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Building the Solar Economy

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Permaculture is a holistic system of DESIGN, based on direct observation of nature, learning from traditional knowledge, and the findings of modern science. Embodying a philosophy of positive action and grassroots education, Permaculture aims to restructure society by returning control of resources for living: food, water, shelter, and the means of livelihood, to ordinary people in their communities, as the only antidote to centralized power. For 30 years Pc has combined top-down thinking with bottom-up action to make a world of difference in over 100 countries. We are everywhere.

Get Out of the Way

Peter Bane

Solar economy has never left us, for it chiefly involves cultivating plants and animals. And we have long enjoyed the benefits of energy from wind and water moved by the sun, though the work these accomplished took thousands of years to match muscle power. The battle of Lepanto in 1571 marked the first time sailing vessels triumphed over slave-powered galleys. Likewise, the ancients played with lenses to start fire, but only of late have we applied science to channel the sun's rays for daily chores. We began heating piped water with solar energy in the 19th century, commercialized it in the 1920s, and took another 50 years to apply solar design to buildings. Only in the past half century have we gained access to electric current from solid state panels, though now this small miracle focuses thought on the more profound uses of sunshine.

This inaugural issue of *Permaculture Design,* like the thin film of silicon cells resting on ten millennia of farmed photosynthesis, promises to galvanize work begun 30 years ago when our predecessors brought *Permaculture Activist* into the nascent world of American permaculture in Seattle. Under the aegis of Publisher John Wages, the magazine continues its peripatetic career criss-crossing a diverse American landscape. It returns to the West (for a time) having raised its often lonely voice from Puget Sound, the central valley of California, the Hawaiian Islands, the southern Appalachians, and the Midwestern country of great rivers and lakes. Now, improbably, it will emanate from Silicon Valley, a fitting place to launch this chapter of its history and with this theme. A digital edition, new website (www.permaculturedesignmagazine.com), web-access to back issues, and color pages lie ahead.

Herein, we bring you superb technical advice on zero-energy housing and insider views of the solar installation business, along with homespun efforts to stretch the limits of tropical agriculture with glazing and insulation. Where sun dominates, as in the mountain West, a counter-economy of water shapes the forces of life, and we go there too. Likewise, among the poor and hungry, whose access to solar nourishment is constrained by social injustice, we look for clues to remove limits to health and productivity.

Forming a backdrop to these sparkling jewels of positive action, a dark cloud of carbon hangs on the horizon, as Richard Heinberg reports even as he scries the terrain beneath and beyond it. As suggested by this issue's authors, the solar future is bright, but our role in it remains obscured by the inertia of mass society, by economic interests working to throttle it in its cradle, and by toxic media broadcasting the religion and politics of fear.

Until we clear this mental fog and its associated structure of outdated and ossified beliefs, our progress will be hampered.

My own work of recent years, building a solar economy behind the veil of editorial license and professional journalism, has been thrilling and rewarding, its joys and struggles amply recorded in The Permaculture Handbook, but also in the past three years hampered and deflected by invisible structures and bitterly contested beliefs that have no ground in our common future.

We have struggled with local officials in Monroe County, Indiana to demonstrate the viability of microfarming in the urban fringe, and with it the need for home enterprise based on greenhouses, workshops, and food storage. These old-fashioned ideas and forms of solar economy went out of vogue 80 years ago, and disappeared during my 1950s childhood; their resurrection is essential to a secure and democratic future. They were banished to the hinterlands by a monoculture of human settlement: autocentric grid streets, just-in-time global deliveries of food and furnishings, and a commuting life scarcely stitched together by billions of two-way radio signals. These obviously insane practices rest on a foundation of laws, regulations, attitudes, and miles and miles of pavement. These are backed by force of arms and land rape that extracts fuels, ores, and calories. Our little part of this story, too long for this page, exemplifies the danger permaculture activists will increasingly meet as we midwife solar economy's rebirth. The pushback reflects our success, a success we claim with the word "Design" in our title—the right to create the world we want, but that pushback can be very ugly. (Remember the metahistory of change: first they ignore you, then they laugh at you, then they fight you. Then you win, and they say they did it.)

Usually justified as a means to protect urban dwellers from CAFOs, zoning and planning laws rarely serve poor rural counties where the city's breakfast is bred, borne, and bled. City folk are meanwhile carefully safeguarded by zoning and planning officials from the dangers of high-traffic hairdressers and front-yard gardeners who threaten the established order of conspicuous consumption. We fell (or actually, were pushed) into this inane dragnet, but the painful drama is of a piece with the idiocies of Indiana's Republican legislature, which, along with its Religious Freedom Restoration Act faux pas, passed out of committee last month—and might still adopt by stealth—a bill to rescind net metering and deliver the state's energy market even more thoroughly into the tender hands of Duke Power and its ilk. As Ryan Zaricki points out, it's not enough to build a solar economy, you have to guard your flanks from attack by the powers that be.

The trials of a low-energy future will be legion, but we might traverse them more safely if we could avoid the tribulations of reactionary politics. Like evergreens in your solar envelope, we need the obstruction of bad laws, bad actors, and bad attitudes to get out of the way. And as with the birth of any new being, there will be a moment to push. Watch these pages. Δ

Next issue:
Life on the Edge
submission deadline: June 1

Why Energy Profit Matters and What it Means

The Gross Society

Richard Heinberg

AS A SOCIETY, we are entering the early stages of energy impoverishment. It's hard to overstate just how serious a threat this is to every aspect of our current way of life. But the problem is hidden from view by *gross* oil and natural gas production numbers that look and feel just fine—good enough to crow about.

President Obama did plenty of crowing in his 2014 State of the Union address, where he touted "More oil produced at home than we buy from the rest of the world—the first time that's happened in nearly 20 years." It's true: US crude oil production increased from about 5 million barrels per day (mb/d) to nearly 7.75 mb/d from 2009 through 2013 (with imports still over 7.5 mb/d). And American natural gas production has been at an all-time high. Energy problem? What energy problem?

While these gross numbers appear splendid, when you look at *net* numbers, things go pear-shaped, as the British say.

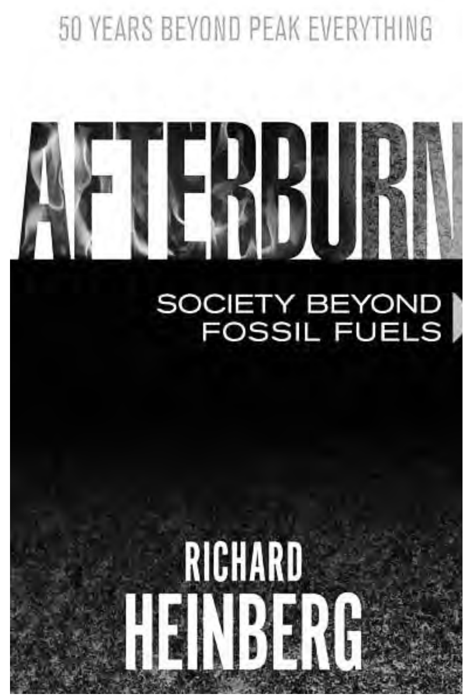
Our economy is 100% dependent on energy: with more and cheaper energy, it booms; with less and costlier energy, it wilts. When the electricity grid goes down, or the gasoline pumps run dry, the economy simply stops in its tracks.

It's *net* energy, not *gross* energy, that does society's work.

But the situation is actually a bit more complicated, because *it takes energy to get energy*. It takes diesel fuel to drill oil wells; it takes electricity to build solar panels. The energy that's left over—once we've fueled production of energy—makes possible all the things people want and need to do. It's *net* energy, not *gross* energy, that does society's work.

Before the advent of fossil fuels, agriculture was our main energy source, and the average net energy gain from that work was minimal. Farmers grew food for people—who did a lot of manual work in those days—and also for horses and oxen, whose muscles provided motive power for farm machinery and transport. Because margins were small, most people had to toil in the fields to produce enough surplus to enable a small minority to live in towns and specialize in arts and crafts (including statecraft and soldiery).

In contrast, the early years of the fossil fuel era saw astounding energy profits. Wildcat oil drillers could invest a few thousand dollars in equipment and drilling leases and, if they struck black gold, become millionaires almost overnight. If you want a taste of what that was like, watch the classic 1940 film *Boom Town*, with Clark Gable and Claudette Colbert. (1)



Huge energy returns on both energy and financial investments in drilling made the fossil fuel revolution the biggest event in economic history. Suddenly society was awash with surplus energy. Farming became an increasingly mechanized (i.e., fossil-fueled) occupation, which meant fewer field laborers were needed. People left farms and moved to cities, where they got jobs on powered assembly lines manufacturing an explosively expanding array of consumer goods, including labor-saving (i.e., energy-consuming) home machinery like electric vacuum cleaners and clothes washers. Household machines helped free women to participate in the work force. The middle class mushroomed. Little Henry and Henrietta, whose grandparents had spent their lives plowing, harvesting, cooking, and cleaning, could now contemplate careers as biologists, sculptors, heart specialists, bankers, concert violinists, professors of medieval French literature—whatever! Human ambition and aspiration appeared to know no bounds.

Unfortunately, there are a couple of problems with fossil fuels. The first is that they cause climate change and thereby cast a pall over the prospects of civilized human existence—but let's set that irritating thought aside for a moment. The other problem is that these fuels are finite and of variable quality; we have extracted them using the *low-hanging fruit* principle, going after the highest quality, cheapest-to-produce oil, coal, and natural gas first, and leaving the lower quality, more expensive, and harder-to-extract fuels for later. Now, it's *later*.

It's helpful to visualize this best-first principle by way of a diagram of what geologists call the *resource pyramid.* Extractive industries typically start at the top of the pyramid and work their way down. This was the case at the beginning of the Industrial Revolution, when coal miners exploited only the very best seams, and it's true today as drillers in the Bakken oil play in North Dakota concentrate their efforts in core areas where per-well production rates are highest.

We'll never run out of any fossil fuel, in the sense of extracting every last molecule of coal, oil, or gas. Long before that point, we will confront the dreaded double line in the diagram, labeled "energy in equals energy out." At that stage, it will cost as much energy to find, pump, transport, and process a barrel of oil as its refined products will yield when burned in even the most perfectly efficient engine (the same principle applies for other fossil fuels). As we approach the energy break-even point, ever-higher levels of investment in petroleum exploration and production will be needed. We can anticipate higher prices for finished fuels and more environmental risk and damage from the process of fuel "production" (i.e., extraction and processing) because we will be drilling deeper and going to the ends of the Earth to find the last remaining deposits, and we will be burning ever-dirtier fuels.

Right now that's exactly what *is* happening.

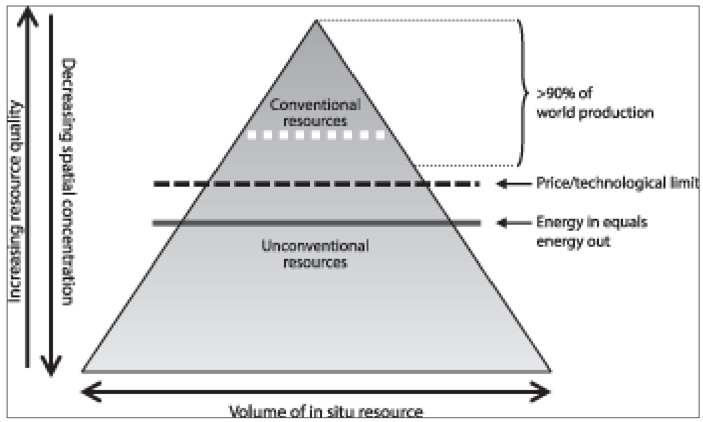
...it will soon take all the drilling the industry can do just to keep production in the fracking fields steady.

Declining energy profits spell trouble ahead

While America's current gross oil production numbers appear rosy, from an energy accounting perspective the figures are frightening: energy profit margins are declining fast.

Each year, a greater percentage of US oil production comes from unconventional sources—primarily tight oil and deepwater oil. (2) Compared to conventional oil from most onshore, vertical wells, these sources demand much higher capital investment per barrel produced. Tight oil wells typically require directional drilling and hydraulic fracturing ("fracking"), which take lots of money and energy (not to mention water); initial production rates per well are modest, and production from each well tends to decline quickly. Therefore more wells have to be drilled continually in order to maintain a constant rate of flow. This has been called the "Red Queen" syndrome, after a passage in Lewis Carroll's *Through the Looking-Glass*. In the story, the fictional Red Queen runs at top speed but never gets anywhere; she explains to Alice, "It takes all the running you can do, to keep in the same place." Similarly, it will soon take all the drilling the industry can do just to keep production in the fracking fields steady. But the plateau won't last long; as the best drilling areas become saturated with wells and companies are forced toward the peripheries of fuel-bearing formations, costs will rise and production will fall. When, exactly, will the decline begin? Probably before the end of this decade. (3)

Deepwater production is expensive too: it involves operating in miles of ocean water on giant drilling and production rigs. (4) It is also both environmentally and financially risky, as BP



The pyramid of oil and gas resource volume versus resource quality. This graphic illustrates the relationship of in situ resource volumes to the distribution of conventional and unconventional accumulations, and the generally declining net energy and increasing difficulty of extraction as volumes increase lower in the pyramid. Source: J. David Hughes, Drill, Baby, Drill: Can Unconventional Fuels Usher in a New Era of Energy Abundance?*, Post Carbon Institute, 2013.*

discovered in 2010 in the Gulf of Mexico.

Canada's tar sands require special energy-intensive processing in order to yield usable fuels. Unless oil prices remain at stratospheric levels, significant expansion of tar sands operations may be uneconomic.

America is turning increasingly to unconventional oil because conventional sources are drying up. The oil business started in the US and, in the past century-and-a-half, more oil wells have been drilled here than in the rest of the world's countries put together. In terms of our resource pyramid diagram, the US has drilled through the top "conventional resources" triangle and down to the thick dashed line labeled "price/technological limit." At this point, significantly new technology is required to extract more oil (of which there is plenty—just look how much of the total pyramid is left!), and this comes at a higher financial cost, not just to the industry but ultimately to society as a whole. (5) Yet society cannot afford oil that's arbitrarily expensive: the "price/technological limit" can be moved up to a point, but we may be reaching the frontiers of affordability.

Lower energy profits from unconventional oil inevitably show up in the financials of oil companies. Between 1998 and 2005, the industry invested $1.5 trillion in exploration and production, and this investment yielded 8.6 million barrels per day in additional world oil production. Between 2005 and 2013, the industry spent $4 trillion on E&P, yet this more-than-doubled investment produced only 4 mb/d in added production. (6)

It gets worse: all net new production during the 2005–13 period was from unconventional sources (primarily tight oil from the United States and tar sands from Canada); of the $4 trillion spent since 2005, it took $350 billion to achieve a bump in their production. Subtracting unconventionals from the total, world oil production actually fell by about a million barrels a day during these years. That means the oil industry spent more than $3.5 trillion to achieve a *decline* in overall conventional production.

The year 2013 was one of the worst ever for new discoveries, and companies are cutting exploration budgets (if there's nothing worth finding, why waste money?). A recent Reuters article quoted Tim Dodson, the exploration chief of Statoil, the world's top conventional explorer: "It is becoming increasingly difficult to find new oil and gas, and in particular new oil…The discoveries tend to be somewhat smaller, more complex, more remote, so it is very difficult to see a reversal of that trend…The industry at large will probably struggle going forward with reserve replacement." (7)

Here is how energy analyst Mark Lewis and US Army Lt. Col. Daniel L. Davis described the situation in a recent article in the *Financial Times*: "The 2013 [*World Energy Outlook*, published by the International Energy Agency] has the oil industry's upstream [capital expenditure] rising by nearly 180 per cent since 2000, but the global oil supply (adjusted for energy content) by only 14%. The most straightforward interpretation of this data is that the economics of oil have become completely dislocated from historic norms since 2000 (and especially since 2005), with the industry investing at exponentially higher rates for increasingly small incremental yields of energy." (8)

The squeeze is also being felt by the global economy, which has sputtered ever since oil prices began their steep march up to the "new normal" of $90–$110 per barrel (more about this below).

The costs of oil exploration and production are currently rising at about 10.9% per year, according to Steve Kopits of the energy analytics firm Douglas-Westwood. (9) This is squeezing profit margins, since it's getting ever harder to pass these costs on to consumers.

In 2010, *The Economist* magazine discussed rising costs of energy production, musing that "the direction of change seems clear. If the world were a giant company, its return on capital would be falling." (10)

Tim Morgan, formerly of the London-based brokerage Tullett Prebon (whose customers consist primarily of investment banks), explored the averaged energy return on energy investment (EROEI) of global energy sources in one of his company's *Strategy Insights* reports (regrettably failing to cite the work of Charles Hall, on which he was basing his calculations), noting in 2013: "For 2020, our projected EROEI (of 11.5:1) [would] mean that the share of GDP absorbed by energy costs would have escalated to about 9.6% from around 6.7% today. Our projections further suggest that energy costs could absorb almost 15% of GDP (at an EROEI of 7.7:1) by 2030. . . . [T]he critical relationship between energy production and the energy cost of extraction is now deteriorating so rapidly that the economy as we have known it for more than two centuries is beginning to unravel." (11) From an energy accounting perspective, the situation is in one respect actually worst in North America—which is deeply ironic since it's here that production has grown most in the past five years, and here that the industry is most boastful of its achievements. Yet the average energy:profit ratio for US oil production has fallen from 100:1 to 10:1, (12) and the downward trend is accelerating as more and more oil comes from tight deposits (shale) and deepwater. Canada's prospects are perhaps even more dismal than those of the United States: the tar sands of Alberta have an EROEI that ranges from 3.2:1 to 5:1. (13)

A five-to-one profit ratio might be spectacular in the financial world, but in energy terms this is alarming. Everything we do in industrial societies—education, health care, research, manufacturing, transportation—uses energy. Unless our *investment of energy in producing more energy* yields an averaged profit ratio of roughly 10:1 or more, it may not be possible to maintain an industrial (as opposed to an agrarian) mode of societal organization over the long run. (14)

You are going to work harder

Rising gasoline prices (since 2005) have led to a reduction in the average number of miles traveled by US vehicles annually, (16) a trend toward less driving by young people, (17) and efforts on the part of the auto industry to produce more fuel-efficient vehicles. (18) Altogether, American oil consumption is today roughly 20% below what it would have been if growth trends in the previous decades had continued. (19)

To people concerned about climate change, much of this sounds like good news. Oil companies' spending is up, but profits are down. Gasoline is more expensive and consumption has declined. Hooray! There's just one catch. None of this is happening as a result of long-range, comprehensive planning. And it will take a lot of planning and effort to minimize the human impact of a societal shift from relative energy abundance to relative energy scarcity. In fact, there is virtually no discussion occurring among officials about the larger economic implications of declining energy returns on investment. Indeed, rather than soberly assessing the situation and its imminent economic challenges, our policy makers are stuck in a state of public relations-induced euphoria, high on temporarily spiking *gross* US oil and gas production numbers.

If our economy runs on energy, and our energy prospects are gloomy, how is it that the economy is *recovering*?

The obvious solution to declining fossil fuel returns on investment is to transition to alternative energy sources as quickly as possible. We'll have to do this anyway to address the climate crisis. But from an energy accounting point of view, it may not offer much help.

Renewable energy sources like solar and wind have characteristics very different from those of fossil fuels: the former are intermittent, while the latter are available on demand. (20) Solar and wind can't affordably power airliners or eighteen-wheel trucks. Moreover, many renewable energy sources have a relatively low energy:profit ratio.

One of the indicators of low or declining EROEI is a greater requirement for human labor in energy production. In an economy suffering from high unemployment, this may seem like a boon. Indeed, wind and solar energy are often touted as job creators, (21) employing more people than the coal and oil industries put together (even though they produce far less energy for society). Yes, jobs are good. But what would happen if we went all the way back to the average energy returns-on-investment of agrarian times? There'd certainly be plenty of work needing to be done. But we would be living in a society very different from the one we're accustomed to, one in which most people are full-time energy producers, and society is able to support relatively few specialists in other activities. Granted, that's probably an exaggeration of our real prospects: at least some renewable energy sources can give us higher returns than were common in the agrarian era. However, they won't power a rerun of *Dallas*. This will be a simpler, slower, and poorer economy.

GDP is a broken indicator

If our economy runs on energy, and our energy prospects are gloomy, how is it that the economy is *recovering*?

The simplest answer is, *it's not*—except as measured by a few misleading gross statistics. Each month the Bureau of Labor Statistics releases figures for new jobs created, and the numbers look relatively good at first glance (288,000 net new jobs for April 2014, for example - 22). But most of these new jobs pay less than jobs that were lost in recent years. And unemployment statistics don't include people who've given up looking for work. Labor force participation rates are at the lowest level in 35 years. (23)

All told, according to a recent Gallup poll, a majority of Americans say they are worse off today than they were a year ago (a minority say their situation has improved). (24)

Claims of economic recovery fixate primarily on one number: gross domestic product, or GDP. That number is going up, albeit at an anemic pace in comparison with rates common in the 20th century; hence, the economy is said to be growing. But what does this really mean? When GDP rises, that indicates more money is flowing through the economy. Typically, a higher GDP equates to more consumption of goods and services, and therefore more jobs. What's not to like about that?

A couple of things. First, there are ways of making GDP grow that don't actually improve people's lives. Economist Herman Daly calls this "uneconomic growth." For example, if we spend money on rebuilding after a natural disaster, or on prisons or armaments or cancer treatment, GDP rises. But who wants more natural disasters, crime, wars, or cancer? Historically, the burning of ever more fossil fuels was closely tied to GDP expansion, but now we face the prospect of devastating climate change if we continue increasing our burn rate.To the extent GDP growth is based on fossil fuel consumption, when GDP goes up we're actually worse off because of it. Altogether, *gross* domestic product does a really bad job of capturing how our economy is doing on a *net* basis. In fact, Daly figures that just about all our current GDP growth is uneconomic. (25)

Second, a growing money supply (which is implied by GDP growth) depends upon the expansion of credit. Another way to say this is: a rising GDP (in any country with a floating exchange rate) entails increasing levels of outstanding debt. Historical statistics bear this out. (26) But is any society able to expand its debt endlessly?

If there were indeed limits to a country's ability to perpetually grow GDP by increasing its total debt (government plus private), a warning sign would likely come in the form of a trend toward diminishing GDP returns on each new unit of credit created. Bingo: that's exactly what we've been seeing in the US in recent years. Back in the 1960s, each dollar of increase in total US debt was reflected in nearly a dollar of rise in GDP. By 2000, each new dollar of debt corresponded with only 20 cents of GDP growth. The trend line looked set to reach zero by about 2015. (27)

...there are ways of making GDP grow that don't actually improve people's lives.

Meanwhile, it seems that Americans have taken on about as much household debt as they can manage, as rates of consumer borrowing have been stuck in neutral since the start of the Great Recession. To keep debt growing (and the economy expanding, if only statistically), the Federal Reserve has kept interest rates low by creating up to $85 billion per month through a mere adjustment of its ledgers (yes, it can do that); it uses the money to buy Treasury bills (US government debt) from Wall Street banks. When interest rates are low, people find it easier to buy houses and cars (hence the recent rise in house prices and the auto industry's rebound); it also makes it cheaper for the government to borrow—and, in case you haven't noticed, the federal government has borrowed a lot lately. The Fed's quantitative easing (QE) program (by which that entity simply creates tens of billions of dollars a month with a few computer keystrokes, using much of the money to buy government debt instruments) props up the banks, the auto companies, the housing market, and the Treasury. But with overall consumer spending still anemic, the trillions of dollars the Fed has created cumulatively have generally not been loaned out to households and small businesses; instead, they've simply pooled up in the big banks. This is money that's constantly prowling for significant financial returns, nearly all of which go to the "one percenters." (28) Fed policy has thus generated a stock market bubble, as well as a bubble of investments in emerging markets, and these can only continue to inflate for as long as QE persists. (29)

With money as with energy, we're doing extremely well at keeping up appearances by characterizing our situation with a few cherry-picked numbers. But behind the jolly statistics lurks a menacing reality. Collectively, we're like a dietician who has adopted the attitude: *the more you weigh, the healthier you are!* How gross would that be?

Less might just be more

The world is changing. Cheap, high-EROEI energy and genuine economic growth are disappearing. Rather than recognizing this fact, we hide it from ourselves with misleading figures. All that this does is make it harder to adapt to our new reality.

The irony is, if we recognized the trends and did a little planning, there could be an upside to all of this. We've become overspecialized anyway. We teach our kids to operate machines so sophisticated that almost no one can build one from scratch, but not how to cook, sew, repair broken tools, or grow food. We seem to be less happy year by year. (30) We're overcrowded, and continuing population growth only makes matters worse. (31) Why not encourage family planning instead? Studies suggest we could dial back on consumption and be more satisfied with our lives. (32)

What would the world look and feel like if we deliberately and intelligently nudged the brakes on material consumption, reduced our energy throughput, and relearned some general skills? Quite a few people have already done the relevant experiment. Take a virtual tour of Dancing Rabbit ecovillage in northeast Missouri, (33) or Lakabe in northern Spain. (34) But you don't have to move to an ecovillage to join in the fun; there are thousands of Transition Initiatives worldwide running essentially the same experiment in ordinary towns and cities, just not so intensively. (35) Take a look at the website resilience.org any day of the week to see reports on these experiments, and tips on what you could do to adapt more successfully to our new economic reality.

All of these efforts have a couple of things in common: First, they entail a lot of hard work and (according to what I hear) yield considerable satisfaction. Second, they are self-organized and self-directed, not funded or overseen by government.

The latter point is crucial—not because government is inherently wicked, but because it's just not likely to be of much help in present circumstances. That's because our political system is currently too broken to grasp the nature of the

...we must learn to be successfully and happily poorer.

problems facing us. (36) Which is unfortunate, because even a little large-scale planning and support could help; without it, we can be sure the transition will be more chaotic than necessary, and a lot of people will be hurt needlessly.

Quite simply, we must learn to be successfully and happily poorer. For people in wealthy industrialized countries, this will require a major adjustment in thinking. When it comes to energy, we have deluded ourselves into believing that gross is the same as net. That's because in the early days of fossil fuels, it very nearly was. But now we have to go back to thinking the way people did when energy profit margins were smaller. We must learn to operate within budgets and limits.

This means decentralization, simplification, and localization. Becoming less reliant on debt, paying as we go. It means living closer to the ground, learning general skills, and keeping a hand in basic productive activities like growing food.

Think of our future as the Lean Society.

We can make this transition successfully, if not happily, if enough of us embrace Lean Society thinking and habits. But things likely won't go well at all if we continue to hide reality from ourselves with gross numbers that delay our adaptation to accelerating, inevitable trends. Δ

Excerpted with permission of New Society Publishers from Afterburn: Society Beyond Fossil Fuels, *all rights reserved. Richard Heinberg lives in northern California where he is a Fellow with Post Carbon Institute (post-carbon.org). He is the author of numerous titles on Peak Oil, Energy Descent, and the dilemmas of a energy-addicted society, including* The Party's Over, The Oil Depletion Protocol, *and* Peak Everything. *The essay above was originally published in April, 2014.*

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Bioshelters and Solar Greenhouses

Enchanted Ecosystems

Jason Workman

NOVEMBER 15, 2014. HOLYOKE, MA. The morning was cool, in the low 40s F. (4-7°C), but inside a 20'x20' (6m x 6m) bioshelter with a window open, it was a balmy 83.7°F. (28.7°C). Before introducing us to the two-year-old bioshelter, Jonathan Bates invited us to explore this light and luminous building with its summer-like climate. The foliage that grew in two beds was abundant and lush. Turmeric and ginger grew side by side to about 4' (1.2 m) in height. A variety of taro grazed the 11.5' (3.5 m) ceiling, growing from an elevated trough in the bioshelter's aquaponics system. At my back was a hardy avocado 8' (2.4 m) tall. I sat on a block of warm granite, which edged one of the beds, and underfoot were planks I was later to discover housed worm compost. Accompanied by the sound of babbling water and the scent of aromatic soil, this brief observation exercise was the perfect introduction to, and perhaps argument for, building a bioshelter.

Large bioshelters have been built in a number of locations around the country: Anna Eddy created SolViva on Cape Cod and wrote a book about it, Darrell Frey has operated one commercially in NW Pennsylvania at Three Sisters Farm for more than 20 years. But these are beyond the reach of most people. What I had come to learn about was the home-scale, rough-and-ready model that Jonathan had just invited us to inspect.

The benefits of a bioshelter are numerous and inseparable from its beauty...

The focus of the day-long workshop was to give the participants—ten of us—an overview of bioshelter design, construction, and functioning, with some analysis of its problems, shortcomings, and consequent solutions. Essentially, the day was a tutorial in D-I-Y paradise. Eric Toensmeier lectured for about an hour on the logistics of the structure: how it functions and what it's like to live with. Toensmeier is an author and co-founder with Bates of Paradise Lot, the one-tenth-acre urban garden where the bioshelter sits, and where the two men live with their respective families. Eric discussed some of the plants being grown in the shelter, explained why they were chosen, and suggested others that would thrive under the conditions there. He spoke briefly to some of the challenges of growing indoors, such as the lack of biocontrols—insects and birds—that you would have when gardening outdoors.

Jonathan Bates discussing the vermicomposting system in the bioshelter.

What is a bioshelter?

In short, a bioshelter is an "indoor food-producing ecosystem (or specialized greenhouse) that contains soil, soil life, plants, insects, and fish ponds." It's a tightly integrated indoor ecosystem, that, as Jonathan declared, seeks to "incorporate as many living elements as possible." The chief systems employed are aquaponics (which itself combines fish in tanks with plants grown in water) and small-bed gardens. Some bioshelters might house small animals such as poultry or rabbits. The primary difference between a bioshelter and the conventional greenhouse is the addition of thermal mass.

The bioshelter is built around aquaponics because the fish and water plants provide a high yield in a small space from stored water. This in turn is critical to the functioning of the whole system. Growing cycles are smoothed out and microclimatic conditions for tender plants are more easily achieved with a thermal battery inside the shelter. Because water provides the best readily available thermal mass, it is used to store and release heat from day to night. The fish and the vegetables take advantage of these conditions, provide a yield from the stored water, and mutually support each other. In contrast, most conventional greenhouses lack thermal mass and must therefore be heated using external fuel sources if anything is to be grown over the coldest months. A bioshelter's thermal mass prevents the internal temperature from plummeting in winter, potentially allowing year-round growth. The central bed of the shelter at Paradise Lot, which houses the aquaponics system, has never dropped below 27°F (-3°C), and that was when it was a chilly -7°F (-22°C) outside! The aquaponic tanks, integral for providing thermal mass, are also a medium for growing aquatic plants, like watercress, and fish, as food and a source of nutrients for the garden.

The bioshelter at Paradise Lot was made with about 80% recycled, reused, or reclaimed material, and it replaced an earlier, smaller, and more rudimentary cold-frame system that was flattened in a storm in late 2011. The new bioshelter was built for about $4,000. In addition to exploiting readily available and inexpensive materials, it makes use of technologies that are within the means of any DIYer able to do a little research. Following the demise of their cold frames, Eric and Jonathan were interested in a system to extend the growing season throughout the year, enabling them, in Zone 5 Massachusetts, to eat herbs, greens, and some exotics throughout the winter months. The climate in the shelter, as Jonathan says fondly, is "Northern Florida, or Zone 9."

Aquaponics system inside Paradise Lots bioshelter.

Over the course of the day, we were given in-depth information about the materials and techniques used in the bioshelter construction, and the process by which it was erected. Later in the day, for an hour or so, we undertook various maintenance tasks in and around the shelter (which included addressing a slight mold problem resulting from condensation and the lack of airflow), and this hands-on work nicely anchored the theory presented earlier in the day. The workshop was interesting and inspiring, well structured, and equally well delivered by Jonathan, an experienced farmer and educator.

The benefits of a bioshelter are numerous and inseparable from its beauty—supporting a rich, enchanted ecosystem, where it is possible to eat year-round, and with snow falling outside, to take up a seat in a warm and verdant place. Δ

Jason Workman has authored articles on various subjects, including social architecture. Recently, he contributed an article to a Japanese forest garden blog Shikigami (https://nakazora.wordpress.com/?s=jason+workman).

Year-round, Low-energy Homes

Designing the *Passivhaus*

Christina Snyder

REGARDLESS THAT FOSSIL FUEL PRICES in the US are low at the time of writing this article (February 2015), passive solar design is still about the best investment with the least risk that one can make, whether building new or retrofitting an existing building. The sun still rises every morning, and delivers free energy to everyone who has invested in a way to capture and use that energy. And even if you don't have good solar access in your existing building in midwinter, many of the principles of energy efficiency that are key to success in a passive solar building will still pay you back in a multitude of ways: savings in dollars and energy, better health, greater comfort, longevity of the building, greater energy security, contributing jobs to your local economy, and helping to stabilize the climate for future generations of all species. What more could you want?

...not all passive solar buildings are efficient enough to be...certified.

I'm currently gambling our life savings on this investment strategy. Our low-income family is building a *Passivhaus* by ourselves—mortgage-free. It employs unusual technologies that most banks wouldn't know how to value. They'd also prefer that we have two reliable jobs in the family, and my current job is building this house. As an architect, I prefer to do my construction experiments on myself before I recommend them to other people, so this is my best and perhaps only chance to take risks that might expand my understanding. But the principles of passive solar design, energy efficiency, and of the *Passivhaus* are no longer experimental—they've been tried, tested, and quantified. They can be successfully replicated worldwide, and I recommend them to all my clients.

Passive solar or *Passivhaus?*

Why do I distinguish between passive solar design, energy efficiency, and *Passivhaus* design? The *Passivhaus* Standard is an energy efficiency standard for the building envelopes of passive solar buildings. It was developed from 1988-1996 by two building science physicists, Bo Adamson and Wolfgang Feist, based on lessons learned by passive solar pioneers in many countries, including the US and Canada. Some of the early passive solar buildings didn't work very well because they didn't have the efficiency parts of the energy balance equation right (too little insulation, not very airtight, too much glass for the amount of thermal storage mass). Feist and others developed tools to calculate how much insulation, airtightness, glass, and mass were needed to make a passive solar building work. They made those tools accessible to the largest possible number of people by way of an Excel spreadsheet called PHPP, Passive House Planning Package. So a *Passivhaus* (also called a Certified Passive House in the US) is always a super energy-efficient, passive solar building, but not all energy-efficient buildings are passive solar, and not all passive solar buildings are efficient enough to be *Passivhaus* certified.

The enclosure of a *Passivhaus* (walls, roof, and floor/foundation) is so efficient that it takes only about one watt of peak heating energy (worst case moment of the year) per square foot of floor area to heat the building, meaning that a modest home doesn't need a bigger dedicated backup heat source than a good sized hair blow dryer to supplement the passive solar gains and internal heat gains (occupants, lights, appliances, and other electrical equipment in the building). About a third of the energy needed to replace the heat lost through the building envelope comes from passive solar energy, with another third from internal heat gains, and the rest from the backup heat source

Our Passivhaus, still under construction, missing two windows, some insulation, and much of the air-sealing work, already stays consistently well above freezing, and on sunny winter days can hit the upper 60s (low 20s C) with no supplemental heating, just passive solar energy. Eventually, it will be our Zero Energy home. See MiPassivehouse.us for more information.

of your choice (which could even be an active solar or other renewable energy system if you want to go all the way to zero net fossil fuel).

The international *Passivhaus* standard sets some very simple quotas for energy consumption no matter where you are located on the earth. This makes it easy to remember and easier to simplify the calculations to determine if you have met the standard, but it also means that it's harder and more expensive to meet the standard the closer you get to the poles, and once you pass into the Arctic and Antarctic regions where there are many days without any sunlight at all, it is likely impossible to meet the standard in a building occupied year-round. Similarly, there are some climates where the need for year-round dehumidification can make it almost impossible to meet the standard, and buildings that are always in the shade can't meet the standard either. But even without enough sun, using the energy-efficiency principles of *Passivhaus* design is always a good investment.

The energy efficiency of a *Passivhaus* depends on a continuous, super-insulated envelope (comprising opaque surfaces, windows, and doors) with minimal thermal bridging; a continuous, impermeable air and water vapor barrier on the warm side of most of the insulation; and a heat- or energy-recovery ventilator (HRV or ERV, depending on climate) to reclaim most of the energy in the air being exhausted from the building. Passive solar gain compensates for part of the heat lost through the building envelope.

Heating and cooling

Accordingly, I recommend to each client that we start the project with a solar site assessment, to determine how much solar energy is available to the new or existing building. On most projects, after less than half an hour onsite, I have a record of the available solar energy not only at the time I took the photos of the measuring tool, but for every hour of the whole year (not including the effect of cloudy weather). It is really a record of where and when shadows from nearby man-made structures and vegetation will fall on the walls and windows that face the equator (and thus the winter sun). With two or more such photos, I can even extrapolate to places I can't yet access, such as the roof of a future building. A good goal is to try to have full sun from 9AM to 3PM solar time throughout the entire heating season on all the windows that face the equator. To the extent that this goal can't be met, you may have to compensate with higher levels of insulation to meet the *Passivhaus* standard.

Another important principle of passive solar design for climates where heating is the biggest concern is to minimize the surface area to volume ratio, and to use the proper orientation, sizing, and placement of windows. Near the poles, the ideal shape for minimizing heat loss is either a hemisphere (like an igloo) or at least a cube, whereas in temperate climates, like most of the US, elongating the cube slightly in the east-west direction is better. It permits more surface for solar gain (a golden section proportion like the shape of this page is good in both plan and section of a building). Vertical windows that face the equator work for you thermally in both summer and winter, and thus should have clear glass with a solar heat-gain coefficient of 0.5 or higher (except if your skies are always cloudy in winter). Such windows can be shaded in summer with horizontal overhangs or better yet trellises with climbing vines that offer the most shade during the hottest part of the year. Other window orientations will gain more heat in summer than they do in winter, and therefore are candidates for low-E or even reflective window coatings, and should ideally be kept small and preferably narrow (taller than wide) and recessed into the depth of the wall for built-in summer shading. Try to keep the building's orientation within 20° of the true compass cardinal directions for best winter solar gain and ease of summer shading of windows.

As you move into climates where cooling and dehumidification pose the primary thermal demand, such as

Correct location of the vapor barrier is probably the most important thing you can do to protect both yourself and your investment in a building.

Passivhaus Standard (copyright the Passivhaus Institut, Darmstadt, Germany) http://www.passiv.de/en/02_informations/02_passive-house-requirements/02_passive-house-requirements.htm

Space Heating Energy Demand: 15 kWh/sq. m of TFA/yr., or Peak Heating load of 10 W/sq. m of TFA (Treated Floor Area). If active cooling or dehumidification is needed, it must also be 15 kWh/sq. m of TFA/yr., plus a tiny dehumidification allowance.

Primary (Source) Energy Demand: 120 kWh/sq. m of TFA/yr. total energy use

Air-Tightness: Maximum 0.6 Air Changes per Hour at 50 pascals (both positive and negative pressure)

Thermal Comfort: Maximum 10% of all hours may exceed 25°C interior air temperature.

All of the above must be verified with the *Passive House Planning Package* by the designer and an authorized certifying agency.

equatorial regions and the Deep South of the US, elongating the building even more and placing windows to keep the sun out but permit cross ventilation by winds becomes about the only effective passive cooling strategy. Hot, dry climates also rely on excluding sun and ventilating (though perhaps only at night), but their elongation may turn back upon itself to enclose a shaded courtyard that can use an evaporative cooler to reduce effective temperatures and increase moisture levels. If there is a significant difference between day and night temperatures, as is common in hot dry climates, thermal mass can store excessive heat during the day and release it during nighttime ventilation periods. In hot, humid climates, care must be taken with nighttime ventilation. If humidity levels outside the home are higher than those inside, ventilation should only be done through the energy recovery ventilator, as it takes about four times the energy to dehumidify air as it does simply to cool it.

3d SketchUp model with neighboring buildings and trees recreated from Solar Pathfinder data in the previous photo. I used a computer model to determine how far to elevate the floor of the Passive House to ensure that windows were not shaded in midday on the shortest day of winter. Drawing by CASnyder.

Whether you are in a heating- or cooling-controlled climate, nowhere do roof skylights (sloped or horizontal glass) work for you thermally—they always lose heat in winter and gain heat in summer. If you need additional daylight coming from the roof, consider dormers or clerestory windows with vertical glass instead of skylights; in heating-controlled climates, face the glass towards the equator for midwinter sun, and in cooling-controlled climates, face the glass away from the equator to keep most of the sun out. You can simulate how much sun will enter your building by using some free 3-D design software such as SketchUp, which has the sun paths for each latitude built into it. Be sure to start your SketchUp file by entering the building's location with your latitude and longitude numbers. This is better than using Google Earth for entering location, as it keeps your project file size small so it regenerates views quickly. I use SketchUp to position and size shading elements such as roof overhangs and vertical fins, and I can even simulate existing man-made structures and existing vegetation that would shade the building using data from the solar site survey photos mentioned above.

Vapor barriers and insulation

In all climates, the location of the air/vapor barrier relative to the insulation is very important to prevent condensation within the building envelope, where it can cause structural decay, in addition to making the occupants sick from mold and mildew. The correct position depends not only on the outdoor climate, but also on whether you will be heating or cooling the building, or both. It also depends on your desired interior temperature and humidity levels, how many living beings (plants and animals) will contribute humidity via their respiration and other activities like washing clothes and cooking, and the type of ventilation system. Do not assume that code-compliant building designs will have the air barrier in the right location for your climate and situation, or that a licensed residential builder or even a professional engineer or architect knows how to locate this air barrier properly relative to the insulation. Instead, ask them to show you their dew-point calculations for the walls, roof, floors/foundations, and even windows of the project. I know that you may not feel competent to check their work, but if they don't even know how to produce a dew-point calculation, you should probably look for someone who does, or at least have a knowledgeable builder check the work. This goes for all buildings, not just energy-efficient passive solar buildings. Correct location of the vapor barrier is probably the most important thing you can do to protect both yourself and your investment in a building.

...consider not putting any [insulation] in the space for the electrical and plumbing runs.

In cases where you only heat or only cool the building, you can safely locate the air/vapor barrier on the warm side of all the insulation, or if that is the inside of the building where all your electrical boxes are required to go, consider putting it just outside the area containing the electrical and plumbing runs. If you can't afford a lot of insulation, consider not putting any in the space for the electrical and plumbing runs, so that the air/vapor barrier is on the warm side of ALL of the insulation. This is also a good idea if your building has metal framing members—which are great thermal bridges. Try to get most if not all of the insulation on the cold side of the framing members and the air/vapor barrier. If you are retrofitting a building away from being only heated, or only cooled, it is very important to know what the existing construction is and to do dew-point calculations for both heating season and cooling season as described below for your final renovated walls, roof, and floor/foundation.

In situations where you have to heat the building some times and cool the building at other times of the year, your air/vapor barrier will need to be somewhere in the middle of the insulation, with the best proportions of insulation on the inside and the outside of the vapor barrier determined by the external climate and the other factors I described above. At least two dew-point calculations should be made: one for worst-case heating, and one for worst-case cooling. There may not be a perfect location at which no condensation can ever form upon the vapor barrier, but the idea is to minimize the time condensation could form, and to make sure all other materials and surfaces within the wall are more permeable than that barrier—any moisture that does condense within the wall will have a chance to dry out to both the interior and the exterior of that wall, roof, or floor. Closed-cell insulations like XPS (blue or pink board) or even spray foams like polyurethane may be useful in these conditions for they are both insulation and an air/vapor barrier. This means that when doing your dew-point calculations, you can assume the vapor barrier is always located on the warm side of that closed-cell insulation—when heating, it is on the inside surface of the foam, and when cooling, it is on the outside surface of the foam. If your calculations show condensation occurring on the foam in either heating or cooling modes, you can just add a bit more thickness of foam on the warm side of the insulation where the condensation tends to occur, and repeat the calculations to see if you've fixed the problem. Spray foam polyurethane propellants are bad for the environment—they should be minimized in on-site applications where their emissions can't be captured and dealt with properly.

In my Passive House, the air-barrier layer in all wood-framed walls is plywood with all seams, corners, and knots and fasteners taped as shown here. All electrical lines will run in a 2x4 wall inside of the air barrier (mocked up in photo) with additional batt insulation.

If you're retrofitting energy improvements, you'll need to pay attention to the sequence of the efficiency improvements so as not to temporarily increase, rather than decrease, the risk of condensation within a portion of the structure. As you tighten up a structure, the differential air pressure that drives air and moisture into the structure will have smaller and smaller areas to leak through, therefore each remaining leak will receive proportionally more airflow and water vapor, increasing the likelihood of condensation at that leak.

Retrofits

Old wood-frame structures with no brick and no insulation at all are some of the easiest to retrofit safely and substantially over many years, even while living in them, for they can be done from the exterior. Take off the siding, replace any exposed deteriorating wiring or plumbing. Do this AFTER you have shut off power at the main breaker or at least covered wiring with conduit so that it can be pulled and replaced later (even new wiring will be living on borrowed time after 25 years, and the bare wire system called knob-and-tube is a definite fire hazard, as is any that has crumbling insulation—those kinds must come out NOW). Get an electrician if you don't know what you're doing, or take classes to learn. Once the utilities in the walls are stabilized for the foreseeable future, you can start insulating and air-sealing work. In a heating-only climate, one solution is to have an air barrier "flash" of polyurethane foam sprayed over the backside of the plaster or drywall interior finish, the studs, and all electrical boxes and other penetrations through the interior wall surface (this is why I suggested running wiring in conduits for future maintenance). Also, apply foam against the plaster or drywall, all electrical junction boxes and wiring in your attic, in the rim joist space, and against the backside of the first floor in your basement or crawlspace ceiling.

He more than doubled his floor area, while keeping the same...system....

You are creating a continuous air barrier over every side and in every crevice of the house—the insulation installers can usually tell if this has been accomplished with a blower door test or an infrared camera. A *Passivhaus* can not exceed 0.6 air changes per hour leakage at 50 pascals air pressure differential during a blower door test, and if you can meet this goal with your retrofit, your building will be more likely to endure for centuries and will be less likely to make you sick. If you plan to do your own air-sealing work, you can track down most air leaks by pressurizing or depressurizing your home with a fan sealed into a window or door opening. For safety, you should first shut down and turn off the gas to all appliances. You'll probably find that many of your leaks are due to your windows and doors, and if you can't replace them at the time you are air-sealing walls, floors, and ceilings, you won't be able to get down to *Passivhaus* airtightness initially. At least try to get all the leaks through the walls, floors, and attic while you are working with the spray foam—you can upgrade windows and doors later. If your air leakage drops below 0.35 natural air changes per hour (not during the blower door test—the blower door operator can calculate this for you), then you're required to put in mechanical ventilation to bring in air, but this is further opportunity for energy savings, more about that in the next article (see page 29).

Once the building envelope is air-sealed to prevent moist interior air from leaking to the structure, you can cover your exterior walls with a breathable house-wrap and then go back and work on super-insulating the remaining envelope cavities and reducing thermal bridging to the outside as money and time permit. A good way to do the latter is to add horizontal framing members over the outside of your studs (at right angles to them), called strapping, the largest 2x dimension as you can afford or even I-joists, which will support your new external finish/ weather protection layer. The cavities between studs and between strapping members can be filled with a cheaper insulation that is moisture permeable (fiberglass, cellulose, wool, rice hulls) before the external finish is put on, or by blown-in insulation, which is often put in at the same time as the exterior finish is going up, so there is something to retain it in the cavities. The same two kinds of low-cost insulation are suitable for floors over basements or crawl spaces (though the blown insulation will need a ceiling to hold it in), and for insulating the attic ceiling (preserve attic venting from the eaves to ridge with baffles that you put in BEFORE air-sealing with spray foam or blowing in insulation). Always wear a dust mask or even a respirator when working with insulation, especially fiberglass which sheds tiny glass bits that can cause asbestosis.

How much insulation is enough?

How much insulation do you need? In Michigan and other far-north, cold climates, a *Passivhaus* typically has at least R-60 walls and floor and R-80 or higher roofs, but the amount of insulation is determined by calculations, especially if the goal is to supply all supplementary heat with minimal ventilation air via a tiny electric resistance heating element in the supply air duct, so that no furnace or boiler is needed. In retrofit projects where you already have a furnace or boiler, your goal may not be eliminating them but making their energy go further, either reducing your fuel bills, or as one of my Michigan clients did, building an addition to a *Passivhaus* level of insulation. He more than doubled his floor area, while keeping the same mechanical system and energy bills (again, calculations can determine how much is needed to hit a defined energy target).

Frame construction of our Passivhaus windows. White fiberglass frame is not continuous between inside and outside—only insulation and black plastic corner ties connect the frame. Plastic lumber window buck beneath also provides a thermal break in the concrete wall. These windows are as insulative as most 2x4 solid walls—consequently they don't get frost or condensation on the inside of the glass, only on the exterior.

If you despise spray foam because of the greenhouse gas effects of its propellants, another retrofit solution for a heating climate is to put the air barrier on the outside of your existing framing members (such as heavy-duty, impermeable plastic wrap—not Tyvek® or other exterior house wraps) with all joints taped with impermeable tape, and IMMEDIATELY add additional insulation over the air barrier such that you are keeping the air barrier warmer than the dew point in the worst case. The additional insulation can use strapped construction as explained above, or be rigid exterior foam board, as long as you get the insulation ratios right to prevent condensation. In Michigan, there should be at least twice as much R-value on the outside of the air barrier as on the inside. I would NEVER allow less R-value outside the air barrier than inside, on one of my Michigan projects, as it would be a recipe for making people sick and getting me sued. Phasing construction over time is more difficult and risky with this method, as you shouldn't put up the air barrier over each section of wall, attic ceiling, or floor until you are ready to insulate it before the start of the next heating season. Where you stop and start, you will need to leave enough of your air-barrier material exposed so that you can lap it over the next section of wall and tape the joint, and you will have to coil up this extra and protect it from exposure to the sun. Most likely, you will still need spray foam to seal where the attic ceiling meets the exterior walls (preserving the air flow with a baffle) and in the basement rim joist area. Also, this is one of those cases where each part of the building envelope that you seal up will increase the amount of interior moisture flowing into the remaining leaks, so you may want to do the last half of your air-sealing and insulating work in a single year.

In a retrofit in a cooling-only climate, you can put rigid closed-cell foam insulation (like XPS extruded polystyrene, which always comes in colors as opposed to the white, permeable bead board) over your existing framing members and put impermeable tape over all the outside joints of the foam board before you put a new exterior weatherproof finish layer over it. Here, the air barrier is on the outside of all the insulation. If you will be both heating and cooling, you need to determine where your air barrier should be for your climate with dew point calculations before you start your retrofit project.

If your roof is framed in such a way that the roof deck comes down to a tight point above the exterior walls, such that you can't fit even the code requirement of insulation into the space (R-38 in Michigan), much less a *Passivhaus* R-80, you are probably already having problems with ice damming and maybe the consequent water damage, if melt water is backing up under your roofing materials. Contrary to popular opinion, ice dams are not caused by an absence of waterproof membranes at the eaves (those are only a band-aid for a bad thermal envelope); instead, they result from insufficient insulation in the roof which allows snow above the exterior wall to melt and then run

I recommend insulating the ceiling above the basement or crawlspace....

down over colder eaves and gutters and re-freeze. With a super-insulated roof that extends all the way out over the exterior walls, the snow stays in place on most asphalt shingle roofs unless they are extremely steep, and you get neither ice-clogged gutters nor ice dams. If you don't have space for the necessary insulation in your attic, you can either close up the attic vents and put your super-insulation over the outside of your roof deck under new roofing, or frame additional insulation space on the inside of the top dwelling spaces just at the top of the perimeter exterior walls, and fill that space with insulation, taking care to ensure it is air-sealed on the inside surface. If your roof is steep or made of slippery metal, you may still want to add ice or snow guards to the roof to prevent unmelted snow from sliding into the gutters. Make sure that your roof framing at least meets current code for structural strength so that larger than usual snow loads don't jeopardize it. In new construction, roof trusses designed to accommodate the *Passivhaus* level of roof insulation over the whole ceiling area, including the exterior walls, will almost certainly be deep enough to accommodate the resulting snow loads.

I recommend insulating the ceiling above the basement or crawlspace because it's very difficult and expensive to retrofit insulation into existing below-grade exterior walls without causing problems, so most *Passivhaus* retrofits typically treat basements and crawlspaces as unconditioned space that won't be heated or cooled. This means that either all the heating

Note how the south windows at left are flush with the face of the wall, while windows at right on the east (also north and west) are recessed. When the house is complete, a row of angled solar panels between each row of south-facing windows will shade the windows while providing electricity.

and cooling equipment such as furnaces, boilers, central air conditioners, heat- or energy-recovery ventilators, and water heaters, and all plumbing pipes, tanks, appliances, and fixtures need to be moved from basements or crawlspaces upstairs into the conditioned space. Alternately, you can build an air-sealed and insulated enclosure completely surrounding them, including an air supply for any combustion appliances—preferably that air supply should come through a heat- or energy-recovery ventilator, which I will cover in the following article. The same two options apply to equipment located in unconditioned attic spaces.

Windows and doors

Don't skimp when upgrading your windows and doors, as you will never get enough payback on future upgrades to afford to do it again. Windows and doors are the weakest insulation and airtightness point in your home, thus having the greatest effect on energy savings and comfort. A *Passivhaus* window will typically be triple-glazed and have a center-of-glass R value of 9 or better, with a whole window value of nearly R-7. Sliding windows and doors can't be made airtight enough to meet the

Passivhaus standard. *Passivhaus* windows and doors are swing doors and casement, awning, or fixed windows, and openable windows and doors most often have more than one complete perimeter of weatherstripping with cam locks acting in more than one place along the frame to pull the door or window sash tight against the weather stripping.

Frames are the weakest insulation points and will often include thermal breaks and insulation levels not seen in cheaper windows. Fiberglass frames often have a lifetime warranty because they have a thermal expansion rate almost identical to the glass they are holding, so that the seals on the glazing which hold in the rare gases last far longer than in vinyl or wood. Argon lasts longer than krypton, typically, and is cheaper but doesn't achieve as high an initial R-value.

Thermal mass helps you both in summer and winter, limiting temperature swings.

In heating climates in the Northern Hemisphere, south-facing windows should be clear glass, with solar heat gain coefficients of 0.4 or higher, which will usually mean a tradeoff of a lower R-value, while all other windows should have the highest R-value available, usually achieved with low e-coatings on the glass, in addition to the rare gases between the triple panes that all *Passivhaus* windows tend to have in heating climates. Also the south-facing windows that are intended to collect winter solar heat should be located at the outside surface of the finished super-insulated wall. They can be shaded in summer with horizontal overhangs or better yet, horizontal trellises with deciduous vines. Windows facing other directions can be recessed deeper into the wall—they will contribute the least to summer overheating if they are recessed with proportions that are narrow and tall, or if they are shaded by vertical fins or trellis with climbing vines. All windows should be sealed back to the air-barrier layer in the wall, even if that means turning that continuous air-barrier layer into the reveal of the window opening and taping all the joints and corners.

Skylights almost always work against you thermally—even if their sidewalls were super-insulated (North American manufacturers most often include no insulation), because the glass is oriented so that it always contributes to summer overheating and greater winter heat loss than does vertically oriented glass. Consider replacing skylights with either a dormer having a vertical glass window (especially if it would face south), or a solar-tube skylight that has a much smaller glazed opening at the top and bottom of a sealed reflective tube. The latter uses the principles of magnifying glasses or fresnel lenses to gather light from a larger area than the size of the opening, then disperse it again at the bottom into your living spaces.

If super-insulating, air-sealing, and fully shading windows in the summer is not sufficient to prevent summer overheating when night flushing ventilation through windows is the only cooling source, or if you have rooms that are going though more than 10° temperature swings over the course of a day and night, you may wish to consider additional thermal mass as a sort of heat storage battery. Thermal mass helps you both in summer and winter, limiting temperature swings. Solid thermal mass like a concrete floor or brick chimney or wall has a much lower specific heat (storage capacity) than water (about 0.25 compared to 1.0 for water), and its effective thickness is limited by our 24-hour day, such that heat doesn't travel more than 4" into solid material over the course of a day before it comes out again at night. For this reason, mass floors and exterior walls over 4" thick, and interior solid mass walls over 8" thick are a waste of material, and one gets better storage capacity from solid mass by having more surface area than by having more thickness (which is why rock beds with solar-heated air pulled through them were popular in early solar buildings). However, containers of water do not have the same thickness limitations—any size can work (as long as the building structure can support it). As the sunward side of the container heats, the hottest water rises to the top and starts radiating some heat to the space, causing it to sink down the shaded side of the container, while the coldest water flows up against the lowest part of the sunny side to start picking up more heat. Thus, these convection currents keep all the thermal mass heating evenly when the sun shines and cooling evenly at night.

Now I've covered all the truly passive solar design principles involved in a *Passivhaus*, but the last thing that all certified Passive Houses feature is a heat- or energy-recovery ventilator (HRV or ERV). The fan makes it technically an active system, although the energy draw is tiny relative to the amount of energy it can save. About 40% of a typical home's energy is lost in the air leaking out of the house, and the HRV or ERV can save 80-90% of that energy, making it one of the most important energy efficiency measures you can implement. Active ventilation also safeguards your health and the longevity of your building, a true triple bottom line or payback. This will be covered fully in the next article. Δ

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Lemons in the Living Room

Sue Gray & Jerome Osentowski

WHEN SPEAKING OF AGRICULTURE, "greening" might not sound so bad, but it's the nickname of a disease that could mean the end of Florida's annual $9 billion citrus industry if something isn't done to stop it.

Named for the color of the misshapen fruit it produces, citrus greening disease was first reported about 70 years ago in China, and has already caused crop failures in Asia, Africa, the Arabian Peninsula, and Brazil.

Virtually all of Florida's citrus groves have been infected, and the disease has killed millions of trees in the southeastern US. The Florida Citrus Commission said the 2013-14 season will probably end with the smallest orange crop in 29 years.

The disease enters the tree when plant lice called psyllids deposit a bacterium while feeding on leaf sap. The bacterial infection starves the tree of nutrients, turns the fruit green, and eventually kills the tree. There is yet no cure for infected trees.

Federal agriculture officials recently allocated $25 million for research to prevent further spread of the bacteria, but greening has already been detected in some of California's backyard citrus trees.

University of Florida researchers think they've discovered a chemical that kills the bacteria, but say it might be years before it could be commercially available to growers.

A solution for citrus lovers

In light of the failing Florida citrus industry, people who enjoy orange juice for breakfast or a squeeze of lemon in their iced tea might wonder whether those habits will become too expensive or even impossible in the near future.

"Not to worry," says Jerome Osentowski, founder of Central Rocky Mountain Permaculture Institute (CRMPI) in Basalt, Colorado— "we can grow our own citrus trees at home." Osentowski grafts scion wood from 25 varieties of citrus from his greenhouse and indoor nursery onto dwarf rootstock to produce trees small enough to fit in your sun room. Scion wood from a desired tree is a small cutting from last year's branch with at least two buds. The rootstock (onto which the scion is grafted) influences mainly the tree's size and its response to soil and climate, while the scion wood becomes the new top growth; it produces your fruit of choice.

Citrus trees loaded with ripening fruit, at 7,200' in the Rocky Mountains

Climate change means you have to keep going higher in elevation.

More than citrus

CRMPI is one of the premier high-altitude permaculture proving grounds and educational facilities in the world. It's also integral to the Heritage Fruit Tree Project. In the last five years, Osentowski's team replicated hundreds of heritage trees from Colorado's Roaring Fork Valley by grafting branches from century-old apple, plum, pear, apricot, and cherry trees onto hardy rootstock. The trees were sold to homeowners, schools, and municipalities as a way of preserving the heirloom fruit brought to the area by 19th-century homesteaders.

Using the same methods, Osentowski is building a healthy inventory of citrus trees. CRMPI sold over 40 citrus trees last year, and Osentowski hopes to double or triple that next spring.

On a recent tour of the CRMPI grounds and greenhouses perched at 7,200' (2200 m) on the south side of Basalt Mountain, Osentowski points out tangerine, lemon, and lime trees laden with fruit within a tropical food forest where 75 other tropical species flourish. The trees, most of which are several years old, are growing in the ground under the protection of a massive greenhouse that Osentowski designed and built with architect Michael Thompson.

Permaculture is a way of symbiotically growing many different varieties of plants, both annual and perennial, in a system that mimics the natural forest or savannah. The method has been shown by researchers worldwide to generate healthier and more productive plants.

The facility also contains the beginnings of next year's commercially available container trees. Combining rootstock with scion wood from three different dwarf citrus—each cutting with two buds from various regular-sized trees—Osentowski can create a single small "patio tree" that can produce one or several varieties of fruit. That means you could harvest an orange, a lemon, and a lime all from the same tree.

As for the citrus disease problem, Osentowski said his trees have no signs of greening, nor does he expect any—the Asian psyllid can't live in the Rocky Mountain climate.

"They're looking for a silver bullet fix," he said about the research to stop greening disease, "but they're not considering that the problem might be in how the crops are grown."

Noting that every major agricultural crop in the world is in crisis, Osentowski believes there will continue to be serious problems because of the unhealthy way crops are grown in monocultures and with heavy fertilizer and pesticide use. "These diseases are evolving faster than we can find silver bullets to fix them," he said, adding that the current agricultural system is "a big ship, and they can't turn it very fast."

In addition to bad farming practices, Osentowski thinks climate change is increasing the difficulty of growing crops in places that were once ideal growing zones. "Climate change means you have to keep going higher in elevation" to grow plants that need cooler temperatures, Osentowski said. But what about plants that normally grow in warm temperatures—like citrus?

The solar economy at CRMPI

Are you dreaming of building a greenhouse to "save the citrus," but think it will be too costly to maintain? CRMPI maintains 5,000 sq. ft. (450 sq. m) of greenhouse space using only the power of the sun and the wonderful people who come to lend a hand.

CRMPI generates all the required electricity from a 6.3 kW solar array on the roof of the house, which produces an average 9,700 kWh per year. A grant financed the initial purchase and installation of the solar panels; such programs exist for residential and commercial operations in much of the country.

In addition to producing its own electrical energy, the

Container forest of dwarf heritage trees grafted from 25 varieties of citrus

Institute also takes many steps to conserve energy. For example, the greenhouses are filled with thermal mass to retain heat. These materials include rocks, which line the sides of raised beds and some of the walls, and aquaponics tanks holding 600 gal. (2300 L) of water that warms up in the day and releases heat at night. Water tanks within the greenhouse store its roof runoff to water the plants. There are countless seemingly small features that can increase thermal mass and solar gain in a greenhouse. For example, water tanks colored black collect the most heat possible during the summer hours. CRMPI's greenhouses are made primarily out of salvaged materials and are maintained with many home-made or homegrown resources. You can make your own fertilizers from animal manure; CRMPI uses rabbits and chickens fed on spent grains from a local brewery.

Greenhouse construction can range from a multimillion dollar ordeal with the fanciest of siding, fans, and coatings, to a simple do-it-yourself project using recycled and salvaged materials. A well planned and thought out design can save money and time, and can result in a highly efficient growing environment.

Gardening indoors

Local architect Michael Thompson says that in a Colorado climate of Zone 4 to 5, you have to design the greenhouse to maintain climate Zone 11 if you want to grow citrus. Thompson and Osentowski are partners in Eco Systems Design, Inc., which specializes in developing permaculture greenhouses and growing domes for schools, businesses, and homeowners.

"If you want to grow citrus year-round at this elevation," said Thompson, "you need to increase your growing climate up to seven zones, to compensate for the frigid temperatures in January and February." If your house lacks a sunny southern window, that would require investing in a small greenhouse or grow dome. Adding a season-extending structure to your property can cost $10-50 per sf, said Thompson, depending on your needs and desires.

Along with a half-dozen examples of different sizes and shapes of greenhouses at CRMPI, there are several such structures nearby, including the 42'-diameter (13 m) grow-dome at Roaring Fork High School in Carbondale. The permaculture greenhouse was built with guidance from Thompson and Osentowski in 2010, and is used to teach math and science, as well as to produce food for school lunches. Like some of the CRMPI greenhouses, it contains temperate-zone novelties like olive and fig trees.

...high altitude citrus is a juicy prospect.

The dome was built from a kit, but was fitted with the earth battery or climate battery that is implemented by Thompson and Osentowski in all of their growing structures. The underground heating and cooling system redistributes the sun's energy down 3' (1 m) in the soil, using little if any electricity from the grid, which makes the greenhouse operation in Colorado winters near net zero.

"If we can grow all of these things with net-zero energy use, why stop at growing radishes in a box?" Osentowski asks, referring to the raised-bed gardening methods used by many home gardeners. "We can take it to another level, and citrus is just one little part of it."

Research and development at CRMPI has shown that high-altitude citrus is a juicy prospect. If greening disease continues to wreak havoc in the Southeast, Colorado might just become the new Florida. Δ

Sue Gray is an organic garden and landscape specialist in Carbondale, CO. She has served on the Town Environmental Board and is actively involved in the sustainable agriculture community. Jerome Osentowski is the founder of CRMPI. CRMPI has been on the forefront of permaculture in North America for 25 years. The CRMPI team is currently finishing a book on permaculture greenhouses titled Bringing the Garden Indoors, *which will be published by Chelsea Green.*

Solar Success in the Midwest

Woodrow Bessler, Darrell Boggess, Anne Hedin & Terry Usrey

THE SOUTHERN INDIANA RENEWABLE ENERGY Network began in 2008 with a mission to promote the adoption and use of renewable energy. Then, as now, Bloomington and Monroe County, IN, had a thriving sustainability and environmentally conscious community with volunteers and groups focused on important issues including local food production, alternative transportation, forest protection, and green building practices. However, no one was carrying the banner of clean, renewable energy. That void accompanied a growing awareness of the state's extreme dependence on coal for power production, and its consequences. Pollution from coal-fired power plants accounted for $100 billion in US health costs and 13,000 premature deaths annually in 2010 (1). In 2013, 84% of Indiana's net electricity generation came from coal—equivalent to 8.23 tons (7.5 metric tons) of coal per Hoosier per year. (2)

...SIREN has presented dozens of Going Solar programs to hundreds of prospective owners....

The group was organized with an acronym (SIREN) that appropriately spoke to the urgency of the climate and energy crisis. Dozens of interested and motivated people were willing to work to advocate for a clean energy future, but they lacked an action plan. Various organizational approaches were explored, including forming an energy producing cooperative or a membership-powered 501(c)3 with a board of directors and elected officers. Ultimately, SIREN became a project in the Center for Sustainable Living, an existing local nonprofit, and evolved into a core group of individuals in a steering committee with a larger group of interested businesses and individual supporters.

Early activities focused on providing formal PV training and barn-raising style solar installation events. By the end of 2008, the county's first three systems were up and running—at a cost per watt of $10. Later, SIREN ran a community-wide energy efficiency contest with a PV system as grand prize. In 2011, the current priority on providing education emerged when Earth Care, a local interfaith group that had been focusing on energy conservation, asked SIREN to present a public program describing the performance, cost, availability, and carbon reduction of renewable energy.

Solar growth spurt

When that program launched in May 2011, nearly 100 people attended to hear the message of keynote speaker, Indiana Nobel laureate Elinor Ostrom: we can't wait for politicians to act. She provided leadership by acting herself. A solar contractor said the Ostroms' garage roof could hold about 30 panels and asked her how many panels she wanted. Ostrom said, "Fill it up." Others followed.

This collaboration showed that a major barrier to renewable energy adoption in the Midwest was lack of information explaining the technology and its trend to lower cost. Subsequently, SIREN has presented dozens of Going Solar programs to hundreds of prospective solar owners, mostly in Monroe County, and provides personal consulting upon request. Perhaps as a consequence of this ongoing education, Indiana's approximately 500 solar owners are not evenly distributed through the state's 92 counties. SIREN has catalogued nearly 200 homes, government buildings, churches, schools, and businesses in Monroe County that use solar energy as of January 2015 (3). A few use it for space and water heating, but the majority harvest the sun using photovoltaic (PV) panels that generate electricity—the application that this article describes.

To thank Earth Care for hosting the first Going Solar program, SIREN teamed with Hoosier Interfaith Power and Light in 2013 to help six faith communities get solar arrays averaging 20 kW for less than $3/W. All the congregations have reduced their electricity consumption by more than 25%; some have reduced it by more than half. An additional eight congregations throughout the state are preparing to go solar now.

Barn-raising style solar panel installation im 2010. Photo by Terry Usrey.

Figure 1. How big should your PV system be?
Measure in kilowatts and kilowatt hours:
A kilowatt (kW) = 1,000 W
A kilowatt hour (kWh) = 1,000 W for one hour
In 10 hours, a 100 W light bulb uses 1,000 W-hours or 1 kWh AC
In 4 hours of full sun, a 250 W DC solar panel makes 1,000 W-hours or 1 kWh
If you want to generate 100% of your electricity:
Total up your annual consumption (example: 12,000 kWh / year)
Four 250 W panels (a 1 kW system) will produce 1,200 kWh in a year.
Forty panels (a 10 kW system) will produce 12,000 kWh / year.
If you follow a 50-50 strategy:
Replace half of your annual kWh with solar PV (20 panels, a 5 kW system).
Try to reduce the rest with energy efficiency and conservation.
Reducing household energy use by 100 kWh a month has the same effect as buying four 250 W solar panels that produce 1,200 kWh a year.

Siting, sizing, and paying for a PV system

Three factors usually determine PV system size: present electricity usage, available space, and budget. The first question solar installers ask is "how much electricity do you use?" In response, most people say something like "our bill is $120 per month." While cost is important, knowing the total number of kilowatt hours (kWh) you use annually is essential for properly sizing a solar system. Utility companies use kWh as their billing unit, so you can get this number from your bill. In 2013, the national average for residential energy consumption was 10,908 kWh annually (the examples below round that up to 12,000 kWh for simplicity) (4). Your energy usage will vary depending on the home's size, number of occupants, and climate. Sizing for a business depends on both current usage and any near- and long-term expansion plans.

Full sun exposure is most important for PV siting, and orientation to the sun is a close second. Panels that generate approximately 1,000 kWh per year when facing south will generate 800 kWh when facing east or west. Figure 1 presents two different strategies for calculating the size and cost of a PV system. They are based on two assumptions: that your system will face south and that you select a 250 W panel. If roof space is limited, consider panels with the same footprint (about 3' x 5') but a higher capacity (up to 300 W; 275 W is becoming the new norm). They are a little more expensive, but the extra energy they generate will pay for themselves over time.

Table 1. The Cost of Solar Varies with Complexity and Power

PV system type:	**Simple 4 kW**	**Complex 4 kW**	**8 kW**
Cost per watt	$3.50/W	$4/W	$3.25/W
Installed cost	$14,000	$16,000	$26,000
Tax credit (30%)	($4,200)	($4,800)	($7,800)
Net cost	**$9,800**	**$11,200**	**$18,200**

Incentives: tax credits, SRECs, and grants

Many factors affect the installed cost of a PV system, from product selection to the difficulty of the job to the contractor's travel time. Table 1 approximates the current cost of three sample roof-mounted, grid-tied configurations. The addition of batteries to make the system independent of the grid, while possible, would add significant expense as well as a maintenance burden. (The panels themselves are virtually maintenance-free.) Fortunately, a 30% federal tax credit offsets a portion of the cost, as shown.

The federal tax credit is set to expire on December 31, 2016, unless Congress extends it. Your state may offer additional incentives; if so, they will be listed in the Database of State Incentives for Renewables & Efficiency (5). To give an idea of how fast solar costs have fallen, a PV system would cost less in 2015 even without a tax credit than it did in 2011 with the tax credit. An investment in renewable energy is an appreciating asset that increases in value as utility rates go up. It is like buying 30+ years of electricity, upfront, at a fixed price!

Solar Renewable Energy Credits (SRECs) are a financial incentive offered by some states with a renewable energy standard (RES). Indiana has no RES, but residents can participate in Ohio's SREC program and possibly that of Illinois in 2016. By registering with a clearinghouse, a solar owner can claim one SREC for every 1,000 kWh generated; the SREC is sold through a broker, who then pays the owner. Ohio out-of-state SREC prices have varied between $30 and $50, providing 3 to 5 cents/kWh income to solar owners. SRECs can increase the return on investment by half when electric rates are near 10 cents/kWh.

The Rural Energy for America Program (REAP) provides financial assistance to agricultural producers and rural small businesses to 1) purchase, install, and construct renewable energy systems, 2) make energy efficiency improvements to nonresidential buildings and facilities, 3) use renewable technologies that reduce energy consumption, or 4) participate in energy audits and renewable energy development assistance.

Eligible renewable energy projects include wind, solar, biomass, geothermal, and hydrogen derived from biomass or water using wind, solar, or geothermal energy sources.

REAP grants are limited to 25% of a proposed project's cost, and the loan guarantee limit is $25 million. The combined amount of a grant and loan guarantee must be at least $5,000 (with the grant portion at least $1,500) and may not exceed 75% of the project's cost. A minimum of 20% of the funds available for these incentives will be dedicated to grants of $20,000 or less.

A total of $12.3 million in grants and $56.4 million in loans were awarded in 2014. Application deadlines for

2015 are April 30 and June 30. More information and application forms are available online (6).

A greenhouse with green power

Susan Welsand, the Chile Woman, has run a permaculture-based nursery business for 23 years. (7) In May 2011, a tornado blew through her property in Bloomington. It sucked potted chiles and tomatillos right out of her greenhouse, disrupting operations halfway through the 8-week window allowed by law for interstate shipping. When the crisis was over, she looked around and realized that she had an opportunity.

“I had always wanted to have solar power. It was my AP physics project in high school. When I bought my land, it was heavily wooded, so I gave up the idea,” Welsand says. “After the tornado, there was a large opening right by the greenhouse. I missed the trees, but then I realized, maybe I can have solar now.”

...these people were already environmentally conscious; going solar made them more so.

She saved up for a year (she doesn’t believe in taking on debt) and applied for grants, but by winter, the only time she had to do the research, they had all been given out. However, Green America responded to her inquiry by nominating her for a People and Planet award, which she won. The prize contributed $5,000 toward the cost of the system.

Welsand installed a 5.2 kW ground-mounted PV system, grid-tied and eligible for net metering. Because its angle and tilt can be adjusted for optimal exposure to the sun in every season, it generates up to 20% more output than a fixed roof-mounted system. Since completion in January 2013, it has provided all the electricity needed for the greenhouse. Welsand says, “Chile peppers need very high temperatures to germinate. Last winter we had brutal cold in early February, just when I was starting my peppers, and it was cloudy so I was not getting any solar gain in the greenhouse. I had to keep the greenhouse at 85°F (29°C), which uses a lot of power. Then in the warmer months, the ventilation fans have to run constantly, and we’ve had darn hot summers.”

Ground-mounted systems cost more than roof-mounted ones anyway, and Welsand’s panels cost more than the average because of site-specific challenges. The installer had to dig a trench through limestone (and some days, ice) to lay conduit for the wires to the meter. In addition, the meter location was changed from the house to a shop belonging to the business to consolidate expenses for tax purposes, with attendant rewiring in both locations.

The Chile Woman proudly displays her ground-mounted, 20-panel PV system. It can be adjusted seasonally for best sun exposure. Photo by Luiz Andre Bispo de Jesus.

Despite the extra expense, Welsand says, “The solar panel investment makes a lot of economic sense for a small business. There is a 30% tax credit right off the top along with a five-year accelerated depreciation schedule, and it is a win-win because you are going to need the power anyway. The initial capital investment can be beneficial financially over a long period of time. This system was rated for a 15-year payback period, but if we continue to have the type of weather we had last year, it’s going to be more like ten years.”

Solar as a permaculture solution

In 2013, we asked the SIREN community how going solar had affected their attitudes and behavior. Here is what we heard from a dozen people who wrote back.

Attitude first—these people were already environmentally conscious; going solar made them more so. One person wrote, “Even before I had solar panels, I got in the habit of reducing my carbon footprint as much as possible. Now I pay much more attention to my lifestyle and its consequences.” Another person, European by birth, wrote, “I grew up more sustainably than an American, so I squander little. With the solar panels, I’ve become even more adamant about not wasting, as power has become personal."

These themes recurred repeatedly. Gaining a measure of control over their supply of electrical power increased their sense of personal power. Monitoring power generation on the PV system dashboard and watching the utility meter spin backwards are powerful motivators for energy efficiency. Every account we received from solar owners told us about energy efficiency improvements they had made and were planning for the future.

This brings us to practical results. The initial size of residential solar systems ranged from 2 kW to 8 kW, replacing between 50% and 90% of the households' previous usage of grid power. A third of the responding solar owners later added more panels. A few households have reached net zero, the balance point where generation meets demand. Over time, they send as much electricity out to the grid as they draw from it at night and under cloudy skies. Others are closing in on that goal.

The starting point is important. One member who installed solar on a new house wrote, "SIREN suggests that new solar users size their system to provide 50% of their needs and try to conserve much of the remaining half. However, given how efficient the house already was, I sized the PV system to generate about 80% of our power... The system was even more proficient than I expected, generating about 92% of our needs in its first year."

If a less efficient house is the starting point, leave room for improvement. This example is closer to the norm: "Our solar system was designed to produce about half of our household energy use. For the past three years, it has reduced our total cost by about half and reduced our energy use by 70%. Other energy-saving strategies included envelope tightening starting with a blower door test; sealing of can lights, chimney, and outer wall holes; and installing LED lights. We are planning more, including replacement of our electric water heater with a natural gas or on-demand system; replacement of the refrigerator with an Energy Star model; replacement of washer and dryer with water- and energy-conserving appliances; adding insulation; and considering a plug-in hybrid when our 2002 Prius needs to be replaced."

Even on cloudy winter days, PV panels keep generating electricity. Susan Welsand's dashboard shows current and lifetime values for her 5.2 kW system. Image by Susan Welsand.

It's easy to overestimate the number of panels you need and underestimate the amount of energy you can conserve. The more energy you save, the less you have to buy or generate. One person replaced a 70s-era refrigerator that used 1,500 kWh annually with an Energy Star appliance that saved 1,000 kWh a year. The new $500 refrigerator cost far less than the number of solar panels it would take to generate 1,000 kWh annually.

One final observation

Like permaculture itself, the adoption of renewable energy encourages and rewards holistic thinking. For solar owners, having some control over the source of their electricity provides the flexibility to develop seasonally adaptive strategies such as those recommended by Peter Bane in the November 2014 issue of this magazine *(PcA #94).* Many people described their strategies for creating synergies between solar-powered electricity and other energy sources (wood, propane, gas, and geothermal) to get the most results from the least resource.

This is not just about the money. One strategy frequently mentioned is using an electric heat pump instead of a gas furnace on mild winter days. The state still gets 84% of its electricity from coal, which is dirtier than gas, and a heat pump heats less efficiently than a gas furnace in weather below 32°F (0°C). For both these reasons, a heat pump is not the best tool for the job—unless it runs on solar power.

We will end with a quote from a SIREN member who bought her house specifically for its south-facing roof. Before she moved here, she had no idea that Indiana received enough sunlight to make a PV system feasible. Now she is at net zero. She wrote, "I view a solar system as not only an appliance, but as a tool for teaching neighbors and the community how to 'Be the change you want to see in the world.' " Δ

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Restoring Urban Watersheds

Planting Rain in the Desert

Jeremy Lynch

AFTER A MILD WINTER IN THE MOAB VALLEY, the season slowly turns. In this land of extremes, high on the Colorado Plateau in southeastern Utah, the climate is dominated by intense sunshine throughout the year; even the heat of the winter sun reminds us of summer's scorched landscape.

As new buds swell, and life stirs in dens under clapboard porches, the plants and animals of our little dryland town are emerging. Patterns shift: the winds pick up, and pre-dawn frost on the fallow fields begins to fade. The brown-gray winter coats of deer fall away, while crystal-clear snowmelt courses through the valley's creeks. Where springs bubble up, and seeps trickle from the rock, old cottonwoods hold their stark and straining form.

Though we sit and stare from the same vantage as in the season past, the arc of the sun has shifted, and we see from a new angle. This privileged perspective grants us a fuller view of our familiar, everyday world. If perpetual change and motion define the first three seasons of the year, then winter is a time for perspective in observation. And observation is the key to design.

Settlement...has long been fostered by the lush and curling riparian corridors....

Looking out a window at Utah State University-Moab, a new and special garden—the work of a community—gleans the short arm of light afforded by the late winter sun. Each detail—from the young fruit trees (now caged against browsing deer) to the curving, rock-lined swale—calls to mind an aspect of the design process as it unfolded over the course of a year. What differentiates these rain gardens from so much urban landscaping here in the valley is neither the aesthetics of the constructed space nor how precisely it functions within the local ecology, but how the design was conceived and carried out. From inception through implementation, the rain gardens have been a community project. Observation was integral—in our case, the shared observation of a vested community.

Our design shares its essence with the science of permaculture. Often referred to as ecological design, permaculture is a multidisciplinary approach to designing

Setting the first trees in the newly established soils of the shade islands.

human-centered ecosystems. To serve multiple functions, these must interact and exchange resources across material and conceptual boundaries and edges. The interactions may involve diverse plant species in a garden, or everyday social encounters in an office. Whether the terrain is geographical, morphological, theoretical, or otherwise, the key to good design is understanding the conditions of the place itself and the ways in which energy and resources define settlement there.

Ancient roots, recent history

Spanish Valley (often referred to as the Moab Valley) nestles amidst a vast landscape of red sandstone arches, spires, hoodoos, pinnacles, towers, and deep sheer-faced canyons. Sagebrush and prickly pear desert encircle the valley where occasional "island in the sky" mountain ranges loom large on the horizon, drawing rain at high elevations. Here, at just over 4,000' (1200 m), with the footprints of ancient creatures fossilized in rock, and the art of former civilizations still on display, Moab carries a long history of settlement and resource abundance in contrast to the drier habitat beyond the valley's periphery. The town receives an average of nine inches of rain per year, often much less, as is the trend in the desert Southwest. Settlement—from the indigenous to the pioneer through to the 21st century—has long been fostered by the lush and curling riparian corridors that draw life from the melting snows of the La Sal Mountains. Mill Creek, the central waterway through town, once swung its tail up and down the length of the Colorado River bend, across a vast alluvial plain, depositing sediment over a wide wetland expanse. As in so many watersheds of the Southwest, before the arrival of tamarisk and Russian olive, cottonwoods dominated

Rain Gardens from a downspout-eye-view during an early winter rain.

the floodplains of these meandering streams, under-storied by willows, reeds, and grasses which are now the focus of extensive restoration work. Today, the creek is constrained, incised. Where once the wetlands stretched, now a pile of uranium tailings is being removed in a decades-long process, while high-end residential development encroaches on the Colorado floodplains. The wetlands persist, and Mill Creek continues to flow despite the draining effects of an extensive and antiquated flood channel irrigation network built over a century ago—concrete-lined, dilapidated, yet clutched at by many as a tradition.

Despite these affronts, the wetlands remain home to numerous migratory bird populations, and the creek still feeds the river. Though the setbacks and oversights of development have taken their toll, and the valley's sandstone aquifer remains little understood, our community perseveres as new collaborations—the Canyonlands Watershed Council, the Moab Area Watershed Partnership, and the Bee Inspired Gardens Group—emerge to integrate the booming tourism economy with our fragile watershed. In a community where hydraulic frackers have cajoled the city into selling its potable water for drilling operations, the more partners one has, the more functions may be stacked, and the better poised we are for action.

Motivated citizens and the local Conservation District, together with USU-Moab and the Bee Inspired Gardens Group are establishing rain gardens on the university's downtown campus to provide water-wise permaculture education to the larger community. This past year, USU Extension Sustainability Director Dr. Roslynn Brain and myself (in the role of permaculture intern) enlisted the guidance of Jason Gerhardt of Real Earth Design in Boulder, Colorado to plan and implement rain gardens amidst a parking lot.

In their design, the gardens harken both to Moab's ancient roots and its recent history, while incorporating present-day permaculture science to "de-pave" the way toward more permeable landscapes, healthier waterways, a fortified watershed, and equal opportunity education.

Rain gardens in the desert

Each element in the rain gardens is nuanced, interconnected, and clear. A long, sloping swale—or depression—lined with river cobble curves through the garden to slow, capture, and infiltrate water from the roofs of nearby commercial buildings. Downspouts feed roof runoff into the swale, which functions like a creek or wash, transporting water during storm events. The channelled water feeds thriving plants along the way. It also controls erosion, mitigates non-point source pollution, and recharges the aquifer. Using rock to harvest water—an ancient indigenous practice—has the added benefit of aesthetic appeal. The 5-10" river cobble is laid in aprons at the entry point of all waterways and at the discharge point of each downspout. To limit erosion, rock also lines the bottom of the swale, as the surrounding gardens slope gently toward its depression. Above the level of the rock and throughout the garden, several inches of woody mulch stabilize loose sandy soils, while also holding moisture. Throughout the winter, morning frosts captured by the metal roofs of the campus buildings and a neighboring lumber yard melt and drain into the garden swales, feeding the soil and the life therein, while the frozen surface slumbers under shaded snow. Though Moab has long dry seasons, these designed features of the system provide water to support perennial ethnobotany and seasonal food production, as well as year-round education.

Always plan for overflow for your overflow!

All of the materials we used are local, and many were recycled. For example, problematic Russian olive trees were turned into a solution as they were cut and chipped to provide a mulch which holds moisture in the soil and breaks down into a hearty tilth. As noted, the entire garden (excepting the swale) is mulched to enhance water retention, including the boomerang-shaped berms enfolding the young fruit trees. By inviting microbial life into sandy soils beneath the mulch, manure from local mules yields nutrients for the young plants.

The guilds of trees, shrubs, and herbs, most of which were grown from locally harvested seed—were planted in patterns that mimic the dryland forests. They create microclimates to sustain unique air, surface, and soil life, while supporting one another by accumulating nutrients, fixing nitrogen, and offering shade from the harsh sun. This last is a resource in any desert environment, but is especially welcome in areas of the garden surrounded by asphalt and backed by a two-story brick wall which radiates heat from the intense sun. The plants were chosen for their suitability to our unique climate, and for their ability to amend soils and provide food and habitat for pollinators, as well as food and education for people. Selections combine the 20th century's history of extensive orcharding in the valley—peaches, pears, plums, cherries, even jujube—with native species such as the desert willow *(Chilopsis linearis).* As an understory, native sand cherry (*Prunus pumila* L. var. *besseyi)*, Utah serviceberry *(Amelanchier utahensis),* and golden currant *(Ribes aureum)* crowd the banks of the swale. Apache plume *(Fallugia paradoxa),* a nitrogen-fixer, pocks the landscape, and ground-level herbs and medicinals—from thyme to yarrow—work the soils near the roots of trees. Native blanket flower *(Gaillardia spp),* lo-grow sumac shrubs, Rocky Mountain penstemon *(Penstemon strictus),* and hyssop fill out the native aesthetic, amidst bee balm and bright daylilies. Banana yucca *(Yucca baccata)* and Indian ricegrass *(Oryzopsis hymenoides)* provide additional food sources, while stabilizing the banks of the swale alongside native three-awn *(Aristida spp)* and little bluestem *(Schizachyrium scoparium)* grasses. Every flowering plant draws hungry native bees, over 900 species of which call Utah, the Beehive State, home.

Shared observation by the community

Most important of all, both the design of the garden and its installation were determined through community participation in a series of public workshops. This is where permaculture design transcends the garden and enters social dynamics. Many of the ideas proposed in these workshops have become realities in the garden, including the two tree islands planted with all native vegetation in the heart of an asphalt parking lot. Two designs prevail here. In one, a single curb cut welcomes runoff flow into a rock-lined entry point, down into a basin cut a foot below-grade and filled with half a foot again of woody mulch. In the other, two curb cuts draw in the water, and between them a raised berm delineates the double basin design. When one island fills to overflowing, the water sheets across the asphalt to the next, where it enters and percolates. Always plan for an overflow for your overflow!

The perspectives offered up during the workshops—from minds new to permaculture, as well as from practiced gardeners and landscape designers—have proven an invaluable resource. Through these workshops we were able to teach, learn, and design—all before a single plant went into the ground. Outside the window stands a wood-framed pergola conceived by university staff who attended the workshop: an outdoor space designed to draw employees out into the beautiful sunshine. Soon, grapes will grow up and over its posts and beams, to provide welcome shade and of course food—a little something to add to the rain-garden fruit salad.

Permaculture design is about more than growing gardens. It's about growing people and communities through an increased interaction with and knowledge of local ecology. In other words, it's about teaching people to teach themselves how the world works around them. In doing this, we build the foundation for shared education and understanding which seeks to work with—not against or in neglect of—our environment.

Our workshops have emphasized the concept of corridors. In a watershed threatened by development, corridors are necessary for wildlife, the water cycle, and nutrient exchange. But they must be created and maintained without denying either agreeable or sometimes disagreeable community members that which they feel to be their right. Just a short walk west of the campus, one enters a lush creekside habitat at the confluence of two streams. Just east of the campus, one of these, Mill Creek, winds back toward undeveloped neighborhoods traversed by deer, coyote, beaver, and the occasional mother black bear and

Instructors and collaborators Jason Gerhardt of Real Earth Design, Roslynn Brain of USU Extension Sustainability, and Jeremy Lynch of In Transition Permaculture.

Group of volunteers and community workshop attendees who built the earthworks for two rain gardens and two water harvesting parking lot tree islands on a Sunday in late fall.

Along the wadi, there will be ample opportunities for learning and public engagement.

cub. Gardens and other features of these creekside corridors express the value of water as a human need and a community responsibility. Each plot is considered for its utility, but not for human use alone. Planting the rain is the seed of a key concept: how do we best manage our water and waterways?

As the Rain Gardens mature, and their design becomes more apparent with age, they will provide students and the community a learning space that shows water-wise habits, grows food sustainably, and supports local pollinator populations. We hope too that the social dynamics of thoughtful design and its positive, community-wide effects will grow on people. If the project is successful, others will 'bee inspired' to pursue their own ecological projects, whether growing gardens, managing cityscapes, creating sustainable buildings, or teaching children.

Next steps

We expect that our partners, USU Extension Sustainability, the Bee Inspired Gardens group, the Moab Area Watershed Partnership, the local Conservation District, and the City of Moab, having seen the positive outcomes of the Rain Gardens, will press forward with more programs of education and action for healthier watersheds and more pollinator-friendly native plantings. A fellow USU-Moab intern and student, Claire Core, is working with a local hotel and school to establish new educational gardens in 2015. The US Bureau of Land Management, in collaboration with Rim-to-Rim Restoration and local nursery Wildland Scapes, is planting native vegetation at public access areas along the Colorado River. Conversations are underway with the City's Community Development Office to install more streetside vegetated water harvesting basins. In addition, we need to look further up the creek to re-establish natural, beneficial water flows. This may come as we create mulched berms by felling tamarisk and Russian olive, or take the form of one-rock dams (ORDs), *media lunas,* zuni bowls, or other proven rock- and earthworks. Inspired by the beaver—a watershed's most effective builder—we will choose methods to suit the circumstances. Along the wadi, there will be ample opportunities for learning and public engagement.

Following on the successes of such organizations as Tucson's Watershed Management Group, as well as the individual efforts of designers such as Jeffrey Adams of TerraSophia, our next step in Moab is to reach further down the corridor, linking today's gardens into broader municipal water-harvesting schemes. These multifunctional, aesthetically pleasing, and prominent examples of proper urban drylands water management are on display for the community and also impact well over one million tourists who visit Moab annually.

It's a bright vision, and the time is as ripe as spring cherries to restore watersheds across the Southwest. In doing so, we call out community spirit, investment, and innovation. Collaboration opens corridors to good work, allowing us to cleanse our waterways, enliven our soils, grow our food, plant the rain, and repeat. ∆

Jeremy Lynch, of Moab-based In Transition Permaculture, has worked with USU Extension Sustainability and the USU Permaculture Initiative since late 2013. For more information about the Moab Bee Inspired Gardens, contact him at jeremyelliotlynch@gmail.com.

Before and After of the parking lot turned rain garden

Active Systems for the Passive Solar House

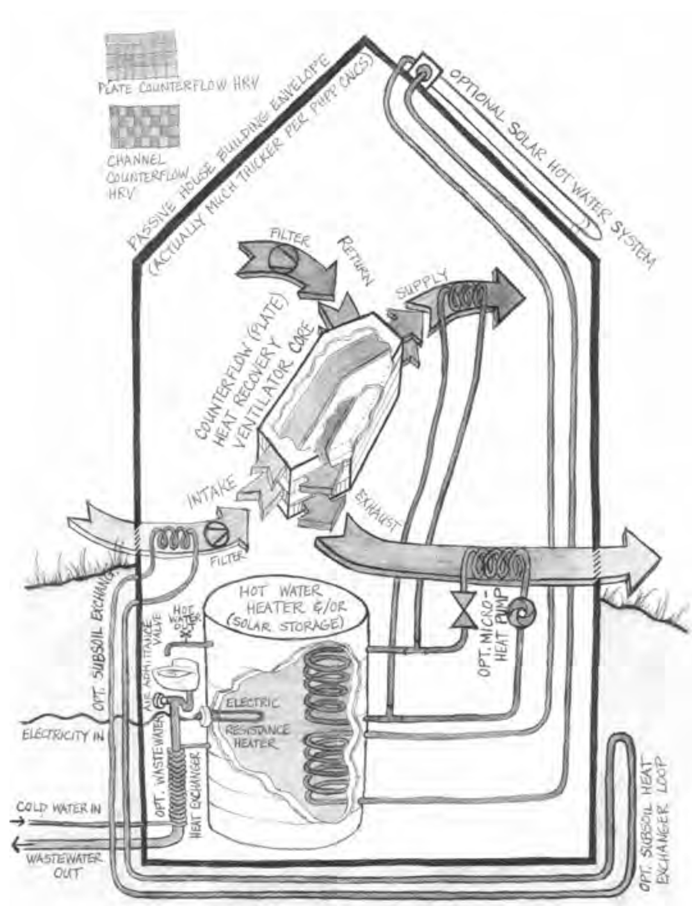
Christina Snyder

IN THE EARLIER ARTICLE, I explained the principles of good passive solar design, as well as the principles of super-insulation, avoiding thermal bridging, and ultra air-tightness that are essential to meet the Passive House Standard. These buildings require so little energy that they need no furnace, no boiler, and no wood stove—they can be heated by an electric resistance element the size of a hair blow dryer. I illustrated those principles with examples from my *Passivhaus* that is still under construction in Michigan. To give you an idea of the energy efficiency achieved by a building envelope like this, I can tell you that all *Passivhaus* use less than 4.75 kBtu/sq. ft. annually for heating. In "Seasonal Energy Flows" *(PcA#94),* Peter Bane told us of all the work he'd done to tighten up his house and make it better insulated and more energy-efficient than the average code-compliant house. He was rightfully proud that he'd managed to drop his heating energy (and thus, wood) consumption drastically, into the range of 50 million Btus annually for the whole house. When you multiply our 4.75 kBtu/sq. ft. by our treated floor area, you arrive at under 8.7 million Btus annually, or only about 1/6th of the annual consumption of Peter's much improved house. This gets us into a range where by introducing active solar systems, we can hope to achieve zero net energy annual consumption with solar energy alone, and maybe even get our home off the grid entirely (it has never had a natural gas connection, and never will).

Passive solar and active solar are mutually complementary parts of an holistic way of life: a permaculture of energy.

Energy recovery systems

Active systems require some electricity input but are able to save even more energy than they consume, and every *Passivhaus* is so airtight (maximum 0.6 air changes per hour at 50 pascals of air pressure differential) that it requires at least one active system to meet the *Passivhaus* Standard (and to meet building code requirements for fresh air): either a heat recovery or energy recovery ventilator (HRV or ERV). While not powered directly by solar energy, these are active systems because they



Concept diagram of an integrated counterflow heat recovery core for a Zero Energy Home, circa 2002. Drawing by CASnyder.

require a small electrical input to run one or two efficient fans to move air into and out of the house. But each unit saves far more energy than it consumes, by transferring most of the heat energy from the stale air that is exhausted from the building into the fresh incoming air that replaces it. Consequently, any *Passivhaus* has better indoor air quality than most buildings that only meet codes, and with a tiny fraction of the energy losses usually associated with fresh air coming into buildings.

The difference between the HRV and ERV impacts the humidity inside the house. The heat exchanger core of an HRV is moisture-impermeable, so that whatever moisture is in the air being exhausted through the HRV will end up outside, and whatever moisture is in the outside fresh air will come into the house. In contrast, an ERV has a moisture-permeable heat exchanger core. Although the exhaust air is always headed outside, and the fresh outdoor air is coming inside, some of the moisture wicks across the core from the high-humidity to the low-humidity air. In winter, the air is drier outdoors than

Husband Chris (L) and brother Mark (R) finish installing evacuated tube collectors. We tested two different models of collectors. Both perform well, and will be installed in new Passivhaus.

indoors. As a result, some moisture flows from the stale air headed outside back into the incoming fresh air, and the ERV retains more moisture inside the home than an HRV would. In summer, it is usually more humid outside than in, so moisture flows from the incoming fresh air into outgoing exhaust air, so as long as it remains more humid outside than inside, the ERV will keep the home drier in summer than does the HRV.

We purchased a German Zehnder Comfoair HRV for our *Passivhaus,* because there is currently only one North American ERV manufacturer that can meet the *Passivhaus* standard for energy efficiency (Stirling Technology's enthalpy-wheel ERV called the Recouperator, but we weren't sure we wanted an enthalpy-wheel design, as both the supply and return air pass through the same foam-rubber wheel). One of the benefits of the Zehnder is that the HRV core and the ERV core are interchangeable—if you decide the unit could do better at controlling your humidity levels, you can replace the core.

At this point, I should tell you that because the North American and German testing protocols for HRVs and ERVs are very different, comparing their efficiency scores is like comparing apples and oranges. If you take the same piece of equipment and test it by both the North American protocols and by the German protocols, you will get two different figures for its efficiency, with the North American 12% higher than the German score. Therefore, if you want to compare a North American HRV or ERV to a German HRV, you'll need to subtract 12 from the North American test scores. For example, our Zehnder is rated as 82% efficient by the German tests, which may not sound very good, until you compare it to, say a Fantech 150R with 72% efficiency measured by the North American test, then correct to 60% efficiency by the German test.

The reason most North American HRVs and ERVs aren't as efficient, but can be much cheaper than *Passivhaus*-certified HRVs and ERVs, is that they use a cheaper core, called a crossflow core. If you look inside at the guts of an HRV or ERV and find a white plastic material whose face is square, but it is rotated up 45° so it appears to be standing on its corner, then you are looking at a crossflow core, where the incoming air and the exhaust air pass through the core at right angles to each other but in alternating layers. Less heat can be transferred with the airstreams passing at right angles to each other than when the airstreams pass each other from 180° opposing directions, which is the case in a counterflow core. The Zehnder and other *Passivhaus* HRVs and ERVs use counterflow cores, that have an hexagonal face. Counterflow cores are crafted with microscopic surgical precision in order to precisely align the cut edges of the corrugated layers to create an airflow path that makes a slight zig-zag with the airstreams in counterflow arrangement, and this manufacturing precision explains why counterflow cores are much more expensive than crossflow designs.

Because these units need to move only the minimal amount of ventilation air, their ductwork is smaller, with a 3" diameter duct sufficient to serve a one-person bedroom, and the whole house duct only about 6" inside diameter. Duct runs between the HRV and the outside of the house are actually the weakest part of the building's super-insulated envelope. Even though they are made of insulative molded foam, the ducts still need to be kept as short as possible, preferably less than 3' long before they enter the exterior wall. Distribution ducts to rooms tend to be shorter, too, and only one type of duct, either supply or return, needs to go to each room. Wet rooms (kitchens, baths, and laundries) should have exhaust ducts, usually extending just into the room at the point closest to the ventilator. Other rooms are living spaces and need supply ducts, again just extending to the nearest point of the room, normally just below the ceiling. With this arrangement, air flows from the supply rooms to the exhaust rooms, either through an undercut door gap, or for more acoustic privacy, through a transfer grille with a foam-rubber muffler insert. In kitchens, exhaust duct ports need to be kept a minimum of ten horizontal feet away from cooktops, grilles, or other cooking appliances, so that they don't carry grease and particulate pollution back to the core of the HRV or ERV. The first line of defense for the HRV or ERV core is a re-circulating range hood over every such polluting appliance, which contains a grease, air, and maybe even an activated carbon filter to clean the air before it goes back to the ventilator, which will carry the excessive humidity from cooking outside.

In a *Passivhaus,* one tries to have all ventilation, both exhaust and supply, pass through the HRV or ERV, and that often means that some things taken for granted in our homes

Seedballs work very well to help plant a living fence, or to expand a planting.

are done a bit differently in a *Passivhaus.* In addition to a recirculating range hood and a separate kitchen exhaust duct back through the recovery unit replacing the more usual vented range hood, one also tries to prevent air loss through plumbing stacks and dryer ducts. Though there is a code requirement in the US for one plumbing stack per building, it isn't actually necessary to the proper functioning of the plumbing, and your building code official is empowered to make an exemption, as ours did. Consequently, we will be able to eliminate plumbing stacks going through the roof of our *Passivhaus.* Instead, we will terminate each stack with a one-way air admittance valve inside the house, which will fill the purpose of a vent stack, allowing air to go down the vent so that the water can drain freely downward, while preventing sewer gases from escaping into the house.

There are two ways one can eliminate the need for a dryer vent pipe. The first approach is to use a highly efficient condensing clothes dryer that doesn't require a vent. Alternatively, one can use the HRV or ERV to accelerate the passive drying of clothes while removing the resultant humidity from the house, which is what we have chosen to do. Dryers are some of the highest energy hogs in a home, due to the heat they use. There is little you can do to reduce the amount of energy it takes to remove water through heat-driven evaporation, but there are more efficient ways to get water out of clothes.

The linear arrangement minimizes work, while maximizing harvests.

Surprisingly, the most important specification for reducing the total amount of energy used per batch of laundry doesn't even appear on the Energy Star appliance lists. The key isn't the dryer you pick—it's the washing machine, specifically how fast it spins. After research, we've chosen an Asko washer with a top spin speed of 2,000 rpm. Separate spin-extractor appliances are also available which are cheaper than a new washer. When the Asko finishes with a batch, there is so little water left in the clothing that if you hang it up to dry, most clothes will dry in about two hours—maybe four for jeans. Drying time can be shortened further by a common *Passivhaus* strategy: a drying closet, with the exhaust air pulled through it just before it goes to the HRV or ERV core. With enough airflow, well centrifuged clothes dry rapidly—nearly as fast as clothes washed in a normal washer then dried with heat in a regular dryer, but with far less energy, especially because the airflow is the same as you were already using for fresh air. I find that hanging clothes to dry actually takes me less time than using a dryer and produces better results—you shake out the wrinkles and hang them in the desired shape wet on their hangers, then walk away. You can come back for the jeans when you're ready to wear them, rather than having to listen for a dryer buzzer to prevent clothes from baking in wrinkles while lying crumpled in the dryer.

Not only does the HRV or ERV provide fresh air, but it also serves to keep the inside of the building the same neutral pressure as the air outside the building. With the building envelope's very low rate of air leakage, the HRV or ERV virtually eliminates the stack effect pressure differential between inside and outside air that in most buildings tends to drive moisture into the structure. Neutral pressure increases the building's longevity, and in conjunction with the proper placement of the air barrier to prevent condensation with wall and roof assemblies, helps to prevent mold or mildew, thus creating a healthy environment for occupants.

Even though these ventilators are not active solar systems, they save so much energy that would otherwise be tossed out with the bad air that they significantly reduce your energy demand, similar to the effect of solar systems that actually capture solar energy and bring it inside in a useable form. Now let's look at other active systems that reduce your energy needs by replacing the need for electricity to run your domestic hot water tank with solar thermal hot water.

The solar water heater assist

In our *Passivhaus,* we will supply our hot water year-round with solar thermal energy from two or three coaxial, evacuated-tube collectors, each with 20 tubes. We are sizing our solar hot water system based on available winter sunlight to meet our domestic hot water demands in winter. We have a surplus of hot water through the other seasons, and when the hot water tank is full, the remaining heat will go to a very large seasonal heat-storage tank. In this system, there is always somewhere for the heat to go, and the hot water tank will tend to stay at maximum capacity through most of the year. The result should be that

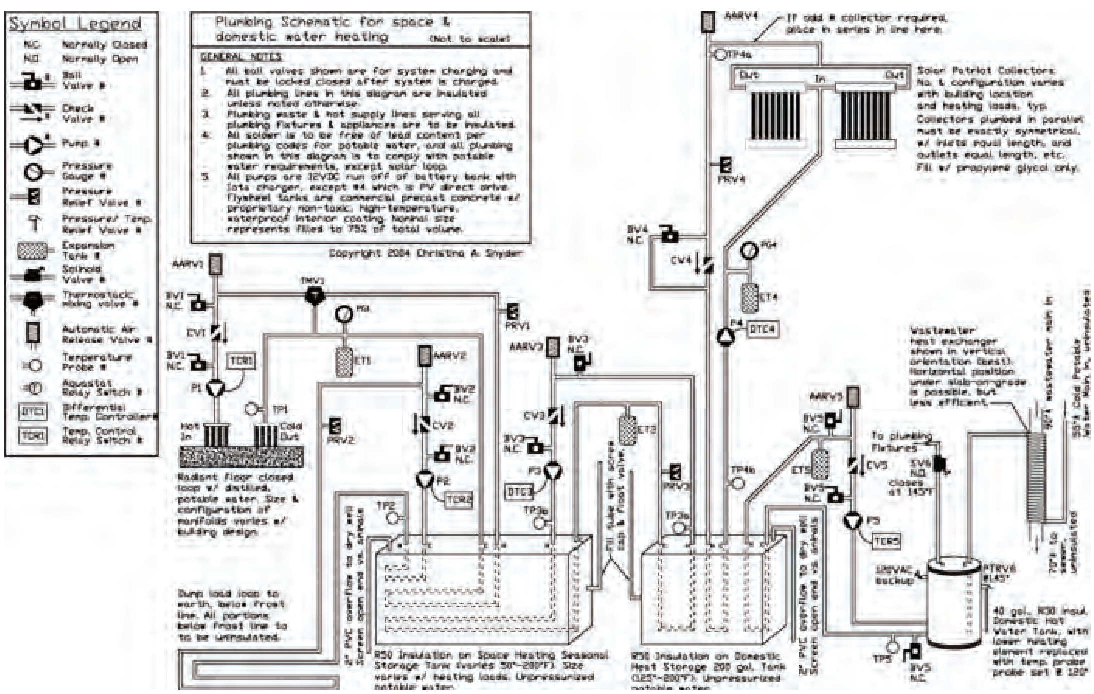
In Stirling Technology's ERV, air flows through an enthalpy wheel of rotating foam rubber. Photo by CASnyder.

by the end of the fall, the seasonal heat storage tank has also maximized its capacity to store heat. Then, we plan to pull heat from the tank and feed it into the radiant floor PEX tubing in the *Passivhaus* when there is a call for space heating. Because we need only about 80°F (27°C) water in the radiant floor, the amount of heat stored should last through most of the winter. This system is far more complicated than anything one would typically do in a normal *Passivhaus* or Net Zero Energy Home, but it's an experiment we wish to try to see if it will allow us to meet all our energy needs with the sun alone, without a backup connection to the electric utility—in short, to go off grid on the sun and wind alone. I won't go into the details of this system because it would take more room than is left to me in this article and be useful to very few people.

Instead, I'll explain a bit about a hybrid active water heating system I proposed to Peter, which may allow him to finally cut the umbilicus to the natural gas utility. This system may be suitable for other readers' needs as well. I'll start by quoting from my letter to Peter:

"Good article, you put your finger on the rub with getting away from your methane addiction (backup to solar and the high connection cost of methane service relative to fuel cost), but I think you already have access to the solution, judging by the photos. There is no reason why your existing wood stoves can't supplement a solar hot water system every time you are doing a burn for space heating. The Amish have been plumbing up domestic hot water systems with wood stove heat for the better part of a century, and you can too. The how-to advice (and even some parts) available from Lehman's is worth the investment (lehmans.com/c-125-hot-water-from-your-stove.aspx). Gravity thermosiphoning circulation is safest for a wood burning heat source. Locating the solar storage tank above an existing wood stove will allow the heat you supply from the firebox to the plumbing to do the circulation work in a closed heat exchanger loop to your storage tank above, and there are no pumps or valves (other than a temperature and pressure, or TP, relief valve) to inhibit water flow. Unless you boil or drain your storage tank dry, you won't risk flashing the water to steam in your circulation loop. In case of power outage in winter, you might need to manually refill your hot water tank with cold water if you start draining it too low and don't have city water or a solar-powered pump to refill it, but that can be done in many small load trips if necessary. But at least you could have gravity-fed hot water, with or without electricity. I suppose re-doing the household hot water plumbing would be the largest issue, but you could opt to abandon the old plumbing and simply surface-mount potable PEX lines from the new tank location, which would also allow you to insulate all your plumbing lines, which offers more long-term energy savings.

The solar hot water might not be an essential initial investment, but could save you some work building fires in winter (and even more so in summer), and could use the same heat-storage tank if it were plumbed with a closed antifreeze loop with double-walled heat exchanger. I recommend coaxial vacuum tube collectors (from Apricus) for durability and maximum winter hot water production (mount at 60° above horizontal). The competitor's single-walled tubes tend to lose vacuum (= insulation), sometimes even before the warranty is up, and more fail with every passing year. Our coaxial tube collectors were in service without maintenance for more than a decade (we should have replaced the antifreeze after seven years) before our



Solar hot water system with seasonal heat storage for a zero energy house, circa 2002. Drawing by CASnyder.

salvaged solar storage tank started leaking. We expect to re-install it in our zero-energy home to save solar heat from summer for use as winter space heating, as well as meeting our hot water needs. As cheap as solar photovoltaics (PV) has become, you could also get more PV panels and put a DC heating element into the hot water tank above your wood stove, to provide your summer hot water when you *want your stove to be inactive. This combination of solar and wood can get you off methane entirely, and saving the monthly connection fees will speed the energy retrofit project to payback faster."*

In addition to the Amish, I know a fellow who built a well insulated solar home in Michigan with a mass wood stove he built of brick with well sealed doors. The stove not only radiated heat to the living room, but also had a stainless steel pipe making a loop through the back of the firebox. The loop went up to the domestic hot water heater positioned on the floor above, as well as into a radiant floor heating system. The system also had flat-plate solar hot water collectors on the roof above the tank. I think he usually did a burn once a day, or once every two days, depending on the weather outside. Between solar and wood, they had a source of hot water for every season, weather, or change in plans. In summer, the solar will get the water blazing hot without having to ignite even a spark inside during the peak of cooling season.

...the evacuated tubes are off and racing long before the flat-plate collectors can bring in their first Btus.

Options for solar thermal collectors

There are two main types of solar hot water collectors: flat-plate and evacuated-tube collectors. Flat-plate collectors are an older design that resemble skylights on your roof. Behind the glass are pipes in a manifold configuration, with collection pipes running vertically up the slope of the roof connected by pipes at top and bottom. Cold water goes in the bottom, and hot water flows out the top, but there are several quarts of fluid in the collector, and the pump will not turn on until all that water is hotter than the storage tank inside the house. In cold, cloudy conditions (like Michigan), such a high-mass collector can take the better part of the day for all of that water to get hotter than the tank so that it can be taken into the insulated tank and stored.

In contrast, evacuated tubes are a super-insulated low-mass collector. The coaxial tubes are like double-walled insulating glass shaped into a very long transparent thermos bottle, with vacuum between the layers of glass, preventing conductive and convective heat losses. The tube has a selective surface coating on the inside of the glass, allowing it to absorb energy from a wider portion of the spectrum, capturing more than 95% of the available solar energy and conducting it via aluminum coiled from glass to central heat pipe and into the tablespoon of refrigerant in each tube. It takes very little heat to start vaporizing the teaspoon of refrigerant, which rises to the top of the heat pipe where it is enveloped by the manifold of water across the top of the collector, which immediately takes up the heat and carries it into the house. The cooler water flowing around the tip of the heat pipe condenses the refrigerant, and it trickles down to evaporate once more. In full sun conditions, flat-plate collectors and evacuated tubes perform very similarly, but in very cloudy conditions, the evacuated tubes are off and racing long before the flat-plate collectors can bring in their first Btus. The one caution is that evacuated tubes lose so little of the heat that they collect, that they can't melt snow that falls on the tubes. Instead, you must mount them at least 45° above horizontal, if not more steeply, so that gravity can remove the snow cover sooner rather than later.

For maximum energy collection in the spring and fall, solar collectors can be mounted at one's latitude angle. To maximize summer energy collection, the angle would be 15° below your latitude, and in winter, mount collectors at latitude plus 15°. In systems without a way to store the energy from one season to the next, maximize annual energy production by choosing the latitude angle. If seasonal heat storage is available, a winter angle becomes more optimal. On an existing building with a shallow roof slope, if it's important to keep the collectors aligned with roof surfaces for aesthetic reasons, you may find the system performance to be better with the evacuated tube collectors mounted vertically on a wall, than below a 45° angle on the roof. In the vertical position, they will shed snow in

Evacuated tubes in a vertical orientation on Michigan's Solar Decathlon Entry.

winter and be at less risk of overheating in summer, as the roof overhang may even give them partial shade.

Just in the last three years, the price of PV has dropped so far that for the first time it costs nearly the same to heat water with PV-generated electricity as with solar thermal collectors. This cost parity makes it possible when doing a wood-solar hybrid water heating system for the solar component to come from PV electricity delivered to a DC heating element in the storage tank, rather than from a solar hot water system. But while relative costs have changed, the power density of the collectors hasn't. PV rarely captures more than 18% of the available solar energy, while evacuated tube collectors capture above 90%, although heat losses from pipes and tanks may reduce overall efficiency to 40%. If you have limited real estate on your roof and south wall for solar collection, these efficiency considerations can inform your choice. The hot water system can capture from two to five times more usable energy than PV in a given roof area. To use PV to heat more water than evacuated tubes, you could use them to power a high COP (coefficient of performance) heat pump water heater. High COP systems have their own challenges, including high start-up voltages, and high energy draw, and this solution would substantially increase the size and cost of using a PV system for water heating.

Cooking with the sun

So we've established that it may be possible to meet your water and space heating needs without natural gas and even without a *Passivhaus,* but what about cooking? Lots of cooks don't want anything to do with electric-resistance cooking, as it is far harder to regulate temperatures, and the range of temperatures often doesn't go low or high enough to suit chefs. While propane may be fairly similar to methane for cooking, it's not an improvement if you're trying to eliminate your use of fossil fuels. Learning to cook well with wood is a real challenge, and many wood stoves aren't well suited for cooking. In our quest to go all-electric and all-solar, we found a solution that we like even better than natural gas cooking, and we won't be going back. I quote from my letter to Peter:

> *"But what about replacing your methane-powered stove? Induction cooking is cheap up front and more powerful than most methane burners while using a bit more than half the energy of your methane burner and a bit less than half that of an electric resistance stove. I prefer to use portable induction hotplates for the same reason you do your canning outside on propane burners in summer—to keep the heat and humidity out of the house. The Athena Max Burton bests all the other hotplates by providing a full 1.5 kW burner that plugs into any regular household circuit (but have every other device on the circuit switched off if you don't want to pop the circuit breaker, as the various power settings are just variations in the frequency of the magnetic field switching full on and then back off again). I've used it for outside canning via our steam juice extractor. Even if you do use the induction burner inside, there is very little heat energy lost into the home—you can have a 1/2" thick sheet of bead-board styrofoam beneath a pot with boiling water, and the foam won't melt. We actually put a flexible red silicone baking dish (about 1/8" thick) on the burner beneath our cast iron skillet to insulate the burner from the cast iron to keep it from giving us an overheating error message and shutting down. With induction cooking, you might be able to kick both the methane and the propane habit, and the Max Burton induction hotplates are cheap and readily available."*

More efficient appliances, like induction hotplates, are beneficial to a multitude of people in different lifestyles, but they are essential in a *Passivhaus.* Not only does the *Passivhaus* Standard require you to restrain your total energy use as measured at the power plant (called primary energy) to 120kWh/sq. m/yr., but also your use of energy and hot water adds significant heat and humidity to your living spaces. While these internal heat gains are good in winter, they may overheat your home in summer. For this reason, many *Passivhaus* owners use induction cooktops, condensing dryers, front-loading washers, laptop computers, LCD screens, microwaves, convection ovens, and compact fluorescent (CFL) and LED lights. CFLs use about a third the energy of incandescent bulbs and last at least three times as long; LEDs use only a tenth the energy and can last ten times as long. We once joked that instead of investing in a heating system, we could simply change the light bulbs twice a year—incandescent lights (heaters) for winter, and cool LEDs in the summer. We have LED shop lights, Edison-style bulbs, and articulated desk lamps, as well as Christmas/fairy lights, and the prices on LED bulbs and fixtures are dropping all the time.

The best *Passivhaus* is complete only with an active ventilation system to recover most of the energy in the stale air exhaust. Without passive building envelopes to hoard the sun's energy, active solar systems would be a drop in the bucket of wasted energy and resources blithely used today and gone tomorrow when the next generation will need them. From this perspective, passive solar and active solar are mutually complementary parts of an holistic way of life: a permaculture of energy. ∆

Christina Snyder, a Michigan architect, authored the article on Passive Solar Buildings in this issue. See her bio on page 17.

Building a Solar Business

N. Ryan Zaricki

I GREW UP IN SOUTHERN INDIANA, about five blocks from the mighty Ohio River, now the most polluted in the country. During my childhood, I was told not to swim or fish in the river—a disconnect from a powerful source of life. This separation was the beginning of my compartmentalizing nature into equations and perfect shapes, oblivious to the inherent energy flowing by (and shining over) my small town every day.

Reducing nature and the world around me into formulas and equations marked my path through engineering school at a small, private college, ranked as the top undergraduate engineering program in the country. While most of my cohorts went to work for defense contractors, I decided to go play in the mountains. In the Rockies, I discovered the power of the sun—not only from my sun-warmed face on a peaceful hike, but also in the warm spaces of the passively and actively solar-powered homes I was lucky enough to visit and eventually work on. It was in Colorado that I first heard the term "sustainability," an 'aha!' moment that grew into an interest in natural building, thermal heating systems, and solar electricity. That interest grew into a job, which grew into a passion and a path in life—and eventually into a business.

Eureka!

The next eureka came when I first saw a 3-D model of the sun's path across the sky over the course of a year. One simple picture explained most of the design parameters needed to harness the power of the sun. With this knowledge, we design overhangs to shelter passive solar homes and solar arrays for optimal collection. I dug into books like *The Passive Solar House* by James Kachadorian, *The Solar House* by Dan Chiras, and *Solar Water Heating* by Bob Ramlow. I was also lucky enough to land a job with a strawbale builder, who also had extensive knowledge of off-grid and grid-tied solar photovoltaic (PV or solar electric), solar thermal, and hydronic heating systems.

My direction in life became crystal clear at my Pa Jim's funeral, which was held in a church that he built as a general contractor. During that trip, I realized that building was in my blood. My great-grandfather had built the house my dad grew up in. My other Grandpap was an iron worker and a woodworker, and my dad has always been a builder. Building felt right. It became my passion to learn how to build stuff and run systems more sustainably. My engineering education made home systems (electrical, heating/cooling, water) especially appealing.

A PDC in 2008 melded my engineering training, my reclaimed lineage in building, and my passion for natural, efficient design, and reconnected those skills to nature, adding elements of "waste" cycling, water systems, and food production, all while teaching me "…there is no Away." This manifested quickly in my creating a small rural homestead in Posey County, Indiana, in the heart of an industrial agriculture zone. In late 2009, I helped install the solar array on the offices of the *Permaculture Activist.* Peter Bane and Keith Johnson had worked with another local installer and a group of local residents to buy a pallet of solar panels. I mounted the array with the help of Chad Frazier, who has since become a lead installer with our Evansville-based company, Whole Sun Designs Inc. (WSD). We formed Whole Sun itself a couple years later, spurred by an email conversation on the Bloomington Permaculture Guild listserv. My homestead became our base of operations, and I ran the business out of The Shack, a 200 sf passive solar, radiant-floor heated, PV-powered structure (with grid back-up) which I built using reclaimed lumber from a 100+ year-old barn just up the road.

Happy customers led us to other happy customers. The business has grown steadily, sustaining several individuals while maintaining a sound financial base. Our intention is to install premium solar power systems and to create a business based on equity as opposed to being driven by profit.

Let the sun shine in

In starting WSD, I wanted to offer a variety of general construction, energy efficiency, and solar power services. Since then, though, we've been lucky enough to spend most of our time installing PV systems. In 2011, the cost of solar panels began dropping like a stone. China had ramped up its manufacturing capacity for solar equipment, leading to a global surplus of modules and sharp downward pressure on prices. We would sign contracts for projects using 240 W panels, and we would get 245 W panels at the same or lower price. It was

A solar shout-out from our web guy. Solar businesses support many other local businesses.

happening that quickly. Mass-produced grid-tied inverters increasingly eliminated the need for batteries, which reduced the cost and complexity of systems and led to major upswings in affordability and thus installations. By mid-2013, we were pricing grid-tied PV systems at close to half the price they had cost two years earlier. With escalating utility rates, many more homeowners began to justify a PV system financially as well as emotionally. Coupled with the environmental benefits, PV had reached a tipping point for people who had been waiting to install systems, sometimes for decades.

Today, the options for equipment are extensive, and I regularly remind myself to keep it simple. The modern US solar industry has its roots in the Pacific Northwest and northern California. The 70s-era back-to-the-landers there used car batteries to meet basic lighting and electrical needs, and they recharged them while driving into town. Homemade inverters powered by the first Arco solar panels replaced car batteries. These systems were battery-based, and they allowed individuals, no matter where they lived, to light and run their homes (or vans, huts, hobbit holes, or whatever else someone could dream up) with solar power.

...we don't need technological innovation to build the solar economy. We need innovation in business models and leadership in policy.

Those groundbreaking engineers started Trace Engineering (eventually bought by Xantrex) and then Schneider Electric. The Trace Engineering team broke off to form Outback Power Systems, Midnite Solar, and Magnum Energy, which have now been building cutting-edge power electronics for the solar industry for decades.

The modern solar industry has grown by taking batteries out of the equation and using the utility grid to absorb excess power generated from the arrays. Grid-tied inverters have replaced battery-based inverters, reducing complexity and price. String or central inverters, similar to battery-based inverters, were a natural design progression for the technology, but the field quickly evolved to module-level electronics, including microinverters and power optimizers. These control the voltage and current of individual solar panels to help maximize system performance.

Economies of scale in manufacturing are clearly the key to cost reduction for solar panels. Researchers and engineers have been trying for major breakthroughs in solar conversion efficiency for years, with limited success. Thin-film solar has the most potential, I believe, but improvements have been slow and steady rather than abrupt. Solar shingles, solar paints, and solar freakin' roadways are all great ideas, but they are mostly hype. Widespread implementation has come from the steady improvement and sheer scale of production of the crystalline silicon cells first produced by Bell Labs in 1954.

I've grown to accept Jigar Shah's philosophy, expressed in his book, *Creating Climate Wealth,* that we don't need technological innovation to build the solar economy. We need innovation in business models and leadership in policy. Shah invented the power purchase agreement (PPA) for solar power systems when he founded SunEdison. These are contracts, usually for 20-25 years, under which a building owner agrees to buy electricity produced by solar panels, as opposed to buying the actual panels. Sometimes referred to as third-party ownership, this innovation removed one barrier to adoption by allowing businesses and home owners to buy solar electricity as a service rather than an investment. Although I believe, on a residential scale, ownership of the systems gives homeowners the most benefit, PPAs led the charge for commercial- and utility-scale implementation. The success of PPAs illustrates that we don't need technological advances to move the field forward. Rather, if we are to achieve widespread adoption of the next-

KC the Sunshine Van at a local market, educating folks about the benefits of solar power.

generation technologies that can curb climate change and take clean, affordable power into the mainstream, we need new and diverse ways of thinking, designing, and running our businesses.

Customers have often approached us for a variety of side projects, outside the normal realm of PV installation. These mostly entail solar thermal combi systems, incorporating solar thermal arrays, wood stoves, and boilers as heat sources and domestic hot water and radiant floor heating for heat loads. Saunas, hot tubs, and pools are an easy extension, and I look forward to adding greenhouses to that list. Water as a thermal battery is elegant and plentiful, and these projects tend to push our boundaries on design. They've been tangential to the main business, but at the same time have played an important role at WSD.

Business 101

We knew that the first and most important step in developing our business would be education. Solar is widely known but little understood. People need a chance to kick the tires. I quickly developed a "Solar 101: Fun in the Sun" slide set to explain the benefits of solar, which I've presented dozens of times around our region. This presentation provides us a framework to talk to a room of interested parties and explain the basics of system options, system layouts, pricing, return on investment, and monitoring. We routinely engage people in conversations, and answer their questions, but when they ask about hail, to let them throw golf balls at solar panels is priceless.

Energy efficiency also figures high on the priority list, because reducing home energy consumption is the key to making solar power affordable for the homeowner. We worked with one family to reduce their usage by 75% before installing a solar array. I've also learned that once people start producing their own electricity, they become much more aware of how they are using it. We've installed many systems with the owner's expressed intent to expand later, only to see that because of energy efficiency measures, the household demand falls below the annual output of the original system, so no expansion is needed. Efficiency is the one-two punch if your goal is to reduce or eliminate your utility bill. Solar 101s are still the foundation of our marketing strategy today.

KC the Sunshine Van

Early on, we worked out of an old Toyota pickup. As the business grew, we bought an ancient bread truck with a Cummins diesel engine and half a million miles on the odometer. This became "KC the Sunshine Van." KC has served double duty as both a mobile workshop and a rolling billboard. At job sites and community events, the solar array on the side of the truck serves as a portable generator and a demonstration of solar. At fairs, festivals, and farmer's markets, the brightly painted truck with a big orange sun and flashy solar array definitely stands out.

At these events, we talk with people who have been dreaming about solar and yearning for it to reach the point of widespread adoption. Fortunately, that time is upon us because a handful of early adopters were willing to set an example for their communities. Solar is not a space-age technology; it is effective today. Over and over again, we have seen that people are ready for solar. Very often, I notice solar-powered landscape lights, security lights, calculators, and most recently, dancing plastic flowers, in the homes of people who contact us about solar power systems. We're not usually their first stop on the road to solar power.

Continuing education and training have been critical to supporting our professional work in this rapidly growing field. The Midwest Renewable Energy Association (Wisconsin) and Solar Energy International (Colorado) offer a wide range of classes, both online and in person, covering nearly every aspect of solar design. Training is sometimes available through local community colleges and job training facilities. The North American Board of Certified Energy Practitioners (NABCEP) offers a voluntary certification for PV, solar thermal, and small wind installers, as well as technical solar sales. Though not required in most states, the NABCEP certifications have pushed us to study the intricacies of solar and electrical design, making us better installers and making our business more credible. I have also held a general contractor's license since 2007, and recently obtained a master electrician license. Most licenses and certifications require continuing education credits—opportunities to review existing standards and to learn about changes. Many manufacturers offer webinars or workshops, as well as professional training institutes, and these are great opportunities to network with other industry professionals.

Solar installation is a cross-disciplinary field. The major skills required are roofing and electrical.

Solar installation is a cross-disciplinary field. The major skills required are roofing and electrical. Equipment these days is mostly plug-and-play—tinker toys for big kids. However, workers in the craft still need skill to incorporate these systems into existing homes in a seamless, aesthetically pleasing way, while at the same time keeping it up to code. It is critically important to work closely with both the local authority having jurisdiction (AHJ) and utility companies. I've been pleasantly surprised at what they've let us install, which sometimes blurs the line of "code-compliant." I think this reflects the generally popular public view of renewable energy.

Leadership in policy

I've also grown to recognize the importance of working with local policy-makers. Admittedly, in the first few years of business, I was content to stay out of the political arena, but I kept a watchful eye on Colorado and other key regions, as bellwethers of growth in the solar industry. While early political and regulatory battles raged around solar power, I focused on wiring up panels.

In 2011, Indiana passed a decent net metering policy, a solar interconnection policy common to nearly all states. This allows customers to put excess solar power into the grid on bright days, then retrieve those kilowatt hours (kWh) at night or in cloudy seasons. This simple, effective policy allows solar homeowners to offset 100% of their electric usage with solar, running in parallel with the utility grid. The grid tie-in also eliminates the need for batteries, reducing costs and complexity.

The incumbent utility monopolies in many parts of the country, however, see solar as a threat to their revenue stream, instead of as an opportunity. This regressive sentiment, being shopped around to state legislatures by ALEC (American Legislative Exchange Council), came to a head in Indiana this year in the form of House Bill 1320, a piece of legislation aimed at killing rooftop solar while touting itself as pro-solar. Threatening to throttle net metering, it would have been a giveaway to the monopoly utilities. Fortunately, a diverse coalition of solar advocates, supported by editorial opinion across the state, joined together to stop the bill. This ad hoc and grassroots alliance included environmental groups, consumer advocates, solar business owners, the state NAACP, and Tea Party conservatives from within and beyond Indiana. This series of events was a red flag, reminding me that solar advocates need to shout its praises from the rooftops and sometimes (reluctantly) get involved in politics.

...we must become more politically active in shaping policies that address climate threats.

It was also a reminder that there are many more policy mechanisms being used in other parts of the country to speed up solar adoption. Variants of net-metering, including virtual or aggregate net-metering, would allow production at an off-site facility to be credited to anyone's bill. This innovation has led to community solar projects or solar gardens, where anyone, including renters or homeowners with shaded properties, can purchase part of a large solar array. These arrays can be optimally sited and also get the pricing benefits of large systems.

As utilities push back against net-metering, states and cities such as Minnesota and Austin, Texas, are beginning to characterize the value of solar generation to the grid more completely. Studies commissioned by the Public Utility Commissions in Ohio, Maine, California, Nevada, and Mississippi have shown that solar electricity benefits all ratepayers through avoided fuel, transmission, and maintenance costs and, of course, it provides environmental benefits. The potentially catastrophic cost of carbon emissions only serves to highlight the benefits of solar.

Be careful what you wish for

My first job in solar was collecting signatures for Amendment 37 in Colorado, which set a Renewable Portfolio Standard (RPS) for utilities in the state. The RPS required the major utilities to get a certain percentage of their production capacity from renewable sources such as solar and wind. The RPS led to lucrative utility rebates for business and homeowners installing solar, but proved to be a bittersweet pill for the state's solar industry, which has come to refer to it as the "solar coaster." In early 2011, Xcel Energy, the state's major utility provider, pulled their Solar Rewards program just as it was getting off the ground. Fortunately, the state's solar industry group was able to get the program reinstated, although at lower incentive levels.

Because of forward-looking policies, Germany led the world in solar adoption until just a few years ago. It also became a leader in solar technology. A generous feed-in tariff (FIT) offered lucrative per kWh pricing for solar installations. High incentives in the early days of the program caused front loading, as companies rushed to install systems. But now the country is burdened with high electricity costs due to legacy payments under the FIT program.

A typical balance of systems (BOS) set-up including two inverters, a subpanel, and a production meter, tied into the existing electrical service.

The California Solar Initiative, on the other hand, took what has proven to be a more efficient approach for promoting solar. The tiered program was based on installed capacity rather than timelines, stepping down the incentives as more solar came on-line. This very cost-effective solar rebate program recently ended.

Another effective incentive has been the use of solar renewable energy certificates (SRECs). Markets for these stem from various state-level RPSs: utilities can satisfy their renewable portfolio mandates by purchasing SRECs produced within their grid area. These certificates are currently valued at about $45 in Indiana and close to $500 each in Washington, DC. In the same grid, Ohio, Maryland, and Pennsylvania have active markets in SRECs. Solar homeowners are entitled to one SREC per 1000 kWh of production, which in Indiana equates to $0.045 per kWh, about one-third to one-half of the retail rate. This performance-based incentive is subject to free market variability. State standards have fluctuated under regulatory review and political pressures, and utilities bring their own projects to the table, changing the market demand.

If we are to advance implementation of solar to a scale that can make major impacts on climate change, leadership through policy must become a front runner. Many examples and models are available. As business leaders and solar advocates, it is our job to be vocal, articulate proponents of sound policy. Good solar policy parallels the need for other policy improvements from local Area Planning Commissions and Zoning Boards for everything from backyard chickens to setbacks and site density issues for intensive land use in urban settings. The bottom line is that we must become more politically active in shaping policies that address climate threats.

Think outside the boss—Whole Sun 2.0

Until the last year or so, I've been the principal player in our business, more or less operating as a sole proprietor. I knew at the outset that the opportunity for growth in the field was great, and I have, I hope, laid the foundation for a larger solar business. We're on the verge of a transition within our organization to what we call "Whole Sun 2.0." We want to transform the business, currently a single-shareholder S corporation, to an employee-owned business structure, in which each employee has the opportunity to own an equal share of the business and thus share in the risks and rewards. We are setting goals, and taking concrete steps toward them.

I've been reluctant to be "the boss," an attitude which is common in alternative or counter-culture circles. My hope is that employee ownership will spread responsibility and opportunity to everyone in the business. Recently, we became members of the US Federation of Worker Cooperatives (USFWC), and we're working with their consulting arm, the Democracy at Work Network (DAWN), to write bylaws, and to develop communication tools and management and governance structures. Both Namaste Solar in Colorado and PV Squared in Massachusetts are employee-owned solar companies, and are good models for us.

...with Whole Sun, I wanted to put systems in place to be able to take on a staff.

After many years as an independent contractor, I had accrued a sizable chunk of back taxes. I've come to realize that this was my first lesson in bookkeeping and tax accounting, and I've learned a lot about both since then. Mainly, having a good accountant is key. Taking a small business development class gave me a formal introduction to these systems, along with legal and business planning, but I've learned the most by just doing it and improving upon our systems as we grew.

There certainly are advantages to being an independent contractor or a sole proprietor, but with Whole Sun, I wanted to put systems in place to be able to take on a staff. Ideally, I think we would have about 11-12 people—we're currently at four. I knew that the formal processes for payroll, payroll taxes, insurance, bookkeeping, and financial statements needed to be in place for long-term viability. Anything more than a two-person partnership deserves and requires these systems for accountability and clarity.

Our processes have improved over time, and current conversations with the Crew have moved toward equitable distribution of profits (also known as "member patronage" in the employee-owned world). This will require transparent bookkeeping practices, defined budgets, and benchmarks for key financial ratios. Again, these indicators have evolved slowly and have remained fluid. The major advantages of these indicators, I think, are that they provide a better understanding of our financial systems, showing how cash flows in and out of the business, and how money is used as a tool or as leverage to implement projects.

Weekly Monday Morning Meetings (MMMs) have been critical for both transparency within the organization and keeping everyone up to speed. We also have regular, though less frequent, Big Picture Meetings (BPMs), an idea borrowed from Namaste Solar. While MMMs are geared toward business operations, BPMs deal more with its governance—an important distinction. We are assembling a Board of Directors, with a vision to transform it into an Advisory Council. We hope this will create a sounding board for our ideas and goals and afford us an opportunity to harness the wisdom of our elders.

My first goal, and the reason I started the business, was to pay off my student loans. I paid off the last loan on Independence Day of 2013. *Mortgage Free* by Rob Roy laid out a philosophy for building a house without taking out a mortgage; he offers many ideas that parallel building a business. This experience made me appreciate the role of debt in my personal and business life, and I use it now with extreme caution. Since getting back on solid financial ground, I've been able to offer steady jobs at good pay to more people in this exciting field. We've also been able to send our Project Manager back to school to complete her engineering degree, as well as send our lead installer through an electrical apprenticeship program.

Admittedly, our current work is focused on the 30% Federal Tax Credit for solar—which expires at the end of 2016—and so has our planning, which begs the question, "what will we be doing long-term?" I hope that by laying a solid business foundation and providing the opportunity for employees to share in the responsibility of ownership and governance of the organization, we're creating a nimble, empowered workforce ready to blaze their own trails.

Storage, smart grids, and EVs—oh, my!

For now, the future of solar PV looks bright! Year over year, installed capacity in the US has grown. Last year, solar and wind accounted for the majority of new power generation—some 6 gigawatts of solar alone—with natural gas being most of the remainder. In the run-up to the end of the 30% Federal Tax Credit, residential rooftop solar installs are at an all-time high, as well. This growth has provided an opportunity for homeowners and small business owners to go solar, while also creating solar jobs at a rate 20 times the national average.

Ground-mounted solar array facing southwest to take advantage of the utility's time-of-use crediting.

I see the industry coming full cycle, again bringing battery storage into the mix. Tesla Motors recently started construction on a $6 billion battery manufacturing facility in Reno, NV, and other battery manufacturers are ramping up manufacturing capacity to keep pace. A sizable chunk of Tesla's batteries will end up coupled to solar arrays installed by their cousin company, SolarCity, which expects that, in five years, most of the solar arrays they install will include battery storage. Hawaii and California recently issued Requests for Proposals (RFPs) for utility-scale storage projects, and they have proven competitive with natural gas peak-load plants.

Hawaii, which already has high levels of solar installation, has become a real-world laboratory testing smart-grid technology. They are trying to figure out how to incorporate high levels of solar and wind with storage and electric vehicles. Smart meters with granular usage data and Internet access are currently available, allowing homeowners to see real-time electricity usage. Solar inverter manufacturers are recognizing the value of higher levels of interaction with the utility grid through home-scale energy management systems that will eventually incorporate smart appliances and remote control via the Web. Forward-thinking utilities recognize the shift away from centralized power production and distribution, toward an energy services platform business model.

In Indiana, at least one Rural Electric Coop (REC) offers time-of-use crediting, with a premium for power put onto the grid during periods of peak usage. Most of the RECs, however, offer net billing instead of net metering, paying wholesale rates for excess solar production put into the grid, which is usually half or a third of the rate consumers pay. But more and more, they are understanding the premium for on-peak versus off-peak electricity—think hot summer days when air conditioners are running. We hope more utilities will see the light, as this will create a great opportunity for solar plus storage, as opposed to mass grid defection, as some are speculating.

Electric vehicles are quickly catching on as well. Tesla, Nissan, Chevrolet, Mini Cooper, BMW, Volkswagen, and more, now offer all-electric vehicles. Recently, I've been looking at used Nissan Leafs, priced at about $12,000 with a range of 80-90 miles. This car would be suitable for my ~20 mile commute, and it could easily be charged with solar PV.

Building a business isn't easy. I wish someone had told me sooner that installing solar power systems and running a solar business are two vastly different things. Maybe an MBA is in my future. Either way, the lessons I've learned during this journey have been well worth the stress and the lean times. We are certainly working on our processes to smooth out the peaks and valleys of contracting work.

If you plan to install a system for your home or business, get several quotes and work with a contractor you trust and who communicates well. If you're looking to start a business, be it solar or something else, hold on—it's a wild ride. But dive in! We need more businesses proving that going green can also save you green. ∆

When Ryan isn't playing with solar panels, he's busy rebuilding the homestead. He looks forward to having more free time to garden, do yoga, play banjo, and make homebrew. Ryan is President of Whole Sun Designs, www.wholesundesigns.com.

A Status Report on Next-Generation Crops - Part II

Perennial Cereals & Pseudocereals

Eric Toensmeier

If your life's work can be accomplished in your lifetime, you're not thinking big enough.—Wes Jackson

AMONG THE MANY LINES OF RESEARCH and possible developments of cereal and pseudocereal crops outlined in Part I of this article (see February 2015, *PcA* #95), the following have advanced further and show greater promise at present.

The prime candidates

Rice ***(Oryza sativa)***

Among the perennial grains, rice is closest to being ready to compete with annual grains for yield. Under the right conditions, some annual rice plants will rattoon (re-sprout) for several years. Rice has several perennial relatives: one an African perennial rice and the other actually a strain of the wild ancestor of annual rice. Perennial rice breeding work was carried out at the International Rice Research Institute in the Philippines in the 90s, and was picked up by the Yunnan Academy of Agricultural Sciences in Kunming, China in 2007. (11)

Yunnan Academy breeder Hu Fengyi developed the PR23 line of rice which has produced grain for three years in a row, showing yields comparable to annual rice **(Table 4).** Over the three-year trial, only 3.5-5.4% of plants died. This variety is now in pre-release testing, and with luck may be in the hands of some Chinese farmers within a year. (11)

PR23 is a paddy rice variety suited to flooded rice production (a major contributor to methane emissions). Researchers hope to develop perennial versions of upland rice which is grown on slopes throughout Asia. It would be interesting to test the suitability of perennial rice for the System of Rice Intensification.

Perennial rice could have a tremendous impact in tropical and subtropical areas of the world. One of the Yunnan crosses has lived ten years, although it is not a heavy yielder. (6)

Perennial rice in China. Photo by David Van Tassel.

Nipa ***(Distichlis palmeri)***

Nipa is a perennial salt-tolerant grass of the Sonoran desert deltas. The flavor of its grain is apparently excellent. Once a staple of the Cocopa people, wild populations of nipa have been greatly reduced due to dams and other watershed disruptions. Wild patches of nipa have been estimated to yield 1.25 tons/ha (over 3 tons/acre), making this one of the most promising perennial grains on the planet. (6) As a C4 grass, nipa is particularly efficient at photosynthesis.

Dr. Richard Felger, a researcher associated with the University of Arizona herbarium and the Sky Island Alliance, has been exploring the potential of nipa for decades. Despite the failure of preliminary commercialization efforts by other researchers, Felger feels that nipa will eventually become a major world crop, comparable to short grain rice in grain size and flavor. (13)

Nipa tolerates salty conditions, including irrigation with saltwater, and is adapted to flooding. In the wild, nipa grows in saltmarshes that are inundated twice daily by tidal seawater; however, nipa does not require salt or waterlogging. As unsustainable irrigation practices and sea level rise result in increasing salinization of coastal plain farmlands, nipa could become prominent in regions like the

Table 4. Yields of Perennial Rice PR23 Over Three Years and in Two Locations in Yunnan, PRC. (4)

Location	Yield (ton/ha) *			
	Year 1	Year 2	Year 3	Plant Death Rate
Jinghong (500 m or 1,600' elevation)	5.6	3.9	4.0	3.5%
Simao (1,300 m or 4,300' elevation)	7.3	very low due to cold	6.7	5.4%
** Compare with the global average of 4.4 tons/ha (11 tons/acre) for annual rice.*				

Colorado, Ganges, Indus, Murray-Darling, and Nile deltas. It is adapted to tropical and subtropical conditions; sadly, prospects for crossing it with the cold-hardy saltgrass *D. spicata* are not promising. (13)

Nipa is still undomesticated, and poses several challenges. Roughly half of plants are seedless males. It also appears to take several years after planting until full yields are achieved. (13)

This perennial grain, already a wild staple for ages, has great promise for salty tropical areas and beyond. Nipa development should be a high priority for agencies and individuals concerned with food security, salinization, and climate change. Perhaps it may also offer an opportunity to productively revegetate barrier islands and help protect coastal areas from extreme weather events.

Sorghum *(Sorghum spp)*

Sorghum is already weakly perennial in the tropics and rattoons or re-sprouts for several years under ideal conditions. (4) Perennial sorghum breeding at the Land Institute has focused on crosses with the perennial weed Johnsongrass *(S. halepense),* while other breeders are using *S. propinquum.* (14) Like corn, there are challenges in overwintering tender rhizomes, which would not be an issue in the tropics. (10)

One interesting new trait emerging in perennial corn breeding is the "ear forest"....

Perennial sorghum is further along than most of the other perennial versions of major grains but isn't yet out of the test fields. Perennial sorghum could be bred not just for grain but also for sweet syrup. Sorghum is tolerant of many climates, but it is particularly appropriate to dry regions where it can outperform corn.

Some very promising hybrids are being trialled. Some are fully perennial. (14) In some cases, rhizomes of *S. halepense* host nitrogen-fixing endophytic bacteria (16)—certainly a desirable trait to pass on to a perennial grain sorghum.

Wheat *(Triticum spp)*

Perennial wheat-breeding efforts began in the Soviet Union almost 100 years ago, (4) but only with recently developed techniques is this research beginning to show results. Perennial wheats are typically crossed with wheatgrass species *(Elymus* or *Thinopyron)*.

Many institutions are working on perennial wheat breeding, including the Land Institute, the Future Farm Industries Cooperative Research Center in Australia, Washington State University, Texas A&M, and the University of Manitoba. (12) International coordination and seed exchange is underway between these and other researchers. (4)

One wheat hybrid yielded 14.5 tons/ha or 5.8 tons/acre (vs. 22.5 tons/ha or 9.0 tons/acre for the annual wheat control) in the first year, but was only weakly perennial. (17) Some wheats have yielded for three years, (13) and some have lived for four years. (19) In Australia, some varieties have lived for many years, but the yields are low and decline each year. (18) Until recently, the Land Institute had no success with perennial wheat survival in Kansas (nor have I in Massachusetts).

Perennial wheat is expected to yield somewhat less but require less labor. In economic projections, this hypothetical crop appears competitive with annual wheat from the standpoint of costs per hectare. (6) An Australian economic study has shown that perennial wheat could be economically viable if it yielded just 40% as well as annual wheat, but provided good fodder for several years afterward for grazing sheep. (14) It seems that even this relatively low bar has not yet been cleared by perennial wheat—breeding work continues. After a century of work, and with hundreds of breeding lines, perennial wheat is still not sufficiently perennial. (3)

Corn, maize *(Zea spp)*

Maize is one of the most important staple crops on the planet. Perennial corn could slow or reverse the degradation of sloping lands around the world that are inappropriately used to grow annual maize. Scientists and backyard breeders have been working toward this goal for many years, and have made some limited progress. Diploid perennial teosinte *(Z. diploperennis),* a wild relative, can be crossed with annual corn. (5) Several other wild corn relatives have recently been found by scientists. Maize can also be crossed with more distantly related hardy perennials including eastern gammagrass *(Tripsacum dactyloides)* and the related dwarf Fakahatchee grass *(T. floridanum).*

Field of rye. Photo by Alan Tattersall. Flickr CC.

The Land Institute has made substantial progress toward perennial corn. One challenge is that the perennial rhizomes that overwinter the plants are not cold-hardy; recent breeding has focused on deeper rhizomes that can survive below the frost line. (15) Of course, this consideration is not important in the tropics where hundreds of millions of people rely on corn as a staple.

Recently, the US Department of Agriculture has begun to show interest in perennial corn breeding. (15) If the federal government were to dedicate a tiny fraction of its agricultural research budget to this effort, great progress could be made.

One interesting new trait emerging in perennial corn breeding is the "ear forest"—the production of multiple ears at the base of the plant. These are produced until the plant is killed by drought, cold, or heat. The ear forest trait might be of use in livestock-harvested perennial grain systems. (5)

Researchers anticipate 10-40 more years before perennial maize is ready, and posit it as a good public sector project. (5)

Rye *(Secale spp)*

Rye is one of the perennial cereals that is closest to commercial viability. Annual rye has been crossed with a wild rye *(S. montanum),* and several varieties have been developed, including Permontra and ACE-1. An Australian variety called Black Mountain Family 10 has been yielding well. (11)

In a recent study, perennial ryes yielded 73% as well as their annual counterparts in years one and two. Not enough plants came back for a third year to make further measurement possible. (20) Annual rye itself yields quite a bit lower than annual wheat. Nonetheless, we are probably closer to seeing perennial rye in production on real farms than with most other global cereals.

Additional perennial grains worth exploring

Indian ricegrass *(Oryzopsis hymenoides)*

This perennial North American native was a major staple to indigenous peoples of the West. Discovery of a non-shattering clone allows it to be grown today on a commercial scale in Montana, producing a specialty gluten-free flour marketed as Montina (TM). High prices make up for low yields (0.1 ton/ha or 0.25 ton/acre), and about 1,200 ha (3,000 acres) are in production. (7) Little breeding work has been done with this remarkably drought- and cold-tolerant perennial.

Kernza *(Elymus hispidus,* formerly *Thinopyrum intermedium)*

The Land Institute has been working for several decades to domesticate this perennial wild grain. They have had relatively rapid success, and intermediate wheatgrass is currently undergoing a 30-acre field trial. (15) The research fields are burned annually to control weeds, and the crop can also be grazed to provide a non-seed yield. Production is still low, though researchers aim to see it reach one ton per acre. *Thinopyrum* species are also used as the perennial parent in attempts to develop perennial wheat. (15)

The Rodale Institute selected kernza as a promising candidate out of almost 100 perennial cereals tested in the 80s. After two generations of selection, work passed to the Land Institute. (11) The University of Manitoba joined the kernza breeding effort in 2011. (3)

Researchers estimate that kernza could yield as well as wheat within 20 years. However, seed size will still be smaller—it might take 130 years until seed size is equivalent unless wheat genes are successfully bred into new hybrids. (3) Gluten quality is also not as good as wheat. (3)

Kernza is an example of domesticating a promising wild grain, as opposed to perennializing an annual staple. (3)

Job's tears, Adlai grass *(Coix lacryma-jobi)*

Wild Job's tears is a perennial from South and Southeast Asia. The seeds of the wild forms *(var. stenocarpa* and *var. monilifer)* have thick, hard shells that are often used as beads. These forms are grown around the world as ornamentals, and have naturalized widely. Though they have edible seeds, the shells make them impractical for use as food. Farmers in India domesticated an annual or mostly annual form with thin, soft shells *(var. ma-yuen)* around 3-4,000 years ago, which by 2,000 years ago was being grown in China. Before the arrival of corn, Job's tears was an important grain in subtropical Asian highlands. Annual Job's tears yields a respectable 0.8-1.4 tons/ha (2-3.5 tons/acre), and tolerates acid, poor, and waterlogged soils. Crossing annual grain types with perennial forms could result in a new perennial grain for the tropics and subtropics, including highland areas. (21)

Markouba grass, or afezu *(Panicum turgidum)*

Markouba grass is a wild perennial, ranging from the heart of the Sahara through Pakistan. It grows in areas with as little as 25 mm (1") of precipitation. Fallen stems root in the soil, spreading the plants vegetatively. Markouba grains are an important staple in the Sahara. (22) Efforts at domesticating this species could serve the dual functions of feeding people in very arid tropical areas and reversing desertification. It might be crossed with proso millet *(P. miliaceum),* a major annual grain.

Pearl millet *(Pennisetum glaucum)*

Pearl millet thrives in arid environments and poor soils. It has been successfully crossed with the vigorous perennial napier grass *(P. purpureum)* to create forage grasses, but not, to my knowledge, with the goal of developing a perennial grain. (23) Successful hybrids of these crosses could give a good head start to perennial millet development. A perennial millet could be significant in African and Indian drylands where millions of people rely on the grain for survival.

...one of several perennial grains that were cultivated by Aboriginal peoples....

Wangunu *(Eragrostis eriopoda)*

This Australian wild edible has been an important staple for millennia, and is one of several perennial grains that were cultivated by Aboriginal peoples. (26) It is reported to have been the most important native grass, in part because of the ease of processing seeds, high yields, and holding onto the plant for months. (24) Wangunu is now cultivated on a small scale by "bush tucker" (wild edibles) enthusiasts in Australia. (25)

Timothy *(Phleum pratense)*

This widely-grown pasture grass has recently been taken into cultivation as a commercial perennial grain crop. The seeds are very small, and yields are low at 0.4-0.5 ton/ha (1-1.25 ton/acre). Protein is 17%. As it is being sold as gluten-free flour, the processing and high price makes up for these deficiencies. (7) ∆

Eric Toensmeier is the author of Perennial Vegetables, *and the coauthor of* Edible Forest Gardens *and* Paradise Lot. *He has a wealth of knowledge about food forestry, permaculture design, and useful plants. This is an excerpt from his forthcoming book* Carbon Farming: A Global Toolkit to Stabilize the Climate with Perennial Crops and Regenerative Farming Practices. *Visit his website* (www.perennialsolutions.org) *for more information on perennial edibles and an update on* Carbon Farming.

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We would like to thank Peter Bane, who inspired writers and editors and worked for 30 years to build the *Activist.*

the Permaculture Design team

Permaculture Institute of North America Issuing Diplomas

Revival of a Peer-Driven Permaculture Organization

Penny Livingston-Stark and Peter Bane

GROWING AND EVOLVING AROUND THE WORLD, permaculture design is reaching into more diverse communities and influencing mainstream culture in profound and inspiring ways. In the United States and Canada, many active permaculturists serve in local government and on non-profit governing boards. Permaculture design is influencing best practices in agriculture, land use, and community planning organizations. Competent permaculture teachers and designers are training thousands, and are being called into many segments of society.

Twenty years ago, most if not all permaculture teachers and design practitioners had studied directly under Bill Mollison or with a few of his earliest protegés. This second generation took the permaculture message to a rapidly growing tide of people who saw the inevitable ecological crises we now face.

Today we live in a world where Bill's student's student's students are teaching and practicing. While a majority of these are great ambassadors for the discipline, there is evidence and growing concern that the brilliant curriculum and ethical protocols that made permaculture a profoundly powerful design system are eroding at the margins as the permaculture movement widens and joins mainstream culture. Internet dissemination has supplemented older systems of education but also weakened personal bonds protecting the community's integrity. As permaculture has gone from a non-entity to a global brand, albeit a generic one, predators have emerged, attracted by the prospects of quick money from a growing interest in deep sustainability. In addition, many permaculturists working in the design and development fields lack professional knowledge and the experience of business protocols and practices expected by clients and public entities in the United States and Canada.

...permaculture practice requires new structures to support its integrity.....

People take permaculture design courses for many reasons and consequently have different needs. A majority want to apply permaculture to their own lives, farms, and homesteads, and may feel no need for professional support. Others are doing important work with non-profits and want to empower these organizations; they are potentially buyers of professional design and education services. And like the movement as a whole, the modest portion of PDC graduates who seek employment as designers and teachers is growing. The appeal of professional self-employment is also greater today because of changes in the broader economy. As its edge with the public sphere expands, permaculture practice requires new structures to support its integrity and promote its influence.

To address these needs and to support the growing economic interests of permaculture designers and teachers, a small group of senior permaculturists have reclaimed the mantle of the first American continental permaculture organization, Permaculture Institute of North America (PINA), but with a sharper focus and a stronger base of support.

In the early 1980s, at the request of Bill Mollison, Sego Jackson, Guy Baldwin, and Bev Reed established the first iteration of PINA in the Seattle area. Most of its staff and key members were centered in the Pacific Northwest. PINA successfully hosted the 2nd International Permaculture Convergence in 1986, and launched *The Permaculture Activist* as its newsletter, accomplishments we now recognize as historic. Rich in visionary ideas but lacking the resources to sustain itself, the first PINA closed its doors in 1989.

Almost a quarter century later, Jude Hobbs and Wayne Weiseman took the initiative arising from a broad continental conversation to call together other experienced practitioners for a new mission. This group has organized a new PINA to uphold professional and educational standards of practice. The design calls for a decentralized governance structure to emerge from the initial board-driven foundation. Drawing on the strength of peer review and regional fieldwork, PINA has ambitions to serve the USA, Canada, Mexico, Central America, and the Caribbean.

Presently board members include: Jude Hobbs (Oregon), Wayne Weiseman (Illinois), Peter Bane (Indiana), Sandy Cruz (Colorado), Darrell Frey (Pennsylvania), Penny Livingston-Stark (No. California), Fred Meyer (Iowa), and Wesley Roe (So. California). Melanie Mindlin of Oregon serves the organization as a part-time paid administrator. Even though their primary focus has been on professional self-employment, board members' collective engagement with teaching organizations, non-profits, local government, financial and academic institutions, and the global permaculture movement is long and distinguished.

PINA is a professional member service organization designed to support students and experienced practitioners of permaculture in North America and associated regions. It operates not-for-profit based on membership fees and related income.

The Permaculture Institute of North America aims:

- To raise and maintain professional standards in permaculture design, teaching, and additional disciplines.
- To support permaculture education through a certifying process that recognizes achievement and excellence.
- To provide a structure for communication among

Permaculture Design Course (PDC) graduates.

PINA intends to work with existing institutes in addition to fostering new regional Hubs that can support local permaculture efforts.

The concept, goals, and structure for PINA were unveiled at the International Permaculture Convergence (IPC-13) in Cuba, November 2013, and further elaborated at the North American Permaculture Convergence (NAPC) in Minnesota in August 2014. The response was very positive at both gatherings, with a strong affirmation by participants of the need for well-articulated protocols and standards. Board members have shared the PINA vision at various permaculture gatherings to supportive audiences. This feedback gave our board members a clear indication that there is enough support to continue to organize and develop the PINA vision. PINA is currently recruiting senior permaculture practitioners to become field advisors and mentors for new diploma candidates.

PINA already offers professional diplomas in two disciplines: Site Design and Education. Others will be added as the criteria to support them can be developed. Standards for the PINA professional diploma are more rigorous than for the conventional permaculture diploma as initiated under the auspices of Bill Mollison. That legacy credential requires only a Permaculture Design Course (PDC) certificate and one documented project to be put in place over two years post-PDC, while the PINA professional diploma requires the PDC plus advanced self-directed work. Successful PINA diploma candidates will complete multiple designs, education candidates will teach in multiple courses, and each will create a portfolio of related accomplishments such as publication, community service, research, and documentation.

Detailed information on the requirements as well as the design for PINA may be viewed on the website, http://pina.in. For more information contact Melanie Mindlin, sassetta@mind.net.

PINA is now accepting applications for diplomas, and we welcome input from experienced permaculturists interested in maintaining the traditions and ethics of the Permaculture Design Course (PDC). We believe the curriculum and protocols that informed our own educations are cultural jewels; they have inspired and enabled us to carry these powerful conceptual tools into a world largely unprepared to receive them. Out of respect for those who came before us and for future generations, we hope, with the help of the community, to preserve, renew, and pass on these treasures. ∆

Species Index Issues 75-90

Scientific (*Latin binomial*) names are alphabetized by genus and species. Common names, when they appear in the list, are cited because neither species nor genus determination could be made from the text, e.g. bamboo, bacteria, crayfish, or foxtail. It has long been the policy of *Permaculture Activist* to provide scientific names in association with common ones, but this has not been followed in all instances for practical reasons of style and page composition. Domesticated animals, garden vegetables, and common weeds comprise the bulk of these exceptions. In cases where common names in the text correspond distinctly to species, these are cited under their scientific name, e.g. chicken, dog, donkey, and honeybee in the original, here become *Gallus gallus domesticus, Canis lupus familiaris, Equus africanus asinus,* and *Apis mellifera,* respectively. Or among plants, references to alfalfa, carrot, and yarrow appear under *Medicago sativa, Dauca carota,* and *Achillea millefolium,* respectively, whether or not so identified in the original. Genera with nine or more citations appear in bold type. The numbers indicate magazine issue number (in bold), and page or pages (following the period).

Reviews

Facing the Music

Review by Peter Bane

RICHARD HEINBERG
Afterburn: Society Beyond Fossil Fuels
New Society Publ. Gabriola Isl. BC. 2015.
205 pp. paper. graphs. $18.95.

TEN YEARS AGO educator and violinist Richard Heinberg shook the sustainability world with a small book from an obscure press in western Canada titled *The Party's Over*. Heinberg, having met petrogeologist Colin Campbell and other thought leaders in the esoteric field of petroleum economics, rather rudely and prominently announced the arrival of Peak Oil. Like *The Limits to Growth,* the historic 1972 work exposing fundamental contradictions of the global economic system, TPO was pooh-poohed, ignored, refuted, and, because its timing was impeccable, quickly enough became accepted wisdom. Several years after it appeared, former US Defense Secretary James Schlesinger calmly declared, "The Peakists have won… (the debate)."

So why has society not crashed? Well, if I recall correctly, the global financial system did in 2008, shortly after oil prices broke through to unimagined heights at $145 a barrel. Now, of course, and for reasons that need only a short explanation, they are in the bargain basement region of $45-50/bbl. In that fearful period, from which we have not fully removed ourselves, unemployment spiked, and the housing market collapsed in the US, Spain, and other countries as millions lost homes, jobs, and retirement savings. Cities went bankrupt, and countries such as Greece, Ireland, and Portugal nearly did so. If you think we are in something like "normal" times, however, please have someone slap you, lest in your confusion you wander off into traffic, and you get seriously hurt.

Afterburn is a collection of essays written from 2009 through this year in which the author attempts to parse the complexities of energy descent and tease out a bit of what economic contraction means for society. The book might be properly classified in the field of futurism, except that the future is already amongst us; it just walks the street unrecognized by most. That ignorant conceit, where it manages to survive due to the propaganda of mainstream media and political lies, will evaporate one of these days. We will then see more of the stages of psychological adaptation to loss (also called grief) that follow denial: anger, bargaining, depression, and one would like to hope, ultimately acceptance. Each of these essays attempts to envision the unfolding of these changes in various arenas of society.

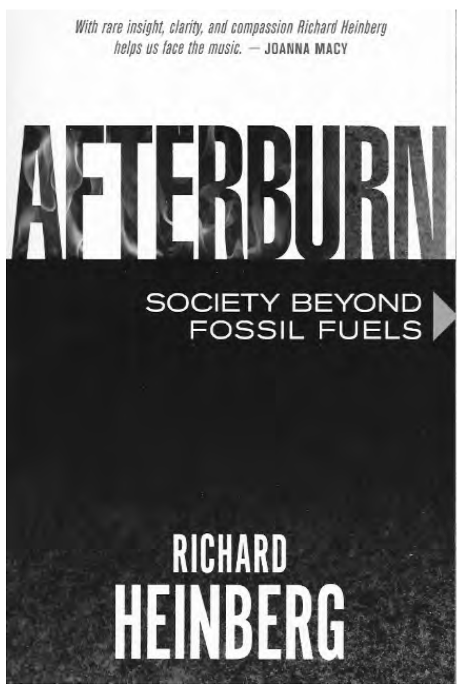
"The Brief Tragic Reign of Consumerism," for example, examines the negative consequences of a religious pursuit of material gain. We already know, from recent sociological and economic studies, that increases in income to levels beyond about $10,000 per year have virtually no correlation to reported happiness or life satisfaction. This seems to be true across cultures and world regions. The potentially earth-shaking change to which Heinberg points is the emergence of new indicators of social well being such as Gross National Happiness (GNH, adopted by the government of Bhutan) and Happy Planet Index (HPI, bruited by the New Economics Foundation of Britain). These, he points out, are "kryptonite to consumerism," a secular dogma that has essentially rendered vast hordes of modern people utterly miserable. The author's thought is far more sophisticated than the imagination that we can solve the dilemmas of modern society by looking at different data. A wholesale adoption

We could wind up much happier than we presently find ourselves to be....

of voluntary simplicity would crash the world's leading economies. By pointing to useful social innovation and trends, however, Heinberg both informs us and helps to change attitudes. The direction is clear: we in the wealthy nations will do with much less than we now have. That is inevitable, and preparing for it is an urgent matter of business not only for political leaders, but for every one of us raised on the expectations of continued growth. Yet, he scarcely adds, there is a silver lining to the cloud. We could wind up much happier than we presently find ourselves to be.

"Fingers in the Dike," casts the shadow of dramatic climate change over the discussion of energy and economy. Drawing on scientific analyses that suggest the period since about 1990 has seen far smaller increases in global temperature than might have been expected from carbon levels in the atmosphere, and which point to the energy buildup going chiefly into the oceans, Heinberg likens the situation to the tale of the Little Dutch Boy with his fingers in the dike, holding back the great and terrifying sea. What, he asks, will we do when the climate system snaps into rapid atmospheric warming, as it is likely to do with little or no warning in the next decade? Palliative and ultimately futile measures such as tar sands extraction and the manufacture of money by "quantitative easing" and other central bank mystifications have allowed modern societies to continue the pursuit of economic growth since the 2008 recession. What happens when these Sisyphean efforts are no longer adequate? Likely economic collapse of a far more severe nature than we have seen in the past century lurks just behind the curtain. The upshot is that we ought not to become complacent just because climate symptoms have worsened slowly. In this brief and uncertain interval, we should be doing our utmost to prepare for more difficult times ahead.

It is impossible to make the



case for dramatic future social and economic changes without arguing from fundamental facts, and the author does this at the beginning of the book, revisiting to some degree his prognostications of a decade ago and finding them broadly accurate. Conventional oil production began declining in 2005. Extraordinary measures, commanding far too great a portion of the world's scarce investment capital, have staunched the overall decline in liquid fuels by exploiting small, scattered, and energy-poor pools of hydrocarbons. The energy and capital invested in these efforts is not being replenished by energy finds or profits and cannot long be sustained. The price of this chimerical pursuit has been paid by the underprivileged classes of the wealthy societies whose benefits (jobs, pensions, education, housing) have been further cut in both the US and Europe.

Energy return on energy invested is falling to a threshold below which modern industrial societies cannot be sustained. Climate has shifted dramatically and for the worse, and yet science suggests that we have yet to feel the real wrath of a hotter atmosphere while numerous tipping-point phenomena are appearing ominously. Real economic growth is flat with almost all gains coming from funny money and going to the very top echelon of the global elite. National and international politics are sclerotic and unresponsive either to scientific data or to popular discontent. Meanwhile, disinformation abounds, technological optimism and religious fundamentalism compete for ascendancy, and mass society becomes unmoored.

Appropriate action, according to Heinberg, is that which many readers of this magazine have engaged: permaculture design, local economic regeneration based largely on food systems and renewable energy, better architecture and urban design, voluntary simplicity, and investing in local social capital. He advocates in one of these essays for librarians to make special efforts (even as digital media appear triumphant) to hang onto books, which can be read without electricity, and which represent in some irreducible manner, much of the knowledge and cultural value created during the modern era of abundant energy. Can we afford to see these precious gains lost because the lights went out?

Perhaps the most insightful chapters in this fine collection are two called "The

Fight of the Century," which outlines four possible scenarios of response to economic contraction, and "Conflict in the Era of Economic Decline," about the likely arenas of conflict in coming decades. The first sketches follow roughly the A, B, C, D characterization of Holmgren's *Future Scenarios:* Business as Usual (BAU), Simplification by Austerity, Centralized Provision of the Basics, and Localized Provision of the Basics. Just as Holmgren has described these variant energy futures as taking place simultaneously in different places, so Heinberg points out that all these pictures are competing today, but in some cases, they are in clear conflict. Permaculture activists in particular should be alert to the difficulties they may encounter in doing seemingly inocuous work such as local food production (Scenario D) because of the implicit challenge this poses to adherents of other future visions. Local authorities holding onto BAU have attempted to suppress many such efforts at local self-provision. And no, it doesn't make any sense from an objective point of view, but then when were we ever guaranteed that humans would act rationally?

As if in response to some of these dilemmas, the insights of the chapter on Conflict are equally varied and sometimes delicious. Heinberg tells the story of rural Madagascar villagers facing the need to take care of their own affairs in the effective absence of central government authority. (They are doing fairly well, by the way.) No taxes are collected nor police services provided. Can it be said that the central government even exists? Well, apparently in name only. To lean into this situation, the locals have made a point of never giving central government officials any reason (or opportunity) to attempt to exert authority.

The opportunities to push a localized economic and political agenda forward are manifold, and with good luck, we who see this future as inevitable will be ready to exert ourselves at every turn of fate by which the centralized economy and political system devolves. Each climate or economic crisis, each shock to the world's energy system should be seized as a chance to direct affairs into our court. The centralized systems are already failing. The trick is not to be caught up in their death spasms, or to be crushed as they fall.

Perhaps Heinberg's best work since *The Party's Over,* this collection of varied initiatives offers a highly adept response to a collapsing world of almost unimaginably complex possibilities. While we have any room for maneuver, those of us with vision should be acting with all deliberate haste and eyes wide open. Δ

The Roots of Freedom

Review by Peter Bane

CINDY CONNER

Seed Libraries and other means of keeping seeds in the hands of the people

New Society Publishers. Gabriola Isl. BC. 2015.

177 pp. paper. illustrated. $19.95.

I WISH THAT WE HAD had this book 18 months ago in the run up to publishing *Permaculture Activist #91* on Seeds. It would have been given considerably more exposure because of the popularity of that subject. We did feature Stephanie Syson's article about the Basalt, Colorado, Seed Library she helped found; and on which the author of this book also reports. But a year and a half is about a third of the lifespan of the popular movement covered by this book. Cindy Conner has done us all a service by documenting the rapid growth and highlighting the importance of this young social phenomenon.

Seed libraries began (the author says) in 2000 in Berkeley, California at the offices of the Ecology Center, a venerable and nonetheless cutting-edge organization closely allied to the permaculture movement. Today, more than 340 may be found across the United States with yet others in Canada. However, the oldest profiled here is the Richmond (Calif.) Grows Seed Lending Library housed at the main branch of that Bay Area city's library, and it was founded in 2010. It would be fair to describe the growth of seed libraries in the last three years as 'explosive.'

Conner, who is the author of *Grow a Sustainable Diet,* also from New Society, is a long-time homestead gardener, seed saver, and community educator. She taught permaculture at the college level near Richmond, Virginia. A mother, grandmother, and committed homemaker, Cindy brings a clear journalistic eye to a major social movement, while writing in a folksy and approachable if somewhat quirky style. Her background in 4-H and steady involvement with family (she invokes her daughter's gardening, and her son Jason took photos for this book) match well with the friendly and caring approach the book takes. Conner is a strong advocate for seed independence and pulls no punches in exhorting people to free themselves, their diets, and gardens from corporate servitude.

[The author]...pulls no punches in exhorting people to free themselves, their diets, and gardens from corporate servitude.

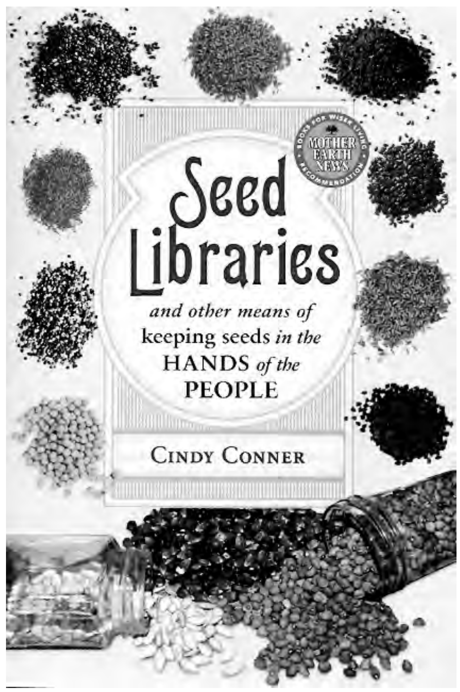
The author's sympathies for native peoples are clear in her photo and in her words; she records the pioneering role played by native groups in Minnesota and Arizona in preserving their agricultural heritage, and ties these efforts into the now burgeoning seed saving movement leaping across the continent.

Concern about the loss of biodiversity in agriculture has been growing since the early 70s when plant patenting laws were first implemented at the national level in the US. This was another dubious contribution to cultural decline brought to us under the Nixon administration, but it was perhaps less Tricky Dick's inherent interest in the subject than a case of persistent lobbying and insider connections that carried the day for corporate privilege. Downstream of this Trojan Horse, community groups, permaculture activists, and informed gardeners of every stripe turned increasingly to saving their own seeds and began finding ways to disseminate them. The Seed Saver's Exchange, founded in 1975 as True Seed Exchange, has its roots in this upwelling of concern. The advent of genetic engineering applied to seeds in the mid-70s and commercialized in the 80s gave further impetus to the movement for popular sovereignty.

The tale of librarians stepping up to support community empowerment is heartening and seems on all counts to be a good-news story, but it's important to remember as we work to expand this movement that powerful interests have worked long and hard to take control of seeds, plants, animals, and food; that this process has a long history deeply embedded in the vile story of empire; and that seed libraries, like any community effort that stands out from the crowd, are subject to pushback, suppression, and outright violence if the stakes are seen as high enough. Does this mean that people shouldn't set up seed libraries? No, but it does suggest that we should expand the movement to a point beyond which it cannot easily be snuffed. It means that locally, the exact placement of seed banks and storage facilities should be known to key people in seed library organizations and perhaps not broadcast to other authorities. It means that seed exchanges and many more seed growers, which are of course the aim of seed libraries in the first place, are even more important than the libraries themselves.

When you come across the concept of seed library, it smacks you in the face as an idea you should have thought of long ago. That's how new things come into the world. If the common heritage of seeds were not under threat, we wouldn't now need to be creating bulwarks of protection for it. This should remind us that the marketplace, which has brought about seed monopoly and a holocaust of loss in seed and plant diversity, cannot be depended upon to meet public needs. Some things belong in the commons and must remain forever there in order for human communities to thrive and be free and sovereign: air, water, forests, seed, land for farming, language, communications, government. Privatization is always a taking from the collective and common resource pool, and while sometimes this is beneficial, on the whole in our era, privatization has been a massively fraudulent meme to enrich the wealthy.

Books don't write themselves, but in a certain sense, this one was just waiting to be done. I'm glad Cindy Conner jumped on it. She has the background and



knowledge to do it justice. Practical and filled with good details, she has informed the discussion of seed library formation with her own experience. She declaims to tell us much about seed saving per se, about which there are many good resources, but the subject can't help but creep into the discussion of seed libraries and the movement to help people save seed. Seed libraries are not only about distribution of seed, but go hand in hand with education about sustainable and organic agriculture, gardening, plants, and of course seed production and storage. While many are broadly engaged in this work, from the Cooperative Extension Service to Master Gardeners, to many community groups and individuals, their focus has only incidentally been on seed saving. We can hope that the emergence of a literature of the social phenomenon to complement the long-standing resources on genetic conservation itself will stimulate new connections and spread seed-saving ideas throughout the conventional world of garden education.

Covering the waterfront from physical facilities, questions of access to seeds, storage in library conditions, promotion and organizing challenges, seed swaps and seed gardens, *Seed Libraries* should become an indispensable resource for the next phase of library and seed exchange expansion. Highlighting individual seed libraries across the country, Conner is generous in praising early leaders of the movement and in pointing to pioneering efforts in different regions. Her bibliography and extensive notes support the scholarship she brought to this rich but slender volume. Filled with common sense, uncommon insight, grandmotherly affection, and pragmatic determination throughout, *Seed Libraries* brings together the right elements at the right time to feed a quiet revolution for local economic resurgence. Highly recommended. Δ

Scrying a New Botany

Review by Peter Bane

STEPHEN BARSTOW
Around the World in 80 Plants
An edible perennial vegetable adventure in temperate climates
Permanent Publications. East Meon, UK. 2014.
284 pp. all color illustrations. $29.95.

WITH A REMARKABLY APT and witty title and a subtitle that tells the essence of the book, you might wonder why anyone would need to say more. *Around the World...* may be one of the highest expressions of globalism we are likely to see. I don't normally sing the praises of the process that is making humanity one people and Earth one place, but in the case of distributing plant diversity, we have to make an exception. The economic processes of globalism are a largely unmitigated disaster. The biotic reassembly of Pangaia may be the silver lining in that vast cloud, and a source of considerable succour to late

21st century people if they can look back on the holocaust of our time with any equanimity.

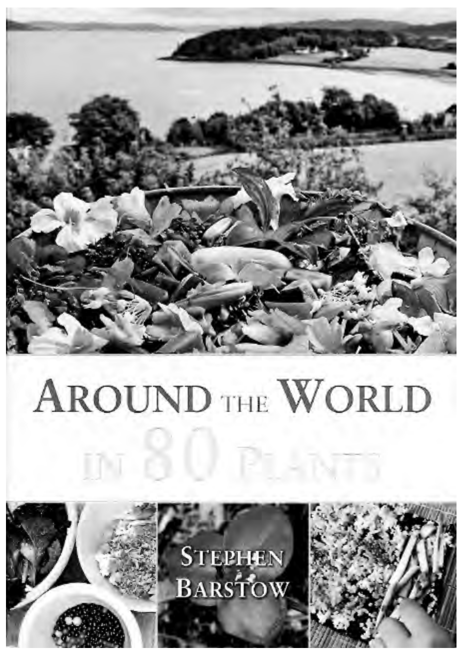
Stephen Barstow, evoking the mythical Phineas Fogg of globe-spanning balloon fame, has laid before his readers a veritable planetary feast of perennial vegetables. Standing on the shoulders of plant explorers and scholars before him: Sturtevant, Facciola, and others, he does them justice by acknowledging and improving on their work. Holder of the world's record for the greatest number of plant species eaten in one salad (537), the author lives and gardens prodigiously at the back of Trondheimfjord on the coast of Norway at 64°N latitude where he and his many plant accessions enjoy a cool but relatively mild climate supported by an ice-free ocean the year round.

Wall-rocket, unlike its more famous relative, is heroically productive, bearing nine months of the year for the author.

Filled with history, botany, recipes, food and garden advice, and excellent photographs, the book provides a top-notch introduction to a world of mostly leafy green vegetables and some roots, exactly the crops that we might expect to do well within 100 miles of the Arctic Circle! As the author reminds us, he did not attempt to write a field guide, and a number of the plants have dangerous or deadly "confusion" analogs. He recommends readers source plants through edible nurseries rather than the ornamental trade because, as he observes, the edible nursery men and women are typically more careful in labeling.

Coining (or at least propagating) the term "edimental" to describe many of the gross or more of plants he discusses, Barstow goes well beyond his catchphrase 80 plants as these are merely the top-level species names that he lists. Within such rich categories as *Brassica oleracea,* the cabbage tribe, he explores not only various perennial kales and tree collards, but nearly a dozen other variants, most of which were novel to me. You can see where this is going. The man loves his work, and he's very good at it. Candidates proliferate, and he uses the book as an opportunity to compare analog plants (onions in Europe and China, for example).

The basic structure of the book is just as its title declares, a region-by-region cataloguing of important vegetable resources, in this case the author's favorites. He begins on the streets of London with samphire, a cruciferous plant that grows on the chalky cliffs of south Britain and which was wildly popular in the 17th century. He describes it as more deadly than poison hemlock in the number it has killed, for the good price paid drove many earnest but unlucky harvesters literally over the cliff to their deaths. He cites Shakespeare as a source of insight to the baleful if delicious 'salat.'



So it is with wall-rocket, *Diplotaxis tenuifolia,* an Italian native that tastes much like its eponymous cousin *rucola,* or rocket, or as we know it from nouvelle cuisine, arugula. Wall-rocket, unlike its more famous relative, is heroically productive, bearing nine months of the year for the author.

Barstow winds up his grand tour back in his adopted Norway (and Scandinavia). There are familiar plants to be met along the way (Jerusalem Artichoke, Salsify, Asparagus, Ramps), and many, many exotics, both known and unknown (*mitsuba, udo,* bladder campion, gunnera). Familiar weeds are revealed to be edible (sow thistle) as are plants that you may already be growing for display (a raft of hostas). You cannot enter in here within coming away changed, and I suspect much for the better.

This book offers many pleasures, intellectual and gastronomic, and it rides high on a lifetime of geographic and scholarly investigation. It seems both close and touching in its intimacy with plants and people. I was tickled to see that *Permaculture Activist* was credited with a small role in the contemporary rediscovery of *Hablitzia tamnoides,* a Caucasian climber long cultivated in Scandinavia but mostly ignored in its native land. Author Justin West read Barstow's article on the plant in *Permaculture Magazine, UK* in 2007, then determined to find it in the wild. He did, and then wrote about it for *PcA* in 2008, introducing many North Americans to this vigorous spinach-like plant. For the rest of the story, read the book. You too may have a role to play in discovering and preserving our vegetable heritage.

One notable complaint, and this has nothing to do with the writing or the photography, which are both stellar, nor with the choice of recycled, forest-friendly paper. The delicate and quite pale-appearing san-serif font in which the text is set is very hard to read. I admit that my eyes are not what they once were, but with tens, nay hundreds of millions of potential readers in the same boat today, I think it warrants pointing out that this was a poor choice. The critique is not artistic but functional and addressed to my good friend Tim Harland who oversees book and magazine design for Permanent Publications.

Around the World in 80 Plants brings honor to its author and publishers by contributing a magnificent work to the literature of permanent agriculture. Worth the effort to read, it belongs on the shelf of all serious gardeners. Δ

EVENTS

Permaculture Design Course
Costa Rica

Dates: May 24-June 6
Location: Monteverde Institute
Description: This course will incorporate visits to the local farms and communities, and immersion in the rich ecosystem of the cloud forest -- students will be immersed in both the cultural and ecological realities of the region and will design from that experience.
Topics include the international curriculum integrated with immersive education on ecosystems, wild foods, culture, regenerative economics, water systems, and more.
For those who wish for a more comprehensive experience, join our Natural Building workshop following the course, and internship programs at the Institute or at local permaculture farms. Monteverde Institute advances sustainable living at the local and global level through place-based education, applied research, and collaborative community programs.
Instructors: Koreen Brennan, local experts
Cost: $1,250 early bird
Contact: 727-495-6145
info@growpermaculture.com
www.growpermaculture.com

Earth Activist Training
Spain

Dates: July 11-24
Location: Spain/Catalunya at Mas Franch, near Girona
Description: A Permaculture Design Certificate Course with a grounding in spirit and a focus on organizing and activism. Learn how to heal soil and cleanse water, how to design human systems that mimic natural systems, using a minimum of energy and resources and creating real abundance and social justice. Learn how to read the landscape, design integrated systems, harvest water, drought-proof your land, build soil, sequester carbon, make compost and compost tea, biochar, and bioremediate toxins. Explore the solutions to climate change, and the strategies and organizing tools that can put them in place. EAT also focuses on the social permaculture: how do we organize ourselves, resolve conflicts, make decisions, work together effectively, and sustain our spirits.
Instructors: Starhawk and Alfred Decker
Cost: 650-950 Euros sliding scale, includes food and lodging.
(Note: our costs are covered at 930 Euros)
Contact: Pep Puig, pep.puigiboix@gmail.com; or, earthactivisttraining@gmail.com

Permaculture Design Course
Western Canada

Dates: August 16-29
Location: Winlaw, BC
Description: This is the basic (72 hours minimum) permaculture design course. 13 days.This intensive course combines theory with practical hands-on learning.
Topics includes: permaculture design techniques & principles, site analysis, soil fertility, organic gardening techniques, herbs & medicinal plants, fruit & nut trees, water uses and ecological buildings.
Instructors: Gregoire Lamoureux & guests
Cost: Before July 16 is CAN$950.
After July 16: CAN$1050
Contact: Gregoire Lamoureux
spiralfarm@yahoo.com
http://www.kootenaypermaculture.com

Permaculture Design Course
Western Canada

Dates: June 7-20
Location: Winlaw, BC
Description: This is the basic (72 hours minimum) permaculture design course. 13 days.This intensive course combines theory with practical hands-on learning.
Topics includes: permaculture design techniques & principles, site analysis, soil fertility, organic gardening techniques, herbs & medicinal plants, fruit & nut trees, water uses and ecological buildings.
Instructors: Gregoire Lamoureux & guests
Cost: Before May 7 is CAN$950.
After May 7: CAN$1050
Contact: Gregoire Lamoureux
spiralfarm@yahoo.com
http://www.kootenaypermaculture.com

Permaculture Design Course
Galapagos Islands

Dates: July 11-24
Location: Santa Cruz Island, Reserva Pajaro Brujo, Galapagos Islands
Description: Terra-Genesis International presents an integrative 15-day Permaculture Design Course in the birthplace of Evolution. Explore how to design with natural systems and cycles in the same wild and beautiful landscape that inspired Darwin in his realizations about natural selection and evolution. Topics include history, ethics, and principles of permaculture, gardening and small-scale farming, designing zones, guilds and food forest design, soil fertility strategies, seed-saving, and much, much more.
Instructors: Miguel Torske, Paulina Lasso, and Gregory Landua.
Cost: $2,200 USD
Contact: office@terra-genesis.com; www.terra-genesis.com (go to trainings section)

Send Event and Calendar Listings for Issue #97
(August 2015)
Life on the Edge
by the June 1st
deadline to (NOTE: new address!):
events@PermacultureDesignMagazine.com

8th Annual
Northwest Permaculture Convergence
Oregon

Dates: August 28-30
Location: River Road Park & Recreation Center
Eugene, OR
Description: The NW Permaculture Convergence is a unique opportunity to share what we are learning to reduce our environmental footprints, build resilient communities and take care of more needs closer to home. For the first time, this event will be held in a suburban neighborhood. There will be site tours and on site hands on projects, keynote speakers, workshops, open space sessions, and a lively skillshare and expo area.
Keynotes: TBD
Cost: TBD
Contact:
info@northwestpermaculture.org
http://northwestpermaculture.org

Permaculture Design Course
Oregon

Dates: July 26-August 8
Location: Southern Oregon Permaculture Institute, Ashland, OR
Description: Two week intensive giving you hands-on permaculture experience plus harvesting, threshing, winnowing wet and dry seeds at a Restoration Seeds farm. Plus medicinal herb walk, greenhouse propagation, garden- to farm-scale design and even bread making. Hosted on a working permaculture farm, you will learn more about plants than anywhere else. You will gain real-world design experience with your group design project. A typical day begins with morning class followed by afternoon hands-on projects and workshops. Bring your work clothes and get ready to learn by doing. Includes camping and three vegetarian meals per day. Discount for couples $50 each; $200 student discounts for course photographer, and assistant cook.
Instructors: Chuck Burr
Cost: Early $1,250 ends 7/26, Regular $1,450.
Contact: Chuck Burr, 541-201-2688,
courses@sopermaculture.org, sopermaculture.org

Permaculture Design Course
Washington

Dates: May 23-June 7
Location: Spokane, WA
Description: The course will have a special emphasis on Earth Repair and Ecological Restoration and the north temperate climate zone.
Instructors: Michael Pilarski and guests.
Cost: $850
Contact: Michael Pilarski
Inland Northwest Pc Guild.
friendsofthetrees@yahoo.com
http://inlandnorthwestpermaculture.com

Permaculture Design Course and Sustainable Living Skills
Oregon

Dates: June 14-July 18
Location: Aprovecho, OR
Description: This course is the oldest program of its kind in the Northwest and includes hands on training in appropriate technology, sustainable forestry, natural building, and sustainable agriculture. The 72 hour Permaculture Design curriculum is woven throughout the program, leaving students with a framework for integrating strategies and techniques into cohesive designs for sustainable human settlement.
Instructors: Jude Hobbs, Tao Orion, Marisha Auerbach, Rick Valley, Andrew Millison, Abel Kloster and Friends
Cost: $2,200 for five weeks
Contact: Abel Kloster
541-556-1426
abelkloster@gmail.com
www.aprovecho.net

15th Annual
Permaculture Teacher Training
Oregon

Dates: July 26-August 1
Location: Cottage Grove, OR
Description: Empower yourself to advocate for change through whole systems design and teaching! In this dynamic and interactive course, you will learn significant teaching techniques to communicate Permaculture principles and strategies in a wide variety of educational settings.

Our goal is to encourage and inspire your unique strengths and talents by demonstrating diverse teaching modalities such as lecture, facilitating class discussions, storytelling, and using visual aids. In this setting of active learning, you will experience essential hands-on practice by preparing and co-teaching multiple presentations.

As a final course project the class will organize, promote and present to the public, a workshop titled: An Introduction to Permaculture.

This is a Certificate Course offered by the Cascadia Permaculture Institute
Prerequisite: Permaculture Design Course Certificate or Instructor's approval.
Enrollment: limited to 15 participants
Instructors: Jude Hobbs, with Guests including Andrew Millison
Cost: $950.00 Includes course materials, camping & 3 deliciously local meals a day Early Reg. discount of $50 by 6/26. Limited local work trades available.
Contact: cascadiapc@gmail.com
www.cascadiapermaculture.com

Permaculture Teacher Training
Oregon

Dates: September 7-11
Location: Southern Oregon Pc Inst.
Ashland, OR
Description: Permaculture design and implementation is vital and building and honoring your skills as a permaculture teacher is an investment not only in your work, but in the communities you will work with. Learn how to teach permaculture concepts and practical applications to a variety of students with diverse learning styles. Prerequisite, Permaculture Design Certificate (PDC) course. You will develop short curriculums and speak in front of a group to practice their presentation skills. We also cover the economics of starting and running an educational center and nonprofit.
Instructors: Chuck Burr
Cost: Early $690 ends Aug 7,
Regular $790.
Contact: Chuck Burr
541-201-2688
courses@sopermaculture.org
www.sopermaculture.org

Permaculture Design Course
California

Dates: May 30-June 13
Location: Quail Springs
Description: This program equips people working in international development and grassroots projects with the perspectives and skills needed to engage with communities in partnership to incorporate elements into the design of communities, smallholder farms and land with household agricultural production. Special topics include: Food and Nutrition Security through Permaculture Design, Practices to build resilience in farming systems, Perma-Gardens Curriculum, A USAID TOPS program, Community Facilitation/Community-Based Development, Cultural Awareness and Honoring.
Instructors: Warren Brush, Jeanette Acosta, Thomas Cole, Pandora Thomas, Janice Setser, Lindsay Allen, Brenton Kelly
Cost: $1,650, discounts for pairs, refresher, families, limited partial scholar. by application
Contact: 805-886-7239
info@quailsprings.org
www.quailsprings.org

Two Options
Permaculture Design Course
California

Dates: July 18-31; or
September 19-October 2
Location: Occidental, CA
Description: This is a two-week certificate course in land–use design based on the sustainable living philosophy of Permaculture. Topics to be covered include permaculture theory, food diversity, soil enrichment, water use, erosion control, natural building, organic gardening, forest farming, and more. Comfortable lodging and outstanding meals are included in the course fee.
Instructors: Brock Dolman and guests
Cost: $1,650; $1,550 if registered three weeks in advance.
Contact: OAEC
707-874-1557 x 101
www.oaec.org

Permaculture Design Course & Summer Apprenticeship
California

Dates: July 5-August 2
Location: Quail Springs
Description: This 30-day course sold out in the summer of 2014, so we are repeating it. This mentoring and hands-on experiential journey will weave together a full permaculture design course, financial permaculture, nature awareness, and community and cultural regeneration. Space is limited.
Cost: $3,400 after;
$300 deposit
Contact: ana@regenerativeearth.com
805-649-8179

Permaculture Design Course
California

Dates: October 25 - November 7
Location: Quail Springs
Description: Immerse yourself in permaculture in action with this 14-day learning journey! Share in the joy of community learning together and changing the world. Take home the ability to design and apply natural principles to create stable and resilient systems that provide food, water, shelter and energy needs while regenerating ecology, community and economy.
Instructors: Warren Brush, Lindsay Allen, Brenton Kelly
Cost: $1,150-$1,450, discounts for pairs, refresher, families, partial scholar. by application
Contact: 805-886-7239
info@quailsprings.org
www.quailsprings.org

29th Annual
Permaculture Design Course
Colorado

Dates: June 15-26
Location: CRMPI, Basalt, CO
Description: The CRMPI Permaculture Design Course is designed to give the participant an understanding of the essential elments and ideas of permaculture so that they can better design and engineer sustainable systems, including forest gardens, greenhouses, and other permaculture endeavors. Experience one of the finest permaculture demonstrations in North America. Thirty years of organic cultivation, state of the art, low energy-use greenhouses, mature forest gardens, rainwater catchment, are all on display along with vigorous and healthy polyculture systems, all at 7,200' elevation.
Instructors: Adam Brock, Jerome Osentowski, Avery Ellis, and Kelly Simmons
Cost: $1,775, requires a non-refundable deposit of $400
Contact: www.crmpi.org

Permaculture Design Course
Indiana

Dates: May 31-June 14
Location: Paoli, IN
Description: Explore permaculture design by day, make music in the woods in the evenings with your fellow students. This permaculture design course includes and expands upon the traditional curriculum including working with soil, water, forests, buildings, energy, economics, and much more. Engage your study of permaculture with an experienced teaching team sharing their own experiences with villages, community organizing, nature connection, homestead life, and more. Live in a more resilient world! Credit with Indiana University is available.
Instructors: Peter Bane, Keith Johnson, Rhonda Baird and guests
Contact: Andy Mahler
971-322-4400
andy@lazyblackbear.org

Kinstone Academy
Wisconsin

Location: Fountain City, WI
Contact: 608-687-3332
info@kinstonecircle.com
www.kinstonecircle.com

Permaculture Design Course
Dates: August 5-16
Description: This course provides a comprehensive introduction to permaculture, exceeding the international standard. Special attention is given to climatic zones represented by course participants.
Instructors: Wayne Weiseman
Cost: $1,380

Advanced Design Course
Dates: Sept. 12-18
Description: Gain the skills and confidence needed to take your design skills beyond your own backyard. We will teach you how to design property infrastructure, the built environment, work with animals and plant, and merge all elements into a designed landscape. This course requires a 7-day session and an independent design. PDC certificate required.
Instructors: Wayne Weiseman
Cost: $895 before 8/1; $995 after.

Permaculture Teacher Training
Dates: Oct. 12-18
Description: There is a pressing need for experienced and well-trained instructors. We have identified areas of training and effective methods of bringing permaculture design to our students. Key skills and proficiencies are covered. Students must have their PDC certificate to participate.
Instructors: Wayne Weiseman
Cost: $895 before 8/31; $995 after.

Permaculture Design Course
Chicagoland

Dates: October 1-4; 22-25; November 6-8
Location: Naperville, IL
Description: People have become increasingly concerned with the resiliency of our food, water, energy, and economic systems and are looking for personal and community security. Explore permaculture design in the Chicago suburbs and at McDonald Farm.
Our course covers the design principles, practical skills, and invisible structures which will lead to greater resilience for all communities. This course is aimed at professional planners, architects, and public servants interested in permaculture design, public welcome.
Instructors: Peter Bane, Rhonda Baird
Contact: Michelle Hickey; The Resiliency Institute
contact@theresiliencyinstitute.net; theresiliencyinstitute.net/pdc/

Advanced Permaculture Design
Great Lakes Region

Dates: November 8-13
Location: Akron, OH
Description: Take your permaculture training to a professional level. Build confidence practicing advanced design frameworks with earnest colleagues and top-notch practitioners. We will cover water collection and management, earthworking, and plant palettes in depth with an emphasis on patterning in design. The focus of serious Pc design in this era is the construction of self-reliant local economies, and this course will offer guidance in deepening community capacities across visible and invisible fronts. Learn resource inventories and how to identify unfilled niches in your region. We will practice land surveying and professional level graphic design for presentation, and address organizing a consultancy.
Instructors: Peter Bane, Karryn Olson-Ramanujan, Jono Neiger, and guests.
Cost: $900, $800 if paid in full by Oct 1. Non-refundable deposit of $200. Payment plans available for help with tuition. Meals and lodging included. PDC required.
Contact: Peter Bane
812-335-0383;
pcactivist@mindspring.com;
www.permacultureactivist.net

Permaculture Design Course
Mid-Atlantic

Dates: August 3-15
Location: Sandy Lake, PA
Description: During this 12-day intensive course, enjoy great food from local farms and country living at Three Sisters Farm, a 25-year old demonstration of permaculture, and visit other local examples of permaculture in action. Learn the design process and co-create a design to enhance Three Sister's Food Forest. Experience hands-on applications of permaculture and team learning while sharing your own expertise. Acquire practical skills that can be integrated into your life and inspiration to create a more sustainable world around you!
Instructors: Darrell Frey and guests
Cost: $1,200, includes fees, food, camping. $200 dep. by June 1.
Contact: Darrell Frey
threesisters@bioshelter.com

Back Issues of *Permaculture Activist* & *Permaculture Design*

I,1 July '85 **Permaculture in Oz**
I,2 Nov. '85 **Fruit & Nut Trees**
II,1 Feb. '86 **Garden Design**
II,2 May '86 **IPC-2** & Pc Courses
II,3 Aug. '86 **2nd Int'l Pc Conference**
II,4 Nov. '86 Fukuoka, Keyline, Genetic Conservation, City Farms, Oceanic Pc
III,1 Feb. '87 Networking, Natural Farm'g, D-Q Univ., Children's Permaculture
III,2 May '87 **Wild Land Restoration**
III,3 Aug.'87 **Annual Planting Cycle**
III,4 Nov. '87 **Trees for Life**
IV,1 Feb. '88 **Marketing Pc Products**
IV,2 May. '88 **Urban-Rural Links,** Economics & Community Development
IV,3 Aug. '88 **Social Forestry,** Gabions, Jap. Org. Ag., Producer/Consum. Coops
IV,4 Nov. '88 **Multi-Story Tree Crops,** Greening Dominican Repb., Runoff Gdns
V,1 Feb. '89 *Permaculture: A Designers Manual,* Tree Bank, Water in Pc
V,2 May. '89 **Plant Guilds,** Roof Gardens, Small Livestock
V,3 Aug. '89 **Rainforest Conservation** in Ecuador, Gaia, Weed Gardens
V,4 Nov. '89 **Earthworks** & Water Conservation: Small Dams, Ponds, Keyline
VI,1 Feb. '90 **Household Greywater** Systems, Soil Imprinting *($5 each to here)*
VI,2 May. '90 **Insectary Plants,** more Greywater, Land Use for people "
VI,3 Aug. '90 **Water:** Forests & Atmosphere, Catchment, Pond Design
VI,4*Nov.'90 **Urban Permaculture:** EcoCity Conf., Soil Detox, Suburbs & Pc
#23 May '91 **Politics of Diversity,** Greenhouse Market Gdn, Pc in Nepal
#24 Oct. '91 **Creativity in Design:** Case Studies, **Index to Issues #1-23** *$5*
#25 Dec. '91 **Design for Community:** CSAs Restoring Forests, Garden Ecology
#26*May '92 **Soil:** Our Past, Our Future, Fertility, Worms, Cover Crops
#27*Aug '92 **Integrating Pc:** Deconstructing Utopia, Grassroots Organizing, Garden Polyculture, Pattern Learning, Living Fences
#28*Feb. '93 **Structures:** Comm'ty Dsgn, LETS, Industry, Strawbale/Timber-framing
#29/30* Jul.'93 **Networks:** Media Revw, Rural Reconstructn, Leaf Concentrate, Comm'ty Food, Palestine Pc, Do-Nothing Educ, Feng Shui, Pc Academy
#31*May '94 **Forest Gdng:** Energy & Pc, Mushrm Cultvn, Robt.Hart's F.G., Spp for No. Cal., Alders, Agroforestry: Belize & China, Honeylocust, N-fixers
#32*Apr. '95 **Animals & Aquaculture:** Animal Polyculture, Sm-scale Cattle, Goat Dairy, Keyline, Feral chickens, Bee Plants, Constructed Wetlands
#33 Dec. '95 **Cities & Their Regions:** Green Cities, L.A. Ecovillage, MAGIC Gdns, CoHousing, Micro-Enterprise Lending, Suburban Conversion *$5*
#34 June '96 **Useful Plants:** Bamboo Polyculture, Medicinals, Pest Control, Root Crops, Oaks, R. Hart's F.G., Russian Plants, Regl. Plants, Sources *$5*
#35 Nov. '96 **Village Design:** Pattern Language, Consensus Democracy, Conflict, Historic & New Villages, Planning for Tribe, Village Economics *$5*
#36*Mar. '97 **Climate & Microclimate:** Climate Change, Windbreaks, Low-Tech Sun Locator, Drylands, Cool Slopes, Straw-Clay Bldg. Round Beehive, Water Catch.
#37 Sept. '97 **Tools & Appropriate Technology:** Dowsing, Workbikes, Scythes, Japanese Saws, Nursery, Ferrocement, Greywater, A-frame & Bunyip Levels, Ram Pump, Solar Toilet, Log Yoke, Cookstoves
#38*Feb. '98 **Economic Transformation:** Speculation, No Middle Class, Coops WWOOF, Global Warm'g, Hol. Fin. Plan'g. Land Use, Adopt-a-Hive
#39 Jul. '98 **Knowledge, Pattern & Design:** Pc Way of Seeing, Native Consvn Sand Dunes, Language-Worldview-Gender, Patterning Process, Land-Use Planning, Teaching Pc, Vietnam, Holmgren on Pc
#40*Dec. '98 **New Forestry:** Regl. Devl., Horselogging, Menominee Reservatn, Forest Investing, Restoratn, Old Growth, Homestead Tenure, Forest Soils, Forest Farmg, Woody Agric., Rainforests, Windbreaks, Coppice
#41*May '99 **Natural Building:** Oregon Cob, Cordwood, Bamboo, Thatch, Ethics, High Winds, Origins of Conflict, Greenhouses, Ponds, Adobe, Road Bldg, MicroHydro, Living Bldgs., Under $20K Houses, Dreams
#42 Dec. '99 **Self-Reliance & Community Cooperation:** Co-Intelligence & Self-Orgn., Archetype Dsgn, Sovereignty, Samoa, Mondragon, Natural Hous'g, Comm. Gdns., Zone 0, Solar Electric Tractor, Beekeeping
#43*June '00 **Food & Fiber:** Hunger, Ferments, Seasonl Salad, Heirlooms, Fencing Self-Fertile Gdns, Rice Revoltn, Cold-Climate Food, Edible Insects, Chilies, Food Origins, Garlic, Ethnobotany, Wild Food, Bamboo, Hemp
#44 Nov. '00 **Earthworks & Energy:** Spreader Drain, Horse Swales, Earth Dams, Machinery, Carpet-lined Ponds, Constr. Wetlands, Biogas, Windmills
#45 Mar. '01 **Medicine & Health:** World & Self, Healthy Home, Designing Care, Ayurveda, Agents of Decay, Comn. Health Centres, Women Trad. Med. 4th World Apothecary, Healing Weeds, Medicnl Crops, Hawaiian Bot'ls
#46 July '01 **Good Work & Right Livelihood:** Pc Golf Course, Downsize Cost of Living, New Forest Economy, Energy Currency, Buddhist Mktg, End Wage Slavery, What's Surplus?, Urban Community, Enterprise Facil'n
#47 June '02 **Watersheds:** Water4Sale, Basins o'Relations, Watershed Devl, Gabions, Urban Runoff, Beavers, Skywater Ctr, Consvn. Investmt, Peat Bogs, Rabbits
#48*Sept '02 **Making Changes:** Co-Intelligent Activism, Webs of Power, Urban Food, How to Change, Teaching for Change, Global Transform'n, City Repair, Escaping Job Trap, Argentine Recovery, Costa Rica Pc
#49 Dec. '02 **Where is Permaculture?** Land-Rent Reform, 10 N. Amer. Sites, Cuba Ag, Rainbow Vall. NZ, Cacti/Succulents, Animal Self-Meds, Challenge2Pc
#50 May '03 **Ecosystems:** Holmgren on Pc Mvmt, Hazelip & Syng. Ag, Chestnuts/ Pigeons, Oak Savannas, Root Crop Polycultures, Alders, Fungal Ecosys. Humans & Wilderness, Indoor Ecosystems, Humid Tropics
#51 Jan '04 **Trad'l. Knowledge & Regeneration:** Cataclysm & Collective Memory, Genome Wisdom, *Waru Waru,* Biosculpture, Inuit Medicine, Fermented Stimulants
#52 May '04 **Aquaculture:** EcoAquac, Fish4Health, Dowsing, Pond Design, Greywater Biotreatment, N. Amer. Polyculture, Manage for Native Spp, Integrated Village Fisheries, Vietnam

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#53 Aug. '04 **Education:** Lifelong Learning, Edge-ucation, Albany Free Schl, Indigenous Ed. & Ecology, Ecocentric Pedagogy, School Gardens & Dances, Ecology of Learning, Brain Gym

#54 Nov. '04 **Fire & Catastrophe:** Design Beyond Disaster, New Opportunities Globalizatn, Invasion Biology, Street Orchards, Community Food Security, Floodwaters Rising, Disrupted Climates

#55 Feb. '05 **Learning from Our Mistakes:** Petrol Dependcy, Village Design, Australian Lessons, RTFM!, Trial&Error, Forestry Experiments, Owner-Bldr, 10 Mistaken Ideas in Pc

#56 May '05 **Tree Crops & Guilds:** Pine Nuts, Tree Vege, Acorns, American Chestnut, Honeylocust Silvopasture, Broadscale Agroforestry, Bamboo, Willow, Social Forestry

#57 Aug. '05 **20th Anniv.:** Challenges & Changes, USA Pc, Hawai'i Retrospect, Permatecture, Pc's Soft Edge, Gaia U, PINC, Oil Depl, IPC-7, Retrofit Suburbs

#58 Nov. '05 **Urban Pc:** Urban/Rural Futures, City Zones & Sectors, Growing Food, Detroit Visionaries, Rebldg. New Orleans & Everywhere, Transforming a Military Base, Workers Co-op, Energy Descent.

#59 Feb. '06 **Peak Oil:** Eco-Collapse & Trauma, Thom Hartmann, Pathways for Energy Descent, How Cuba Survived, Oil & Food, Biofuels, Algae for Fuel, Relocalize

#60 May '06 **Land Use Past & Present:** Sust.Ag an Oxymoron?, Negev Bedouin, East. Woodlands AgroForestry, Pc Heals in India, Arocsanti, Pop. Growth/Land Hunger, Mexican Reforestation

#61 Aug. '06 **Unseen Kin-doms:** Observation as Design Tool, Soil Food Web, Bees, Mycelial Internet, D-I-Y Mycorrhizal Inoculum, Cover Crops as Bee Forage, Earth Energies, Local Currencies, Dead Zones

#62 Nov. '06 **Art of Permaculture:** Painting, Writing & Pc, Ecoartists, Art, Activism & Cmty, Street Theatre, Art & Bioremediation, Living Willow, Body as Zone 0, Art of the Found, Water Magic

#63 Feb. '07 **Building & Technology:** How to Dwell? Natural Bldg & the Law, Bldg Code, Strawbale in China, Cob in Armenia, Integrated Solar Heating, Cooking, Pumping, Nation-Scale Pc in Brazil

#64 May '07 **Waste = Food:** Throwaway Econ, Strategy of Salvage, Peak Soil, Pigs & Waste Mgmt, Bikes, Soil & Garbage, Farm as Organism, Opportunistic Plants? Simple Biodigester, Vermiculture

#65 Aug. '07 **Climate Change:** Shrinking Seas, Forests' Role in Climate, Urban Forests, Making Trees Pay, Rainwater Harvesting, Indoor Gardens, Water Filtration, De-Stabilizing Climate

#66 Nov. '07 **Animals in Design:** Jumbo Shrimp, Pawpaw Patch, Alpaca, Insects as Food, Integrated NH Farm, Pastured Poultry & Rabbits, Urban Livestock, Predator Restorat'n, Bees, Complementary Animals, Agrichar

#67 Feb. '08 **Kids in Pc:** School as Ecosystem, Pc Education, Gardening Kids, Pc to H.S. Students, Tlaxcalan Kids Make Seedballs, Fostering Research Skills, Bottled Water Boycotts, Feeding 8 Billion.

#68 May '08 **Plants on the Move:** Rethinking Non-Natives, Forest Migration, Black Walnuts, Saving Seed Savers, Grow a Community Gdn, N'hood Greening, Healthy Honeybees, Biofuels & Food Prices

#69 Aug. '08 **Permaculture at Home:** Hawai'ian Cmty, London Forest Gdn, Suburban Renaissance, Calif. Campus, Phila. Orchards, Drinking Roofwater, Floating Island Bioremed., Bike Transport, Miss. Pc

#70 Nov. '08 **Ethics at Work:** BAU is the Enemy, 13 Princ. of People Care, Pc in Business, Ecovillages, White Man in India, Uganda Boarding School, No Waste, Qual. Control, City Farming w/Runoff, Amaranth

#71 Feb. '09 **Earthworks:** Hopewell Mound Water Mgmt, Belize, Keyline, Road & Dam Bldg., NW AgroFor, Pc&Landscape Arch, Earthbag Bldg, Low-Watt Fridge

#72 May '09 **The View from Abroad:** War, Oil & Snails in Nigeria, Green Tech Future, Ethiopian Water Mgmt., Shrinking Forests, Food Exploration in Caucasus, Maya Agroforestry/Biochar, Pc to Trinidad,

#73 Aug. '09 **Bioregionalism:** New Paradigm, Rocky Mtn. Wildlands, Wild Elephants, Organizing Houston, Heirloom Seeds, L.A. Gdns, Reclaim. Commons, Transition Hohenwald, Tenn., BioCongress Saga

#74 Nov. '09 **Energy Descen**t: In the Home, Transition Communities, Pc in Mexico, Biochar, US Consumption Dropping, EcoTechnic Future, No More Throwaway Economy, Making Fuel Alcohol

#75 Feb. '10 **Local Food:** A City & Regl. Food System, Working Family on 5Ac, CSAs & Wild Foraging, City Backyard Gdng., Food Bank Gdns & Orchards, Salt Collecting, Regional Staples, City Grains.

#76 May '10 **Soil Fertility:** Permaculture Way of Soil, Biochar, Sheet Mulch, Hawai'ian Soil Farming w/ Worms, Demystifying Humanure, Urine Fertilizer, Crop Rotations, Mushrooms Build Soil

#77 Aug. '10 **Eco-Nomics:** Measuring Many Forms of Capital & Quality of Life**,** Bob Swann & Invisible Structures, Bioshelter Market Gdn, Green Collar Economy, Pc & Finance, Pc Inst., Cert. & Diplomas

#78 Nov. '10 **Water Wise:** Restoration Engineering, Watershed Relations, Colorado Runoff Gdns, Cisterns in Saudi Arabia, Energy Use & H_2O, Trad'l. Mexican Catchment, Rooftop Garden, Home Water

#79 Feb. '11 **The Urban Frontier:** Indoor Denver Farm, Rooftop Food, Home town Returns, Urban Ecovillage, City Bees, Urban Pc Projects, Start Pc Farming: Mark Shephard, **Index to issues #24-40.**

#80 May '11 **Designing for Disaster:** Collapse Mitigation, Global Storming, Responding to Major Events, Stabilizing the Climate, Self-Care, Ensuring Food Supplies, Living Through Drought

#81 Aug. '11 **Hidden Connections in the Garden:** Neighborhood Gdn, Urban Ag on Empty Lots, Food=Land Access, Indigenous Practices, Seeds, Deep Raised Beds, Greenhouses, Urban Wild Edibles

#82 Nov. '11 **Growing Staple Crops:** Broadscale Farming, Local Grain & Mkts, Non-Tillage Beans/Corn, Pigs and Potatoes, Rice in Vt. Perennial Staples - Pt. 1, Garden Farming, Acorns & Chestnuts.

#83 Feb. '12 **The Economy of Wood:** Polewood, A Northwoods Economy, Basketmaker's Landscape, Ligurian Alnoculture, Wood as Fuel, Clearing Woodland, Black Locust, Perennial Staples - Pt. 2

#84 May '12 **Home and Hearth:** Domestic Permaculture, Natural Building, Roundhouses, Hearthfire, Retrofits, Home Economy, Homeschooling, Drylands Pc, Nova Scotia Homestead

#85 Aug. '12 **There Goes the Neighborhood:** So. American Neighborhood Projects, N'hood Pattern Language, Community Solar, Food Security, SENS House, Moving Groups, Fracking & Common Rights

#86 Nov. '12 **Health and Nutrition:** Naturopathy Centre, Seasonal Eating, Plant Medicine, Mushrooms & Vit. D, Herbal First Aid, Campus Forest Gdns, Beer, Growing Wise Children, Fenugreek

#87 Feb. '13 **Weeds to the Rescue:** Managing Weedy Spp, Favorite Weeds, Weed Wisdom, Paulownia, Grafting onto Weed Trees, Polycultures, Burdock, Reputation of Weeds, **General Index to *PcA* #41-58.**

#88 May '13 **Earth Skills & Nature Connection:** Mentoring, Cultural Repair, Connecting Youth to Nature & Self, Living with Wild Animals, Observation Skills & Design, Oyster-tecture, Personal Forest.

#89 Aug. '13 **Practicing Democracy:** Slow Democracy, Seed Libraries, Rhode Island Prosperity, Lessons from the Iroquois, Community Gardens, Entrepreneurship, Social Pc, Pastoralism, Sweet Cicely

#90 Nov. '13 **Appropriate Technology:** Technology & Culture, Zone 4 Tools, Rocket Mass Htrs, Solar Pump, Solar Food Dryers, Social Sharing Software, Oil Presses, Woody Ag Trials, Scythes, PV Dbl. Cropping

#91 Feb. '14 **Seeds:** Arizona Seed-Sheds, Seed Saving Primer, Leucaena, Volunteer Plants in the Garden, Seeds of Cheese, Seed Banks, GMOs in Uganda, **General Index to Issues #59-74.**

#92 May '14 **Stacking Functions:** Primer; Biochar; Commty Gdn.; Pc of Oaks Nature, Culture, Self; Fodder Banking Central America; Rule of Three; Colo. Flooding; IPC-11; **Spp Index to *PcA* #41-74.**

#93 Aug. '14 **Experimentation-Science in Pc**: Method & Theory; Dynamic Accumulators.; Experimentation; N-fixing Vege.; Biochar & Soil; People's Science; Malawi; Pc & Academia; Soil & Biodiversity Tests

#94 Nov. '14 **Seasonal Cycles of Work:** Festivals & Forestry; High Desert Homestead; Market Seasons; Wisconsin Gdn. Cycles, Seeds; Energy by Seasons; Homestead Resilience; Forest Gdn. Research

#95 Feb. '15 **Perennial Crops:** Perennial Cultures; Hybrid Swarms, Hickory-Pecans; Perennial Sugar; Haiti; Perennial Veg.; Perennial Cereals; Guild Patterning; Hardy Kiwi; Foraging; General Index

Back Issue Prices & Ordering

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Send notice of your events to events@permaculturedesignmagazine.com

Permaculture Design Course
Eastern Canada

Dates: July 26-August 8
Location: The Whole Village Ecovillage, Caledon, ON
Description: This is the basic (72 hours minimum) permaculture design course. 13 days. This intensive course combines theory with practical hands-on learning.
Topics includes: permaculture design techniques & principles, site analysis, soil fertility, organic gardening techniques, herbs & medicinal plants, fruit & nut trees, water uses and ecological buildings.
Instructors: Gregoire Lamoureux & guests
Cost: Early registration before June 8 is CAN$988 (After CAN$1088)
Contact: Brenda Dolling
519-942-4010
bdolling@wholevillage.org
http://wholevillage.org

Earth Activist Training
Northeast

Dates: May 31-June 14
Location: Rowe, MA
Description: Learn how to heal soil and cleanse water, how to design human systems that mimic natural systems, using a minimum of energy and resources while creating real abundance and social justice.

Explore the strategies and organizing tools we need to make our visions real, and the daily practice, magic, and rituals that can sustain our spirits.

Participatory, hands-on teaching with lots of ritual, games, projects, songs, and laughs along with an intensive curriculum in ecological design.
Instructors: Starhawk, Charles Williams, with Dave Jacke
Cost: $1,650-$1,850 sliding scale, includes food and lodging. Some worktrade and scholarships available for those working for social and food justice.
Contact: 1-800-381-7941
earthactivisttraining@gmail.com
www.earthactivisttraining.org

Permaculture Design Course
Northeast

Dates: June 20-July 2; OR July 19-31
Location: Johnson, VT
Description: Unlike all other Permaculture Design Certification courses- students work to create both collaborative and individual designs, allowing the opportunity to practice the design process twice, work with real-world clients and sites, as well as developing ideas for your own sites, bioregions, and specific interests with professional guidance. Students' final individual design presentations are from a wide geographical and cultural diversity- ranging from 100+ acre farms, to vacant-lot community gardens, to natural building renovation, 'renter's permaculture' apartment / urban strategies, and more! The balance between collaborative and individual work, combined with the diverse students we attract make each design a highlight, and broaden our collective experience and practice.
Instructors: Keith Morris, Mark Krawczyk, Alissa White, Lisa DePiano
Contact:
www.prospectrockpermaculture.org

Permaculture Design Course
Northeast

Dates: July 17-30
Location: Sirius Ecovillage Amherst, MA
Description: Sowing Solutions Permaculture Design Course and Training! Gain hands-on ecological design experience alongside leading permaculture designers and educators at a renowned ecovillage in the northeastern US!

We offer extensive design time and practice, as well as skill shares (in this course you may be: mapping, working with solar light tools, sheet mulching, preserving and fermenting food, mixing earth plaster, designing a forest garden guild, making oxygenated compost tea, preparing herbal medicine, tending to a masonry stove, etc.) During class time we will integrate the methods of storytelling, slide shows, films, discussions, hands-on design activities, etc. In the break times there are yoga classes, meditations, dancing, saunas, hiking trails, permaculture movies, and more!
Instructors: Kay Cafasso, Keith Zaltzberg, Ryan Harb, Walker Korby, Conner Stedman, and special guests
Cost: $1,350-$1,600 sliding scale; includes organic meals.
Contact: www.permacultureseries.org

Permaculture Design Course
Northeast
Dates: July 10-19, and August 21-30
Location: Mad River Valley, VT
Description: This course offers an exceptional opportunity to gain hands-on applied permaculture skills immersed in one of North America's most diverse and intensive permaculture research sites. Participants will engage with high-performance home and community resource systems. These will be more resilient in the face of problems posed by peak oil, climate change, environmental toxicity, and the inability of existing economic and social systems to deal with such challenges. This course goes beyond the standard curriculum by using the skills-based trainings offered in Whole Systems Skills.
Instructors: Ben Falk, Cornelius Murphy, Erica Koch, Mark Krawczyk, and guests
Contact: 802-343-9490
erica@wholesystemshealthvt.org
www.wholesystemsdesign.com

Permaculture Teacher Training
Northeast

Dates: June 24-June 30
Location: Brooklyn, NY
Description: Empower yourself to advocate for change through whole systems design and teaching! In this dynamic and interactive course, you will learn significant teaching techniques to communicate Permaculture principles and strategies in a wide variety of educational settings. Our goal is to encourage and inspire your unique strengths and talents by demonstrating diverse teaching modalities such as lecture, facilitating class discussions, storytelling, and using visual aids. In this setting of active learning, you will experience essential hands-on practice by preparing and co-teaching multiple presentations.
Instructors: Jude Hobbs and guests.
Cost: Sliding scale $650-$950
Contact: Monica Ibacache
events@beyondorganicdesign.com

Permaculture Practitioner Training

Southeast

Dates: August 15-October 31
Location: Summertown, TN
Description: Experience what it is like to live by the ethics and principles of permaculture on a day-to-day basis. Learn many aspects of homesteading and practical permaculture skills.
Instructors: Cliff Davis, Jennifer Albanese
Contact: Spiral Ridge Permaculture
info@spiralridgepermaculture.com
www.spiralridgepermaculture.com/practitionertraining/

Permaculture Design Course

Southeast

Dates: May 22-June 2
Location: Spiral Ridge Homestead
Summertown, TN
Description: This course will cover; Permaculture principles and ethics, professional ecological design process, holistic management, base mapping, reading the landscape, pattern and pattern application, water harvesting, swale building, zone and sector analysis, climate and micro climate, land access, community building, plant guilds, food forests and agroforestry, principles, strategies and techniques, nature awareness, soil building and sheet mulching, pond management and ecology, forest management, much more.
Instructors: Cliff Davis, Jennifer Albanese and several guests.
Contact: Spiral Ridge Permaculture
info@spiralridgepermaculture.com
http://www.spiralridgepermaculture.com

Permaculture School

Southeast

Dates: May 23-August 14
Location: Asheville, NC
Description: Permaculture School is a rigorous, 12-week, college-level program for students who want to learn more in the field of Permaculture. Embody it. Understand how it fits into your life. And how your life fits into it. You are especially encouraged to apply if you're on a path toward being a permaculture leader, professional practitioner, designer, educator, activist, or advocate. If you are someone who wants to develop your own permaculture project, clarify your vision, make a plan, and move forward in accomplishing this within a framework of accountability, we welcome you to apply.
Contact: Kathryn Blau
Permaculture School
kathryn@thepermacultureschool.org
www. ThePermacultureSchool.org.

Calendar

May 1-17. Vancouver Island, BC. Permaculture Design Course/Earth Activist Training. info@ourecovillage.org.
May 15-July 3. Vancouver Island, BC. Natural Building Series. info@ourecovillage.org.
May 20-24. Vancouver, BC. Permaculture, Natural Building, and Community Colloquium. info@ourecovillage.org.
May 22-June 2. Summertown, TN. Permaculture Design Course. info@spiralridgepermaculture.com.
May 23-June 7. Spokane, Washington. Permaculture Design Course. Michael Pilarski, friendsofthetrees@yahoo.com
May 23-August 14. Asheville, NC. Permaculture School: Design Ecology & Living Skills, Contact: info@ThePermacultureSchool.org. www.ThePermacultureSchool.org.
May 24-June 6. COSTA RICA. Permaculture Design Course. 727-495-6145, info@growpermaculture.com.
May 31-June 14. Paoli, IN. Permaculture Design Course. Andy Mahler, andy@lazyblackbear.org.
June 2-6. Asheville, NC. Water Retention Landscape Course. www.thepermacultureschool.org.
June 3-7. Fountain City, WI. Plants in Permaculture. info@kinstoneacademy.com, 608-687-3332.
June 5-7. Midwest Women's Permaculture Gathering. shelteringhills@gmail.com.
June 7-20. Winlaw, BC. Permaculture Design Course. Gregoire Lamoureux, spiralfarm@yahoo.com, http://www.kootenaypermaculture.com.
June 15-26. Basalt, CO. Permaculture Design Course. www.crmpi.org. 970-927-4158.
June 24-30. Brooklyn, NY. Permaculture Teacher Training. Monica Ibacache, events@beyondorganicdesign.com.
July 5-August 2. Quail Springs, CA. Permaculture Design Course + Apprenticeship. 805-649-8179. ana@regenerativeearth.com.
July 9-27. Vancouver, BC. Earthship-Inspired "Mini-Ship" Workshop. info@ourecovillage.org.
July 10-13. Basalt, CO. Greenhouse Workshop. www.crmpi.org.
July 14-17. Basalt, CO. Forest Garden Workshop. www.crmpi.org.
July 10-13. Basalt, CO. Aquaculture/Greywater Workshop. www.crmpi.org.
July 10-19 & August 21-30. Mad River Valley, VT. Permaculture Design Course. 802-343-9490, erica@wholesystemshealthvt.org, www.wholesystemsdesign.com.
July 11-24. Santa Cruz Island, Reserva Pajaro Brujo, Galapagos Islands. Permaculture Design Course. office@terra-genesis.com, www.terra-genesis.com.
July 17- July 19. Sirius Ecovillage near Amherst MA. Permaculture Design Course. www.PermacultureSeries.org.
July 19-31. Johnson, VT. Permaculture Design Course. www.prospectrockpermaculture.org.
July 26-August 1. Cottage Grove, OR. Permaculture Teacher Training. cascadiapc@gmail.com.
July 26-August 8. Ashland, OR. Permaculture Design Course. 541-201-2688, courses@sopermaculture.org, www.sopermaculture.org.
July 26-August 8. Caledon, ON. Permaculture Design Course. Brenda Dolling, 519-942-4010, bdolling@wholevillage.org, http://wholevillage.org.
August 3-15. Sandy Lake, PA. Permaculture Design Course. Darrell Frey. threesisters@bioshelter.com. www.bioshelter.com.
August 5-16. Fountain City, WI. Permaculture Design Course. info@kinstoneacademy.com. 608-687-3332.
August 16-29. Winlaw, BC. Permaculture Design Course. Gregoire Lamoureux, spiralfarm@yahoo.com, http://www.kootenaypermaculture.com.
August 28-30. Euguene, OR. 8th annual Northwest Permaculture Convergence. info@northwestpermaculture.org.
September 7-11. Ashland, OR. Permaculture Teacher Training. Chuck Burr, 541 201-2688. courses@sopermaculture.org.
September 12-18. Fountain City, WI. Advanced Permaculture Design. Plants in Permaculture. info@kinstoneacademy.com, 608-687-3332.
October 1-4. Fountain City, WI. Permaculture Earthworks/Access & Circulation Workshop. info@kinstoneacademy.com. 608-687-3332.
October 12-18. Fountain City, WI. Permaculture Teacher Training. info@kinstonecircle.com. 608-687-3332.
September-October. Naperville, IL. Weekend Permaculture Design Course. Michelle Hickey, The Resiliency Institute. contact@theresiliencyinstitute.net.
October 18-24. Kingston, NM. Natural Building Colloquium. www.BlackRangeLodge.com.
October 25-November 7. Quail Springs, CA. Permaculture Design Course. info@quailsprings.org, 805-886-7239.
Fall 2015. Online. Orientation for Diploma and Degree Candidates. Gaia University. info@gaiauniversity.org. www.gaiauniversity.org.

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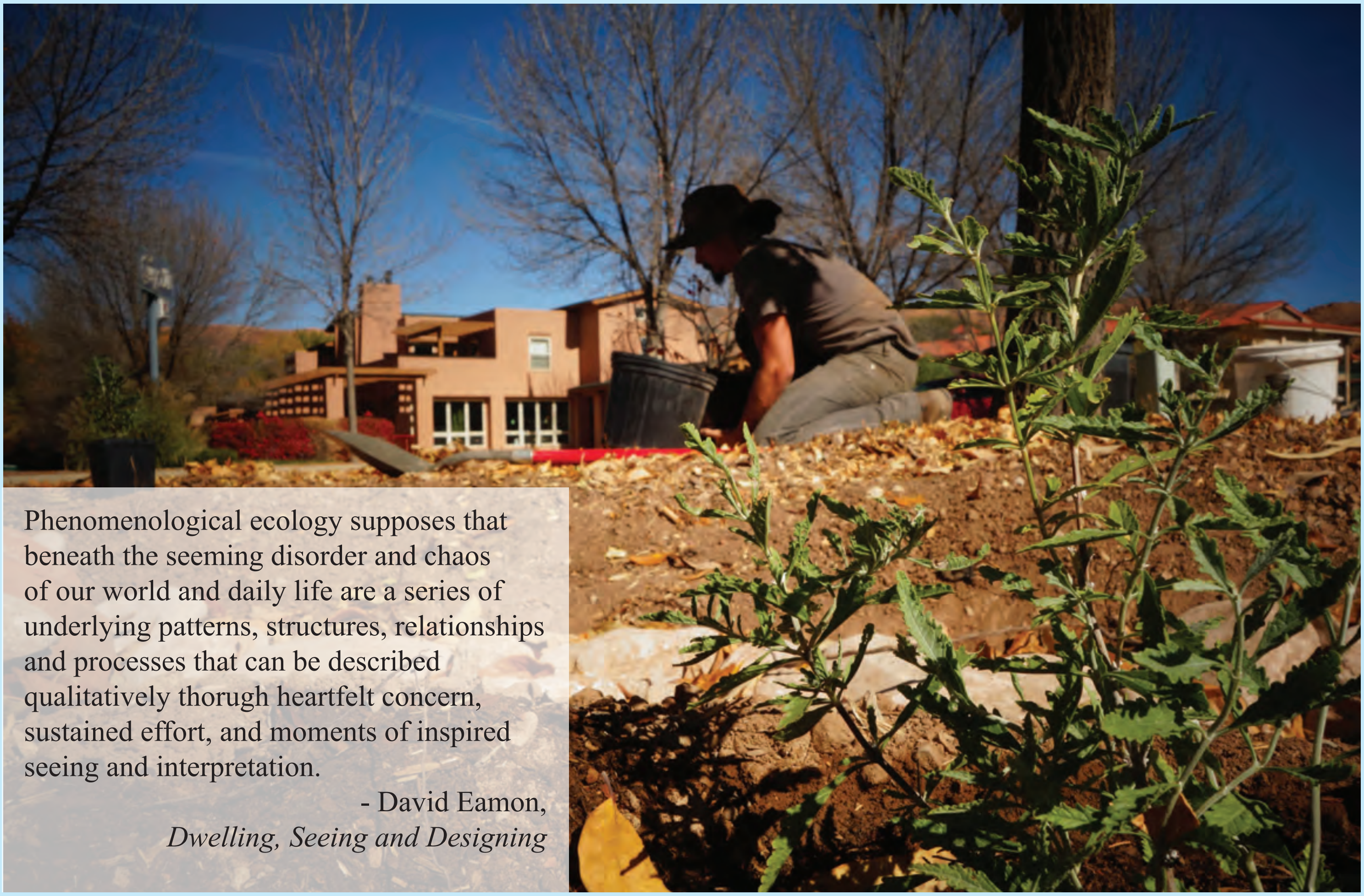

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