many of its industries. In the face of these conflicting political and social currents, when the firm engages in a strategic effort where environmental performance is a major component, it does so in a difficult context. We next examine how DuPont made a specific strategic choice to address environmental concerns in one of its markets.

Introducing PCR Polyethylene into TYVEK³

The Envelope Business

The road that took TYVEK into PCR polyethylene started at a trade show. The following is part of an interview with Debra August, account manager for TYVEK Envelopes:

It was the late 80s, and one of the places that our envelope business exhibits is the

Table 4 DuPont releases and transfers in the United States of U.S. EPA Toxic Release Inventory chemicals*

	1987	1993	1994	1995	1996	1997	1998	1987–1998	1997–1998
	Releases							% change	% change
Air	67.6	28.9	31.5	31.9	24.3	22.4	19.2	– 72%	– 14%
Water	2	3.5	0.9	3.8	6	8.1	9.6	380%	19%
Land	1.4	0.3	0.5	0.9	0.4	0.7	0.1	– 93%	– 86%
Deepwell disposal	236.8	172.5	170	49	37.2	50.7	46.7	– 80%	– 8%
Total releases	307.8	205.2	202.9	85.6	67.9	81.9	75.6	– 75%	– 1%
	Transfers							% change	% change
Off-site	23	61	59	62	53.6	53.3	43.9	91%	– 18%
Publically owned treatment works	12.6	2.1	1.1	1.3	1.1	0.9	0.7	– 94%	– 22%
Total transfers	35.6	63.1	60.1	63.3	54.7	54.2	44.6	25%	– 18%
Total releases and transfers	343.4	268.3	263	148.9	122.6	136.1	120.2	– 65%	– 12%

Source: DuPont (1999c). Used with permission.

*Figures are in millions of pounds.

Table 5 DuPont waste in the United States as generated*

	1991	1993	1994	1995	1996	1997	1998	1991–1998	1997–1998
	Releases							% change	% change
Energy recovery on-site	245.6	205.7	203	85	69.9	84	77	– 69%	– 8%
Energy recovery off-site	69	56.2	56.1	45	65.5	50	53	– 23%	6%
Recycled on-site	16.4	18.7	13.4	13	16.6	18	13	– 21%	– 28%
Recycled off-site	177.7	41.1	15.7	15	45.5	86	140	– 21%	63%
Treated on-site	21.3	18.7	22.8	26	22.7	21	10	– 53%	– 52%
Treated off-site	341.5	409	345	381	244.1	258	272	– 20%	5%
One-time release	17.4	25	22.4	24	13.6	12	20	15%	– 66%
Total waste as generated	0.6	0.5	1.3	0.04	0.2	0.03	0.05	– 92%	– 66%
Total waste as generated	889.5	774.9	679.7	589.04	478.1	529.03	585.05	– 34%	11%

Source: DuPont (1999c). Used with permission.

*Figures are in millions of pounds.

Postal Forum, which is sponsored by the U.S. Postal Service. The trade show includes educational business sessions and exhibit displays on mailing products and services. This format provides us the opportunity for direct interface with the end user. So, I remember standing at a booth in San Francisco, probably in 1988, and having someone come up and for the very first time ask me, “Is TYVEK biodegradable?” That was the key question: Is TYVEK biodegradable? It was such a foreign question to me that I

didn’t have a response for him. I didn’t understand the implications of the question.

That simple question, “Is TYVEK biodegradable?,” set off the entire chain of events that led to the introduction of PCR polyethylene into the manufacture of TYVEK. August continued:

So, the first thing we realized was that consumers didn’t know it [TYVEK] was 100% plastic, and we were concerned that they’d find out, because plastics were not “socially acceptable” at that time pe-

riod. The business had thrived for a long time without having to even define the product, as it were. We could describe it as a “specialty material,” and it was never questioned. At the same time, we had two significant users of TYVEK envelopes, Federal Express and the U.S. Postal Service, that were both very visible to the public. With FedEx, here is a company that since their inception over 25 years ago has specified TYVEK for high-strength envelopes. Now, they were beginning to get questions from their customers about TYVEK, like “What is this stuff made of?” and “If I want to recycle it, how do I do that?” Recycling was an especially tough question because, certainly at that time, the plastic recycling infrastructure was just being developed. This posed a challenging situation to DuPont: FedEx’s customers had increasing sensitivity to environmental issues, and FedEx asked us to help answer questions about their packaging. Here you have a very important customer asking us to respond to their customer base. . . . We’re very close with Federal Express, and they asked for our help.

FedEx was not the only source of questions concerning the environmental characteristics of TYVEK. According to August and other interviewees, many other end users were asking similar questions of DuPont or the distributors and converters of TYVEK. This accelerated the pressure on the business unit. August continued:

We had questions here we couldn’t answer, [including] “how are we going to position this product now?” So, we looked at our product, first of all, because by then, of course the U.S. EPA had set out its guidelines “Reduce, Reuse, Recycle” . . . and so we looked at the product from a “reduced” standpoint, clearly, this is the classic case of resource reduction. . . . We knew TYVEK was lighter weight than any comparable packaging and mailing material because we had been advocating that for years, and everyone knows that and believes that

because it is obviously easy to test. . . . You have TYVEK replacing paper, and TYVEK is lighter than the paper. But, then you even had lighter weight TYVEK replacing heavier weight TYVEK. The U.S. Postal Service had been using one style of TYVEK. It was a 20 lb. TYVEK, as an example, and part of their directives at the time was to reduce their packaging, and that was even before the executive order had been signed by Clinton [1993 Executive Order 12873 mandating federal purchase of products with recycled content]. This is back when they were just source reducing for documentation sake. So, they actually reduced the type, the size, or the weight of their packaging to a 14 lb. TYVEK, documented a source reduction [weight savings], and calibrated that back to a fuel savings.

The first response of the TYVEK business unit to the environmental questions the unit received was to form a team to study the problem. This team explored a variety of options and alternatives. They quickly realized the need to introduce PCR polyethylene into TYVEK. Again, August summarized the clear message DuPont was getting from its envelope customers and end users.

If we put the postconsumer recycle content in the product, then that is the environmental value that takes away some of the environmental concern . . . for the person that uses TYVEK. . . . From an environmental perspective it is a psychologically better product.

August continued to describe the strategic wisdom about the product:

We have all these good attributes with TYVEK, and we didn’t want any environmental negatives. The interesting thing about it was that even though there wasn’t a huge public outcry and FedEx was getting only one or two inquiries a week, it was enough to attract everyone’s attention. The fact was that FedEx was under scrutiny and we decided to help them do something about it. This

was ahead of the regulations . . . ahead of the paper guidelines for postconsumer recycle content.

In 1990, the business unit set up a structure to address the problem. Although no one person was specifically assigned to the task, Dave Scarborough, business planning manager for TYVEK, became the focus of the efforts. He began an informal liaison with the U.S. EPA on the project as well as with other groups inside and outside the company. Within the TYVEK unit, however, the envelope business drove the effort. This business had the most concern and had to face the challenge most directly.

The team met over a two-year period. Much of the team's work was done in three subcommittees: marketing, technical (engineering), and manufacturing. In addition, because the introduction of PCR polyethylene was going to reposition TYVEK in the market, the business unit's advertising agency, Young & Rubicam, was involved from the very beginning. It became evident early on that the success of the project would hinge on how well the subcommittees understood the problem and worked together to solve it. Scarborough summed the problem up as follows:

We positioned it [the environmental concerns] as a marketing driver that this business was at risk. The single largest piece of TYVEK business in the world is at risk unless we deliver the 25% postconsumer-recycle content. . . . What we didn't want to do is lose one pound of business or not be able to do business, and indeed, if we could do it, [we wanted to] get additional business by participating in a responsible way.

The TYVEK staff recognized the problem, but that did not mean that the solution came easily or quickly. The first major obstacle was a conflict between marketing and production. August described the first meeting with the production people:

They went ballistic. No, they didn't go ballistic because they couldn't even deal with the concept of putting a foreign substance (used milk jugs) into a top-

quality, pure, 100% high-density polyethylene product.

DuPont prides itself on the quality of its products. In the case of the TYVEK business, the manufacturing unit had spent more than two decades perfecting the TYVEK production process and, according to DuPont's in-house data, reaching the industry's highest level of average outgoing quality. The manufacturing unit could not conceive of any reason why recycled material had to be included in their pure, high-quality product. After the initial fireworks, production reacted by simply saying "No." Therefore, the toughest marketing task was gaining the support of the production personnel. Because of the decentralized nature of the market segments and the autonomy that each unit had, the fact that production was not in favor of the request meant that the envelope business could not push ahead unilaterally.

A strategy of perseverance gained the cooperation of the production staff. Although the production personnel continued resisting, the team and, particularly, the technical staff at the Richmond, Virginia, plant gradually wore down the production staff simply by facing the pressure and continually showing the production people the positive data from the tests that had been run. The technical team was thorough. They examined the effects of the introduction of PCR polyethylene on both the production process and on the performance characteristics of TYVEK. In terms of both process and performance, TYVEK with PCR polyethylene was equal to virgin TYVEK.

Gaining the cooperation of the production personnel was just the first hurdle to overcome. In fact, getting their cooperation only signaled the start of the real difficulties to come. Although there were literally thousands of tons of low-cost high-density polyethylene (HDPE) in the recycling stream, virtually all of it was dirty. Much of the cleanest HDPE in the recycling stream came from milk jugs because these were often segregated in the recycling process. Even within this rather homogenous input stream a wide range of contaminants was present, including the label, the label's glue, dried milk, plus dust and dirt from the recycling bins. Given the

refined nature of the TYVEK-production process, even minute amounts of contaminants could ruin an entire batch. The task was daunting. The following excerpt is from an interview with John Lazare, technical marketing specialist for TYVEK:

We had spent many years in TYVEK saying we needed a very specific polymer that had a molecular weight distribution like this, and otherwise the stuff was not going to go through our process. . . . It's very sophisticated how the process works, and we need this gold-plated kind of polymer, and now we're going to take something that was picked up off the street and could be almost anything in terms of different cuts of polymer that are used to make some of the plastics that ended up in the recycle stream. So, how are we going to put this in our process and then make a suitable product out of it?

At the time, much of the recycled HDPE was going into applications (e.g., plastic lumber, detergent bottles, etc.) where high purity levels were not much of an issue. As such, no supplier of high-purity PCR HDPE existed. DuPont attempted to work with both suppliers and the plastics trade associations to develop a supplier who could deliver the kind of PCR HDPE they needed. After a few unsuccessful alliances with vendors that could not provide either the quality or quantity of material necessary, DuPont was finally able to locate a supplier willing and able to work with them, a small recycler by the name of Enviro-Plastics.

Again, gaining an agreement was just the start of the problems. Then the technical problems surfaced. The desire for purity and quality had to be matched with the technical ability of the supplier to clean the HDPE stream. David Roberts, the key process engineer in the PCR HDPE effort, described what happened:

We put together a team to systematically analyze the cleaning process. We studied both the clean [accept] stream and the waste [reject] stream at each step of the process. We even worked with our sup-

pliers' recirculating water process to optimize final product quality. After solving the initial problems, a new one—polyester contamination—arose. The [milk] bottle producers increased their use of polyester film to cover their paper labels. The film maintains label readability by protecting it from condensate [water]. Some film stuck with the HDPE throughout the cleaning operations and subsequently plugged critical filters in the TYVEK process. Further change to the cleaning process ultimately eradicated polyester contamination.

With the amount and variety of contaminants in the recycling stream, the technical concerns focused on a variety of filter and filter cleaning problems. The technical team experimented with changing the filters and the filter sizes they used for screening at the end of the melt extrusion process. (The recycler first reduces the recovered HDPE plastic to flakes. The flaked plastics are then washed and put through melt extruders as antioxidants are added to the mixture. This mixture is then extruded through a fine mesh filter and emerges as pellets that can be used for a variety of products, depending on the purity level.)

The team experimented with 50-, 100-, and 120-mesh filters to find the proper size for cleaning the material. They found that the finer the filter, the more rapidly the filters broke as a result of contamination. In the end, DuPont and Enviro-Plastics, in figuring out how to produce high-quality PCR HDPE, learned several hard lessons and spent a large amount of money on extruders, better filters, and better washing systems to remove the labels. An unanticipated problem was that because the federal government mandated the use of nutrition labels, DuPont now had to remove an additional label, making cleaning the PCR HDPE flake even more difficult.

Even when the technical team believed a clean PCR flake was produced, further problems emerged when early rolls of PCR TYVEK were sent to printers. Much of the printing on TYVEK, particularly for envelopes, is done by offset lithography. This process uses sensitized

aluminum plates that transfer the ink and water-fill (water that limits the area to which color is applied) to a rubber blanket, which then imprints the TYVEK. As the TYVEK sheets went through the press, the blanket picked up little pieces of grit. Each time the blanket came around, it scratched the plate, causing further sensitization. At first, the technical team could not see defects in the printed areas. What was happening, however, was that these little pieces of grit got on the blanket and stayed. Every time the blanket came around, the grit moved just a little bit. The presses make approximately 8,000 impressions an hour. Every time the grit moved, it put a new scratch into the plate. Eventually a little track formed on the plate, causing fine squiggly lines on the printed material. When the technical team first discovered the defects, they were misled by the fact that these squiggly lines looked like fiber impressions. The team looked at the dampener rolls (the rolls in the press that control the dispersal of ink and water), which are usually fabric covered, thinking that fibers were separating from the rolls. A laboratory analysis, however, indicated that silicon was scratching the plate. The contaminant was sand. Given that the testing was done during the winter, it was assumed that the sand was from the roads and ended up in the recycling bins.

The technical team began further experiments with the filtering process. Although filtering eventually took care of most of the problem, not all the sand could be removed until the new PCR polyethylene cleaning process was introduced in 1998. After technical analysis at the time of the original problem, DuPont recommended that printers wipe off their blankets after every two rolls. DuPont's tests indicated that this practice would result in only a few pinpoint- to pinhead-size defects that could be seen only on extremely close inspection. In longer-term studies, inspectors never saw the problem, although the tracks were there. Asking printers to clean the blankets every two rolls was not a problem, because normally they do so each time they stop the presses to change and put a new roll on. Because of DuPont's emphasis on quality, the technical personnel found new ways to reduce contamination in PCR TYVEK to extremely low levels.

Another customer had an unanticipated problem with grit/sand. This firm purchased web-cutting machines to speed up the process of making floppy-disk sleeves. The machines' rotary die cutter was essentially a knife and an anvil. The DuPont technical staff discovered that the knives were wearing out very quickly because of grit in the PCR TYVEK. Further advances by the technical staff allowed the PCR polyethylene supplier to lower the level of grit down to essentially undetectable levels. A series of cooperative efforts with the supplier finally managed to overcome the obstacles that the dirty PCR presented. All of these cooperative efforts entailed direct technical and financial assistance from DuPont to the supplier. With the major technological hurdles surmounted, in 1992, DuPont was able to offer Federal Express TYVEK with 25% post-consumer recycled content. This material also met the preferred purchasing guidelines promulgated in 1993 by the U.S. federal government.

Broader Market Acceptance

The next problem came in the form of broader market acceptance. Although the key customers in the envelope market had requested the introduction of PCR TYVEK, several other industrial markets were either neutral or not in favor of PCR HDPE in TYVEK. Consequently, DuPont was faced with the problem of generating sufficient business from the envelope market to justify the investment in the new processes.

In the envelope business, particularly with FedEx and the USPS, a base of customers and end users that favored PCR TYVEK already existed. For FedEx and the USPS, the issue was getting PCR TYVEK to a level of quality sufficient for their needs. Despite this demand, a pricing problem remained. DuPont was faced with the problems of increased costs due to the addition of PCR TYVEK into the envelope stock and little ability to pass those costs on to its customers. The question became what to do in light of the market resistance to any price increase commensurate with the new cost structure. One option was to maintain separate PCR TYVEK and non-PCR TYVEK production lines and product lines. The concern was that if DuPont

offered both PCR TYVEK and non-PCR (virgin) TYVEK, customers would buy the cheaper non-PCR product all the time. If that occurred, the company would be unable to claim that TYVEK envelopes had 25% PCR content. DuPont had made the strategic commitment to PCR in all envelope TYVEK, so dual products were not an option because they would cause confusion in the marketplace and increase costs as a result of separate production lines.

Another strategy was to take advantage of the premium position TYVEK enjoys in the marketplace and institute modest price increases every year. TYVEK has a unique leadership position in the envelope industry, and as such, customers are already used to paying higher prices for TYVEK than they would for either paper or other types of plastic envelopes. This market leadership position already allowed DuPont to institute periodic, small price increases. Once the PCR HDPE had been added, as August put it, the rationalization for an initial price increase to the customers became something like, “Last year we offered PCR HDPE; it’s in all TYVEK envelopes. We aren’t charging a premium for this offering. We’re doing all this for your customers.” As such, small price increases became plausible at a time when perhaps otherwise, they would have been challenged. Efforts continue to recover the costs of using PCR HDPE through periodic, small price increases. Even with the ability to institute these small, regular price increases, there were pressures on the profit margins in the envelope part of the TYVEK business. This pressure provides ongoing incentives for the technical team to find cheaper, more efficient ways of both developing the feedstock and producing the PCR TYVEK. With the market leadership provided by FedEx and the USPS, the envelope business continues to grow and remain profitable.

The Other Markets

The transition to PCR TYVEK in the envelope market was generally smooth. This was not the case in the other three major markets: protective clothing, house wrap, and medical packaging. At the time of this writing, none of these markets have yet embraced the concept of PCR

TYVEK to anywhere near the extent that the envelope market has.

Much of the difficulty in getting PCR TYVEK into the protective-clothing market had to do with the structure of the market itself. Protective clothing with TYVEK is primarily used where protection from particulates is needed, such as in asbestos and lead abatement and in clean rooms in electronics and semiconductor manufacturing. DuPont works regularly with regulatory agencies such as the U.S. EPA and the U.S. Occupational Safety and Health Administration to advocate the use of TYVEK as protective clothing. Literally thousands of manufacturers, distributors/wholesalers, and retailers sell protective clothing. In an interview with Craig Wallentine, marketing manager for TYVEK protective apparel, he summarized the attitude toward PCR TYVEK in the protective-clothing market.

The general flow goes from roll goods to converters, to what I call the supply chain distributors, and to the end users who are actually buying it. That supply chain is critical. Now, compare that to the envelope market. They had one big customer, Federal Express and then the Postal Service, who said we want 25% PCR content, and therefore everybody in the value chain lined up and took that lead. You have a very, very fragmented marketplace here. There is no real channel commander, and that kind of signal does not come out of the marketplace.

The TYVEK protective-clothing market is also particularly price sensitive. DuPont surveyed end users as part of their assessment of whether to introduce PCR HDPE into the TYVEK used to make protective clothing. This assessment also examined purchase likelihood as a function of the price increases from using PCR TYVEK in protective clothing. As figure 1 shows, all of the end users expressed a great deal of interest in product made from PCR TYVEK—as long as the price did not increase. The figure shows that there was essentially a linear relationship between the decrease in predicted purchase interest and the magnitude of the expected price increase. Whereas the envelope market could

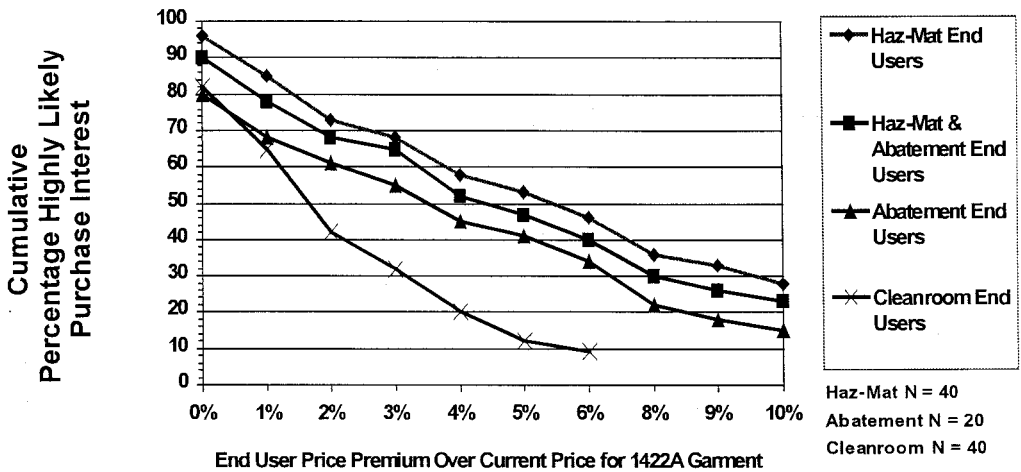


Figure 1 TYVEK PCR polyethylene in protective apparel end-user purchase interest for 25% PCR polyethylene TYVEK. Source: DuPont internal data, 1996.

withstand the modest price increases from using PCR TYVEK, it was clear from the data that the protective-clothing market would not.

Another source of resistance to PCR TYVEK in the protective-clothing market stems from the nature of inventory in the industry. As with any clothing industry, the distributor and retailer must stock different sizes of the same garment. In clothing-trade parlance, each garment or garment piece is called a stock keeping unit (SKU). DuPont's early market research suggested that most distributors would not switch to an all PCR TYVEK line. Rather, the data indicated that most TYVEK protective-clothing distributors would want to carry both PCR TYVEK and non-PCR TYVEK garments. An inherent problem came with carrying both garment types. Most protective garments come in seven different sizes and usually with a separate hood and boots. Each base garment then accounts for seven SKUs. The hood and boots each add seven more SKUs, bringing the total to 21 SKUs. This total further increases if the garment has detachable sleeves, booties, or other elements. A distributor carrying garment styles with several accessories could have more than 100 SKUs per style. Adding a PCR TYVEK version of a garment style would double the total number of SKUs for that style. DuPont realized that their distributors did not want to double the number of SKUs in inventory. Consequently, with no dominant force to

push for PCR TYVEK in the protective-clothing market, distributors had little incentive to carry PCR TYVEK garments.

Although no dominant firm in the supply/distribution chain exists, there still are two large, relatively homogenous end users. The first of these is the U.S. military. The military is one of the largest end users of protective clothing in the world, particularly for asbestos abatement. Given the properties of TYVEK, the military has specifications that favor this material in a large percentage of the protective clothing that they buy. That standard military specification (called a mil spec) is accompanied by test results that demonstrate the barrier properties of TYVEK. Mil specs posed a double-edged sword for DuPont. On the one hand, the mil spec is a barrier to competitive products. Because virtually no other product has TYVEK's characteristics, nothing can meet the mil spec in the way that TYVEK can. On the other hand, as Craig Wallentine noted, mil specs also pose an obstacle to use of PCR TYVEK:

The historical test data that was used to document particulate holdout [particulate resistance] for normal TYVEK did not exist [for PCR TYVEK]. So, we couldn't just go back in there and say, "Look, we give our word, we submitted our plan, we use the same process, and we believe it

has the same barrier, and all of our internal tests say it has the same barrier. They said, "You need to run the tests," . . . even though the people that sit on these ASTM committees said it was the same, and there's a guy in the military that sits on these committees, and he worked with our scientist, and they both knew there was no apparel test to demonstrate that [the properties were the same]. So, we have been working for the last two and a half years to get a new test method approved so we could show that our particle barrier [in PCR TYVEK] was the same as [for] old TYVEK.

Both DuPont and the military have an incentive to find a way to allow TYVEK to meet the mil spec for protective clothing. If the military endorsed PCR TYVEK for protective clothing, there would be two important consequences for DuPont. First, assuming that DuPont could convince distributors and suppliers to carry PCR TYVEK, the U.S. military would provide a large base of orders for protective clothing with PCR TYVEK. Even if companies manufacturing protective clothing were forced to produce both PCR TYVEK and non-PCR TYVEK lines, the quantity of PCR TYVEK clothing the military purchases would help meet the costs of producing it. Secondly, and perhaps more importantly, if the military switched to PCR TYVEK, a strong signal would be sent to the entire protective-clothing market. Although the signal would not match that sent by FedEx and the USPS to the envelope market, it would, nonetheless, confer some market legitimacy on PCR TYVEK protective clothing.

The military's strongest incentive for the use of PCR TYVEK protective clothing comes from the general push by the U.S. federal government toward more environmentally friendly purchasing. In 1993, President Clinton issued Executive Order 12873 (President 1993), which mandated that the federal government purchase products containing either recovered or recycled materials. Department of Defense (DOD) implementation of this policy requires the purchase of products manufactured from recovered material unless the price, performance, or delivery of the

product made the purchase infeasible. Although no definitive data exist to show this, the DuPont staff believed that the DOD has been slower than the USPS in changing to products containing recovered materials and is more likely to invoke the price, performance, and delivery exceptions; however, as the DOD feels more pressure to increase its compliance with the PCR material purchasing requirements, it will also perceive a greater incentive to use PCR TYVEK.

Another major barrier might block the creation of a mil spec for the use of PCR TYVEK in protective clothing. If the DOD creates a standard that implicitly or explicitly calls for TYVEK, DuPont will be perceived as a sole source—an anathema given the current state of federal purchasing. Also, regardless that several distributors exist that the military can buy from, none make TYVEK. Military procurement personnel have asked for the names of TYVEK's competitors (mainly polypropylene suppliers) to see if they will make a PCR product. Unfortunately, the polypropylene-recycling infrastructure is much less developed than that for recycling polyethylene. As such, PCR polypropylene products do not exist, and a lot of time and investment would be needed to create such products. Again, without market incentives, polypropylene companies are unlikely to invest the time and money toward producing PCR products. (It should be noted that DuPont virgin TYVEK enjoys a status close to sole source because no competing product has the same characteristics, although technically, competitors for TYVEK protective clothing do exist).

State and local governments are the other large end users of TYVEK protective clothing. In this customer segment, DuPont sees potentially more business for PCR TYVEK protective clothing. At the time we collected data for this case study, 30 states had guidelines that gave preference to paper products with recycled/PCR content, whereas 22 had guidelines that gave preference to recycled/PCR plastics. In addition, many cities and the U.S. Conference of Mayors have expressed interest in similar guidelines. These customers and potential customers could not provide the level of market leadership that the federal government could or that FedEx and the USPS do for PCR TYVEK envelopes, how-

ever, together they could generate sufficient demand to justify the development of PCR TYVEK protective clothing.

In the durable house wrap market, DuPont has had little interest from customers or end users in a PCR product. At present, there is no clamor in the construction industry about the environmental characteristics of TYVEK house wrap because it rarely ends up in the landfill. TYVEK house wrap is a relatively new product; therefore, homes constructed with it are generally still standing. When there is scrap after a job, it is easy to recycle should the builder wish to put it into DuPont's recycling system. Further, although various government agencies follow environmentally preferred purchasing guidelines for envelopes, fewer regulations exist in the construction trade. Without more customer and end-user interest or incentives to use PCR TYVEK the construction market will be slow to adopt it. Two factors, however, may increase pressure in the construction industry for PCR TYVEK. First, some government units and a few corporations (e.g., Herman Miller and Ford) have begun to build green and require environmentally friendly products in construction projects. Secondly, several industry groups (e.g., Green Building Council and American Institute of Architects) have created green building guides and specifications. As preferred purchasing and green building guidelines proliferate, pressure for PCR TYVEK house wrap is likely to develop.

TYVEK is also used extensively in the medical packaging field; its recyclability is one of the key reasons. Packaging waste is a major problem in the health care industry. The fact that TYVEK is now relatively easy to recycle (see the next section) makes it an attractive material. Because of concerns about sterility in medical packaging and U.S. Food and Drug Administration requirements, however, the company has encountered no customer demand for PCR TYVEK in the medical packaging field.

Toward Closing the Loop: Recycling TYVEK

Although much of the effort of the TYVEK team went toward the introduction of PCR TYVEK, the environmental properties of TYVEK

were still a concern for many customers and end users. As the reader may recall, the PCR TYVEK project started in response to questions about whether TYVEK is biodegradable or recyclable. Although TYVEK is not biodegradable, the team felt pressure from customers and end users to identify other environmentally friendly characteristics. In the late 1980s when the project started, Dave Scarborough (business planning manager for TYVEK) characterized the pressure the product faced as follows: "Plastics were bad, landfills were bad, anybody involved with plastics was bad, so what are you doing about it?"

In 1990, the envelope group approached Dave Welch, then in the TYVEK customer service group, to identify other potential environmentally friendly characteristics TYVEK might have. Welch, now environmental coordinator for TYVEK, reported in his interview that the envelope group said, "We would like you to head up your own think tank, to try to come up with what else TYVEK is, even though we know it's not biodegradable."

Welch first contacted customers to see what their thoughts were on the matter. He quickly found out that material recycling in general was becoming popular, but that customers were landfilling TYVEK. Given that TYVEK is a pure, high-density polyethylene with nothing holding it together but heat and pressure, a recycling system seemed eminently logical. After speaking with customers, Welch determined that a recycling system was possible. He began calling recyclers to see if they would accept TYVEK and began putting a list together of recyclers willing to do so. Welch sent the list to customers and end users. He updates the list every six months, adding recyclers as he finds them. To broaden the extent of TYVEK recycling, it is critical that the list of recyclers gets longer. The biggest problem with recycling anything is getting it to the recycler. The shipping costs for recycled goods can make recycling an economically irrational choice for many businesses. It is incumbent on Welch to identify recyclers located close to TYVEK customers and end users to bring the cost of transporting TYVEK for recycling down as far as possible.

Identifying recyclers to which customers and end users could ship TYVEK worked well for

large users; however, it was often of little or no help to the small user. Many of the smaller customers and end users were either too far from a recycler, making shipping impractical, or had too small a volume to be of interest. Once the company had made the commitment to ensure the recyclability of TYVEK, the team had to devise a method to allow smaller end users to participate. Even though TYVEK is pure HDPE, most local recyclers will not accept it because they do not know what to do with it. The issue became one of getting the TYVEK to recyclers that would accept it.

Welch and other members of the team came up with the idea of the TYVEK pouch. The TYVEK pouch is a mail pouch made of TYVEK that is given to anyone who requests it. For larger users, the pouch comes with a prepaid mailing label. End users collect TYVEK envelopes in the pouch and, once it is full, mail the pouch directly to the closest TYVEK recycler. DuPont will not release the figures on this program, but supplying the pouches and covering some mailing cost does not appear to be a major cost to the company. The program helps keep TYVEK flowing into the recycling stream. Its function is far more important as a symbolic activity, saying to customers and end users that DuPont is truly committed to the recyclability of TYVEK. As Welch put it, "If you truly are recyclable, which we claim we are, then you just better be able to walk the walk."

Three other elements exist concerning the recyclability and reuse of TYVEK: actual reuse, preconsumer recycling, and waste-to-energy. In terms of reuse, there is a budding market for used TYVEK clean-room garments. Reused TYVEK garments available for clean-room work are nearly free of any particulate that might have adhered during their original use. One firm on the recycler list buys used TYVEK garments, cleans them, and resells them for nonhazardous applications.

Preconsumer-recycled TYVEK starts as scrap TYVEK generated when TYVEK first comes off DuPont's production line. Scrap TYVEK is also generated by the processing functions at DuPont's customers. It would seem logical to simply pelletize this scrap and use it to make more TYVEK, which is done at DuPont's TYVEK plant in Luxembourg. Unfortunately, in the

United States there are two barriers to pelletizing and reusing scrap at the plant. First, although this scrap TYVEK is still pure HDPE, it is too dirty to be used directly in the production of new TYVEK. Selling the scrap to recyclers (something DuPont does with several million pounds of scrap a year) is more cost effective in the U.S. plant than in the Luxembourg plant. One key reason for this cost difference is the differing regulatory environments between the facilities. Secondly, this scrap TYVEK is not considered PCR material, so using it would not help DuPont achieve preferred purchasing PCR-content levels. By sending recyclers its own and customer's TYVEK scrap, DuPont keeps more TYVEK out of landfills, maintains a high-quality recycling stream for the recyclers, and keeps customers happy by helping them dispose of their waste at a good price.

As the customers and end users have learned that TYVEK is recyclable, Welch's list of recyclers has had to become more sophisticated. The list now is broken down by the types of material the recycler accepts (e.g., perfectly clean TYVEK; TYVEK with glue and ink; TYVEK with glue, ink, and paper; TYVEK medical packaging; and TYVEK with a coating).

Although not a preferred approach, the final element of reuse/recyclability of TYVEK is waste-to-energy. Welch's list of recyclers who accept TYVEK continues to grow; however, DuPont customers in many parts of the country still cannot get cost-effective service from a recycler. When customers and end users contact DuPont, they are directed to waste-to-energy programs for their TYVEK waste. Because TYVEK is pure HDPE, it burns cleanly. If there is no printing on TYVEK, there is no residue when it burns. Burned TYVEK ends up as water and carbon dioxide, and it has the same heat value as an equivalent amount of oil (see previous comments about how TYVEK burns). Printed TYVEK, FedEx envelopes for example, leaves some residue from the inks, but according to DuPont, the residue is minimal. DuPont maintains a list of waste-to-energy firms for the customers who need them.

Welch is constantly looking for new ways to recycle TYVEK. One idea was to establish collection points at grocery stores. A person who has two or three TYVEK envelopes could bring

them to the store much the way that HDPE grocery bags are recycled. Recyclers of grocery bags like the idea (they get more high-quality HDPE), but there has been resistance from the grocery stores. Their concern is that consumers would dump all sorts of envelopes (not just TYVEK) and cause storage and other problems. Some preliminary discussions with the USPS took place to see if post offices could serve as collection sites, but they raised many of the same objections that the grocers did. As such, these two ideas for collecting TYVEK have not materialized. What started as a search for environmentally friendly characteristics for TYVEK ended up as a mission for Welch. He has a simple goal to keep as much TYVEK as possible out of landfills.

The Business Case

The business case in this instance is quite simple. Although DuPont will not release economic performance information on individual units, TYVEK is, and has been, a profitable business for the firm, according to our interviewees. In the late 1980s, however, the TYVEK team faced the real possibility of losing the business that FedEx and the USPS provided if they did not add PCR HDPE to TYVEK. FedEx and the USPS are heavy users of TYVEK, and such losses were not acceptable. Although this case started off with the threat of lost business, it became an opportunity for DuPont. Now, everyone who uses a TYVEK envelope from either the USPS or FedEx also sees a statement about the PCR content in TYVEK. The FedEx envelopes also list DuPont's toll-free telephone number for information on recycling TYVEK. These statements are informational but also function as brand awareness for both TYVEK and DuPont.

Secondly, the increasing societal preference for recycling and the use of recycled materials puts DuPont and PCR TYVEK (particularly in the envelope business) in a leadership position. The TYVEK team has already met the challenges of introducing PCR content. Competing products exist, but TYVEK has a commanding presence.

The increasing use of preferred purchasing guidelines also is an opportunity for TYVEK, particularly in the hazardous materials protective-

clothing markets. Although these markets do not have the concentrated use pattern that the envelope business does, the military and local and state governments collectively are likely to generate a large amount of business for PCR TYVEK protective clothing. Again, as the first to market with a PCR product, DuPont will have a material advantage.

The Environmental Case

Two key environmental elements occur in this case.⁴ We know that by introducing PCR HDPE into TYVEK, DuPont estimates it has pulled in excess of 400 million milk jugs out of the recycling stream. By doing so, the company helped maintain the market for the material and lessened the likelihood that such material would end up in landfills rather than being recycled. DuPont also recycles its own TYVEK scrap as well as that of several of its customers. As of 2000, we were advised that the firm was able to arrange for the recycling of millions of pounds of TYVEK scrap per year. Finally, the company has established a system for recycling PCR TYVEK. By working with a network of more than 100 recyclers, DuPont has made it possible for TYVEK users in the envelope, hazardous materials clothing, and medical packaging businesses to recycle their TYVEK products once their useful lives are over. In this way, the valuable HDPE in TYVEK stays out of landfills, and DuPont helps its customers and end users manage their costs in a critical way, and by doing so, DuPont further cements these relationships.

Future Challenges

The TYVEK business unit still faces challenges. Their first concern is that purchasing preference programs will increase required levels of PCR content in regular jumps. As state and federal government purchasing preference programs increase the level of required PCR content, DuPont will have an incentive to match the new levels. Technologically, this is not a problem. DuPont's tests have shown no technological difficulties, even for increases of up to 50% PCR HDPE. The difficulty stems from being able to secure sufficient levels of clean PCR

HDPE economically. To do so, DuPont found a second supplier of high-quality PCR HDPE. This supplier may be sufficient for now; however, as the demand for PCR TYVEK increases, DuPont may have to develop stronger supplier relationships. Dave Scarborough described their approach as follows:

PCR is no longer a tactical issue in our business, it's a strategic part of our business, and as much as we love Enviro-Plastics and it's a great company—they've done great work—but it's one building and if it went up in fire tomorrow. . . . We have dealt with people saying, "We want a second supplier to handle 15% to 20% of our business." We [have] a primary supplier, but we need a safeguard, and that's the way we work with the people; and Enviro-Plastics knows that's what we're doing and that's why we're doing it, but we're working together.

A second challenge is maintaining market leadership. TYVEK is a premium product with broad name recognition. Relatively few direct competitors (i.e., other pure HDPE products) exist; however, many indirect competitors and substitute products exist. The addition of PCR content gives TYVEK a competitive advantage in the marketplace, particularly as preferred purchasing guidelines proliferate. Being the market leader implies staying ahead of the competition without being too far out. In addition to keeping pace with the PCR content requirements and the quality of the recycling stream described above, market leadership also implies continued vigilance in cost control. Using PCR HDPE is still more expensive than using virgin material. Some modest price increases can be expected; however, if the cost structure of the PCR material market changes, DuPont could be in real trouble. By keeping its own costs as low as possible, DuPont protects itself at least somewhat from price uncertainty for its PCR inputs. It is also essential that DuPont keep pace with customers' needs, the general characteristics of the marketplace, and the competition's efforts. Any of these variables, if left unattended for long, can turn a profitable business into an unprofitable one. Market

leadership also implies further penetrating old markets and finding new markets for TYVEK, particularly for PCR TYVEK.

Finally, consistent with DuPont's overall goals and the trend in the TYVEK market, the TYVEK unit's business practices have to be sustainable both in a business sense and an environmental sense. This means pushing the TYVEK manufacturing process closer and closer to zero waste and finding more ways to reuse and recycle scrap TYVEK. Scarborough summed up these challenges by saying, "It's a basic understanding that in order to have freedom to operate in the future, you've got to be doing what's right."

Lessons Learned

This case study is instructive for a variety of reasons. First, we clearly see the role of the marketplace in environmental innovation. The impetus for the introduction of PCR HDPE into TYVEK came directly from two important end users: FedEx and the USPS. These end users likely were facing a variety of forces including political pressures created by customers, advocacy groups, and, in the case of the USPS and the U.S. EPA, the U.S. congress regarding their environmental performance. The original decision was made as an effort to respond to the needs these end users faced from their customers. Despite the possibility of lost business because of the original environmental demands raised by the USPS and FedEx, DuPont was able to turn this threat into an opportunity. Adding PCR HDPE to TYVEK enhanced its already premium position by making TYVEK more environmentally appealing. Further, by satisfying the customer requirements that the USPS and FedEx faced, DuPont strengthened its relationship with them. Given the environmentally based, federal preferred purchasing requirements, once DuPont introduced PCR HDPE into TYVEK, it would be very difficult for the USPS to switch to another product or vender.

In this case, we also see the restraining role that markets can play. In the envelope business, DuPont introduced PCR TYVEK in response to demands it received from large end users of TYVEK. In the three other large markets for TYVEK (house wrap, medical packaging, and pro-

tective clothing), such concentrated demand does not exist. Customers and end users, therefore, are much less willing to accept the new product and its concomitant price increases.

This case also illustrates the role that institutional structures can play in facilitating innovation. In this case, the institutional structure took the form of the environmentally preferred purchasing guidelines put in place by the U.S. EPA's "reduce, reuse, and recycle" policies and, later, by Executive Order 12873 (President 1993). These policies created built-in demand for PCR TYVEK products in some markets. They gave the USPS the impetus to buy PCR TYVEK and also guaranteed DuPont a market. Preferred purchasing guidelines at all levels should help diffuse PCR TYVEK into the protective-clothing markets as well.

We also see from this case study the value in working with the entire product value chain when creating environmental innovation. The introduction of PCR HDPE into TYVEK occurred as a response to the needs expressed by customers and end users. These needs created enough baseline market demand to make the introduction of PCR HDPE into envelope stock feasible. Making the innovation work required extensive work with DuPont's PCR HDPE supplier. To improve the recyclability of TYVEK, DuPont had to create a recycling infrastructure for both pre- and postconsumer material. At each step, DuPont's efforts had to be integrated with those of other firms up and down the product value chain. Without the efforts of these other firms, this innovation would not have occurred. Now that DuPont has completed the changes in the envelope market, its position with key end users in that niche is stronger than ever.

The last important lesson from this case concerns the role that a cross-functional team can play in addressing the multidisciplinary nature of environmental problems. It could be argued that this case started out as a marketing problem. The TYVEK marketing staff was the first division approached with questions about TYVEK's environmental characteristics. The marketing staff became the chief proponents of the introduction of PCR HDPE. Although the marketing staff was responsible for instigating the strategic change, they could not facilitate the change themselves.

The successful innovation required the expertise and assistance of a variety of engineering and production personnel. The introduction of PCR HDPE into TYVEK was an engineering challenge, a marketing challenge, a production challenge, and a value-chain management challenge. Without the concerted efforts of personnel in each of these areas, the innovation would not have occurred.

Conclusion

This case study described the process DuPont went through to introduce PCR HDPE into TYVEK. The change was made initially in response to concerns raised by customers and end users. Once the change was completed however, the introduction of PCR TYVEK enhanced the already premium position that TYVEK occupies. The case illustrates several aspects of environmental innovation such as the roles that the marketplace and institutional structures play, the importance of working with the entire value chain, and the necessity of using an interdisciplinary team in addressing the multifaceted nature of environmental problems. Interestingly, whereas the introduction of PCR TYVEK has been highly successful in the envelope market (from where the original impetus came), the nature of other key TYVEK markets (house wrap, medical packaging, and protective clothing) has limited or prevented introduction of PCR TYVEK.

As a future research issue, the life-cycle environmental implications of TYVEK would be interesting to explore. Although PCR TYVEK certainly has many environmental advantages, the full nature of these advantages will not be known until someone completes a life-cycle assessment of PCR TYVEK versus virgin TYVEK. For instance, although PCR TYVEK keeps millions of pounds of HDPE out of landfills, is this outweighed by the energy costs involved in creating the PCR product? How do the emissions generated by the transport of PCR HDPE for TYVEK compare to those of virgin TYVEK. These types of questions can be answered only by a complete life-cycle assessment for virgin and PCR TYVEK.

The introduction of PCR HDPE into TYVEK is a logical and environmentally attractive use

of a common waste stream. This case study characterizes the market and institutional forces that advance, shape, and constrain environmental innovation of this sort. The case study indicates that a rich understanding of organizational and market behavior has the potential to help such innovations become reality.

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Notes

1. In general, DuPont does not sell directly to many of the ultimate end users of TYVEK. Usually, DuPont sells to converters who process TYVEK into end-use products such as envelopes and protective clothing.
2. For competitive reasons, DuPont declined to release production or market share data for TYVEK. Efforts to estimate these figures from public data were unsuccessful because of a lack of detail in the data.
3. Much of the material presented in this case we took from interviews conducted at TYVEK facilities in Richmond, Virginia, and Wilmington, Delaware, during a site visit made on December 5–6, 1996. We have included a list of the interviewees as appendix 1. We augmented the data from the interviews with information gathered during follow-up discussions with the interviewees plus data gleaned from DuPont proprietary

and public documents as well as from other published sources.

4. Despite extensive efforts, we were not able to locate a formal life-cycle assessment of the environmental characteristics of PCR TYVEK.

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About the Authors

Mark P. Sharfman is an associate professor of strategic management at the Michael F. Price College of Business and a faculty associate in Science and Public Policy at the University of Oklahoma. **Rex T. Ellington** is professor emeritus of Chemical Engineering and a research fellow in the Science and Public Policy Program at the University of Oklahoma. **Mark Meo** is a professor of Civil Engineering and Environmental Science and a faculty associate in the Science and Public Policy Program at the University of Oklahoma.

Appendix I

List of Interviews

Name	Title
Debra August	Account Manager for TYVEK envelopes
Joe Guckert	TYVEK Administrative and Technical Organization Supervisor
John Kmec	Production Engineer for TYVEK
John Lazare	Technical Marketing Specialist for TYVEK
Diane O'Leary	TYVEK Marketing Staff
David Roberts	Process Engineer for TYVEK
David Scarborough	Business Planning Manager for TYVEK
Craig Wallentine	Marketing Manager TYVEK Protective Apparel
David Welch	Environmental Specialist for TYVEK