White Paper

Innovating through Alliance:
A Case Study of the DuPont–BP Partnership on Biofuels

By

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Preface—An Update Provided by DuPont and BP on their Advanced Biofuels Partnership

This paper aims to provide insights into how industry alliances can deliver innovation and new technologies in an accelerated fashion. Since work began on this paper, the relationship between DuPont and BP has evolved significantly. This preface to the case study, written by representatives from DuPont and BP, provides an update on the companies' work together.

In June 2009, the partners formalized their relationship and created Butamax Advanced Biofuels LLC, a joint venture tasked with completing the technology development and commercialization of biobutanol – the advanced, premium biofuel molecule that had catalyzed the companies' initial partnership. Butamax combines DuPont's leading capabilities in biotechnology with BP's expertise in fuels technology, development and infrastructure.

In addition to the formation of Butamax, construction of a biobutanol technology demonstration facility is now underway in Hull, UK, and plans are that it will be operational in 2010. The facility will be used to conduct the required process development programs and scale-up to generate commercial design packages. These will be used to develop biobutanol production plant designs for facilities around the world. The first commercial plant is expected to be operational by 2013.

At the onset of the partnership, it was understood that BP would provide an analysis of the performance of biobutanol as an advanced biofuel while DuPont would focus its efforts on the technology package to produce the fuel. During the course of 2008, extensive fleet testing of biobutanol was conducted by the DuPont-BP partnership. Vehicles travelled a total distance of more than 1.3 million miles using biobutanol-blended gasoline. These tests demonstrated that biobutanol blended at a 16 percent[1] volume into fuels provides excellent vehicle performance. Additionally, a commercial fuels trial confirmed that butanol is compatible with existing fuel infrastructure and consumer satisfaction with the fuel.

Work was also done to determine the initial understanding of the environmental footprint of biobutanol. Biobutanol has chemical properties that already allow it to be blended at 16% by volume in gasoline, thereby displacing more gasoline per gallon of fuel consumed than the standard 10% by volume ethanol blend. Therefore, it has the potential to reduce greenhouse gas emissions further than the standard ethanol blend, given similar biorefinery site and process specific conditions. Lifecycle analysis is used alongside process development and economic evaluation to guide the research and development team to the most sustainable biobutanol design.

For more information and updates on this joint venture, please visit: www.butamax.com.

[1] A 16 percent biobutanol blend has equivalent oxygen content to a 10 percent ethanol blend.

I. Introduction

In June of 2006, DuPont[2] and BP[3] announced a partnership to develop and market advanced biofuels designed to overcome many of the environmental and economic limitations associated with biofuels currently on the market. The first product scheduled for commercialization is biobutanol, which can be made from the same plant materials as ethanol, the currently dominant biofuel. Biobutanol, however, has several advantages over ethanol, including potentially lower lifecycle greenhouse gas (GHG) emissions, higher energy content, and better supply and distribution dynamics. These advantages stem in part from the novel method DuPont developed to convert plant sugars and starches into a combustible liquid, using an advanced biocatalyst instead of traditional yeast. If the technology advances as the companies predict, biobutanol could capture a significant share of the growing global biofuels market.

The partnership is designed to leverage DuPont's world-class biotechnology and bio-manufacturing capabilities with BP's fuels technology and marketing expertise. At the same time, the venture takes advantage of the increasingly favorable policy environment for biofuels.[4] Driven by climate change and energy security concerns, governments at the state and federal level, as well as internationally, have enacted tax credits, grant programs, and biofuel blending mandates to increase production and use of biofuels. The U.S. Congress, for example, has mandated that by 2022, 36 billion gallons of biofuels be blended nationwide.

DuPont and BP's partnership on advanced biofuels is an example of the creative approaches some leading companies are taking to adjust to, and profit from, the market transformations spurred by climate change. In this case, two companies that have long been leaders on climate and sustainability are pooling their resources and expertise to develop transportation fuels with a

[2] DuPont is a science and technology company that offers a wide range of products and services for markets, including agriculture, nutrition, electronics, communications, safety and production, home and construction, transportation and apparel. For more information on DuPont, see: www.dupont.com.
[3] BP is a global integrated energy company operating in more than 100 countries on six continents. Its major operations consist of oil and gas exploration and production, oil refining and products marketing, petrochemicals, natural gas and natural gas liquids marketing, and solar energy. For more information on BP, see: www.bp.com.
[4] For a useful description of the current state of play on biofuels policy and legislative issues, see Pena, N. June 2008. "Biofuels for Transportation: A Climate Perspective." Pew Center on Global Climate Change: Arlington, VA. Available at: http://www.pewclimate.org/docUploads/BiofuelsFINAL.pdf, accessed Jan. 11, 2009.

lower environmental impact when compared to first generation biofuels.[5] The partnership demonstrates how companies with a history of progressive action on climate change are shifting their strategies from a focus on risk management and bottom-line protection to instead capture and create climate-related market opportunities. Neither company could accomplish this biofuels venture without the strengths of the other. Both have a superior understanding of how climate will affect markets and both want to get ahead of the curve to gain competitive advantage in a fast-growing market.

Focusing particularly on DuPont's perspective, this paper describes important elements of the corporate strategy process that resulted in this effort to capture a new business opportunity for climate-friendly technology. It is part of the Pew Center's ongoing research into best practices for corporate strategies that address climate change.[6] The paper is not an endorsement of biobutanol or any specific fuel DuPont and BP may develop in the future. Rather, the goal of this paper is to highlight the strategy and process DuPont undertook in partnering with BP to develop the fuel, in hopes of identifying lessons that other firms can apply in advancing climate-related technologies as changes in public policy dramatically transform markets worldwide. The Pew Center also aims to help policymakers understand how to shape policies and programs in a way that unleashes the innovation and investment capabilities of the private sector in addressing climate change.

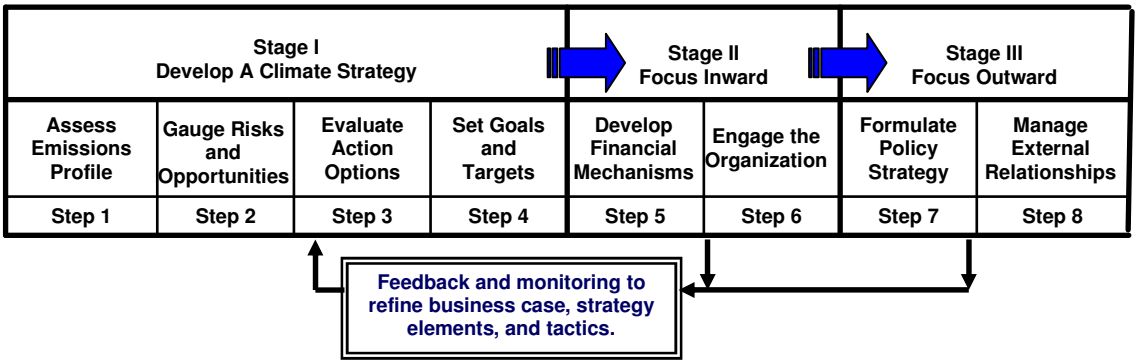
Much of the Pew Center's ongoing business-focused research builds on findings from its October 2006 report, "Getting Ahead of the Curve: Corporate Strategies That Address Climate Change," which outlined a step-by-step process for developing climate-related business strategies (see figure 1 below). A number of key themes emerged from this report. First, climate strategies must be fully integrated into a company's core business activities—they cannot be

[5] First generation biofuels are typically produced through fermentation of corn starch (from the corn kernel), sugar beets, or sugarcane in the case of ethanol, or transesterification of soybean or palm oils in the case of biodiesel. For a useful overview of existing and emerging biofuels technologies, see the Pew Center's Climate TechBook, available on-line at: http://www.pewclimate.org/climate-techbook.

[6] See also Margolick, M. and Russell, D. November 2001. "Corporate Greenhouse Gas Reduction Targets." Pew Center on Global Climate Change: Arlington, VA; Hoffman, A. October 2006. "Getting Ahead of the Curve: Corporate Strategies That Address Climate Change." Pew Center on Global Climate Change: Arlington, VA.; Sussman, F.G. and Freed, J.R. April 2008. "Adapting to Climate Change: A Business Approach." Pew Center on Global Climate Change: Arlington, VA. All reports are available for download at the Pew Center's Web site: www.pewclimate.org.

viewed as add-ons to business as usual. Second, businesses must shift their focus from bottom-line risk management to business opportunities presented in meeting the challenge of climate change. Third, the ultimate goal on climate is a game-changing strategy that allows a company to leap far ahead of competitors by creating or reshaping key markets that they can then dominate. For climate change, this often means shaping policy, which leads to a fourth key theme from the report: companies need to engage in the policy process to ensure they have a voice as important regulatory decisions are made.

Figure 1: Stages of Climate-Related Strategy Development



Source: Hoffman, A., 2006.

This paper on the BP-DuPont partnership combines excerpts from two interviews conducted April 17 and June 5, 2007, with John Ranieri, then DuPont Biofuels Vice President and General Manager,[7] with Pew Center commentary to distill lessons from DuPont's strategy and planning around climate change and bio-based technologies, known as Applied BioSciences. The paper is organized into four sections that describe: how DuPont's partnership with BP fits with DuPont's broader corporate strategy and long-running commitment to sustainability and climate solutions; the background, history and benefits of the partnership, including a discussion of the unique and complementary attributes each company brings to the initiative; the process, organizational structure and financing methods DuPont put in place to pursue the biofuels initiative; and the importance of government policy, particularly in supporting the transition to low-carbon biofuels made from sustainable feedstocks.

[7] Ranieri is now VP/GM DuPont Applied Biosciences—Biomaterials.

II. Corporate Strategy

The corporate strategy literature includes extensive research and case studies on approaches for establishing new "growth platforms"—bases on which to build families of products, services, and businesses that extend a company's capabilities into new domains and markets.[8] Companies need to review systematically their strengths (including intellectual property, customer relationships, sales channels, and capabilities in areas such as research or marketing) to determine if these could be applied profitably to meet existing or emerging market needs. This requires that a company know itself well and be able to accurately gauge its strengths relative to competitors and market forces. It also requires a thorough understanding of changing customer preferences and regulations in potential markets. Seeing competencies in a new way, different from the way they have been historically utilized in the company, requires creativity and an atmosphere that rewards creative thinking. And, because there are so many possible competencies and markets, a successful approach to selecting the growth platforms that offer the highest potential new revenue and profitability needs to begin with a clear mission.[9]

A key to the early success of the Applied BioSciences business is its compatibility with DuPont's broader corporate strategy that focuses on "Sustainable Growth." DuPont was one of the first Fortune 500 companies to embrace sustainable growth, which over time has become an inseparable component of its business strategy. DuPont defines sustainable growth as enhancing shareholder and societal value while decreasing its environmental footprint along the value chains in which it operates. The roots of this evolution, and the corporate culture supporting it, may ultimately extend back to the period when the company underwent its first instance of transformation or "creative destruction,"[10] when cousins T. Coleman, Pierre S. and Alfred I. du Pont in 1902 began transforming DuPont from an explosives business to a diversified chemicals company.[11] The integration of sustainability with strategy is intertwined with the second major

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[8] See, for example, Laurie, D., Doz, L., and Sheer, C. May 2006. "Building a Platform for Growth." *Harvard Business Review*.

[9] Laurie, D. et al, 2006.

[10] The term "creative destruction" comes from Foster, R. and Kaplan, S. 2001. *Creative Destruction: Why Companies That Are Built to Last Underperform the Market—And How to Successfully Transform Them*. New York: Currency/Doubleday. Foster and Kaplan propose that corporations can outperform capital markets and maintain their leadership positions only if they creatively and continuously reconstruct themselves.

[11] From "DuPont Heritage" on-line at http://heritage.dupont.com/, viewed July 16, 2007.

remaking of the company into one based on knowledge and biology as a science platform, along with chemistry and materials science, to produce materials and solutions for the marketplace—a process that is currently underway. It also stems from a major success during the 1980s and early 1990s in cooperating with policymakers worldwide to develop regulations to cut ozone depleting substances (ODS) like CFCs while at the same time developing a dominant position in the changing marketplace as a manufacturer of substitute chemicals that reduce damage on the ozone layer.[12]

The integration of sustainability into broader strategy can be seen in the evolution of DuPont's environmental goals. DuPont started laying the groundwork for its first GHG reduction goal in 1991, when it began tracking its emissions. This coincided with a larger expansion of its environmental efforts, including the first-time publication of an external environmental report, and formation of a board-level Environmental Policy Committee. Three years later, DuPont publicly announced a GHG emission reduction target of 40 percent below 1990 levels by 2000. The company's first actions in pursuit of that goal were aimed at "low-hanging fruit"—namely reducing emissions of two particularly potent GHGs, N_2O and HFC-23. After developing processes and making the necessary investments to efficiently reduce emissions of those two gases, DuPont realized its initial 40 percent goal would be readily met. Spurred by this success, in 1999 DuPont set a new series of targets to: hold energy use flat at 1990 levels; source 10 percent of its energy from renewable resources; and reduce GHG emissions to 65 percent below 1990 levels, all by 2010.[13]

Then, in an October 2006 speech, CEO Chad Holliday announced a new set of goals, which tie DuPont's business growth to the development of products that have positive, or less negative, environmental impacts. In these new goals, DuPont committed to:

- Double its investment in research and development programs with direct, quantifiable environmental benefits for customers and consumers along its value chains

[12] Hoffman, A., 2006.
[13] Hoffman, A. 2006.

- Grow its annual revenues by at least $2 billion from products that create energy efficiency and/or significant GHG emissions reductions for customers
- Double its revenues from non-depletable resources to at least $8 billion
- Source 10 percent of its energy use from renewable sources in a responsible manner.

Consistent with these goals and the broader strategy around sustainability, DuPont set objectives in the Applied BioSciences area to target transformative opportunities that promote environmental sustainability and create shareholder value. In pursuit of this objective, the company is adhering to the following four principles:[14]

1. Target areas of unique advantage
2. Shape the industry with integrated knowledge base by leveraging the company's broad, diverse science, materials and market knowledge
3. Establish partnerships to maximize value creation
4. Allow the market to expand the value proposition.[15]

Bio-PDO™, a non-fuel, renewable chemical traditionally made from hydrocarbons was an early success of this strategy, and served as the springboard for much of DuPont's subsequent work in Applied BioSciences. Propanediol (PDO) is a key ingredient in DuPont™ Sorona®, a renewable polymer that can be used in a variety of applications, including soft floor covering, textiles and packaging. For decades, DuPont could not profitably manufacture Sorona® because of the high costs of producing PDO through hydrocarbon-based chemical processes. In the 1990s, however, the company began experimenting with ways of producing PDO through biotechnology. This research resulted in the development of a fermentation process that can cost-effectively produce

[14] Ranieri, J. "Sustainable Growth: Renewably Sourced Solutions to Global Needs." 2006. Presentation at October 18, 2006 Pew Center workshop on Corporate Strategies That Address Climate Change. Available at: http://www.pewclimate.org/companies_leading_the_way_belc/business_resource_portal/corpstrat_wkshp.cfm?preview=1, accessed Jan. 11, 2009.

[15] Value propositions are the specific characteristics of a product, service, or integrated solution that matter most to target customers, communicated in a way that demonstrate how that offering is valuable based on a customer's business priorities and needs. A thoughtful discussion of definitions for "value proposition" is provided in Anderson, J., Narus, J., and Van Rossum, W. March 2006. "Customer Value Propositions in Business Markets." *Harvard Business Review*.

the compound from corn sugar. Sorona®, which was successfully launched in 2000, doubled its revenue in the first two years, and is forecast to grow significantly by 2010.

Through the development of Bio-PDO®, DuPont established a new base of technical competence in biology, which it almost immediately began looking to apply elsewhere. In particular, leveraging the company's well developed understanding of energy markets trends (given its traditional use of energy as a major input and previous ownership of oil company Conoco) and environmental sustainability, the company recognized a possible opportunity to apply its new competency to the fuels sector. DuPont understood that state, federal, and overseas governments were beginning to respond to challenges in energy security and climate change by enacting policies to promote biofuels development, production, and use. The company also recognized that ethanol as typically produced was effective but not ideal as a fuel for several reasons, including its relatively lower energy content per unit than gasoline, and inability to be distributed using the same infrastructure as gasoline and diesel.[16]

The following text, excerpted from interviews the Pew Center conducted in April and June of 2007 with John Ranieri, then DuPont's Biofuels Vice President and General Manager sheds more light on the development of biobutanol and its compatibility with DuPont's overall sustainability strategy.

Pew: *When and how did the company start moving in a direction that led to pursuing biobutanol?*

Ranieiri: It began about 10 to 12 years ago. We started by asking ourselves a question: could we reengineer a microbe at an efficiency rate that creates a new, cost-competitive, and useful compound? Bio-PDO® is a validation of that proposition. Through that achievement, we were able to create a new, foundational, core know-how and competence that allows us to do many different things with biotechnology that produce products of value for the marketplace.

[16] For more detail on some of these issues see Pena, N. "Biofuels for Transportation: A Climate Perspective."

It was also critical that we approached this with the mindset that we were going to make products with significant advantages from an environmental footprint perspective. We were going to focus not just on the outputs, but the inputs into a product as well, and start with a foundation that is sustainable by using renewable feedstocks as the inputs to make products. We were looking at how to most effectively make the next generation polymer Sorona® and we wanted to do it in a more sustainable way, a bio-based way. And we approached it with the notion that the primary ingredient could be made more economically and also sustainably with biology—this is what led to the development of Bio-PDO®.

Sorona® is an advantaged[17] product, but it could not be made in an economically acceptable fashion as hydrocarbon-based PDO is expensive. Two things came up: one was we can produce [PDO] with biology instead of chemistry—which would get us to the price point we needed; and, two, we can use biology to design a more sustainable product. That set in motion this whole platform of a biology competence that allowed us to come up with the foundational technology to make our bio-based materials business work.

Pew: *How did you make the leap from Sorona® to biofuels?*

Ranieri: We realized that one of the greatest needs and opportunities in the marketplace is in fact fuels. We were looking to see how we could contribute. What innovation could we bring to the fuel space? And again, we were interested in applying the learning and the know-how to make something with the new tools of biotechnology. In the meantime we recognized that ethanol is not exactly the ideal fuel, and we started asking what else could we make?

[17] Sorona's advantageous properties include softness, UV- and chlorine-resistance, easy dyeability and handling, and natural stain resistance. For more information, see: DuPont, "The Birth of Sorona, DuPont's First Bio-Based Polymer," March 21, 2005.

We weren't initially looking at making butanol, but when you have the core competency you can ask questions you could not ask previously: you can ask, well, what biofuel would I like to make? You never asked the question because you never knew the question was valid to ask. Knowing ethanol had limitations was not something that was obvious to us right up front. But after we developed this new capability we could ask, if we had a clean sheet of paper, what would we make?

> "That's really the key to innovation: it's not about always having the answers—it's about first being able to ask the right questions."
> –John Ranieri

Pew: *Once you started asking those questions, then what happened?*

The more we started looking at it, the more we recognized that ethanol was not an advantaged fuel. In fact, it is disadvantaged in several ways. It was simply something nature-made that humans applied. If you really could cause nature to make the kind of fuel that would best fit the infrastructure we put together, it would be something maybe very different. That's really the key to innovation: it's not about always having the answers—it's about first being able to ask the right questions. I think that's really important. And related to that, you have to understand when the right question is being asked.

The fact is, ethanol has vapor pressure issues, it has water absorption issues, you can't pipe it, you have to truck it around. These are accepted limitations that only when reality can be changed, or is changed, can you then look at those as solvable problems. The first big question we had was: could you make an alternative? Is there something different, first of all, and secondly, can you make it economically? We had a seminal initial meeting with BP where we questioned the whole existing order, which led to a more descriptive meeting where we got together isolated for three days—DuPont and BP guys—and started discussing what are going to be the next generation of fuel molecules that really do change the game, that really are transformative. But it really started with first questioning the existing dogma and looking to recreate a new market opportunity.

> "What we set out to do from the beginning was to evaluate how to transform a marketplace using biotech to deliver advantages that chemistry couldn't offer, and reduce the environmental footprint associated with that product at the same time."
>
> –John Ranieri

Pew: *How does biobutanol, and the DuPont Applied BioSciences business in general, fit in with the company's strategy of "sustainable growth"?*

Ranieri: What we set out to do from the beginning was to evaluate how to transform a marketplace using biotech to deliver advantages that chemistry couldn't offer, and reduce the environmental footprint associated with that product at the same time. If you can do that, you can have a potentially transformative offering.

That was the point. It was about transforming the space with the tool kit, and pointing biotechnology into an application where you both come up with an advantageous product and serve the environmental needs. A lot of boxes get checked and you start looking at it and you realize, this really can make a difference. We've done that in a few areas, and we're getting better at being able to do that—that whole process of being able to look at the feasibility of a new technology and being able to look back from a market perspective and understand how you best put it all together. How do you put the right technology in a market space that really will reward you for being able to bring products forward?

Pew: *In terms of "transforming the market," how profound an impact do you think biobutanol will have? To what extent will it displace ethanol?*

Ranieri: It's not a question of choosing between ethanol and butanol—we've always said that, right from the first announcement in June. There's such a large potential market for alternative fuels. Look at the situation today: 95 percent of our fuels are gasoline or diesel—renewables are only five percent. We have such a long way to go. Ethanol and butanol are not mutually exclusive. They're miscible with each other in fact.

There's plenty of room for everyone. But we'd certainly like to believe that if you're going to put up a plant, and biobutanol and ethanol are at an equivalent price point, that you would choose biobutanol. There are different aspects to it that give it advantages: you can put it directly into a pipeline; you can ship it; you don't have to worry about some of the vapor pressure issues. Butanol is more similar to gasoline. You can put it directly into the refinery. So I think it has significant advantages. But right now its major disadvantage is its price point. And that's what we're working on.

III. Partnership

The partnership between DuPont and BP on advanced biofuels is in many ways a marriage of necessity as opposed to one of convenience. It would be nearly impossible for either company to develop and market biobutanol on its own, at least quickly and effectively. DuPont brings the biotechnology and bio-manufacturing capabilities, and BP provides the fuels technology and marketing expertise. How these skill sets are combined and utilized will be a key determinant of the success of biobutanol and other advanced biofuels that come out of the partnership.

The value of joint ventures and strategic business alliances, particularly in a globalized economy, has been covered extensively in the academic literature.[18] Joint ventures can help manage risk, catalyze innovation, and spread the costs of capital investment.[19] Given the likely economy-wide impacts of climate change regulations, collaborative ventures between two or more companies may become even more important as success in climate change technology markets will require a set of competencies and assets that rarely occur in a single company. Already, a wave of alliances are springing up as companies seek early toeholds in markets they anticipate will be either created or radically altered by forthcoming climate change regulations. Similar to the DuPont-BP biofuels initiative, these partnerships are designed to leverage each company's

[18] See for example Ohmae, K. March-April, 1989. "The Global Logic of Strategic Alliances." *Harvard Business Review*; Bamford, J., Ernst, D., and Fubini, D. February 2004. "Launching a World-Class Joint Venture." *Harvard Business Review*; and Kanter, R.M. July-August, 1994. "Collaborative Advantage: The Art of Alliances." *Harvard Business Review*.
[19] See note 16 above.

existing expertise and resources to create new product and service lines that can serve new markets.

For example, in another biofuels venture, Chevron is collaborating with Weyerhaeuser, the world's biggest lumber producer, to explore the feasibility of developing biofuels from cellulose-based materials, like wood fiber and other nonfood sources.[20] This venture would leverage Chevron's refining expertise, knowledge of fuels markets, brand, distribution capability, and service station retail network with Weyerhaeuser's knowledge of timber production, cellulosic materials and biofuel research, as well as the company's extensive forest and mill holdings. In a similar venture, oil giant ConocoPhillips is teaming with Tyson Foods to produce and market a renewable biodiesel made from beef, pork and poultry fat.[21] DuPont has also formed a joint venture with Danisco, a company with significant enzyme expertise (DuPont Danisco Cellulosic Ethanol LLC), to bring its cellulosic ethanol technology to market.

Collaboration between companies that have traditionally operated in separate spheres is also occurring outside of the biofuels industry. One such area is in the development of technology to capture and store CO_2 emissions (CCS) from coal-burning electric power plants. CCS is widely considered to be a critical technology needed to address climate change. Successful execution of CCS will require coal-fired electric generators to work closely with pipeline operators and companies with experience in injection of CO_2 into geologic formations, such as oil and gas producers. BP and mining company Rio Tinto are pursuing such a partnership, having launched in 2007 a new joint business: Hydrogen Energy International to develop hydrogen-fueled power plants produced from fossil fuels while capturing carbon dioxide in deep underground geological formations.[22]

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[20] Weyerhaeuser. "Chevron and Weyerhaeuser Create Biofuels Alliance." Press Release. April 12, 2007. Available at: http://www.weyerhaeuser.com/popups/_frameset.asp?bodyFrame=/popups/pressReleases.asp?id=07-04-12_ChevronWeyerhaeuserCreateBiofuelsAlliance, accessed July 25, 2007.

[21] Ball, J. "Conoco, Tyson Agree to Use Animal Fat to Make Diesel." Wall Street Journal. April 16, 2007. Available at: http://online.wsj.com/article/SB117669276713570908.html?mod=rss_whats_news_us_business, accessed July 25, 2007.

[22] Hydrogen Energy. "Nation's First Application for a Revolutionary Hydrogen Fuel Electric Generating Facility with Carbon Capture and Sequestration to be filed before the California Energy Commission." Press Release. July 30, 2008. Available at: www.hydrogenenergy.com, accessed Jan. 11, 2009.

In another joint venture, Ford Motor Co. and the electric utility Southern California Edison (SCE) announced a partnership to explore the development and potential commercialization of plug-in hybrids.[23] In this instance, Ford brings knowledge of vehicle design and patterns of vehicle use, marketing, and sales capacity. SCE brings to the table knowledge and physical assets associated with electricity market supply and demand patterns, transmission, distribution, and storage, as well as customer relationships and billing services in one of the most promising markets for plug-in hybrid vehicles. Importantly, both Ford and SCE have sophisticated knowledge of policy in their respective domains and seasoned government affairs professionals. Policy engagement is a critical component of all climate-related business ventures, as government policies and programs will have a major impact on the profitability of CCS, plug-in hybrids, as well as biofuels and many other technologies likely to flourish in carbon-regulated markets. The ability to simultaneously influence policy while adapting the business model to the shape of emerging carbon-regulated markets will be a key competitive differentiator.

Not all joint ventures, however, are successful—in fact studies have shown that they fail roughly as often as they succeed. In 2001, Bamford et al. looked at more than 2,000 joint ventures and found that the success rate was a bit better than half (53 percent), mirroring results from a similar study conducted a decade earlier. Reasons for failure, they write, often come down, to "wrong strategies, incompatible partners, inequitable or unrealistic deals, and weak management."[24]

Choosing the right partner is crucial to the success of a joint venture. When it comes to climate-related business ventures, it is critical that the companies be of like mind on the seriousness of the climate issue and its potential impact on markets. On this point, DuPont and BP appear to be highly compatible. They both stand out as among the first major corporations worldwide to realize that environmental and social sustainability practices preserve a company's "license to operate," help attract and retain talent, and enhance brand value. In 1997, BP became the first major oil company to say that climate change was a problem and a year later, it became the first

[23] Zimmerman, M. "Ford, Edison to Test Hybrids." Los Angeles Times. July 9, 2007. Available at: http://www.latimes.com/business/la-fi-hybrid9jul09,1,444944.story?coll=la-headlines-business, accessed July 25, 2007.
[24] Bamford, J. et al 2004.

to set a voluntary target to reduce GHG emissions.[25] BP became a founding member of the Pew Center's Business Environmental Leadership Council (BELC) [26] in 1998, and DuPont joined just a few months later. The BELC is the largest U.S.-based association of companies committed to business and policy solutions to climate change. In addition, BP America and DuPont are founding members of the U.S. Climate Action Partnership (USCAP), a coalition of major corporations and leading nongovernmental organizations calling on Congress to pass legislation to slow, stop, and reverse the growth of GHG emissions at the earliest possible date.[27]

Perhaps more important even than a shared culture of environmental responsibility, the two companies have been far more attuned than most to the way climate and sustainability concerns will transform markets, and both set about to capture some of the resulting new business opportunities. Both companies have announced plans to significantly expand investment in product lines that advance climate solutions. BP has pledged to invest $8 billion over the next ten years in alternative energy. It is focusing investments in a number of material businesses—including Wind, Solar, Biofuels, CCS and Hydrogen Power. DuPont, meanwhile, has pledged to double its investment in R&D programs that deliver direct, quantifiable environmental benefits, which, if current projections hold, would equal around $422 million by 2015. DuPont has also set a goal to grow annual revenue by $2 billion from products that improve energy efficiency and reduce greenhouse gas emissions, and had nearly 200 U.S. patents in the Applied BioSciences space in 2007. DuPont is ranked first in biotechnology patents and innovation based on recent surveys completed by The Patent Board® and Nature Biotechnology magazine.

Initial conversations between the two companies began with a cold call from DuPont to BP to discuss the companies' mutual interest in biofuels. Specifically, DuPont wanted to know if the cellulosic ethanol technology it was developing would be of interest to the oil major. The conversation shifted, though, when BP asked whether DuPont's new biotechnology tools could be used to make a biofuel that could improve on traditionally distilled ethanol. After some

[25] Frey, D. "How Green is BP?" *The New York Times Magazine.* Dec. 8, 2002. Available at, http://select.nytimes.com/gst/abstract.html?res=F20B14FE345C0C7B8CDDAB0994DA404482&n=Top%2fNews%2fScience%2fTopics%2fGlobal%20Warming, viewed July 25, 2007.
[26] For more information on the Pew Center's BELC go to: http://www.pewclimate.org/companies_leading_the_way_belc
[27] For more information on USCAP go to: www.us-cap.org.

investigation by its scientists, DuPont replied that, yes, the company probably could use biotechnology to produce such a fuel.

At this point, teams from the two companies met for a brainstorming session in the UK. The group combined people with expertise in biochemistry, fossil fuels engineering, and the transportation fuels market, and the basic question they explored was how DuPont's "platform technology"[28] for using biological processes to transform basic biological materials into advanced compounds could be used to produce a fuel that holds advantages over traditional ethanol. BP participants brought to the table a clear understanding of the characteristics such a fuel would need in order for it to have practical applications in a world dominated by fossil fuels, and ethanol positioned as the incumbent biofuel. DuPont's experts were able to describe the types of fuel molecules that biochemistry such as that underlying PDO could produce, and the attributes such molecules would have.

Ethanol is "hydrophilic," meaning it associates with moisture in a way that can cause it to separate out of fuel mixtures, making it unsuitable for distribution and storage in the same pipelines and tanks used by gasoline, which is a limitation of ethanol as a fuel. A "hydrophobic" fuel would not only be able to share use of the existing fuel system infrastructure but could also be blended more simply and less expensively with gasoline than ethanol. Additionally, the growing and distillation of corn into ethanol, and complicated process of transporting the fuel to consumers' vehicles, often delivers only modest advantages over gasoline in terms of life cycle greenhouse gas emissions. Advanced biofuels made possible by biotechnology have the potential to deliver better fuel attributes and very low life cycle greenhouse gas emissions.

The collaboration that day and in subsequent meetings revealed significant opportunities. It appeared possible to use DuPont's biotechnology to transform sugars and starches into a fuel that would have advantages over ethanol. DuPont's other core competencies included experience in scaling up such new chemistry technology from the lab to large volume production. BP's core competencies throughout the transportation fuels value chain—in refining, transporting,

[28] Defined as a technology that establishes the basis for further research and development, leading to the creation of many different types of new products and processes.

blending, marketing, and selling fuels—would unlock the potential of the new fuel and create the potential for it to capture a significant share of the world transportation fuels market.

While the initial conversations about the partnership were held between leadership in both companies' biofuels businesses, over time, corporate management and sustainability leadership were brought into the discussions.[29] The two companies formalized a realistic and equitable deal structure for the partnership early on. Negotiations were relatively easy, Ranieri says, because both companies recognized the magnitude of the potential gains. The size of the market left a lot of room for delivering high expected returns for both partners.

The following text, excerpted from Pew Center interviews with John Ranieri in April and June of 2007, sheds more light on the formation and advantages of the DuPont-BP partnership.

Pew: *What was the motivation behind the partnership with BP?*

Ranieri: The idea behind the partnership right up front was to maximize value. When you're in these uncertain areas, and you partner up, you actually create value with complementary skill bases and new synergies. Sometimes people look at partnerships as a way of *sharing* value, but actually you *create* more value early on, and that's something that not everyone saw. In fact the surprises of putting us and BP together to do butanol were geometric.

And what's interesting about the partners too is that we really are dependent on one another for success. Our expertise is more on the technology side, and BP's is more on applications development and marketing, rolling the product out, making sure the fuels aspects of it are very favorable, and working with the OEMs [automobile original equipment manufacturers]. So the relationship is very complementary, which has been very positive.

[29] Authors' e-mail correspondence with DuPont, Nov. 26, 2007.

There are many different things you have to consider from a fuel mixture perspective. There is much from the market perspective that had to be understood that BP brought to the partnership. Fuels are sophisticated. You have performance and infrastructure issues that need to be considered. And we had the capability on the biotechnology side to be able to ask the right questions, or know when the right questions were being asked. The fact that you can make biofuels other than ethanol economically was not completely obvious at first. It became obvious to us because we had completed Bio–PDO®, and from that we were able to gauge how feasible it was for us to make butanol. And without that dialogue, butanol would not have come up. This went back almost four years, and we got it going pretty quickly and with intensity for two large companies.

> "The idea behind the partnership right up front was to maximize value. When you're in these uncertain areas, and you partner up, you actually create value with complementary skill bases and new synergies."
>
> –John Ranieri

Pew: *What were some of the early meetings like? What was the process like?*

Ranieri: We went through a very interesting process with BP to look at a whole spectrum of different molecules we could make. Starting with a divergent process and then converging on the opportunities that were technically feasible with our platform technology and would bring significant value to the market. That focused things quite quickly on a few candidates, and right now we're pursuing our primary candidate, which is butanol.

We had a very open, candid discussion with BP right from day one. We had a mindset of collaboration and a good rapport, and from there we dispassionately looked at how do you bring a product to the market that would be beneficial with a much lower environmental impact. Right from day one both we and BP asked some very hard questions about what's feasible with the technology, which really opened up a whole new kind of avenue to what would be possible.

Pew: *Were there any problems or complications in partnering with another major corporation? What helped make the collaboration work?*

Ranieri: What I find is that there are always issues but, in this case, they were relatively small, and when you look at why we came together, it was because we both saw a transformative opportunity. Our skill sets and capabilities were also complementary. Any time you create a large pie and everyone has a chance to grow with that pie, behaviors tend to be pretty good, even with people who can be difficult. Everyone sees a stake for themselves. It is when you have the shrinking pies, when you have zero sum games, no matter how good the people are, it can get pretty ugly. But these are growing pies, and it's about creating the future, and you tend to attract a certain phenotype that looks to try to accommodate and to try to grow. Everyone is pulling in the same direction because success really allows for quite a large new opportunity for growth and new types of possibilities for the people that are involved.

IV. Organization Approaches

The underlying goal of the DuPont Applied BioSciences strategy is to pursue transformative opportunities that can result in both increased shareholder value and a decreased environmental footprint. Since biobutanol has a higher energy density than ethanol, lower vapor pressures in mixtures and thus lower volatile emissions and can, unlike ethanol, be transported together with gasoline through the existing pipeline system, biobutanol has the potential to be a breakthrough product. This is particularly true if DuPont and BP are successful in their ultimate goal of producing the fuel from cellulosic sources, which would result in significantly lower lifecycle emissions than fuels produced from fermentation of corn starch.

But biobutanol's ability to capture market share largely depends on whether it can be produced at costs close to or lower than the costs of producing ethanol or gasoline. If DuPont and BP can produce biobutanol at competitive prices, they will be able to deliver a low GHG emitting transportation fuel as inexpensively as gasoline or ethanol—a significant development as governments and businesses around the world seek the most cost-effective means possible of

reducing GHG emissions. This becomes easier in the event that transportation fuels carry a "carbon price" under a policy to address greenhouse gas emissions.

Through their advanced biofuels partnership, DuPont and BP are pursuing what the Pew Center's corporate strategies research has identified as the ultimate climate-related business achievement: the development of a game-changing strategy that allows a company to leap ahead of competitors by creating new markets or reshaping the rules of existing markets in their favor. In effect, DuPont and BP are pursuing disruptive innovations—products that overtake established incumbents by creating or reshaping markets.[30] While it is far too early to say whether biobutanol fits the description of a disruptive innovation vis-à-vis gasoline, due to its advantageous properties it may have the potential to progressively become a more significant aspect of global biofuels production and use.

Disruptive innovations emerge infrequently, and when they do, they usually come from smaller companies or start-ups. It is difficult for large, established firms to pursue, much less successfully execute, disruptive strategies.[31] Established firms typically focus their energies on "sustaining innovations," which are incremental improvements to existing products and services. To illustrate the difference: early personal computers were a disruptive innovation, but faster, more user-friendly PCs are sustaining innovations.[32] Generally speaking, sustaining innovations allow firms to protect and grow existing customer bases, whereas disruptive innovations seek to attract entirely new sets of customers. Most established firms are institutionally biased toward sustaining innovations because, as Harvard Business School professors Joseph Bower and Clayton Christensen put it, "Using the rational, analytic investment process that most well-managed companies have developed, it is nearly impossible to build a cogent case for diverting resources from known customer needs in established markets to markets and customers that seem insignificant or do not yet exist."[33]

[30] Bower, J.L. and Christensen, C.M. January 1995. "Disruptive Technologies: Catching the Wave." *Harvard Business Review*.
[31] Christensen, C.M., and Overdorf, M. March 2000. "Meeting the Challenge of Disruptive Change." *Harvard Business Review.*
[32] Example adapted from Christensen and Overdorf, 2000.
[33] Bower et al, 1995.

Notwithstanding the difficulties, the quest for disruptive innovations runs high in the corporate community. Many of the most dramatic success stories in business history have been propelled by disruptive innovations.[34] In pursuit of these innovations, many companies have launched new businesses and ventures, or engaged in other forms of corporate entrepreneurship. However, research has shown that corporate entrepreneurship is often difficult to execute, and in fact fails more often than it succeeds.[35] To be successful, according to management experts David Garvin and Lynne Levesque, companies launching new ventures must negotiate several balancing acts, including:

- Encouraging unconventional thinking, while rejecting radical ideas that are foolish or unrealistic
- Engaging in open-minded experimentation, while applying enough discipline to shut down projects that clearly have no future
- Drawing from the existing strengths and proven processes of the company, while applying the fresh thinking needed to develop a novel business line.

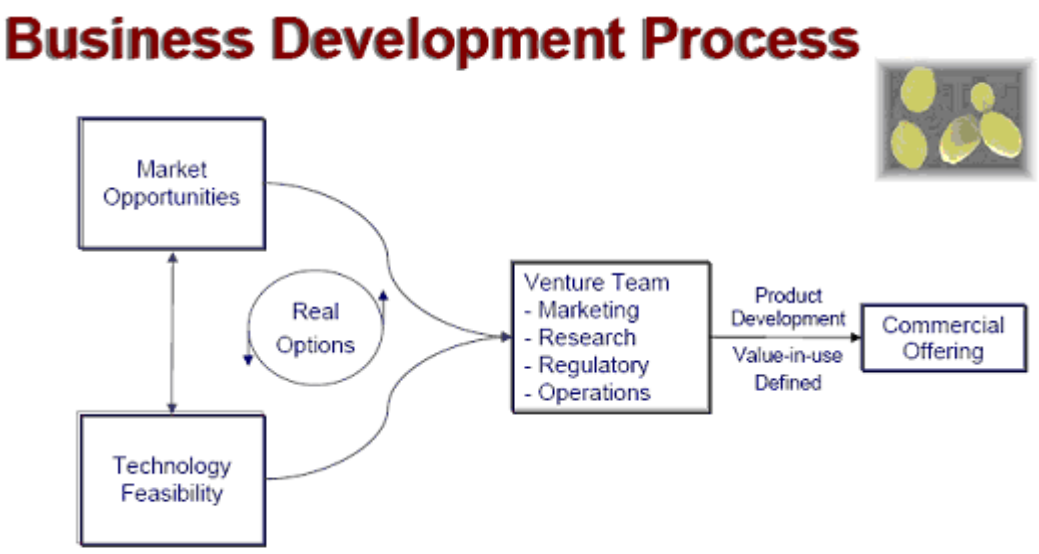
Different companies have used different processes and organizational structures to help navigate these balancing acts. There is no magic formula that can guarantee success, but according to the Pew Center's research, one critical element is leadership from the highest levels of the company. In a survey of 34 companies for the Pew Center's report, "Getting Ahead of the Curve: Corporate Strategies That Address Climate Change," CEO leadership was identified as a key driver at all stages of climate strategy development and implementation. DuPont and BP, over the years, have benefited from strong leadership from their CEOs and senior executives on environmental initiatives, including the development of biobutanol and other advanced biofuels.

While it is unclear whether biobutanol or any of the products BP and DuPont may develop through their partnership will emerge as successful disruptive innovations, the process, organizational structure and financing methods DuPont put in place to pursue the opportunities

[34] Christensen, C. M., Johnson, M. W., and Rigby, D.K. 2002. "Foundations for Growth: How to Identify and Build Disruptive New Businesses." *MITSloan Management Review.* Spring 2002, Vol. 43, No. 3.
[35] Garvin, D. A., and Levesque, L.C. October 2006. "Meeting the Challenge of Corporate Entrepreneurship." *Harvard Business Review*.

hold lessons for other companies (see figure 2 for a diagram of DuPont's business development process).

Figure 2: DuPont Applied BioSciences Business Development Process



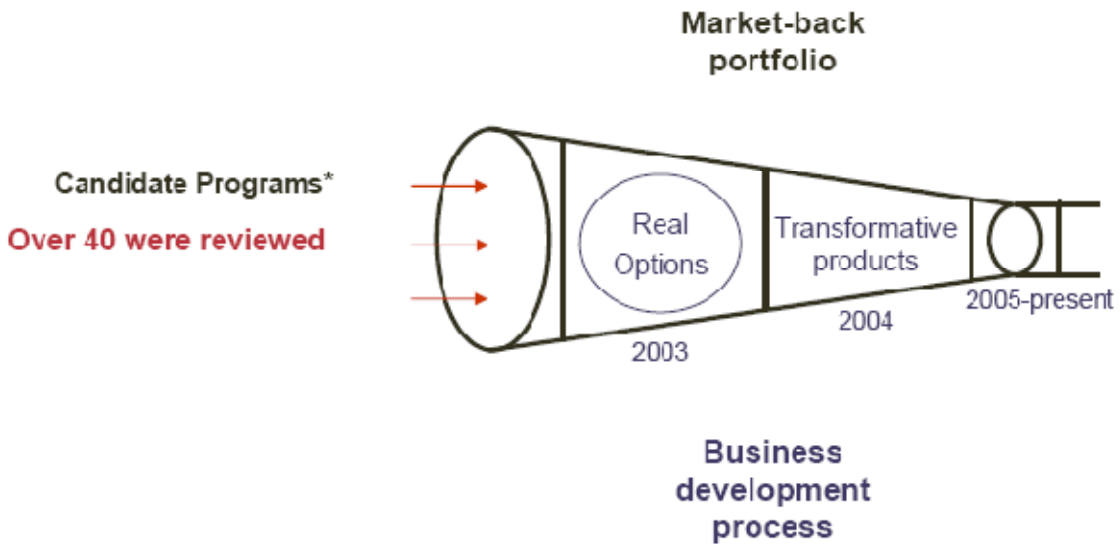
Source: Ranieri, J. "Sustainable Growth: Renewably Sourced Solutions to Global Needs." 2006.

First, building new businesses and leveraging existing capabilities to enter new markets for environmentally sustainable goods and technologies was part of DuPont's core corporate strategy. Second, DuPont established and structured its Applied BioSciences materials business unit specifically to explore transformative opportunities. It set the unit up as a separate business platform within the company with the flexibility to look for skills throughout the corporation and determine how those could be integrated and used to pursue the emerging market opportunities. Third, the company employs a variation on typical stage gating[36] of its research and development process that screens carefully for financial potential but also allows certain R&D efforts to

[36] Stage gating is a common process companies use to manage the development of new, innovative products and services. Beginning with a broad set of possible innovations, the goal of stage gating is to winnow out—step-by-step—the least viable options until only the most promising opportunities are left. Products and services are developed through a series of successive "stages" separated by "gates." Gates are typically review meetings where teams report to senior managers who evaluate the product offering usually on the basis of projected revenues, profits and associated risks. At these meetings, senior managers will make a decision whether to move the product on to the next stage, return it to the previous one, or kill it outright. For a useful discussion on the stage gating process, and its limitations, please see Christensen, C.M., Kaufman, S.P., and Shih, W.C. January 2008. "Innovation Killers: How Financial Tools Destroy Your Capacity to do New Things." *Harvard Business Review*.

continue even when uncertainty obscures real option value[37] (see figure 3 for a diagram of DuPont's biobased materials screening process). The system is designed to address the ambiguity at the front end of a project, allowing the company to pursue promising ventures while weeding out projects that have little or no market value.

Figure 3: DuPont Applied BioSciences Materials Screening Process



Source: Ranieri, J. "Sustainable Growth: Renewably Sourced Solutions to Global Needs." 2006.

[37] Real option value is a term that stems from "Real Options Analysis," a corporate finance tool that recognizes and quantifies the value associated with the opportunity to modify projects. For example, after making an initial decision to invest in the development of a new product line, a firm may later choose—depending on a range of factors, including market considerations, competitive pressures, technological conditions, etc.—to ramp up production, roll the product out in limited quantities in select markets, kill the project, or modify it in some other way. A real option is typically defined as the right, but not the obligation, to make a certain business decision. The dollar value of the ability to make that follow-on investment decision is the "option value." For more information about real options and option value, see Brealey, R.A. and Myers, S.C. 2003. *Principles of Corporate Finance, 7th Edition*. New York: The McGraw-Hill Companies, Inc. (pages 268-278 and 617-636). A useful primer on real options is also provided in Latimore, D. 2002. "Calculating Value During Uncertainty: Getting Real with 'Real Options.'" New York: IBM Institute for Business Value. Available at: http://www-935.ibm.com/services/in/igs/pdf/g510-3248-calculating-value.pdf, accessed June 4, 2008.

DuPont's views around the internal processes of biobutanol development are highlighted in the following excerpts of the Pew Center's interviews with Ranieri conducted in April and June of 2007.

Pew: *How did DuPont organize itself internally to pursue biofuels and biobased materials opportunities?*

Ranieri: We were reporting to Tom Connelly, the executive vice president and chief innovation officer at DuPont. There are five business platforms in DuPont: Agriculture and Nutrition; Performance Materials; Electronics & Communications Technologies; Coatings & Color Technologies; Safety & Protection. And then there is this technology platform now called Applied BioSciences that created the mindset and flexibility to use the skill set that exists in CR&D [corporate research and development] with the intention to transform markets. The Applied BioSciences business unit's function was to identify market opportunities that would make sense for us, considering our core strengths. Once these areas of unique advantage have been identified, we can commercialize and be transformative in the marketplace.

Pew: *What were the advantages to having this organizational structure?*

Ranieri: We were able to deal with the tension between having enough freedom and flexibility to innovate, while at the same time having enough process to be able to codify and integrate the information so that it's got some value. Too much process early on can squash the creativity, which is something you have to watch out for. On the other hand, as an existing organization there's process for a good reason. So the way we were structured, reporting to the chief innovation officer Tom Connelly, gave us the flexibility to integrate the information and codify it into a value proposition that made sense, while still having the flexibility to be somewhat divergent.[38]

[38] According to DuPont, being "divergent" means having the ability to continue to look at a variety of options even as they maintained a high level of focus on things like biobutanol and cellulosic ethanol.

Pew: *How active was then-CEO Chad Holliday in this? What role does he play in the biofuels/biomaterials business?*

Ranieri: He drives this and has a strong influence on it. He understands quite well the feasibility of the science, the market opportunities and the partnerships, so he's very involved. And his involvement is real and has been critical. These are risky projects that really do need that kind of shepherding and foresight to be successful. In fact, we wouldn't have these very significant programs if we didn't have the corporation really behind us.

> "The upfront decisions that you make about taking those first few steps and knowing where not to go are absolutely critical because it is easy to go down a rat hole."
> –John Ranieri

Pew: *Considering the uncertainties and risks involved in launching a new product in a market DuPont has not historically been active in, did you do anything differently in terms of financing the venture, or evaluating its progress?*

Ranieri: We had a process we actually invented ourselves to be able to very quickly, or much more quickly, assess early stage front-end innovation where it's hard to evaluate, or to even put a degree on, the value that you can create. But we actually came up with a system, a pretty rigorous financial system, which we applied to an early stage project.

There's two aspects to this system. One is being able to take the somewhat harder to define, more qualitative types of milestones, and being able to put some value around those. And secondly, being able to arrange projects where you are maximizing the leverage of your investment money early on and creating that value, or getting out. So it's really about being able to continually challenge yourself to create options that have good leverage with your money. It allows you to work through those, "I'm not sure what I'm looking for, but I'll know it when I see it" situations. This system allows you to continually move forward through uncertainty and do it in a way that creates a lot of value.

It was part of a deliberative process we took to much more effectively take what might seem like interesting programs, and have them go through a process where the business people and technical people could work together and align their interests and come up with a program that allows you to find surprises and identify the options that really can play, that can transform a market in a time period that allows you to get multiple returns on the invested capital. The process allowed our people to align their interests while also dealing with the ambiguity at the front end of innovation in a much more effective fashion than what's previously been done by using an options-based type of thinking.

> "[W]e are challenging our teams to tackle the tough problems first, or fail fast."
>
> –John Ranieri

Pew: *When you talk about the front-end of innovation, you mean the early stages of the project. Why is this phase so important?*

Ranieri: The upfront decisions that you make about taking those first few steps and knowing where not to go are absolutely critical because it is easy to go down a rat hole. And once you go, then there's human nature: once you start a program it's hard to change direction because then you have to admit failure. So if you don't design in certain exit options or these smart ways of challenging your capital to do as much as it can, you will not best assure an effective return on the deployed capital.

Pew: *How exactly does DuPont avoid those rat holes?*

Ranieri: What we tend to do is stage the technology where we understand where the major uncertainties are, and then either knock those down or show that we have a very good chance of knocking them down. Instead of achieving milestones that bring very little incremental improvement, we really go after the stuff that poses the biggest hurdles to the success of the technology—the greatest uncertainties. We get at those first and we go at those hard, and if we feel that we have a good handle on them, then we're as good

as or better than anyone else at being successful. We go after the major hurdles and solve the problems that are most responsible for preventing the product from getting to the market. That may sound obvious, but it is not usually how science is done. Usually with science you try to get some quick successes first and then deal with the more difficult problems later. But we are challenging our teams to tackle the tough problems first, or fail fast.

The question is how do you really do innovation smartly? And I think the process we set up on bio-based materials has been very instrumental to our success. We've been able to put those two pieces together—putting our money and technology together into market propositions that really are transformative.

V. Policy

A key point underlining the Pew Center's corporate strategies research is that climate change policies will profoundly affect markets and, in some cases, create large new markets with winners and losers. Companies ahead of the curve recognize this and are increasingly stepping up their involvement in the development of climate policies both to protect existing market positions and maximize future business opportunities. As University of Michigan Professor Andrew Hoffman puts it, "any company that sits on the sidelines as policy is formulated is recklessly playing the bystander to a significant shift in its market environment."[39]

Businesses increasingly realize that mandatory carbon constraints in the United States are imminent. As a result, major elements of the mainstream business community have begun engaging constructively in climate policy. This has been most noticeable through the advocacy efforts of USCAP, a unique coalition of businesses and nongovernmental organizations that is calling on the U.S. Congress to pass comprehensive climate legislation as soon as possible. The group, which includes DuPont, BP America, and the Pew Center, supports a reduction in U.S. GHG emissions by 14-20 percent below 2005 levels by 2020, 42 percent below 2005 levels by

[39] Hoffman, A. October 2007. "Regulation: If You're not at the Table, You're on the Menu." In HBR Forethought Special Report, Climate Business, Business Climate.

2030, and 80 percent below 2005 levels by 2050. USCAP also calls for a set of measures designed to contain the costs of the program, as well as a series of complementary measures to spur technological transformation in areas including buildings, carbon capture and sequestration, transportation, and energy efficiency.

DuPont has a long history of strategic engagement in environmental policy. Dating back to its experience with CFCs,[40] DuPont has consistently engaged in the policy process, consistent with its public environmental commitments, to help manage the business risks and opportunities presented by emerging environmental regulations.[41] Rather than taking a primarily defensive approach on environmental policy, the company has sought market opportunities from regulations, programs, and elements of intergovernmental agreements that serve the public interest.

The biofuels market is a classic example of how companies can benefit from using their government affairs function as a business strategy tool. The most influential drivers of growth in the biofuels market over the last few years have been policies and public incentives that aggressively promote production and use of these fuels. Analysts from McKinsey & Company rank policy as one of the four key variables influencing the future profitability of biofuels, along with gasoline prices, feedstock costs, and conversion technologies.[42]

Governments at the federal, state and local levels have so far deployed a number of different tools to help spur the nascent biofuels industry,[43] and there are many different ways companies can exploit these policies for strategic advantage. But not all policies will benefit all companies equally. While some government programs are designed to grow the biofuels market as a whole, other policies create more targeted opportunities for specific technologies and processes (see Textbox below). Companies can most effectively capitalize on government support in the biofuels space by analyzing the range of existing policy mechanisms and going after the ones

[40] Hoffman, A., 2006.
[41] For example, a 2005 *Business Week* article described DuPont as being "an experienced hand at making the most out of changing regulations." Aston, A. and Helm, B. 2005. "Financial Services Leaders." *Business Week*, December 12.
[42] Caesar, W.K., Riese, J., and Seitz, T. "Betting on Biofuels." *The McKinsey Quarterly.* June 2007, Number 2.
[43] See Pena, N., 2008.

that offer the highest expected returns. This requires careful consideration of the drivers, benefits, and drawbacks of various biofuels policies, and how they relate to the company's core strengths and assets.

The key drivers influencing the development of biofuels policy in the U.S. are concerns about climate change,[44] dependence on foreign oil,[45] and agricultural issues. How these concerns are reflected in policy has helped determine the relative winners and losers in the biofuels market thus far, and these distributional effects will persist as the U.S continues to define its broader climate, energy, transport, and agricultural policies.

Companies also need to understand the political situation in which certain policies were enacted, and assess whether that situation is likely to remain static or fluid. For example, ambitious biofuels production mandates were enacted with bipartisan support through the 2007 Energy Independence and Security Act (EISA). But some are now questioning whether these mandates may create or exacerbate environmental, social, and economic concerns. These concerns are likely to become more acute in the short term as conventional biofuels use expands, potentially chilling the political support that has been so important to the growth of the industry.

Most notably, expanded biofuels production was identified by some as playing a role in the dramatic run-up in global food prices experienced during global commodity price rises in 2008, which had severe consequences in many developing countries.[46] U.S. consumers were not immune to the price shocks either. Texas Gov. Rick Perry asked the federal government to cut the national biofuels mandate in half, in light of "skyrocketing" food prices.[47] While his request was ultimately denied, the move was indicative of growing disenchantment with corn-based ethanol among some interests. Ethanol producers themselves were heavily affected by the rising

[44] In the U.S., the transportation sector is one of the leading sources of GHG emissions accounting for about 28 percent of the domestic total.
[45] The transportation sector accounts for about 98 percent of oil consumption in the U.S. Most of this oil comes from outside the country, leading to energy security concerns, driven especially by the fact that a significant portion comes from the Middle East and Venezuela, according to the U.S. Energy Information Administration.
[46] "The New Face of Hunger." *Economist.* April 17, 2008. Available at: http://www.economist.com/opinion/displaystory.cfm?story_id=11049284, accessed June 3, 2008.
[47] Gralla, J. "Texas Seeks U.S. Ethanol Cutbacks; Cites Corn Costs." *Reuters.* April 25, 2008. Available at: http://www.reuters.com/article/environmentNews/idUSN2547879120080425, accessed June 3, 2008.

Text Box: Biofuels Policy Approaches

The United States and other countries have put in place a wide variety of policies intended to promote production and use of biofuels, usually by either mandating levels of use or subsidizing production and distribution. Many of these policies seek to grow the biofuels market as a whole. But as recognition grows that lifecycle environmental impacts vary across the range of biofuels, policymakers have begun crafting incentives that seek to spur more rapid development of more sustainable fuels. Below is a sample list of policy measures employed in the United States and abroad.

Policies that Support the Overall Biofuels Market

Volumetric Mandates: These typically come in the form of volumetric targets for the use of biofuels in the transportation sector. For example, the 2007 Energy Independence & Security Act (EISA) establishes a biofuels blending mandate of 36 billion gallons by 2022. Volume mandates are also sometimes expressed as a percentage of total fuel use.

Tax Credits: These are direct subsidies intended to offset the higher costs of producing biofuels relative to gasoline. In the U.S., refiners receive 45 cents for each gallon of ethanol they blend into fuels. Tax credits have also been used as an instrument to subsidize the development of biofuels infrastructure.

Low Carbon Fuel Standards (LCFS): These standards are intended to promote low carbon fuels, as measured on a lifecycle basis. As such, they can give a distinct advantage to cellulosic and other low carbon biofuels relative to conventionally refined corn-based ethanol. While not a full LCFS, in the 2007 EISA, Congress established minimum GHG targets (expressed as improvements over petroleum fuels) for different types of mandated biofuels. California has adopted an LCFS that sets a target of 10 percent reduction in the carbon intensity of the state's transportation fuel supply by 2020 from 2010 levels. In general, an LCFS provides better market signals for the development of low carbon fuels compared to threshold targets contained in EISA.

Research, Development & Demonstration grants: These grants are usually targeted at early-stage research into products and processes that have great environmental potential, but are not yet commercially viable. The U.S. Department of Energy, for example has distributed two rounds of grants totaling over $450 million to cellulosic ethanol plants as part of its effort to bring production costs down to the level of corn-based ethanol.

Upstream Cap on Fuels Producers: Proposals to incorporate the transportation sector in economy-wide climate change regulations could also have a significant impact on the biofuels market. Climate change legislation introduced at the federal level has proposed an upstream cap on fuels, which will require refiners to hold emissions allowances equal to the carbon content of the fuels they provide. In theory, this should create an incentive for fuels producers to move toward lower-carbon fuels to reduce their compliance obligation.

price of corn, since feedstock prices make up a significant percentage of biofuel production costs. As the price of corn rose above historic levels ethanol producers, for whom corn is the major raw material cost, saw their profit margins fall.[48]

While these concerns pose risks to the industry, they also create opportunities for companies to pursue alternative biofuels—especially those that are both more favorable from a lifecycle GHG standpoint, and that sidestep the food versus fuel debates associated with corn-based ethanol. DuPont's biofuels strategy for the medium-to-long-term is built on the understanding that advanced biofuels that achieve greater GHG benefits and that use non-food plant materials will be needed if biofuels are to displace a significant portion of gasoline in the transportation fuels market. The company's ultimate goal is to produce first ethanol and then biobutanol from more sustainable sources, like cellulosic materials such as corn stover and switchgrass.[49] Expanded use of cellulosic ethanol should have little or no potential impact on food prices, while relieving pressure to grow crops on sensitive land. Additionally, the production of cellulosic ethanol requires far less natural-gas derived fertilizer, making its overall energy balance and GHG benefits much more favorable compared with corn-based ethanol (see figure 4).

Congress and the Administration are already beginning to move biofuels policy in a direction that creates incentives for the production of cellulosic ethanol and other advanced fuels. In addition, California is proposing a low carbon fuels standard to provide incentives for the development of fuels with low lifecycle GHG profiles in general, an approach more compatible with climate goals. The EISA of 2007 included a requirement that 21 billion gallons of ethanol produced in 2020 be made from cellulosic sources, while DOE has set a target of 2012 to achieve technological advances that would make cellulosic ethanol cost competitive with corn ethanol.[50] To help meet this goal, DOE has provided millions in grant funding to pilot and demonstration facilities. DuPont has been a beneficiary of these DOE grants, including in 2003 when the company received a four-year, $19 million matching grant to develop cellulosic ethanol from corn stover—the stalks, cobs, and leaves left in the field after harvest.

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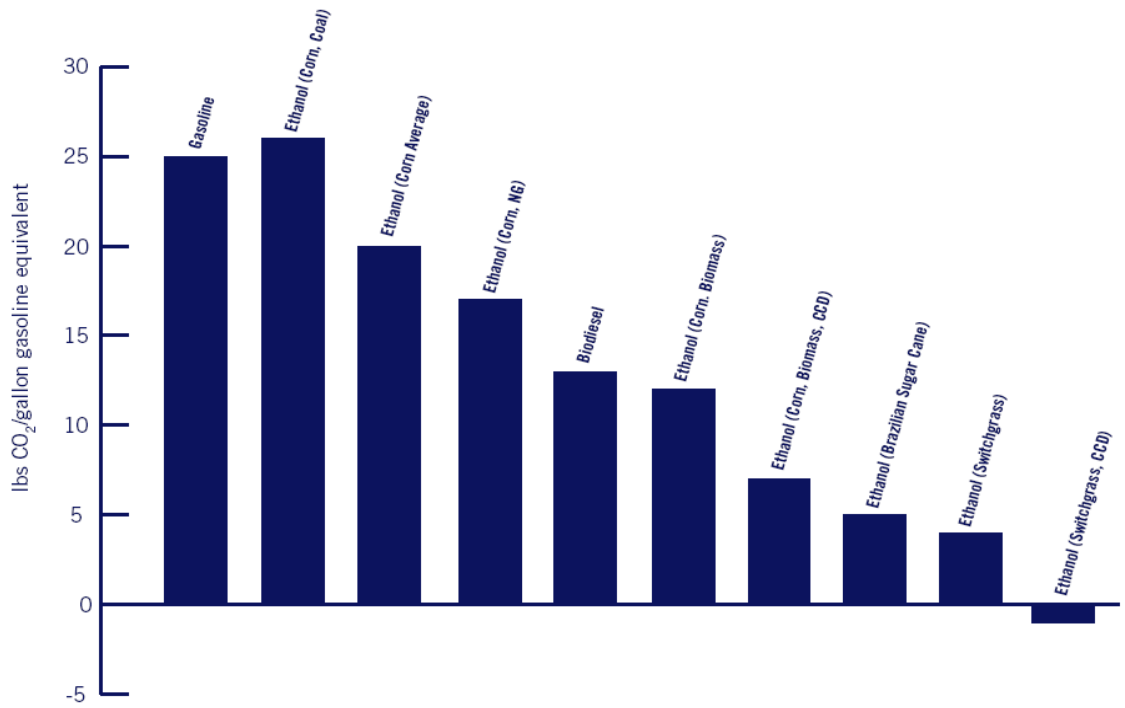
[48] Etter, L. "Ethanol Craze Cools as Doubts Multiply." *The Wall Street Journal,* Nov. 28, 2007. Available at: http://online.wsj.com/article/SB119621238761706021.html, accessed Nov. 30, 2007.
[49] Switch grass and corn stover form the initial feedstocks for DuPont's cellulosic ethanol technology.
[50] Government Accountability Office. 2007. "Biofuels: DOE Lacks a Strategic Approach to Coordinate Increasing Production with Infrastructure Development and Vehicle Needs." Washington, DC: GAO-07-713.

Figure 4: Lifecycle CO_2 Emissions from Various Fuels



Sources: Adapted from NRDC: Getting Biofuels Right; Wang et al., 2008. http://www.nrdc.org/air/trasnportation/biofules/right.pdf. This graph can be found in Pena, N. "Biofuels for Transportation: A Climate Perspective." June 2008. Pew Center on Global Climate Change: Arlington, VA.

NOTES:
1. These estimates include emissions due to U.S. land-use changes estimated to occur at the 4 billion gallon production level. Current U.S. production is already over 8 billion gallons, so the estimates of emissions due to land-use change are already out of date. No emissions due to land-use change are included for Brazilian ethanol because available studies to date indicate that ethanol production does not induce land-use change in Brazil (Fagundes, et. al. 2007).
2. NG = natural gas
3. CCD = carbon capture and disposal. In effect, some of the CO_2 removed from the atmosphere during photosynthesis is not returned to the atmosphere but rather is permanently (or for very long time periods) kept out of the atmosphere. Storage of CO_2 in geologic formations is one way to do this.
4. The negative emissions shown in the case of ethanol produced from switchgrass mean that this pathway would remove more CO_2 from the atmosphere than it releases.

DuPont believes that, in the short term, subsidies and other policy measures will be critical in advancing technology development and bringing down the costs of cellulosic ethanol and other advanced biofuels, but eventually advanced fuels will have to stand on their own without government support. DuPont believes that technology, feedstock and fuel type neutral performance-based policies and incentives can most effectively advance the development of a sustainable biofuels supply.

DuPont's views on policy issues related to biofuels development are highlighted in the following excerpts from the Pew Center's interviews with Ranieri conducted in April and June of 2007.

Pew: *What is it that led you to focus so much attention on second generation biofuels, like biobutanol and those that use cellulosic materials as a feedstock?*

Ranieri: When we started looking at this, the reason why we picked biobutanol and cellulosic fuels was we understood that you had to get to cellulosic to get to the volumes you are talking about [in the EISA]. And from an environmental perspective, cellulosic is advantaged over grain. With biobutanol, we applied our core competencies to produce an advantaged downstream product that brings significant additional advantage to consumers. We can also apply what we learned in the materials space and use it to be disruptive in the fuel space.

> "Policy has been critical, absolutely critical. ... The venture capital world would not have picked up on [biofuels development], large corporations like us would not have invested as much as we have without government support. So that is smart spending by the government."
>
> –John Ranieri

With ethanol currently using grain as a feedstock, you're seeing food-fuel debates occurring. So the question is, with first generation technology, how far can we go? There's no doubt we need to get to second generation technologies; we have to get to a non-food crop to grow sustainably and successfully.

Pew: *How does public policy and government support factor in?*

Ranieri: Government has a role to play in moving the technology forward. You can make cellulosic today, but it is very costly. So the technology component, moving the technology forward by driving the science to make cellulosic fuels more economically advantaged is critical, and that takes support to de-risk the programs, and governments are doing that. Now the question is, as these plants come up, is there going to be a differential subsidy or tax credit, or whatever you want to call it, for cellulosics? Our

position is that there has to be if you're really going to drive this forward. It has to be shepherded smartly by the government.

Pew: *Up to this point, how important has public policy been in the development of the biofuels industry?*

Ranieri: Policy has been critical, absolutely critical. You would not have first generation fuels without government policies and support. The venture capital world would not have picked up on it, large corporations like us would not have invested as much as we have without government support. So that is smart spending by the government.

Pew: *What's your view on subsidies? Can the biofuels industry survive without them?*

Ranieri: Eventually we have to be competitive without subsidies, and we can, but right now subsidies are critical.

You need some kind of fly wheel, something to support new strategically important businesses vis-a-vis entrenched assets that maybe do not have all of the environmental impacts internalized in their costs. So policy is critical. Technology moved by good policy works in certain circumstances.

Pew: *What about targets and mandates, like the RFS in the recently passed EISA? What effect does that have?*

It makes the industry and its people enthusiastic and you want to see specific policies to address the significant challenges that we are going to be dealing with to get to a biofuel production volume to meet the policy goals. The incentives are important. It would be nice to see specific policies and guidelines to move forward and meet that 36 billion gallon target.

We need a national road map of how we get to 36 billion gallons. How much needs to come from Iowa, how much from corn, how from much cellulosic, how much from sugar cane down in Florida, or Louisiana? If this is of strategic and national importance, and it's an environmental imperative how do we draw that map and say this is how we get to 36 billion gallons in the most sustainable manner, not causing food price concerns.

Pew: *How active has DuPont been in the development of biofuels policy?*

Ranieri: We are very active. We are very involved in trying to educate policymakers. We've had many requests from the Congressional districts to go and speak at public hearings. [Former] Senator Hillary Clinton [now Secretary of State] visited DuPont's Pioneer business in Iowa, [former] President Bush came to DuPont's research and development facility in Delaware. [Current Vice President] Joe Biden is from Delaware and has been aware of our efforts for some time. Several of our guys have been in Congressional hearings, educating members on where the technology is from a feasibility perspective. And it is exciting. It is one of the few things in America where you have the so-called red states and blue states that are pretty much in agreement about the need to move to cleaner, renewable fuels.

VI. Conclusion

Over the last several years, corporate views on climate change have undergone a transformation. Initially, while some companies like DuPont took leadership positions, most major U.S. companies responded with strong resistance to the prospect of government regulation to reduce GHG emissions, fearing potentially serious threats to their profitability. Over time, these views softened as many companies realized there were numerous methods available to reduce emissions while cutting costs and improving performance. Today, the corporate response to climate change is entering a third phase, as companies begin to accept the inevitability of climate policies that transform markets and to embrace the vast economic opportunities presented by the global shift to low-carbon energy sources, goods, and services.

This paper offers an in-depth examination of how two leading companies have partnered to develop and market new transportation fuels that have the potential to thrive in a carbon-constrained future. The paper is not an endorsement of biobutanol or any specific fuel DuPont and BP may develop in the future. Rather, the goal of this paper is to highlight the strategy and process DuPont undertook in partnering with BP to develop the fuel, in hopes of identifying lessons that other firms can apply to pursue similar new ventures—especially in advancing technologies that address climate change. Some of these key lessons include:

- Efforts to pursue new climate-friendly business opportunities are most likely to be effective if they are compatible with, and supported by, a company's broader corporate strategy, goals and vision. This is particularly true of initiatives that require companies to work with a partner.

- Strong and consistent support from companies' executive leadership may be a prerequisite for success in long-term initiatives to capture climate-related markets opportunities.

- Companies like DuPont and BP with a long commitment to environmental sustainability, experience in tracking and managing emissions, and expertise in policy engagement on energy and environment, will generally be able to recognize and capture climate-related business opportunities more quickly and effectively than their competitors.

- Cross-sector collaboration will be essential for success in many emerging climate-related business opportunities, since few companies possess all the skills and resources necessary to rapidly develop and bring to market a range of new low-carbon technologies (not just liquid fuels, but also electricity based transportation, power generation with carbon capture and sequestration, etc.).

- Climate partnerships and joint ventures have improved chances of success if the parties: 1) possess complementary skill sets; 2) share a common vision and commitment; and 3) structure their financial and organizational processes to support and encourage

innovation. Choosing the right partner or partners is important to ensure there are synergies that create new value.

- Companies may need to adopt new internal approaches and processes to thrive in a carbon-constrained world. This is especially true given that the policy "rules of the game" that will transform markets have not yet been fully set. Companies will need to be nimble and flexible under conditions of uncertainty, and they will need to link disparate corporate functions in these efforts such as R&D, government affairs, and corporate development. To achieve success, large companies accustomed to operating under relatively stable market conditions may need to consider joint ventures, special business units and financing mechanisms, and other organizational approaches that support corporate entrepreneurship.

- Since public policy is a determinative force in the shaping of new climate-related markets, success in these markets will require strategic integration of policy engagement into corporate strategy. A cap-and-trade system that puts a price on carbon will strongly affect capital flows. In addition, a number of complementary policies, such as performance standards, production mandates, tax incentives, grants, and subsidies, also have significant market impacts. Companies will need to review the full suite of policies in place, or under development, and leverage opportunities from which they are best equipped to benefit relative to competitors.

- Companies should also consider the political risk related to particular policies. Unintended consequences of ill-designed policies to protect the environment can drain political support and require major policy revisions that cause market turmoil. Before investing capital and effort in pursuing opportunities dependent on policy-based market change, companies will have to apply foresight, in some cases thinking farther ahead of policymakers themselves and recognizing political motivations that may be at odds with sustainability goals.

Already, companies across the economy are beginning to roll out new products and services designed to thrive in a carbon-constrained future. The companies that are ahead of the curve stand to gain competitive advantage over their peers as they acquire early toeholds in new markets created by climate change regulations. The DuPont-BP partnership on biofuels is one example of a creative approach two major corporations are taking to tap these new market opportunities. At this early stage, there is much to be learned about the new approaches, methods, and tools that innovators like DuPont and BP employ to speed the development and deployment of the technologies needed to mitigate and adapt to climate change.