Biological Future

An Argument for the Use and Development of Biodegradable Materials for Design

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Abstract

By using biomass as the primary source for our energy and material needs we will contribute to reduce emissions of green house gasses, simplify our disposal and recycling infrastructure and deal appropriately with products for which no feasible collection currently exists. Biomass is produced by living organisms that are tightly related to Nature's life-supporting cycles, and its use within sustainable parameters would set the pace for industrial activity. Technological materials would be saved for applications where no biological material performs adequately, and their availability would be guaranteed for a longer period of time. Fewer regulatory and certification entities will be needed if capital production and waste recycling depends on efficient natural cycles, since industrial activities would rely on healthy ecosystems for their energy and materials supply.

A few cases are mentioned to exemplify different areas of this biological metabolism and the application of “100bio” materials, such as CO_2 balance, availability and cost of raw materials, disposal structures and design limitations and potential.

Premise: Towards a Biological Future

Our existing production and consumption paradigm relies on a set of industrial processes and business supporting infrastructures whose conceptual basis were developed taking into account only those requirements and limitations of each participating entity's scope of work. Their ways and premises are not usually challenged and have defined our palette of materials, manufacturing processes, marketing requirements, distribution channels and disposal policies. As these entities work directly in a fraction of the world's industrial activity, they relate external inputs and outputs just to immediate steps in a sequential process, instead of to larger cycles and mechanisms.

Due to the increasingly damaging environmental and social impacts of existing systems of production and consumption, there is a growing interest in closed loop approaches that encompass the complete lifecycle of manufacturing activities. Such strategies, based on the assumption that additional steps or regulations are needed to alleviate industry's damaging areas, are growing in complexity and therefore more difficult to implement. As the involved parties' planning is informed by a one-step-forward or one-step-backwards approach, the system becomes a linear progression of seemingly independent processes, and distant issues are only considered through governmental regulations, civic pressure or market forces. Industry's large-scale impacts and general direction are therefore a consequence of this compartmentalization, instead of a result of planned strategies and global coordination.

We need a new framework to work within, sustainable in the long term and capable of guiding present and future industrial developments through a series of strategies applicable regardless of scale, context and available technology. It should rely on the use of biomass as Industry's main source for materials and energy, and utilize biomes for capital generation. By locking our production, consumption and disposal capabilities to Nature's cycles we will ensure sustainability in the long term. Through its adoption it would reduce or eliminate several problems of current systems, including:

1. The imbalance that current materials create on the carbon cycle and its impact on global warming
2. The limited availability and increasing cost of current sources for energy and materials
3. Problems and complexities of waste reclaiming, sorting, disassembly, storage and

recycling mechanisms, and their dependence on scale

4 Impacts of products with no feasible end of life collection

This paper describes the difference between the current paradigm and a 100% biological framework, with emphasis on long-term sustainable strategies.

The Carbon Cycle

The environmental impact of current systems of production and consumption is tightly related to the imbalance that such activities create in nature's carbon cycle. Most industrial activity today acts only as a producer (releaser) but not as a consumer (sequester) of CO_2. To achieve a sustainable balance we must consume CO_2 at the same rate as we produce it. In other words, the problem is not that we are releasing CO_2 into the atmosphere but that we are creating an imbalance in the carbon cycle.

Carbon sequestration is necessary to counteract this imbalance, which refers to the removal of carbon dioxide from the atmosphere into a long-lived stable form that does not affect atmospheric chemistry. Currently the only feasible way to sequester carbon is through photosynthesis, which fixates CO_2 in organic matter, being an immediate and potentially crucial way to slow global warming. Although some agricultural practices are more efficient than others at sequestering carbon, in can be said that contrary to technological materials, biological materials coming from plants contribute to slow global warming through carbon sequestration. Care should be taken that other greenhouse gasses are not released through specific agricultural practices. Organic agricultural principles should be adopted to prevent other environmental and social illnesses related to current practices.

Polylactide acid (PLA) is a bio-based resin synthesized by fermenting biomass (usually from corn or potatoes), and it has been successfully used in applications such as cutlery, disposable containers and computer housings. The Japanese electronics manufacturer Fujitsu has used since January 2005 a PC/PLA combined resin for their FMV-BIBLO laptop casing, developed by Kioichi Kimura and Yuzo Horikoshi. Even when the percentage of PC was higher than that of PLA, and was essential for the parts' heat stability, a company's LCA estimates a 14.8% to 28% reduction in CO_2

emissions depending on the product's disposal mechanism when compared to PC/ABS casings.

Larger reductions will be accomplished when biopolymers can perform at the levels of petroleum-based resins. By using 100bio materials or energy sources we contribute to achieve balance in the carbon cycle and to sequester CO_2 excess in the atmosphere. Fujitsu's laptop is just one example of the potential of this approach at designing greener goods.

Availability And Costs Of Current Materials And Energy Sources

Recent rise in oil prices, new international environmental regulations and limited availability of new sources for metals and minerals have significantly increased the cost of traditional materials for industry and complicated foreign politics due to intra-corporation, international trade. Oil prices will continue to rise due to higher costs of extraction, the difficulty to overcome social concerns about the industry's environmental impacts and the decay of proven reserves. This translates directly into higher prices for plastic resins, which have risen 40% on average since 2003, as well as for other petroleum-based materials, glues, finishes and additives. Coupled with increasing demand coming from the industrialization of countries like China and India, we can only expect prices to elevate even more.

Some biopolymers are now competitive thanks to these issues and will be even more so as demand increases and more efficient facilities are built. Some companies are already offering affordably priced biopolymers that can successfully substitute petroleum-based plastics. One such company is Cargill Dow, which introduced several years ago many PLA resins and now produces over 300 million lb of their NatureWorksÆ product family a year. The price gap between traditional plastics and biopolymers is closing, and in some cases the later are cheaper in specific applications. Being independent of oil prices and related politics that might affect their price, biopolymers' cost and availability will eventually be more stable and easier to integrate into long term business planning.

Even more promising are materials that were not designed to substitute an existing resin or alloy but were designed from scratch as a new material. One such material is MaplexÆ, made by Weidmann Industries from unbleached cellulose fibres and zero binders. Maplex can be stamped, embossed, laminated, drawn, bent, rolled and formed. It can also be painted, dyed, stained and coated. Because it is a truly engineered material made from actual wood fibres, the resulting boards are stronger than plywood or OSB. Produced with only water, pressure and heat, it contains no added formaldehyde or chemical binders and remains 100% biodegradable and recyclable. All these characteristics render Maplex as a truly new material, capable of shapes and appropriate for applications where no other material performs adequately. Certified wood is used and great improvements have been made in cellulose manufacturing, which further minimizes the material's environmental impact.

Designer Erika Hanson and myself developed some of the first prototypes that Weidmann produces for a different industry than their traditional electrical insulation customers. These prototypes were shown at the International Contemporary Furniture Fair '05 with great success, which has allowed the company to introduce their material and manufacturing capabilities to a new and demanding consumer pool. They are currently evaluating the possibility of bringing some of these products to market.

Our work with Weidmann highlighted the potential of involving designers into the decision making process regarding a material's application and its future development. It has also shown how new materials may have a brighter market future when applied to projects that do not compete with existing substances and which exploit the material's unique capabilities.

Disposal

Current distribution networks were designed to take goods to as many places as possible in the most efficient and reliable way. Reclaiming, sorting, disassembly and recycling systems that collect those products are usually managed by a different entity, with very expensive, complex and fragile procedures. Some successful examples do exist, such as the Green Dot in Europe, a system with over 95,000 licensees that works on a producer-pays fee structure and "takes into account the varying costs of collection, sorting and recycling of various packaging materials". However, these systems cannot deal effectively with many components of regular MSW (Municipal Solid Waste). A great proportion of materials and products will inevitably end up in landfills because of composition or market reasons. In broad terms, materials are recycled when the collecting, sorting and recycling infrastructure exists and when they are not assembled or combined in a way that prevents disassembly. Plastics also depend on the existence of market demand for that specific resin and colour. Because of the high level of complexity of existing distribution networks it is difficult to collect all the products sold throughout the world and bring them back to the appropriate recycling facility. Many times the environmental impact of transporting waste back to a recycling plant will be much higher than the benefits of recycling that material. And since this system depend so strongly on demand; changes in market prices or trends can easily disrupt the flow.

One of the most compelling arguments to produce 100bio products is that composting and degradation facilities are simpler and cheaper to operate and setup, no disassembly or sorting facility is required and waste could travel much shorter distances to reach a biodegradation location. Impacts from transporting, recycling and storing waste can be significantly reduced, as well as costs related to taxes or tariffs. Increased interest in composting and biodegradation has produced several standards and regulations, such as the European standard EN 13432, DIN CERTCO’s compostable symbol, and the standard ASTM D6400-99 in the USA. Contrary to metals or plastics recycling, composting can be accomplished in both small and large scale while complying with these standards.

Further complexity is present when different materials are combined into a single part. With the introduction of each additional material into an object, we introduce a new set of factors that must be accounted for to achieve a sustainable product. In some cases the manufacturing process chosen for a particular product will prevent its eventual disassembly, recycling or biodegradation, such as glass fibre reinforced plastics, varnished wood or co-injected plastic pieces. When all materials are biodegradable, this is no longer a problem since they share disposal mechanisms. With this thinking I developed a sandwiched panel for doors, partitions and interior walls made with Kraft honeycomb, wood boards (such as 100bio plywood or Maplex), 100bio glues and finishes. Although the idea of a structural panel made with different layers of varying properties in not new and has been successfully applied into kitchen and closets components for many years, by using only 100bio components the product presents no end-of-life problems.

A 100bio production and disposal structure features products with easier disposal, composting plants with simpler setup and operation than landfills and recycling facilities, and fewer regulations and involved parties. It is also feasible at any scale and allows for products with combined materials and no end of life disassembly.

Impossible Products

Many product categories are specifically hard to deal with through traditional closed-loop approaches: cutter blades, pills packaging, firecrackers, soles, pencils, etc. These “impossible products” are used in a way that they end up in varied and remote locations where no collection strategy really works. One such case is targets for skeet and trap shooting: discs made from clay, designed to replace living pigeons. The destroyed targets are left in the field, which contaminates the soil and surrounding water bodies with debris and dust. This would pose no problem if it wasn’t because dust from crushed targets contain Petroleum Pitch, which might cause skin, eye, or lung irritation, nausea, vomiting, diarrhoea, and increased susceptibility for sunburn. It has also caused internal cancer and skin cancer in laboratory animals. Petroleum pitch contains polynuclear aromatic hydrocarbons, some of which are classified as carcinogens.

For products such as these it is imperative to use non-toxic, biodegradable materials that are appropriate for the ecosystem where they are used. I worked on an alternative made from sugar and cream of tartar, bound together with pressure and water. The new targets are biodegradable and, since there are no fibres to break, they dissolve in water easily. This design is part of my Sweet Disposable project. The objective was to develop a material for disposable applications where the product’s life span was coupled with the materials endurance. Products resulting from this project include golf tees, seeds packaging, coat hooks, votives, table lamps and the aforementioned shooting targets.

There are several products that have no feasible collection and pose a serious threat to the environment. I see no other approach for these products than a non-toxic, 100bio composition. Of course, we can also stop shooting flying discs for fun.

Current Design Limitations and Opportunities

If we intend to design truly eco-products with our existing manufacturing capabilities we would be pretty limited in the design stages. For example, we could not use plastics in colours for which recycling demand is not present; most combinations of materials or reinforcements of parts would not be appropriate either; and parts or components that would eventually be disassembled in communities where no supporting infrastructure exists would not live to its full potential. As long as adding a new material into a product adds so much complexity and relies heavily in third party entities or governmental regulation it will be very difficult to design responsible products that are market appropriate.

To implement bio-based production and consumption systems, new materials must be developed for applications in which technical materials are currently used. New 100bio materials should be designed to share degradation or recycling mechanisms, making disposal easier, more energy efficient and more cost effective. There will be applications where no biological material performs adequately. By adopting a biological metabolism elsewhere we would guarantee non-renewable materials' supply for crucial applications. Designers will prove key in this process, since they can identify the required properties and acceptable limitations of these bio-based materials. Commercial demand is usually the strongest and most persuasive force in the development of new systems and products, and designers will be critical players in establishing this demand.

Furthermore, approaching design from this new perspective is a great source of creativity. Unexpected solutions come from adopting such a framework from the beginning. In 2004 I designed a chair with the intention of producing a 100% biodegradable object that also expressed its intended disposal. The construction of the Knit chair speaks about smaller pieces coming together to form a bigger structure. Held together by rope, the piece breaks apart in smaller elements when those fasteners wear out or become loose. The small, individual components can then be put outdoors or into a compost pile, allowing nature to finish the job. Flexibility is incorporated into the design, allowing the chair to dynamically respond to the user's body, adapting lightly to the movements, size and posture of the user. This would be very difficult to achieve with a different construction technique. The design won a Bronze Leaf at the International Furniture Design Competition Asahikawa '05.

Conclusion

By using biomass as our source of as many materials and energy as possible, we will contribute to reduce greenhouse gases emissions and support a simpler and more efficient closed-loop manufacturing cycle. As exemplified in the cases above, to produce goods in such manner is presently feasible and marketable. By adopting this approach on a large scale the results will be more visible in a shorter period of time.

Most importantly, this system relates industrial activities to nature’s capabilities, therefore locking our development to a pace that the planet can withstand. Further growth would then be a consequence of innovations and productivity improvements, instead of an unsustainable activity supported by the use of non-renewable resources and the depletion of natural capital.

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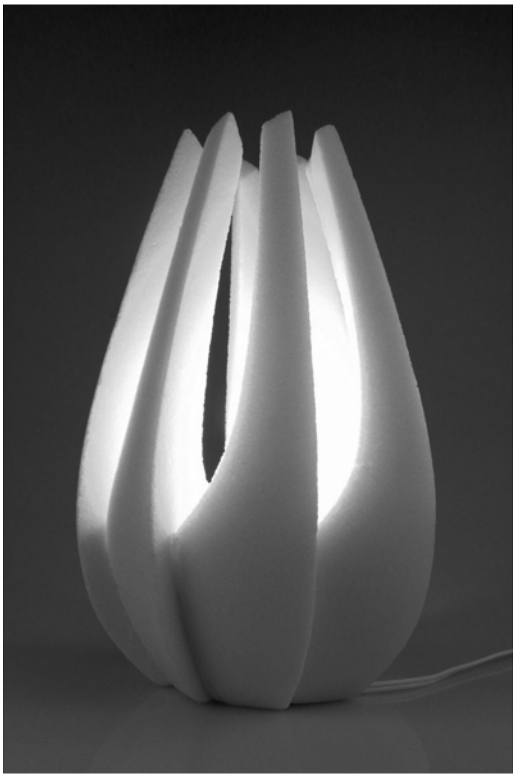
Information about the *Sweet Disposable* project, the *Knit Chair* and *HoneyBoard*, visit: GODOYLAB's website. [WWW Document] URL: www.godoylab.com

FMV – BIBLO notebook by FUJITSU
Casing in PC/PLA

Weidmann Chair designed by Emiliano Godoy
Seat and back in Maplex®

Sugar shooting targets
Sweet Disposable project by Emiliano Godoy

Sugar golf tees
Sweet Disposable project by Emiliano Godoy



Sugar table lamp
Sweet Disposable project by Emiliano Godoy

Sugar seeds packaging
Sweet Disposable project by Emiliano Godoy

Sugar votives
Sweet Disposable project by Emiliano Godoy

Knit Chair designed by Emiliano Godoy