Designing a Sustainable Future

By William A. Wallace
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Summary

Clean air, clean water, waste reduction and recycling, reduced emissions, hazardous waste clean up… These are part of a long string of environmental accomplishments made possible in large part by the work of engineers. It’s been almost 40 years since Rachael Carson’s book Silent Spring warned us about the dangers of chemicals in the environment. Responding to public concern and working with a myriad of environmental laws and regulations, the engineering community developed new technologies to cut air emissions, treat industrial and municipal wastewater, and clean up contaminated soils. Today we in the U.S. enjoy a noticeably cleaner environment and a better quality of life thanks to advances in environmental technology and a substantial investment by business and government, and the efforts and creativity of engineers.

Today, there is hard evidence that we are extracting and stressing our ecological resources to such a degree that we are jeopardizing the survival of future generations. These problems are by-products of the production-consumption model of our industrial age, a “take-make-waste” model which draws freely on energy, materials and ecological resources under the assumption that they are limitless. And, as engineers, we help perpetuate this model. For the most part, our efforts are directed towards finding cheaper ways to extract more resources, not on ways to recycle or use less. Inner cities with their existing infrastructures are left to decay, while we claim more open lands, and add to our sprawl. We solve transportation gridlock by adding more highways instead of rethinking our transportation systems. We figure out ways to access more of our limited water resources rather than finding ways to demand less or recycle what we have.

Today, the engineering community is uniquely positioned to provide leadership for the good of the nation as well as the rest of the world. Not only
do we possess the predictive tools to see these impending problems, we also possess the technological tools and creativity to help solve them. It seems we have two choices. The first choice is to do what we have always done: tinker with the current production-consumption model hoping to make incremental changes while navigating from crisis to crisis. The second and far better choice is to use our vision and tools to lead the country out of this impending crisis and into a new industrial age of sustainable development.

To lead, the engineering community must take on five tasks:

1. **Develop a strong business case for sustainable development.** For the most part, sustainable development is currently portrayed as a noble cause without much practical application. Corporate CEOs, faced with increasing competition, cost pressures and a rapidly changing business environment, need solid proof that becoming sustainable will help their companies survive and be profitable. The business case does exist. It needs to be communicated.

2. **Develop technologies that foster sustainable growth while maintaining and enhancing quality of life.** Sustainable development is a string of design problems: How do you produce products and services that use fewer critical resources, release fewer contaminants, contain less toxics, and can be recycled, but offer the same quality at an equal or lower cost? Clearly these are complex and difficult problems. At the same time, these are invigorating problems that stretch our thinking and create whole new markets and technical disciplines. They are also the kind of problems that excite and attract our young engineers.

3. **Become leaders as well as doers.** Our vision and tools put us in a unique position to lead the way into a new industrial age. To do so we must become part of the policy making process. Unfortunately, most engineers are not comfortable working in this arena.

4. **Teach others about the problems with our current production-consumption model and the concepts of sustainable development.** To reset our course toward sustainability, we need to develop simple messages that explain the rationale behind sustainable development and the need for action. On a global scale this problem is daunting. How do you teach a world composed of a myriad of political boundaries, religions, value systems and levels of economic development how to work together to manage the global commons?

5. **Learn more about the impending problems of non-sustainable behavior and the requisite technologies needed to solve them.** Although the negative effects of the current model are becoming more evident, we still have a lot to learn about the current state of our resources and ecological systems. At the same time, we need to learn how to gauge our progress towards sustainability, and begin to develop the technologies needed to move forward.
Introduction

At no other time in history has our nation enjoyed more prosperity or a higher quality of life. Not only does the U.S. have the strongest economy in the world, but it also acts as the primary engine for global growth, accounting for almost half of the growth in world demand in 1998. As a result of this prosperity, most of our citizens enjoy an incredible array of affordable goods and services, a situation to which other nations aspire.

All of these things are due in no small way to the contributions of engineers and scientists working to improve the built environment.

“Engineers are probably the single most indispensable group needed for maintaining and expanding the world’s economic well-being and its standard of living,” notes Richard Weingardt in his recent book, Forks in the Road. He goes on to describe how much of what we have today is made possible because of the work of engineers.

“If no engineering minds existed, we would still travel at horse-speed, carry water by buckets… live and work in unlighted spaces without air-conditioning or central heat… [T]here would be no high-rise buildings, long span bridges, interstate highway or rail systems, water control dams… More people today would be dying young from contaminated water, spoiled food, and unsanitary conditions than of old age, or cancer or heart disease.”

Our remarkably strong economy and quality of life has been built upon a complex set of technological, industrial and municipal infrastructures that are, perhaps, the most productive in the world. Because of the work of engineers, we find and extract raw materials more cheaply than ever before. We also move these materials efficiently through many interconnected modes of transportation (air, water, surface) to efficient and productive manufacturing facilities at home and abroad. There they are converted and returned as parts or finished goods to be sold and used by consumers here and abroad. Technological advances and their corresponding engineering applications have led to continuous improvements in the form of better-performing materials, more efficient extraction methods, and new, more effective production techniques.

At the same time, we have also learned about the detrimental effects of unwanted by-products on the environment, and have made a considerable investment to eliminate, treat or properly dispose of these materials. Yet in the face of these advances and general prosperity, many of us are beginning to question whether or not this is sustainable—for ourselves or for succeeding generations.

3 Ibid., p.10.
In citing his reaction to accepting an environmental award for a company he represented, Paul Hawken in *The Ecology of Commerce* recounts an awakening about the futility of corporate environmentalism.

“Despite all this good work, we still must face a sobering fact. If every company on the planet were to adopt the best environmental practices of the ‘leading’ companies—say, Ben & Jerry’s, Patagonia or 3M—the world would still be moving toward sure degradation and collapse. So if a tiny fraction of the world’s most intelligent managers cannot model a sustainable world, then environmentalism as currently practiced by business today, laudable as it may be, is only a part of an overall solution. Rather than a management problem, we have a design problem, a flaw that runs through all business.”

**Is Our Quality of Life Sustainable?**

Our quality of life is derived for the most part from a linear “take-make-waste” production-consumption model of the industrial age, one which draws freely upon energy and raw materials to produce and deliver goods and services to meet consumer needs. As a result, we as a nation consume more resources, in terms of both size and per capita, than any other country in the world. Our model is based on the underlying assumption that the earth’s carrying capacity (supply of natural resources, ability to assimilate wastes and ecological services) is more than sufficient to support all the activities of a large and increasing population.

“While there is nothing inherently wrong with a population, even a large one, meeting its needs by consuming resources and creating wastes. Problems do arise, however, when the numbers of people and the scale, composition, and pattern of their consumption and waste combine to have negative effects on the environment, economy and society.”

Clearly there is no shortage of critics arguing that the consuming culture and lifestyle of the industrialized countries is a recipe for disaster. Over the past decades there have been a number of “doomsday-ish” predictions regarding the serious depletion of critical resources or ecological ruin. Perhaps the most recent and famous one was the 1972 report from a group known as the Club of Rome called “The Limits to Growth.” Using sophisticated computer models, this analysis predicted the times when our society would run out of critical resources. This apocalyptic work sold over nine million copies printed in 30 different languages and sparked outrage and heated debates everywhere. Fortunately, most of its predictions were wrong. Unfortunately, its errors have been held up as evidence of the folly of making such predictions. Furthermore, it reinforced the notion that our technological cleverness will continue to save the day, by providing us with new sources or alternatives to meet our resource and energy needs.

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DESIGNING A SUSTAINABLE FUTURE

As technology progresses, however, so has our ability to see things we were never able to see before. With high resolution satellite imaging, better computer models, and advances in contaminant detection, we are now able to detect and assess environmental risk and damage with greater accuracy and relevancy. Moreover, advances in telecommunications and information technology have enabled global communication and collaboration across a wide range of scientific and engineering disciplines. Listed below are a few examples of the kind of problems now being uncovered that bring our current practices into question.

- In 1998, deforestation triggered flooding in China’s Yangtze River basin, killing 3,700 people, dislocating 223 million, and flooding 60 million acres of agricultural land. The losses are estimated at $30 billion.\(^5\)
- During the past 30 years, the number of oxygen-depleted coastal water bodies has tripled worldwide. Experts relate this trend to increased concentrations of nitrogen and phosphorus in coastal areas, due to

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wastewater discharges and agricultural runoff. Since 1991, economic losses from these incidents have cost the U.S. an estimated $280 million.\(^6\)

- Eleven of the fifteen most important fishing areas in the world (including the Grand Banks off the coast of New England) and 70% of the major fish species are either fully or over exploited, according to the U.N. Food and Agricultural Organization.\(^7\)

- The Ogallala Aquifer, a water source for farmers and residents in the midwestern U.S., once held as much water as Lake Huron. Irrigation and other uses have resulted in withdrawal rates which far exceed replenishment rates. Now the aquifer is dry in some regions and continues to be rapidly depleted in others.\(^8\)

- There is increasing concern over the so-called endocrine disrupter chemicals in the environment, including chlorine, that affect reproductive systems. Over the last 50 years, human sperm count has dropped by 50%.\(^9\)

- Emissions of carbon dioxide and other so-called “greenhouse gases” from energy production, transportation and other activities are noticeably changing the ambient temperature of the earth. The consequences of global warming include radical climate changes, increased disease, a devastating rise in sea levels, and productivity changes in agriculture.

It is unlikely that our course toward an unsustainable future will be altered by some global-scale environmental catastrophe that will galvanize public opinion. Rather, it will continue as a seemingly unrelated string of events, e.g., resource scarcities, atypical weather, new taxes and regulatory constraints (to control non-sustainable behavior), environmental problems, all contributing to a diminished quality of life. These will appear locally, regionally, nationally or globally with increasing frequency.

Today, arguments about the loss of critical resources and environmental damage have risen from a conglomeration of isolated instances or hard to support trends, to credible and dramatic portraits showing the consequences of unsustainable behavior. Perhaps more importantly, improvements in the cost and performance of information technology and telecommunications have made this information available at low cost to NGOs\(^10\) and public interest groups. Armed with compelling evidence, these groups have become increasingly active in taking companies to task for non-sustainable performance, often with serious negative effects on profits and their reputation in the marketplace.

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\(^10\) Non-governmental organizations
A Design Problem

So far, we have treated these problems and associated incidents as the unintended consequences of an otherwise beneficial industrial system. In all cases, our response has been essentially to send in the repair crews (often the consulting engineers) to fix the problems and then get on with business as usual. Each time, the engineering community responded, first by devising technologies and methods to clean up the discharges and contamination, and then by devising ways to reduce or eliminate contaminants from the processes themselves. As a result, most of the direct contaminant discharges have been reduced substantially, leaving the U.S. with a noticeably cleaner environment.

But what if these problems were not just symptoms of a good system out of adjustment? What if these problems were symptoms of a fundamental design flaw? Taking a retrospective look at our industrial system, Bill McDonough places this matter in the context of a design problem.

“If someone were to present the Industrial Revolution as a retroactive design assignment, it might sound like this:

“Design a production system that

- puts billions of pounds of toxic material into the air, water and soil every year
- measures prosperity by activity, not legacy
- requires thousands of complex regulations to keep people and natural systems from being poisoned too quickly
- produces materials so dangerous that they will require constant vigilance from future generations
- results in gigantic amounts of waste
- puts valuable materials in holds all over the planet, where they can never be retrieved
- erodes the diversity of biological species and cultural practices.”

Things are about to get worse. Because of rapid economic growth, our world, especially the undeveloped and underdeveloped countries, is poised to expand its resource consumption rates by 5- to 10-fold in the next 35 years. And we’re on track to do so by extending the same linear, “take-make-waste” production-consumption model used in the industrialized world. In what is becoming a borderless world, companies can now produce and sell anything, anywhere, anytime. Seeing the advantage of scale economies, and lower labor and operating costs, companies are expanding their facilities into the developing countries. The developing countries welcome this investment, and its attendant economic growth, jobs and overall improvement in their standard of living. The concern that this pathway is not sustainable is much less important than their drive for economic growth. Besides, they argue, how

can the industrialized nations ask us to limit our growth and development to what can be achieved using sustainable technology. The industrialized nations got where they are today by exploiting their natural resources and the environment. If they want us to be sustainable, let them show by example and then give us the required technology.

**The Natural Step Model**

Out of this growing evidence of unsustainable behavior has emerged a useful mental model that provides the linkage between the evidence of environmental and resource damage and business operations. This model, called The Natural Step, is depicted in Figure 2. The model reduces the complexities of this issue into a simple visualization.

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12 The Natural Step model and its four system conditions were first explained by Dr. Karl-Henrik Robert and Dr. John Holmberg. Paul Hawken is credited with bringing the concept to North America. Since its inception, many companies have incorporated this model into their strategies and business processes.

transportation, etc., and ecosystem services such as clean water, clean air, and healthy soil. As aggregate societal demand increases and the capacity to meet those demands decreases, society as a whole moves into a narrower portion of the funnel.

“As the funnel narrows, there is less room to maneuver and there are fewer options available. The inactive company that remains oblivious to the changing environmental realities is likely to hit the wall and go out of business. The reactive company waits until it gets clear signals from the environment, often by running into the wall, and then it must react quickly or fail. Often, options for action that would have been possible earlier, and usually at much less expense, are no longer available. There is little time for experimentation or strategic corrections.”

The Natural Step model tracks well with the examples above. While one could imagine a doomsday date (the date when demands for the earth’s resources exceed the supply) far in the future, society is now experiencing the symptoms of non-sustainable behavior with ever increasing frequency and at many levels.

Ray Anderson, in his book *Mid-Course Correction*, proposes a further refinement to the model, which addresses the design concerns expressed by Bill McDonough. Anderson revisits the impact equation which describes the lower wall of the curve. The equation reads,

\[ \text{Impact} = \text{Population} \cdot \text{Affluence} \cdot \text{Technology}, \]

or

\[ I = P \cdot A \cdot T_1. \]

Anderson observes that the technology term applicable to the Natural Step Model should be depicted as “\( T_1 \)” referring to the extractive, linear (take-make-waste), fossil fuel-driven, abusive, consuming, and otherwise unsustainable technologies of what he calls the first industrial age. He then proposes a new equation which identifies “\( T_2 \)” technologies. These technologies are renewable, cyclical, benign and focused on resource productivity. The equation can be restated to read

\[ I = P \cdot A / T_2. \]

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14 Nattrass, Brian and Altomare, Mary, p. 18.

15 Behind The Natural Step model are four first order principles that society must meet. In order to be sustainable, nature’s functions and diversity are not systematically: (1) subject to increasing concentrations of substances extracted from the Earth’s crust; (2) subject to increasing concentrations of substances produced by society; or (3) impoverished by overharvesting or other forms of ecosystem manipulation. And, (4) resources are used fairly and efficiently in order to meet basic human needs worldwide.

16 Anderson, Ray C., *Mid-Course Correction*, The Peregrinzilla Press, Atlanta, 1998, p. 19. Ray credits Bill McDonough, then Dean of the School of Architecture of the University of Virginia for the concept. Ray Anderson is the Chairman and CEO of Interface, Inc., the world’s largest producer of commercial floor coverings.
Now instead of technology being cast as one cause of a degraded future, technology is a solution, offering an improved quality of life to an ever increasing population, and all the while mitigating the overall impact on resources and ecological services.

The Engineers’ New Design Assignment

The future implications of sustainable development to the engineering community are both enormous and exciting. As the concept of sustainable development takes hold and we enter the next industrial revolution, industry in the U.S., as well as in the rest of the world, will be looking to design and apply benign (T₂) technologies, making technology part of the solution as opposed to part of the problem. This change in direction will create entirely new challenges and opportunities for engineers and scientists to apply their knowledge and creativity to a new set of problems, or perhaps to old problems recast in a new way. For example, instead of working on ways to extract more natural resources for a lower cost, we can be looking for ways to increase the productivity of natural resources, i.e., doing more with less. Instead of figuring out how to sell more product, we can be selling higher margin services, helping the customer use less product more effectively to satisfy their customer needs.

In Figure 3, examples of engineering design assignments are mapped showing their position on a path to sustainability. Using this chart, it is easy to observe that these assignments are indeed challenging, but are meaningful and will contribute to our quality of life. These are the kind of assignments that excite and attract the young and creative engineers to our companies.

These examples are derived from a useful framework developed a few years ago. In their book, Eco-efficiency, Livio DeSimone and Frank Popoff defined the seven key dimensions that every business should consider as part of becoming sustainable. This is useful in thinking about how we might assist our clients.

1. **Reduce the material intensity of goods and services.** Do more with less. Use less materials per unit of product or service.

2. **Reduce the energy intensity of goods and services.** Become more energy efficient.

3. **Reduce toxic dispersion.** Eliminate toxic or otherwise hazardous substances from products or in the delivery of services.

4. **Enhance material recyclability.** Reuse materials and energy in the same or another system.

5. **Maximize sustainable use of renewable resources.** Use renewable rather than non-renewable resources.

6. **Extend product durability.** Extend the useful life of products.
7. **Increase the service intensity of goods and services.** Create additional value for customers through shared use, multi-functionality, or easy upgrading.\(^\text{17}\)

<table>
<thead>
<tr>
<th>Engineering Design Assignments</th>
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<tbody>
<tr>
<td><strong>Current</strong></td>
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<tr>
<td>Meet product codes for toxic materials content</td>
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<tr>
<td>Design more efficient energy resource extraction techniques</td>
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<tr>
<td>Optimize current processes and reduce product costs</td>
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<tr>
<td>Reduce transportation costs</td>
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<tr>
<td>Build new highways</td>
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<tr>
<td>Expand old highways</td>
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<tr>
<td>Expand marketing programs to sell more products</td>
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<tr>
<td>Design &amp; build an all glass skyscraper office building on a &quot;greenfield&quot; site</td>
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<td>Design systems to track wastes, meet regulations</td>
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<tr>
<td>Bury hazardous waste-contamination in &quot;leakproof&quot; structures</td>
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<tr>
<td><strong>Transition</strong></td>
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<tr>
<td>Develop low-cost sensors, systems to detect environmental damage</td>
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<td>Develop reclamation techniques for mined land</td>
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<tr>
<td>Develop efficient methods to extract raw materials from landfills</td>
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<tr>
<td>Reduce process water consumption</td>
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<tr>
<td>Develop new processes to reduce wastes, use less toxics</td>
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<tr>
<td>Replace aging transportation infrastructure with smart systems</td>
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<tr>
<td>Develop services to show customers how to use less product more effectively</td>
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<tr>
<td>Design waste water treatment systems using natural biological processes</td>
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<tr>
<td>Devise accurate and reliable methods to measure the earth’s ecological carrying capacity</td>
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<tr>
<td><strong>Sustainable Development</strong></td>
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<tr>
<td>Restore major fisheries resources</td>
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<tr>
<td>Develop low cost renewable energy systems</td>
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<tr>
<td>Devise a way to use an industrial waste as feedstock for another process</td>
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<tr>
<td>Bio-mimicry: design processes that mimic biological processes</td>
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<tr>
<td>Design products that are totally recyclable and environmentally benign</td>
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<tr>
<td>Develop new structural materials produced entirely from waste materials</td>
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<tr>
<td>Develop small scale, low cost water/wastewater treatment plants</td>
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**Figure 3: Engineering Design Assignments**

Lovins, et. al.,\(^\text{18}\) extend the concept even further. In their recent article in the Harvard Business Review, they present the concept of natural capitalism as a way of recognizing the value of ecosystem services, and argue that the journey to natural capitalism requires four major shifts in business practices.

- **Dramatic increase in productivity of natural resources.** Reduce the materials and energy intensity even further. Develop ways to make natural resources stretch 5, 10, even 100 times more than they do today.

- **Shift to biologically inspired production models.** Don’t just reduce waste, but eliminate it entirely. Eliminate all toxic materials. Use closed loop systems such that all material outputs are recycled into this or other processes, or become nutrients in the ecosystem.


\(^{18}\) Lovins, Amory B., et. al., pp. 146-147.
• Move to a solutions-based business model. Dramatically increase service intensity.

• Reinvest in natural capital. Invest time and resources in restoring ecosystems.

A question that occurs is how to sell these concepts to the business decision makers. Many business leaders around the world have already determined, and are proving every day, that sustainable development is the only kind of development that makes sense, even in the context of shareholder value and quarterly profits. In fact, we have evidence that sustainable business in more and more regarded as:

• a global competitive advantage,

• a catalyst for innovation, and

• a way to capture new market and financing opportunities.

Anderson has many examples in his business of “doing well by doing good.”

“The $1 billion of sales we recorded in 1996 consumed 19 percent less material per dollar of sales than we consumed in 1995, reflecting both
increasing efficiency and our shift toward services, especially downstream distribution. This happened while we were realizing record profits, which was not an unconnected coincidence.

“. . . I believe that in the 21st Century, the most resource-efficient companies will win!”

Carl Frankel (in Earth’s Company\cite{19}) says the new goal of enlightened businesses is “eco-efficiency,” which considers resource inputs as well as harmful outputs.

“In one oft-cited example of eco-efficiency, Lockheed’s Building 157 in Sunnyvale, CA, a 600,000 square-foot, $50 million structure, used extensive ‘daylighting,’ an architectural strategy for bringing as much sun as possible into the building, the reduce lighting expenditures to one-quarter what they would have been had a standard design been used. The daylighting features cost an additional $2 million, but with savings of close to $500,000 per year, payback was in about four years. In addition, Lockheed reported sharp increases in productivity from workers in Building 157, due not only to the daylighting but to other people-friendly features as well.”

There are many examples of businesses using advanced or reworked technology to save money or find new markets for what had been waste.

- EBARA, a Japanese environmental engineering company, has developed a technology to recover fuel gas from gasification of mixed municipal or industrial wastes. Energy recovery is superior to burning the waste directly and other components, including ammonia, and metals such as iron, copper, aluminum and nickel can be recovered and separated for sale. Residual ash is sold as a construction material.

- At 3M, pollution prevention has been an important part of the corporate culture for 25 years, however any new projects to cut pollution must compete with other company priorities for funding. They must link environmental improvements with product performance improvements or changes that bring a business advantage, such as an innovative solvent-free technology to eliminate the use of expensive drying ovens that resulted in lower manufacturing costs.

- The Swiss Eternit Group (SEG) through its Costa Rican subsidiary RICALIT, developed a substitute for asbestos cement that uses a blend of fibers from cellulose, recycled newspaper and used banana boxes. The final product was both less expensive and more manageable than asbestos cement. In Changing Course\cite{20} Stephan Schmidneiny says the discovery of the asbestos substitute brought a fresh drive into the whole business. “The skills and motivation of employees were improved. Last but not least, the

\begin{thebibliography}{9}
\bibitem{19} Frankel, Carl, in Earth’s Company, New Society Publishers, Stony Creek, CT, 1998.
\end{thebibliography}
asbestos-free, fiber cement sheets eliminated potential health risks, while the use of recycled material and of waste made it possible to minimize the consumption of natural resources.”

- One result of Dow Chemical Company’s WRAP (Waste Reduction Always Pays) program is that less than one percent of Dow’s hazardous waste now ends up in a landfill. In one example, a project team at a Pittsburg, California agricultural chemicals plant found ways to recycle and improve the control of a reactant that had been incinerated after a single use. They were able to cut consumption of the reactant by 80 percent, eliminating 2.5 million pounds of waste and saving $8 million each year from reduced raw materials use and lower environmental and labor costs.

- At its Candra Sari dyestuffs plant in Jakarta, Indonesia, Ciba-Geigy, a Swiss based multinational manufacturing firm designed a process to minimize water use and store and recycle wastewater as a low-cost method to reduce the effluent loads into the Candra River.

- In the United Kingdom, Laing Homes overcame a number of obstacles to introduce energy efficient timber frame homes to a region that had traditionally built homes using brick, cavity and internal concrete block. The homes were profitable because the walls could be prefabricated and distributed in containers from warehouses, reducing construction costs, time and site traffic. The homes have an annual energy savings of 12 percent and consume 18 percent less energy in the manufacture and distribution of the construction materials.

- ALCOA has developed sustainable mining practices in the Jarrah Forest of Western Australia that enabled it to continue working with that country to extract bauxite, gold, tin and coal.

Companies that are reluctant to embrace new technology may find the decision will be made for them. In *Financing Change*21 Stephan Schmidheiny and Federico Zorraquin note that commercial bankers are beginning to respond to the sustainable development agenda.

> “Their attention was first caught by court cases in the United States in which a few banks that had loaned money to companies were held liable for those companies’ cleanup costs.

> “In 1992, about 30 leading banks signed a ‘Statement by Banks on the Environment and Sustainable Development’; this said they ‘regard sustainable development as a fundamental aspect of sound business management’ and noted that ‘environmental risks should be part of the normal checklist of risk assessment and management.’”

Taxes and increased regulatory burdens may also be an impetus for transformation. In discussing the theory of early 20th century English economist Nicolas Pigou regarding taxing the full costs of production, including the externalities of pollution, Hawken argues that such taxes can create the incentive for businesses to seek out change.

“The purpose of integrating cost into pricing is not to provide a toll road for polluters, but a pathway to innovation. The incentive to lower costs is the same one that presently operates in all businesses, but in this case the producer’s most efficient means to lower them is not externalizing these costs onto society, but implementing better design.”

As Richard Weingardt points out, “…the world is run by those who show up.”

Right now, the engineering community is uniquely positioned to take action for the good of the nation as well as the rest of the world. Not only do we possess the predictive tools to see this impending problem, but we possess the technological tools and creativity to solve it. It seems we have two choices. The first choice is to do what we have always done: tinker with the current production-consumption model hoping to make incremental reactive changes while navigating from crisis to crisis. The second and far better choice is to use our vision and tools to proactively lead the country out of this impending crisis and into a new industrial age of sustainable development.

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22 Weingardt, Richard, p. 75.