Off-Grid in Chicago

John Berton

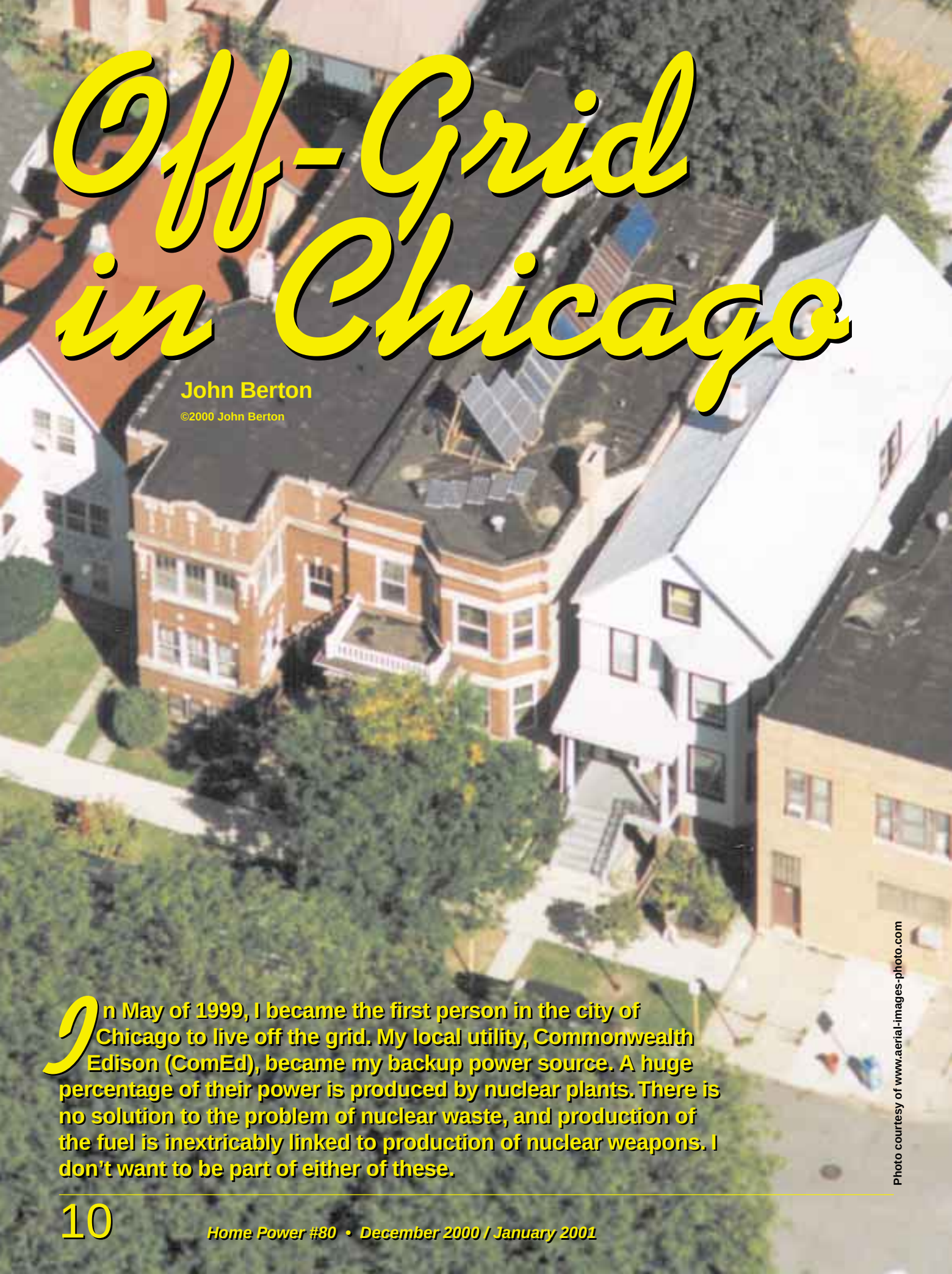


Photo courtesy of www.aerial-images-photo.com

In May of 1999, I became the first person in the city of Chicago to live off the grid. My local utility, Commonwealth Edison (ComEd), became my backup power source. A huge percentage of their power is produced by nuclear plants. There is no solution to the problem of nuclear waste, and production of the fuel is inextricably linked to production of nuclear weapons. I don't want to be part of either of these.

My dream started somewhere back in the late 1980s when I became aware of the possibility of generating enough electricity from photovoltaic panels to actually do something. Until then I had the assumption that you needed massive equipment to produce useful amounts of energy.

Renewable Inspiration

The very first seeds of my interest in power generation were sown in the late '70s, just after college. A college friend was involved in restoring a microhydro plant in southwestern Michigan. My roommate and I were invited to visit for a weekend. For me it was love at first sight. I was fascinated with the task at hand, the building, the people involved, and the setting.

Nothing else came of my interest in that microhydro project, but over the next decade I remained aware of power issues. My roommate became involved with the American Friends Service Committee. He spoke publicly about the problems of nuclear power in general and ComEd in particular. I listened intently, and slowly became aware of other possibilities for power generation.

At some point, someone mentioned *Home Power* magazine. There I learned that some people were producing enough power to perform useful tasks in a home environment. I was hooked. My first contacts in the renewable energy world were *Home Power* advertisers who had 800 numbers. I spent a year picking their minds and learning about equipment.

At the same time, I was trying to save money, and determining what changes I would have to make in my apartment to use home-produced electricity. I realized that I would not be able to power the entire apartment immediately, and decided to convert just the study and the refrigerator. In early 1991, I had enough money to begin collecting equipment.

Not much visible from the street.

Almost all of the motley array of modules John collected over the years.

Code Dilemma

When I began thinking of building a renewable energy system in Chicago, I wondered about city codes, inspections, etc. Since Mrs. O'Leary's (legendary) cow kicked over the lantern in her barn back in 1871, we have had a history of zealous inspectors and rigidly—if unevenly—applied codes. I called the city department of buildings.

When I began to explain what I was doing, I was transferred. Each person and department transferred me to someone else. Finally

Left: DC distribution. Right: PV disconnect.

someone confessed, “We don’t know what that is, and we don’t have any codes on that.” I thanked him and hung up. Except for the *National Electrical Code,* I was on my own. As long as I didn’t burn the place down or electrocute anyone, I was free to do as I wished.

First Gear

I started with twelve Tri-Lams from the Carrizo Plains project in southern California, a Trace 2012 inverter, a set of old Edison nickel-iron batteries, and a Sun Frost refrigerator. I replaced the lights in my study with compact fluorescents.

All this equipment was delivered to my workplace—a traditional 9 to 5 real estate company in the Chicago suburbs. My co-workers thought I was nuts. I purchased #3/0 (85 mm^2) cable, #8 (8 mm^2) cable, conduit, a number of boxes, fuses, disconnects, and lumber for the panel mounts. Then I started the project.

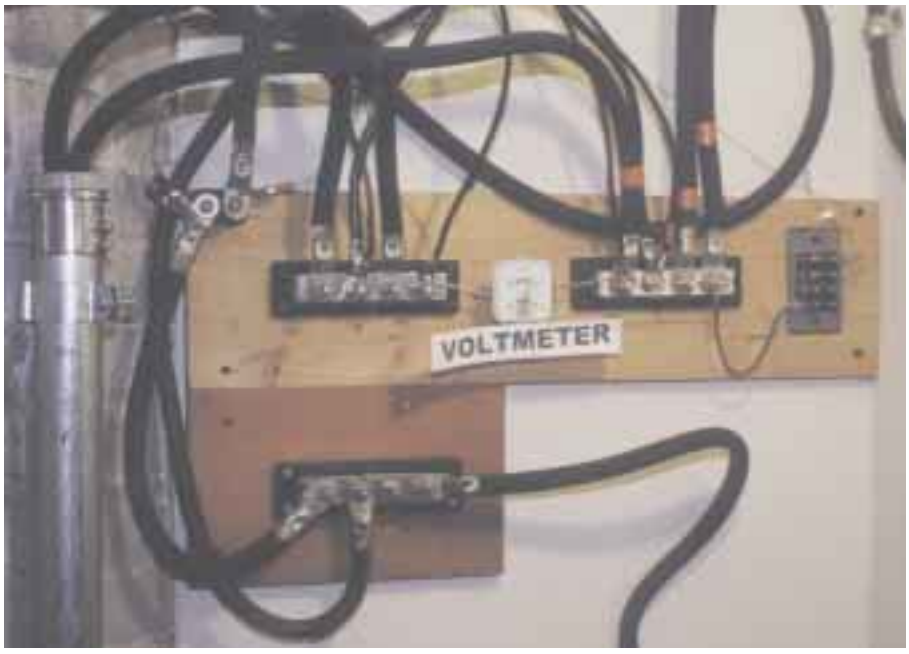
It was a task that took far longer than I expected. Had I known or stopped to consider how long and involved it would be, I might never have started. But I just plunged in with no definite plan other than an idea of how things were theoretically supposed to be hooked up. I started by building the racks. Everything had to be hauled up a 24 foot (7 m) ladder and through an 18 by 24 inch (46 x 61 cm) trap door to get to the roof.

The building directly south of me had a peaked roof that cast a shadow on my roof. I calculated the angle of the sun on December 21st, and figured as well as I could where that shadow would be then. I also needed to arrange the racks so that I could walk behind them to do seasonal adjusting. The space needed would put the panels in a shadow as the days in December grew shorter, so I made the racks 15 inches (38 cm) higher to keep them in the sun.

Panels were wired together on the roof after being installed in the frames. Perhaps the most difficult part of the job was getting two #3/0 (85 mm^2) non-welding cables through 60 feet (18 m) and four 90 degree bends of 2-1/4 inch (5.7 cm) conduit by myself. The 2-1/4 inch conduit runs from the junction box on the roof, over the parapet, and down the wall to the basement, where it goes through a boarded-up window into the battery room.

I ordered the first set of batteries from Utility Free in Colorado (no longer in business). They arrived well battered and leaking electrolyte. There was no problem returning them to the shipper. A second shipment arrived in excellent condition. I unloaded them from the truck and lugged them into the basement. A battery rack was the next order of business. I used 2 by 8 lumber and metal shelf supports (L-brackets). Then I installed a fused disconnect for the array and a breaker for the inverter.

Main DC bus bars.

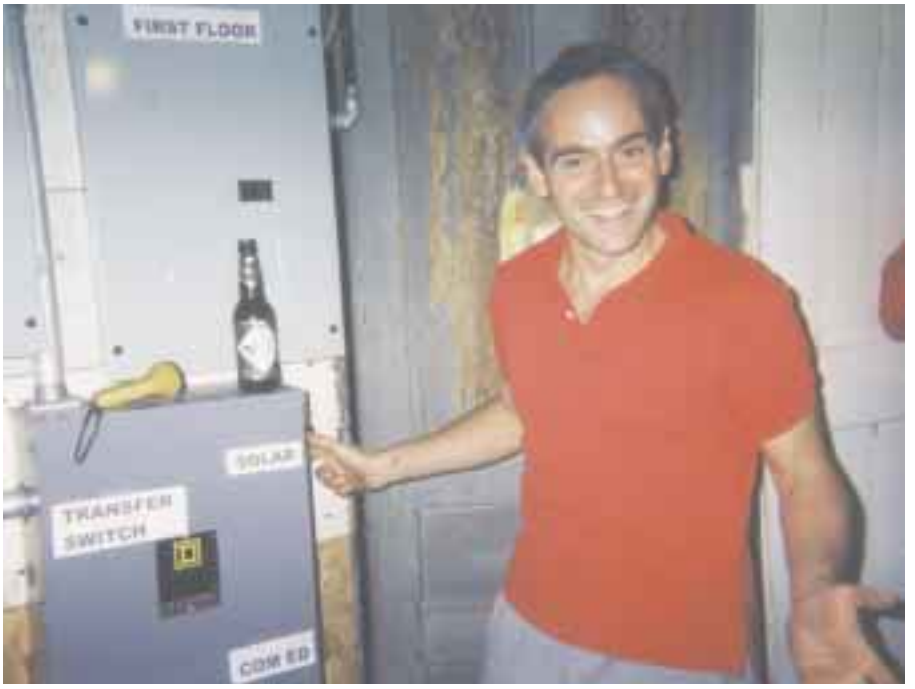


It Actually Works!

The Sun Frost had arrived earlier, so I had two refrigerators in the kitchen. Once the panels were connected to the batteries for a few days, the voltage remained well over the 12 volts necessary. The Cruising amp-hour meter showed that the batteries were full and overcharging.

I connected the wires from the Sun Frost to a fused switch on the system in the basement, ran upstairs, and listened. The compressors kicked on. I was amazed. It really worked!

Sometime during the next week, the Trace arrived. I installed it on the rack right next to the batteries in the basement. I separated them with a piece of wood to protect the inverter from corrosive fumes.



Author John Berton switches to solar power.

The giant print on the terminals and the even larger plus and minus signs, the cost of the inverter, and the warnings in the manual made me check and recheck my wiring. Convinced that I had installed things correctly, I gingerly attached the #3/0 (85 mm^2) cables to the inverter. Nothing happened. I plugged my drill into the Trace. I was ecstatic—I couldn't believe that it actually worked! This was real 120 V power. This was what I needed to run the whole apartment. The system functioned perfectly—it ran two lights in my office, computer, printer, boom box with CD player, dual tape deck, and an AM/FM radio.

From time to time over the next nine years, the batteries got low and the Trace would charge them from the grid. The batteries functioned flawlessly. I watered them every three to four weeks. The only problem was that I didn't have a charge controller. The nickel-iron batteries didn't care about being overcharged. It didn't hurt them. I just had to add water more frequently. Adding a charge controller would just increase costs, and I was running out of money.

On sunny days, the batteries would go over voltage at about 11 am and the Trace would shut off. This was annoying if I happened to be home during the day and working in the study. So I planned to add a charge controller.

Nickel-Iron Batteries

When I go to energy fairs and talk to people about batteries, they worry about overcharging, equalizing charges, sulfation, and reduction of battery life by taking too much power out of the pack. They also need to be concerned about the age and size of batteries if they want to add to their lead-acid battery pack. When I first started planning a renewable energy (RE) system, the

Nickel-iron cells: Twenty Russo-Hungarian (top) and thirty Edison (20 shown).

Close-up of a 30 year old Edison NiFe cell.

idea of taking care of lead-acid batteries was daunting. None of these things are a concern with nickel-iron batteries.

Nickel-iron batteries are not harmed by being overcharged. They don't need equalizing. You can add to the nickel-iron pack with any size battery of any age at any time. And, according to the supplier, they last forever.

The drawback was that they cost about three times as much as lead-acid batteries. Their energy density (power per pound) is half that of lead-acid batteries. Their internal resistance is greater, making it harder for them to give up large amounts of energy as fast as lead-acid batteries. And they tend to self discharge faster than lead-acid batteries.

Last but not least, they were not being produced anymore. The only ones available were at least twenty years old. But I was assured that they had many years of life left. The advantages seemed to outweigh the disadvantages.

In the time I have had my original battery pack, my friend and electrical consultant, Vladimir Nekola (see the cover story of *HP46),* who also installed a system at about the same time as mine, has replaced his lead-acid batteries three times. My batteries have performed better than I could have imagined.

The recommended way to store nickel-iron batteries is to discharge them completely and put them away. You can come back years later and charge them up. They never need equalizing. I have never experienced any problem with overcharging.

Watering them happens much more frequently than with lead-acid batteries, but this is not much of a drawback. There are precipitous voltage drops under heavy loads, but this has not yet been a problem. Carbonation of the plates or electrodes is supposed to be a problem, but has not happened yet.

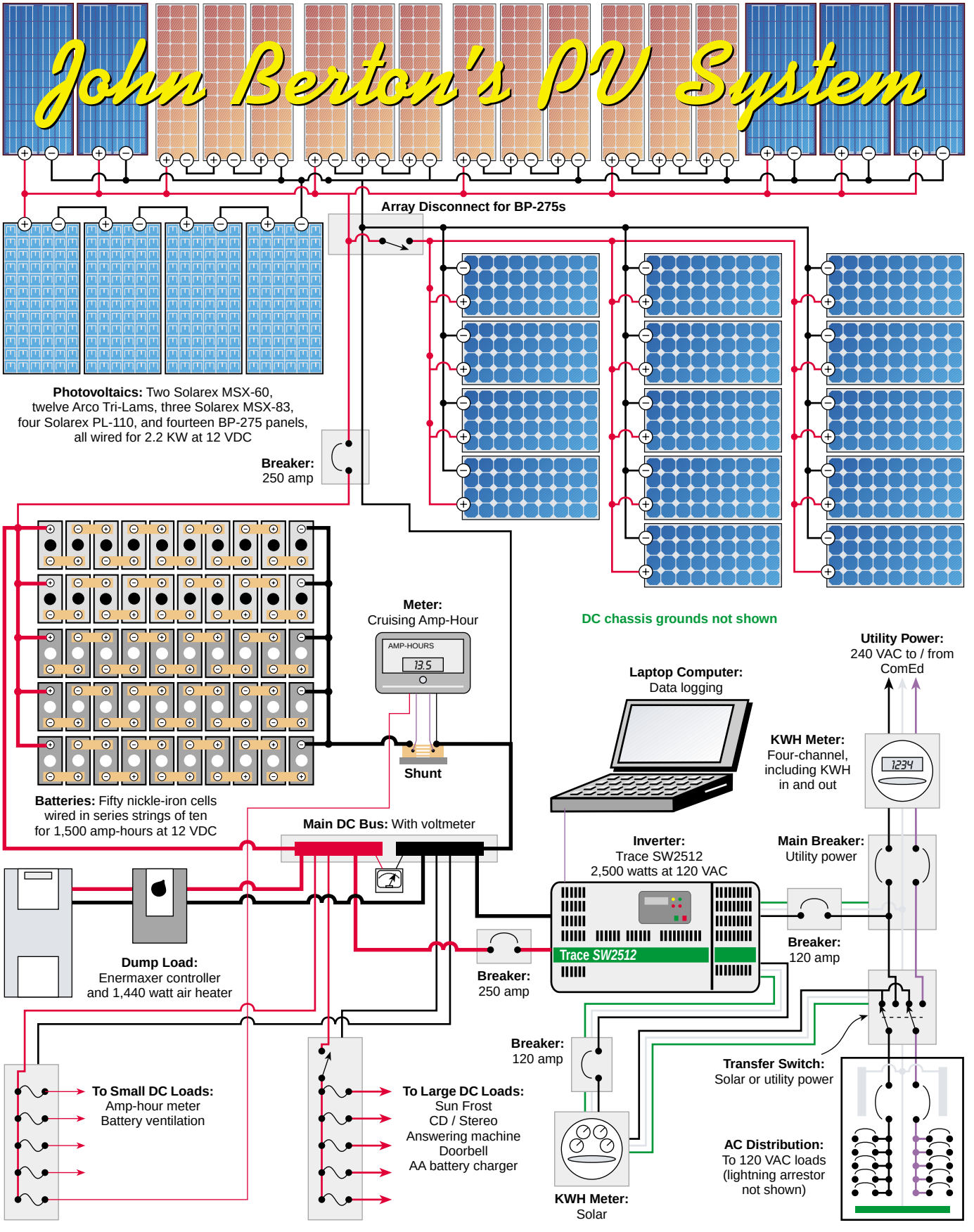
KWH meter shows solar energy produced (left); Trace 2512 inverter.

Not only would I use nickel-iron batteries again, but I would probably not want to set up a new system without them. The idea of using lead-acid batteries after the ease of nickel-irons is horrifying.

The problem is that the only new NiFe batteries available are produced in Shanghai, China or St. Petersburg, Russia. Shipping is prohibitively expensive. Power Technology Systems is rumored to be trying to produce a North American nickel-iron battery, but nothing has happened yet. Nobody in the U.S. that I am aware of has any of the new batteries in stock. And I'm unaware of any used ones currently available.

Off to the Midwest RE Fair

When I was first getting my system set up, all contact I had with the


John Berton's PV System
Array Disconnect for BP-275s
Photovoltaics: Two Solarex MSX-60, twelve Arco Tri-Lams, three Solarex MSX-83, four Solarex PL-110, and fourteen BP-275 panels, all wired for 2.2 KW at 12 VDC
Breaker: 250 amp
Meter: Cruising Amp-Hour
AMP-HOURS
13.5
Shunt
DC chassis grounds not shown
Utility Power: 240 VAC to / from ComEd
Laptop Computer: Data logging
KWH Meter: Four-channel, including KWH in and out
1234
Batteries: Fifty nickle-iron cells wired in series strings of ten for 1,500 amp-hours at 12 VDC
Main DC Bus: With voltmeter
Inverter: Trace SW2512 2,500 watts at 120 VAC
Trace SW2512
Main Breaker: Utility power
Breaker: 120 amp
Dump Load: Enermaxer controller and 1,440 watt air heater
Breaker: 250 amp
Breaker: 120 amp
Transfer Switch: Solar or utility power
To Small DC Loads: Amp-hour meter Battery ventilation
To Large DC Loads: Sun Frost CD / Stereo Answering machine Doorbell AA battery charger
KWH Meter: Solar
AC Distribution: To 120 VAC loads (lightning arrestor not shown)

Renewable energy or the grid—notice the position.

renewable energy crowd was via 800 phone numbers. In the spring of 1992, after living with my system for almost a year, I attended my first energy fair in Amherst, Wisconsin (MREF), put on by the Midwest Renewable Energy Association. The range of equipment available, the people and their experiences, and the workshops and lectures, were fantastic.

Over the next eight years, I went to the fair every year. As money became available, I purchased more equipment. Two MSX-60 panels one year. Three MSX-83 panels the next. Four ancient Solarex panels, a Trace 2512 inverter and control panel, an Air 303, fourteen BP-75 panels, an Enermaxer, two more strings of 30+ year old Edison batteries (300 AH each). Twenty brand new Russian-made nickel-iron batteries (300 AH each). Two 3 by 8 foot (0.9 x 2.4 m) panels to heat water, and two to heat air. Another Sun Frost.

Some people spend US$40,000 on a new SUV, and nobody questions them. I chose to spend close to that on my solar-electric installation, and was seen as eccentric.

Time & Money Merge

Much of this equipment spent literally years on my living room floor waiting for its companion equipment to be purchased. Then it spent more time waiting for me to find time to begin installation. A standard joke developed among suppliers at MREF. When they met me intent on making another purchase, they would ask if I had managed to install the stuff from three years ago. In the spring of 1999, time and money finally came together. I also swore to get the system installed before the 1999 fair.

First I changed all the bulbs in my apartment to compact fluorescents. I eliminated any phantom loads I found by using power strips and rechargeable AA batteries.

I was unable to install the new Trace alone, but I determined I could go off the grid with the old 2012 if I could just get the new batteries and panels installed. It was a lengthy procedure and went off largely as planned except for a scary battery explosion. As I was lifting the old Edisons onto a platform, something inside one of them shorted and with a loud noise sent a corrosive plume into the air. I happened not to be leaning over that battery at the time.

It was a good thing, since I was not using protective eye gear. My mind instantly recalled Richard Perez' story about exploding batteries. To this day, any time I look into my batteries, I have my goggles on. My vinegar is also close at hand (my batteries are alkaline, so baking soda is not the neutralizer).

When finally assembled, the battery pack seemed not to hold a charge well. I conditioned them by charging them twice with my Trace 2012 as much as I could, and then discharging them. They then held a charge and functioned as expected.

The Trace was still feeding only one circuit in my apartment, but I was now technically off the grid. Grid power was still available at every wall outlet and in overhead lights, but I didn't use it. I had long orange extension cords snaking their way throughout my apartment from the one circuit that was powered by the Trace. Clamp lights and power strips were everywhere. All my power came from my Trace. At the energy fair, I could honestly say I was off-grid.

Wind Power

I spent a long time at the fair talking to the people from Southwest Windpower about mounting an Air 303 without actually attaching it to the building. I had concerns about noise and vibration.

As an experiment, I designed a mount that would be anchored by sandbags. The base measured 22 by 22 feet and was 13 feet tall (6.7 x 6.7 x 3.9 m). In some places, on top of a two story building, this might be adequate. Not so in my neighborhood of Chicago. I had a two story building just north of me and a two story building with a peaked roof south of me. The peak of that roof was 10 feet (3 m) above my building, giving me only 3 feet (0.9 m) of clearance.

Adding to my problems was a giant cottonwood tree well over 80 feet (24 m) tall across an alley just east of my building, and a row of three story apartments across the street. These proved to be enough to make my Air 303 almost useless unless there was a constant northwest wind. The solution would be to raise the turbine another 10 to 30 feet (3–9 m).

So far, the noise was negligible compared to the roar and shaking of city buses, ambulances, trucks, and general street traffic just two houses away on Lawrence Avenue, a major four-lane east-west artery. I was told, however, that once the Air 303 started to self regulate in strong winds, the vibration and noise would become intolerable.

I am unsure about whether the sandbags would have supported an additional 30 feet (9 m) of tower, or how to attach more cables. I concluded that the time and expense would be better spent on additional photovoltaic panels, so I decided to take the Air 303 down. A taller tower was the solution. But the effort to do this, the maintenance necessary, the possible conflicts with city ordinances, and potential problems with neighbors if the thing fell during a storm influenced my final decision.

The Air 303 just didn't have the exposure it needed.

All solar energy is counted with a KWH meter.

Pull the Plug Party

One day during the summer of 1999, I returned to my apartment to see a group of my neighbors gathered in the alley behind my garage, chatting with each other. I pushed the button to open the garage door. They were quite surprised. There was a power outage in my neighborhood, the first of many in Chicago that summer. None of them had power, nor would they for hours.

They were already aware of my efforts to produce power and that I had "some equipment" on the roof. But suddenly they realized what it really meant that I was producing my own power. I ran an extension cord to my building partner's refrigerator (she also has a Sun Frost RF-16 but hers is 120 V). She disconnected the extension cord when power came back on.

By late summer, I still had not finished the installation. I decided to have a "Pull the Plug" party to celebrate

being off the grid. I wanted to have the system really finished so people would not be tripping over extension cords. The date of the party forced me to get the system finished.

Vladimir Nekola came over and had me change a number of things that I had wired. He also helped me install the Trace SW2512, Enermaxer, resistor dump, meters, and disconnects.

The final task was to wire the whole system into the breakers for my apartment through a disconnect that would, in emergencies, send grid power back into my apartment and disconnect the solar power. We finished one day before the party—just enough time to stock the Sun Frost with beer and pop. The highlight of the party was to be "the only solar-cooled beer in Chicago."

Dealing with the Surplus

I have recently started selling back to ComEd. ComEd has instituted a program to buy back power from people like me. There is a special meter that they have installed, and an external locked switch they can throw if they need to work on lines in the area.

It's not ideal for me, however. I want the inverter to sell back to ComEd only when the batteries are full. So I want the charge controller, instead of shunting the power to a resistive load, to send it to the utility. When the batteries get low, I want the inverter to stop selling solar power and redirect it back to the batteries.

I want the house to be powered from the batteries *all the time,* unless the batteries are low *and* there is no sun. At that time and only at that time do I want the inverter to take grid power to charge the batteries. I have talked to Trace. They say the inverter I have can't do that. Right now I sell to ComEd only when I'm home and can get out of "sell" mode when the sun goes down. This seems complicated. I hope I have misunderstood Trace and that someone can tell me how to do what I want to do.

Future plans include a car charging station in my garage, and an electric truck. The truck has been purchased, as well as all the parts necessary for the conversion except the batteries. Construction of motor and equipment mounts and battery boxes, lack of welding experience, and a host of other problems have delayed this project. I hope to have it completed by Spring 2001.

Berton System Loads

#	*Item*	*Watts*	*Average Hours / day*	*Average WH / day*	*%*
1	Food dryer	260	8.00	2,080.00	38.7%
1	Sun Frost RF-16	120	6.30	756.00	14.0%
1	Blender	1,000	0.14	142.86	2.7%
1	CD player & radio	15	5.00	75.00	1.4%
1	Fountain	3	14.00	42.00	0.8%
1	Answering machine	2	24.00	38.40	0.7%
1	Stereo & turntable	30	1.00	30.00	0.6%
1	Food processor	400	0.05	20.00	0.4%
1	Vacuum cleaner	750	0.01	8.93	0.2%
1	Iron*	1,100	0.00	3.27	0.1%
1	Juicer*	300	0.00	0.14	0.0%
1	Coffee grinder*	110	0.00	0.05	0.0%
	Lighting				
3	Study, CF	23	5.00	345.00	6.4%
2	Kitchen, CF	23	3.00	138.00	2.6%
5	Dining room, CF	23	1.00	115.00	2.1%
4	Bedrooms, CF	23	1.00	92.00	1.7%
4	Living room, CF	23	1.00	92.00	1.7%
4	Hallways, CF	23	1.00	92.00	1.7%
3	Bathroom, CF	23	1.00	69.00	1.3%
2	Closets, incand.*	75	0.00	0.22	0.0%
	Computer Equipment				
1	Dell laptop	66	10.00	660.00	12.3%
1	Desktop computer	400	1.00	400.00	7.4%
1	Printer	60	0.29	17.14	0.3%
1	RW CD-ROM	100	0.14	14.29	0.3%
1	AT&T laptop	60	0.14	8.57	0.2%
1	Scanner	50	0.14	7.14	0.1%
1	ZIP drive	13	0.07	0.93	0.0%
	Power Tools				
1	Circular saw	1,560	0.03	52.00	1.0%
1	Router	1,200	0.03	40.00	0.7%
1	Drill	660	0.03	22.00	0.4%
1	Reciprocating saw	581	0.03	19.36	0.4%
			Total average watt-hours per day	5,381.31	

*Average daily use is too low to show at two decimal places.

I have purchased more panels that are not yet installed. These, added to what I already have, should allow me to recharge the truck. I hope to eventually stop selling excess power back to the utility, and instead use it myself—recharging electric vehicle batteries.

Off-Grid in the City

My power bills initially didn't change because the utility had not been out to physically read the meter for almost two years. I was getting estimated bills. When they finally read the meter, I had been seriously overcharged. There is a minimum charge just for being connected. There are also decommissioning charges for the nukes that they have. These charges run between US$7 and $10.

Instead of refunding the money that I had been overcharged, they are gradually reducing it by applying the monthly charge against what they owe me from the overcharge. So, for now, I have a zero bill. Eventually, I will pay the connection charge and whatever else they deem necessary to keep me connected.

My apartment has now been off-grid for a year. The inverter switched me back to grid power once in December after many days without sun. It happened again in early February. I am now trying to convince my building partner on the first floor that self-made power is reliable. She already has a Sun Frost and compact fluorescent bulbs. She only needs to buy into the idea of conservation to make this the first entire building off-grid in the city of Chicago.

I knew nothing about solar power and very little about electricity when I started. Now I can't imagine living without solar power. In any moves I consider, I always have the question of solar power in mind. Will this building be easy to convert to solar? How is the roof situated? Are there any obstacles to putting up panels? Is it the kind of neighborhood where the neighbors will complain?

Solar Anywhere

Since I have done this in Chicago, I believe I can do it just about anywhere. We don't have the best situation for solar, but it works. But this also poses a dilemma. Sometimes I consider moving somewhere just for a year, like Paris, or Oslo, or Peking. How would I rent out my apartment with the solar-electric system?

I've learned what it takes to supply my energy needs and satisfy my philosophical stance. I'd need to find someone truly committed to being off the grid. Someone to care for the system, water the batteries, and be able to go to the battery room and talk to the equipment. Someone who does not need air conditioning (that's hard for some people in Chicago). Someone who can turn off lights, and spend more for replacement bulbs when the compact fluorescents go out. It would have to be someone who's generally aware of power usage, or someone who's willing to learn.

Enermaxer dump load.

It's not as carefree as utility power in the short run. But you get a guilt-free conscience when ComEd starts moaning about their nuke liabilities and the rate hikes that are necessary for their upkeep and eventual decommissioning.

Solar panels are ideal for urban environments. Flying over most large cities, I'm amazed by the square footage covered by roofs. Covering large areas of desert with solar panels, taking energy from waves, building dams, and even harvesting power from the wind somehow changes the environment from which the power is being taken. Whether the change produced is significant is debatable. Someone may someday discover that we are irreversibly changing certain micro-environments to the detriment of their inhabitants.

By covering urban roofs with PV, we can reduce the amount of land we need to devote to power production/collection. Of course, reducing need is still the best solution—even for urban PV-created power.

Access

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vladimir@nekolux.com • www.nekolux.com • Great advice, support, wiring

Backwoods Solar Electric Systems, 1395 Rolling Thunder Ridge, Sandpoint, ID 83864 • 208-263-4290
Fax: 888-263-4290 or 208-265-4788
info@backwoodssolar.com • www.backwoodssolar.com
12 V Sun Frost RF-16, various gauges and meters

Vertis Bream, Energy Options, 1755 Coon Rd., Aspers, PA 17304 • 717-677-6721 • Fax: 717-677-6466
New and old nickel-iron batteries

Great Northern Solar, Christopher LaForge, 77450 Evergreen Rd., Suite #1, Port Wing, WI 54865
Phone/Fax: 715-774-3374 • gosolar@win.bright.net
PV panels, tracker

Jim Kerbel, Photovoltaic Systems Co., 7910 Hwy 54, Amherst, WI 54406 • 715-824-2069 • PV panels

Abraham Solar, 124 Creekside Pl., Pagosa Springs, CO 81147 • 800-222-7242 • Phone/Fax: 970-731-4675
Trace 2012 and original Tri-lams

Applied Power (formerly Alternative Energy Engineering), PO Box 339, Redway, CA 95560
800-777-6609 or 707-923-2277 • Fax: 800-777-6648 or 707-923-3009 • info@appliedpower.com
www.solarelectric.com • Enermaxer and dump load, Cruising meter, switches, fuses

Electro Automotive, Mike Brown, PO Box 1113-HP, Felton, CA 95018-1113 • 831-429-1989
Fax: 831-429-1907 • mike.brown@homepower.com
www.electroauto.com • Car conversion kit