Chapter 8 - Ten Years with a Bucket of Shit: An Attempt to Live Consistent With My Values.

By Pete Schwartz

Sept. 2, 2017. Yesterday, I installed a water toilet, the kind that mixes purified water with feces and urine to be returned to a processing plant; ending my 10 years living with a dry bucket toilet that diverted urine directly to our plants with the rest of the grey water. My family's poop was composted in the back yard with dead vegetation and then spread on fruit trees. My friends and students asked me why I replaced my bucket toilet. Maybe it was because my super partner, my daughter who constructed it with me at age four, is now an embarrassed teenager who won't bring her friends home any more. Or because my extended family is disgusted at how we "live in our filth." Or simply that after about 250 hours of shoveling shit, maybe I can find something more creative to do with my time. But maybe I was motivated by one student's final exam essay describing their transformation through the appropriate technology class I teach at California Polytechnic State University (Cal Poly). He said that he never wanted to stop changing and growing. He recounted the class trip to my house where I indicated that I may have learned what I needed to learn from the bucket toilet, and it was time to move on. My willingness to change identified my commitment to innovate more than my bucket toilet did. Besides, ***I myself*** don't use the water toilet. I use the other bucket toilet in the shower.

Quick Facts:

Net Energy Emissions – 82 percent less than the typical American family
Home – 700 square feet in Coastal California, United States. Others live in a 440 sf annex
Technologies Employed – Passive solar, solar hot water, home gardening, bicycling, grey water
Annual Energy Costs - $775

But isn't the more pertinent question: what motivated me to shit in a bucket in my house in the first place? It wasn't actually my idea. That idea came from my daughter's mother. She was so excited about getting a bucket toilet that she researched and mailed away for one. I read The Humanure Handbook by Joseph C. Jenkins, and figured out how to make it work. And built one for inside the house… after we split up.

But *really*, how did this whole thing happen? Previously a lecturer at Cal Poly, I was hired as permanent faculty in 2003, so I bought my first house. I could never have guessed what an effect it would have on me… owning a house. I remember sitting in the luxury of the hot tub, with the uncomfortable feeling that if the police showed up, they wouldn't arrest me or chase me away because it was my hot tub I was in. I contemplated erecting a chain-link fence around the hot tub and cutting a small hole in the bottom for me to crawl through, so I could feel more at home. But I knew, of course, the hot tub was mine, and the annex: mine. The yard, the fence, the trees: I owned them. So, what does this mean? I'd spent most of my 40 years bitching about the way people irresponsibly use our land and resources. I was struck by the realization that I would hold myself accountable for the choices I would make as a home owner. So, I began making choices that felt consistent with my previous rants; choices that in the last decade changed many things in the house and in me.

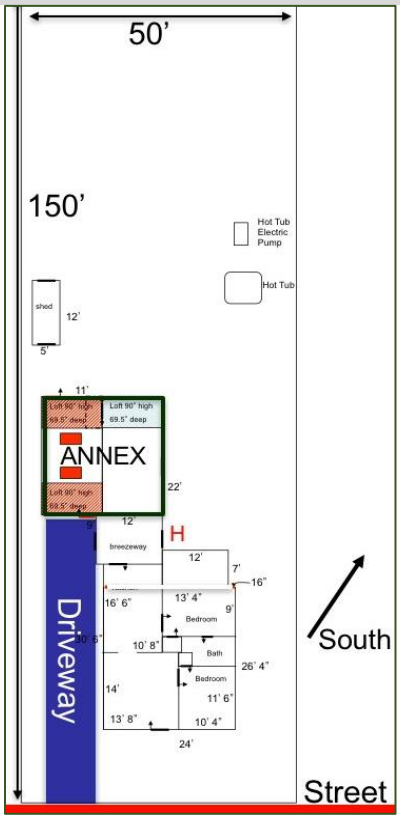

Figure 1- Lot & House Plot

Figure 2- Evolution of my home over the years, from kit house, to when we moved in to present.

My house, built in 1924, likely from a Sears Roebuck kit, is about 670 ft^2 with a 440 ft^2 annex (where another family lives) on a long, thin 7500 ft^2 lot.

Composting

The toilet is made from a 15-gallon bucket under a wooden platform. An air tight seal is made between the bucket and the platform as well as between the platform and the lid. For this reason, the lid rests directly on the platform rather than on the seat. I made a urine diverter from a funnel, allowing the urine to join the grey water and be deposited directly onto the plants. We quickly found that urine crystals would accumulate and block the urine diverter drain. Before and after urinating in the toilet, we then flushed the urine diverter with about 10 oz. of water via a flush tube connected to a plastic peanut butter jar emptying into the urine diverter. I made this realization at about the same time that waterless urinals were everywhere replaced with low flow urinals. After using the toilet, one would also cover their poop with leaves to reduce smell and moisture

Figure 3- Bucket Toilet System

Figure 4- Technical details of bucket toilet.

I learned to compost the poop in the back yard with layers of yard waste and compost from the kitchen. Every two weeks, I built a 4' high compost pile onto the previous pile, following a row that would repeat itself in about a year. With proper layering and ratio of poop to dry plant matter to water, the thermophilic bacteria would drive the temperature to 140° F for a few days resulting in considerable condensate and a reduction to half its original size. Rather than turning the pile over to make sure that all the poop was exposed to this temperature, I only put the poop near the middle of the pile. I could write a book about this topic alone, but I don't have to. Please do read the *Humanure Handbook*. Even if you don't want a bucket toilet, it's insightful and funny.

Figure 5- Composting yard, kitchen, and human wastes. Sheet (not necessary), but shows condensate.

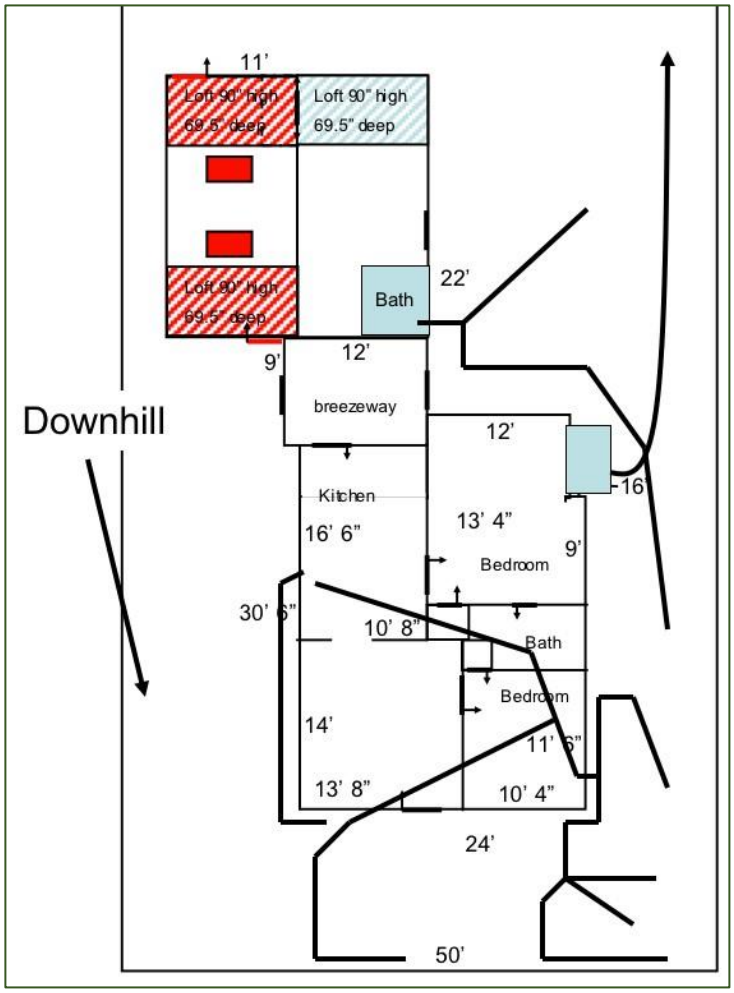

Figure 6- House plan with grey water system.

Grey Water System

In order to maximally use our water and water-born nutrients, I installed a branched grey water system. I was able to run 1 ½" ABS piping at a standard ¼" per foot minimum slope into a branching network, terminating in many buried plastic receptacles that I covered with pieces of brick for (relatively) easy removal and maintenance. The virtue of a branched grey water system is that there are no moving parts, filters, or process requirements. The down side is that you don't precisely control the water flow, and wet earth can seep into a receptacle, requiring it to be dug up and emptied.

Figure 7- Brick covering grey water receptacle.

Figure 8- Washer drain, brief uphill to grey water.

One sees one pipe heading uphill from the blue shaded laundry area in Figure 3. This is possible because the washing machine has a pump. It is not advisable to pump water uphill in a long pipe because the inertia of the water can provide excessive load on the pump. Instead, I have the washing machine pump the water upward into an open pipe, reducing the mass of water that the pump moves. The water then travels down the ABS pipe into the ground uphill: to the fruit trees in the back yard. Such a practice is prohibited in standard plumbing because debris will accumulate in the lowest part of the pipe and block. Consequently, I put a valve at this lowest point that I can open to the outside. And every few years, I dig up the clogged pipe at this point and drain the debris.

Passive Solar aspects

The plan of the house also indicates that the backyard faced mostly South. This is important in that south-facing windows (in the temperate North) let in the winter sun. However, the house had no windows facing south. I had large windows put in the south face of the annex, a sliding glass door put in the bedroom, and a light pipe put in the kitchen. We extended the peak of the roof southward, allowing a row of windows to be placed at the top and finished the attic into a loft for my daughter's room. This loft roof extension has significant overhang to shade the summer sun, while allowing penetration of the low angle winter sun. We also removed a good piece of attic flooring, allowing sunlight to come into the northern-most portion of the house. Potentially, the greatest difference was the way we used the master bedroom. It was initially cold, dark, and dead. The sliding glass door we installed made it a bright, warm passage to the back yard, transforming it to the center of our living space. We put two queen-sized mattresses on the floor under a trapeze, and it became the gym, library, and entertainment center. We added decidious trees to the south to shade and cool the house in

Figure 9- Adding considerable glass on south side for solar gain & light. In the summer (bottom), deciduous fruit trees shade the house.

the summer. The transformation inside the home was far larger than what can be seen on the outside. The loft and opened living area is shown below.

Figure 10- Loft area serves as daughter's room and allows southern light to penetrate.

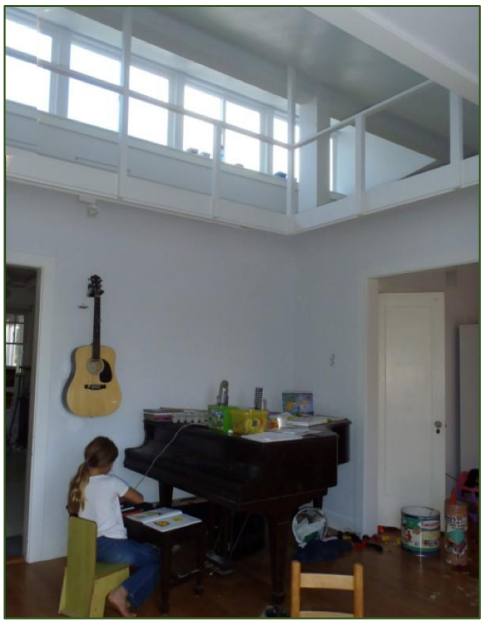

Figure 11- Living room brightly lit, naturally.

With the extra light and brightness in the master bedroom it was transformed to a favorite gathering place for my kids and their friends.

San Luis Obispo has a mild climate, with only a few frosts each year. So, it is possible to get by without a heater. There are additional passive solar strategies that make the home more comfortable. The corner facing South (labeled "H" for "hot" in figure 1) reaches 120° F even on cold winter days as the white walls and low-e glass function as a solar concentrator. Additionally, the south face of the annex was unpleasantly hot in the summer. I planted a fig tree south of the annex and a peach tree in the "H" corner, and grapes for the trellis. These trees provide shade (and fruit) in the summer, and strong sunlight in the winter, when the heat is appreciated.

Figure 10- Master bedroom bright and inviting with double glass doors.

I put a polycarbonate enclosure in the area that receives the most sun, and pump the warm air into the kitchen on cold sunny days.

I also improved the thermal qualities of the house by more traditional means. I had insulation blown into the void between the external skin and the interior plaster and I had an energy audit. We sealed the lights, electrical outlets, and insulated the ceiling. When it came time to reroof the house, I chose white shingles to reduce heat loss in the winter, and solar gain in the summer. I also had polycarbonate storm windows installed on the inside of my windows.

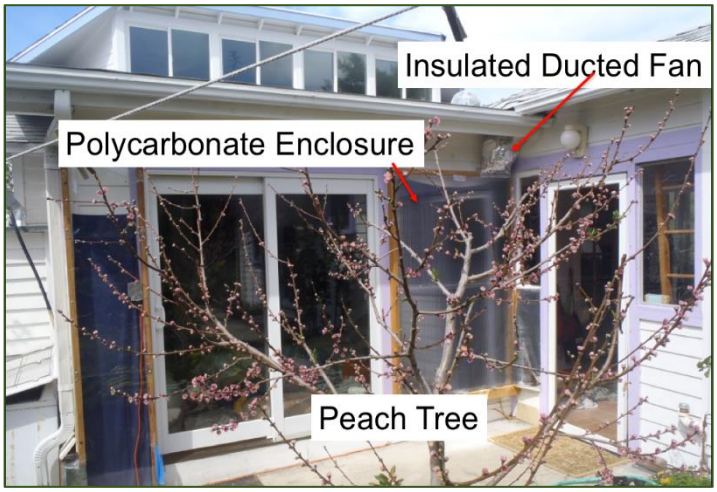

Figure 11- Passive solar features added to house.


Figure 12- Pear tree shortly after planting.

The southwest side of the house gets beaten on by the evening sun in the summer. I planted pear trees at the base of the house to climb this wall. They reached the roof in three to four years, shading this wall significantly. Now, both the fig and the pear trees are fixed to the roof eves with large eye-bolts, and will continue to grow onto the roof, providing a green roof with the roots in the ground.

The professional advice one receives often reinforces the status quo, so you're more likely to find out something new by disregarding what professionals tell you. But things are also more likely to go wrong. For instance, "plant these trees at least *some distance* from your house." I forget some *distance*, because I dismissed the advice. So, then what should I do about the cracks in my foundation a few years later? I dug down beneath the bottom of the foundation, cutting the roots that went under the house. Then I laid another layer of concrete with rebar. Finally, I planted another row of fruit trees considerably further from the house. When the new trees grow big enough, I may remove the older trees closer to the house.


Figure 13- After several years the pear tree has grown.

Initially, the property had mostly ornamental plants. About 7 years ago I decided that if I support plants, they should support us as well. I replaced almost all of the ornamentals with food-bearing plants. We don't grow too many vegetables because we have a wonderful weekly farmer's market in town. But I planted fruit trees, and grafted onto some of the existing trees. For instance, our ornamental plum, now produces plums and pluots.

Figure 14- Grafted plums and pluots for eating.

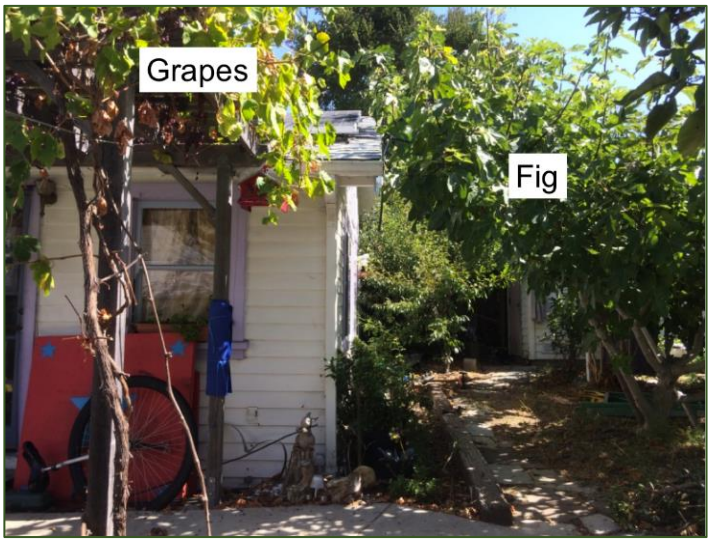

Figure 15- Grapes & Figs provide shade and food.

We grow lots of passion fruit, guavas, figs, grapes, pears, and all kinds of stone fruit. We make several gallons of jam a year – mostly from fruit that was already partially eaten by animals – opossums, raccoons, rats and birds. All these animals were already there before I started growing fruit. Likely, they live better now.

Figure 16- Some of the passion fruit we grew and then turned into jam.

Solar Shower

The guys working on the house and I designed and built a solar-heated outdoor shower. The picture below was taken before I replaced the trumpet vine with guavas, strawberry guavas, pomegranate, and thornless blackberries (watered with shower runoff) that one sees in previous pictures of the back yard. Two solar thermal panels are made from copper tubing soldered to a thin copper sheet, painted black and sealed under glass. A small photovoltaic panel powers an electric pump that circulates the water through a discarded water heater when the sun is up. The water is still hot in the morning. A discarded concrete wash basin served as a tub for my daughter who preferred bathing over showering.

Figure 17- Our solar shower with water heated via solar thermal panels and my daughter's tub we removed from the house.

Showering is so much better outside: under the stars, there's two shower heads and enough room for the whole family, although it's usually just my partner and I. After the water's off, we're immediately dry because there's no cloud of water vapor hanging over us. Even in January it's amazing to run out into 35 °F to get blasted with scalding water. The colder the air, the hotter the water one can bear; so, it's like being steam cleaned. On cloudy winter days, the showering is cold and fast… and lonely.

In designing the solar shower (the thermal and mechanical calculations) my daughter's mother noted that I was more excited about the research in the back yard than about my nanotechnology research in the laboratory. She suggested I think about that. It was 2005, and I was planning my coming sabbatical year with a nanotechnology group at New York University. I considered her suggestion for about 20 minutes and instead spent the next year at UC Berkeley with the Energy and Resources Group studying strategies for global sustainability.

I struggled with my feeling of hypocrisy in owning a hot tub and sought ways to heat it without burning natural gas. I bought a transparent pool cover for it, like heavy-duty bubble wrap. This brought the water temperature to close to 100 °F. However, I had started using ozone instead of chlorine to purify the water, and in a week enough algae grew to turn the tub, cover, and water black. After a few more failed efforts, I threw a pale full of tadpoles in the water, solving my personal conflict about owning the tub. Then there were mosquitoes. I got guppies. They died when the water got cold. I facilitate Cal Poly's Student Experimental Farm, where the most vibrant project is PolyPonics, the Aquaponics Club. I took some minnows from them, which multiplied to be an estimated population of 1000 in about a year. Then I brought home some tilapia and catfish from campus. Then I got three bass. I couldn't get the bass to eat fish food for more than a month, until all the minnows were gone.

Aquaponics and the Lawn

I find aquaponics to be a great idea. However, it typically requires pumps, pipes, tanks, and power sources that make it inappropriate for the world's poor. Thus, we experiment at home with growing plants in the stagnant (but aeriated) water. We've managed to grow a forest of water lettuce, but you can't really eat it. I tried. We've been unsuccessful with peppers, tomatoes, and passion fruit. However, we're still learning.

Figure 18- Our first attempts at aquaponics, fun and we are learning, but yet to provide food.

Grass is likely the largest irrigated crop in the US. Manicured lawns consume water, petrochemical fertilizers, and lots of effort. Additionally, many people put their grass clippings in landfill to produce methane, a potent greenhouse gas. The lawn was the first thing that had to go, but what are the options? The first option we tried was to do nothing, letting Nature do it by herself. This worked out great, but resulted in tall grass that dried to be a fire hazard, lovely wild plants that spread seeds angering our neighbor, and nasty foxtails and bur clover. I introduced and neglected several ground covers to see which variety prevailed. Diamondia was one that proved to be very hardy. However, in a bad drought it dies back. The overall winner was a chunk of Cape Weed (Arctotheca Calendula) that I took growing from a neighbor's into the road. It dies back a little during the summer, but comes back when it rains. It's now covering most of my yard. In researching the plant for this chapter, I discovered that Cape Weed is California invasive!... bummer. However, I'm quite sure that the variety I have does not go to seed, so it's invasive speed is likely only about one meter per year rather than hundreds of miles per year if it were to have fertile seeds. Shown below from left to right is what naturally grew up, dymondia, drought cape weed, and lush cape weed.

Figure 19- Natural ground cover, dymondia (at our wedding), dry cape weed, and lush cape weed.

Retained Heat Cooking

Another important professional/personal crossover is our retained heat cooker (RHC, or "hot box", or "Magic Basket") that I first saw at our friends at Tryon Community Farm, an intentional community in Portland. If you need to stew something like beans, you can bring them to a boil and then put them in an insulated chamber to continue cooking without added heat. We have successfully done this both inside the oven, and inside a cooler. We routinely cook beans this way in large amounts to freeze for a few weeks at a time. It was not much of a stretch to put an electric heater in the pot directly connected to a 100 W photovoltaic solar panel to develop (what I think) is an improved solar cooker for the global poor. My students and I recently published this work in Development Engineering: http://www.sciencedirect.com/science/article/pii/S2352728516300653

Figure 20- Retained heat cooking in an oven and cooler; with added PV, a possible cooking solution for the global poor.

I don't pretend to think that my practices at home are the answer to society's problems. However, I think that the answer to our challenges lie in the collective discussion that takes place when humanity innovates. When I bring students to my home, I don't suggest they should compost their family's feces in the back yard or take on any of my individual practices. My message is only that when you see how everyone else does something, you might consider, "what if I did it differently?" and walked down that path as far as you consider beneficial. For instance, when a friend asked if she could live in the back yard in a teepee, I might have been inclined to ask "why?" However, my response was "why not?" I think that this practice of versatility itself may be the most beneficial.

Figure 21- Friend in a teepee

Some Numbers

My students and I calculate our carbon footprints for the energy and appropriate technology classes. One can use any number of websites (such as this one at UC Berkeley: http://coolclimate.berkeley.edu/carboncalculator). The four of us together emit about 16 tons of CO_2 per year, making us about the same as the average world dweller, or ¼ that of the average US citizen of about 16 tons of CO_2 per person per year.

Automobiles: We bicycle exclusively around town providing transportation, exercise, and probably more adventure than we would like. We drive our 1996 Subaru Outback to the beach and other out of town trips logging about 4000 miles per year, corresponding to 140 Gallons of gas, or about 1.4 tons of emitted CO_2. We fly to Phoenix every year to visit family over winter break.

Electricity: We use very little electricity, about $14/month, corresponding to about 100 kWh per month. As the marginal electricity in California is generated with natural gas combined cycle, it may be reasonable to assign about 1/3 kg of CO_2 per kWh, for about 400 kg of CO_2 per year from electricity. My students and I installed about 1600 W of solar panels last year. It's not grid connected, but rather for experimenting. They heat the hot tub in the winter so the tilapia don't die, and we also have an electric immersion heater in our natural gas water tank, a design that we patented. We are looking for an interested entrepreneur to market this add on water heater as part of the independent system operators effort to shift electrical load to meet demand: http://appropriatetechnology.wikispaces.com/file/view/WaterHeaterPatent.pdf

Natural gas: my family uses about $10 worth of natural gas per month, or about 30 therms. Per year, this is about 360 therms or about 36,000 MJ. About 25 grams of CO_2 per MJ equates to 900 kg of CO_2 per year for cooking and heating water. Additionally, we have a small hydronic heater that we use from time to time when it's very cold…well, "California cold" that is (I grew up in Buffalo NY). A pump circulates water from the hot water tank through a hydronic baseboard radiator.

Embodied energy/carbon: The embodied energy and emissions in putting up a building is equivalent to about 15 years of operational emissions for a regular building and more for an energy efficient building. The embodied energy for an internal combustion automobile is about equal to that of 15,000 miles of driving. Electric cars require more because of the batteries. And the recent surge in lithium mining has dramatically increased the cost of lithium, and likely also the environmental cost because the remaining lithium is more difficult to mine. How will we account for all this? It's complicated. However, it is simple to understand that everything we use, buy, dispose of has an environmental cost. One of the nice things about my house is that it was already here. It's been 15 years, and I'll likely get another 30 years of use out of it before I'm … "done". What will happen then? It's nice to think that I have transformed the house into something that people will value into the next century. However, this may be wistful thinking. In a place where property goes for about $100 per square foot or, over $4 million/acre, the overwhelming majority of the value of my home is in the plot and location. It is very likely that future buyers would optimize their investment by building a much larger house. Thus, what I have here may simply be a reasonable experiment. However, that is still something – to provide talking points, to stimulate the conversation to innovate society.

Conflict: There's very little written about military-related emissions, and I support these emissions by paying taxes and educating engineers. If we are to build a sustainable future, we have to consider what the global costs are of maintaining the US industrial military complex. The budget of the defense department is presently only 5% of the GDP, but has been much higher at other times, and the military must use a greater portion of its budget for petroleum than the rest of the GDP. Additionally, much of the rationale for enlarging our economy and the related emissions is to maintain global dominance. Certainly, there is a significant global environmental cost to not getting along. This extends to all levels of society from world wars to my daughter's complicated transportation schedule because I wasn't able to make things work with her mother. I'm embarrassed to admit that I tried to prevent my neighbors from putting in an apartment complex in 2008 and only succeeded in making enemies for life, never mind that infill is a legitimate sustainability strategy. Conflicts cost us dearly: financially, environmentally, and emotionally. So, what do we do? We remember to listen and empathize. We make empathy and collaboration part of the discussion – for me, part of the classes I teach. I think I'm getting better, but change is hard.

Food, we eat as much as the average person, so this is the largest part of our energy/carbon footprint. We grow about half of our fruit. We also have a "vegan leaning" diet. We try to eat for a healthy body and healthy planet. We don't make rules, but rather recognize cost – just as someone might enjoy a very expensive meal once in a great while, we might sparingly enjoy a meal with environmental impact. I liken it to driving a car. It's not whether you own one or not, but how much you emit. Cars only emit when you drive them, just as the environmental impact of eating beef scales with the amount of beef you eat. I was a vegetarian for more than 30 years. When I started teaching and studying sustainability, I was disappointed to learn that milk products have as high an environmental footprint as beef, where the environmental footprint of poultry is much lower. Consequently, we eat a little poultry and milk products, but not so much.

Figure 22- The sofa trip from curb to my daughter's loft.

Buying stuff (we don't need): Much of our consumer society is dedicated to digging things up to be buried shortly thereafter in landfills. I don't pretend to not be a consumer, but we make this awareness part of our family discussion. Part of the holiday tradition used to be watching videos of Black Friday fist fights at Walmart and talking about what was behind the commercials that constantly assault us and our children. In trying to strike a balance between giving in and tyrannically imposing my values on my children (which probably wouldn't work anyway), we discuss about where things come from and where they go. We keep our things until we can use them again, give them to someone who needs them, or drop them at the free box in town. While walking my daughter to her mother's house, she expressed an interest in a sofa on the sidewalk saying, "I know you don't like to be a consumer, but I'd like that in my loft." I returned home, and my partner and I gave the sofa a trip across town.

Discussion with the kids used to be easier. However, my son is forever enamored with the latest robotic gadgetry, and my daughter insists that I should drive her wherever she wants like all the other kids' parents do, because bicycling is so embarrassing… "homeless people bicycle". At present, I've made a deal with her that I'll buy a used Nissan Leaf and charge it with the panels on our house if she'll ride her bicycle when it is reasonable. We differ on the meaning of the word "reasonable".

Conclusions:

My Daughter told me I need a conclusion… like, “you probably think this all sounds weird...” so I should explain something.

There’s a lot of things we can do. Some of it is technical, but to me a lot of it boils down to the life choices we make. The largest challenges related to our/my practices and interventions is in fielding others’ responses. However, this may be where we find the greatest potential for positive impact. We do not know what lies ahead of us, technologically, socially, politically, environmentally. Which way will we go? This steering lies in our discussions. What do we think? How do we feel? What do we prioritize?

You’ll soon be at a party: They’re talking about the Lakers. You might just listen, but you could suggest it’s a shame that all this good food and drink will become bodily waste to be mixed with purified drinking water and transported away. And you’re curious if instead you might deposit the resources you’re processing outside somewhere as to be of value to the family’s ecosystem. Or maybe you’ll bust out a 10 pack of LED lightbulbs and replace the incandescent ones while explaining the difference. Or maybe you’ll find some other way to upcycle the conversation… Or you’ll talk about the Lakers.

Let me know how it goes.