THE UPCYCLE

BEYOND SUSTAINABILITY—
DESIGNING FOR ABUNDANCE

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We have talked about carbon, the building block of life, and of the desire to keep carbon where we most need it—earthbound. We have discussed how the upcycle asks us to conceive systems that maintain carbon in loops of endless resourcefulness. We would like to discuss now the *how* of keeping carbon on earth. Let's touch down for a moment in Scandinavia, in a place and at a time where the photosynthetic act of carbon dioxide being converted into carbohydrate is sometimes difficult to achieve.

The problem, of course, is that in Denmark, during the winter, it can get dark early. At least that's how it seems sometimes to Danes when December rolls around and the days shorten to a scant seven hours. It's amazing how much one can start hungering for a breath of spring, or the first greening of a plant, or a fresh strawberry. Danish supermarkets are, of course, full of options due to the wonders of international markets, but we considered what we could do to promote happiness of the revivifying kind for people where they live and work every day.

Over the years, we have been asked several times to consult on the concept of Cradle to Cradle islands because, with their ocean boundaries, islands are contained systems with clearly identifiable inputs and outputs. Michael helped conceive systems for an EU-funded project for the islands of the North Sea. We also worked with a small island off Denmark. There, along with designers and engineers from six different countries, we were asked to devise concepts for a science park. We wondered what it would mean to help people get a chance to feel as if they're a part of rejuvenation of the planet anytime, any month.

In the days of plentiful daylight, the science center lobby could benefit from shades. But Bill, an architect, thought, *Wouldn't it be marvelous if the shades were plants growing behind glass, thin horizontal hydroponic planters?*

Then he thought about winter.

The days shorten dramatically beginning in September, so how would these plants keep flourishing? Or how would we get fresh local food in winter?

The answer: another form of solar energy. The wind.

For Bill, this was a conceptual leap, because while it came to him in the context of architectural design, it was the seed of a much bigger idea: What if a darkened island surrounded by water could use wind to feed itself with fresh green food in the winter? When Bill first said that wind equals food, people scratched their heads and said that wind makes it hard for things to grow.

But Bill had worked on wind power in the early 1980s, helping to develop wind turbines that used electric generators to control and break the speed and the angle of the blades instead of mechanical gears. Wind can be used to generate electrical power. Electrical power can be used to generate light. Bill had become interested in LEDs (light-emitting diodes) for growing food and found a botanist who was conducting experiments showing that some fruits and vegetables, such as strawberries, don't actually need the full spectrum of light granted by the sun to do their growing. Strawberries, for example, really are interested in only a portion of the spectrum: reds and blues. We now know that LEDs can be tuned to emit only these frequencies, which reduces the amount of energy needed to power the lights.

So for a portion of the energy needed to create the full spectrum, light can be emitted that strawberries love, which makes them grow big as a fist and sweet as honey. This can all happen at night when people are home in bed. The strawberries don't care what time of day they get their dose of light. They will happily receive a supply at midnight, when a gust of wind comes through. And in the morning, when people get active again in the building, the plants are flourishing. You might get to have a fresh strawberry at the morning meeting.

We're sharing that story to underscore a larger point: We think discussions about energy can expand into new dimensions instead of being laterally focused on conventional practice. Modern society and most designers look at energy as a separate phenomenon unconnected to other functions, an isolated need rather than a means to an end. Because of that conceptual limitation, short-sighted decisions cause missed opportunities for upcycling.

If you think about electrical energy from its power source, through its grid, to its potential multiple-use cycles, and on to the ultimate needs for power in the first place—warming your house, heating water, lighting your desk lamp so you can do your homework—you can begin thinking of how to optimize the system for more abundance, more productive use. This kind of full-circuit thinking can expand your inventiveness.

This is upcycling energy.

At this moment in history, society has begun to reckon with energy shortages and with the desperate need to wean itself off fossil fuels—to use less. But we want to restart the discussion with a use of energy for pure pleasure, because such an idea is possible with an effective renewable source. No one *needs* strawberries at his morning meeting. No one *needs* to see green plants lining her windows year-round. But they sure do bring a smile to people's faces. If those LEDs were powered by fossil fuels, everyone might declare the strawberry project a waste. But if free wind input, economically, ecologically, and ethically delivered, can make a continuous source of pleasure through the year, then who would gripe with a ripe local strawberry in winter near the Arctic?[6]

6. It is worth mentioning that the Icelanders have long been proud of being able to use geothermal energy to heat and light greenhouses that can grow tomatoes and even bananas near 66° north latitude.

These energy concerns are not new to us. In *Cradle to Cradle*, we made a point of focusing on products and material flows because so few people were considering materials and because so many people were already debating energy efficiency. Then, as even today, it seems most environmentalists were focused in that direction.

It wasn't until we developed the Cradle to Cradle Product Certification program over the past few years that we started publicly articulating our energy position and integrating it into our design protocols. Clearly, energy is a key question in any work.

When many people who are focused on energy read *Cradle to Cradle*, they said, "This is all well and fine about redesigning products, but the glaring issue is power. Without a Cradle to Cradle fuel source, the end product can only be an improvement of an ineffective system."

Basically, they were highlighting something that even Edison, back in the 1800s, understood. While he searched for a workable bulb design, he was thinking too about electric generators and the grid. He understood the lightbulb to be only one outlet in the larger issue of how power could flow to homes and businesses and focused his efforts on direct current (DC). Nikola Tesla understood this issue too and invented the alternating current (AC) generator, allowing longer transmission distances.

So we take up the question of energy and its distribution now because it is one that human society needs to engage. The solutions will require us all. And no product can be considered truly exquisite or well designed unless the amount or type of energy used in its production has been considered.

As society goes forward in devising solutions, we believe it is key to bear in mind how important it is to respect and understand the end goals—the real needs—of all the players; that the energy is extracted in the cleanest manner possible; and that we use energy that is ever replenishing.

And, finally, to expand our thinking as we consider solutions, let's reflect on the different ways we typically think about energy and about how it serves us. Sometimes energy might conjure the image of a gallon of gas that powers our car for a certain distance. Sometimes we think of a kilowatt-hour that lights a bulb. Other times—and here this exercise begins to get curious and opens up creative opportunities—we might look at energy as calories, which measure heat potential. We even talk about calories for human consumption. In the remainder of this chapter, we will look at energy from a richly diverse set of perspectives and see where the modes of energy might meld and foster growth, foster the upcycle.

Complex Systems: How to Cook Naan Without Killing a Tiger

Let's look first at the end goals of energy. Energy concerns are complex, with many competing stakeholders. It does us all a disservice to deny the merit of their needs. But we believe that fully understanding those needs might allow opportunities for innovation. A person turning on a lamp is not asking for 100 watts of energy; the person is asking for beautiful light by which to read a book. If one can address that core need in a delightful way, the person is happy.

As an example of how to broaden our thinking, let's visit India and hear a story, one with sister stories in places such as Nepal, that demonstrates how one can deal with complex competing needs. In a village nearly six hours south of New Delhi, a conflict arose between humanity and ecology. Local farmers were going into the Ranthambore National Park in Rajasthan to cut down trees for firewood. They were also sending their cows into the forest to graze.

The national park served as a rare tiger habitat. As the villagers cut down the trees, the forest receded. And the tigers now found themselves in proximity to herds of grazing cows, which, of course, they attacked for food. To save the cows, the farmers looked the other way when poachers came to kill the tigers for their pelts.

The farmers wanted fuel for themselves and food for their cows. Conservationists wanted to preserve the forest and the tigers. What an unfortunate sequence of events—and how interconnected they all were. How could one solve a problem with such complex effects?

Park steward Fateh Singh Rathore's first solution was to put up fences. But the villagers simply climbed over or broke them. (Regulation as temporary fix, not solution.)

The solution had to be as interconnected as the conflicting needs of the environmentalists and villagers and tigers and cows, and it was brilliant, bringing what appeared to be separate agendas into a productive community of profit for all: for the individuals, the ecological system, and the species.

The steward's son, Dr. Govardhan Singh Rathore, who inherited oversight of the park, first set up a health clinic to improve overall conditions locally and build goodwill. Then he helped the villagers breed cows that produced more milk with less feed (less vegetation needed). Then he suggested to the farmers that, rather than cut down the forest for fuel, they gather cow manure and transform it into fuel and fertilizer using biogas plants. The farmers could keep the cows closer to home (and wouldn't have to venture into a forest with ferocious tigers). They could stop cutting down trees.

At first the biogas plants were provided free to the villagers, but Rathore soon realized that ownership conferred responsibility. Now villagers buy the biogas plants for approximately 3,000 rupees (about $54), and 600 of them operate throughout the area. Rathore also planted new trees to replace the ones cut down and paid villagers if they could keep their assigned tree alive; the pay rises incrementally

for each year the tree survives. He offered the poachers free education for their children if they stopped poaching and gave them camels to create income from milk and to use for transportation. Now the poachers help protect the tiger habitat; it is in their best interest. We see almost exactly the same situation with converted big game poachers in Kenya.

Let's look at what happened here: Energy was the needed resource. The farmers valued fuel and cows. The preservationists valued the forest and tigers. Both groups valued success. And Rathore, the one who conceived all this, valued all of these elements—people and community, nature, a fruitful and enjoyable life for all involved.

In this instance, what appeared to be a conflict between a small rural community's modest "economy" and the ecosystem was resolved by a creative solution.

Energy economies large and small, of the most modest means and of the greatest monetary value or assets, can be upcycled. First, clearly identify the triple top-line value for each constituency, then aim to protect those values while reconfiguring the system. The farmers in Rathore's village wanted energy for cooking. They weren't particularly wed to the requirement that the fuel come from the forest. The preservationists wanted the survival of the tigers, but they didn't want the community around the forest to perish. By understanding individual and mutual values, and attempting to address them in new ways, we may discover unexpected solutions for energy challenges.

Getting the Energy You Need . . . Cleanly

Another important aspect to consider in energy solutions is *how* we glean energy. We want you to consider pigs for a moment.

In the United Kingdom and Europe, farmers traditionally sent their pigs into forests to forage. This custom served many functions: Pigs could eat a wide variety of foodstuffs, the farmers didn't have to pay for extra scraps to feed them, and the pigs' foraging helped control weeds and small pests and recycled nutrients for improved soil quality. In essence, pigs were calorie and nutrition skimmers. The pig went into the forest—the perhaps frightening, brambled forest—and came out with the best pickings of that forest in its belly. When the farmer killed and cooked the pig, he and his family benefited from its expert foraging. The pig was an efficient machine for capturing the riches of the forest for human consumption, for gathering energy for human consumption.

The only problem came when the forests became seriously depleted and authorities had to come up with ways to keep the farmers and their pigs out.

We can consider our energy needs in this light. How can we reach the best resources, no matter where we are? How can we collect the energy we need without literally and figuratively depleting the forest?

Capital vs. Currency: Spending Resources

Finally, before we get into specific energy discussions, we think it's important to consider which kind of energy we might prefer. An appropriate way to differentiate between what we consider the better sources of energy comes to us from the world of economics and frequently crops up in our work advising companies. One has to define what in one's world is currency and what is capital and how goods move between these categories.

The Peruvian economist Hernando de Soto in *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else* dramatically describes the dimension of informal economies in which the poor face great difficulty because of their inability to

accumulate capital. Capital does not "flow" but is stored, saved, invested, or embodied for future deployment. As de Soto says, "Capital is not the accumulated stock of assets but the *potential* it holds to deploy new production" that "must be processed and fixed into a tangible form before we can release it." Currency lubricates the wheels of commerce and is both a lubricant and a measure of flow.

De Soto's point is extremely relevant to the upcycle, to how humans handle planetary materials and manage nutrients. People are currently burning, burying, and otherwise dispersing and contaminating their earthly capital. We're treating capital like currency. Here is the difference: Say you have a goat. You get hungry and you eat it. The goat is currency. You have converted it to human food (caloric energy, by the way) and it is no longer with you. You have nothing left.

What if you have an apple? It's crisp. It's here. You eat it. Again, it is food. Let's hope you did something good with those calories because you don't have another apple. It's gone.

But if you have a herd of goats or an apple orchard, you have capital. These can go on perhaps forever with endless resourcefulness, multiplying, bearing fruit, providing you with more energy and abundance for long centuries.

Since the oil crisis in the early 1970s many commentators have made a devastatingly simple point: When humans use petroleum, they're using ancient sunlight. In the previous chapter, we described how fossil fuels represent ancient biosphere—plant and animal life from long ago.

How was that biosphere created?

Photosynthesis.

What lies beneath earth's crust is, by extension, stored-up ancient sunlight.

So we can ask again and again: Why aren't we using current sunlight instead? The sun's energy—solar income—is recurring; it's the only income (other than meteors and cosmic dust) that our planet receives. Fossil fuels, on the other hand, are limited in quantity and must be dredged up, with laborious and deleterious efforts. In other words, fossil fuels are actually capital, and we could be using currency.

For decades, humans have dwindled the supply of oil when another energy source has been there all the time, good enough for nature to use for most of its processes. Now that photovoltaic panels and wind turbines have become cost-effective commodities, they can be considered part of our real estate, or capital, that creates currency, whereas burning fossil fuels is capital used as short-term currency without accounting for liabilities—its deleterious effects to the climate and human and ecological health.

As we discussed, it is not wise to put valuable carbon into our atmosphere and our oceans, where it serves no positive use and does real damage. It is also not wise to use and rely on fossil fuels as if they were currency, when they represent a finite material on the planet. By using the planet's fossil fuel "life savings," so to speak, to meet daily energy needs, societies become entrenched more deeply in a system that can't perpetuate itself. There is no good reason to squander this capital when humans have so many energy resources that are capable of rejuvenation.

Fossil fuels optimally would be the nest egg—used only in emergencies, for example, to create the important medicines that require benzene, such as acetaminophen, antispasmodics, antibiotics, and such. It's probably best not to use benzene to drive an inefficient car.

The Ultimate Nuclear Reactor

If human beings don't use fossil fuels, what's the best solution? We are often asked point-blank about more common and controversial ideas for replacing fossil fuels, such as nuclear power. Many

environmentalists and technologists have recently come out in favor of nuclear power because they believe it does not involve massive CO_2 emissions in its operation phase.

In the United States, nuclear power has its own regulatory commission, with a budget of more than $1 billion a year. As we have said before, a regulation is an indicator of the need to redesign. Not only that, but regulations herald high financial expenditures, because it costs money to put the systems in place to meet those regulations. Given that, the financial cost of nuclear power is nearly prohibitive. In August 2012, Jeffrey Immelt, the chief executive of General Electric, said that the cost of building nuclear reactors was so high that it had become "really hard" to justify them compared to other energy systems.

Beyond any question of profitability (or lack thereof), we have a more fundamental design concern about nuclear power. We prefer humble systems wherein if their designs show the mark of human error, the result is not catastrophic. We prefer to focus effort and attention on systems that do not burden future generations with remote tyranny. Perhaps in this we are also influenced by the time and places in which we grew up—Bill was five years old when his parents let him see what nearby Hiroshima looked like after the bombing.

So to the question of what we think of nuclear power: We love nuclear power. We are particularly fond of fusion. We think it's a great idea to spend trillions of dollars immediately to access it. And we are so glad we have our fusion-based nuclear reactor 93 million miles away. The even better news—the power is wireless, reliable, and free.

Now, we recognize that turning the nuclear question to talk about solar might come across as glib or annoying to anyone working seriously on the larger energy-deployment models because of the practicalities surrounding current energy sources, fossil fuels in particular. On the other hand, we truly feel this way, and there are plenty of plausible ways to achieve a renewably powered world. It's hard for us to view that goal as unreachable or quixotic when we are working with Walmart, with two million employees, and with Google, with 33,000 employees, to implement renewable energy as their working systems.

Governments like Scotland's have committed to becoming 100 percent renewably powered by 2020. Iceland is entirely locally powered and, as one of its next priorities for optimization, has targeted vehicle fuel with research.

When envisioning what energy could look like in a Cradle to Cradle world, we like to think again about Thomas Edison. In 1931, the inventor reportedly said, "We are like tenant farmers chopping down the fence around our house for fuel when we should be using nature's inexhaustible sources of energy—sun, wind, and tide . . . I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait until oil and coal run out before we tackle that."

Not All Renewable Energy Is Equal

We named this chapter "Wind Equals Food" because, in the spirit of the upcycle, we want you to imagine a self-replenishing system of which energy constitutes one part. We didn't call it "Wind Equals Electricity" or "Electricity Equals Food," because those titles wouldn't encompass the full story line. We want you to think about interdependent reuse periods and even interacting loops of materials and energy. In the cycle, renewable energy converts to value, even if the value is simple pleasure—a fresh strawberry to start your day.

Renewable energy is not only an inexhaustible option but also the most delightful option in stimulating design innovation—it is inherently local, is typically silent, and represents a broad spectrum of design options from passive design, such as allowing sunshine and breezes to naturally light and cool a building, to active design, such as

using solar photovoltaic cells and wind turbines. In building designs, we have also employed low-grade geothermal. (If we wish to drill, why not drill for renewable energy and not molecules?) High-temperature geothermal is interesting as well (oddly, it is nuclear like the sun—the earth's core harnesses the fission of nuclear isotopes). Iceland, for example, powers 66 percent of the country with such high-temperature geothermal generators.

Of the renewables, solar remains a favorite, in its most basic form and via the other sources to which it contributes—for example, wind (which gets additional help from the rotation of the earth and gravitational forces).

But not all renewables are equal. Just as in the Rathore solution, where the why of each person's action was considered and new routes devised to get there, one must always bear in mind the value behind using renewables—a healthier natural world, more carbon preserved in the soil, preserving underground stores of capital for more worthwhile endeavors.

Sometimes when a renewable is used, the metric of the renewable is considered (a company saying 30 percent of its power comes from renewables, for example) but not the total value. Not considering the value in design causes problems. The ideal solution looks around the corner and understands "What's next?" As Rathore and his tigers will tell you, one person's solution is another's ecological disaster. Or what works renewably here is not renewable there.

As we mentioned earlier, the European Union declared in 2004 that 20 percent of its total energy consumption needed to be supplied by renewable energy sources by 2020. Unfortunately, perhaps, they started with a metric that ultimately may prove to be inadequate to the task. If 20 percent is good, doesn't that imply that more is better and that 100 percent would be ideal? Remember the upcycle chart from the introduction? Why not use it as a guide? Then, when the EU meets its interim goal, the leaders remain aware of the larger ambition—where they are going. They have planned for the whole thing. You need to set your destination.

But the EU, at that moment in 2004, did not have the courageous vision of the explorer. Fair enough. The project of figuring out renewables is hard and different and surprising and uncertain. That project has all the characteristics of exploration and experimentation and innovation. It's difficult. Unfortunately, the EU had driven a stake into the ground before optimizing around the creative opportunities inherent in saying, "We want to go renewable generally."

Part of the problem, as we have been stressing, is that starting with a metric blinds planners to the larger effects of one's actions in a way that a values-based plan does not. Some of the EU strategies did not work so well. For example, one of the ways the EU tried to meet the 20 percent objective was to begin importing palm oil from Indonesia, which they felt could be burned to make a "clean" non-fossil-based biofuel.

Switching to palm oil may result in less CO_2 being released from burning fossil fuels in Europe, which was ostensibly the value of switching to renewables. But Europe's importation of 3.8 million tons of palm oil in one year alone has accelerated deforestation of the Indonesian rain forest after land was cleared to plant palm forests.

Beyond the tremendous loss of flora and fauna, there is, ironically enough, a large increase in the emission of carbon dioxide into the atmosphere. Why? The Indonesian rain forest grew in peat bogs where the wet soil slowed the decomposition of the plant material. To grow the palm trees, foresters had to drain the rain forest land, exposing the decomposing peat, which releases methane and carbon dioxide.

Because of these emissions, Indonesia is now the third-largest emitter of greenhouse gases, behind China and the United

States. Ironically, the lower carbon dioxide emissions in Europe from using biofuel are offset by this other carbon dioxide release in Indonesia.

After the Flood: Creating Jobs That Keep Working

Let's look at another "clean" project: the Kárahnjúkar Hydropower Plant in eastern Iceland. This was essentially an effort by the Icelandic government to create jobs and revenue by harnessing the nation's potential energy production, not for use in powering the country but for Alcoa to make aluminum.

This makes some sense. Iceland knows how to create vast amounts of excess power through renewables. For all intents and purposes, 100 percent of the country's electricity and space heating comes from geothermal and hydro sources.

Iceland knew it could create more renewable power for export. But how could it deliver that tremendous resource overseas? It's not efficient to run cables to Europe to deliver electric power. Essentially, what Iceland wanted was to create a battery capacitor to store the energy and ship it out.

If you think about it, aluminum is similar to a fossil fuel in what it represents, energetically speaking. It is a material used in modern industry that requires vast amounts of energy to create from bauxite. When you see aluminum, the very fact of its existence means that huge amounts of energy were used to bring forth its creation. The aluminum has what is known as high embodied energy.

To create enough power to smelt aluminum, the engineers in Iceland designed a dam that is now the largest in Europe, nearly 633 feet tall, and flooded a 23-square-mile wilderness area to create the necessary vertical drop to power 40,000 average households annually. The Icelandic government anticipated 1,000 permanent jobs from the new smelter, which would be run on "clean" energy (to a population of 309,000, that's a lot of jobs). In 2008, the value of aluminum exports exceeded that of Iceland's fishery for the first time.

But the dam was built in what was the second-largest unspoiled wilderness in Europe (not anymore). Use of the land around the plant is now limited because of emissions from the smelter. Many environmentalists have documented serious damage done by the creation of the dam. Also, huge carbon anodes are required for smelting. This is not carbon-free production.

Now, if we look at the perceived economic value, Iceland's plan makes sense. The government wanted to create 1,000 permanent jobs and was willing to invest $1.3 billion in the hydroplant to make that happen. Alcoa invested $1.1 billion in the smelter. But, given the size of Iceland's capital investment (and the fluctuating price of aluminum), one can ask the question: Is aluminum, fabricated this way—from imported bauxite and with such large-scale hydropower—the most optimized capacitor for the country to be creating?

What if, instead, Iceland decided to obtain aluminum through recycling, which requires 5 percent of the energy needed to extract alumina from bauxite? What if Iceland, using renewable geothermal power, devoted itself to being the aluminum recycler of choice for all of Europe? It has been reported by Alcoa that 66 to 75 percent of all the aluminum ever produced is still in circulation today. How wonderful to imagine a technical nutrient of such endless resourcefulness cycling over and over on renewable geothermal power.

Also Iceland—with its brilliant engineers and scientists—can help lead the renewable economy, as it continues to investigate hydrogen, experiment with high-latitude greenhouses, and create geothermal technology that has a global market. That would be putting Iceland's brainpower and its renewable power into a capacitor to solve the world's energy problems. Iceland would be exporting innovation *and* energy.

Brazil too tried hydropower, resulting in a slew of negative effects. The rain forest wasn't cut down, which sounds good. Instead, the rain forest was flooded to create the requisite water mass and vertical drop to drive the generators.

Unfortunately, wood and other vegetation soaking in the water create methane as they biodegrade. The methane emissions made more greenhouse gases than were offset by using hydropower. Highly corrosive hydrogen sulfides caused by the biodegrading plant matter wreak havoc on the turbines. Those hydrosulfides kill wildlife in the rivers.

Yet the surface facts remained: Trees weren't cut down, which is environmentally beneficial, and money was saved because there was no cutting, which is economically beneficial. But, really, is this good design?

A Renewable Fixing Its Flaws

What makes large-scale hydropower so troublesome is that it does not allow for easy revision.[7] What if the designers and engineers are wrong? How can the structure adapt? If you've flooded square miles of wilderness and built a dam 63 stories tall, it's hard to revise, to amend the system. It is not much different than strip mining or generating nuclear waste in that one has no opportunity to revise. That's

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7. We are certainly not against hydro overall. Bill, for example, helped restore small-scale hydroelectric plants in Vermont in the early 1980s. We especially prefer "high head hydro," in which essentially the water comes down a mountain in a pipe and spins a Ferris wheel, and certainly we don't mind "run of the river," which doesn't change the course of the stream with disruption or storage. The water doesn't care and the fish don't care. The water is falling regardless. Of course, you can't generate enough power to smelt aluminum from small-scale hydro. We understand that. But it is often difficult to see large-scale hydro as the best option given the other renewable sources becoming available, like distributed solar and wind. Think of large-scale hydro as the last generation of renewable power—big dams, siltification, habitat destruction, and anadromous fish interruption (think of the lost salmon and shad runs). Now compare that to what human beings can do today.

why we believe the best solution is a humble approach combining small solutions that add up to something huge.

Wind power was a renewable that seemed flawed early on but is now fixing its problems step by step. Wind power had the advantage of not massively reconfiguring our terrain at the start and *then* discovering the downside. That relatively smaller profile allowed wind power to adapt, fix itself, and grow.

Wind power, of course, is nothing new. Windmills have been used for centuries to grind grain on Mykonos, drain the polders of Holland, or pump water from wells into fields in North America. Before rural electrification in the United States, tens of thousands of small electric wind generators dotted the rural landscape. In the 1970s and '80s, the U.S. government funded the development of large-scale wind turbines, as did other countries such as Denmark, Germany, Spain, India, and, later, China. Now there are many manufacturers of large-scale wind turbines in the market, including big companies like General Electric.

The market for wind blows hot and cold based on local energy pricing, available tax incentives, market production, transportation costs, and so on, but generally, it has been a fast-growing renewable energy sector. Since the 1980s, the cost per kilowatt-hour of wind has dropped 80 percent; it is approximately 2¢ cheaper per kWh than coal-powered electricity on the U.S. market as of June 2012. And that's without accounting for the cost it saves our system due to decreased carbon dioxide emissions. About 24 percent of Denmark's energy needs reportedly are met by wind, and the country has plans to grow that to 50 percent by 2020. Serious wind development is happening. It has all the hallmarks of a new industry with ups and downs, but it is clearly here to stay—even with cheap natural gas coming from hydraulic fracturing (fracking) in shale formations.

But for many people, wind power doesn't seem like a clean renewable because it can create visual blight on formerly beautiful country landscapes. Where wind turbines crowd, say, the Tehachapi Pass in California or the Nantucket Sound in Cape Cod, some observers think they might as well be looking at big, unattractive power plants.

Many individuals and government bodies have begun to address this eyesore problem.

The University of Maine is developing the engineering for large floating wind turbines 20 miles offshore (out of sight) that would produce the energy equivalent of 150 nuclear power plants. Maine could have a new cash crop to add to its famous lobsters—clean energy. Minnesota recently passed legislation to provide incentives to individual wind turbine owners, residents of the state, who do not own more than two wind turbines. In other words, you can win tax breaks on property—the purchase of the wind turbine itself—and a business tax credit if you generate wind on a small scale. This sort of legislation could help every Midwestern farmer buy a source of renewable power for his or her work, generate income by selling up to the grid, and fashion a distributed generation network appropriately scaled to the other human activities in the locale.

Dan Juhl, who understands farm life from his own childhood in Woodstock, Minnesota, has been creating profitable business arrangements to encourage this kind of small-scale wind-plant cooperative. Often big utilities and energy buyers enter a community to negotiate the cheapest price for land and end up pitting one farmer against another. One farmer becomes the winner and all the others get left out. Instead, Juhl, through his Juhl Wind Inc., brings together a group of farmers to invest in a common future.

For a set rate of return, an outside investor injects significant capital to fund the larger construction costs. As the tax incentives and revenue accrue from producing and selling electricity, the investor is paid out his or her return. In ten years, when the investors have achieved their goals for financial return, the ownership of the wind turbines transfers to the farmers, who can use and sell the energy produced. The wind turbines become the capital real estate of the local residents, producing "currency" for the perpetuation of jobs and benefits to the local community for decades.

The result? Wind turbines dot the Great Plains, local family farmers earn enough for their mortgages and their kids' college educations—and a new industry, renewable power, is created *in places where we need power.* The investor is happy too, because the guaranteed return has been paid out in full. The dispersed wind turbines make a more pleasant visual for the neighbors. Wind is the new cash crop.

Another issue with wind has been how to store the energy produced, not just sell it to the grid. This issue has sparked creativity and innovation. One of our favorite small-scale proposals involves using wind turbines to help solve a pressing rural problem. In farming regions, school authorities have been having difficulty affording school buses to pick up children each day. The farms are too far apart, and the fuel gets expensive. But of course everyone wants their kids to be able to live on the farms, for the parents not to have to trade in their lives as farmers simply to be sure their kids can be educated.

Juhl's solution is to install small wind turbines, an optimized design, at community centers in the Midwest and use these centers to power up electric buses. These vehicles require less maintenance because there is no need to change spark plugs or oil, as with internal combustion engines. The buses deploy in the morning and the late afternoon. The rest of the time they are sitting idle. But what if that time were optimized? What if, when parked, waiting, the buses were getting charged by the sun and by the wind?

The wind would actually be healing the community. The children could still be at home on the farms, and the buses could fetch them for their school day. The community would have optimized around a local resource for concentrated energy instead of farmers sending their money far away to the Middle East looking for fossil fuels that are insecure and might inspire even military intervention. Or instead of spending their money on nonlocal sources in Pennsylvania or Alberta, they could collect the clean, free, abundant energy flying right overhead, ready to pay for mortgages and college tuitions. No one has to leave the farm to protect a way of life.

Letting Industry Strike the First Blow

Another problem wind originally had was finding the investment capital to get the turbines built. But many companies buy CO_2 offset credits for their power uses, either out of their own concern for the environment or as an investment or PR strategy; investment in wind has now become one option for how to do that.

In 2008, Steelcase, the office-furniture maker that produces the Think chair, invested in a Texas Panhandle wind farm to help offset carbon releases. The renewable generator that was created—Wege Wind Farm—powers almost 3,000 homes and businesses with clean energy, and Steelcase receives 20 percent of the farm's carbon offsets for its own production needs. The company gets the satisfaction of knowing it is making a specific investment in wind power for a community that needed such an energy source. It's a CO_2 offset, but the real key is that it's creating what we call additionality—i.e., creating more of a good thing, in this case creating a new renewable power system, instead of merely supplementing the cost of existing renewables.

Other companies are taking these steps too, following aspiration and commitment with action. Herman Miller, another major furniture manufacturer, has cost-effectively implemented wind power solutions that support the manufacture of all their Cradle to Cradle products. These kinds of initiatives are the beginning.

Another Way to Offset CO_2 . . . and Make Energy

Here's another energy solution: A cow produces enough manure a day to provide more than 2.4 kilowatt-hours of energy—in other words, the power needed to light one incandescent bulb to burn all day, or three CFLs (compact fluorescent lights), or five LEDs. Biogas is a near perfect example of upcycling. It is the methane and carbon dioxide produced by biological matter as it decomposes, which then is burned for fuel. If the cow manure and decomposing vegetation or other organic matter were contained in a biogas plant, not only could the off-gas turn into power, the methane and carbon dioxide that would otherwise be released into the atmosphere would be contained. Methane is estimated to be more than 20 times as potent a greenhouse gas as CO_2, so that containment is a great asset.

The sources for biogas material are everywhere on our planet: from gardens to cemeteries, from wool to pet droppings. We are seeing landfills that have been capped and the methane is being collected and used to provide power—electricity, for example. Companies such as Axpo Kompogas in Germany, a CO_2-neutral fuel provider with more than 50 facilities around the world, are showing the way with their fermentation processes. Between 600 and 1,000 kilowatt-hours can be generated from one ton of waste (approximately enough to power a typical energy-inefficient house for 38 days), and nearly a ton of natural fertilizer is created as a by-product. The United States alone produces 220 million tons of garbage a year. Imagine the power that is possible.

Clearly, biogas could not sustain all our energy needs (as our needs are currently designed), but it would certainly assist. It's readily

available and right in front of us, it can be optimized around greenhouse gas concerns, and it adds no foreign processes to the natural progression of material into soil. As you will see in the next chapter, human beings can continuously benefit from soil enhancement.[8]

Dam: Upcycle in the Desert

Okay. We have discussed various renewables and their attributes. We have discussed the grid. We now want to invite you to engage with us in an evocative, big-thinking exercise about how to take all we have discussed in this chapter and power something huge. How about the United States?

Let's take a fresh look at the Hoover Dam in Nevada, America's most famous hydroelectric dam, responsible for a major WPA job creation program and for enabling Las Vegas to exist. Remember jobs and power again when we get to the end of this chapter.

If one had the need for a certain amount of power—and let's presume that humans could optimize the demand side (is it possible to imagine an energy-efficient Las Vegas?)—then how would one, in the desert, deliver that energy? Would you block up the Colorado River, which is how we got Lake Mead, the body of water that was created when the Hoover Dam was built? Because of extraction for cities' water needs, as well as evaporation, the Colorado River rarely reaches the Sea of Cortez anymore. The delta claims only 5 percent of the wetlands it had previously. How many people lived in the delta of

8. We could be looking at methane extraction from our garbage, not just capping landfills, as is often done. In an optimized system, we could extract methane immediately from our garbage for practical purposes—heat and electricity—and then use the resulting materials for soil amendments. Instead of leaking methane over centuries in bits and pieces, we could harvest it. As it is now, well-meaning people making compostable packaging might be seen as adding to our methane-release burden—another ill effect of "good behavior."

the Colorado in Mexico before the Hoover Dam was created? Was that dam designed with these consequences in mind?

The people who love the Hoover Dam probably prefer not to imagine a world without it. They say it's a massive economic development area because of powerboats and water skiing. But one can build recreational lakes without having to dam the Colorado.

Instead, what if we switch our thinking? As an imaginary exercise, and just to get a feel for how amazingly powerful the sun could be, consider exactly how much desert area covered in solar collectors would be required to power the entire United States: 140 square miles. How big is that? (We will discuss distribution later on.)

Get in your car. Start driving.

At some point in the desert you will start seeing a gleaming field of solar collectors on your left side. They spread on, as far as you can make out in the haze of the heat mirages. They are a fairly daunting spectacle. You keep driving at the speed limit. About two hours later, you come to a corner of the field of collectors. You turn left, following their edge, driving south into the desert.

The gleaming field stretches deep to your left here too. About two hours later, you turn again to the left to follow the southern edge. Two hours later, one more left and you get back to the point where you first saw the collectors. You have just driven around a field of solar energy collectors that can power the entire (mostly inefficient at this point) United States of America, a whole country.

That square is the equivalent in area, relative to the total area of the United States, of a beach towel on a basketball court.

Now get out your scissors.

Cut up the beach towel into tiny pieces. Spread it around. Connect them with a thread.

How about putting some of those pieces outside Las Vegas, or even on the rooftops of Las Vegas? Making them solar? In a new Las

Vegas development program, if developers wanted to build houses, office buildings, or casinos, they could install parking lot and other solar collectors to meet the new demand.

What if we used existing highways for renewable energy distribution? Imagine ribbons of road running through the desert covered with lightweight shading devices made of solar panels, or with the panels stationed adjacent to the highways in the public rights-of-way. Instead of drilling for oil and gas on public lands and in national preserves, where few benefit and we put more carbon into the atmosphere, we could mine solar or wind on public rights-of-way for energy and jobs. What if we optimized the existing industrial landscapes? You could obviate the need for massive doses of fossil fuel or nuclear power plants, and the system, because it would be dispersed, would distribute power where it is needed. If you crunch the numbers, you'll see that this really would solve our energy needs.

In Europe, Michael has encouraged putting wind turbines within large power transmission towers, since these towers already represent public infrastructure visible in the landscape; the urban blight issue would be contained, since these areas are already in use for industrial purposes. Such proposals would also address grid issues, since the tower locations could be fully optimized for electrical transmission and power generation. Regardless of whether or not these technologies are ready for installation today or will even make practical sense, this is the kind of thinking that leads to innovation. For innovators, it's a worthy stimulus for dialogue.

Bill has been developing a similar idea whose time may have come: using public lands to help America achieve energy independence. Let's call it upcycling Amtrak.

We begin by considering infrastructure we already have. If we look at the Amtrak train system, we learn it was subsidized at the level of $1.4 billion in 2011 alone. What if on the land right around the train tracks, which already has been secured as public rights-of-way, renewable power systems were installed? Our team ran those numbers and it appears that the area available for potential use in generating renewable energy would be so significant that Amtrak could be *the* major contributor to the U.S. power requirements in a distributed fashion, even using only solar collectors.

Just imagine railroad lines running across Kansas with solar collectors on the rights-of-way on both sides of the track. What a terrific resource and what a great location, since it's ideally positioned for maintenance and transmission using the infrastructure that is already there.

Suppose a map of such a grid were shown to Amtrak officials and they were told, "You have 14,000 miles of easements that could be used for solar collectors." Amtrak, almost overnight, could provide the real estate for the distributed large and small power utilities all over the United States, along with thousands of local jobs all across the country. Why couldn't Amtrak be financed, not subsidized, by multi-megawatts of power instead of billions of tax dollars? Not to mention the opportunity to run solar-powered electric trains.

Since this grid would be able to uptake energy, all manner of localized energy production could be integrated and employed. Add wind turbines where appropriate. Add the methane from our garbage. Add biogas, gastrification of organic materials from our farms. We are not talking here about ethanol production for fuel; we are talking here about biofuels. We are talking about normal life becoming productive without the strange need for ongoing subsidies.

People just need leadership, guidance, and optimization from an engineering perspective to get such a project done. Society would get jobs, mobility, clean energy, and distribution. We would get to send a signal everywhere we go that the world is getting better. Every mile you travel, every train ticket you buy, becomes a story of

regeneration, of the beneficial opportunity to mine public land for public benefit.

This scenario can evolve a step further. How about upcycling our treatment of the United States border with Mexico? Imagine that we would like to send a sign to our friends south of the border in Mexico. What kind of signal do we send now? Fences saying, "Stay out." Instead, what if we created a giant welcome mat to the future? Instead of spending hundreds of millions of dollars digging holes to put up only marginally effective barriers, what if we dug holes and built solar collectors, a giant sculptural ribbon—like the artists Christo and Jeanne-Claude's *Running Fence*? The United States could create an ad running from Imperial Beach, California, to Brownsville, Texas, announcing that it is a renewably powered country, to benefit the world, and is happy to share innovation.

We could help Mexico build its solar industry too. We could have thriving border communities where we meet and share. Upcycling relationships. Renewable friendship.

Ask Not How Much the Grid Can Give to You but How Much You Can Give to the Grid

Now that we've talked about energy sources, we want to discuss the system of delivering that energy. Some people talk about getting off the grid. As you can tell, we are quite interested in *contributing* to the grid, from a diverse and distributed perspective. We are not suggesting everyone run away and be independent. We want to celebrate interdependence.

The grid can be optimized to take advantage of the possibility of local power production fed into the common system. The concept of distributed energy is nothing new. The Jacobs farmstead wind turbines that dotted the Great Plains of the United States or the windmills of Europe were locally distributed energy systems. They were small and they worked, or the farmers would not have bought them.

The difference is that when people added transmission, the system moved toward centralized power because of the efficiency of concentrated sources and AC distribution. In conventional electric power production, energy is created at a base-load station, with peaking power plants backing up production for high-need fluctuations. When power is transmitted along the grid to your house or business, it whispers away due to line resistance. The farther the electricity must travel, the more energy is lost, up to 10 percent.

The power goes to a step-up transformer, which, if it is working properly, doesn't lose more than another 2 percent of the energy.

Then it runs along transmission lines to a step-down transformer. The purpose of a substation is to step down the power load so it doesn't explode your toaster oven. Again, a loss of about 2 percent. It moves on to a subtransmission customer, to a primary customer, and then on to you.

We could say the total line loss is about 14 percent. For every 10 tons of coal burned to make your electricity, 1.4 tons are lost just to move it around over long distances. It's suboptimal. And you, the customer, have to pay for it.

But if you have a solar panel on your roof, there's no distance. There's no security threat, because the whole system is dispersed. The power you collect can be used or even, in 43 states, sold into the grid when you receive an excess of productive sunlight. As society moves into the future, the ancient practice of a distributed unconnected system can be integrated with the connected system and then move into decentralized generation within a connected system—upcycling the grid. The whole population could be not just consumers but energy creators.

Hundreds of policy makers and entrepreneurs are working on this decentralized model, and it appears to have immense potential from all sorts of economic, sociological, practical, and security perspectives. Walmart is committed to becoming 100 percent renewably powered as soon as it is cost-effective and even looking at ways of becoming a power wholesaler in certain markets.

Clearly, this will cause disruption—you could even call it Schumpeterian disruption, creative destruction. Existing utilities that are providing base-load power can feel disrupted by renewables coming on in new business models. A new system of generating and transmitting power will require society to develop the frameworks for this to be optimized, which may be difficult with a lot of incumbents fighting that change, especially since the incumbents are very entrenched, very organized—might we say, powerful (pun intended). (Imagine Thomas Edison's undaunted courage and optimism taking on the whale oil or gas lamp lobby.)

It may sound herculean to transform existing electrical generation and distribution systems, but the creation of the federal highway system under Eisenhower is an astonishing undertaking if you stop and try to imagine it all at once. The Internet is astonishing if you try to consider it as a whole. How could it be invented in its scale to date? And yet it has rapidly come into being in recent times. How quickly can these things happen?

The Little Lightbulb That Could

Remember, in our energy formulation, how we said we want to consider the whole circuit, from source to grid to where and how the energy is used? As we described before, when Edison invented the lightbulb, he also understood the need for electrical energy generation and the grid. We have talked about the generation of energy and the grid. But if we don't consider how we enjoy its benefits at home, or in the office, or at the factory, the entire energy discussion is left unfinished. If we optimize the design of our buildings, appliances, and consumption patterns, the energy saved is potentially so huge it could make us feel as if we have just (to borrow yesterday's enthusiastic phrase) struck oil.

We could talk about a refrigerator or a house or a train or a city, in rethinking the appliances of modern life. But let's return to the lightbulb. It's the perfect device to consider when aiming for optimization since it is so small, so important, and yet could make such a huge energy difference.

Traditional incandescent bulbs, the very lion of a new idea, have gotten old. They are now a problem for modern society because they burn off too much energy in heat and not enough creating light. That's why countries from the Philippines to Argentina to France, Finland, and many more are banning the production of inefficient bulbs.

But as we discussed earlier, compact fluorescents contain mercury. CFLs reduce a negative effect in one area of the system (energy demand) but cause a problem in another (materials toxicity). So while humans are being "less bad" in terms of power usage, they end up with many, many bulbs in landfills releasing mercury—a toxic rare-earth metal that does not safely circulate in biological systems. (It could, if safely utilized and managed, be *prized* as a rare and valuable "technical species," as a component of safely recycled technical products.)

In response to new laws to create more energy-efficient bulbs, many companies are innovating on Edison's design and "form factor"—the A bulb—to provide more effective and efficient light per watt without mercury. LED high-performance bulbs can retain the basic shape and form of a standard bulb while configured to cast

an extraordinarily flattering and enjoyable glow. LEDs also have the advantage of generating bright illumination. While LEDs are more expensive at the moment than conventional bulbs or compact fluorescents, it is expected that the price will come down to compete with CFLs—they dropped from $36 to $18 per thousand lumens in 2010 and are expected to decrease to $2 in the next few years—and we think they will then be popular. A bulb will last for 10 to 15 years, and every part of it can be designed to be safely reusable in technical cycles. We are working with lightbulb companies as part of their product creation programs to strategize so components can later become anything from a bicycle part to a nutrient in the biosphere, or even . . . another lightbulb. Imagine if we took this a step further, and the bulb materials were products of service that you leased from the maker—you would have light overhead rather than bulbs in the trash. What an idea!

With LEDs in hand, we would now like to look at a whole upcycle theoretical model, from power source to power need.

In a fanciful analogy, let's return to the Hoover Dam: If the surface area of Lake Mead behind the dam, which produces 4.2 billion kilowatt-hours per year, had solar collectors floating over it, the collectors would actually produce 10 times the energy the dam produces. (As a bonus, the floating solar collectors would reduce water evaporation.) Now, while the boaters may wish the whole lake were still set aside for boating, we can renegotiate the shared water space later. Right now, we wish to float collectors in this imaginary model.

In 2010, the estimated energy needed to power residential and commercial lighting in the United States was 499 billion kilowatt-hours. How could we reconceive that need with far fewer kilowatt-hours and from renewable power? (Once again, companies such as Google, Walmart, and Procter & Gamble, looking to save money for customers and help them live better, are doing these things. There are a great many examples of leadership . . . and plenty of opportunities to follow.)

The numbers we are about to give you are rough—we are not accounting for the different savings of different wattages or the possibility that in 2010 a substantial portion of the lighting in use might have been compact fluorescents—but here's the conceptual model. Let's say this lighting demand across the United States came from 100-watt bulbs, and you switched out all the lighting for the new positive material LED bulbs, whose energy demands are typically 20 percent by comparison. The dramatic reduction in wattage per light fixture in America could result in an astonishing energy drama. The country's energy needs for lighting would diminish to 99.8 billion kilowatt-hours.

In terms of Hoover Dams, and just for effect, if we add in the supply side of this discussion, with the tenfold increase in energy production of a *solar* Hoover Dam/Lake Mead, you would need only 2.4 solar Hoover Dams to light up the whole country. In our current system—with suboptimal lighting systems—you need 119 Hoover Dams.

With redesign, the whole required energy system shrinks. What we thought we needed for energy might be a whole lot less.

Isn't this amazing?

Is this idea overly dramatic?

Well, let's think a minute. The Hoover Dam was considered an engineering miracle of its time. Was that overdramatized? Wasn't that a dramatic moment, a project as ambitious as that? Was the moon shot dramatic? The federal highway system? Would you sit back today and say, "You can't do that," because building a highway system all over the United States, six lanes of traffic in every direction, is too big to consider?

Is it too big? Or are human invention and daring too small?[9]

9. Our theoretical model brings up opportunities for all sorts of lightbulb jokes:
Q: How many Americans does it take to change a lightbulb? A: 311 million.
Q: How many libertarians does it take to change a lightbulb? A: None. They wait for the market to do it for them.

Take this another step: What if society upcycles the energy question "How can the system create adequate energy?" to "In a world of abundance, what does society do with its excess energy?" What's next? How might people upcycle systems so that not only does wind equal food, but we could also fruitfully store energy *in food*?