The Making of the Next Industrial Revolution
at Ford Motor Company

William McDonough + Partners
Architecture and Community Design

△MBDC
Ford Rouge Existing Conditions
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“McDonough is truly one of the great visionaries. He’s worked closely with Ford on a number of projects that combine cutting-edge technology with environmental insight.”

Lana Pollack, Director,
Michigan Environmental Council
SCOPe OF PROFESSIONAL ENGAGEMENT

• Construction of a new automotive assembly plant, body shop, conveyor system, and associated infrastructure
• Restoration of public access to a site that had hosted hundreds of thousands of visitors from 1924 to 1980 through construction of a tour facility and visitor center
• Preservation (and in one instance reconstruction) of certain significant historic structures
• Commemoration of important site events including the establishment of Organized Labor and achievements in assembly-line manufacturing
• Commemoration of those who lost their lives at the site
• Implementation of an innovative stormwater infrastructure based on natural principles
• Restoration of natural habitat in areas not required for production
• Restoration of soil using natural processes of phytoremediation
• Workplace improvements including the introduction of daylighting, temperature control and improved ventilation
• Analysis and implementation of energy-efficiency measures and alternative energy solutions

The project has also served as a working model allowing the client to test ideas of product development, lean, flexible and sustainable manufacturing, creating replicable solutions for the future.

The client wished not only to update its brand image, but to create a new path for industry in a world that increasingly recognizes the limitations imposed by dwindling resources and environmental degradation.
William McDonough + Partners has led the master planning of the revitalization of Ford’s historic River Rouge facility. This ambitious 20-year plan will pioneer strategies and technologies for brownfield redevelopment, sustainable industry, corporate citizenship, and environmental regeneration.
Henry Ford, like other Detroit industrialists, built his factory along the Rouge River. Early in the 20th century, rivers were the industrial corridors, and the Rouge River, up to Ford’s plant, was more of a dredged canal than a living stream. The plant’s proximity to its namesake, along with the site’s shallow water table and the high clay-content of its soil, made the natural drainage system more of a wide-open sluice than a slow, percolating flow of water. When heavy rains fell, storm water washed toxins and cinders off all the impervious surfaces—vast parking lots, buildings, chimneys, blast furnaces—and carried them swiftly away. There was little between the rooftops and the river to slow the water down.

As the design process was unfolding, the U.S. Environmental Protection Agency was developing new stormwater regulations. Ford had estimated that the conventional technical controls required to comply with the new rules could cost almost $50 million. The natural storm water management system was estimated to cost only $15 million. The math was simple and compelling: The living roof and wetland gardens offered millions of dollars in savings, with the landscape thrown in for free.

New green spaces naturally absorb storm water. Porous paving, which allows water to seep into underground retention beds and percolate slowly into the soil or into swales, has replaced impervious paved surfaces. Swales
are channels cultivated with wetland plants that absorb and filter water. In many places on the site, particularly along roadways, swales are lined with hedgerows to create green breaks in the landscape and even greater capacity for storm water retention. The natural storm water system also creates new and revived habitats on the site for native birds, butterflies, insects and microorganisms, generating a larger biological order.
Eighty-five years of 20th century manufacturing can have a heavy impact on the land. Nowhere is that more evident than in the soils of the Rouge, which are contaminated with hazardous chemicals. Typically, industrial sites with toxic earth are “cleaned-up” by excavating the topsoil and hauling it away. The project team had a different idea—it decided to do on-site remediation instead. Along with landscape architect Julie Bargmann, the team has been working with Dr. Clayton Rugh, a professor in the Department of Crop and Soil Sciences at Michigan State University, who is doing pioneering research in phytoremediation.

Phytoremediation is a process that uses plants to neutralize toxins in the soil. Dr. Rugh has been testing phytoremediation at the Rouge for the past year. He has cultivated 20 native plants in contaminated soil and is monitoring them to test how well each breaks down and purifies polycyclic aromatic hydrocarbons (PAH), a prevalent on-site toxin. So far, big bluestem and green ash seem to have the biggest appetites for PAHs. With other native plants, which will be monitored by Rugh and a group of scientists, big bluestem and green ash are being planted in phytoremediation gardens along the Rouge’s main thoroughfare. The researchers will continue to systematically test which plants are the best long-term toxic avengers. Other scientists are doing research on plants they believe may neutralize heavy metals and other
compounds. These industrial strength plants, adding to the landscape as they purify the soil, may be the most productive living things at the Rouge.
And indoors? We’ve tried to bring as much of the outdoors into the Rouge factory as possible. Our work with other manufacturing companies has shown that job satisfaction increases measurably when workers are able to experience a relationship to nature from the factory floor. At Herman Miller, in Zeeland, Michigan, where the company’s furniture assembly plant provides fresh air, sunlight and ample opportunities to observe the outdoors, researchers have credited our building design with elevating both worker productivity and employee retention.

The design team aimed for the same sensitivity to worker satisfaction at the Rouge. Our first goal was to bring sunlight deep into the building so workers could sense the changing light and weather and have visual contact with the outdoors. To achieve this, the factory design includes ten 25 x 100 foot rooftop monitors—essentially, pop-up roofs—each glazed on all four sides. Skylights of this scale are unprecedented in an automotive assembly plant, which are ‘typically boxes filled with tools.’ In addition, the roof is sloped to the north to allow more northern light to enter the building and to block some of the strong, direct sunlight from the south. The glass is frosted to cut glare and thermally insulated to mediate heat fluctuations. Thirty-five smaller skylights establish an even, well-tempered level of light.
The factory’s state-of-the-art manufacturing processes are designed for flexibility. The assembly lines are capable of handling three different vehicle platforms and nine different models. That’s impressive, but we’re especially interested in manufacturing flexibility for the opportunities it provides for disassembling cars and trucks so that materials may be continuously reused in a closed-loop cycle.
A green roof was the most compelling solution to the storm water problem at the Rouge. The idea made intuitive sense: The soils and grasses that comprise functional living roofs absorb water just like the soil and plants in a healthy landscape.

Within five days of the roof going down, local killdeer had nested and laid their eggs in the sedum (see below). Turns out that those who had said a 10-acre green roof was ‘for the birds’ were right after all.

The Rouge design team discovered a host of cost-effective benefits. In addition to absorbing storm water, soil and vegetation on the roof would also:

• provide extra insulation
• protect the roof membrane from wear and thermal shock
• create habitat for native birds
• contribute to mediating the urban heat island effect
• capture harmful particulates
In addition to energy efficiency, 21st-century sustainable industry is powered by systems that maximize energy effectiveness and generate clean power. William McDonough + Partners studied and outlined strategies for Ford Rouge Center to maximize energy efficiency for immediate cost savings. WM+P also proposed further study of renewable energy production possibilities at the Rouge.

The Big Foot Mechanical System, designed by Tom Kiser of Professional Supply, Inc., directs natural air flows to tamper air in the occupied zone of the building. Pressurized air is released through small apertures all around the facade which can be adjusted to maintain a pressure balance. Distributed Chiller Units, which are much more energy and cost-effective than a Central Chiller Plant were spaced across the roof.

Renewable energy sources were proposed for targeted applications at Ford Rouge Center. Photovoltaics and solar thermal panels are featured outside of the new Visitor Center.
The Rouge Complex is the embodiment of Henry Ford’s vision for a vertically integrated manufacturing plant, and an icon of industrialization for the world. The historic value of the site has been recognized by the National Trust for Historic Preservation.

As the plant was redeveloped to support manufacturing into the next century, there were opportunities to honor the historical significance of the Rouge by retaining key buildings.

Important structures include the Dearborn Assembly Building, the Dearborn Glass Plant, Powerhouse No. 1, and the Coke Oven operations area.

The Dearborn Glass Plant has both architectural and historic value. Designed by Albert Kahn, it represents the state of the art industrial building for its time and was integral to the development of early modern architecture.

The Powerhouse and Coke Ovens also have value as industrial artifacts. Because they are now obsolete, it may be difficult to retain them. We see an opportunity, however, to preserve some portions or provide documentation for future study.
Clients:
Jay Richardson, Ford Vehicle Operations
Gordon Cooley, Ford Motor Land Services

Ford Participants:
Roger Gaudette, Ford Land Services

WM+P Manager:
Roger Schickedantz

Outside Team Members:
Quinn/Evans Architects
Arcadis Giffels
Conceived as both an extension and an integral component of the industrial landscape, this LEED Gold certified visitor center supports a key goal of the 20-year revitalization of the historic Rouge complex - the restoration of public access to a site that hosted hundreds of thousands of visitors from 1924 to 1980. Its design evidences sustaining strategies throughout the Center and the site as a whole, and its exhibits enmesh visitors into the themes and strategies of this industrial landscape. A three-sided glass observation platform rises above the roof, offering visitors a panoramic view of the world’s largest green roof installation on the adjacent assembly plant. Solar thermal panels in the large entry plaza produce the building’s hot water. Roof-mounted photovoltaic panels and a translucent PV array on the entry canopy transform sunlight into energy. The surrounding landscape embodies the same commitment to environmental design with its crab-apple orchard, apiary, bioswale system, and a 40-foot high vegetated trellis around the building perimeter.
RESEARCH AND DESIGN CONSULTING

The Rouge River Facility revitalization project also included a series of projects focusing on applying Cradle to Cradle® design concepts to Ford’s product design and manufacturing practices. MBDC consulted with Ford on the following initiatives:

- Source more ecologically intelligent materials from its supply chain
- Work with selected suppliers to provide “proof of concept” products for early stage design initiatives;
- Conduct research on recycling technologies that might preserve the highest value of automotive polymeric materials
- Find economically and technically feasible applications for Design for Disassembly and Design for Recycling methodologies
- Work with Ford concept car teams to research and identify innovative materials for automotive interiors that could enhance vehicle indoor air quality
- Provide on-going research and advisory support to Ford executives in a monthly publication to provide insights for how eco-effective design can lead to new business opportunities
- Propose initiatives for establishing a revolving loan fund to enable Midwestern farmers to use their lands to harvest and sell wind energy to the grid and providing a bank of renewable energy credits to assist Ford in meeting some of its sustainable energy goals
As landfill space dwindles and tipping fees increase across both continents and legislation emerges in Europe that mandates recycling of automobiles, there is growing recognition that polymers need to be recycled to reduce both the economic and landfill burden they pose and to meet recycling limits for the automobile industry. As polymers represent an ever-increasing percentage of an automobile’s weight and, there will be a concomitant need to recapture and reutilize the materials value of these polymers.

In response to these trends, the Polymer Recycling Study was conceived as a comprehensive investigation of chemical recycling technologies and facilities in both Europe and the U.S. The study focused on those technologies appropriate for recycling nylon, polyethylene, polypropylene, and rubber – all commonly used in automobiles.

Polymers represent an intrinsically valuable material from both a functional point of view and as embodied chemical energy. Chemical recycling represents an opportunity to recover both material and chemical value from polymers that are not suitable for reuse or mechanical recycling. As oil resources become scarcer and prices rise, chemical recycling offers the potential to close-the-loop for some polymers and ensure that the maximum value is gained from a material that is based on a non-renewable resource.
Material Returned to auto industry for recycling
"Design for Disassembly"

Material Recycled through advanced mechanical & chemical recycling
"Technical Nutrients"

Product
"Zero Emissions Manufacturing"

Vehicles Recovered
"Eco-Lease"

Lost Material Assets
Current Scenario: Material Loss
Material is lost in each phase of handling, from extraction of crude material to the recovery and recycling of material from retired vehicles.
Lost material must be replaced by virgin materials.

Accruing Material Assets
Alternative Scenario: A Closed Loop
Instead of mining the earth to create cars, cars themselves are mined for their valuable material.
In theory, no material is lost during handling, and all material remains in the automotive industrial metabolism.

Waste and Downcycled Materials

>50,000 lbs unrefined material

>10,000 lbs raw material

>7,000 lbs process waste

>40,000 lbs tailings & mining waste

3,000 pounds returned (100% of material needed)

3,000 pounds recovered (100% of material used)

1045 lbs returned to auto industry

1100 lbs downcycled to other industries

705 lbs landfilled shredder residue

180 lbs abandoned vehicles

2,145 lbs downcycled to other industries

2,850 lbs processed waste

3,000 pounds returned (100% of material needed)
U260 ECO-EFFECTIVENESS STUDY

U260 Program was identified as a vehicle program to work with MBDC in implementing its Design Protocol.

MBDC committed a full-time employee to work on-site with the U260 team. This person educated team members about the design objectives of the Protocol, and demonstrated the application of the Protocol to the material selection process. He also established relationships with other Ford groups whose participation is essential to facilitate a cross-functional approach to eco-effective design.

MBDC produced a report of its findings, which included specific feedback about polymeric materials being considered for U260 and related human health and ecological toxicity issues. Particular emphasis was placed on specifying positive additive profiles and their potential contribution to vehicle interior air quality (vIAQ). MBDC also gave preliminary feedback for staging the U260 vehicle for maximum reutilization (e.g., design for disassembly [DfD] guidelines and the potential of each polymer as a technical nutrient).

MBDC also evaluated Ford’s Product Development System and its Restricted Substance Management and Recycling System to identify how the Protocol might be used as an eco-effective design standard to influence material
selection, and ultimately, the product development process. MBDC outlined current business drivers or rationale for implementing Protocol criteria, identified variables to compare different materials and possible external costs, and offered some ideas for successfully communicating and marketing eco-effective products to Ford’s customers.
With the advent of legislation in Europe that mandates the recycling of automobiles, it has become apparent that effective and efficient disassembly of automobiles will play an increasingly valuable role. Due to the fact that an automobile is a complex mixture of a wide variety of materials, an appropriate disassembly strategy is key to recovering and recycling those materials.

By implementing an appropriate disassembly strategy coupled with a Product of Service™ concept, Ford could reduce long-term costs while enhancing quality, customer satisfaction and overall service to the end user.

With a pilot disassembly facility Ford could demonstrate its commitment to the environment by keeping materials in closed loops thus allowing the automobile to enter a Cradle to Cradle® lifecycle rather that the current cradle-to-grave scenario.

MBDC delivered a series of proposals to Ford outlining how we could collaborate on this exercise to first identify the economic benefits inherent in a design for disassembly strategy, second exploring the feasibility of implementing such a strategy, and third actually constructing a pilot disassembly plant.
Lost Material Assets (waste or downcycling to other industries)
RIDE THE WIND

MBDC proposed that Ford Motor Company launch the Ride the Wind™ Revolving Loan Fund, enabling Midwestern farmers to harvest and sell clean wind energy. By installing wind turbines on family farms in the Midwest, Ride the Wind™ (RTW) will provide Ford with economic and public relations benefits. A letter of intent announcing Ford’s commitment to providing an investment as the sole debt holder will facilitate participation from other identified partners and the launch of Ride the Wind™ LLC. Immediate action is required for Ride the Wind™ to be operational in 2001.
Ride the Wind™ presented the following business opportunities for Ford Motor Company:

**Financial return on investment**—Wind farming is an economic model that has already proven successful—wind power is a growing cash crop in the upper Midwest. Government policy and incentives also favor wind energy development. Ford can tap into the financial rewards of this growing energy sector through Ride the Wind™. Ford may also benefit from the future sales of emission credits, which have not been accounted for in this financial model.

**Environmental Leadership**—This is an opportunity for Ford to lead an integrated approach to sustainability, with benefits that are at the same time environmental, economic, and social. As electric vehicles proliferate, they will continue to come under increasing criticism from environmental advocates, because in the current energy market, EVs displace pollution rather than preventing it. (EVs running on power generated by fossil fuel-burning plants indirectly create more air pollution than gas-powered cars.) By investing in wind power generation, Ride the Wind™ makes Ford’s EV cars truly zero-emissions vehicles and helps lead the energy industry toward greater sustainability.
An ongoing initiative at Ford through the Ford Research Lab was the development of a “Zero Emission Vehicle.” The goal of this initiative was the development of an internal combustion engine vehicle that produced no emissions. MBDC’s contribution to this exercise was the evolution from a zero emission vehicle to a positive emissions vehicle. The goal of such a vehicle is no longer the elimination of harmful emissions, but the capture and productive use of automotive emissions as either feedstock for industrial processes or food for biological systems.

MBDC contributed to the development of the Positive Emission Vehicle Vision Statement:

*A key step toward a Nutrivehicle™ is the removal of substances that are hazardous for environmental or human health: a zero emission vehicle. The next step is to make emissions healthy for the environment and human beings so that all components emitted during operational life of the vehicle are nutrients for biological or technical systems. For example, emissions from a fuel reformation process (e.g., carbon black) would be food for other systems such as metallurgical industry, tire industry, and plastics industry, while emissions from the vehicle itself would be in the form of H2O vapor which could be food for any number of natural systems.*
A true “Emission = Food” vehicle would also consider the manufacturing process, life cycle of materials used, and the potential human and ecological effects in the design of these inputs.

MBDC also provided comprehensive Nutrient Fact Sheets for those nutrients likely to be produced by the Positive Emission Vehicle. These nutrients included water, carbon dioxide, hydrogen, elemental carbon, and nitrous oxides. The fact sheets contained information on the nutrient type (i.e., biological or technical), supply and demand characterization, feasibility of sequestration on board an automobile, and next steps for further study.
In order for Ford to successfully employ eco-effective strategies and lead the auto industry into the Next Industrial Revolution, its supply base needed to share a common vision and goals to be able to provide products that embody the principles of ecological intelligence. MBDC worked with Ford’s suppliers to create products that meet its Protocol and that allow Ford to offer its customers products that are truly of superior quality.

MBDC’s worked with Ford’s supply chain to develop products that meet Ford’s desire to create a new manufacturing paradigm, distinguish its product from its competitors, define a new standard for corporate citizenship, and firmly establish the Ford trustmark with its ideals of innovation and product quality.
Remaking industry and leading the Next Industrial Revolution require constant attention to opportunities for positive change as well as profitability. Leading also requires increasing insights into the principles of sustainable industry and the possibilities for their near- and mid-term realizations.

Feedforward was created to facilitate and communicate these kinds of awareness and insights. It is intended to keep its audience at Ford Motor Company on top of key environmental and business issues that MBDC sees as significant in light of its eco-effective design philosophy and the Next Industrial Revolution.

Feedforward delivers monthly summaries of key news stories, featured topics of possible interest to Ford Motor Company in pursuing eco-effectiveness, personal observations from Bill McDonough and Michael Braungart, occasional updates of important MBDC projects with Ford, and other topics. Collectively, this regular stream of eco-effective information and insights offers ideas for deepening understanding of business leadership opportunities.
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