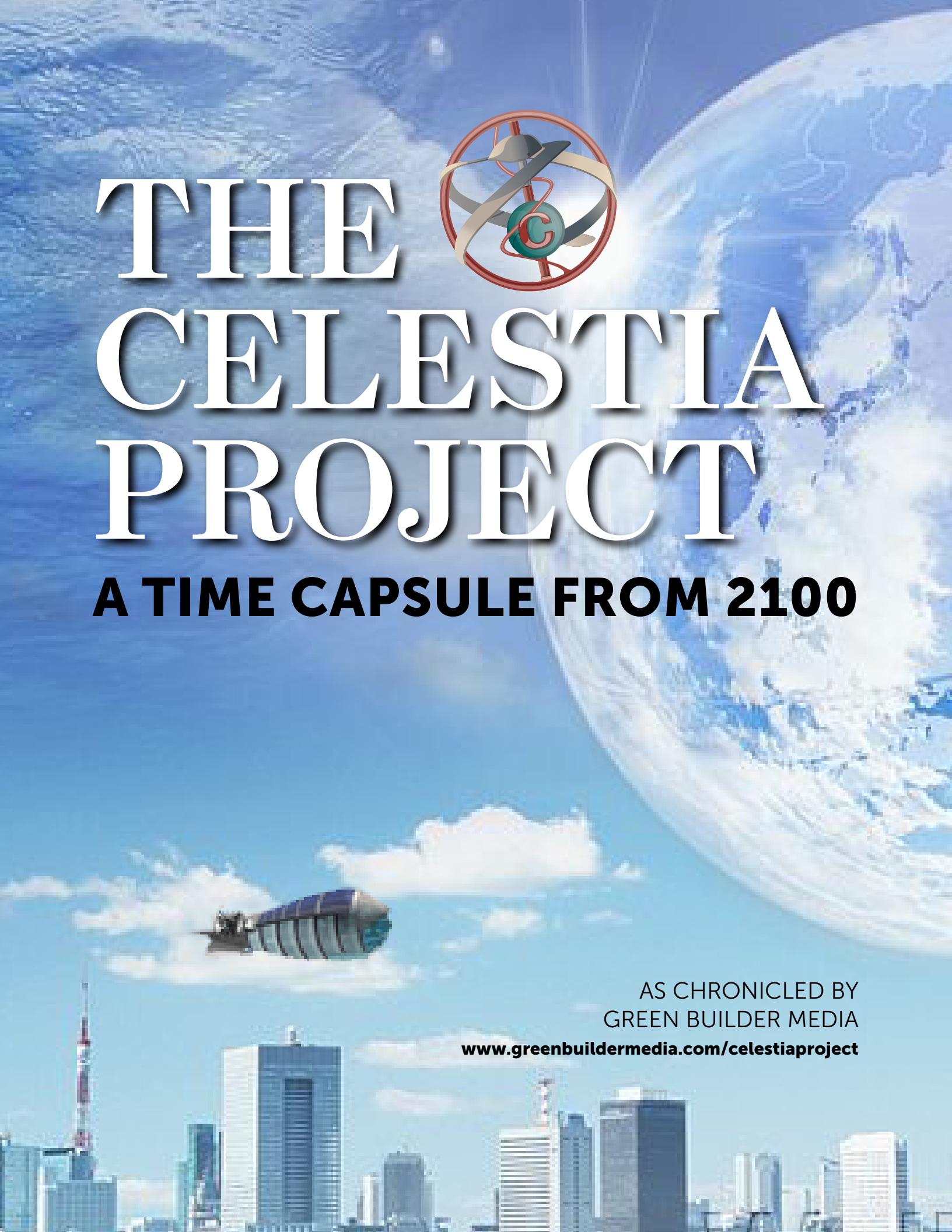
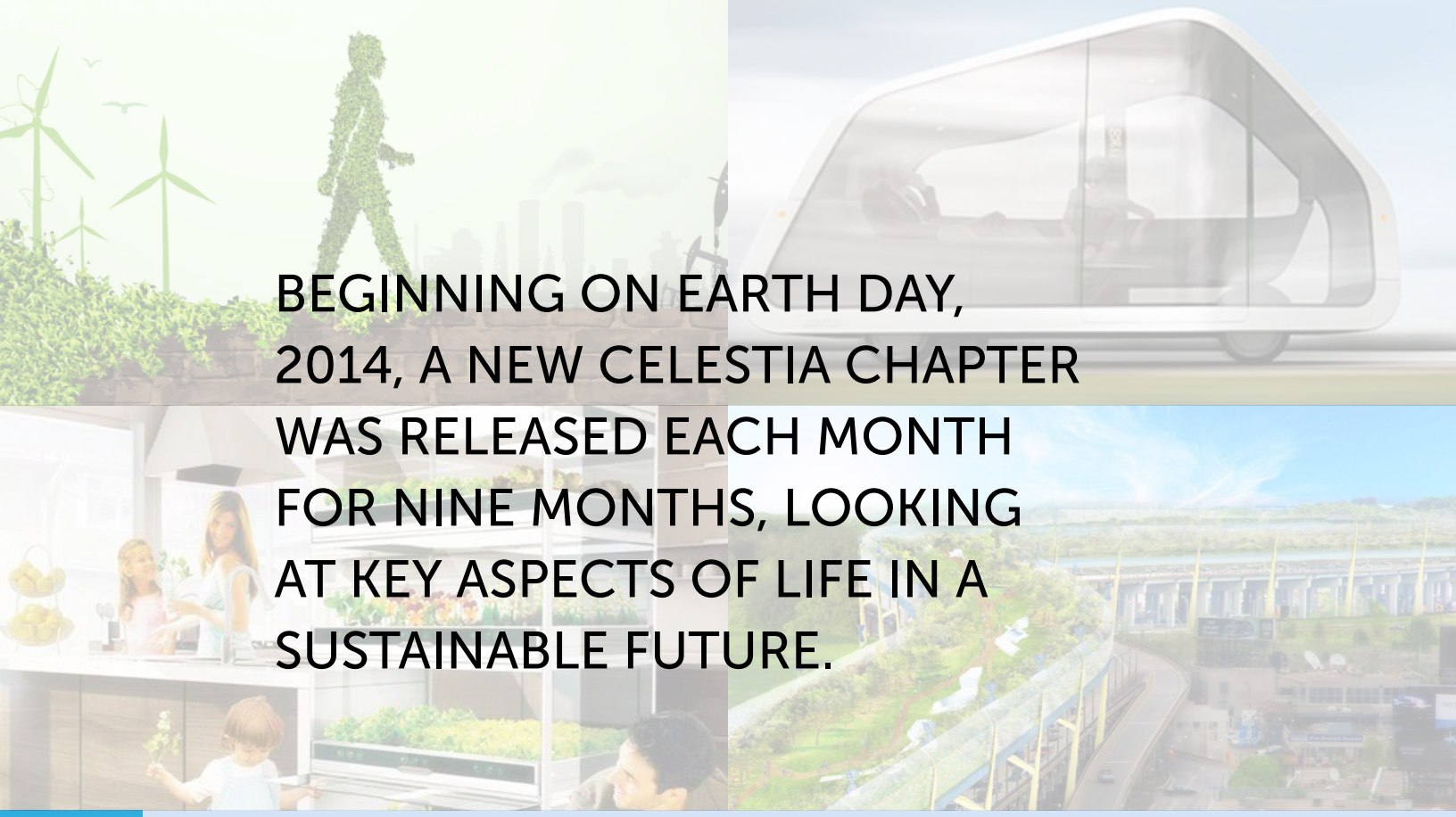
THE CELESTIA PROJECT

A TIME CAPSULE FROM 2100



AS CHRONICLED BY
GREEN BUILDER MEDIA

www.greenbuildermedia.com/celestiaproject



BEGINNING ON EARTH DAY, 2014, A NEW CELESTIA CHAPTER WAS RELEASED EACH MONTH FOR NINE MONTHS, LOOKING AT KEY ASPECTS OF LIFE IN A SUSTAINABLE FUTURE.

THE CELESTIA PROJECT

APRIL 2014: Food Security and Abundance

MAY 2014: Living in Harmony with Nature

JUNE 2014: Transportation and Density

JULY 2014: Technology and Building Science

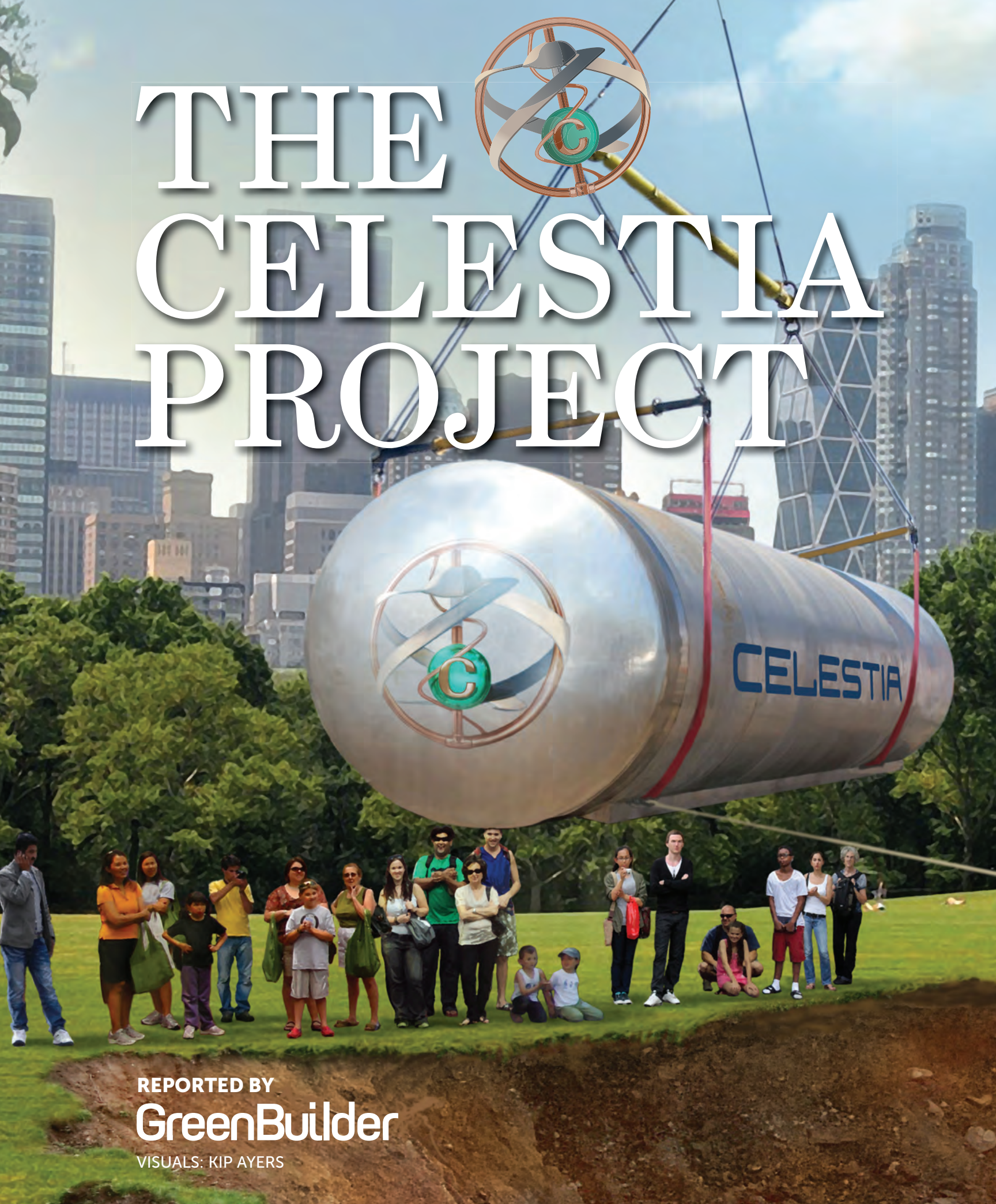
AUGUST 2014: Energy Use and Conservation

SEPTEMBER 2014: Fresh Water Abundance

OCTOBER 2014: Material World: Sourcing of Raw Materials

DECEMBER 2014: Resilience: Durability and Fire Resistance

JANUARY 2015: Community: Living Together


THE CELESTIA PROJECT
CELESTIA
REPORTED BY
GreenBuilder
VISUALS: KIP AYERS

Scientists have just begun to absorb the significance of an object unearthed in New York this spring. After successfully opening it by following pictographic instructions, they have confirmed that it contains documents, videos and artifacts from another time. But these artifacts come to us not from some eccentric industrialist of the past. Rather, they've been sent back from the future. The Celestia Project (so named by its creators), offers proof that a future of sustainability and survival is both possible and desirable. More information is expected to be released in coming months, as the 11 sections of the capsule are analyzed and published.

Precious Cargo. Workers unearthed the Celestia time capsule last summer, but scientists have only now begun to publish the contents.

IMAGINE A HOPEFUL FUTURE. The world's pressing environmental issues have been solved. Ecosystems are stabilizing. Fresh water is clean and bountiful. The marriage of ethical technology and good intentions have allowed us to make a major course correction. **Life is good. This is premise of *The Celestia Project*.** Divided into 11 chapters, our epic story looks at how an idealized "green" future could become reality. "Unveiled" month by month over the next year, each chapter will include notes and analysis about past and current technology and social trends, products and insights.

Utopia: Inspiration, not Aspiration

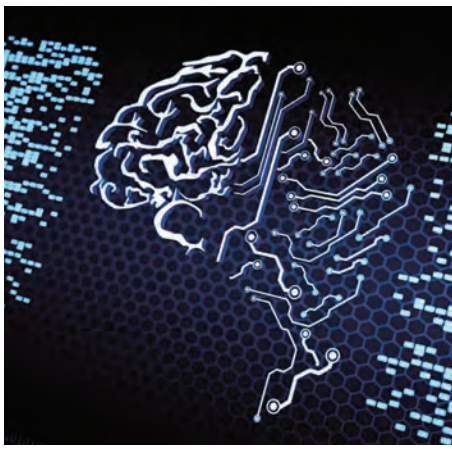
Making predictions about the future is risky (some might say foolhardy). Nothing is certain. On the other hand, guessing future trends isn't as random as predicting the weather. As author Jeremy Rifkin points out in his book *The End of Work*, futurists at the turn of the century—mostly science fiction writers—"correctly predicted electric clothes washers and dryers, vacuum cleaners, air conditioners, refrigerators, garbage disposals, even electric razors."

Of course, futurists also got a lot of other stuff wrong. We don't travel around the planet in pneumatic tubes or flying cars, nor do we travel regularly to the moon or eat our food in the form of paste—at least not yet.

As we progress through the year, we'll be looking at many ideas about what an idealized sustainable lifestyle of the future might look like. As the book, *Visions of Utopia*, astutely notes, utopian dreams since the time of Ovid (43 B.C.) tend to depict similar ideals: "rivers of milk and nectar shall flow, that the wolf shall dwell with the lamb, and spears be beaten into ploughshares. [...] There shall be neither hate nor envy nor hunger nor thirst. There shall be much leisure and few lawyers. There shall be no private property, and there shall be communal camaraderie..." And of course, there will be lots of consensual no-strings-attached-sex and no war. Fun will be had by all.

On the other hand, one person's utopia is another person's dystopia. We like our utopias at a distance, or at least in small doses. Many of us would balk at the strict rules of behavior, commerce and social relationships required to live in one.

Consider the popularity of theme parks such as *Walt Disney World*. Millions flock to visit this "magic kingdom" of nostalgia and fantasy. But the kingdom maintains its brand image with strict rules about employee behavior and relentless attention to cleanliness and order. Perhaps Disney found the secret formula for utopian success: Give them a fantasy, but don't make them live (or work) in it for very long. Visitors know they can leave the narrowly defined world of the park, and return to the ambiguities and struggles that constitute "real" life.



Digital Dreams. In this engineering-based vision of the future, nanobots prepare our food, and human beings become more machine than "organic," living forever.

THE CELESTIA PROJECT

Release Dates

The team of anthropologists, scientists and environmental experts expects to release regular reports on their Celestia findings, as follows:

APRIL 2014: Food Security

MAY 2014: Living in Harmony with Nature

JUNE 2014: Transportation and Density

JULY 2014: Technology and Building Science

AUGUST 2014: Energy Use and Conservation

SEPTEMBER 2014: Fresh Water Abundance

OCTOBER 2014: Products: Sourcing of Raw Materials

NOVEMBER 2014: Resilience: Durability and Fire Resistance

DECEMBER 2014: Healthy Lifestyles and Indoor Air Quality

JANUARY 2015: Financial Freedom

FEBRUARY 2015: Community Living

Low-Tech/High-Tech Synergy. **Other trends point to a more human-centric future, where technology and automation are tools used in pursuit of a better quality of life—not replacements for the things that make us human.**

Which Future?

The next century, depending on whom you ask, looks vastly different. To illustrate, consider the following two views:

Technotopia. In the world of Ray Kurzweil (*The Age of Spiritual Machines*), everything comes down to how fast we can crunch the numbers. He sees a future of human beings merging with computer technology as inevitable. In Kurzweil's world, in 100 years, we'll not only be virtually immortal, we'll hardly need housing, transportation or food as we know it—so complete will be our transformation. By 2099, he predicts, "The number of software-based humans vastly exceeds those still using native neuron cell-based computation. [...] Humans who do not utilize such implants are unable to meaningfully participate in dialogues with those who do."

How many of Earth's billions will actually participate in this radical shift in the human condition, should it come to pass? That's not addressed, but if you consider that only 34 percent of the world has Internet access today (internetworldstats.com), you can bet the digital divide of the future will be deep and wide.

Third Sector Uprising. Jeremy Rifkin, author of *The End of Work*, suggests that an underestimated force in American culture could lead us toward a more humanistic future. This "third sector" consists of organizations that operate outside of the corporate or government power. These include schools and colleges, hospitals, social services organizations, museums, libraries, art galleries, orchestras, theaters, animal welfare organizations, neighborhood groups and so on. They carry enormous clout, and may not accept the path that technocrats have mapped out for our future.

Rifkin suggests that as more people lose their traditional jobs to computerization, they will find themselves free to devote time to the third sector, influencing local politics, community directions, and "offering a much needed antidote to the materialism that has so dominated twentieth century industrial thinking."

New Directions

Our view is that each of these predictions is only partly right. New trends and technological advances are changing ALL of the rules. These include the sharing economy, the foodie movement, permaculture, inward migration to cities, green urbanism, a huge drop in the cost of solar technology, the return of co-op business models and more. All of these trends form a countercultural, and in many cases, more sustainable response to the wasteful economic models of yesteryear. Why own a car when you can share one? Why eat oranges from South America when your neighbor grows a better-tasting variety? Why live in outer ring suburbs when everything you need or want is within walking distance in the city?

The *Intuit 2020 Report* predicts that in just a few years, "Work-life balance will no longer be a myth, but a reality as people invest in the places they live to make them better, forging new communities. This weave of community fabric will see people re-establishing stronger ties with family, friends and community spawning local economic development in new, dynamic ways."

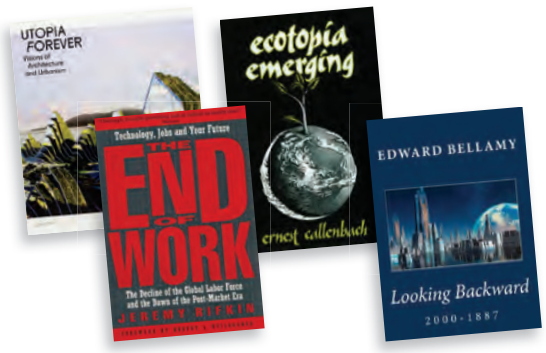
Looking Ahead

As citizens of one of the most affluent countries on Earth, we're among the fortunate few who get to choose from a whole palette of opportunities. As you journey with us into the future through The Celestia Project, we look forward to hearing your ideas about how things *might* go—how we might pass down to future generations a place of stability and wonder. We begin this month with that most fundamental of human needs: food security.

We'll have a lot more content available at our onlineheadquarters: videos, slide shows, articles and handouts. To visit go to:
www.greenbuildermedia.com/celestiaproject

Further Utopian Reading

We've included handy links in case you'd like to order any of these books direct from our Amazon shop.



Utopia Forever: Visions of Architecture and Urbanism BY LUKAS FEIREISS
A compelling look at how architects and urban designers are challenging conventional norms to create idealized places to live, work and grow our food. **http://tinyurl.com/qj98ss6**

Ecotopia Emerging BY ERNEST CALLENBACH
This well-known utopian novel chronicles the rise of an ecologically based alternative lifestyle in the Pacific Northwest. **http://tinyurl.com/ppkgjzy**

Looking Backward: 2000-1887 BY EDWARD BELLAMY
In this classic utopian book, a traveler from 1887 is shown the wonders of a future Boston. Entertaining, informative and, at times, very funny. **http://tinyurl.com/q63mqfq**

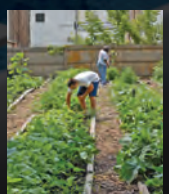
The End of Work BY JEREMY RIFKIN
Rifkin has long been a few years ahead of his time. This book, published in 1995, points out how the computerization of industry has failed to deliver the leisurely lifestyle its advocates promised. **http://tinyurl.com/qyrxxx6**

THE CELESTIA PROJECT

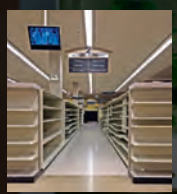
The Path to Abundance

"MY MOTHER DIED TOO YOUNG. She was only 90, but she knew everything, or so it seemed. She lived through the transition, and she had a million stories. Her generation was smart. They combined the old ways with the new ways and brought life out of every inch of soil. They made things grow in dead deserts, in swamp water and even from thin air. We all know these things now. This is the future. This is life, reinvented." **—Sylva Terrasdottir, 2100**

Climate change leads to desertification of major grain- and corn-producing regions, creating vast shortages worldwide. Global wheat speculators turn what might have been a manageable crisis into starvation for almost 3 billion people.



Resilience gardening becomes a major movement in the U.S., as small-scale food production becomes a national obsession.



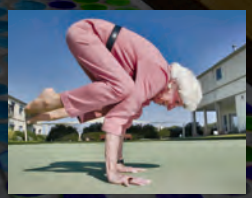
The last major supermarket chain in the U.S. declares bankruptcy, as citizens rally around co-operative stores and local farms.

Genetically "enhanced" products sold to thousands of elementary schools result in a health disaster. Biotech-modified foods, already under suspicion, become highly unpopular, and strict labeling standards are applied.

2014 2020 2030 2040 2050

Meat consumption in the U.S. drops to the lowest level since World War II. A soy-based imitation steak fools one of New York's top chefs.

Nanotechnology, although banned from foods, helps restore soils in Arizona, Utah and around the world, allowing local populations to feed themselves.



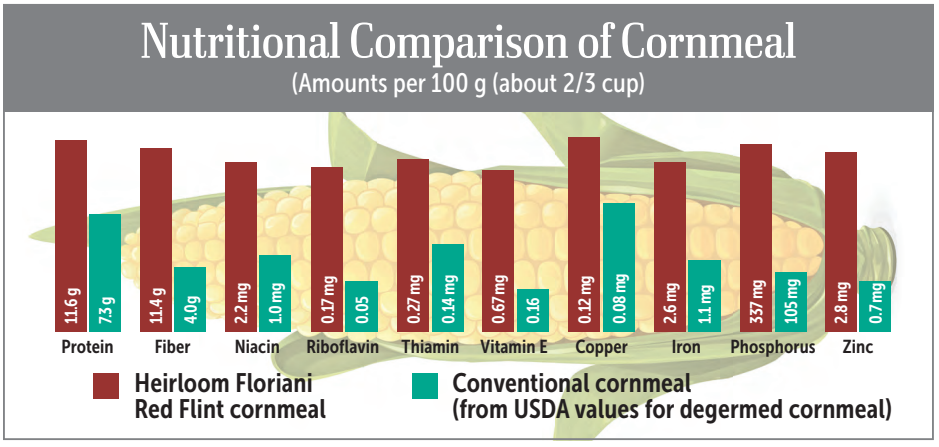
The first person to reach 140 years of age reveals her secret. Local, organic food, yoga three times a week, good sex and no stress whatsoever.

2060 2070 2080 2090 2100

When we envision how we will live over the next 100 years, we are faced almost immediately with issues of food security. How do we design a building, a city, a house or a kitchen—or even a cooking method—without factoring in where and how people will acquire and prepare their food?

ACCORDING TO MOST STATISTICS, hunger *should* no longer exist on Earth. Technological advances in farming mean that the total amount of food production worldwide now outpaces population growth. Yet almost a billion people go hungry each year. The reasons why, according to *Harper's Magazine*, are not what you might expect: Food has become a speculative commodity—especially wheat—that is bought and sold for profit, even when it doesn't actually exist. Real food is held back until prices rise, and people starve.

The U.S., on the other hand, has a different problem: obesity. While other parts of the world starve, 35 percent of our population is overweight. The problem isn't just an excess of supply—supermarkets glutted with thousands of boutique items from far-flung corners of the world—it's also in the poor quality of our heavily subsidized foods. Plants farmed conventionally depend on large doses of fertilizers, fungicides and herbicides, and are typically shipped hundreds of miles. By the time they hit the dinner table, they may contain only a fraction of the nutritional value of locally farmed or heritage plants (see chart, left).



Empty Calories. **Industrial farms tend to deliver vast quantities of low quality crops.**

Quantity vs. Quality

As we try to predict the future of food security, these issues make it clear that our current food system is unsustainable. It may be cheap and fast, but it's also out of control.

Although U.S. citizens, on average, spend only 10 to 12 percent of their income on food (compared with 40 or 50 percent in places such as the Middle East), the hidden costs are much higher. We're sick more often, and exposed to more pollution in our fresh water and in our food. We waste precious water on inefficient irrigation, and our health care costs are among the highest per capita in the world. The Office of Medicare & Medicaid Services predicts that healthcare costs in the U.S. will double by 2022. Yet we don't tend to live any longer than people in places who spend much less.

It's simply costing too much in resources and environmental

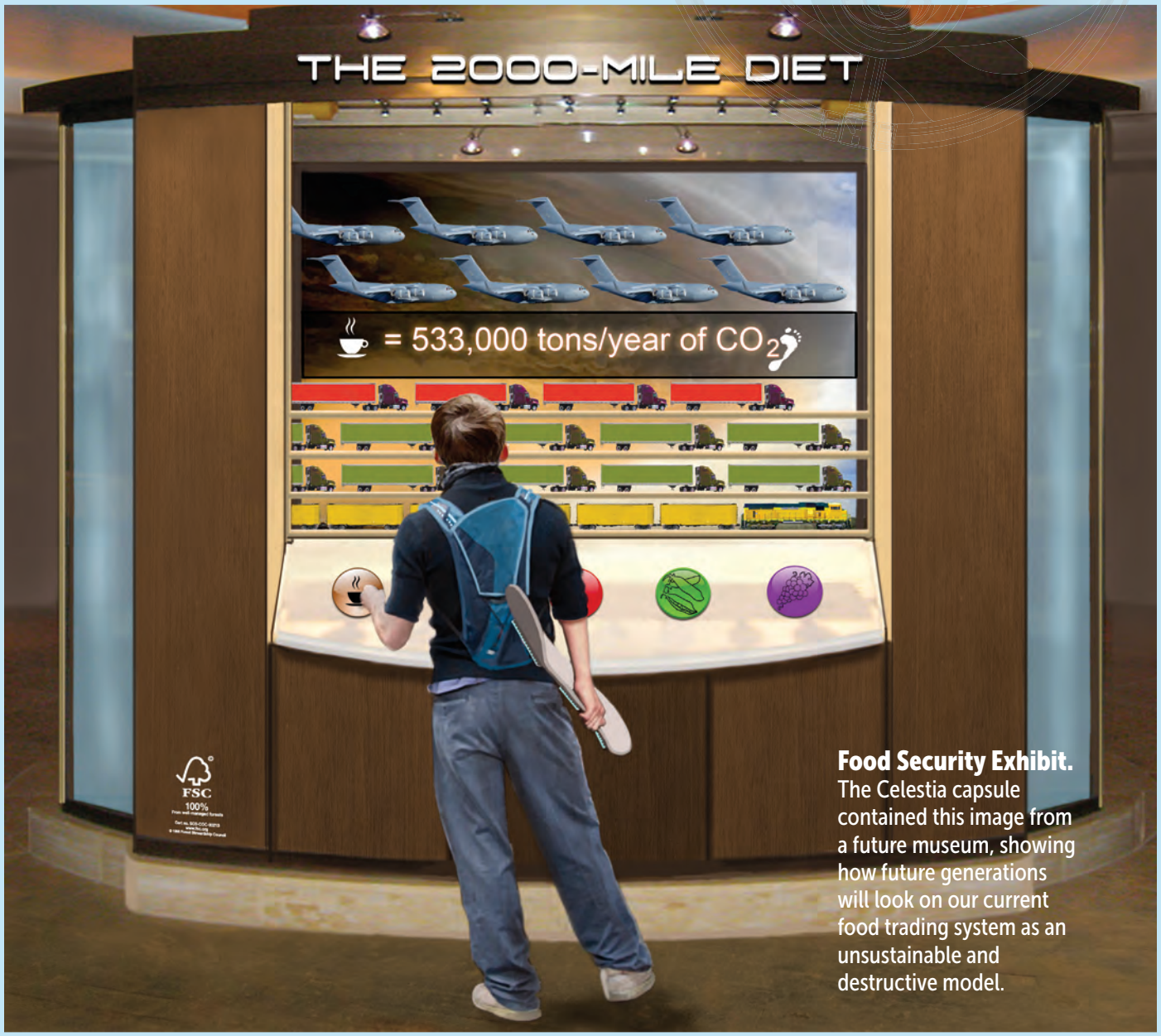
The End of Factory Farming

Like cracks in a dam, the negative aspects of factory farming could bring the whole poorly built structure tumbling down.

"There are more kilograms of antibiotics sold in the United States for food-producing animals than for people. This use contributes to the emergence of antibiotic-resistant bacteria in food-producing animals. Resistant bacteria can contaminate the foods that come from those animals, and people who consume these foods can develop antibiotic-resistant infections."
—Centers for Disease Control

"Consumers [want] to know where their food comes from. The symptoms are evident in increasing consumer interest in food that is organic, natural, sustainably produced, locally produced. [...] Since factory farming is positioned as antithetical to the things that reassure consumers about their food, this also provides insight into the effectiveness of the activists' campaign."
—National Cattlemen's Beef Association Survey

THE CELESTIA MUSEUM



Food Security Exhibit. The Celestia capsule contained this image from a future museum, showing how future generations will look on our current food trading system as an unsustainable and destructive model.

damage to maintain our current food system: transporting inferior foods vast distances, and shopping at gigantic retail outlets that constantly hammer prices down (resulting in lower quality produce). Wal-Mart, for example, now sells almost a third of the nation's food. When box stores and factory farms link arms to bring prices to their absolute rock bottom, you can bet that the real costs—to the environment and public health—are not being counted.

Factory farms seem to have a monolithic hold on the American diet. But the signs of structural stress are beginning to show. Our history includes a long list of "has-been" industries that seemed invulnerable before the sea of time swept them away or shrank their magnitude. Look at the railroad industry, the steel industry, the ship-building industry, and most recently, the nuclear power industry.

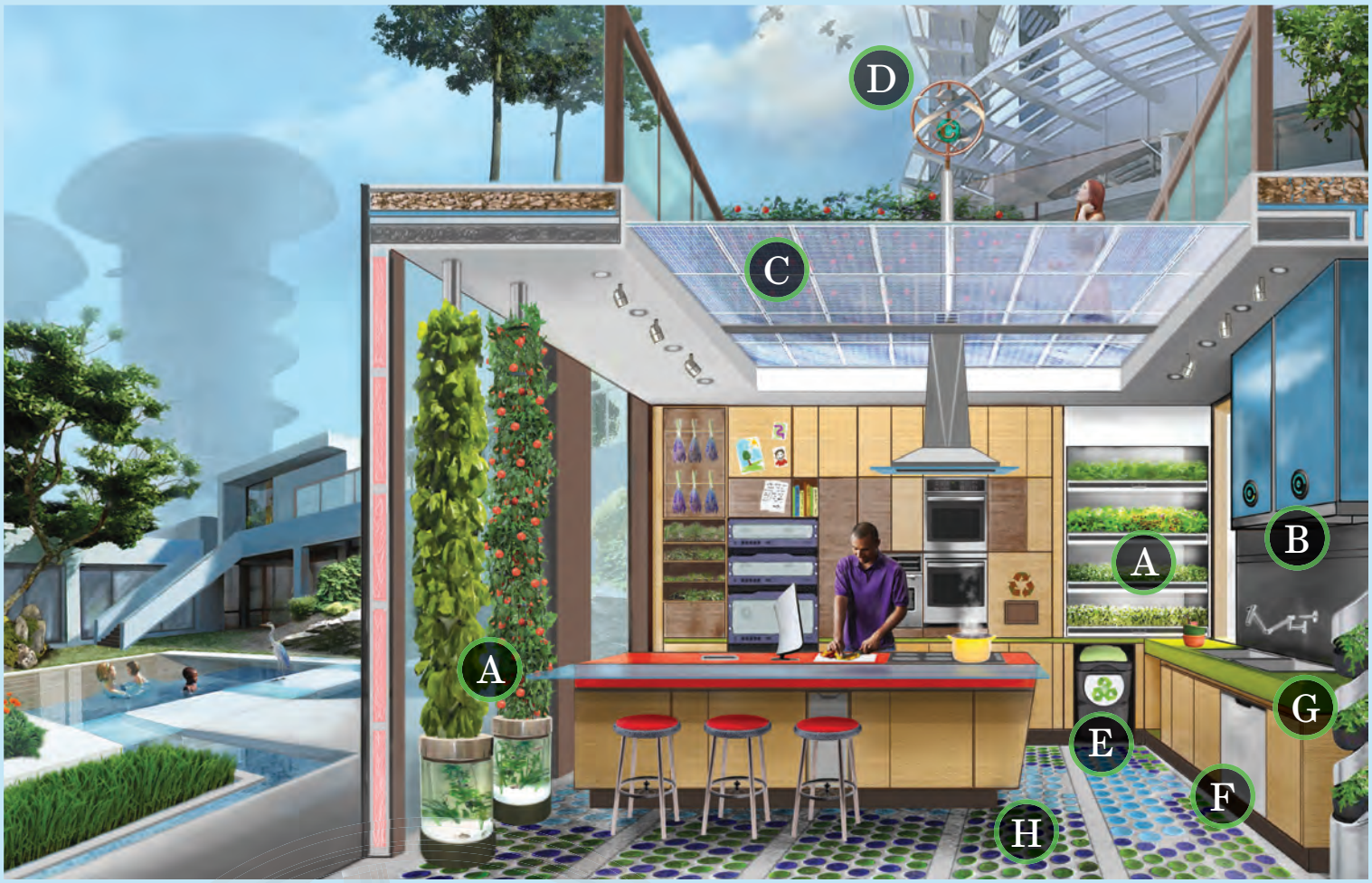
continued on page 21

What Makes A Food Crisis?

The causes of food crises, according to researcher Evan Fraser of the University of Guelph in Ontario, Canada, tend to center on three major factors:

- Excessive reliance on a single crop
- Citizenry that has no farming ability
- Political situations where the normal "safety net" for food fails

THE CELESTIA KITCHEN



Age of Excess. In the early 21st century, fruits traveled on average more than 2,000 miles before being consumed. Vegetables and greens were not far behind, especially in off-season months. As fuel prices rose and climate change awareness grew, however, local farms and nurseries filled the void. By 2100, only 2 percent of fresh foods consumed in the U.S. were grown more than two states away.

A: Food Is Abundant and Within Arm's Reach. Note the use of fish tanks to feed indoor plants, along with indoor growing stations powered by low energy LED lighting (running on stored solar power at night).

B: On-Demand Water. Collected rain supplies much of our drinking/dishwashing water. A small water storage tank with a digital meter contains potable, filtered water. Water-smart fixtures (Kohler *Karbon* served as our model) provide a durable, high-performance combination.

C: Translucent PV. Glass serves double duty, producing electricity as well as providing daylight.

D: Point-of-Use Power. Whenever possible, household devices power themselves. Note the addition of the tiny wind turbine above the vent fan.

E: Zero Waste. Scrap food is fed into an indoor composting station, recovered as a compost "tea" that can be added to roof gardens and hydroponic plants.

F: Super-Efficient Dishwasher. Stainless steel models (the Bosch *800* served as a template here) operate quietly, using very little water.

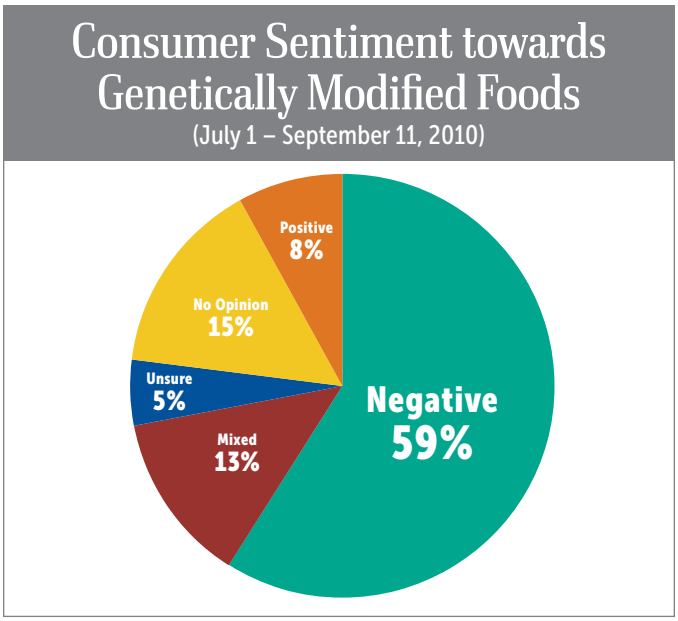
G: Recycled Countertops. Made from recycled materials, yet highly durable, countertops can be easily repaired or even resurfaced over the years (Caesarstone products provided modeling for these tops.).

H: Salvaged Materials. Flooring is made from discarded bottles. Bar stools consist of used bicycle parts.

"What we are seeing today is nothing less than the rapid-fire downsizing of nuclear power in the United States," notes economist Marc Cooper of the Vermont Law School's Institute for Energy and the Environment. "It is important to recognize that the tough times the U.S. nuclear power industry faces today are only going to get worse."

It's no secret that big biotech firms see our food future as one that is largely created in laboratories: Their ideal scenario, says Rifkin, would be to break all food material down into a bioengineered cellular paste that could then be manipulated to resemble foods we know. Kurzweil says that by 2049, we'll all be living on "nano-produced food" [made with tiny robots], which has the correct nutritional composition and the same taste and texture of organically produced food. Does that mean the kitchen of the future will contain just one primary appliance—a 3D printer—as IKEA (sidebar at right) has suggested? Consider the implications.

In this biotech dream scenario, any raw cellular material could be considered "food," making price the only differentiator. Food would truly become a commodity that could be produced in any country (lowest price wins, of course), barely regulated—and the consumer (a.k.a. *human being*) would never know the difference.



Tipping Point? **Globally, people are turning against GMOs.**

Decision Points

Set aside the "yuck factor" this is likely to stir in the average person. Will we embrace such technology, simply because the genie is out of the bottle? Is nano-engineered food "inevitable," as many futurists believe? Are stoves and refrigerators headed for extinction?

The late, brilliant George Basalla, who wrote *The Evolution of Technology*, would say "no." I spoke with him on a similar topic a few years ago. We discussed the reasons that some technologies become mainstream and others fade away. His lifelong research showed that the adoption of new technology is NOT inevitable

continued on page 23

IKEA Is Dead Wrong

The giant firm sees nothing but dollar signs in the commodifying of our food supply.

IKEA's prediction for the kitchen of the future reveals a lot about how multinational firms see the world. Apparently, IKEA believes that science will put an end to the inconsistency and unpredictability of small farms and local food production. Instead, the human race will begin eating "plant tissue culture" that is transformed into food using 3D printers in our own homes.

A breathless blog on *Inhabitat* shows how easy it is for companies such as IKEA to cast the spell of technotopian ideas: "IKEA's kitchen of the future contains some pretty incredible theoretical tech, but we're most excited about IKEA's vision for kitchen-based smart energy monitoring and 3D food printers—imagine how much energy you could save by ditching trips to the grocery store." Seriously?

Among the Swedish company's creepy predictions:

- **Paste Into Products.** We will "print" our food in layers (using genetically engineered cellular material) to create our meals.
- **Obi-Wan's Secret Recipes**. Hologrammatic celebrity chefs will help us cook our genetically modified "food." What will they be cooking exactly? Layers of cellular "paste"?
- **Oven Drones.** Now, you can cook your meal on your way home. But wait. Is anyone this organized? And would you want to leave something in the oven all day, awaiting your command? Maybe paste would not spoil.

The problem with a company such as IKEA making forecasts about food futures is that they are powerful—and widely seen as a "green" brand. But their primary motivator, it must be remembered, is to increase profits. And, as environmentalists point out, no matter how many LED lights they put in their stores, "the key issue with IKEA from an environmentalist's point of view is that the company encourages the mass-consumption of goods that generally need to be replaced after a few years, putting an increasing strain on the world's natural resources." (**theecologist.org**)

The Food Co-op Resurgence

FOOD CO-OPERATIVES—LOCAL GROCERIES OWNED and run by local employees—were a major force in American culture prior to being sidelined by World War II. In the Minneapolis region, for example, co-ops once accounted for 30 percent of food sales, according to *Food for Change*, a new documentary film. The rapid rise of industrialized farming, along with communist paranoia, drove co-ops out of business after the war, as bomb makers converted their factors into fertilizer and pesticide production—using hefty government subsidies to pay for advertising about the perils of profit sharing and collaboration.

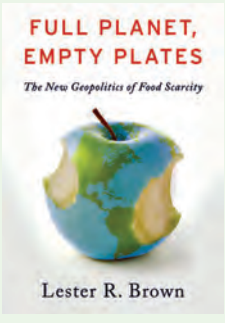
But now, co-ops are back, and they've become a symbol of resistance to the kind of food future biotech firms would like to see for us. While they still represent just half a percent of the nation's food retailing business, many co-ops report swelling memberships and sales growth of 10 percent or more each year.

Co-ops have a long list of sustainability advantages over big retailers. They support local agriculture, resulting in a reduced food transportation footprint, put money and jobs back into local economies, encourage organic farming methods and can provide food security to almost any demographic group.

Changing the Rules. **The Wedge food co-op in Minnesota did $49 million in retail sales in 2012, up 11 percent above 2011. They have about 16,000 members.**

Pre-Emptive Change
How to Avoid a Food Breakdown

We've featured and interviewed Lester Brown a few times in *Green Builder* magazine. An author and futurist, he recently set his sights on what many see as an approaching food crisis, as climate change throws production out of balance, and land becomes more scarce. In his new book, *Full Planet, Empty Plates*, he maps out three steps that need to be taken worldwide to prevent massive starvation and related strife in coming years. Read the book if you want to know more.

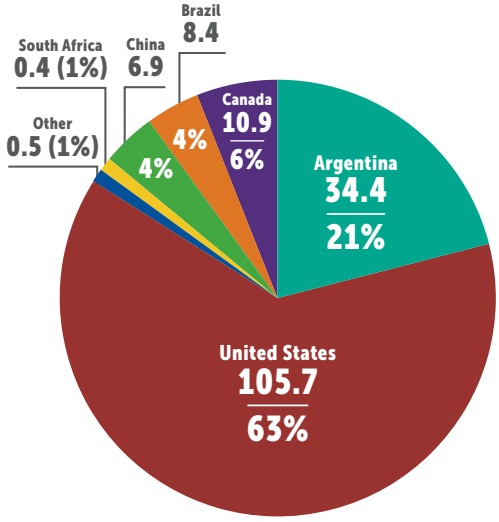


- **Stabilize World Population**. Family planning and reproductive health care have been shown to dramatically reduce runaway populations in poorly educated regions. Kids need to be encouraged to attend school, perhaps by offering school lunches in the poorest regions.
- **Reduce Animal Product Consumption.** Excessive consumption of meat, milk and eggs, Brown says, is contributing to heart disease and obesity. "Moving down the food chain also lessens pressure on Earth's land and water resources."
- **Cancel Biofuel Mandates.** "There is no social justification for the massive conversion of food into fuel for cars. With plug-in hybrids and all-electric cars coming to market that can run on local wind-generated electricity at a gasoline-equivalent cost of 80¢ per gallon, why keep burning costly fuel at four times the price?"

His supply side solutions include reducing carbon emissions to lessen the effects of climate change, removing subsidies to big oil, using fresh water more efficiently, and changing from agri-farms to "no-till" farming methods such as permaculture, which leave soil structure intact year after year.

The book is available for purchase here: http://astore.amazon.com/grebuimed-20/detail/0393344150

Total Acreage of GMO Crops



Blind Ambition? Even as Italy, France and Germany ban many genetically modified crops, the United States continues to flood markets with biotech foodstuffs.

Source: *Issues Surrounding Genetically Modified (GM) Products*, by Subhuti Dharmananda

simply because it exists, nor because it might be necessary for survival. Human beings tend to think more creatively than that. They crave diversity and novelty.

"The history of technology is not a record of artifacts fashioned to ensure our survival," he wrote. "Instead, it is a testimony to the fertility of the contriving mind, and to the multitudinous ways the people of the Earth have chosen to live. Seen in this light, artifactual diversity is one of the highest expressions of human existence."

What Nukes Can Teach Us

Back to the nuclear power industry. After the Chernobyl disaster, Germany's Green Party surged out of nowhere, making that country a solar powerhouse that has banned nukes. And Fukushima's ripple effect is now having a similar effect on the U.S. The nuclear power industry here is in a state of "near collapse," according to some experts.

What's the takeaway for the future of food? All it takes is one highly publicized "scare" to cause the public to do a complete about-face on technology. Will that event take the form of tainted meat from factory farms, or a deadly sickness that can't be cured with current antibiotics?

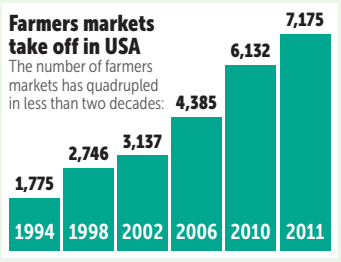
"The history of technology is not a record of artifacts fashioned to ensure our survival. Instead, it is a testimony to the fertility of the contriving mind, and to the multitudinous ways the people of the Earth have chosen to live."
—George Basalla

At present, most Americans are highly dependent on the factory farm system for their food. Even states once known for their farms are shadows of what they were. Farmland in the past 10 years in the U.S. has declined by 7.5 million acres. Soils are used more aggressively, ever more dependent on petroleum-based fertilizers, pesticides, fungicides and herbicides. With greater understanding of these "externalities," we believe, will come greater resistance to a factory farmed future. **GB**

Why Small Food Will Win

The Organic Consumers Association compiled this list of reasons why smaller and organic farms are superior to factory farms. We've condensed their list here:

- **Major Economic Potential.** Sustainable farming, once dismissed as the pastime of crackpots and idealists, has grown into a business worth some $7.3 billion a year in the European Union and around $15.6 billion worldwide.



- **Community Supported Agriculture**. CSAs connect local farmers with consumers; local farms grow food specifically for CSA members. In 1986, there were only two CSAs in the U.S. Now there are as many as 6,500 (according to thecalloftheland.wordpress.com).
- **Small Is Healthier.** Sixty percent of all U.S. farms include less than 180 acres. Responsible management of the natural resources of soil, water and wildlife produces significant environmental benefits for society.
- **More Profitability Per Acre.** The smallest U.S. farms, those of 27 acres or less, have more than 10 times greater dollar output per acre than larger farms.
- **Local Prosperity.** Where family farms predominate, there are more local businesses, better maintained streets and sidewalks, schools, parks, churches, clubs and newspapers, better services, higher employment and more civic participation.

In the United States, small farmers devote 17% of their area to woodlands, compared to only 5% on large farms. Small farms maintain nearly twice as much of their land in "soil improving uses," including cover crops and green manures.

Source: Organic Consumers Association

THE CELESTIA FORECAST

The future of food security in the U.S. will ultimately be decided by the public. To put it in Star Wars terms, if big agribusiness is the all-powerful empire, the rebel force is everybody else: permaculturists, farmers, state governments, millennials, foodies, parents, preppers and anyone who cares about their health, or the health of people they care about. We're betting on the rebels. If novelty and diversity are the cornerstones of innovation, in our view, high-tech approaches to our food futures won't go away. But instead of using them to create food, we will put them to work restoring the damage we've already done—making it possible to produce safe, healthy food. This future will be easier to achieve in the U.S. than in other, hard-pressed regions with depleted soils and fewer resources. Bio-tech firms will find willing buyers there. But freed from the anxieties of food insecurity, our example here in the U.S. ultimately will inspire other nations to seek more holistic solutions, and slowly, ever so slowly, the dream of abundance will become reality for all.

THE CELESTIA PROJECT

Equilibrium

"WELL, WE WENT BACK to visit the old neighborhood, and it just isn't the same. Hah, that's a laugh! You can't believe this was once suburbia. We found a family of opossums living in the old foundation. We saw quail, a Bicknell's thrush—even got a glimpse of an Eastern cougar. Not much manmade stuff left—just some patches of pavement here and there. Imagine! Five minutes by levi-tram from city center, and my granddaughter thinks this is normal."
—Josh DeSantos, Elder Transition Historian, 2087

Rapid industrialization, coupled with population growth and climate-change effects results in rapid extinction of thousands of species.

In response to activist pressure, homeowner groups begin to work with ecologists to redefine key landscaping guidelines to increase biodiversity in suburbia.

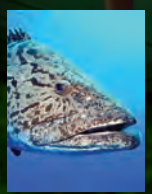
Cities emphasize walkable green lifestyles, attracting new residents with family-friendly lifestyles, farms and micro-wildlife habitats.

In-migration to cities leaves suburbs nearly abandoned. Biodiversity activists call for making all suburbs protected areas.

Farmers make a strong case for dividing suburban tracts into farms as well as habitats, as "re-greening" spreads outward from city hubs. A compromise is reached.

2014 2020 2030 2040 2050

In the cities, localized habitats become a matter of pride, as neighborhoods compete to create the most biodiversity. Cancer rates reach lowest rate since 1950.



Nearly extinct fish species return to oceans and lakes, as toxic plastics, metals and other compounds are removed by high-tech industries.

A global inventory of species is made possible with wearable mobile "life-taggers," which allow people everywhere to identify and record species—even tiny ones. Biodiversity is increasing annually by 2 percent

Bio-remediation of desertified regions begins in earnest, ushering in a return of some species not seen in these regions for centuries.

2060 2070 2080 2090 2100

SIMPLY INVOKING THE WORD "NATURE" can get you in trouble these days. Entire books have been written debating whether the concept of nature even exists any more. Bill McKibben's *The End of Nature* may have sparked the controversy 25 years ago, but the debate continues.

IN HIS BOOK *Living Through the End of Nature*, environmentalist Paul Wapner argues that with 7 billion people on the planet (and rising), our very concept of nature *must* change. "Nature is no longer an independent realm separate from human beings," he argues, "but instead part and parcel with the human world." To save what's left, instead of trying to protect other species from the impacts of humans, he says we need to "realize that environmental questions can no longer be framed as trade-offs as what is best for humanity or nature."

> **"My greatest concern is in the small creatures... that is where the bulk of life on Earth exists..."**
> **—E.O. Wilson**

Instead, he advocates a "middle path," a post-nature future "in which there is no such thing as either humans or nature, but a hybrid of the two." In other words, human needs and the needs of the rest of life on Earth must be thought of as one and the same.

To those who see no limits to growth, of course, the very idea of "saving" nature is absurd. If man is part of nature, then human dominance of the planet is a natural part of evolution. Things are exactly as they should be.

Why preserve or restore ecosystems at all? Can't we simply mechanize, industrialize and digitize our way to a prosperous future, with or without polar bears or spotted owls or Pacific salmon?

The answer is: No, we can't. And this is where science and human self-interest are stepping in, on the side of an issue that until now has often been advocated with appeals to ethics, empathy and emotion, as something separate from people. But we now know that with the death of every ecosystem, *tangible* assets disappear—and humans lose. These assets may include cures for cancer, or a way to control the spread of Lyme disease (read on), or beneficial insects that cause crops and fruit trees to flower, or oysters that remove heavy metals from our fresh water. The list goes on and on.

A Life and Death Lottery

Half the world's grasslands are gone. Half of its forests. We're losing thousands of species every year. Some biologists believe

Restoring Urban Habitats

How can landscape design help protect and even restore wildlife and plant species?

According to ecologists, construction and development on the urban fringe typically results in habitat "fragmentation," where the interdependency of species in a region is disrupted. It's possible to reduce or even reverse this impact with good planning. Research shows that open spaces set aside are not good enough to protect species diversity, unless they also include key "natural" features. Isolated tree stands, for example—cut off from "umbrella" ecosystems—suffer from extreme micro-climates, and tend to attract non-native predators such as cats, raccoons, crows and mice. The Oregon Dept. of Forestry suggests the following strategies:

Plant for Plenty. In a living ecosystem, almost every plant is a food source for one species or another. Arborists recommend including a diverse combination of plants (native as much as possible) along with fruit and nut trees to create abundance for both large and small wildlife in an area.

Delhi, India integrates "wildness."

Let Water Flow. Let gravity take its course. That's the best approach to stream "management," say the experts. Leave curves in streams alone. Often, life happens at different speeds, and rivers tend to be connected to larger ecosystems nearby. Plants and trees growing along the edge of streams and rivers—along with wetland plants—tend to be critical to the survival of a wide range of species.

Think in Three Dimensions. Each "tier" of plant life—ground cover, plants, shrubs and trees—provides a different sustaining level for life in an ecosystem. We should encourage forested areas and semi-forested "parks" to achieve a three-dimensional structure.

Trust in Deadfall. Entropy is part of a constant cycle in a real ecosystem. Leave dead plants, fallen trees, stumps and deadwood alone. A lot is happening in those damp and hidden zones.

Protected Corridors. Many types of wildlife, large and small, travel extensively in an area, especially birds. Provide pathways.

THE CELESTIA MUSEUM

The End of Excess: By about 2040, most of the so-called McMansions of the 21st century had been dismantled, their durable parts re-used in urban projects.

we've entered a new period of mass extinction. Extinctions happen naturally, but this one is different, they say: It is greatly amplified by human stress on ecosystems.

Lifeboat Earth is not sinking—yet—but it's clearly time to man the pumps, while we make the necessary course correction. In the short term, however, which species or ecosystems do we rescue? That's a question conservationists wrestle with every day. Some will live. Others will perish. The endangered species that the public knows best—polar bears, spotted leopards, pandas—are not necessarily the most important in the big picture. But they play an essential role psychologically, by triggering empathy.

That "biophilia" (instinctive bond) we have with other species is probably not the only conservation tool we should count on to preserve biodiversity. Studies show that people have widely different attitudes toward wild animals, for example. Their empathy is affected by past relationships with pets, how much the animal in question is suffering and the age and "cuteness" of the animal. Do we really want to hang the fate of the world's amphibians on how "cute" they are?

The problem, notes biologist E.O. Wilson, is that most of the species we're losing are not cuddly mammals. They're tiny worms, insects, arthropods and plants. They're not likely to trigger a "cuteness" reaction—or much reaction at all.

Apathy-Proof Conservation

Another way to conserve organisms and natural systems is to understand, plan, protect and restore habitats. Approaches to habitats tend to take one of two approaches: *landscape-specific design*, which creates ecosystems where species will naturally find homes there, or *organism-specific design*, designed around one important species. The idea is that if this "keystone" species thrives, many others will find balance.

Often, landscape architects try to incorporate a "natural" ecosystem into a region, but what about cases where humans displaced the natural balance hundreds, or even thousands of

continued on page 45

HAPPINESS:
Nature's Role in Our Health

Surveys of human happiness tend to ignore our relationship with climate, ecosystems and other species. Do these connections matter?

Woods Walk. Regular interaction with other species has been shown to have numerous beneficial impacts on both children and adults.

MANY TECHNOLOGY ENTHUSIASTS envision a future on Earth that is abundant for human beings. They point to greater overall "wealth" for humans, but they tend to measure that wealth in conveniences and material comforts and "time-saving choices." In the book, *Abundance*, for example, writer Peter Diamandis notes that life today is superior to the past, because "We have massively increased access to goods, services, transportation, information, education, medicines, means of communication, human rights, democratic institutions, durable shelter..."—and that tomorrow will hold more of the same.

While few would argue those points, what's missing from this book—and from most technotopian forecasts, is any acknowledgement of how the other millions of species on Earth will play into man's grand plan for the future. Don't we actually need biodiversity to stay sane and happy?

Author Richard Louv, who coined the term "Nature Deficit Disorder" says we do. In a recent essay, he pointed out several ways that nature is good for our psychological and physical health, including improving our psychological health, helping kids develop empathy, building stronger family and social bonds, and buffering us against the drastic changes that climate change may cause in our lives.

Test Tube Conservation
Saving DNA instead of habitats is a deeply flawed solution.

AT THE NEW ORLEANS AUDUBON ZOO, an experiment is underway. DNA samples from some of the world's most endangered species is being extracted and frozen. Some call it an act of conservation desperation. Others consider it a prudent move, a way to offer a last chance to animals on the brink of extinction.

Dr. Betsy Dresser, with the Audubon Nature Institute in New Orleans, says that in 50 years, scientists may be able to tap into this bank of DNA samples and resurrect species that can't be saved today.

Scientists have already dabbled with this idea. According to *Livescience.com*, "Biologists briefly brought the extinct Pyrenean ibex back to life in 2003, by creating a clone from a frozen tissue sample harvested before the goat's entire population vanished in 2000. The clone survived just seven minutes after birth, but it gave scientists hope that 'de-extinction' could become more than a pipe dream."

De-Extinction Dreams. Along with squirreling away DNA from endangered species, some people hope to bring back long-extinct species from the past.

Such a last-ditch solution to saving species offers the tempting promise of a business-as-usual approach to conservation. But the structural flaws (without discussing the ethical ones) in such an idea make it even more absurd. First, consider the tenure of the typical human-run facility. *Businessweek* **(http://tinyurl.com/c83ytcd)** found that even the world's best-known multinationals (are you listening, Wal-Mart?) have a life expectancy of only about 40 years. And the global average for most firms is much lower: closer to 12 years. Who's going to keep the power on? And thanks to the digitizing of information, attention spans are short, and getting shorter (eight seconds at last count—see my Editor's Note from the February 2014 issue). Governments change. Organizations come and go. Power outages happen.

years ago? Do these areas make good candidates for habitat restoration? These are complex questions, but ecologists are doing their best to come up with answers.

As a result, research on "what works" for habitats is becoming much more sophisticated, especially in highly populated urban areas. Until now, the typical development model for most urban areas has been a mathematical equation: Retain a certain percentage of open space, divert a certain volume of stormwater and make sure you leave room for parking.

"The issue of conservation is something that can unite humanity, if people know enough about it, to change the view that gross materialism and the search for wealth are not the only things in life."
—David Attenborough, from *Planet Earth, The Future* (BBC)

According to researcher Zhifang Wang at the University of Michigan, however, this model eradicates most biodiversity. "Urban ecosystems lack habitat patches," he writes. "Instead, they have abundant invasive and non-native species, as well as strong external control of natural succession."

This approach is changing, in part because architects and land planners in China, Brazil and elsewhere are showing that habitat planning can work. The U.S. is starting to catch on. According to Richard Conniff at *Environment360*, "The U.S. Forest Service, which once laughed off the idea that anything urban could be wild, now supports a growing urban forest program." Urban ecology and urban wildlife programs are also proliferating on university campuses.

Wilding Future Cities?

The key to future biodiversity, ironically, may be how we plan and adapt our cities. The World Health Organization predicts that by 2050, the number of people worldwide living in cities will almost double, "increasing from approximately 3.4 billion in 2009 to 6.4 billion in 2050." In coming issues, we'll talk about the need for human populations to migrate inward toward urban living, rather than outward into functioning ecosystems.

Will new generations squeeze out the last wild creatures in these new megacities? Not necessarily. Growing interest in urban ecology suggests just the opposite. It's highly likely we will bring the forests and fields to the city with us. This is something new, still an inexact science to be sure, but radically different from "business as usual."

Conniff points to research showing that 20 percent of the world's bird species are found in cities, and a study in the UK showing that community gardens greatly increased the number and variety of pollinating insects.

He adds that would-be urban ecologists also have powerful new digital tools at their disposal, such as *i-Tree,* from the U.S. Forest Service, which maps trees in urban area, and *eBird*, from Cornell, which keeps track of bird sightings from thousands of volunteer observers.

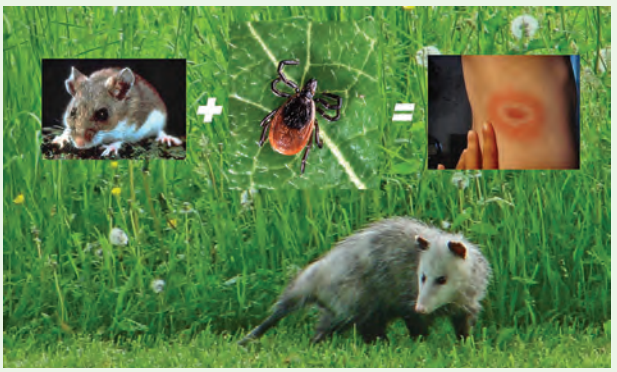
continued on page 46

Why Biodiversity Matters

Even if you never set foot on a hiking trail, here's why saving other species is in your best interest.

THE RARE PLANT YOU PROTECT today might cure your kid's cancer tomorrow. That's the underlying point made by Greg Yarrow, professor of wildlife ecology at Clemson University. Here are some reasons he says we should all care about conservation.

"Every species is an encyclopedia of genetic information, a reservoir of biologically active compounds," Yarrow writes. "If we consider that the lowliest bacterium may have 1,000 genes, and that many flowering plants and some animals have 400,000 genes, every species is a hidden treasure chest of information that may be important to humans. So far, we have barely begun to unlock the potential benefits of the world's plants and animals."



Lyme Disease Forensics. Loss of opossum populations has allowed mice that attract ticks to thrive, greatly increasing human cases of Lyme.

In addition, recent research at Bard College in Annandale-on-Hudson, New York, identified a connection between loss of species biodiversity and human health. "The work reveals a critical connection between conservation and disease," according to analysis by *Science Daily.* "Species losses in ecosystems such as forests and fields result in increases in pathogens—disease-causing organisms."

As an example, the study cites the proliferation of Lyme disease, a devastating health problem in the Northeast—as I can attest first hand, having watched several friends go through crippling bouts. The scientists found that as forests become fragmented, opossums die. This in turn causes the white-footed mice population to soar (opossums eat them). The mice carry Lyme disease, and also tend to attract black-legged ticks that acquire the pathogen—and pass it on to humans.

NATIONAL CENTER FOR ECOLOGICAL ANALYSIS AND SYNTHESIS

Suburban Greening. Changing the rules about landscaping in suburbs could vastly increase biodiversity.

Madhusudan Katti, associate professor at California State University, notes that cities worldwide tend to have one-third less plant and bird diversity than the regions surrounding them, but "the overall picture is not bleak. Cities can provides new habitats and niches that may be quite different from those in natural ecosystems, but still can support a variety of species. Species that evolve under such urban conditions may well represent what the future holds for much of Earth's biodiversity."

Suburbia's Transitional Role

Although migration to denser cities may be desirable, and even inevitable, for survival of life on Earth, in the meantime, we live in a nation of suburbs. The good news is these communities tend to have a lot of room for ecological improvement, in the form of lawns, back yards, parks and sporting fields. Here's where one of the most vilified private organizations in American society can help: homeowner associations (HOAs). A recent study in *Ecology* **(http://tinyurl.com/maxb4ul)** found that homeowner associations could be a powerful force for adding biodiversity to the 'burbs.

Cute Killers. Looking for an easy way to preserve bird species? Neuter your cat.

A study by the U.S. Fish and Wildlife Service found that domestic cats kill as many as 3.7 billion birds. A large part of the problem are so-called "unowned" cats. As many as 84 million of these cats are thought to roam the U.S. For cat owners, the fix may be easier: adding a bell to a collar, or keeping the cat indoors.

UNEXPECTED GUESTS

JOEL RHYMER, NEW HAMPSHIRE FISH AND GAME

As their natural habitats become polluted by light, noise, chemicals or automobiles, wild species are increasingly finding their way to populated areas. Among them, black bears like this one, attracted by a bird feeder in New Hampshire.

"Virtually all new developments in the United States use HOAs due to local zoning codes," the study notes. "The HOA developments range in size from small clusters of two or more houses to large, city-scale developments."

Because most developers tend to walk away from projects and hand over the keys to HOAs, these organizations wield significant clout. They decide what happens to and around the properties *in perpetuity*. Even small changes in HOA rules matter, when it comes to ecosystems, and HOAs have a lot to say about landscaping. This power can be used for either good or ill with regard to species diversity.

On the "ill" side are measures such as "rapid localized landscaping" (pruning plants, removing certain weeds, maintenance of certain lawn aesthetics and so on). These measures limit the potential for wildlife diversity.

On the other side, an HOA with progressive policies can "promote multiple habitat patches and zones throughout a neighborhood, and assign management regimes appropriate for different species composition." In layman's terms, they can allow wild plants to flourish, restrict the use of toxic herbicides and limit aggressive landscaping, thereby becoming stewards of biodiversity.

Squirrels Yes, Moose No

Of course, not all types of species will get a warm welcome in either the 'burbs or cities. Large mammals, especially predators such as grizzlies, wolves, and some large cats are out, as are alligators and poisonous snakes. But even foxes and moose sometimes trigger "biophobia" (fear factor) in us. They get a cold welcome.

For example, a few summers ago, a male moose wandered into my suburban neighborhood (I've since moved downtown) in Portland, Maine, heading for the inland bay on Portland's West Side. As a mixed crowd of kids, retirees and Boomer parents gathered on the shore, a local cop walked up to the moose, shot and killed it at point-blank range. He defended the choice, saying the moose posed a threat to public safety. Not everyone agreed, and the moose had little say in the matter.

EVERYWHEREONCE.COM

Wild Bison. **At Paynes Prairie Preserve State Park in Florida, hundreds of species co-exist, not far from human settlements.**

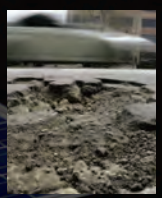
Big animals often need large stomping grounds. They like to wander. And human development is breaking up their old habitats. Certain scavenger creatures, such as squirrels, raccoons, mice, rats, skunks, crows and pigeons, can adapt to more urban environments. But the rest require more isolated and specific types of habitats. This could mean retraining future generations to respect large animals, rather than regarding them as man-eating stalkers.

Creating barriers between living areas and habitats is a well-established science. In Micanopy, Florida, for example, the 22,000-acre Paynes Prairie Preserve State Park supports wild horses, 10-foot-long alligators, barred owls, gopher tortoises and more recently, a herd of bison, encompassing almost 300 ecosystems. And to my knowledge, no one living nearby has yet been eaten by an alligator or trampled by a bison.

On the edge: That's a good term to remember. The challenge for the next century is to make sure that "the edge" of human settlement is established and recognized around urban areas. As permaculturists often point out, it's along the edges where life happens. **GB**

THE CELESTIA FORECAST

While traditional methods of conservation are both essential and valuable for the short term, the long-term solution to species extinction will be systemic. As stewards of planetary diversity, building experts, landscape architects and ecologists will join forces, creating habitats of "controlled chaos" that mimic natural ecosystems. They will think more like landlords, and less like firefighters. Instead of trying to save the occupants in each burning building, they will overhaul the whole block. They will integrate habitats with human shelter in ways that enrich people's lives, yet protect vulnerable creatures from unwelcome intrusion. By making room for the rest of Earth's bountiful diversity, they will ensure that human beings fulfill the promise of their special place in the natural order.



Crumbling infrastructure of U.S. suburbs marks beginning of the end for picket fence dreams.

2014

Council of mayors convenes to produce manifesto for livable cities across all income brackets.

2020

Renewable energy powers over half of all vehicles. Super-train between NYC and Chicago ushers in high-speed, net-zero intercity travel.

2030

Exodus from decaying suburbs accelerates, as federal and state subsidies dry up. Residents cannot maintain roads, waterways or utilities.

2040

Refined nanotechnology enables harvesting of ocean plastic waste—put to use in recyclable road and rail line construction.

2050

2

THE CELESTIA PROJECT

Congregation

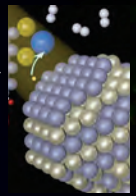
"CASSI AND I KNEW ONE ANOTHER for a year before anything romantic came up. I barely spoke English! She was living on the deck below me. But you know how these things go. We shared garden tips over the rail, talked about books and birds and our children. They're all grown now, but it's easy to visit them by tram. Before long, she invited me for a little car-share trip to an orchard on the fringe. We came back and made cider. Now we're partners, exploring everything the city has to offer. It's a good life."
—Elaine Zhao, VR engineer, New Chicago, 2093

Massive urbanization projects underway in 120 U.S. cities produce a record 150,000 units of new compact, market-rate rentals per month.

As robotic construction technology and communication converge, costs of construction and rentals drop.

Global leaders relax immigration policies as cities and digital technology converge. A true "global village" begins to take shape.

More than 80 percent of Americans now work at home or in their building of residence. About 70 percent walk every day.



Breakthroughs in materials, physics and computing promise radical changes in vehicles, buildings and entertainment.

2060 2070 2080 2090 2100

THE FUTURE LIES IN CITIES. **Not the future for the poor, or the rich, the Chinese or the Brazilians or Japanese—the future for all of us. The more you understand the increasingly dire state of the world's ecosystems, and the relentless upward curve of population growth, the clearer it becomes that moving in—densification, the opposite of what we've done for the last 50 years—is the best option left, and the one that might save us from ourselves.**

CITES DON'T ASK you to change how you see the world. To live in a city, you don't have to become a nature lover or activist, cut your consumption of plastic junk from Wal-Mart, create less waste, have fewer children, or eat less meat. But chances are, the cities themselves will transform you.

That's because the greenest places to live in the world are extremely dense cities, such as Vancouver and New York City. As author David Owen (*Green Metropolis*) points out, however, it's not that the people living there are inherently greener—it's because *density is its own reward*. When you live in stacked apartments, each unit below heats part of the unit above. When your space is smaller, you collect less furniture and "stuff" to fill the void. And perhaps most importantly, when you're close to stores, schools, restaurants and hair salons, you tend to drive less and walk more. Put simply, you use less of everything.

Our views about eco-friendly development patterns (my own included) have become outdated and now appear completely upside down. In advocating single-family housing—in the 'burbs or rural countryside—albeit net-zero or better, we may be handing out fluorescent light bulbs on the deck of the Titanic. With the population headed for more than 9 billion by 2050, the stress on biodiversity, climate change and resource shifts will make such lifestyle choices increasingly difficult to rationalize.

Yet in the U.S. especially, where resource use per person dwarfs that of most of the rest of the world, urging people to reduce consumption is heresy. The party continues, despite ever more dire warnings about climate change, drought, the percolating dangers of global inequality and so on.

Here's where cities come in. They offer a choice that is *by design* more sustainable than the suburban narrative of the 1950s that still dominates U.S. policy and planning. People in cities consume less, because of where and how they live, not because they occupy the moral high ground.

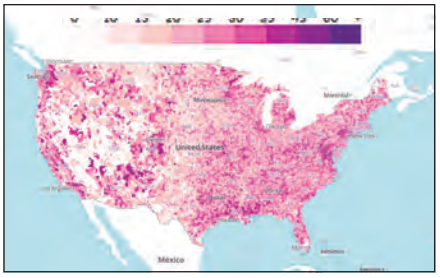
How Much Less? Researchers have put some figures on the consumption impact of urban living. The starting point is usually density. Owen notes that residents of New York, living at a density of 26,403 people per square mile, have rates of Co_2 emission (per capita) that are 71 percent lower than the national average. But current zoning laws in most of the U.S. actually preclude the kind of mixed-use zoning found in New York. This is a problem. Without such high-density "congregation," population growth will be increasingly burdensome. If the residents of New York City spread out the way people in Vermont do, Owen notes, every acre of land in the northern six states would be part of a gigantic suburb.

THE 16-MINUTE RULE

For commuting to and from work, special limits apply.

A study (**http://tinyurl.com/kgy86ql**) by the UK's Office of National Statistics recently put commuting to work in a new light. What it found is that virtually any type of commuting—including bicycles and walking—makes people less happy. They would rather work at home.

Research by Patricia Mokhtarian (**http://tinyurl.com/mx9hsmw**) reinforces the idea that the destination of travel affects how people feel about it. And when it comes to mobility, feelings dictate behavior. Mokhtarian found that for people in the San Francisco area, 16 minutes is the magic number. That's the length of time people are willing to spend commuting between work and home. After that period, unhappiness increases steadily. Sixteen minutes apparently plays out psychologically like a heroic journey. Drivers feel pleased that they have endured the stress and mental demands of driving for that time, so that they can feel the satisfaction of making it home. The average commute time for most Americans, however, is closer to 40 minutes.



CREDIT: PROJECT.WNYC.ORG

American Gridlock. **Darker areas indicate longer commute times.**

What Makes Cities Work?

- Smaller plazas with green spaces.
- Views of nature.
- No cul-de-sacs or dead ends (these thwart walking and bikes).
- Grid-style street patterns.
- Short blocks (to encourage walking).
- Healthy indoor environment. One study found that mold indoors impacted happiness more than dog excrement on the sidewalk or street conditions.
- Multi-mode transit options.
- Equal transit access for all.

Back to the Drawing Board

If you've ever wondered why we built cities that scared people into the 'burbs, take a look at how visionaries past and present have misread what really makes people happy.

CREDIT: COMPUTERHISTORY.ORG

Highway World. This exhibit from the 1939 World'S Fair showed how industrialists imagined the world would look by 1960.

CREDIT: TUMBLR.COM

New Paris. Le Corbusier's *Plan Voisin* for Paris envisioned a major overhaul. He thought all architecture should be stripped down to its bare utility.

CREDIT: WIKIMEDIA.ORG

Ghost Community. A Chinese developer built this satellite city in Africa. According to Uncubed, the buildings, located 30 miles from Luanda, Angola's capital, include 500,000 units of housing, but occupants "have yet to appear." Even with government subsidies, the model has attracted few people.

The Happiness Agenda

To accelerate the in-migration to cities, we first must make them incredible places to live for all ages, all income levels, all cultural backgrounds. That's not as daunting a task as it sounds. We have decades of research about what works, and what doesn't.

The biggest hurdle to making cities great places to live, says author Charles Montgomery (*Happy City*) is balancing two human needs: proximity and isolation. "In some ways, our needs are at war with each other," he says. "We need the nourishing, helping warmth of other people, but we also need the healing touch of nature. We need to connect, but we also need to retreat."

Also, there are the lingering negative stereotypes that cities carry for many Americans, including traffic gridlock, high crime rates, pollution, lack of privacy and separation from nature. But as Owen and other urban evangelists explain it, almost all of these stereotypes have, in the modern city, become far less significant. In fact, many of the drawbacks attached to cities should really be applied to suburbs.

For example, the chance of being killed in the 'burbs is far higher than in the city, due to speeding automobiles. And people generally get a lot more exercise in cities than out on the fringe because they walk more. That sounds like a small thing, but studies have found that people in the 'burbs tend to weigh, on average, 10 pounds more than urbanites. City folk generally live healthier, longer lives, while demanding less of the Earth.

But the research on what makes "happy" cities all points to one main perk: social connectivity. As Montgomery notes, this is where cities really shine, because we live in an age of increasing isolation. Surveys show that most of us can name only one or two people with whom we can confide closely. Just 30 years ago, people had three or four such close connections, and before that, deeper community involvement and a social network far more personal than any number of Facebook friends.

But *Happy City* makes an important and ultimately optimistic point. We didn't reach this level of isolation and anti-urban bias by accident. It was *designed* into the infrastructure of our lives, in the form of ever-widening suburban living arrangements. It was based on ideas—put forth by iconic visionaries such as Frank Lloyd Wright and Henry Ford, who could hardly have foreseen a world of 9 billion people dispersed across the planet's land mass. But if those ideas changed the world in a few short decades, why can't new ideas change it again—for the better?

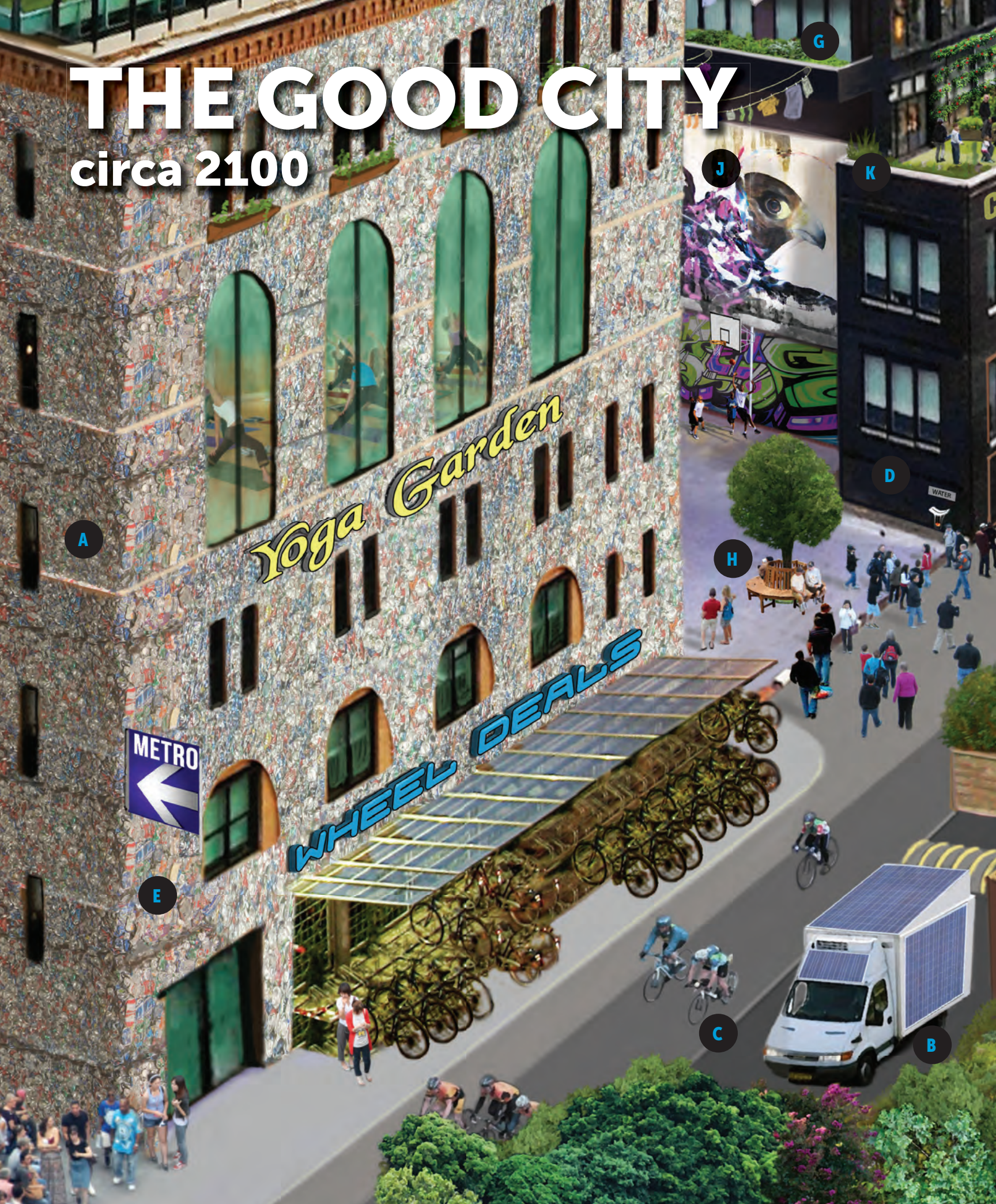
What Works?

So what makes a good city? If we expect people to want to move closer—to accept and embrace urban lifestyles, Montgomery says, we have to recognize that there's an underlying push and pull that has to be addressed.

Architects of the past—from Frank Lloyd Wright to Le Corbusier—created radically different ideas of what a utopian city should look like. But the age of the lone genius has given way to an era of research and social inquiry. Wright was fully invested in the idea of spreading out as the path to healthy lifestyles.

The idea of isolated vertical living, for example, as important

continued on page 44


THE GOOD CITY
circa 2100
Yoga Garden
WHEEL DEALS
METRO
WATER
A
B
C
D
E
G
H
J
K


F
I
L
CELESTIA CO-OP
Safari Club

KEYS TO THE CITY:

IF YOU'RE THINKING that the city of the future looks a lot like the city of a century ago, you're right on target. Picture dense cities like Manhattan, with its grid streets, compact design and sense of controlled chaos.

A. RECYCLED "BALES." Many buildings are constructed with "bales" of recycled aluminum cans and other products, held together with a polymer resin reclaimed from plastic debris scourged from the world's oceans. The polymer creates a thermal break that makes the bales super-insulating.

B. SLOW BUT ACCESSIBLE. Streets are wide enough to accommodate small trucks as well as bicycle traffic. Recyclable speed bumps made from tire rubber slow vehicle momentum.

C. BIKE-SPECIFIC LANES. To make bicyclists feel safer, raised curbs between bike lanes and streets add a buffer.

D. MIXED-USE STREETSCAPES. Storefronts, exercise areas and studios co-exist with ample and affordable housing. Rentals are flexible and diverse in layout, ranging from condo-type purchases to long-term leasing.

E. EASY TRANSIT ACCESS. Multi-modal transit, including subways, buses and new technologies such as pneumatic tubes enable the dense city center to expand into a "megacity," without leaving residents feeling trapped.

F. SOLAR ELEVATORS. Vertical lift is one of the most energy-efficient forms of transportation, so fast, efficient elevators will play an important role as cities condense. With careful siting and dynamic glass, they can also serve as passive solar heating.

G. ROOM TO GROW. Codes require all apartments to incorporate viable space for home gardening, such as these small terraces irrigated with graywater from each unit. Small wind turbines and solar panels power LED lighting.

H. PLEASE LOITER. Benches and "encounter-friendly" street design encourage community conversations.

I. SOLAR SMART. Integrated solar panels throughout the city power vehicles, lighting and other infrastructure.

J. LOW-TECH SAVINGS. Easy-access clothes-drying lines save energy and connect residents.

K. SHARED SUNLIGHT. Staggered building designs optimize solar orientation and protect views of greenspaces, at the same time creating many more opportunities for roof gardens.

L. NATURAL EDUCATION. To keep young people (who are far more invested in video games and electronic devices than in camping) connected with other species, community centers show holographic films about wild animals and locations.

continued from page 41

as that is to achieving the necessary density to support transit and other urban features, holds little appeal for many people. It's simply trading one form of isolation—automobile-dependent subdivisions in sprawling suburbs—with neighbors who never see each other, locked away in high-rise apartments.

But even that problem is one that can be improved with good design. For example, one successful way to add density is to create "staggered" elevations. This technique not only allows more sunlight into more units, but opens up outdoor living areas and connects units above and below (wave to the people on the patio).

The psychological nuances that breathe life into a city are often surprising. In Vancouver, for example, the importance of the "view" can't be overstated, and planners have gone to great lengths to adjust building profiles and heights to protect that view.

On the other hand, urban engineering that is based on assumptions—not research—can backfire. In Toronto, for example, the new mayor removed some bike lanes from a major street to make commuting easier for cars. But the number of vehicles commuting remained about the same, and collisions between vehicles on the road rose significantly.

Transit: Multiple Choice

Attempts to radically change transit to one mode above all others have notoriously created unforeseen problems. The auto-dependent vision of the 1939 World's Fair, for example, is still widely emulated today. It emphasized high-speed auto thruways surrounded by towering buildings. But those wide streets proved dangerous, and nearly impassable. There's a great scene in the movie *Bowfinger*, where Eddie Murphy tries to cross one of these modern freeways, at hilarious peril to his life.

But as researchers point out, all predictions about future cities that rely on narrow modes of transport—be they underground pneumatic tubes or flying cars—tend to miss the point. The reality is that people want a wide variety of options, based on their lifestyle, age, cultural views and whims. And the basic modes of getting around don't tend to change much over time. In 100 years, we may still be using some variation of buses, trains, bikes or cars to supplement walking.

Montgomery cites the work of transportation guru Eric Britton, who has studied virtually every angle of how and why people get around. Britton realized by the early 1970s that the key to happy urban residents is something called *new mobility*. New mobility differs from old mobility in that instead of offering one or two solutions (drive to work or take the subway), people can ride a bike, walk, take a bus, or maybe ride in an automated taxi. It's about freedom.

One of Britton's successful activations of that idea was convincing the city of Paris to offer residents a "magic card" that would allow residents to use ANY form of transit with one easy pass. Bus ridership increased by 40 percent the first year the card was issued. "Gradually,

Hands-Free Future?

Will drivers give up the perceived "freedom" of the open road for semi-automated, self-steering vehicles? That depends which drivers you're talking about. While Baby Boomers might resist the idea, they're rapidly graying—and research shows that about half of the generation now coming of driving age would rather spend time online than driving. Perhaps they will jump at the opportunity to simply get in and tell a vehicle where to go—allowing them to continue their mobile social chatting, gaming and video watching. Also, such vehicles will allow elderly citizens to continue "driving" despite failing health or poor eyesight.

Transit Killer?

We've all seen the new *Smart Fortwo* personal vehicles in U.S. cities—more popular every day. But as is so often the case, Owen points out, we have to look at the bigger picture. When urbanites see these vehicles, they see a vehicle that could solve the problem of city parking. But if they normally use transit, they help create the critical mass that makes mass transit efficient. As a personal automobile owner, they've actually become a bigger environmental drain.

Transit Density Requirements

Deep and Wide. Note that for trains to thrive, these are minimum densities, and some are spread over many acres. More density per acre is better. And for best results, transit must be accessible and affordable to young, elderly and poor patrons.

Mode	Service Type	Minimum Density (Dwelling Units Per Acre)	Area and Location
Dial-a-Bus	On-demand response serving general public (not just people with disabilities)	3.5 to 6	Community-wide
"Minimum" Local Bus	1/2-mile route spacing, 20 buses per day	4	Neighborhood
"Intermediate" Local Bus	1/2-mile route spacing, 40 buses per day	7	Neighborhood
"Frequent" Local Bus	1/2-mile route spacing, 120 buses per day	15	Neighborhood
Express Bus – Foot access	Five buses during two-hour peak period	15	Average density over 20-square-mile area, within 10 to 15 miles of a large downtown
Express Bus – Auto access	Five to 10 buses during two-hour peak period	15	Average density over 20-square-mile tributary area, within 10 to 15 miles of a large downtown
Light Rail	Five-minute headways or better during peak hour	9	Within walking distance of transit line, serving large downtown
Rapid Transit	Five-minute headways or better during peak hour	12	Within walking distance of transit stations serving large downtown
Commuter Rail	20 trains a day	1 to 2	Serving very large downtown

SOURCE: PUSHKAREV AND ZUPAN (1977)

the card underwent a series of dynamic upgrades," Montgomery notes, "evolving by 2008 into the Navigo pass, a chip-embedded ID card. With a wave of your Navigo card over an electronic reader, you can ride any metro, bus, airport shuttle, regional train, express train or tram in the city."

More is better—which may explain why New York City, at 26,400 people per square mile, has a packed transit system.

Nature: Just Enough

We're all familiar with the term "concrete jungle." Architects have long recognized that cities need green space to improve livability. But the science of city greening has become far more sophisticated, and what sociologists tell us is quite shocking. Surprisingly little may be enough to fulfill our need for contact with nature. We don't necessarily need eco-tourism trips to the jungles of Peru to retain our mental health. In fact, even a photo of nature helps.

As Montgomery discovered in his research, the performance and satisfaction of prison guards in one study improved dramatically when a nature mural was hung in their workplace. Patients have said they experience less pain if they have a nature scene to look at, and visitors passing a brick wall with vines growing up its side reported feeling happier because of it.

Anecdotes like these provide hints for urban planners and developers. People need to encounter nature at regular intervals, as they walk through a city. Urban life is stimulating—and we need stimulation, but we also need nature to break us out of that aroused state and allow our brains to recharge. In other words, our "natural" state as human beings is to strike a balance between arousal and relaxation.

That's why creating giant centralized parks is not always the best green choice for a city. Large green spaces such as Central Park in New York can actually go awry, because they create artificial borders between residents. Citing *The Death and Life of Great American Cities* by Jane Jacobs, Owen notes that "large urban parks, including Central Park, have many of the same drawbacks that sprawling suburbs do: they

continued on page 46

THE CELESTIA FORECAST

Transportation's Slow Mode. The best guess for future transportation is multi-modal. City residents will have little need for high speed travel. All amenities will be within easy walking, bike or transit distance. They can choose from a palette of affordable and easy-access options. A variety of incentives will reward walkers and bikers: lower insurance costs and discounts at stores and restaurants, even clothing stores.

Satellite Cities and Farms. Automobiles will remain a transport mode of choice for short-hop journeys and excursions to small towns, satellite cities and farm areas. Drivers may choose driverless options, traveling on roads made from recycled plastics and rubber (from tires) left in ample supply by former inhabitants. Roads will be narrow and some will allow for one-way traffic only at various times of day, creating purposeful obstacles that encourage planning and discourage unnecessary trips.

Intercity Travel. For travel to distant large cities, wilderness destinations or distant relatives, high-speed trains will operate on zero-friction tracks, but citizens will need to plan ahead, as these will run less frequently—but more efficiently—than today's rail lines.

Freight Shipping. Heavy shipping also will change dramatically. Barring the longshot of mankind mastering fusion-powered mechanics, dirty diesel freight will be replaced by super-efficient wind-powered transports made with lightweight, recycled composites.

Air Travel. The devastating impact of jetliners on the atmosphere will make fossil-fuel-powered jetliners a costly and highly regulated form of travel, available only to illegal drug smugglers and the military. In their place will be a wide variety of slower, self-powered flying machines, including composite planes and dirigibles, covered with flexible solar cells that self-repair with nanotechnology. Jules Verne may have been right, after all.

Cities. Urban centers of tomorrow will look a lot like the best cities of today, and less like the highway-dependent fantasies of Le Corbusier.

Bicycles: The Fear Factor

Just creating bike paths is not enough to increase ridership. You need to understand what keeps would-be bikers at bay.

SHAREABLE BIKES SEEM to have popped up almost overnight in U.S. cities, and shareable cars may not be far behind. Transportation guru Eric Britton calls bicycles "the ultimate metro," because they allow users to travel in urban areas at a reasonable speeds in all different directions without any wait time.

CREDIT: BLOGSPOT.COM

Research shows, however, that the reason more people in the U.S. don't bike isn't laziness. It's fear. A study by Robert Geller in Portland, Oregon, discovered that only 12 percent of people are daring and fit enough to get on a bike and engage with auto traffic, the way most cities insist they must—although fully 60 percent like the idea of biking. At Portland State University, researcher Jennifer Dill found similar results—adding that women are far less likely to risk pedaling in heavy traffic than men. They simply don't feel safe.

Montgomery blames early bike enthusiasts for insisting that bikes be treated like automobiles. The courage to pull into a turning lane in front of a car terrifies most would-be bikers.

They're not completely irrational. One study found that when people wear bike helmets, drivers consider them armored, passing far closer to them than they will if the rider is unhelmeted.

The solutions (also tested with research) are straightforward: Either slow traffic to the point where bikers feel safe, or separate bikeways from street traffic, with raised curbs, planters or even parked cars. This limits the freedom of bikers somewhat, but tends to greatly increase ridership.

continued from page 45

insert so much space between individuals and uses that they actually inhibit many of the activities they are intended to encourage."

Montgomery elaborates on the Central Park example. He says the park is not the problem. The problem is that it's not integrated into the daily life of residents. It's a separate place they may not visit or see for days at a time.

One thing every developer understands gets a major thumbs-up from researchers: the "view." People need to *see* natural landscapes. Just seeing the ocean, mountains and forests is good for the psyche. One way to approach that in a dense, vertical city: designing staggered buildings (as noted above) and the careful use of glass, protecting important views. Vancouver has mastered this approach, if you're looking for an example.

Humans have shown an affinity for views that include open grasslands and sparse tree cover (the suburban home with a big lawn is a microcosm of this idea) but what we think we want isn't actually what we "need" to create positive physiological effects in our bodies. Instead, our minds crave "biological complexity,"—a wide range of plant species, colors, heights and settings—not manicured parks. **GB**

IMAGE: WIKIMEDIA COMMONS

One of the world's most successful urban greening remodeling projects, the Cheonggyecheon public recreation space, was created by removing freeways above a drainage canal in Seoul, South Korea. Residents now flock to the area to recharge and renew.

URBAN GREENSCAPE **RULES OF THUMB**

Break It Up. Rather than one megapark, cities should include regularly spaced medium-sized parks and "pocket parks" that integrate with neighborhoods—inviting foot traffic.

Green "Strips." Even smaller green oases are essential to human ecology. Small areas of green at regular intervals improve general well being. These can include container plants, vertical wall climbers—any living green is good green.

Community Gardens. All residences should have local gardens within easy walking distance.

Equal Opportunity Vistas. Just seeing nature out the window has surprising positive effects. Protect those views and make them available to all income brackets.

TRANSIT—SECONDS AND STATUS

One of the biggest deterrents to people using mass transit is waiting.

A MINUTE SITTING IN A TRAIN STATION feels stressful. To counter this, many cities, such as Washington, D.C., now include digital arrival clocks at every subway station. Some metro systems, such as Providence, Rhode Island's, offer smartphone apps that allow users to monitor buses in real time. These tools are increasing ridership, by removing anxieties about late trains and sitting too long in lonely bus stations.

It's not time alone that puts people off transit, however. According to Montgomery, transit in some cities is seen as a mark of low social status. But that's an image that can be changed. He notes how Bogota, Columbia, reconfigured its bus system, offering "sexy" new buses and giving priority to transit and pedestrians by creating special lanes that cross through all neighborhoods, no matter how affluent or poor—an effort that greatly increased ridership.

Racing against climate change, governments, universities and industries intensify R&D projects aimed at reducing CO2 impacts of construction and maintenance.

2014

Breakthroughs in virtual reality interface to open door to advanced control of labor-intensive robotics.

2020

New "frictionless" joint technology and ultra-efficient servos reduce cost, extend lifespan of mechanized tools. Price of robotics continues to drop.

2030

"Near-miss" incident spurs urgent global rethinking on nanotechnology, resulting in strict rules for autonomous nanobot use and research.

2040

Atomic-level nanos successfully tackle ocean plastics, mountains of automobile tire rubber, integrating almost any post-consumer waste for 3D printing.

2050

THE CELESTIA PROJECT

Transference

"MY BOT'S NAME IS KAKU, after the famous physicist who discovered string theory. Of course, it's not a theory now. Scientists are using it to do some crazy stuff: warping time, teleporting a golf ball—it's amazing. Kaku's not mine, of course—he belongs to the company, but I'm his chief operator. He's like an extension of my body, but way faster, way stronger. He can fly, or float, and never gets tired. We helped build some apartments around a water recyc park together last month, all out of gyre plastic. The monsoon slide is awesome—and the whole thing came up 20 percent under budget." **—Kirk Taliesin, RC Actualizer, 2073**

Guided by virtual reality "eco-tects," third generation of net-zero robotics begins large-scale urban "makeover" projects designed to improve quality of life.

New mobile 3D printer can convert almost any demolition debris on site to useable raw material—up to 21 tons daily—greatly speeding urban reconstruction.

Domus Immortalis, a zero-maintenance, net-plus-zero 40-unit apartment building, is completed by two college students (and their robots) in 40 minutes.

Young people rank building construction as their "number one dream job." With many of humanity's problems solved, many will have a chance to carry their creative skills to the solar system and beyond.

2060 2070 2080 2090 2100

NO FEWER THAN three major U.S. magazines last year, including *The Economist* and *Wired*, featured robots on their covers. The age of machine-assisted labor is here. But robotics is just one of many advancing technologies that are likely to change our lives dramatically. Converging technologies, including virtual reality, 3D printing, augmented reality, robotics and nanotechnology will combine to alter the way we construct buildings and products, and how we define work. What will occur is nothing less than a transference of power, where our technology will allow us to manipulate and control our environment as never before in human history.

AND IT'S A GOOD THING. Because the next generation—as I pointed out in this month's Editor's Note—has been weaned on digital technology. The Millennials, who by 2030 will constitute 75 percent of the workforce in the U.S., will shun careers in construction or manufacturing—unless those careers become an extension of their techno-centric, eco-conscious world view.

And the need for highly skilled construction experts is about to explode, as flight from the suburbs into urban areas accelerates. In Houston, for example, more than 5,000 units of residential apartments are breaking ground right now—and Houston is a city with only 3,500 full-time residents in its downtown core.

To get a better sense of how this transference will play out over the next century, let's focus on the construction industry. Get ready for a wild ride.

Infrastructure: What's Old Is New Again

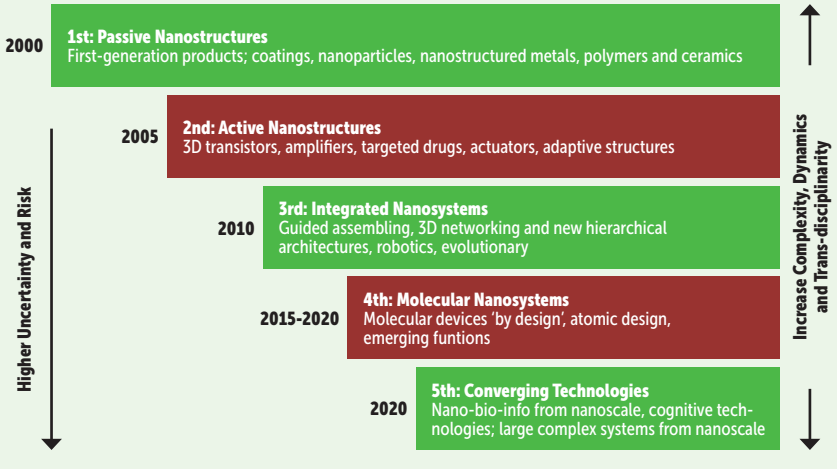
Entropy happens. But what if instead of tearing up old bridge pilings, or tossing 100-year-old house framing into a landfill, we

SOURCE: WWW.BDCNETWORK.COM

Worker Drones. Future job sites promise to be a hubbub of activity as robotic, VR-controlled devices take over dangerous, dirty work.

The Tao of Tiny

The science of nanotechnology is advancing rapidly—even faster than this report, published in 2006, anticipated. As we reach the level of "molecular nanosystems," the potential for product and material innovation will be enormous—as will the potential risks **(see sidebar, "Nanobots: Can We Survive the Hive?")**.



Increasing Complexity: Experts predict that by 2020, molecular-level devices will be able to perform special functions, potentially becoming interactive with their environment.

Source: *Nanotechnology Research Directions to 2020*, Roco

Insta-House

This prototype for a gigantic 3D printer "replaces construction workers with a nozzle on a gantry, which squirts out concrete and can quickly build a home based on a computer pattern." The unit, designed by a professor at the University of California, could theoretically construct the entire home structure in 24 hours.

Source: MSN News and gadgets.ndtv.com

reuse these materials in brand new products? I'm not talking about repurposing salvaged stuff. That's always the best environmental choice, sure, but not everything has salvage value for new construction. Who wants to deal with dusty wall insulation from the 1950s, for example? New technology, however, might give that stuff—along with crumbling drywall, concrete rubble and even rusty nails—a chance to start over.

We're not there yet, but nanotechnology is pointing in the direction of breaking materials down to their molecular (or smaller) levels and reusing them. And as if by magic, 3D printers are exploding as a new technology. They're going to need lots of raw material to build new objects.

For example, in the near future, EWP producers may want to know if sections of century-old wood framing can or should be re-incorporated into sheathing panels as raw wood fibers. A little digging turned up a report from Sweden (**http://bit.ly/T4PQyz**) on wood structures, which found that wood retains its integrity for millennia: "Under dry conditions, the effects of age on wood structure appear minimal up to an age of 4,400 years." This suggests that wood fiber from deconstruction *could* be reincorporated into new materials almost indefinitely. Use of salvage wood for that purpose is cost-prohibitive for now, but that could change as the massive reconstruction of the 'burbs accelerates.

As research on nanobots proceeds, researchers are experimenting with simpler techniques of nanoengineering, such as bonding extremely small particles chemically with other materials. But even this advanced chemistry has its limitations.

For example, concrete suppliers have been testing various recycled aggregates for many years. One goal is to include more recycled materials, such as tire rubber or asphalt from roof shingles. But when, for example, they try mixing recycled tire rubber in concrete, they find that the additive only improves heat transfer when the mix is less than 5 percent rubber in the mix. Add any more rubber, and heat transfer actually increases. This is because the tiny particles in the recycled rubber reduce air space in the concrete (source: *Excellence in Concrete Construction Through Innovation*). This makes the material better suited for road use in cold climates, where surface freezing is a problem, but less attractive for green building.

It's likely, however, that such simple "mix and test" approaches to materials could become less definitive, as nanotechnology improves. It's conceivable that nanobots added to the mix could

continued on page 46

Durability Advances

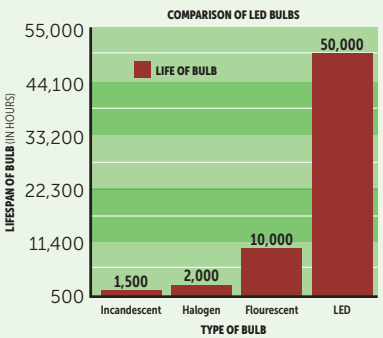
Innovation has already expanded the lifespans of many common building products. Here are just a few examples.

Epoxy Grouts

Two-part products resist mold, have greater strength and generally do not depend on regular homeowner maintenance. Newer products such as PROMA's *PRO GROUT EXTREME* (shown) contain no VOCs and claim the same low maintenance as epoxies.

Cementitious Tile Backers

Remember when drywall was installed behind tile showers? It's no wonder showers were among the shortest-lived components of a new home. New cement-based underlayments, such as CertainTeed's BackerBoard product, contain about 25 percent recycled material, and last for decades.



LED Lighting

With a lifespan of up to 50,000 hours, an LED bulb outshines all previous technologies (except possibly sodium lamps). It also contains no mercury.

Synthetic Underlayments

A clay, concrete or metal roof should last at least a century. The old 15-lb. felt underlayments, however, tended to fail after less than 20 years. New high-tech, rubberized and self-sealing products promise to at least double the tenure of a good roof material.

"adjust" spacing between materials, vastly improving a material's energy performance.

The End of Physical Labor?

As we noted in the article on Page 34, building is "dirty, dangerous and dull" work. It's increasingly tough to find laborers willing to do the backbreaking work of framing, tiling, roofing, erecting and dismantling scaffolds and trusses. But this hands-on tradition may fade away in coming years.

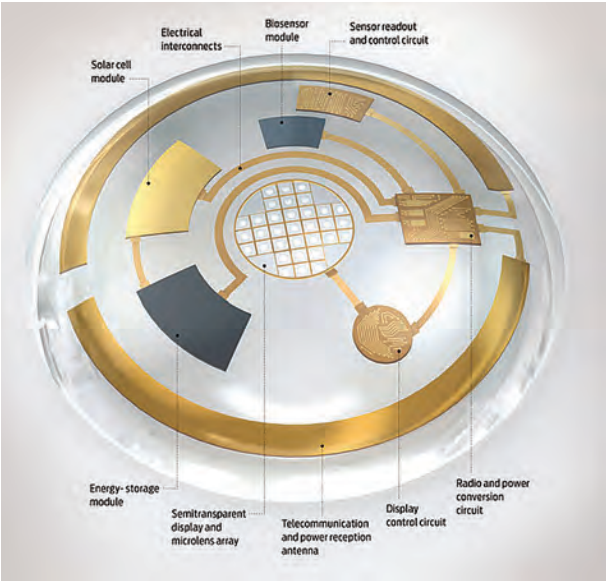
If you visit a steel-forming plant in Japan, you don't see grimy, haggard looking workmen covered with blackened hands and clothes like you do at many plants and distribution centers in the U.S. You see men and women in white lab coats, behind glass, operating remote machinery with digital screens and interfaces.

There's actually a term now for controlling robots with virtual reality technology: *tele-operation control system of construction robot*, or *TCSCR*. This technology is closer to field-ready than you might think. A century of tinkering with automated equipment in manufacturing—especially the auto industry—has created a vast body of work on robotics. And I've seen modern, autonomous robots at work in building product factories as well, including one on a visit to Ireland a couple of years ago that could pick up extremely fragile evacuated solar tubes and move them around at post-human speed.

But the Holy Grail of robotics is a synthesis of human control with robotic magnification of those assets. For example, the science of "haptics" refers to conveying our sense of touch to a machine. Tests of human control of robots using joysticks and servo valves were already underway at least a decade ago. It's likely that VR control will continue to improve, become more precise, more "real" to the controller—and more fun (thus more attractive to Millennial workers).

One obstacle to virtual reality's viability has been computing power, but that roadblock is fading, as Moore's Law continues to hold (at least for now; as Michio Kaku points out, it won't accelerate forever).

One of the major advantages to robotic construction is design optimization. Robots have already been used to create extremely strong structures using much less raw material than their human counterparts. For example, they can create complex joinery in plywood that allows them to construct walls with compound curves unlike anything human crews can handle.



Magic Eyes. Experts say wearable contact lenses that can project virtual realities invisibly to our eyeballs are on the horizon. This "iOptic" prototype includes an energy-storage module, and a radio and power-conversion circuit.

Source: illumin.usc.edu

Anticipating Life Cycle Changes

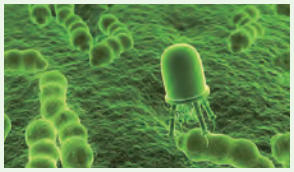
Already, building science has greatly increased the maintenance for many products—with fiber-cement siding, manufactured stone, "lifetime" faucet and door hardware finishes. But we're still a long way from a zero-maintenance structure. Many organizations are focused on establishing life-cycle assessments (LCAs) that offer real information on the environmental impact of a material or product.

That's the right direction for today, but what if in the near future, life cycle becomes more or less meaningless, as biotechnology creates components that can literally last indefinitely, with minimal maintenance? Imagine the reduction in resource consumption if we never had to replace another asphalt shingle, repaint siding or replace the grout in a tile shower.

Of course, any durability discussion must include the realities of human behavior. People get restless, often changing their residences for personal reasons, or to accommodate changing family situations.

To that end, the most durable structures of the future will need to be flexible and changeable—designed for easy disassembly and reassembly. And as I've written before, durability isn't the only way to achieve environmental balance. Another approach is to create structures that are "made to degrade," using components that can dissolve into their natural surroundings without causing harm. Here again, biotechnology might play a role—for example, by giving an entropy nudge to "behind-the-walls" mechanicals that biodegrade when exposed to sunlight, or triggered by a passcode.

Nanobots:
Can We Survive the Hive?



Biotech believers are giddy about nanotechnology. But before we rip the lid off Pandora's Box, some very serious ethical and risk factors need to be addressed. That's because once we have the power to manipulate objects at the molecular (or smaller) level, we could easily get into trouble.

For example, tiny bots might be programmed to carry out a specific function, such as converting suspended plastic molecules in the ocean into biodegradable material, or they might remain inside concrete wall assemblies, with the sole purpose of repairing cracks and other degradation.

But what if nanobots become sophisticated enough to mutate or multiply, and attack the wrong molecules, destroying or transforming other life forms or ecosystems? Clearly, before scientists pursue this technology blindly, worldwide scrutiny and guidelines must be put in place. The prospect of godlike power over the building blocks of matter is tantalizing, to be sure, but let's make sure the cost is not too high.

Putting the Fun Into *Factory-Built*

MAKING BUILDING PARTS in factories reduces waste, sometimes guarantees better tolerances in buildings, and centralizes delivery of materials and components. But it faces the same labor challenges as site work, only maybe worse. Working in a factory—at least most of the factories like any I've ever visited in the U.S.—is Millennial hell. It's noisy, repetitive physical labor. They might do it for a summer. But they won't stick around.

As Ryan Smith points out in his book, *Prefab Architecture*, "In many fabrication environments, reliance on minimal skills leaves laborers with little room for skill advancement or intellectual challenge. Although prefabrication may save on material waste, it does not say anything about the environmental impact of materials used in construction other than the distance of transportation from shop to construction site."

Augmented Reality: The Ultimate Rose-Colored Glasses

WITH AUGMENTED REALITY, the line between reality and imagination blurs. Architects are using it to make a 2D image seen through a smartphone become 3D. Others have created animated characters only visible through the phone camera. But these early augmented reality applications are just a taste of what's to come. When augmentation converges with other technologies, it could revolutionize many creative fields, including building design.

For example, combine AR with virtual reality, and building engineers and architects can visualize the outcome of their most whimsical design ideas in real time. Robot controllers could literally "construct by numbers," directing their mechanical avatar to assemble a virtual 3D rendering of a building from the ground up. Don't like the view through your office window? Augment it with palm trees and a sandy Caribbean beach. The boss will never know—she's living three states away, doing the same thing.

Appliances from a Printer?

Ask any production builder: one of the biggest challenges to any construction project is managing the flow of goods and materials to the site. Price and dealer fluctuations and varied installation methods (an issue tied to labor) slow things down. Even with streamlined shipping and packaging, much of any building's footprint lies in its use of far-flung materials. Locally sourcing materials reduces that impact, but what if the buyer wants granite countertops or Mexican tile?

That's where future generations of 3D printing may provide a solution. Right now, a 3D printer, which can create three-dimensional objects, uses spools of polymer. But future printers may be able to transform the rawest materials—cellulose fibers from old timber, raw gypsum from demo drywall or scrap metal—into new, precision engineered objects.

It's possible that 3D printing could have the same effect on the building industry that Netflix had on DVD rental chains like Blockbuster. How will a company that makes windows or vent fans or door hardware survive if every builder has a 3D printer on the job site, along with a few thousand cubic tons of raw materials, ready for conversion?

The answer is simple: the company owning the brand will sell the elaborate code that the printer needs to produce a certain model of sink or faucet. Imagine something like the Kindle audiobook model, applied to product blueprints. You can download a blueprint license for a certain number of sinks or toilets before it self-destructs. Manufacturers can finally leave behind the industrial age, and enter the knowledge-based economy. GB

THE CELESTIA FORECAST

Building science has traditionally been slow to change, but rapid advances in commercial construction, combined with public demand for re-urbanization, will quickly carry over into large-scale residential construction projects. Convergence of robotics, virtual reality and nanotechnology will drastically alter how buildings are restored, constructed and designed. In future chapters, we will address in depth the systemic changes that need to occur politically, socially and physically to make these changes possible.

2014

As the world passes Peak Oil, polluting fossil fuel industries, engaged in shale fracking and deep drilling, face increasing opposition.

2020

Fresh water concerns push local governments to ban certain fuel extraction methods, as more federal subsidies go to clean energy.

2030

Dropping costs of solar PV beat all predictions. U.S. hits 60% renewable energy benchmark. New technology: sun-powered air cooling without refrigerants.

2040

First generation of reliable, biodegradable (algae-based) battery systems become mainstream, allowing transitional use/conversion of older vehicles, homes.

2050

Large-scale wind farms are gradually phased out, as national grid concept is abandoned in favor of regionalized and local green power distribution.

THE CELESTIA PROJECT

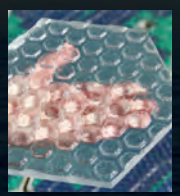
Decarbonization

New technologies converge to make fossil fuels obsolete, as renewable materials and systems reshape our lives.

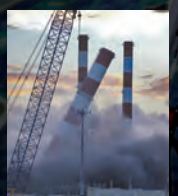
"PRETTY MUCH ALL my stuff makes power. My jacket. My bike, my helmet—even the bike paths. So I don't think about it much. I've never had to charge my *EyeJack*. The new stuff makes power from almost any kind of light. It sort of borrows it—even moonlight and street spotters. Plus, my sneakers make electricity just by moving. My dog, Omega—he's a robot—he sleeps in an algae shack, so he's all bouncy and ready to go by morning."

—Jake Taunton, Age 12, Newark Restoration Farm, 2090

New standards and codes restrict size and energy footprint of all new dwellings. Tax cuts and incentives reward low energy use and renewable sources.



"Power Play City" rises in Vermont: Solar-surfaced buildings, roads and materials plus hydroelectric passively produce three times the energy consumed in the urban footprint.



Demolition of the nation's last fossil fuel power plant is completed, on the same day that the nation achieves 100% renewable energy sourcing.

Tech wiz kid powers an entire living unit, including kitchen, sending power wirelessly using only his solar nano-infused clothing and personal effects.

2060 2070 2080 2090 2100

NUCLEAR POWER IS OUR FUTURE. But this nuclear power plant requires no government to guard it day and night, no federal oversight. It operates 24 hours a day, disposing of its waste byproducts where they can do no harm. Of course, we're talking about the sun.

AT SOME LEVEL, most forms of renewable, sustainable energy likely to power our future are derived directly, or indirectly, from photons of sunlight.

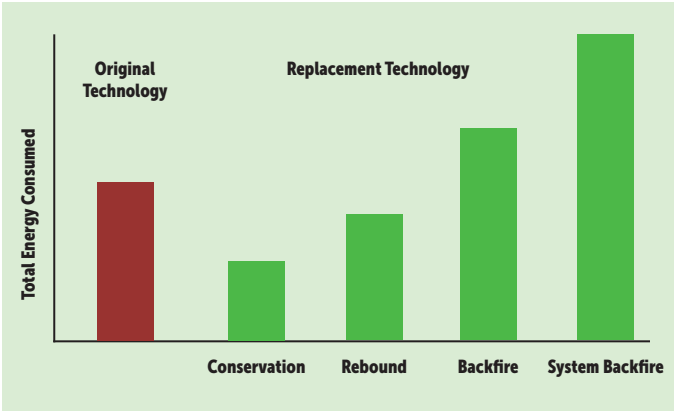
But the discoveries and innovations now could change *everything* about how we collect, store and distribute energy. Let's hope we have the courage to give them a chance.

The forerunners of the necessary technology are already in our midst: nanoparticles that collect and convert energy; super-efficient and "smart" photovoltaic panels that adjust to shadows self-optimize and self-repair; "organic" solar technology that turns algae into power producers; affordable geothermal systems that replace heavy-handed air conditioning; hydroelectric plants; wind turbines. The list goes on and on.

Of course, we first have to survive the potentially apocalyptic threat of runaway CO_2 and climate change. Perhaps the biggest obstacles to this goal are not technological. They're psychological. As Alexis Madrigal points out in his romp through alternative energy history, *Powering the Dream*, this isn't the first time we've been offered a new path to cleaner, greener energy. He describes how the solar dreams of the 1970s were underfunded and ultimately abandoned, despite the fact that in one of the rare cases where real money was invested in solar PV technology (ironically by Esso—later Exxon), the price of panels dropped by about 90 percent in just three years.

The big decision point now, he says, has to do with scale. At the federal level, politicians like to think in broad strokes, favoring centralized power production on a large scale—market-driven solutions pushed by profit motives and number crunching. But as if in counterpoint to this "bigger is better," perspective, another current is rising. It's an idea shared by both Henry David Thoreau and E.F. Schumacher: *Small Is Beautiful*.

Ultimately, if humanity survives the next few decades, our energy portfolio will change dramatically, becoming ever more fragmented, as technology becomes smaller and more efficient. Producing energy, as you'll read, is likely to get easier and cheaper.



Conservation Backlash. Often, a new technology that saves energy results in changes in behavior or products that result in even more energy use. This "efficiency trap" can be beat, but it may require new, enforceable rules about consumer behavior.

A SOLAR EVOLUTION

Thriving solar companies have made steady, gradual improvement in everything from panel performance to installation tools.

A few of our show favorites:

SunPower: This company is pushing the limits of residential solar panels. Their *X-Series Solar Panels* hit efficiencies of 21.5 percent, well above most other residential products.
Info: http://tinyurl.com/ppp8adw

Spice Solar: With a focus on streamlining installation, Spice has developed an entire line of tools and accessories designed to get solar onto rooftops—and fast.
Info: http://tinyurl.com/phguefl

Bosch Thermotechnology: Although Bosch divested from its solar PV business in 2013, Bosch Thermotechnology has developed an outstanding geothermal leasing program that may help bring geothermal into the mainstream.
Info: http://tinyurl.com/ncaly34

Rheem: Offering a wide palette of solar thermal products, Rheem continues to make inroads in residential installations with products such as its *SolPak* solar hot water system, with automatic electric backup/assist.
Info: http://tinyurl.com/l42bxnd

ReneSola: More than just a solar panel company, Korea-based ReneSola makes a bunch of neat, solar optimized products such as LED street lighting and the *Replus* super-efficient residential inverter.
Info: http://tinyurl.com/p8zckup

JinkoSolar: Based in China, JinkoSolar has developed solar cell technology that reduces the degradation caused by continuous use—extending panel life, while at the same time keeping units highly affordable.
Info: http://tinyurl.com/qayav3p

IMAGE: SUNPOWER AT THE INTERSOLAR EXHIBITION

SMA Solar Technology: This German company sells turnkey panel systems that are priced to compete with other global imports, including a clever *Sunny Boy* inverter for residential use.
Info: http://tinyurl.com/nwmd4vd

Trina Solar: This company has developed special fire safety technology and computer integration that allows for remote monitoring of system safety and performance.
Info: http://tinyurl.com/oqcyk4j

THE CELESTIA MUSEUM

Close Call.
Outlawed by most nations in 2025, window air conditioners proliferated globally for the 10 years prior to the ban, and did tremendous atmospheric damage.

ILLUSTRATION BY KIP AYERS

AN EPIDEMIC OF POLLUTION

According to *The New York Times,* "Leading scientists in the field have just calculated that if all the equipment entering the world market uses the newest gases currently employed in air conditioners, up to 27 percent of all global warming will be attributable to those gases by 2050."

We need to transition to other methods of cooling our homes and our bodies. Here are a few current and prototype alternatives:

Quiet Whole-House Fans. These air-moving units are quieter and more efficient than their predecessors.

Geothermal Systems. Although a bit pricier to install upfront, the lifelong costs of these systems are far more reasonable than multiple window air conditioning units, and do less harm to the atmosphere.

Wrist-Mounted Sensors. Why cool a whole room when a wrist-mounted device can make you *feel* cool?

Retractable Awnings. Low tech and affordable, retractable awnings protect windows from sun when and where you need them.

Mini-Split Heat Pumps. In the greenest homes being built today, ductless mini-split systems are taking the place of inefficient window units.

This report (**http://tinyurl.com/pau2lwz**) suggests how to improve air conditioner efficiency (a modest 10 percent), but ignores damaging impacts of the proliferation of these devices.

This article addresses some of the environmental impacts of air conditioning and small-scale solutions: **http://tinyurl.com/omk5xkf** (*Environmental Impact of Air Conditioners*).

But unless the technological change happens in tandem with behavior change, we won't live to reap the benefits of the "ecotopia" proposed by *The Celestia Project*.

Caveat: Cheaper Energy Is Only Step One

The cover of Steve Hallet's book, *The Efficiency Trap*, shows a planet made of glass that is less than half full of liquid. It's an apt metaphor for his bleak perspective on our chances of surviving Earth's tipping point. Hallett's thesis is simple: Whenever human beings discover new ways to create energy more efficiently, they inevitably ratchet-up consumption to take advantage of the new bounty, resulting in the use of even more resources. This process, he says, happens in every sector of the economy, including homebuilding.

"In heating your home, you may invest in insulation to reduce heat losses in the winter, a seemingly obvious example of energy conservation, but, even in this benign example, there is likely to be a rebound. People with well-insulated homes and lower heating bills are likely to keep their houses a little warmer. Cheaper and more efficient insulation allows us to build bigger houses with cheaper materials. A more efficient furnace would appear to conserve energy, but here again, efficiency improvements tend to make it more cost efficient to build bigger homes.

"What efficiency conserves with one hand," he continues, "it consumes with both hands."

If Hallett is right about the human tendency to take advantage of efficiency gains by using them elsewhere, how do we break the cycle? By linking gains in efficiency to changes in behavior. By rewarding real conservation and penalizing overconsumption. With carrots and sticks. And taking a hard look at technologies

continued on page 42

that are not worth the price of admission.

Using renewable energy as an example, every gain in the efficiency of a solar panel must be accompanied by, at the very least, a freeze in the level of consumption of the end user. Even better would be a "complementary" response. In other words, as solar cells become twice as efficient, refrigerators match them, using half as much electricity. This may require more than a simple market approach. It may mean mandating limits on energy consumption of any appliance, the same way water flow through faucets and showers is now controlled. This will require cooperation from manufacturers and trade groups, but without it, real progress on conservation may be impossible.

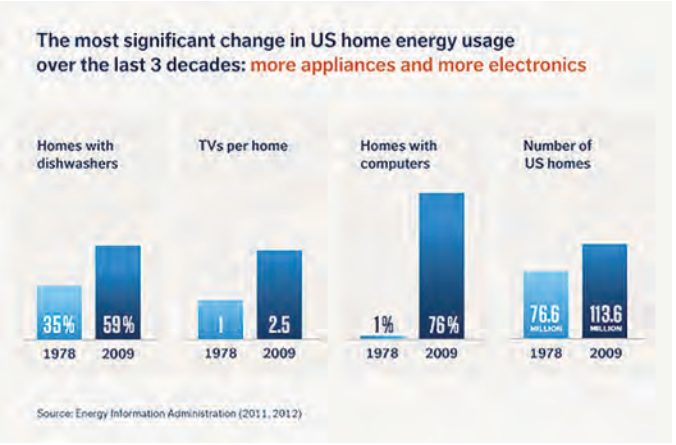
Is Solar up to the Job?

As we mentioned above, most sources of planetary power are derived from the sun. Solar cells have their detractors, of course—not because people don't like the technology, but simply because solar is seen as too costly, too limited in power capacity for large-scale use. These weaknesses, however, are vanishing rapidly in the face of rapid innovation. Steve Hallett argues that "the American economy consumes more energy than is fixed from the sun over the entire landmass of the lower forty-eight states." Whether or not you agree with his math, the equation is likely to change within a couple of years, if not a few months. Solar cell efficiency is on a bell curve upward.

For example, scientists at the German Fraunhofer Institute for Solar Energy Systems just created a solar cell that's 44.7 percent efficient, far above the average 15 percent efficiency of most commercially available panels. It's not mainstream yet, but it shows where things are going.

Tom Murphy, associate professor of physics at the University of California, San Diego, says criticism of solar photovoltaics tends to be overly strident. Even the most common PV panels, he argues, stand up well to most other energy alternatives. A corn field growing biofuel, for example, has an efficiency of 1.5 percent if you look at the actual wattage likely to be produced per square foot. The average automobile converts gas to energy at about 25 percent—no great bragging rights there. And a coal-fired power plant fueling an electric car operates at about 35 percent efficiency.

Murphy's analysis includes an assessment of the total square footage of solar needed to power a home.



Moving Target. **Although some electrical products have become more efficient, the number of gadgets (and homes) keeps increasing, so overall electrical usage keeps climbing. And smartphones are not even included in this 2012 chart.**

"At 15 percent efficiency, our square meter captures and delivers 0.75 kWh of energy to the house. A typical American home uses 30 kWh of electricity per day, so we'd need 40 square meters of panels. This works out to 430 square feet, or about one-sixth the typical American house's roof (the roof area of a two-car garage)." (from **http://tinyurl.com/ckjfr4x**)

Much of our national power load, of course, comes from outside the residential housing industry. But his point is a good one. Solar already can easily supply the power needed for most housing.

Forecasting the Energy Mix

Most economists, investors and industry groups don't foresee rapid change in the world energy portfolio. Instead, they contend that various pressures, including population growth, demand for personal vehicles and the booming economies of China, India and other "rising" nations, will by necessity lead to continued reliance on oil and coal as primary sources of the world's energy, at least as far as mid-century.

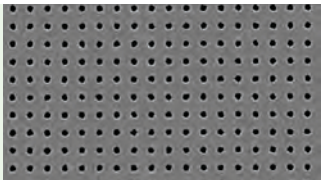
We think the pundits are wrong, for three reasons. First, they're underestimating the impacts of emerging solar technology, as biotech, robotics and micro-engineering converge. Second, they don't understand the Millennial world view. A culture of environmental awareness will soon become a driving force in the economies of affluent nations, as Millennials come to dominate the work force. And finally, climate change is likely to deliver a succession of paradigm-shattering shocks to the status quo in coming decades.

Any attempt to take a "business-as-usual" approach to the use of polluting energy sources will create tremendous friction between nations and also among generations. An obvious way to avoid such dystopian scenarios will be to through a rapid, orderly shift to clean, renewable energy sources that do not deplete food and water supplies or require oversight from large, centralized governments. The effort will need to be global, however, not nationalistic and isolationist. Efforts to control and dominate access to innovation are likely to backfire.

Here's where we think things may be headed over the next century:

Getting into Hot Water

Solar hot water systems such as this self-contained *Solaraide* rooftop model from Rheem are one of the most easily identifiable "winners" in any future energy independence scenario. Even small solar hot water systems typically pay for themselves in just a few years.



Crunching Space.
Scientists recently applied "nanoholes" to solar panels, allowing them to capture more sunlight in less space.

Loser: Nuclear Power

Barring the remote possibility that the controlled fusion can be harnessed in coming years, it's likely that the fission-based nuclear power industry will continue to decline into gradual obsolescence. Already marked for decommissioning in Germany, and under siege in Japan, nuclear's greatest weaknesses may not be (as its advocates protest) the lack of public understanding of the technology, but its *scale*. Towns don't build nuclear plants. As David Indiviglio wrote recently in *The Atlantic*, "One of the big problems with nuclear power is the enormous upfront cost. These reactors are extremely expensive to build. While the returns may be very great, they're also very slow. It can sometimes take decades to recoup initial costs. Since many investors have a short attention span, they don't like to wait that long for their investment to pay off." Add to that cost the ongoing need for monitoring, inspection and even military protection, and it seems that the "nuclear nanny state," is an idea that may not stand the test of time.

Winner: Hydroelectric Power

Tried and true, small- and medium-scale hydroelectric plants continue to operate in much of the U.S. Hydropower currently accounts for as much as 90 percent of the world's renewable energy, although that dominance is on the decline, as other sources come online. Newer hydro designs solve some of the problems with fish migration and species diversity, so it's likely they will remain a viable core energy supply throughout the transition to new solar products. The prospects for future hydro, however, are rather limited, compared with solar PV. According to Unesco's World Water Assessment, the planet's total potential hydroelectric potential is only about three times higher than what's already being harnessed.

Loser: Biofuel

The use of crops, such as corn and soy, to create fuel for cars should automatically raise some red flags. Put simply, creating biofuels is a short-term replacement for increasingly costly fossil fuels, but it's social and environmental costs are unsustainable and unacceptable. Using leftover fryolater fuel from fast food joints is one thing—growing corn to make fuel to run cars is "biofoolish," as Hallett puts it.

Loser: Wind Power

Although they're likely to remain part of the transitional energy portfolio for at least 20 years, we foresee a gradual decline in utility-sized wind turbines. Again, the problem is scale. They won't be able to compete with the fast-moving innovation of solar PV, because of their need for regular maintenance and the unpredictability of winds. These are limitations that can't be innovated away. Small-scale wind has seen a decline in sales recently, so the writing may be on the wall for them, as well. One possible way forward could come in the form of nearly frictionless vertical turbines that can be operated without vibration and noise. These could open up the market to new regions and end users.

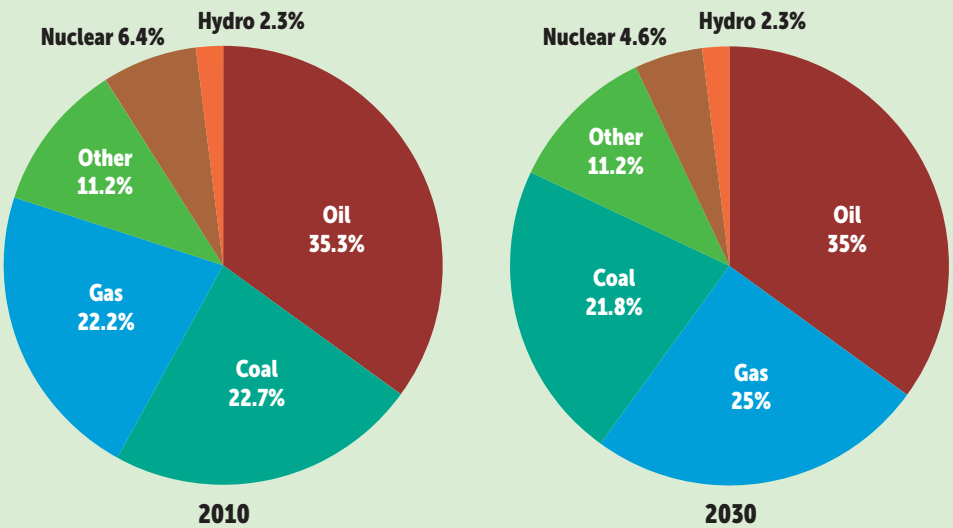
Winner: Central Power Towers

Also known as "heliotopic" power plants, these systems are relatively new to the power generation scene. An array of solar panels heats up the central towers, which are filled with liquid salt. The heated salt then flows to power some steam generators. Several proposed plants were put on hold recently, as solar PV prices dropped, but in urban areas, especially, the technology may survive solar's success. New plants can operate at about 30 percent efficiency. Keep in mind that this is still solar power, and that is

continued on page 44

FOSSIL FUEL FANTASIES

Aiming Low.
The International Energy Agency likes to take things slow—so slow that they apparently have been completely left behind by the 21st century. In 2004, they published this prediction about energy sources for 2010 and 2030.



double the efficiency of most solar panels on the market. For a city looking for a fast, clean and reliable power source, a heliotopic system may be just the right investment.

Loser: Tidal Power

Expensive to build and expensive to maintain, only a few tidal electrical generators exist, to date. Most are the "barrage" type that extract power as tides flow in and out of inland basins. They're known to put strain on local ecosystems, although newer technologies might reduce that damage. While some pundits forecast the growth of this industry, it has some of the same problems that nuclear does—namely, simply building one requires a huge budget. While not yet "dead in the water," tidal power will need some sharp innovation to keep pace with the rise of solar, if it's to be considered as a dollar-for-dollar energy alternative.

Winner: Geothermal Heating and Cooling

About 15 percent of total energy use can be attributed to space heating and cooling and water heating for residential and commercial buildings. While the only completely "green" technology for accomplishing this is solar, it's often difficult to achieve high enough temperatures for space heating with solar alone. Geothermal, on the other hand, can pre-heat or pre-cool spaces significantly, with very low embodied energy, other than manufacture of the initial components. Run it with a solar-powered pump and it becomes a net-zero-energy source for heating or cooling a structure. We're expecting to see huge growth in demand for this technology, as awareness about its many benefits become common knowledge.

Big Winner: Solar Photovoltaic

Nearly every day, new discoveries are announced. A spray-on coating for windows that turns them into translucent solar power panels. A chemical hurdle crossed that makes possible "paint-on" solar cells. Soon, every building exterior will become a solar collector. Clothing that collects solar power and keeps your personal electronics at full charge. Solar roadways. Solar vehicles. And eventually, all of it will be invisible: molecular level technology that simply captures both the direct and ambient light of the sun (or moon, or street lamp).

Space Age Reality. The Ivanpah Solar Power Plant in San Bernardino County, Calif., collects sunlight and focuses it on tall towers filled with liquid salt.

As this story goes to press, a new study just hit my desk. Workers at the A*Star Singapore Institute of Manufacturing Technology added tiny, tubular holes to PV panels. These "light holes" allow much more sunlight to be collected than conventional panels, greatly increasing the efficiency of a solar panel—without increasing its cost.

According to *PVBuzz.com*, solar is already overtaking nuclear power in the U.S. as the renewable energy of choice: "*The Renewables Global Status Report* (GSR) states that new installations increased by 32 percent (39 MW) during 2013, totaling 139 GW of installed capacity." Barring a major breakthrough in energy creation, solar is likely to remain in the ascendant well into our future.

A natural progression from wireless charging is to put the actual energy source closer to the chargers—and photovoltaic technology could be a great way to do this. If PV panels can be built to be durable, replaceable and affordable, they could actually "become" the road.

That's exactly what a company called Solar Roadways is working on (**http://tinyurl.com/o67ly78**). Now into their second prototype, they're creating a mom and pop version of solar roadways that is clever and cool.

One of the things I like best about solar road technology is that it could be built with modular components, with power lines and communications cables underneath or next two it. Consider the advantages:

Phasing-Out Asphalt. Less use of costly, environmentally polluting asphalt (**http://tinyurl.com/ohkj7kv**), with potential for use of recycled composites and plastics.

Less Demolition. Need new cables or sewer pipe repairs? No problem, just pop off a few solar road panels and go to work. Pressure on C&D landfills could decrease dramatically.

Durable Grid. Widespread use of the panels would not only power cars, but could be tied into existing grids, creating a massive, resilient new source of power nationwide. **GB**

THE CELESTIA FORECAST

Although a mix of technologies will continue to power the world's energy needs, that mix will lean heavily on solar collection by mid-century, overtaking all but the most nimble competing methods of energy production. At the same time, public consciousness about the *real* costs of energy will shift, triggered in part by the shocking impacts of climate change. Calls for change from around the world will finally be heard by wealthier nations. Solar power, now ubiquitous and inexpensive, will power devices that are not just lightweight, compact and super efficient, but designed for disassembly and easy repair. Any excess power will be used to restore the ecological damage of the 20th century, cleaning polluted water, restoring wetlands and powering the robotic crews that will rebuild cities and homes into hip, efficient shelter for a new century.

GOLD AWARD WINNER

Best Residential Trade Magazine

"This magazine packs a lot of information in a small space. It broke new ground by challenging readers to do better with features on living with a smaller carbon footprint and detailing environmental crises of our time. The photography helps this publication stand out."

NAREE JUDGES COMMENTS

GREEN BUILDER® MEDIA
Defining Green

Get your subscription today!

www.greenbuildermedia.com/subscribetogreenbuilder

Abnormal levels of drought persist, both in the U.S. and many other nations, causing alarm.

2014

The first armed conflict over water rights unfolds in Africa, drawing global attention to the issue.

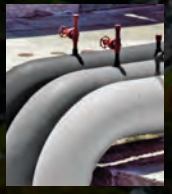
2020

U.S. finally recognizes water as a human right, despite desperate lobbying from multinationals, spurring dramatic changes in water management.

2030

Phase out of toilet tissue is mandated, as flush-only toilets are banned in all states except Texas.

2040



Most U.S. municipal water plants now include "fit-for-purpose" water sourcing, greatly reducing potable water waste.

2050

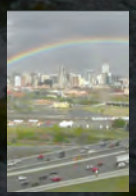
THE CELESTIA PROJECT

Rehydration

As access to fresh water becomes a human right, innovation and conservation converge, restoring Earth's natural hydrology.

"IT'S FUNNY TO THINK that people used to shower and even defecate in drinking water. And these were so-called civilized people! I'm working in several of the world's deserts as an Arid System Stabilizer. That's a clever name for someone who spends night and day thinking about how to reverse desertification. We're making progress, thanks to better land use, terracing, nanotechnology and—just as importantly—behavior change. People have finally started treating water like the miracle it is."

—Teri Corman, Los Angeles, 2045



Denver becomes first U.S. city with 100 percent rainwater catchment and reuse in place, including pervious pavers and streets.

Nanotechnology, soil terracing, sensors and reduced beef grazing help restore desertified soils in the Western U.S., although migration of population continues.

Cotton, corn and other "thirsty" crops are phased out, as self-cleaning fabrics and drought-tolerant foods take their place.

Two-thirds of U.S. cities now capture and reuse enough water to require no outside source, except in drought situations.

U.S. "fossil water" aquifers show rise in level for first time since measurement began, thanks to a century of change in how water is used.

2060 2070 2080 2090 2100

ONE WATER, INDIVISIBLE. Although we tend to think of water as broken reservoirs of different quality and value, it's time to think of all water as one.

ARE WE REALLY entering "a new geologic age," as 500 scientists proclaimed recently during a meeting about water in Bonn, Germany? In our time, access to this basic life need is already restricted for many. If current usage and population trends continue, according to Maude Barlow, author of *Blue Future: Protecting Water for People and the Planet Forever,* "global demand for water in 2030 will outstrip supply by 40 percent."

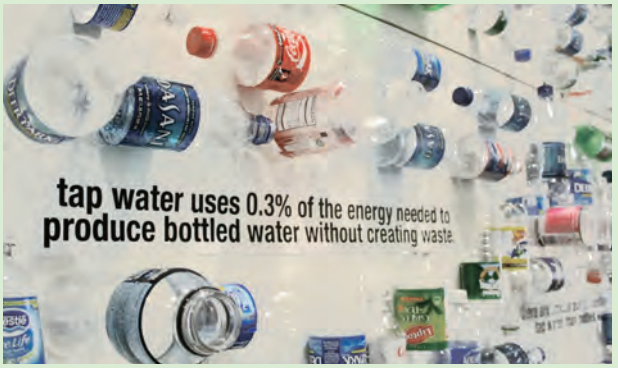
If you're not convinced that "saving" our water supply is an urgent priority, you may want to catch up on some of the latest statistics from various water-monitoring organizations worldwide. When you do, you'll find that the future we can expect from a "business as usual" approach to water management is terrifying, no matter where you live.

Broken Hydrology

When we were kids, we all learned about the hydrologic cycle. But that simple model of evaporation, condensation and replenishment simply can't keep up with the pace of human activity in the form of mega-farm irrigation, thirsty lawns and cattle ranches. Consider just a few of the worst-case scenarios for our current trajectory, outlined in *Blue Water*:

Depleted Aquifers. We can expect a dry-up of some of the world's major "fossil water" aquifers, including the Ogallala, which supplies irrigation for much of the large-scale farming in the Midwestern U.S., commonly known as the nation's "breadbasket." Farmers have been tapping it heavily in recent years to keep up with corn production for ethanol and to compensate for drought cycles.

Ghost Cities. China plans to build 500 new cities in the next 20



The Bottled Water Hoax

AN ANALYSIS BY *Business Insider* says it all. The price you pay for bottled water is up to 2,000 times higher than that of tap water. The irony is that in the U.S. especially, tap water has been shown to be of equal or better quality than many bottled water brands.

Does bottled water have its place? Certainly, as an emergency life-giver in drought-stricken parts of the world, or in regions hit by natural disasters, but not as a staple of board rooms, hotels and campsites.

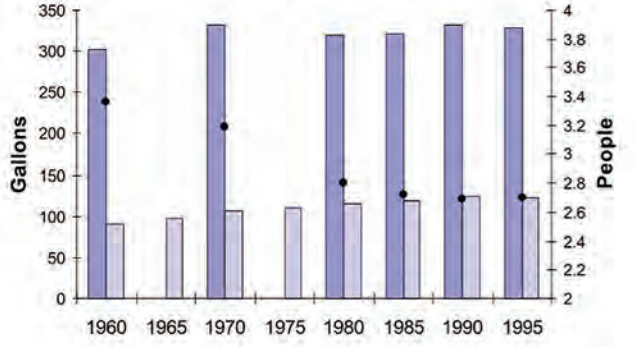
Rising Consumption

Despite the advent of low-flow toilets, faucets and smarter irrigation, water use per capita in the U.S. keeps rising. Why?

THE ANSWER, ACCORDING TO THE USDA, is multi-fold. First, household size overall has been shrinking, which results in rising per-capita water use. As the agency notes, "A minimum level of water use per household, especially for lawn and garden watering, is largely unrelated to household size, causing per-capita use to rise as household size drops."

Other factors include "the use of appliances such dishwashers, washing machines, swimming pools and lawn sprinkler systems. These changes are consistent with the increasing real incomes experienced in many areas of the U.S. over the past 30 years."

Domestic and public withdrawal in the U.S.



SOURCE: PAST AND FUTURE FRESHWATER USE IN THE UNITED STATES (WWW.FS.FED.US/RM/PUBS/RMRS_GTR039.PDF)

MUSEUM OF THE FUTURE

By 2050, free-flow sprinklers could be found only in antique shops, and advanced septic transport and filter systems made scenes like the annual visit from "the pump man" a distant memory.

years. Where will the water to sustain them come from? Futurist Lester Brown warns that much of Asia may be "headed for a Dust Bowl."

Desert Planet. Desertification of arable land is increasing rapidly in more than 100 places worldwide. Climate change is likely to accelerate the problem.

Add to this list the pollution of fresh water from natural gas fracking, the rising global consumption of water-thirsty beef, the water waste associated with growing corn for biofuel and the devastating impacts of the cotton industry, and you can see why scientists are sounding the alarm. It's not that water is "disappearing." We still have the same amount of water on earth as we ever did, but human activities are making drinkable versions of it less and less accessible.

The desperate scenarios in our future are not inevitable. They assume the worst in human behavior—where current trends in water use (and misuse) continue unchecked, including population growth, meat consumption, consumerism, stormwater runoff and wasteful lifestyles. Add to this mix the certain uncertainty of climate change, and you can see why the mood among many scientists is generally bleak—and getting bleaker.

Water as a Human Right

It may not be on your radar here in the U.S., but much of the world is engaged in what they rightly see as a life-or-death struggle to retain control of local water supplies. The power of giant corporations and their front organizations, including the deceptively named World Water Council, should not be underestimated. Multinationals such as Suez, Nestle and Pepsi hope to secure rights to fresh water resources worldwide, then sell them back to the world—at a profit.

Until recently, this bizarre theft of essential regional resources for sustaining life seemed to be unstoppable. But consistent efforts, particularly by people in South America, are beginning to turn the tide.

According to Maude Barlow, at a recent U.N. Assembly, "One

continued on page 42

hundred and twenty-two countries, including China, Russia, Germany, France, Spain and Brazil, supported the [water is a human right] resolution, and many of those that abstained said they would revisit their opposition if the Human Rights Council were to weigh in with a similar resolution." The support the resolution received that day demonstrated that the world was finally moving to address the issue. The countries that voted in favor represent 5.4 billion people.

Barlow adds that in June 2012, the *water as a human right* argument took a major step forward: "After a strenuous campaign, the rights to water and sanitation were included in *The Future We Want*, the official statement of the summit. Even Canada, the last holdout, signed the document, signaling the end of the debate."

What does such political wrangling mean in the real world of water access and conservation? It makes access to water a legal entitlement, not a "charity," or commodity that can simply be sold off to the highest bidder. In principle, everyone who depends on a given water source is entitled to a say in how it's used. Now, carry that precedent into the American landscape, with its water-dependent "breadbasket" of farms and isolated desert cities such as Las Vegas, and you get a sense of the enormity of change on the horizon.

Impending H_2O Shakedown

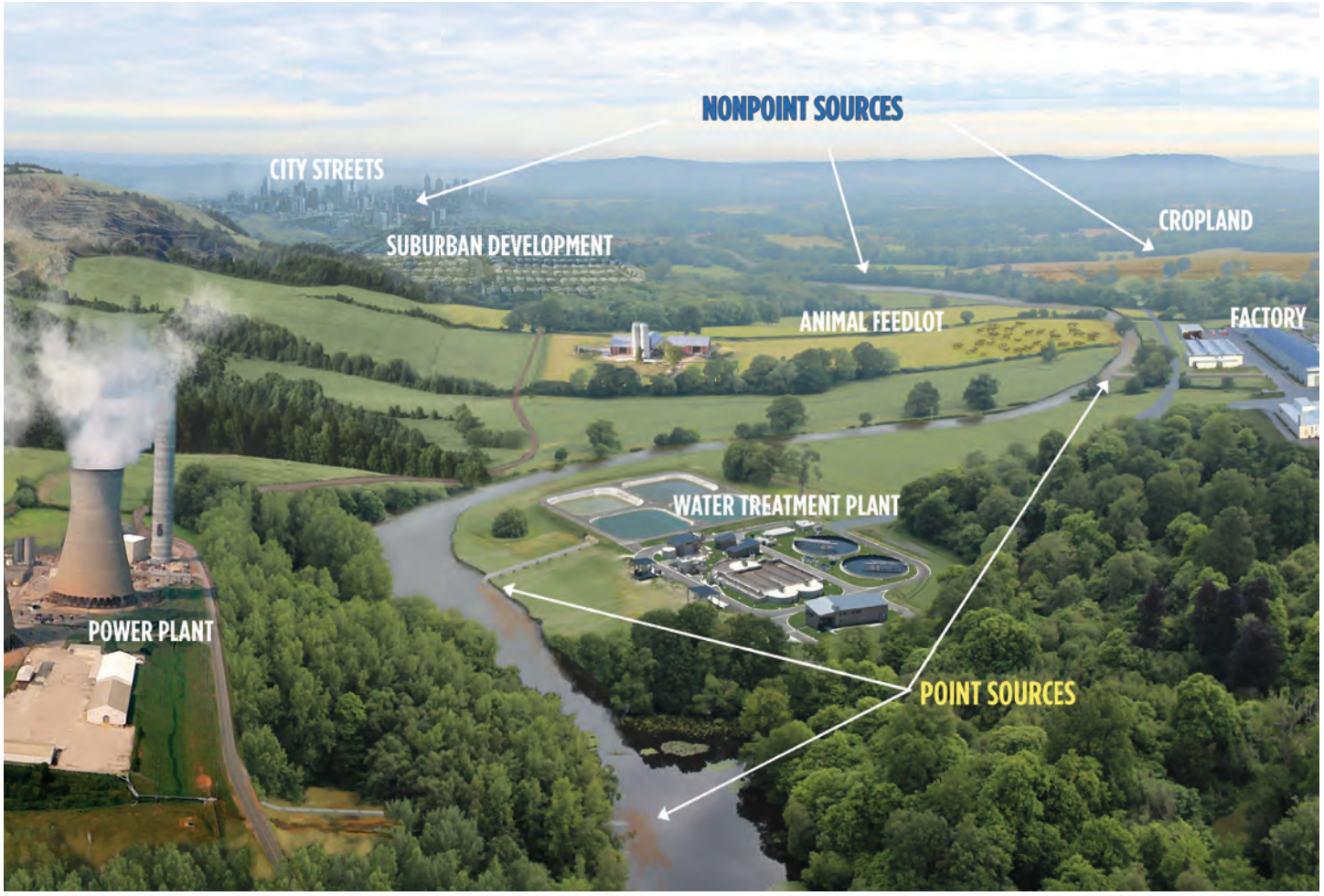
For decades, fresh water has been treated like an infinite resource, provided at almost no cost to farms and industry. The U.S. West has just suffered the worst drought in 800 years. In the Midwest's heavy farming areas, the backup system of tapping groundwater is coming to an end. Water is about to get a lot more valuable.

Author Steve Maxwell (*The Future of Water*) explains:

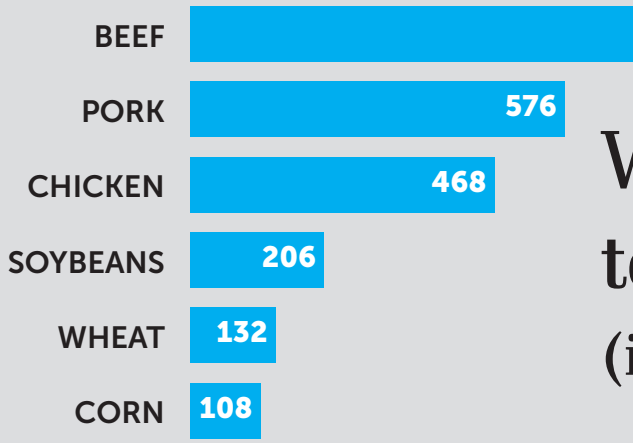
"Farmers generally pay almost nothing for their water, for one of three reasons: first, because in many regions that water simply falls out of the sky onto their fields; second, because they can pump the water out of an aquifer below their fields without paying for it, and they don't have to replace it; or third, because they get their water from a government-built reservoir or other subsidized water project."

But those aquifers are running low. Once they're dry, they may

A Long Way to Flow

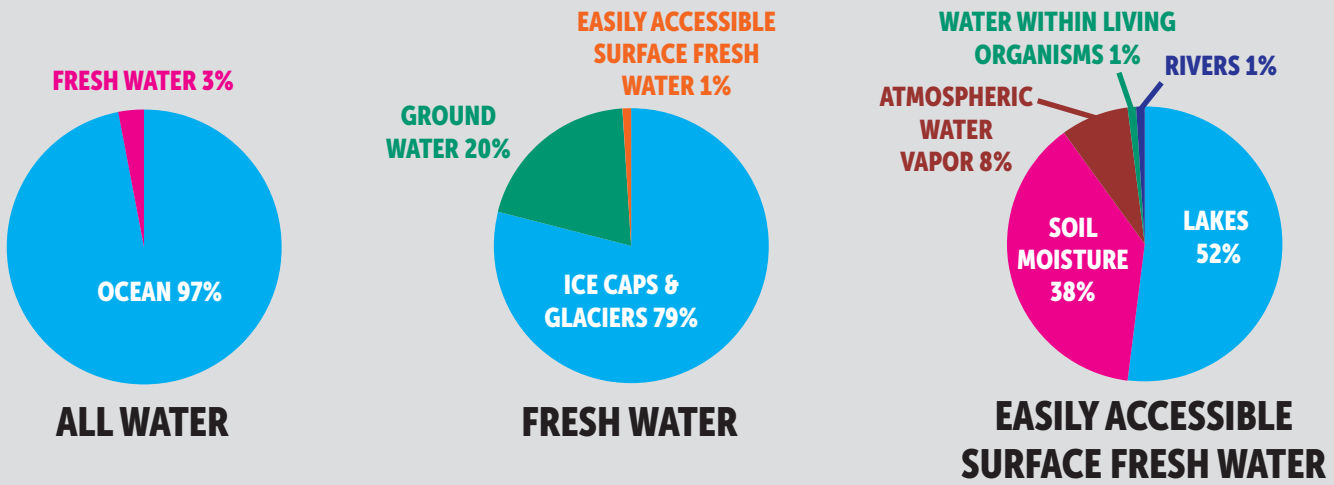


Hot Spots. Fresh water picks up pollutants and excess nutrients from a wide range of human sources, often with negative environmental impacts.



Water Required to Produce One Pound
(in gallons of water)

SOURCE: **NationalGeographic.com (http://tinyurl.com/yg3c67u)**



Why Change? Although the planet is abundant with water, most of it is not directly consumable. Adjusting our water guzzling dietary habits (top) could vastly reduce the strain we're putting on that precious 3 percent. SOURCE: USDA

not refill for centuries (or longer). At the same time, the growth of the cattle and biofuels industries is guzzling ever-more water. Suddenly, blue is the new gold.

The next couple of decades are likely to be contentious. Major issues will be decided around water rights, both globally and here in the U.S. Do citizens have the right to collect rainwater if aquifers are dry? How much water should go to farms versus cities? Do residents of Las Vegas have rights to water that originated in their state? These are very emotional, tough questions. But what if they could be "softened" by dramatic changes in conservation?

Serious Action

In our view, impending debates about fresh water don't have to become bitter. We have within easy reach a whole palette of conservation solutions that would not result in major societal disruption. Of course, the challenge will be to avoid the "efficiency trap." As we've discussed in other chapters of *The Celestia Project*, people have a bad habit of using efficiency gains to justify additional consumption. Reductions in fresh water demand must be accompanied by ongoing attention to water's true value.

Conservation as a path to water security is not a new idea, but in most places, it's proceeding at a pace that's glacial. In water-worried Las Vegas, for example, there's a plan to reduce per capita water consumption to about 199 gallons per capita per day by 2035. That's a gain of only about 120 gallons below the national household water-use average over a period of 20 years.

These "baby steps" may be as far as utilities dare to project, but we're under no such political restraints. So let's look at just five attainable behavior and industry changes that could solve most of our future water woes at a throw—some of them by themselves. What you begin to realize is that the dire condition of our water future has a lot to do with the way we have chosen to live. The fault, in other words, "lies not in our stars, but in ourselves."

continued on page 44

Balancing the Water Budget

1. Skip the Burger. Whenever humans make something, it contains a certain amount of "virtual water." This is an estimate of the amount of water required to produce this product. Recently, researchers have tried to estimate the virtual water footprint for various types of foods. Americans, on average, eat about half a pound of meat a day (**eco-centric.com**). Some estimates put producing a pound of beef at 1,800 gallons of water. So for the meat alone, we're using 900 gallons of virtual water per day. That's almost three times the total daily household water use for a U.S. family (320 gallons), according to the EPA. It's no wonder that a study in Finland calculated that by switching to a vegetarian diet, enough water would be saved to feed an additional 1.8 billion people around the world.

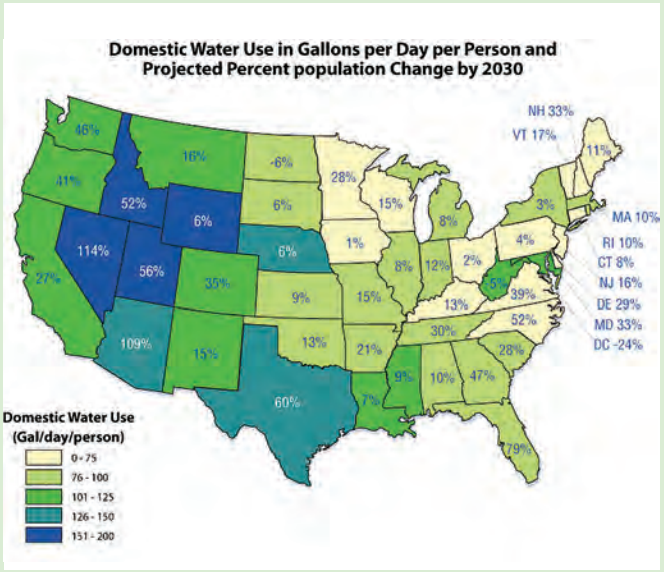
2. Forego that T-Shirt. Some crops are more equal than others. WAY more equal. Cotton is one of the worst water guzzlers on the planet. According to *WorldWildlife.org*, producing a single cotton T-shirt can require up to 2,700 gallons of water. In addition, growing cotton usually involves vast amounts of water-polluting chemicals: "2.4 percent of the world's crop land is planted with cotton, and yet it accounts for 24 percent and 11 percent of the global sales of insecticide and pesticides respectively."

Add to that the lifelong costs of washing and drying it, and a simple T-shirt becomes a virtual water Goliath. What are the alternatives? Innovations in nano-fabrics that are self-cleaning may hold the key. That 100-percent cotton T-shirt from Patagonia may *seem* like a green statement, but the world's water supply might be far better served if we all wore permanent press synthetics. The challenge for manufacturers is to create synthetics that feel like cotton, and for fashion leaders to embrace a new age of synthetic clothing. We've done it before. In World War II, the military sold us on the benefits of rayon and nylon. Even polyester seemed sexy when John Travolta was wearing it in *Saturday Night Fever*. Fashion is flexible, whereas the need for fresh drinking water is not.

3. Go Net Zero (Preferably Solar). Most U.S. power plants deliver electricity at 30 percent efficiency. Beyond that sobering fact, however, is their water cost. Cooling thermoelectric plants

Irrigation: The Other Giant Sucking Sound

What's Wrong with Texas? The impacts of agricultural irrigation can be seen clearly in this map of projected per capita water use for the year 2030. Many of these large agri-farms rely on sources such as "fossil water" aquifers that may take many years to replenish. But the map also highlights just how big an impact localized irrigation has. Note the low water use in the New England states, which are just as lawn-crazy as other states. But annual rainfall in the Northeast greatly reduces irrigation needs. Along with other major shifts in water consciousness, the use of water-thirsty lawns in regions that can't support them with natural rainfall must be curtailed.



SOURCE: EPA

"Fit for Purpose" Comes of Age

Do we really need drinking water in our toilets? In the U.S., we drink about one percent of the drinking water quality water piped into our homes. The other 99 percent of this high-quality H_2O is used to flush toilets, wash laundry, water lawns and take showers.

THIS INEFFICIENT USE OF water treatment has begun to get more scrutiny, now that water availability has become an issue. So-called "fit for purpose" water supplies (separate pipes carrying differently treated water) are being taken more seriously. In fact, the new 2012 International Residential Code includes a non-prescriptive section encouraging graywater reuse in homes.

demands vast quantities of our nation's fresh water resources (albeit returning much of that to the hydrologic cycle). Renewable energy such as solar photovoltaic requires water to manufacture the panels—but not continuous cooling over their lifespan. This is little considered advantage to standalone and small, decentralized solar plants. As we build our homes and multifamily projects to net-zero standards, we are automatically making major strides in fresh water conservation.

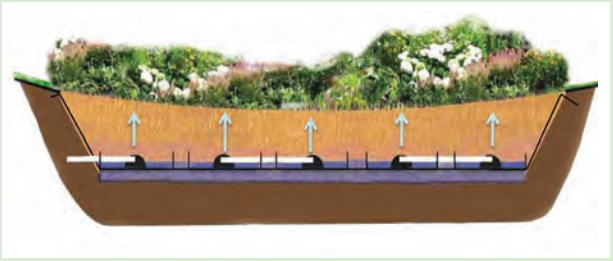
Next Generation? The Kohler *Numi* toilet has a built-in bidet cleansing function. It even warms your exposed regions as it cleans.

4. Embrace the Bidet. As I detailed in my *Editor's Note* in this issue, a simple lifestyle change in our bathrooms could save millions of gallons of water and untold acres of biodiverse forests. Toilet tissue is a real water guzzler, using almost as much "virtual water" per flush as the most efficient low-flow toilet. By switching to water-based sanitation, we could halve the impact of every flush.

5. Invest in Drip Irrigation. Switching from traditional sprinkler irrigation to drip and other "advanced" watering systems can reduce water use by 60 percent. The potential water savings for large-scale farms is almost incalculable. Why not redirect subsidies from water-wasting biofuels to irrigation systems for food farmers? This is one farm subsidy that could yield many layers of "downstream" benefits. For residential properties, homeowners can achieve similar efficiency gains by installing drip systems when landscaping. GB

Reusing Stormwater

Instead of removing or treating stormwater, localized "green stormwater" systems can return it to thirsty landscapes.



Hidden Reservoir. Traditionally, stormwater is treated almost as a toxic waste, redirected to local sewer lines or directly discharged into nearby fresh-water bodies such as rivers. But the converging pressures of water scarcity and stricter rules about development have spurred interest in reuse. For example, this *EPIC* system from Firestone Specialty Products offers a "no moving parts" way to reuse stormwater. The installation involves excavation to about 36 inches, followed by placement of geotextile that will trap the stormwater underground. According to Firestone, a layer of sand provides all the filtration necessary to control nitrates or phosphates—especially the top four inches or so. Water trapped in the chamber area below grade returns to the surface for irrigation. The top sand will need to be replaced in approximately 10 years.

THE CELESTIA FORECAST

The nightmare scenario of global water wars, drought and human suffering is not inevitable. As urban planners and citizens awaken to the real sources of water waste, they will seize upon opportunities to reduce it. Systemic changes will restore vast fresh water resources to the world portfolio. Innovations in farm irrigation, reuse of stormwater, decoupling from thermoelectric cooling (for fossil fuel-powered electric plants) will join with behavioral shifts. As citizens reduce consumption of meats, cotton, toilet tissue and other water-guzzling commodities, the Earth's hydrologic cycles will stabilize, allowing ancient aquifers to refill, even during long drought periods.

THE CELESTIA PROJECT

Material World

"IT SEEMED TO happen so fast, but of course it didn't. It had been coming for a long time. At first, it was the same old story: panic, lines of cars at the gas stations, hoarding. But a lot of people—and a few governments—were already off oil. They changed how the most polluting materials are used and reused, and taught the rest of us. We still use steel and aluminum and concrete, but we also maximize the potential of trees and other renewable resources. We stay within the limits of what Earth has to offer."

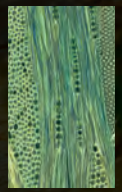
–Transom Vector, Bio-Engineer, 2094

Use of the "Top 5" pollution-causing materials continues unabated, despite dire warnings of climate impacts.

Life Cycle Analyses shift emphasis from manufacturing to production of raw materials, as governments align to combat Climate Change.

Global agreement restricting production of high-impact materials causes global price spike for cement, steel, aluminum and plastics.

Responding to higher value of materials, producers and manufacturers innovate highly efficient reclamation/reuse systems,reducing virgin material use by 60% over 2030.



Biotech breakthroughs enhance viability of renewable materials. Trees can be grown to meet precise engineering specifications.

2014 2020 2030 2040 2050

Advances in nanotechnology ease pressure on high greenhouse gas building materials by reconstructing end-of-life materials at the molecular level.

Solar-powered mobile 3d printers remove the "middle man" in reuse of construction waste and debris.

Global eco-restoration continues, with bioremediation and nanotechnology restoring blasted mountaintops and desertified forests.

As population gradually falls, optimized use of materials allows great artistic freedom and high quality of life.

2060 2070 2080 2090 2100

MATERIAL WORLD: A PLAN OF ACTION

To head off resource depletion and the worst climate change scenarios, our construction materials playbook must be rewritten.

LET'S CUT TO THE HARD FACTS. According to the International Energy Agency (IEA), buildings now produce about 31 percent of manmade greenhouse gases globally. Progress is being made, albeit very slowly, in reducing the impact of new buildings—at least in the U.S. and parts of Europe. But we need to move faster, not just in the building industry, but across all industries, reducing our overall CO2 emissions. ...So, how do we do so?

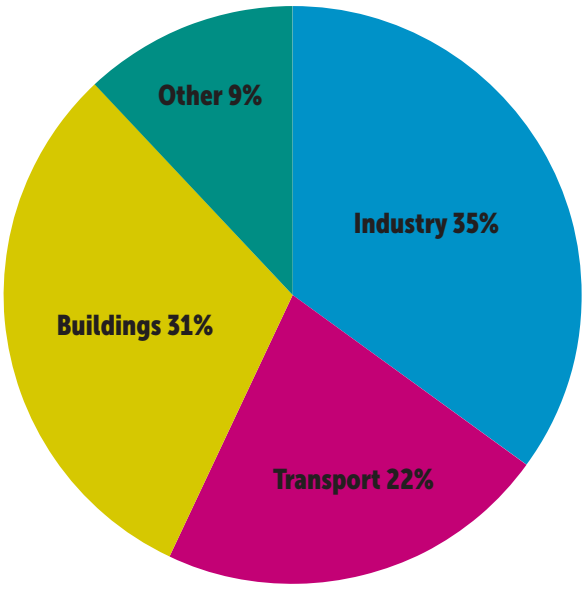
According to the authors of *Sustainable Materials: With Both Eyes Open*, one answer is to turn our focus to a handful of the most polluting materials used by both industry and the building sector: steel, aluminum, cement, plastics and paper. Producing these materials—especially steel and cement—is playing a major part in pushing us past the dangerous 400 ppm CO2 "tipping point" of climate change.

Our choice to use materials such as steel and concrete for buildings is no accident, of course. They're strong, durable, predictable and abundant. But the latest environmental forecasts suggest that the ecological cost of continuing to produce them at current volumes, using current methods, could be disastrous for life on Earth.

CO_2 Pollution

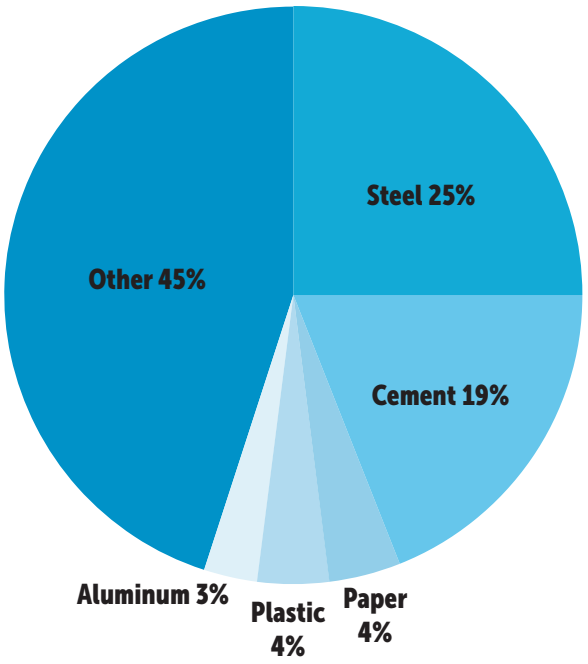
Industry's five biggest energy-consuming materials offer clear targets for the building industry.

Global Manmade CO_2 Emissions



Energy Breakdown. The IEA breaks down emissions by sector based on energy use. The use of buildings is second only to industry in scale of $C0_2$ pollution. This data does not include the embodied energy of the materials in buildings.

Industry Material CO_2 Emissions



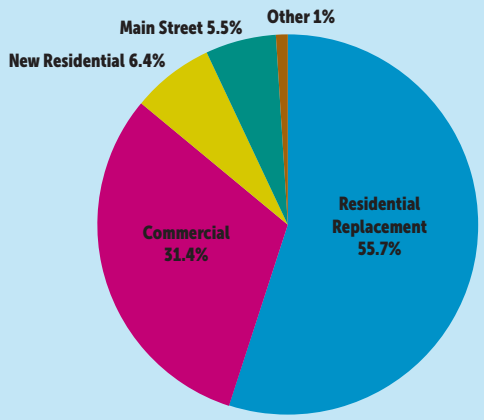
The Five Horsemen. The production of these five materials accounts for 55 percent of all industrial CO_2 emissions globally. Note that many are used in construction.

Source: *Sustainable Materials,* Allwood & Cullen, 2012

THE CARPET CONUNDRUM

Homes and apartments still account for about 62 percent of sales in the U.S.

Carpet Sales by End Use



Replacement Blues. Why is carpet the biggest CO_2 polluter in many new homes? Because over a 50-year life cycle, it's replaced several times—and little of it is recycled (or made from recycled content). Sales of carpets for homes slowed over the last decade, but have been rising again in the last couple of years.

Source: *Floor Covering Weekly*

So what's the fix? There's no quick and easy answer, but we have several options, some more extreme than others. A few of the approaches past and future:

Squeeze Growth. This is probably the most controversial and contested way to reduce material use. Past efforts to limit or curtail growth have required a reversal of the dominant economic growth model in favor of a "no growth" benchmark.

One major argument (and it's a good one) is that even if the U.S. decided to attempt such a move, it's doubtful that China, India and other expanding economic powers would agree. If the calamities of global warming become the alternative, however, extreme measures such as growth moratoriums may meet less resistance.

Optimize Design. A better option, especially for those who make their living in the building industry, is to optimize the use of both existing and future materials (e.g., more use of demolition salvage). But this solution is subject to "The Efficiency Trap," that I've written about in other chapters. Environmental gains often get converted into different polluting choices—negating the CO2 avoided by the first effort. (i.e., *If I can build a skyscraper with half the steel, I've saved enough steel and done enough environmental good to build another one.*)

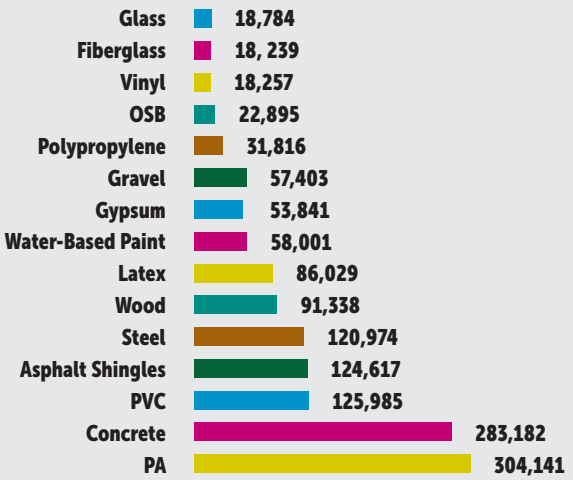
Hope for High-Tech Innovations. Advances in computer modeling, robotic fabrication and biotech offer tantalizing prospects for future materials that are less energy intensive, such as mushroom and other plant-based insulation, algae-powered photovoltaics and engineered plants and trees with qualities that make them ideal for specific uses. These advances are coming, but most are not commercially available yet. It's important to take action now, during the transition period, to more benign materials and better use of existing stock.

Materials in the Modern Home

You might think that the conventionally built, wood-framed house has a relatively minor greenhouse gas (GHG) impact, because it's framed with wood, not steel, and only uses concrete at ground level and few plastics. But when you look more closely at a home's complete life cycle, as noted in the Univ. of Michigan study results (above), it embodies energy in surprising ways.

Materials in New Homes

(In Megajoules of Energy)



Carpets and Concrete. This research at the University of Michigan looked at a 2,000-sq.-ft. home's total embodied energy over a 50-year life cycle (including replacement). Note that PA, or polyamide, turned out to be *the biggest energy user of all*. It's a compound found in carpets. A subsequent redesign of the home with alternative flooring, roofing and optimized foundation reduced total life cycle CO_2 release from 1,013 metric tons to 374 metric tons of CO_2—a 63 percent reduction.

Source: ***bit.ly/1riiH0i***

For example, synthetic carpet has an enormous embodied energy footprint. And although companies such as Mohawk and

continued on page 46

The Carpet Problem. The reason synthetic carpet looms so large as a CO_2 polluter is largely because it's replaced so frequently.

Interface are trying to find more sustainable materials, use of extensive carpeting is a huge polluter—in part because carpets are typically replaced every seven years or so. A typical modern carpet is made up of nylon, polyester, polypropylene or a new material called triexta. Only about 1 percent are made up of natural materials such as wool or hemp.

Another surprise in the conventional home is the big emissions footprint of latex and paints in general. This makes more sense for the same reason that carpet is a major player. Products that require regular replacement—especially ones that are energy intensive in production—tend to spike very high over life-cycle analyses.

What about steel? Where's the steel in a new home? You might think "appliances," but much of the mass of steel is hidden. For example, a lot of rebar is buried inside the concrete footers and foundation. Then there's the big gray elephant on any building site: concrete, with its high percentage of energy intensive Portland cement, especially if it's a conventional mix.

That last point is key, because it highlights one of the many ways building professionals can greatly reduce a building's CO2 impact. By paying close attention to the "five horsemen" materials used in a project, it's possible to cut life-cycle emission by almost two-thirds—with little, if any, visible sacrifice for the end product.

Embodied Energy, Revisited

Before we look at the pathway to those reductions, it's important to look more closely at the idea of embodied energy versus operational energy. We've often talked about how a home's initial construction may account for just 6 percent of its life-cycle impacts. Some estimates in the UK, however, put that figure closer to 16 percent. Our educated guess is that the figure is somewhere between that (around 11 percent) for U.S. homes, due to greater use of insulating plastics and PVC windows and composites.

But as a report in a British trade publication recently pointed out, a ton of CO2 released at the time a home is built *is not equal* to a ton released over the building's lifespan. It's worse. That initial CO2 may remain in the atmosphere for the life of the home, doing

Which Sidings are Greenest?

NOT INCLUDED IN THE MICHIGAN case study were other sidings, such as fiber cement, brick veneer and manufactured stone. It's tough to make a $C0_2$ side-by-side call on these materials. Fiber cement, for example, lacks good third-party data on paint longevity. Brick's durability is bulletproof, of course, but most emissions studies only look 50 years out, a mere fraction of brick's potential lifespan, so judging brick's life-cycle CO_2 impact based on a 50-year timeline seems skewed. Perhaps these are good research topics for our new Mariposa Meadows research facility in Colorado, scheduled to open next year.

The Right Roofing

Complex variables hamper life-cycle comparison of roofing materials.

THE CHOICE OF A "GREEN" ROOF IS not as clear-cut as you might imagine. Standing seam metal roofs, for example, can last 100 years, but their emissions footprint is high on the front end, depending on the proportion of directly recycled steel in the product. The same can be said of clay tile or slate, with a lifespan in the centuries. Other contenders such as recycled rubber look viable, as do wood shingles. More "apples-to-apples" emissions analysis is needed. We expect to do a full report on this product category in a few months.

What's Recycled? An aluminum standing seam roof can last for a century, but make sure you ask whether the roof is made from recycled content, not just recyclable. The latter is a greenwashing term. The former reduces the embodied energy of the aluminum by about 75%.

IMAGE: METALROOFING.COM

damage every year (full article at **bit.ly/1rhengC**). In other words, says article author Kate de Selincourt, the damage is cumulative.

The implication of this analysis: *The choice of initial materials used in a new home may have as much impact on its greenhouse gas emissions as the lifetime performance of the building.* That's weighty information. Now what do you do with it? Change the way you build.

What Builders Can Do Now

As the researchers at Univ. of Michigan discovered, it's possible to reduce the lifetime greenhouse gas footprint of single-family homes dramatically, by focusing on stuff that causes the most emissions. The suggestions below don't suggest that you forsake energy efficiency for low impact materials. On the contrary, when you do use plastics, paint, concrete or steel, they should be specified carefully and with extended durability in mind. Here's what we can safely suggest:

Remix that Concrete. The cement industry has begun to get serious about testing and monitoring the fly ash that's now frequently used as a cement additive. Adding lightweight fly ash can reduce cement's GHG emissions per ton drastically.

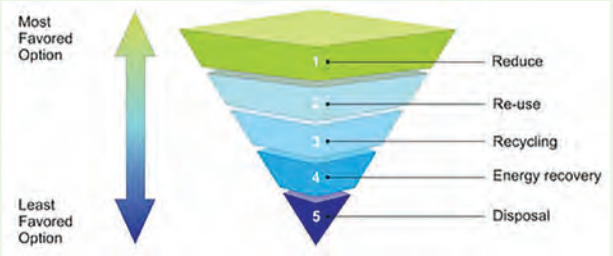
Choose Simple Slabs. A full foundation for a 2,000-sq.-ft. home will produce about 38,000 lbs. of CO_2 pollution. Compare that with a slab on grade at 24,500 lbs. of CO_2 emissions. Add fly ash to the mix and reduce that impact by 15 to 30 percent.

The other hidden benefit of switching to a shallow foundation is that it requires less steel rebar. If you're interested in further reducing the embodied footprint of your slabs, you could try some of the new fiberglass rebar products. Fiberglass is less energy intensive to produce than raw steel, although more research is needed to quantify the exact CO_2 savings resulting from a switch to FRP. Will the product impact important concerns such as foundation cracking?

Paint by the Numbers. If you choose siding materials that

continued on page 49

These Rules Still Hold



Upcycling for the Win. The same rules of thumb that apply to the casual homeowner trying to reduce waste also apply at a global resource level. First choice should always be to use LESS, followed by re-use of materials.

WOODEN SKYSCRAPERS?

A new idea for fighting climate change is rising worldwide—to build high-rise structures using wood, and even the USDA is interested.

Tree Housing. **This upscale 10-story wood building in Melbourne, Australia, is one of many wood-framed high-rises going up in other countries. The wood used is cross-laminated timber, said to be similar in performance to concrete and steel.**

WALKING THROUGH BOSTON last month, surrounded by beautiful, towering architecture, roof gardens and dense, urban efficiency, I felt overwhelmed by the city environment. If concrete and steel are the biggest polluters or our time—ones we need to use less of—how can we ever create incredible urban spaces without them? At that moment, serendipity struck, as I passed by an exhibit by the Boston Society of Architects titled "Urban Timber: From Seed to Tree."

The exhibit, now closed, included some fascinating examples of the way wood is being manipulated for greater strength and performance, along with dozens of case studies of unusual wood structures, including a litany of high-rise wood apartment buildings.

Wood hadn't been taken seriously as a contender for the high-rise framing market in the U.S. until recently, but the USDA issued a statement in March that it's looking at the buildings as "climate mitigation tools."

Plenty of examples of successful wood high-rises can be found abroad. Sweden, for example, has approved the world's tallest wood high-rise—30 stories—and another 34-story unit is in the planning phases.

PHOTO: "URBAN TIMBER" EXHIBIT, BSA

Wood Flexibility. **New forming techniques will soon be combined with biotech, allowing wood to approach steel's performance.**

Exhibit Website: ***bit.ly/1oTBMWr***

require painting, longevity should be a major concern. Wood siding should be dried to recommended moisture content, never left exposed to UV, back-primed and end-coated.

Ponder PVC. Polyvinyl chloride products such as vinyl floor coverings and vinyl siding come at a high emissions cost. But are they worse, for example, than wood siding that has to be painted repeatedly? Probably—once you factor in the effect of the initial greenhouse gases over time. Although the study suggests that PVC balances out with paints in emissions over 50 years, PVC's emissions will be cumulative, because they're produced at the early stage. That's lingering pollution in the atmosphere.

Consider Carpet's Impact. Conventional synthetic carpet has a major uphill struggle to demonstrate its viability in our green future. Carpet makers need to rethink the sourcing of their materials, their poor recycling record and their role as major polluters.

Weigh Roof Shingle Impacts. Modified asphalt roofing shingles are inexpensive, ubiquitous, and their production results in significant CO2. An increase in post-consumer recycling in the past few years has reduced their overall impact. But shingles are often still treated as a disposable product. At best, they can last 50 years. At worst, under 15.

When they are thrown away, unfortunately, only a small portion of the millions of tons of tear-off asphalt roofing collected each year is actually reused in paving. The paving industry reports that "1.2 million tons of reclaimed asphalt shingles (RAS) were collected in the United States during 2011 for use in new pavements." About 11 million tons of roofing are torn off each year, so that's about a 10 percent recycling rate.

To their credit, the roofing industry has done what most carpet makers haven't—they've sunk a lot of money into reducing their emissions. But they're up against what so far have been insurmountable technical challenges in waste separation and reuse.

Think Small. With initial emissions playing a larger role, the impact of a building's overall size should be front and center. By this standard, a smaller house is quite simply a greener house, assuming it's built with the same mix of materials. This negates one of the few rationales for building large homes—that their performance should overshadow their initial polluting impact.

B.S. Versus Building Science

It's tough to separate manufacturer claims from third-party research on embodied energy. As de Selincourt notes, "With so many measuring systems to choose from, everyone can show their product is 'lower' in embodied energy, through the careful choice of figures or—if that's too much bother—just leaving out figures altogether."

That being said, we've identified for you "the big five" polluting materials. If you take nothing else away from this article, simply by changing your practices to use less of these materials, you can take part in the building industry's part of reeling in greenhouse gas emissions. That's today's priority—but what about tomorrow? GB

THE CELESTIA FORECAST

Concerted efforts to reduce the amount of high-intensity materials used in construction and industry will buy us time in the face of looming climate change. We'll use this time to pursue advanced nanotechnology and biotech advances, including the creation of genetically modified trees and plants designed for specific architectural uses, molecular revitalization of used materials and complete material separation (making 100 percent recycling rates possible for any substance). At the same time, designers will harness powerful digital tools and imagination, creating structures that use a fraction of the resources to achieve better performance than the best structures today.

THE CELESTIA PROJECT

Building Bubble. Despite many warning signs, conventional construction continues worldwide, as CO_2 levels pass the "tipping point" of climate change.

Shaky Ground. Intensive fracking for natural gas elevates seismic activity worldwide, leading to stricter seismic standards for both residential and commercial structures.

Wash Out. Devastating floods in Florida shock the nation, but resilient homes that survive the deluge draw national attention, leading to rapid changes in coastal codes.

2014 2020 2030 2040 2050

Resilience

Tomorrow's housing will be designed to survive nature's extremes.

"WE HAD A SMALL TSUNAMI YESTERDAY, but no one panicked. That's the third one this year, since they started fracking in Mexico. The thing is, we saw this coming 20 years ago, so we've got all kinds of safeguards in place: restored marshlands on the coast, hydro-aqueduct systems, home elevation systems. We're ready for anything."
—Chantal Rivers, Builder, New Orleans, 2041

Risk Blowback. Soaring flood claims bring the federally subsidized insurance business to an end. Private insurance costs force many people to sell or abandon their coastal homes, as waterfront access is returned to the public.

Above the Fray. Radical new flood protection method allows a home to be elevated up to 0 ft. above its foundation, in winds up to 120 mph. Other homes simply "float" in extreme flooding.

Ready to Roll. New codes limit home sizes in at-risk areas, restricting them to modules that can be moved by vehicle to safe ground within 24 hours of a storm event.

Redundant Defenses. Homes and cities are built smarter, with double- and triple-backup systems and self-sufficiency as part of every design.

2060 2070 2080 2090 2100

READY FOR ANYTHING. The frequency and intensity of future weather events and food crises make preparing for unpleasant surprises a precautionary principle for all new and retrofit construction.

ALL BETS ARE OFF with regard to the extreme weather threats of the future. That's more or less what FEMA now says about its "best guess" tools for determining the probability of floods and other major disruptors.

As an example, look at the list of exceptions they make to the inset graph predicting how likely it is that floods will exceed expectations:"FIRMS (flood insurance rate maps) do not account for the following:

- Shoreline erosion, wetland loss, subsidence and relative sea level rise
- Upland development or topographic changes
- Degradation or settlement of levees and floodwalls
- Changes in storm climatology (frequency and severity)
- The effects of multiple storm events

Thus, what was once an accurate depiction of the 100-year floodplain and flood elevations may no longer be so."

Assuming FEMA, NASA, the Pentagon and thousands of scientists worldwide are right about the side effects of impending climate change, what's the best preemptive strategy for building and designing the homes and cities of the future?

Redundant Engineering

The airline industry considers redundancy one of the best tools for preventing disasters. Hydraulic systems, for example, are often duplicated—or even triplicated—to ensure that if one fails, another takes over. Why can't housing be designed with the same principles in mind?

Some methods and systems in modern construction already rely on redundant systems. Roofing underlayment, for example, plays a backup role to shingles or tiles. In well-built custom homes and factory-built modular panels, fasteners sometimes serve as backup to the adhesive that connects drywall to frame.

The homes and cities of the future will take redundancy for granted, as a fail-safe against storms, wildfire, earthquakes and flooding.

Simply elevating a home in a flood zone, for example, won't be the only measure taken against flooding. It may also contain advanced systems for surviving prolonged sea level rise, tsunamis and other threats. And if living spaces are breached, lower floors will be made of materials that can be easily cleaned, perhaps with high-pressure washing equipment that's already part of the home's infrastructure. Future homes will be "ready for anything."

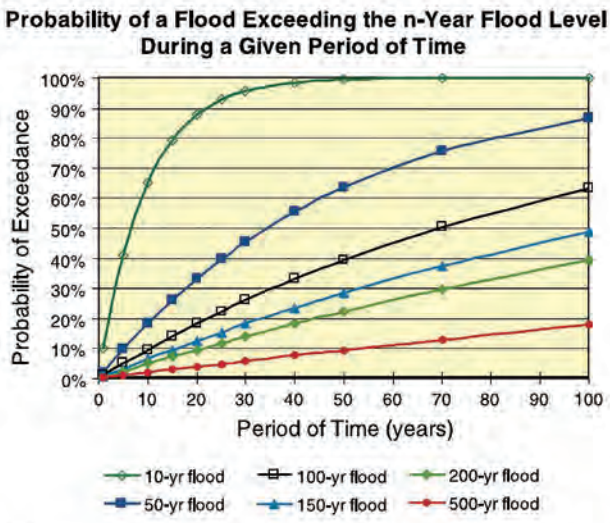


Figure 3. Probability that a flood will exceed the n-year flood level over a given period of time (Note: this analysis assumes no shoreline erosion, and no increase in sea level or storm frequency/severity over time).

Why We Will Change

A lot of the initial spending on resilient building likely will be driven by homeowners looking to retrofit their one-of-a-kind residences in at-risk areas. They'll be looking for a stable, secure setting. They don't want to lose that million-dollar view, nor sacrifice comfort and stability. Some of those dreams will be harder to hold onto than others, however, and owners without deep pockets may find themselves retreating from shorelines, seismic areas and parched wildfire zones sooner rather than later. Here are some of the major reasons why:

1. The End of Subsidized Risk. As we move into a more frugal future, federally backed flood insurance will face increasing scrutiny. It just makes economic sense. At present, just under 6 million homes are now protected by federal flood insurance—a protection NOT offered by most homeowner policies. When this protection ends, all of the risk will transfer to the private sector.

2. Insurance Rollback. Current flood protection policies typically cost about $600 a year for $350,000 in residential coverage ($250,000 for property, $100,000 for possessions). But what if that subsidized insurance dries up? As extreme weather events increase, private insurers will face whopping bills, which they will pass on to homeowners in higher premiums. Some owners will be unable to handle those costs. And it's not just flood insurance that's likely to become inaccessible—homes in earthquake-prone areas are only slightly better off. A private policy for a $300,000 single-family home in San Francisco could run about $650 annually. But what happens if frequency of quakes increases dramatically? (Source: **http://www.earthquakeauthority.com**)

Dome Fortresses

If only we could learn to love domes. With no eaves to catch wind uplift, great flood resistance and even earthquake stability, what's not to love? The trouble is not in these designs, it's in what makes us feel "at home."

Want a tornado-proof home that can stand up to everything, possibly including a nuclear blast? Try a dome home with no windows that's anchored to the ground right through its monolithic walls.

Monolithic domes still represent only a tiny portion of the new home market, but they have arguably the best wind performance of any structural design. Schools in the Midwest are using dome designs to safeguard kids against sudden hurricanes.

3. Coastal Surrender. About four years ago, the U.K. began abandoning certain seaside areas to nature, because it couldn't afford the billions necessary to keep flooding at bay (http://tinyurl.com/o5khcmm). The U.S. is feeling similar strain, as civil engineers try to contain eroding beaches and protect homes near the water, especially along the lower Atlantic coastline. Rising sea levels alone may be enough to stymie the best efforts of civil engineers to protect coastal housing. Add monster storms to that mix, and you can understand the sense of panic that some coastal residents are feeling. The city commission of South Miami, for example, just voted in favor of a resolution calling for dividing Florida into two states, one in the north, the other "South Florida," in the low-lying southern half of the state.

Their concern—and it's a legitimate one—is that sea level rise is imminent, and the politicians on the high ground in Tallahassee show none of the political will necessary to protect the millions of residents who will be "losing ground" this century.

The Best Defense

The term "resilience" gets a bit muddied at times. It's often used to refer to two different types of future challenges: extreme weather-related events (floods, wildfires, earthquakes, superstorms) and resource scarcity. The latter category include shortages of food, water or breathable air—basic human survival needs.

In previous chapters of the Celestia Project, we've talked about how to avoid scarcity and achieve food and water abundance over the next century. So our resilience focus is primarily on the weather-ready aspect—ways to survive and mitigate some of the worst-case weather scenarios in the shelter we build and strengthen over coming years.

Floods: A Surge of Ideas

We begin the discussion of weather threats with flooding because it's one of the most destructive—and hardest to build against. It's generally less costly to

continued on page 50

"By elevating the buildings on plinths made of mounds of compacted fill, it has been possible to connect HafenCity with the existing city area and develop it step by step from west to east, and from north to south. All new buildings stand on artificial bases eight meters above sea level—out of reach of the most extreme flooding. [...] It is the responsibility of the private developers of buildings to put these artificial compacted bases in place, so their number is growing as the number of buildings increases."

CREDIT: WWW.HTTP://NLPPLANNING.COM

retrofit a home or multifamily structure for hurricanes and moderate earthquakes than to withstand a major flood, or repeated flooding.

The Boston Society of Architects just hosted their annual conference, with emphasis on storm-ready, resilient housing. Boston's city officials are keenly aware of risks related climate change, according to Crystal Aiken of The Boston Harbor Association. She notes that the city has seen four recent storm surges that "have come within hours of striking Boston at high tide." She and her panel of experts described how other countries such as the Netherlands have adopted a "Live with Water" approach to rising tides. That approach, however, involves storage of huge amounts of excess water during certain months. They have waged an aggressive PR campaign to convince the public to "make room for water" in their communities, in the form of giant seasonal lakes and reservoirs.

Such an approach might work in parts of the U.S., but what about major coastal cities with little undeveloped land to spare? HafenCity, part of Hamburg, Germany, is preparing for storm surge flooding by raising multi-family structures on special "plinths." The technique is described by city planners, as quoted on the previous page.

If flood intensity (and depth) increases over the next century, planners will apply new tools. They'll be looking much more closely at materials and active, as opposed to passive, flood resistance.

Raising buildings above flood levels is not a new idea, of course. Even "old school" wooden pilings often outlast the structures they support. The city of Portland, Maine, for example, is debating what to do with some partially submerged piers on the waterfront that were sunk into the mud about 90 years ago.

But what if sea level rise results in repeated flooding or lengthy submersion? Buildings will need to incorporate not only the usual flood-ready details, such as water inlets, pilings and structural bracing, but also materials (left) that can be cleaned instead of replaced.

FLOOD-RESISTANT MATERIAL LIST

Types of Building Materials	Uses of Building Materials		Classes of Building Materials				
			Acceptable		Unacceptable		
	Floors	Walls/ Ceilings	5	4	3	2	1
Structural Materials (floor slabs, beams, subfloors, framing, and interior/exterior sheathing)							
Asbestos-cement board		■	■				
Brick							
Face or glazed		■	■				
Common (clay)		■		■			
Cast stone (in waterproof mortar)		■	■				
Cement board/fiber-cement board		■	■				
Cement/latex, formed-in-place	■			■			
Clay tile, structural glazed		■	■				
Concrete, precast or cast-in-place	■	■	■				
Concrete block		■	■				
Gypsum products							
Paper-faced gypsum board		■			■		
Non-paper-faced gypsum board		■		■			
Greenboard		■				■	
Keene's cement or plaster		■			■		
Plaster, otherwise, including acoustical		■				■	
Sheathing panels, exterior grade		■			■		
Water-resistant, fiber-reinforced gypsum exterior sheathing		■		■			
Hardboard (high-density fiberboard)							
Tempered, enamel or plastic coated		■				■	
All other types		■					■
Mineral fiberboard		■					■
Oriented-strand board (OSB)							
Exterior grade	■	■				■	
Edge swell-resistant OSB	■	■				■	
All other types	■	■					■
Particle board	■						■
Plywood							
Marine grade	■	■	■				
Preservative-treated, alkaline copper quaternary (ACQ) or copper azole (C-A)	■	■		■			

Tough Stuff. FEMA classifies building materials based on how well they can handle flooding, with Class 1 and 2 "unacceptable" for flood resistance. Class 5 materials, on the other hand, are "highly resistant to floodwater damage, including damage caused by moving water." See the full chart at **http://tinyurl.com/qxfb89y.**

Storm Wind Readiness: *The Details Matter*

Techniques and products for storm-ready construction have advanced over the last 40 years. If you have any doubt, visit the aftermath of a hurricane. The homes that suffer the most damage are usually the ones built prior to modern building codes. Modern U.S. homes, built properly to the code adopted by their local region, tend to perform extremely well in hurricanes and earthquakes.

That being said, however, all it takes is one chink in a home's armor to turn minor storm damage into a total property loss.

The powerful succession of storms and tornadoes in the last decade have led to a lot better understanding of how and why homes "fail" in storm winds.

A few years back, I visited the sites of both the La Plata, Maryland, tornado and Hurricane Katrina immediately following those storms, so I got a first-hand look at why things fall apart. In extreme winds, homes typically go to rack and ruin because of either wind uplift or pressure differentials as air enters the home.

Oddly enough, homes from the 1920s and '30s sometimes fare better than ones built in the 1950s.

Brick Veneer Best Practices

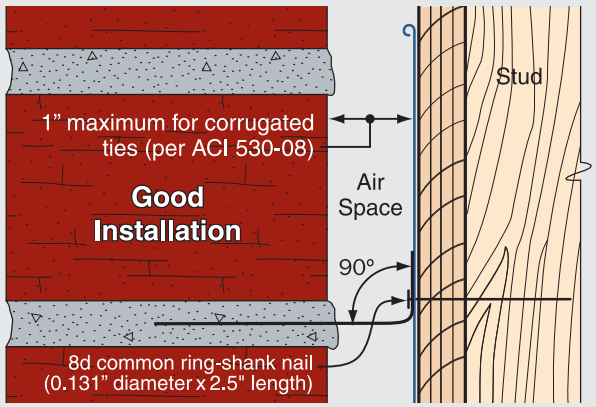
IF INSTALLED PROPERLY, brick veneer can handle hurricane-force winds. Too often, however, they are not attached as the code dictates. Failures can usually be traced back to the metal ties that hold the brick to the wood frame. They can fail if they are corroded (common along coastal areas) or misaligned. Here are some of FEMA's general and specific best practices recommendations for veneer brick, based on post-failure analysis:

Stud Spacing: For new construction, space studs 16" on center, so that ties can be anchored at this spacing.

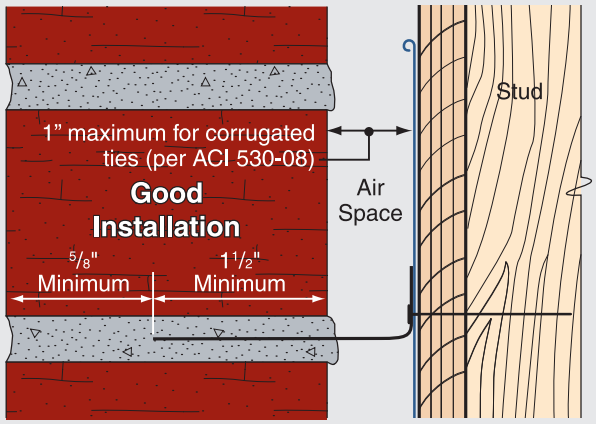
Tie Fasteners: Ring-shank nails are recommended in lieu of smooth-shank nails. A minimum embedment of 2" into framing is suggested.

Ties: For use with wood studs, two-piece adjustable ties are recommended. However, where corrugated steel ties are used, use 22-gauge minimum, 7/8" wide by 6" long, with a zinc coating. Stainless steel ties should be used in areas within 3,000 feet of the coast.

- Install ties as the brick is laid, so that the ties are properly aligned with the mortar joints.
- Install brick ties spaced per Table 1. Studs should be installed at 16" spacing. Veneer tie locations for 24" stud spacing are included for repairing damaged veneer on existing buildings with the wider stud spacing. In areas where the 2006 Editions of the IBC/IRC are adopted, install brick veneer ties spaced no more than 18" vertically to satisfy the requirements of ACI 530-05.
- Locate ties within 8" of door and window openings and within 12" of the top of veneer sections.
- Bend the ties at a 90-degree angle at the nail head in order to minimize tie flexing when the ties are loaded in tension or compression (**See Detail A**).



Detail A: Bend ties at nail heads.



Detail B: Tie embedment.

- Embed ties in joints so that mortar completely encapsulates the ties. Embed a minimum of 1 1/2" into the bed joint, with a minimum mortar cover of 5/8" to the outside face of the wall (**See Detail B**). *Image: FEMA*

Those old homes were overbuilt, mortared to their foundations, and so on, while homes in the age of Levittown subdivisions were built light, with minimal connection to foundations and no added straps or tie-downs.

Lots of recent research offers clear advice on how the homes and multi-family properties of the future can weather severe winds. Here are seven rules to live by:

1. Remove or Reinforce Soffits. Windblown rain entering soffits has been a major cause of roof blow-offs. If you're not a fan of vent-free attics, look for soffits that are designed to keep out storm winds.

2. Lock Down Roofing. Flying clay roof tiles caused a lot of secondary damage in some of Florida's big hurricanes. Mortar attachment is not enough; they require metal fasteners to stay put. Use extra nails on asphalt shingles and replace any that are old and brittle. Once they lose their grip on the roof, you're inviting trouble.

3. Follow the Code. Don't fudge it on fasteners, tie-downs or other important details. Install impact glass or shutters as required.

4. Build Low. Single-story homes tend to suffer far less damage from wind events than two-story homes. They offer less surface area for wind pressure and a smaller target for projectiles.

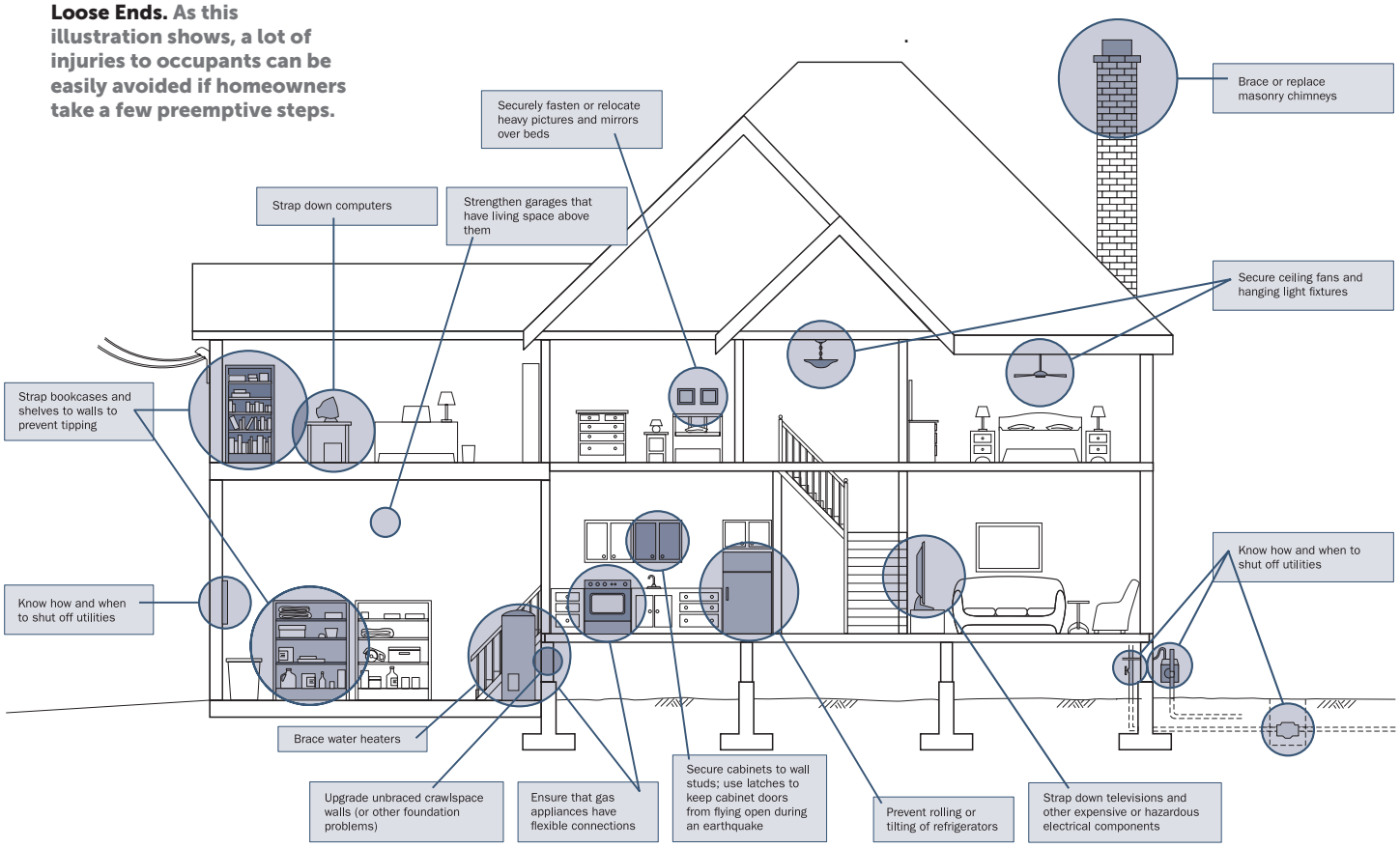
5. Strengthen Wall Layers. Wind-flung projectiles have been found to penetrate vinyl siding that's placed directly over a thin-wall sheathing. They can also smash through certain types of garage doors. Adjust accordingly.

6. Reinforce Chimneys. In the La Plata tornado, almost every unreinforced chimney we looked at had broken off and/or collapsed. Brace and repair existing chimneys to make them safer for both wind and seismic pressures. Build new chimneys with reinforcing rebar.

continued on page 52

Quake Readiness: What Homeowners Can Do

Loose Ends. As this illustration shows, a lot of injuries to occupants can be easily avoided if homeowners take a few preemptive steps.



FEMA

Siding Test. A burning brand applied to a test wall assembly at UC Davis set alight the composite wood siding (left side), but the fiber-cement-covered wall did not ignite.

7. Add Sheathing Grip. By using longer fasteners at closer intervals (six inches is good) to attach sheathing to rafters (8d versus standard 6d), you gain significant fastening strength.

Seismic Shakedown

Wood-framed homes tend to handle seismic activity quite well, according to FEMA, due to the fact that systems in wood-framed house tend to be interdependent, not monolithic. Failure of one doesn't automatically lead to failure of others. This might be considered an inherently redundant design feature of wood framing.

And redundancy (through connectivity) is key to any strategy for earthquake-resistant housing. Essentially, what's important is bracing. There's no single right way. The code recognizes multiple ways to achieve the recommended resistance to sliding, overturning or racking.

Fortunately, many of the same principles that apply to hurricane-resistant construction also work for seismic loads. Build (and retrofit) to code, and you've probably achieved most of what is presently possible (and affordable) with regard to earthquake-

proofing a home or building. An excellent training series for builder on seismic retrofit is available at **http://tinyurl.com/kv3axy7**. It includes some important but often overlooked details such as how to brace a hot water heater properly so it doesn't become a loose cannon in the basement.

Masonry Construction. The same basic rules of thumb for seismic resistance apply to homes with above-grade masonry walls. The IRC requires an engineering plan for walls more than a story high, but whatever the height, walls, ceilings and foundations have to be connected diligently. Masonry walls are heavier, so they resist more force, but they're also more likely than wood to collapse sideways in the right conditions. A good "best practices" guide for builders is available at **http://tinyurl.com/q6tc8oh**.

Wildfire Preparedness

Spurred on by record-setting droughts and migrating forest conditions, wildfire often dominates the nightly news. Home losses to fire are rising, in part because we keep pushing deeper into wilderness areas.

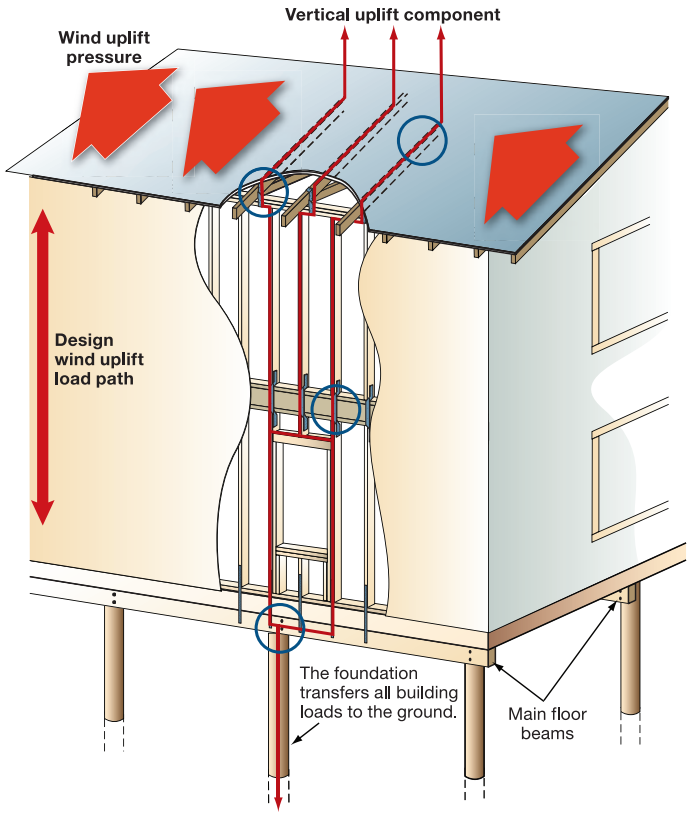
But another, sometimes overlooked aspect of fire protection is that water is getting scarce, particularly in the Southwest and West, so water management and accessibility is likely to become a major factor in building or retrofitting a home at risk for wildfire. A resilient, fire-ready home will have a ready supply of local water that can't be compromised.

Over the next century, as in-migration to urban living continues, we expect to see some of the threat to lives and property lessen. But weather extremes are expected to get worse, so the smart money for those who still plan to live "on the edge" will be to create homes and sites that can handle a blaze, and build with fireproof materials.

FEMA publishes the extensive *Home Builder's Guide to Construction in Wildfire Zones*, which is downloadable at **http://tinyurl.com/n35gqa7**. GB

Storm Wind Readiness: The Details Matter

Techniques and products for storm-ready construction have advanced over the last 40 years. If you have any doubt, visit the aftermath of a hurricane. The homes that suffer the most damage are usually the ones built prior to modern building codes. Modern U.S. homes, built properly to the code adopted by their local region, tend to perform extremely well in hurricanes and earthquakes. *Image: FEMA*



THE CELESTIA FORECAST

Despite herculean efforts to maintain existing coastlines, sea level rise in many places will be too costly to confront with conventional building techniques. New and improved technology such as "floating" homes and flow-thru foundations will slow the pace of human retreat, as new coastal cities rise, which are far more resilient and built "for the centuries." Seismic risks will be addressed with new engineering systems and a halt to damaging fracking techniques. Wildfire-proofing of homes will play an essential role in the 50-year transition away from rural isolationism toward denser urban cities, and all structures will be strengthened and adjusted to withstand powerful storms, with self-sustaining features that make them drought resistant, self-powered and more a part of the solution to climate change than an added problem.

THE CELESTIA PROJECT

Living Together

Communities will be evaluated not just for their street plans and amenities, but for how they make us feel.

"I GREW UP in a small town—well, more like a small village in the Boston urban growth boundary. We knew everybody on our street, and we took care of each other. When my mother got sick, six families delivered dinner to our front porch seven days a week for months. We never forgot. Now my kids live across the way. We're close, all of us, just like our families have been for decades."

—Teri Gordon, Spiritual Advisor, 2083

Auto-centric suburbs dominate the American landscape, as baby boomers continue to self-identify with consumer-based lifestyles. Discontent and anxiety are widespread.

As Millennials finally hit their stride, neighborhoods change, becoming more intimate, less predictable and more inventive.

As corporate systems fall out of favor, new and old communities reshape their cultural identities toward resilience, and away from excessive consumption.

2014 2020 2030 2040 2050

Urban planners embrace the concept of "nested" communities, where small, diverse groups create towns, villages and neighborhoods within the metropolitan limits of large cities.

As world population stabilizes, obsolete community models make way for more holistic settings, as young people migrate to safer, healthier communities—and stay there.

A convergence of science and spirituality leads to community living that is more peaceful and harmonious than ever in human history. The age of transcendent creativity begins.

2060 2070 2080 2090 2100

COMMUNITY: CELEBRATING COMPLEXITY

In this final chapter of the Celestia Project, we look at what it means to live with and near other people. What makes one neighborhood or city thrive while others dwindle? Where is the balance between nature and social activities? And where does happiness factor into the equation?

ANTHROPOLOGISTS HAVE long held that the ideal number of human beings for a healthy, relatively conflict-free community is about 100. Robin Dunbar in the 1990s suggested that 150 people are about as many as the human brain cortex can handle. That's a lot better than Jean-Paul Sartre's existential argument that "Hell is other people," but it's still not much to work with, given the billions of people now astride the Earth.

I've introduced this point to demonstrate just one of many reasons why new communities so often fail. Good intentions don't always lead to lasting harmony, any more than good street designs and building layouts do—although they certainly boost a community's chance of "making it." The biggest obstacle, however, is the shadow side of human nature.

That's not to say people are inherently "evil," if you'll forgive my use of that word. Sociologists have demonstrated that most people lean toward empathy, compassion and kindness, rather than the "shadow" of negative emotions: jealousy, anger, greed and so on. And like it or not, it's the people that decide the fate of a community, not the number of walking paths.

"What people actually need from their communities should reflect the true human condition: the truth of the decay, restoration and growth processes that are a part of every living system. Variety, uniqueness and appreciation for the one-of-a-kind are its essence."

—John McKnight, Author of *The Abundant Community*

In his book, *The Abundant Community,* John McKnight suggests that many feelings of discontentment in our lives are triggered by the false promise of our modern, consumption-oriented answers to questions that have no answer. Because we think of ourselves as consumers rather than citizens, we believe that "what we are

Why Communes (Usually) Fail

Access to woods, streams and wildlife certainly add value to a community. But people also need people.

Back in Chapter 3 of Celestia, we talked about how much nature is "enough" to keep people happy. Surprisingly, we just need regular, small doses—not constant immersion.

Writing in *Daily Kos*, self-described ex-hippy Soarbird (his writing handle) recalls his time living communally in the sixties. What caused things to fall apart? Apart from the occasional bad seed drifting into the community, he says there were other, systemic reasons, including "too much hard work. It was after World War II, and people traditionally shunned physical labor, except in a symbolic sense, such as mowing the lawn or working out at the gym. In this regard, back-to-the-land seemed like a step backward to many people."

Also, he notes that many commune dwellers had little cash money and, notably, "too much isolation. The countryside might be beautiful, but you're surrounded by teabaggin' rednecks, and there's not enough entertainment and culture."

THE CELESTIA MUSEUM

Male Existential Crisis?
With the gradual phase-out of combustion engines, lawn care becomes costly. After an initial spike in depression among men especially, many former mowing addicts find themselves becoming more physically fit and productive.

seeking is, in fact, attainable in the marketplace." But this simply isn't true, McKnight argues. We keep buying stuff, yet never achieve satisfaction. A bigger house, a better wardrobe—nothing does the trick. We end up "purchasing experiences rather than actively producing them. We have become spectators."

Getting Real

The real heart of the matter, McKnight contests, is that we're trying to make our communities work like corporate factories. This model results in homes and communities that are organized with "consistency, uniformity and replaceable parts."

Consumers see themselves as self-supporting, independent individuals, not part of a greater (or local) tribe, he explains. As a result, they make decisions based on their own self-interest, without considering the greater good of the community. They can be small things that result in big rifts: the decision to start a dog breeding operation, heavy use of lawn herbicides next to an organic gardener, driving too fast on a local street. The possibilities of friction are limitless. And friction, left unresolved, can lead to big problems.

Often, the solution to friction comes from code officials, city planners or other "authorities" in the form of generalized regulations and one-size-fits-all rules: a change of zoning to prevent animal husbandry in the area, an ordinance requiring a permit to spread herbicides. These top-down rulings are likely to please one neighbor and outrage another. Let the feud begin. Neighborhood associations run into the same issues. If their values are rooted in property values and individualism, they are likely to mandate the most mundane of choices—house color and mailbox size, dog leashes and solar panels on the roof—stifling creativity and personal growth, and cutting off resilience at the knees.

continued on page 33

Elements of a Desirable Community

Flexible Commons. While most experts agree that having some kind of common outdoor area is important, it needs to accommodate different interests. Personal garden options are great for some residents, but not everyone wants to participate, so allow them to opt in or opt out of regular maintenance without guilt or obligation. **Case in Point:** **Greenwood Avenue Cottages in Shoreline, WA**

Sweat Equity. Neighbors who are involved in the hands-on construction of their homes and landscaping tend to be more heavily "invested" in its success. While this isn't a guarantee of peace and prosperity (see The Witching Hour), it's a step in the right direction. **Case in Point:** **Northport Habitat for Humanity in Dane County, WI.**

CONCEPTS: *POCKET NEIGHBORHOODS* BY ROSS CHAPIN

"Popsicle Index." In a safe community, children can range freely in a wide area. The key, says Chapin, is shared common areas that mix private and public space in a way that creates a safe pathway for children.

Streets as Rooms. Good communities have streets that create a sense of enclosure that makes them walkable, where kids can play and porches overlook activity. Make the entry points at each end of the street narrow and well defined, with traffic speeds under 20 mph. **Case in Point:** **The Great Oaks Cohousing in Ann Arbor, MI.**

Remote Parking. When cars are parked remotely, yards and commons are more foot friendly, and clustering of homes can be denser, encouraging neighborly interaction. **Case in Point:** **Duwamish Cohousing in West Seattle.**

What people actually need from their communities, McKnight argues, should reflect the true human condition: "the truth of the decay, restoration and growth processes that are a part of every living system." Variety, uniqueness and appreciation for the one-of-a-kind are its essence.

To avoid incidents that turn into full-grown feuds, the members of a community (or would-be community) need to develop intricate layers of trust. How do you do that? A *competent* community keeps three key principles at work: Focusing on the gifts of members, nurturing associational life and offering hospitality to strangers. But these are just the baseline.

Real trust, they argue, may mean neighbors opening up in ways that might shock conservative middle-class residents of bedroom suburbs. You have to share your personal vulnerabilities. Sharing stories about personal tragedies and challenges creates bonds that are more lasting and genuine than passing a pair of hedge clippers over the fence. This type of open communication, McKnight notes, breaks the consumer cycle of relationships.

"It is an answer to the conspiracy of secrecy in our families," he says. "It is the way a village raises a child...reclaiming power from the hands of professionals who are sworn to secrecy and putting it in the hands and hearts of citizens."

Setting the Stage

Traditionally, the success of a community has been measured in demographics: the rise or fall of population, percent of land developed versus "preserved," the rise of home values and so on. But isn't the satisfaction (a.k.a. happiness) of residents also a key indicator of a community's health and sustainability?

Human happiness is an elusive target, of course, and one that involves inner work. So let's leave it for last. Creating the right type of environment for living can lay the groundwork for satisfaction. So let's start there.

In his outstanding book, *Pocket Neighborhoods*, Ross Chapin

continued on page 34

The Witching Hour

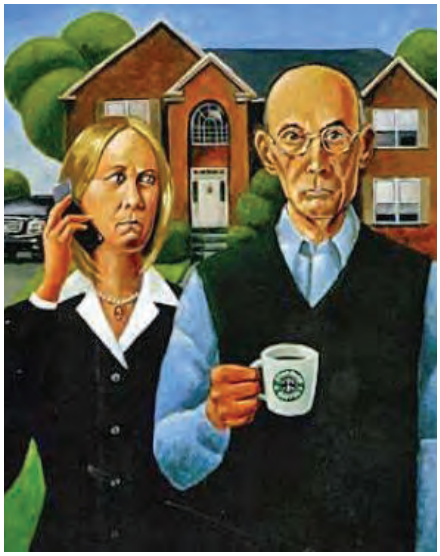
The fate of the early Salem community demonstrates that good design is only part of the recipe for success. Negative emotions can lay waste to the best-made plans.

LOOKED AT FROM THE perspective of a site plan, the quaint, 17th-century town of Salem, Mass., should have been a haven of peace and contentment. Narrow, walkable streets, common areas, gardens, religious institutions—it had all of the ingredients we know to be good for community cohesion. So why did it erupt into a literal "witch hunt" of terror and superstition?

A friend of mine, Lisa Wolfinger, produced a documentary a few years ago about the Salem witch trials. She did a lot of research when writing the show and discovered the underlying issue: grievances. Salem was a hornet's nest of anger, jealousy and envy. Neighbors were feuding about land rights, sleeping with each other's wives and husbands, engaging in lawsuit after lawsuit to right perceived wrongs. For a group of people who perceived themselves as pious and Christian, the resulting mess made history.

The Misery Cure

Despite their relative wealth, modern people are simply programmed to get stressed out by smaller and smaller inconveniences.



According to Gregg Easterbrook, author of *The Progress Paradox*, Americans, despite being citizens of one of the world's most affluent nations, have high levels of anxiety, stress and often wallow in despair. Some of the main physical causes:

- **Not Enough Sleep.** This one's obvious.
- **Too Little Vacation.** Not only do Americans have less vacation available than Europeans (two weeks vs. six weeks), they often don't even use it, opting instead to trade the time for flexible pay or to work during the vacation..
- **Poor Diet and Lack of Exercise.** Fast foods and minimal exercise are the norm.
- **Poor Quality Family Time.** Although fathers, for example, spend more time with kids than 20 years ago, most of that time is stressful, hectic or spent in the car commuting.

takes on the challenge of "creating small-scale community in a large-scale world." In a series of case studies of fast-selling, desirable small projects, he notes many key features (see p. 32).

Faith and the Future

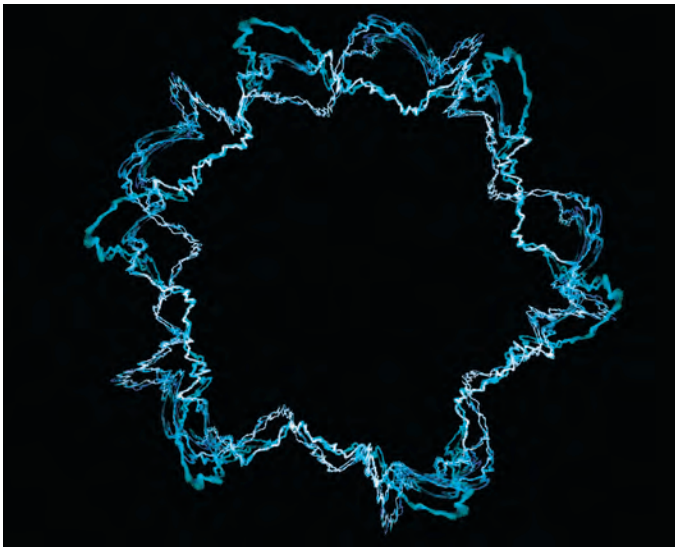
If greater happiness is the ultimate goal of community, what will it take to reach that frontier? We may have to explore uncharted territory: our own fears and neuroses. At least that's the perspective of Gregg Easterbrook, author of *The Progress Paradox*. The path to satisfaction, he says, lies in two simple words: gratitude and forgiveness. The words are simple, but getting there is anything but. In fact, they may require an act of faith.

That's because most people—and Americans especially, he says—are self-absorbed and afraid. Part of their fear, he says, stems from a "baseline anxiety" about death. They know that no matter how rich, famous or powerful they become, they can't avoid oblivion.

But Easterbrook argues, quite rationally, that life either has meaning here and now or meaning eternally. Either way, we should not, as William Blake says, "Rage, rage, against the dying of the light." Instead, we must embrace the moment, be thankful for what we have and forgive those who are on a different path.

Fortunately, even for devoutly anti-religious people, the convergence of science with long-held spiritual ideas has made it possible to reconcile the rift between the two. The brilliant theoretical scientist, Michio Kaku, co-founder of String Theory, now tosses around phrases such as "the Mind of God," when discussing physics. Some studies suggest that our thoughts may actually shape our reality, so you can see why projects such as Celestia focus on the light, not the darkness of possibility. If we imagine a better future, we may clear the way for it to happen.

Opening ourselves up to the universal concepts of gratefulness and forgiveness are the KEY personal characteristics we need to be happy. And until we know how to be happy, no community will be good enough, no neighbor trustworthy enough, no lawn mower sharp enough to satisfy our endless, unquenchable longings. **GB**



Unifying Theory? String theory has been called a candidate for the Theory of Everything; for many, it evokes the same feelings of wonder and mystery as religion.

PHOTO CREDIT: ANDREW PYSH

Tribal Selfies. At home with sharing their lives with an online "tribe" of friends and family, millennials tend to be collaborative, concerned for the planet and social justice.

THE CELESTIA FORECAST

An age of change in how we gather and live together is coming. The millennial generation is just the first of many that will see community building through a new lens. Less concerned with accumulating material wealth, millenials value friends and social connections highly. Interested in resilience, culture and environmental responsibility, they and their offspring will change the way neighborhoods, towns and cities work. As the population in the U.S. and worldwide becomes increasingly diverse, acceptance of others will become as natural as breathing. Technology will offer us all new frontiers to explore, but our feet will remain rooted in our small, customized communities.