Post-Petroleum Design

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As the global oil supply dwindles and concerns about its use rise, designers are searching for alternatives. An increasing number are choosing to reduce the amount used in their raw materials, manufacturing processes and product distribution. Some are achieving significant reductions throughout the entire product lifecycle. By interviewing over 40 industrial designers and architects practicing post-petroleum design, I found that significant reductions in petrochemical use often begin with design. The design intent of the designer in many cases establishes the goal of minimal petrochemical use, which is then achieved through material acquisition, manufacturing, distribution and recycling. Analysis of the design processes and their lifecycle repercussions as revealed in the interviews exposed five principles: energy flows, cycles, resource balancing, resilience and interdependence. The results of this study of post-petroleum design will be of value to architects and their educators in two ways. First, the analysis of interviews with architects reveals specific principles and practices for reducing petrochemical use in architecture. Second, the analysis of interviews with the designers and manufacturers of post-petroleum products and materials, which can be specified by architects, opens new approaches to green building.

A WORLD MADE FROM OIL

Of all the materials found on Earth, none has had the impact of oil. It powers our economy and sustains our civilization. Every day we use 90 million barrels of it. Design professionals have taken the lead in reducing our dependence on oil by improving auto efficiency, reducing emissions, and bringing down energy use in buildings. They have succeeded in curbing the rate of increase in oil consumption in cars and buildings, two of the largest users of oil. But as oil use in cars and buildings levels off, one use of oil is outgrowing all others—plastic. More oil goes to make plastic building products than to any use except transportation and consumer products. And the results are significant: 300 million tons of new plastic added to the planet every year, 2.6 billion barrels of oil used to make it, and 30 million tons of it dumped into our landfills and afloat on our oceans. Global plastic production generates two billion tons of CO2 annually, and polyvinyl chloride (PVC) faces growing restrictions for health reasons.

These effects are making many consumers, corporations and design professionals think twice before using plastic. PVC, the third most commonly used type of plastic, is banned from packaging in Canada, Spain, South Korea and other countries. Cities like New York, Seattle and San Francisco have ordered their purchasing programs to buy fewer products containing it. The Sustainable Sites Initiative for landscape architects recommends avoiding its use, and LEED credits for toxic materials avoidance are increasingly taking aim at it. Design professionals have been quick to respond. Companies including Apple, Honda, Nike and Wal-Mart have committed to phase out PVC.

Design firms like Alessi and Lake|Flato Architects have already developed plastic-free objects and environments. Plastic-free packaging,

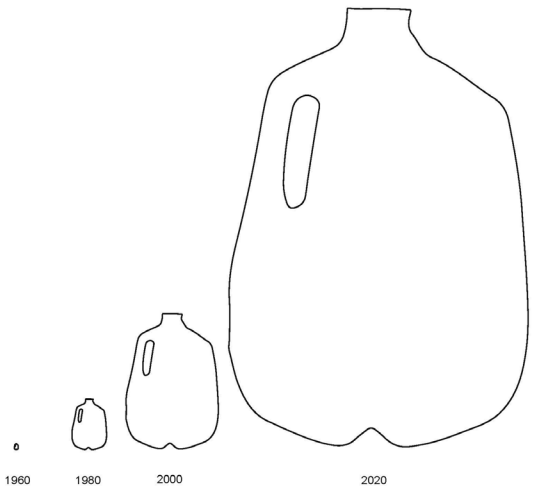

Figure 1: **World Plastic Production** Global plastic production is expected to triple during the first 20 years of this century. (Illustration by Maria Meza)

clothing, and consumer electronics are all on the rise in an otherwise stagnant market. But designers searching for knowledge in plastic- and petroleum-free design can find few resources. Most current books on green product design stress recycling and emissions reduction, while green architecture, landscape architecture and interior design books emphasize energy conservation. However, a growing trend toward post-petroleum design is emerging among innovative design professionals, people like Eben Bayer, the American innovator whose company, Ecovative, is growing houses from mushrooms; Mohammed Bah Abba, whose Zeer Pot is helping families keep produce fresh in the sweltering Nigerian summer without electricity; and the engineers at Mercedes-Benz Advanced Design Studios whose Biome concept car evolves from genetically engineered DNA.

We can see the growing demand for post-petroleum design in the rapid rise of these and other plastic-free products. Nike, Coca-Cola, Under Armour, and many other industrial giants now offer plastic-free products, and environmental design firms are turning to these products to meet their clients' green building needs. Certification programs including LEED, Greenseal and Cradle-to-Cradle offer credits for products and designs with reduced plastics, petrochemicals, and fossil fuel consumption. In the near future, more clients will join cities like Seattle and Santa Monica, as well as a growing number of universities, in divesting from fossil fuel companies.

Post-petroleum design offers a low-energy, low-emission, less-toxic alternative to oil based on renewable materials. Post-petroleum design embodies innovative, plastic- and petroleum-free products and projects in industrial design, architecture, transportation, electronics, apparel and more. It reflects new consumer motivations behind the demand, and offers the case studies, principles, best practices and opportunities for all designers. Post-petroleum designers are developing new strategies for sourcing plastic-free materials, reducing petrochemical use in manufacturing, and marketing their post-petroleum products. They are developing new methods to research, evaluate, and select materials, technologies and design strategies that meet the growing demand for sustainable design, plastic-free materials and process energy conservation.

PRINCIPLES OF POST-PETROLEUM DESIGN

Today's young designers will have to design for a post-petroleum world within their lifetimes. But even before the oil runs out, many are making their work more sustainable by adopting principles of post-petroleum design. Their work is characterized by reduced reliance on petroleum products in both their materials and operation, but most significantly by pointing to an emerging approach to eco-architecture identifiable as post-petroleum design. The result is a step toward a design process that harmonizes its products with nature and begins to free us from our dependency on petroleum.

Energy Flows - Nature's energy flows include more than just fuels. Nature's energies in all their forms tend toward cyclical, self-regulating, decentralized and regenerative patterns. Understanding our place and work in this complex web of energies, we can optimize our designs and our products to work with, rather than against, them.

Cycles- Energy flows in cyclical patterns where the outputs from one process become inputs to others, eliminating waste. Designing with awareness of nature's cycles—even the simplest ones like night and day—can make the resulting products more sustainable.

Resource Balancing - Natural systems adjust to balance production with available inputs. This is true for energy as well as other resources including water, food and heat. Nature minimizes waste and is the ultimate recycler. By distinguishing between energy income and energy capital, products and processes can be optimized to balance energy use with available energy income. Products can, for example, be designed to serve as inputs to new processes or products at the end of their service.

Resilience - Because nature is made up of dynamic flows, all things are in a perpetual state of change. "Adapt or die" is as true in design and commerce as it is in nature. Resilience is the ability of our designs and products to adapt to changing conditions. Many post-petroleum designers practice biomimicry, taking lessons from nature and emulating the resilience they see in the bending of a tree, the slow shifting of a streambed, or other aspects of natural systems.

Interdependence - Energy flows within and between natural systems, resulting in mutual influence, components and processes in one system responding to cycles in another. Recognizing these deep connections, post-petroleum designers minimize harmful impacts over space and time, asking questions such as, "Where does this material come from?" and "How will it affect future generations?"

CASE STUDIES

Hy-Fi Tower - When David Benjamin, principal at Architect of The Living, visited the facilities of Ecovative in Green Island, New York, he knew he wanted to use their Mushroom Materials in his next building. Benjamin was designing the installation known as Hy-Fi Tower for New York's Museum of Modern Art as part of their Young Architects Program. As he examined row after row of mycelium, the growth stage of fungus that grows to become packaging, building materials and other products at Ecovative, founders Eben Bayer and Gavin McIntyre explained their new "Grow It Yourself" program. The program allows designers, artists, educators, and other innovators to grow their own creations with Mushroom Materials, and Benjamin could imagine them forming the building blocks of the tower that would occupy the courtyard of MoMA's PS1 complex.

Benjamin described Hy-Fi Tower as "a kind of local economy of materials. Everything from the project, in its entire life cycle, comes from within a 150 mile radius," he told The Creative Project. "Then at the end of the lifespan of the temporary structure, we're going to compost it, again, right here in New York City, and then return that raw material to local community gardens and tree planting." It took three months to pile the project's 10,000 mycelium bricks to its full 40-foot height. And as Hy-fi Tower rose up in the courtyard, MoMA apparently grew to like it too, declaring it the winner of their 2014 Young Architects Program.

ArboSkin Pavilion - The snake-like structure of the ArboSkin pavilion at the University of Stuttgart not only combines skin and structure in a

Figure 2: **Hy-Fi Tower** The building blocks of the Hy-Fi Tower installation at New York's Museum of Modern Art were grown from Ecovative's Mushroom Material. (Permission of Ecovative)

single, innovative system, it's also biodegradable. The building's façade, developed by students and professors at the university's Institute of Building Structures and Structural Design (ITKE), consists of 388 three-dimensionally triangulated panels made from a specially-developed bioplastic. "The goal of the project," the university declared in a press release, "was to develop a maximally sustainable yet durable building material while keeping petroleum-based components and additives to a minimum." To accomplish that goal, they turned to the German firm, Tenarco, which combined different biopolymers such as lignin, a wood pulping by-product, with natural reinforcing fibers. The resulting "Arboblend", as Tenarco called it, was then extruded into sheets that were in turn formed into the triangular panels that make up the façade. Waste from the process was even recycled back into new panels. "Thermoforming sheets of bio-based plastics can be a resource-efficient alternative in the future," explained professors and project leaders Carmen Köhler, Manfred R. Hammer and Thiemo Fildhuth. "We linked the moldability of thermoplastics with the environmental benefits of materials made from over 90% renewable resources."

Cortiça Chaise Lounge - "I think that we're all getting a little tired of shiny plastic," according to New York furniture designer, Daniel Michalik, "and we're trying to retreat a little bit back to natural materials, and I think cork is ideal for that." But it's clear that he sees his work with cork as more of an advance than a retreat. hat I find so inspiring about this material is that I see it as a jumping off point. It's not just a material to design interesting objects, which it is, but it's also a model for a different way of thinking of how we use natural materials. And it's got huge potential for design, for furnishings forobjects, for interiors, for architecture; it's got just potential everywhere."

"Cork is a sustainable material, regenerating every nine years for harvest. The Portuguese regions of cork production hold centuries-old farming and manufacturing traditions that can teach us how objects can be made more responsibly. The cork objects I design and make reflect a love for the origin and context of a material, and it has led to exciting collaborations with adherent cultures and industries. My studio in New York City is a laboratory dedicated to unlocking new potentials for cork and other materials. In this space we explore the deepest potentials of cork as an unusual natural material, allowing it to perform in new ways, and as no other material can." For Michalik, his works in cork are the result of a vision combining innovative design with craft and natural materials. "Manufacturing," he said, "has new models that are being engaged now, using different kinds of materials and different kinds of manufacturing techniques that are healthier than what we've known before. And this work that I've done with cork is a great starting point."

Figure 3: **Arboskin Building** The ArboSkin pavilion at the University of Stuttgart is made from 388 biodegradable bioplastic panels. (Permission of Manfred Hammer)

Figure 4: **Cortiça Chaise Lounge** Cork, as used in this furniture piece by New York designer Daniel Michalik, is extremely renewable, regenerating itself every nine years. (Permission of Daniel Michalik)

Darkling Beetle Lanterns - Not all bioplastics come from plants. Dutch designer Aagje Hoekstra makes hers from the shells of dead Darkling Beetles. The shells are made of chitin, a natural polymer also found in crab and lobster shells. After heat-pressing, the shells are still visible in the plastic, which is waterproof and heat resistant up to 200 degrees centigrade. "I wanted to keep the structure of the beetle in the plastic so you know where it has come from," Hoekstra told Dezeen magazine. She has already made jewelry and decorative pieces from her Darkling Beetle plastic, and has plans to make plastic spoons and cups. It's not clear how many consumers are eager to eat and drink from plastic made from beetle shells, but it does appear that Hoekstra's bioplastic utensils don't contain the toxins found in many petrochemical plastic utensils.

LOOKING FORWARD

Products, homes, and cars—these three things account for 99% of our petroleum consumption. But before we ever use these things, someone has to design them. In today's consumer society, our lives are shaped by the products we use, and our future is shaped by how we design and make those products. Are they made with renewable resources? Can they return to the Earth without harming it? We are all affected by global climate change, and post-petroleum design is critical in our effort to abate it. We can only make a more sustainable world by designing a better alternative to the one we've made from plastic and petroleum. Post-petroleum design is the story of that change.

The world we've made with petroleum and plastic has brought us power and convenience beyond our ancestors' dreams, but at a heavy cost to our health and environment. Recognizing this, we now design with greater awareness. Buildings and vehicles today must conform to ever-stricter energy conservation standards, and products are scrutinized for their impacts on planet and people. Still, no single material has as much impact on our environment and our health as petroleum. The intersection of petroleum and design therefore may be the biggest single determinant of our future quality of life. Can we create a new breed of vehicles, homes and products less reliant on oil, and less harmful to people and planet than their oil-dependent predecessors? The inspiring stories of the designers who are leading the way to a positive, post-oil future suggest the answer is yes.

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Figure 3: **Darkling Beetle Bioplastic Lanterns** The shells of dead Darkling Beetles, which are made of the natural polymer, chitin, are the material of choice for lanterns by Dutch designer Aagje Hoekstra. (Permission of Aagje Hoekstra)