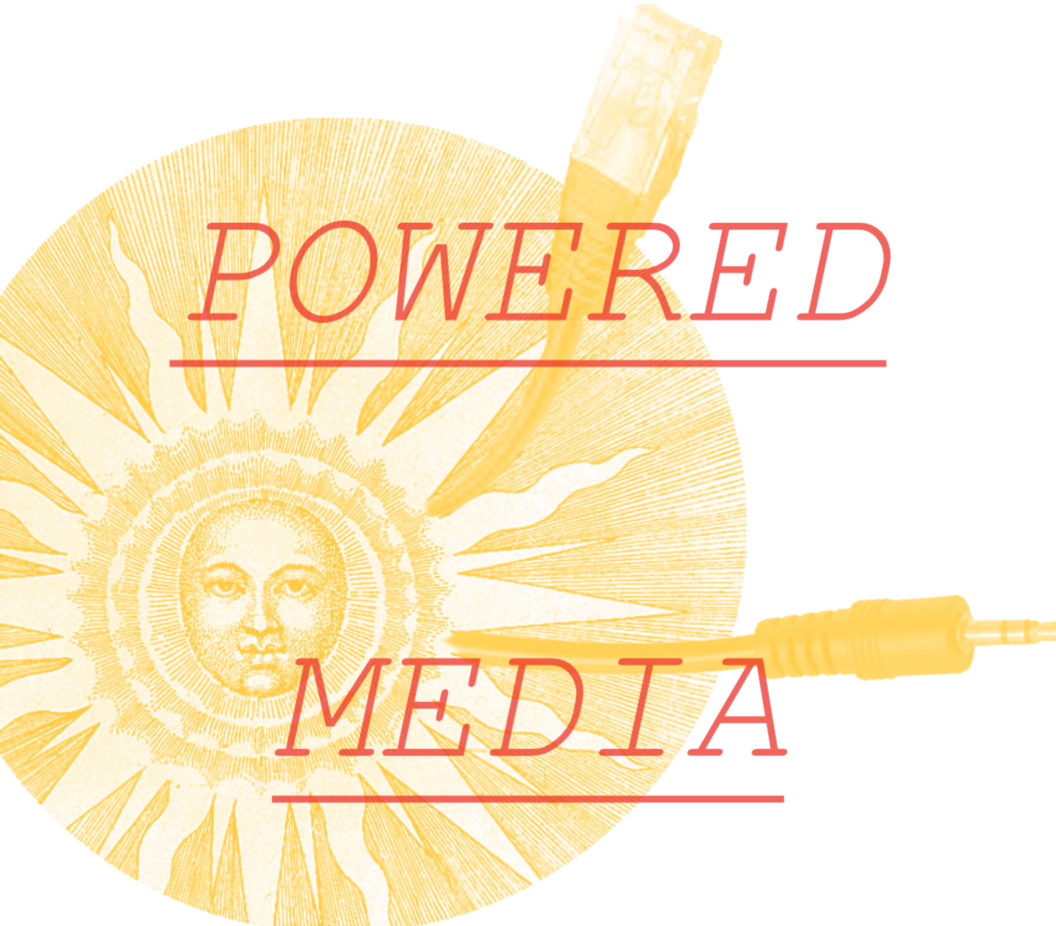
SOLAR-POWERED MEDIA



Anne Pasek & Benedetta Piantella

This is a zine about building your own solar-powered digital media storage infrastructure and sharing it online with the rest of the world. It includes instructions and suggestions about the hardware and software this task requires, as well as ideas and directions for the kinds of applications and aesthetics that seem to work best with such systems.

What kind of media you host is up to you. This could include a personal website (or several); a portfolio; a small-scale, open-source social network; a community information portal; a set of scholarly papers and presentations; or a networked art project in and of itself.

The designs that follow were developed by Tega Brain (http://tegabrain.com/)*, Alex Nathanson (https://alexnathanson.com/), and Benedetta Piantella (https://engineering.nyu.edu/faculty/benedetta-piantella), who were in turn inspired by Low Tech Magazine's solar web design (https://solar.lowtech-magazine.com/). The three's work continues in Solar Protocol (http://solarprotocol.net/), which is a web platform hosted on a global network of solar-powered servers, modelling a more naturally intelligent Internet.*

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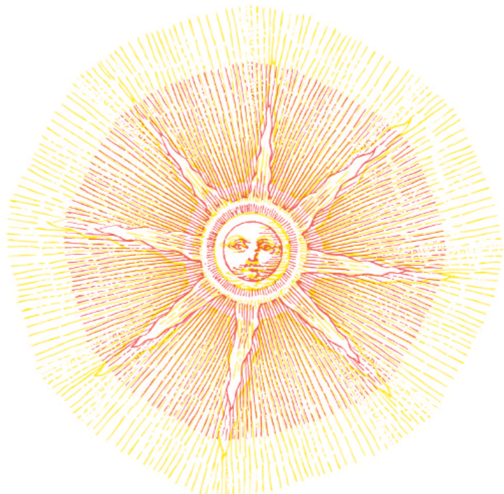
why make solar-powered media?



Energy structures our lives.

Environmentally, this is an increasingly obvious observation. The forms and demand intensities of the energy we use everyday will largely determine the rates of planetary warming to come, and thus the sum of human misery or thriving to follow. Accordingly, energy is something we need to consume less of, that we need to transition, and that we need to distribute and think about differently. This is both a practical and moral imperative.

But energy also has its social impacts. Inclusions, exclusions, consumer rights, and social contracts are all mediated through wires, pipelines, and generators. Unbroken and extractive access to fossil energy has made modern cultures possible. Its provision, deprivation, or strategic interruption, can create crises and power in equal measure. And so, there's politics and culture to energy, implying that shifts in this (infra)structure will also produce shifts in the kinds of social connections, practices, and demands that are possible in its wake. Energy, in other words, is about who we are, or might want to be, with and for one another.

Finally, energy is also aesthetic. It's a question of sensation: how far, how frequently, and how subtly, we communicate. And these questions are not disconnected from ecologies and politics. A transition in how we power our daily lives also implies that our lives will look and feel differently—at first, the shock of the new and then, with luck and dedicated organizing, shifting norms, pleasures, and expectations. Feeling towards different energy futures might be a way of engaging them more quickly.

And so, as a means of prefiguring or stress-testing a better energy future, solar-powered media offers a small part through which to imagine a wider whole. Without guaranteed 24/7 electricity from fossil fuels, solar invites questions of intermittency, thrift, and compression. It encourages us to think about the aesthetics of the small, the immediate, and that which can be stored, but not always accessed all of the time. It asks us to think about power locally and as disruption as an everyday quality, turning towards the sun and each other as sources of energy and rest in equal measure.

hardware

Before you can host your own solar-powered media, you'll need a photovoltaic (PV) panel, a way to store and direct its energy, and a server to store and deliver your content. This requires some hardware, but not a huge amount of specialized skills or tools. In the end, you'll have a panel that connects to a waterproof box with a tiny computer in it and a bunch of tech to keep it running safely as the sun rises and sets.

Equipment List

You will need to buy/barter the following system components. All bought new, you should budget about $700 USD or $1,000 CAD (before taxes and shipping).

☼ *The costs for this project aren't astronomical, but they're probably more than you want to* *front personally. If you don't have research funds, you could look for local arts council grants. Alternatively, maybe you have friends and neighbours interested in sharing the costs of solar-powered server space (as well as the skill development involved)?*

☼ *Additionally, The following set up is a bit of a 'bells-and-whistles' plan with highly protected circuits. If you know your way around the design and risks of electrical systems, you can downgrade some items to reduce the cost.*

(Illus.)

For the PV System

(A) One 50W 12V Monocrystalline PV module (a solar panel)

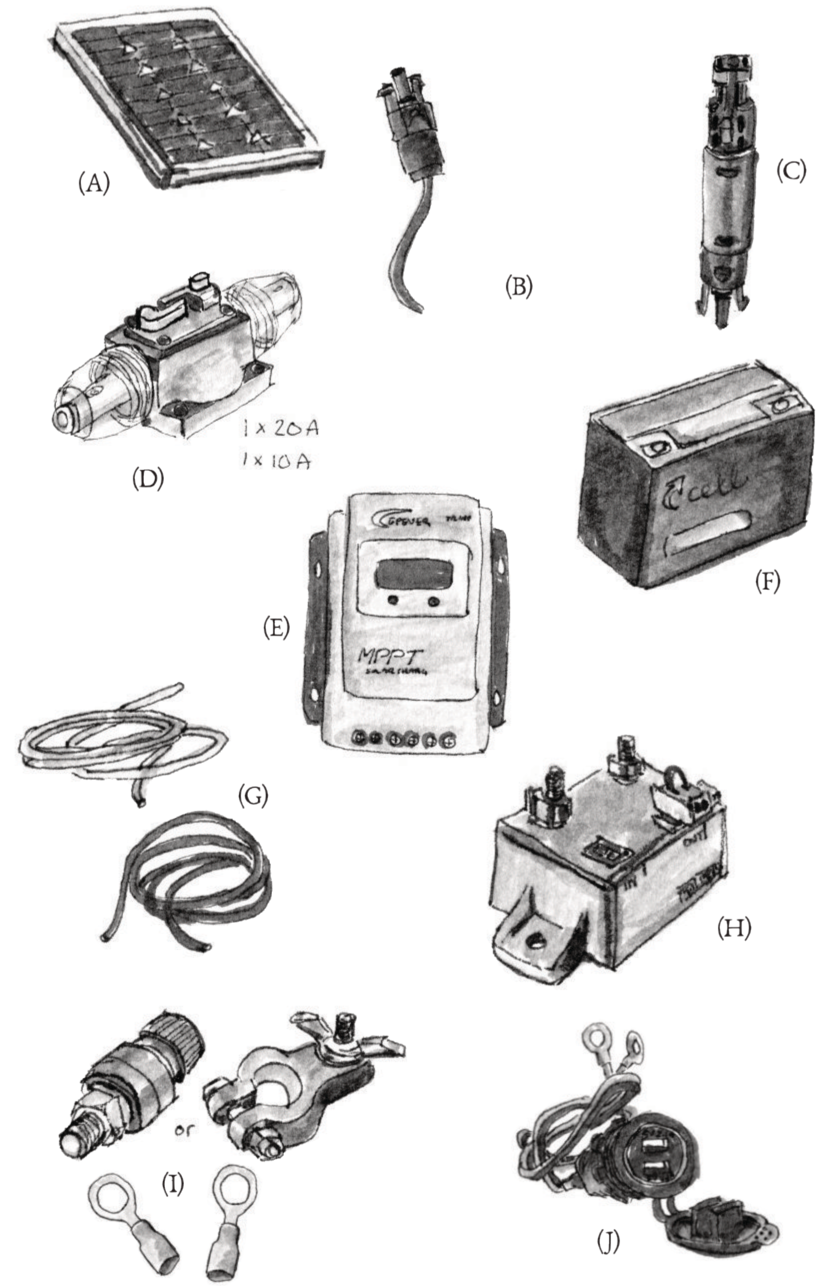
(B) One pair of ~40ft* MC4 extension cables 10-12 AWG *(to plug into the panel)*

☼ *These only need to be as long as you need to run between your PV panel and your NEMA box. Shorter, cheaper cables might work well for your set up. What's important is the gauge of the wire.*

(C) A waterproof 15A inline MC4 holder with fuse *(to prevent surges from the panel)*

(D) One 12V DC 10A inline circuit breaker fuse *(to prevent surges on the output line)*

(E) One Epever 20A solar MPPT charge controller *(to control the flow of electricity between the*



panel and your battery/server and read live data from your PV system)

For the Battery

(F) One 12V 22Ah AGM sealed lead-acid battery with battery terminals *(to store your electricity)*

(D) One 12V DC 20A inline circuit breaker fuse *(to prevent damage to your battery)*

(G) Some 12 AWG electrical wire - about 10ft red, 10ft black *(to connect your battery to your system)*

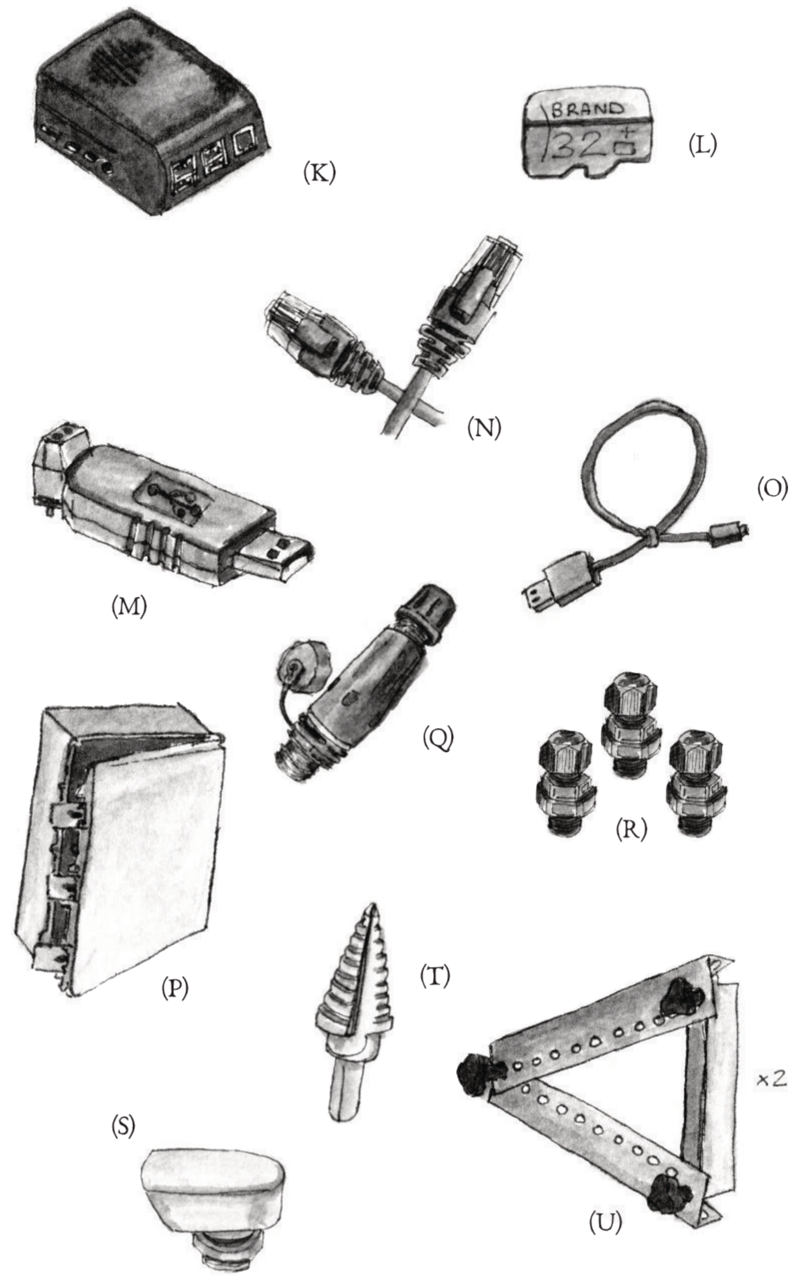
(H) One Victron battery protection circuit *(to take better care of the battery, which is usually the most expensive part of an off-grid solar system)*

(I) A handful of 12 AWG Wire crimp connectors, sized for connecting to the battery protection circuit and, if appropriate, the battery itself *(to connect your wires to your terminal*s)

For the Server/Computer

(J) One 12V to 5V USB power outlet with an inline 10a fuse *(the kind sold for cars, RVs, and boat*s)

(K) One Raspberry Pi 4 Kit *(including a board, heat sinks, a HDMI to micro USB cable, a power cable, and a case—ideally with an integrated fan)*



☼ *The Pi4 does tend to get pretty hot so any way to cool it down is very useful.*

(L) One microSD card *(this might come pre-loaded in your pi kit. The storage size you need is up to you, but you don't need more than 32 GB to make your server work comfortably)*

☼ *We find the Samsung Evo+ to perform really well over time.*

(M) One USB to RS485 converter/adapter with a ch340T chip *(a weird specialty part we're going to use to connect an ethernet cable to your pi and charge controller)*

(N) One 1 foot Cat6 Ethernet cable *(a longer one is fine if you already have it on hand)*

(O) One USB to USB-C cable *(to power the Pi from the USB adapter)*

For the enclosure/box

(P) One outdoor-rated NEMA enclosure (~10" long x 16" wide x 8" tall will give you room to maneuver) *(a box to keep all your electronics safe outdoors)*

(Q) One RJ45 waterproof IP68 Ethernet coupler—double-socket *(to run an ethernet cable from your router to your server directly—not needed if you're using wifi instead)*

(R) A handful of waterproof cable glands (sized to

your MC4 cables) *(to run cables through your NEMA box without letting the water in)*

(S) One air & moisture vent (style B NBX-10911) *(to let air circulate through your NEMA box)*

(T) A step drill bit set that can go up to 1 inch in diameter *(to drill holes in your NEMA box)*

For installing your solar panel

(U) Solar panel mount brackets designed to fit your solar panel

☼ *These come in different configurations whether you are looking to pole mount, wall mount, ballast your system, or pursue some other creative configuration to keep it secured.*

You will also need on hand:

A hand drill

Zip ties or sturdy cord/tape

Wire strippers or scissors

Eyeglass screwdriver with a slotted screw bit *(for wiring the USB to RS485 converter)*

An allen wrench key *(for opening and closing the in line circuit breaker fuses—and so sized accordingly)*

A USB mouse, USB keyboard, and HDMI external monitor for configuring your pi

¼ inch Pegboard/mdf/plywood *(or another medium you can put in the NEMA box to hold the components securely)*

A microSD reader that works with your personal computer *(these sometimes come included in Raspberry Pi kits)*

An Internet connection via an ISP that allows port forwarding *(many residential ISPs do, but it's good to check first!)*

Optionally:

A wire crimper *(nice but not totally necessary)*

One electrical wire nut *(a plastic cap and spring that will hold the ground wires together—though electrical tape alone will work okay)*

A small lock for the NEMA box *(airport luggage locks work great)*

Sandbags, cinder blocks, bricks or something heavy to hold down the legs of your mount brackets, if you aren't actually mounting them to anything

☼ *Solar panels belong outside where they can get adequate amounts of sunlight. Your router, however, is almost certainly inside. So, a key decision you need to make is whether or not you want to run an ethernet cable through your house/apartment/workplace (either via a permanently opened window or by directly drilling through one of your walls), or if you want to keep everything outdoors, but close enough to the envelope of your building to still get a fair-to-good WiFi signal. Both will work!*

☼ *Similarly, you can decide if the box with the computer hardware will sit closer to the panel or closer to your internet connection, which can both be accomodated by purchasing longer cables.*

sourcing parts

Tracking down these supplies can be a bit of a challenge. Here's some good places to look:

Renogy (renogy.com) supplies good quality consumer-sized PV panels and accessories in both the US and Canada.

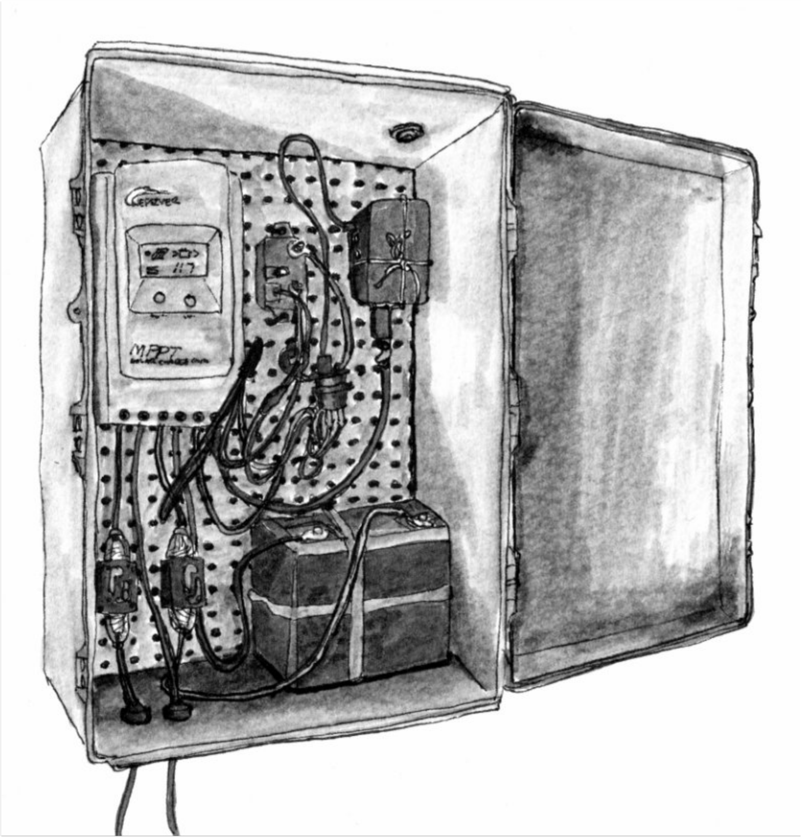
☼ *There are of course many PV suppliers on the market. The Silicon Valley Toxics Coalition tracks the labour, toxics, and greenhouse gas standards of different manufactures at www.solarscorecard.com/.*

Batteries, electrical wires, drill bits, and pegboard are easy to find at local hardware stores.

Raspberry pis and their accessories are available at Adafruit and DigiKey (US) or buyapi.ca (Canada). Vilros and CanaKit are nice

sources for all-in-one kits and are sold at most electronic suppliers.

Battery disconnects/USB converters might be available in specialty electronics, automotive, and boat shops, though an online search for retailers may also be necessary.



configuring the pi

Loading the OS

First, let's get your pi up and running. Start by downloading the lite version of the Raspberry Pi OS onto your microSD from https://www.raspberrypi.org/software/. We encourage following their guide and using free software like Balena Etcher to properly flash your SD card. Then, put the microSD card in the slot on the board of your pi.

Assembling the pi

If your heat sinks aren't pre-installed, adhere them on the pi by removing the sticker backing on each heatsink and pressing them firmly to the corresponding sections on your board.

Next, you may need to insert the little rubbery feet into the bottom of your pi case, so it stands slightly

above whatever surface you rest it on. Screw the fan into the pi case lid, with the label facing downwards (towards the board). Attach the red wire on the fan to pin #2 on the GPIO and the black pin to a ground (like #6). Then you can click your pi into place in the case (you may need to angle it downwards slightly to do so) and attach the lid.

Now you can connect your pi to your external monitor, keyboard, mouse, and power source. Turn it on by plugging it into a wall outlet, follow the usual setup at https://projects.raspberrypi.org/en/projects/raspberry-pi-getting-started/4, and then connect to your wifi.

Setting up SSH

If you want to access your pi in the future without having to remove it from the box and bring it inside it will be very useful to enable the Secure Shell protocol (SSH). You can find this via Preferences-> Raspberry Pi Configuration -> Interfaces -> SSH.

PuTTY is free, open-source software that will help you make use of this option. Instructions on generating keys and installing the necessary software on your personal computer can be found at https://www.ssh.com/ssh/putty/.

Setting up your server

Next, follow this guide to install apache on your pi: https://www.raspberrypi.org/documentation/remote-access/web-server/apache.md.

You'll end up with a file called "index.html" in the folder /var/www/html. This is the default page of your server.

Coding a webpage in HTML

To change what your server displays, you'll need to change what files are in the /var/www/html folder and the code that's written in the index.html file. This isn't as hard as it might seem.
If you've never done this before, try opening the file in a basic text editor (or download a simple program like Notepad++ for this purpose). Write out the following:

```
<!DOCTYPE html>
<html>
<head>
<title>Page Title</title>
</head>
<body>

<h1>This is my first heading</h1>
<p>This is my first paragraph.</p>

</body>
</html>
```

Then, save the file and open it with your web browser. You should see your work reflected in the content of the page. Alternatively, you can test code in real-time at https://codepen.io/pen/ and then copy/paste your results into the index.html file.

Now you're designing. Good tutorials on the basics can be found at https://www.w3schools.com/html/. You can also borrow interesting design ideas from other websites that you like via the "inspect element" tool in your web browser. Fancier layout designs may require the additional use of a cascading style sheet (CSS), which is a simple extension of the same principles of HTML (see https://www.w3schools.com/css/css_intro.asp for more).

Media are hosted on HTML sites by linking them in .html files using the appropriate file name and html syntax (for instance, <img src="portrait.jpg"> or <audio controls><source src="noisemusic.mp3" type="audio/mpeg"></audio>). You'll need your media to be stored on your pi, either in the same /var/www/html folder or elsewhere, with a relative path (https://www.w3schools.com/html/html_filepaths.asp) specified in your code.

The easiest way to get media on your pi is by putting your files on a USB drive, plugging it into your pi, and dragging them to the folder you want via the mouse/visual interface. You can also use SSH and the mv command line function (http://www.penguintutor.com/raspberrypi/useful-command-reference) instead.

☼ *Keep an eye on accessibility as you write your code so it's easy for a screen reader to navigate. See https://developer.mozilla.org/en-US/docs/Learn/Accessibility/HTML for more tips.*

Connecting to the Internet

Next you've got to configure your pi so that it will be publicly accessible over the Internet. This will involve enabling port forwarding on your router, and linking that port to your pi. This will look a little different from router to router, but you can find a good general guide at https://pimylifeup.com/raspberry-pi-port-forwarding/.

☼ *If possible, while you're working with your router, set up a static IP address for your pi.*

At the end of this process, your website should be accessible at [your pi's public IP address]/index.html. You can find your public IP address by visiting https://whatismyipaddress.com/ with your pi. You may want to link this IP to a domain name you own for an additional layer of security and user ease.

Once you've got your pi and website ready (or, alternatively, well before!) you can start assembling the solar system to power it safely.

hardware assembly

Before you get started, here's how to avoid causing a spark:

This is the big thing to remember: never plug in the solar panel and charge controller without first connecting the battery (i.e. you should always give that electricity a place to go!).

To avoid a potential shock, always connect the components in this order:

1. battery
2. charge controller
3. solar panel

And when unplugging, always disconnect the components in this order:

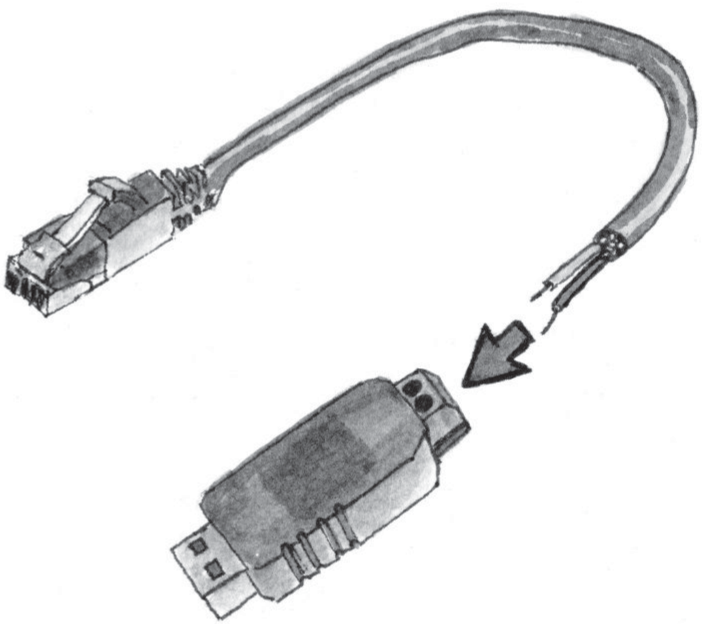
1. solar panel
2. charge controller
3. battery

☼ *You might want to write this on a sticky note in your NEMA box so you can better keep it in mind.*

What to wire, where, and how

Start by making the homebrew ethernet to USB converter:

Cut your ethernet cable with your scissors, leaving a comfortable length between the end and your inci-



sion (>2 feet). At the cut end, peel back about 3 cm/1 inch of the cable sleeve to expose the wires underneath. Of those wires, separate out the solid blue and green wires, and trim down the rest. Strip a ½ cm/0.2 inch of the plastic coating off to expose the copper interior of the two remaining wires and twist the exposed wires into neat coils.

Then use your eyeglass screwdriver to open the ends of the USB to RS485 converter. Place the exposed inner core of the blue wire in the B (D-) port and the exposed wires of the green cable in the A (D+) port, and screw them tight. Behold! You have made a bespoke dongle. You could use electrical tape to further secure these components together.

Venting the box and making exit ports for the wires

It's bad for a lead acid battery (as well as electronics in general) to be stuck in an airtight space. To keep the enclosure weather-resistant without trapping all the air inside, it's best to install a vent (or multiples if you notice your box heating up in the warmer months). This means that you'll first have to make a carefully controlled hole in the box. It's a good idea to place this hole near wherever the battery will end up. This will to ensure that it will get good air circulation and towards the bottom of your enclosure so that rain won't have a chance to get inside.

Using your step drill bit, drill into the side of the box , widening it step by step until your vent threading can just fit through the hole. Then screw the vent pieces together around the box's wall, making sure that the external opening faces whatever direction will be 'down' in the box's final configuration.

☼ *Pick the sides you're putting holes into strategically. Consider whether or not you want your box to lie on its back, or stand up on one of its sides.*

Next, do the same with the glands for the rest of the cables that will need to exit the box (your MC4 cables running out to your solar panel, for sure, and also an ethernet cable if you plan on a using hardline connection to your router instead of connecting via wifi). The holes for the PV cables will likely be smaller than the vent, while the ethernet gland might require a slightly larger hole (~1 inch). These glands come in two or multiple pieces, some of which will protect from the elements and sit on the outside of the box, and some pieces which will fasten the gland from the inside. Run about 2 feet of the PV wire through both the gland and the hole in the box, and then slip the interior piece of the gland around the cable to meet its twin at the box wall, tightening around the point of entry.

Once secure, strip the casing from the last few cm of the MC4 wire now inside your box. Use a piece of red tape or some other handy labeling device to clearly designate which of the internal wires is the positive one. Secure these cables inside your charge controller terminals by unscrewing the openings on the bottom left (with the solar panel icon), matching positive to positive, negative to negative, and screwing them tight.

Tying it all down

Next you'll need to roughly plan the configuration of all the parts in your box and how you'll want to secure them so that they won't shift and move around in transportation. A simple way to do this is to cut some pegboard down to the inner side of your box and zip tie or otherwise lash down your components and their cables. Alternatively, you can use ¼ inch MDF or plywood to securely screw your components in place, as most come with screw holes.

You may find it useful to put the charge controller in the top left of your box, with some "runway" for all the cables that will enter the terminals at its bottom. Additionally, the battery is heavy, and so should probably go in the bottom side of your enclosure (especially if you plan on resting it vertically). Everything else can fit in between, with space made for the cables to connect without strain.

Wiring the battery

Now we're going to bring electricity in the mix. Your battery probably already has a charge, so do be sure to keep things safe by never accidentally letting the live wires running from the battery terminals touch each other (this could cause some sparks and other, more dramatic unpleasantness).

Start by cutting about 60cm/2 feet of red wire and black wire and use your scissors or wire strippers to remove a bit of the rubber coating from both ends. On one set of wire ends, fasten crimp connectors (or whatever other component is needed to connect to your battery terminals) to each of the exposed sections of the wire. Secure the connectors in place with wire crimpers or plyers. Feel free to use electrical tape if you want to insulate or secure things even further. Don't attach anything to the battery yet.

Next take the red wire you're working with and cut it in half. Expose a few cm of the metal underneath the cable coating at either side of the cutting point, and insert the 12V DC 20A inline circuit breaker fuse between them (unscrew the caps at either end, insert the wire ends, then screw the caps back on snugly). You will need an allen wrench key to do this.

Then connect the connector ends of each wire to your battery: the red wire to the positive terminal and the black wire to the negative terminal. Depending on your battery type you may need to tighten a washer or screw to hold each wire terminal in place around a threaded stud, or you may need to tighten clamps around unthreaded posts. Be careful about touching the wire ends—they are live!

Connect your battery wires to the charge controller's battery ports by loosening the screws directly above the port on the charge controller. Insert the exposed end of the wire into the port, and then re-tightening the screw on the charge controller to hold it firmly in place. When both wires are connected the charge controller should turn on, displaying battery levels and indicating whether or not energy is set to flow from the battery to the rest of the system. A **>** symbol between the battery icon and the lightbulb icon means that the controller will let electricity flow for-

ward. Press the enter button on the charge controller to disallow this for now. On the left side of the display you should see a moon icon, indicating that no solar panel is currently attached.

Programming the battery disconnect

The battery disconnect comes pre-programmed with a few different modes; setting the correct one requires electrifying the device and cycling through its display options. To do this you're going to temporarily bypass the charge controller.

Start by removing the battery disconnect's smaller green plug (it has only two ports and is labeled 'REMOTE"). Set it aside.

Cut an additional piece of black wire (about a foot in length), strip both ends, and connect with the exposed metal on the other end of the wire attached to the GND slot.

Next, unscrew the battery wires from the charge controller. Take the wire connected to the negative pole of the battery and add it to this bundle of ground wires, making sure the ends of all three ground wires are touching. Temporarily secure them in place and insulate them with electrical tape and/or a screw cap.

Now connect the exposed metal of the wire connected to the positive end of the battery to the terminal marked 'IN' on the battery disconnect. A light in the corner of the battery disconnect's numerical display should blink, showing that the component is powered.

Now that the unit is powered, it’s time to program it. Take the loose wire from your recently-fashioned cluster of ground wires. Touch it to the ‘PROG’ pin on the battery disconnect unit and keep it there for a few seconds. The numbers on the device’s screen will now start to cycle. Remove the wire from the PROG pin when it displays the number 8.

Next, untape all the ground wires, discarding the short wire used with the PROG pin. You can now re-plug in the green terminals marked REMOTE.

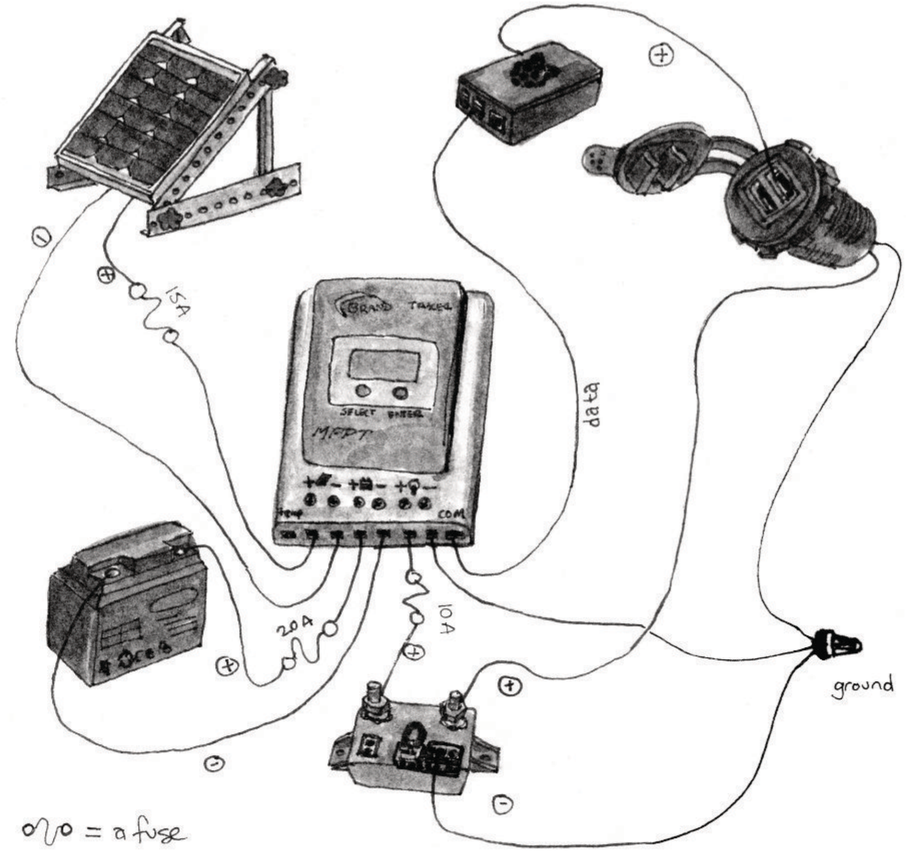
Placing the output wires

Next, cut another pair of red and black wires, about two feet each, and strip the ends. Add crimp connectors to one end of each wire. Then, take the red wire and, as before, cut it in half and insert the 10Amp in-line circuit breaker in between.

Take the un-crimped ends of each wire and attach them to the corresponding ports (red for positive, black for negative) on the output side of the charge controller (the ones marked with a lightbulb icon).

Next, a mildly complicated bit of connectors and wiring

Now we’re going to connect all the remaining components in the box and create a more permanent ground for the system.



Start by finding your USB to USB-C cable and connecting it from the power input of your pi to a USB port in the USB power outlet. Easy peasy.

Next, take the black, negative wire coming out of the back of the USB power outlet. Intertwine it with the other ground wires, the one connecting to GND on the battery disconnect and the negative output wire from the charge controller. Insulate and bind these wire ends together with a judicious amount of electrical tape and by screwing them together with an electrical wire nut. This will act as the common ground for your system.

Now you can connect the red, positive wire from the charge controller output to the battery disconnect's 'IN' side, screwing down the connector around the terminal. Similarly, take the red, positive wire from the USB power outlet, and secure it in place at the 'OUT' side of the battery disconnect.

Finally, there are just a few simple things left to plug in. Find the tiny thermometer insert for your charge controller and click it into its slot on the bottom left of the device. Then, plug the ethernet side of your ethernet to USB cable into the ethernet port on your charge controller and plug the USB side into any USB port on your pi. Everything is now in place, so connect the battery terminals and watch everything come to life!

Check your connections by hitting the enter button on your charge controller to send electricity through your system. A small light in the pi and in the corner next to the numerical display on the battery disconnect should blink on. If they don't, power down the system and make sure your wire connections are secure.

Adding the PV

Find the MC4 cable you labeled as positive. Plug the 15A fuse into the end of this cable, clicking it into place like a buckle on the back of the solar panel.

Next insert both positive and negative MC4 cable ends into the charge controller and screw them in place.

Assuming that your panel isn't totally obscured, it should now be generating some amount of electricity. Your charge controller should now display a solar panel on the left side of the display and a **>** symbol between the solar panel and battery icons.

As a final step, be sure to tie down any components and wires that you haven't already secured to your pegboard, such that nothing will shift in transit or be strained by gravity.

You're finished! Now your system is ready to be installed in your desired location.

☼ *Stuck? Check out the hardware install notes at* https://github.com/alexnathanson/solar-protocol *for additional photos and tips.*

panel installation

A solar panel yearns for sun. And, while you can put your panel just about anywhere outside and it will work to some degree, it's also true that where and how you set up your panel will have a big impact on the amount of energy it generates. Finding that perfect site requires a bit of attunement towards the sun.

So, in the days leading up to your install, spend some time outside. Where in your site gets the most direct light, especially during the hours of 10am-3pm? Where does it get (perhaps unpleasantly?) hot at the height of summer? Where does the snow melt the fastest in the spring?

Next, think about cardinal directions. (Just like an indoor cactus) the panel should be placed facing towards the equator so that it gets the most sun. So, if you live in the northern hemisphere, face it southwards. If you live in the south, face it north. You'll also want to pick a place that'll keep cables out of the

way of foot (or other) traffic. No one wants to trip and you don't want people to yank cables out of their connections.

Rooftops, especially flat apartment and enterprise roofs, have much to offer on both accounts. If you need to place the NEMA box on the ground level, where its access to wifi and your access to it might be a little easier to come by, you can neatly run cables down from the roof by zip tying them downspouts. Alternatively, solar panels can be attached to fences, poles, sheds, or just given a designated spot in the yard.

If your panel isn't screwed down into anything solid (as might well be wise for the watertightness of a roof, for example) you can just screw the L bracket of the panel mount onto some 2x4 pieces of wood to give it a wider base, and then weigh that wood down with heavy bags of sand or cinder blocks in order to ensure that it doesn't get blown around in a storm.

☼ *Check local building codes for requirements and regulations about installing solar panels on fixed structures.*

Finally, the part that we find most poetic: you'll want to tilt your panel at approximately the same angle as the latitude of your part of the world. In Peterborough, Ontario, my latitude is 44.3°N, so my panel should sit a little shy of 45° off of the ground. If you're intense about things you can also modify the angle over the course of the year, adding 15 degrees in the winter, and subtracting 15 degrees in the summer. It's a reminder that the world isn't flat, that our access to the sun differs across time and space, and that when we think about solar power, we're also thinking about our planetary condition.

solar design constraints & opportunities

There are a few obvious limitations to this system: you can't host more content that you have local memory for on your server and you can only keep your content online for as long as you have a battery charge or shining sun. A highly bandwidth-intensive system will require more energy and so will require more sun—perhaps more than you can provide with the panel and battery you have or the hours of sunshine in the day. The weather and the seasons will therefore limit how much data you can share, and so the size of your audience and/or the size of your files. Your local upload speeds could also present a further impediment.

This is all obviously much more difficult, expensive, and inconsistent than uploading something to YouTube or Facebook. And yet, this is in part what makes such projects interesting. The point, to our minds, is not just to replace one energy source with another and expect that it will or should work exactly the same. Instead, we want to ask: What might have to change in our media practices amid the process of energy transition? What difference makes a difference? And what different futures are worth building today?

On the one hand, this proposal isn't radically new; we've designed for similar constraints before. A low-data and low-energy-intensity system might look a lot like the Internet did in the 90s and early 2000s, before the arrival of massive data centers, platform capitalism, and the attention economy. Simple HTML and CSS, with an eye on local hosting limits, can make for engaging sites without ad tracking, tech monopolies, or grid-straining energy demands.

As such, solar-powered network aesthetics might look a little retro—more geocities pixels than solarpunk watercolours. In the solar-powered Internet, such as it exists today, it's common to see dithering (a technique to create the illusion of colour depth with minimal data) and very simple fonts. Experiments in low-res video (smallfile.ca) are a further source of practical and creative inspiration. But this is more than an affectation; designing with these aesthetics in mind means that you'll produce websites that are more accessible to a wide-range of devices, broadband speeds, and screen readers around the world.

However, solar power comes with an additional design characteristic: its intermittence. In the middle of a sunny day, you'll likely receive far more energy than your battery can store. But this abundance is temporary; at night, and through especially grim and

cloudy days, your battery will be about all you have to go on. If energy demand exceeds your energy supply, your pi will shut off and your website will go offline.

Of course, you could overdesign a way around this problem by adding more solar generation capacity or a bigger battery to catch more sun when it's shining. However, this would get expensive and cumbersome quickly. Instead, you could think about down periods as an expected and useful part of your design: as a desired feature, not a hindrance. Do you have a weather-dependent message worth sharing? What would it be like to sync our media habits with the temporary abundance of the sun? What do you wish could go down at sunset?

At this time, we have more questions than answers. It's tempting to imagine the pleasures of disconnection by way of the weather. What if your work email was hosted on a solar-powered server, such that you couldn't access it in the middle of a storm? Or what if you used your own server to host a social network (for example, a Mastodon instance) that powered down in the middle of the night (no doom scrolling permitted)? Might linking your media access to planetary cycles afford some useful opportunities for rest? What is valuable, and worth organizing towards, in a world where we aren't always assumed to be connected?

This is a hypothesis currently under investigation. Help our project by filling in the postcard on the back cover with your thoughts, or by writing us with the details of your own experiments in solar-powered media and mailing them to:

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further ideas, inspiration, and resources

De Decker, Kris. "How to Build a Low-tech Website." Low Tech Magazine, 24 September 2018, https://solar.lowtechmagazine.com/2018/09/how-to-build-a-lowtech-website.html.

Formafantasma's design portfolio: https://formafantasma.com/website.

Jarrett, Tom. "Designing Sustainable Interaction Design Principles." Branch Magazine, 15 October 2020, https://branch.climateaction.tech/2020/10/15/designing-branch-sustainable-interaction-design-principles/.

Kazemi, Darius. Run Your Own Social. https://runyourown.social/.

Neocities (a community of often retro-inspired, user-coded, low-bandwidth personal websites): https://neocities.org/.

Nathanson, Alex. *A History of Solar Power Art and Design*. New York: Routledge, 2021.

Parnitzke, Daniel. *Finding Pleasure in Scarcity*. http://pleasureinscarcity.com/

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The Synthetics Collective's solar-powered website and fieldguide to lower-impact art exhibition practices: https://plasticheart.solar/.

University of Oregon Solar Radiation Monitoring Laboratory's Sun Path Chart Program (for getting really wonky with your panel angles): http://solardat.uoregon.edu/SunChartProgram.html.

Ye, Lu. "Design for Carbon-Aware Digital Experiences." Branch Magazine, 10 October 2020. https://branch.climateaction.tech/2020/10/11/design-for-carbon-aware-digital-experiences/.

A Final Note on Networks

Of course, your server is part of a much wider network of digital and electrical infrastructures that you can't control, and which probably aren't very solar powered. (For a glimpse of these connections, enter sudo traceroute + your favorite website in the pi's terminal program, and then look up the location of the IPs you're crossing. The Internet is big and geographically dispersed!).

That being given, local servers are still a useful place to begin to think about network chokepoints and constraints, to re-territorialize digital spaces, and to develop greater skills and community that can be applied to the creation of ever-more ambitious and interesting alternatives.

Additionally, many systems used to provision remote or underserved communities tend to be low-powered, and are thus already (or are more open to) being run on small-scale renewables. A few inspiring examples:

> Red Hook Wifi is a solar-powered mesh network, maintained by a team of community stewards, that provides free Internet access to the community and was, for a time, the only network left standing after Hurricane Sandy.
>
> Community Tech NY's Portable Network Kit is suitcase-sized, solar-powered network infrastructure, for use as a teaching tool and as emergency communications.
>
> A similar solar-powered Community-Wifi system

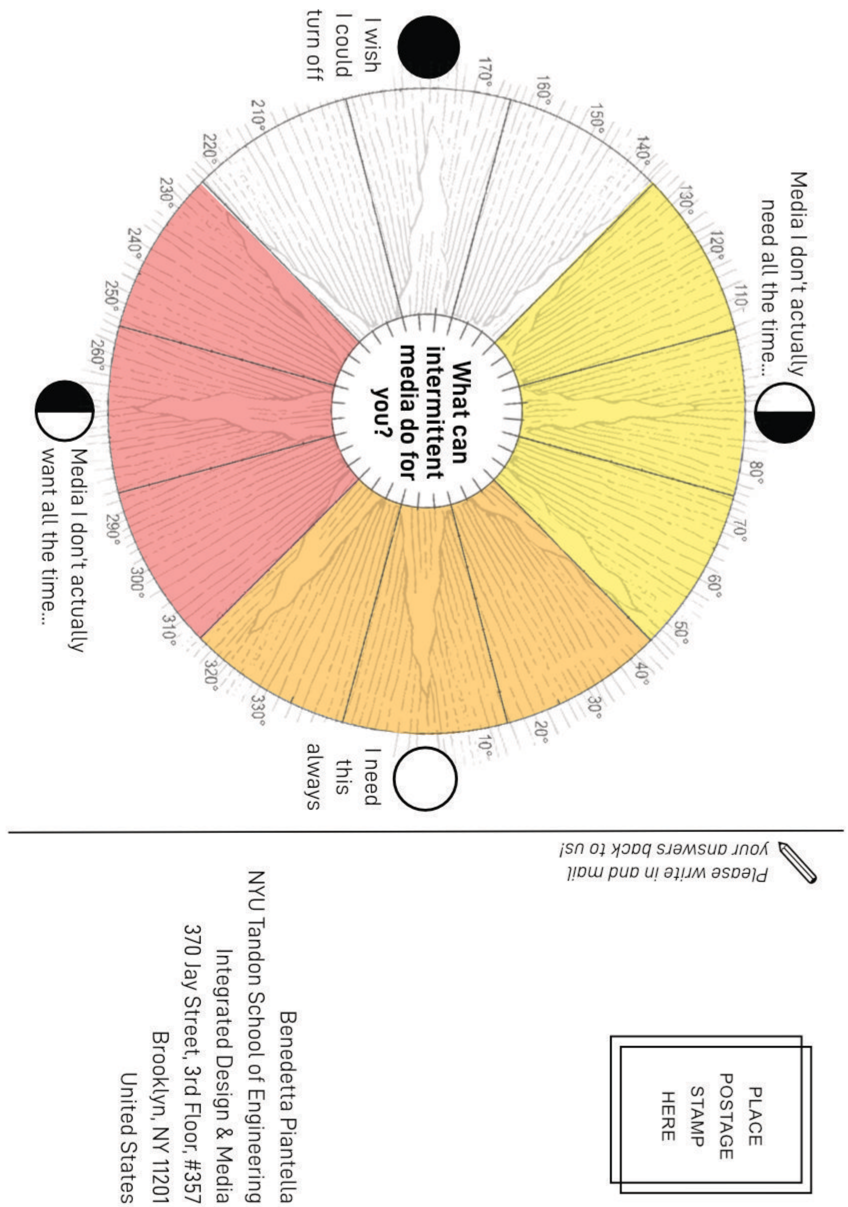
was used to provide local networking during the aftermath of Hurricane Maria in the Kalinago Territory in the Commonwealth of Dominica.

Solar Protocol is an experiment in interlinking a growing group of solar-powered servers around the world, such that internet traffic is routed to whichever node has the most energy, rather than the route that is fastest and closest.

Of course, on the broader horizon, we want to think ambitiously and collectively. Climate action requires both that we use our resources more efficiently, and also—very probably—that we use less energy overall. This implies a necessary challenge to the endless growth of data collection and its related business models, as well as greater public and environmental regulations on network infrastructures as a whole. Demystifying the mechanics of digital systems is a good first step to building the kind of political power this task requires. And so, we leave you with this farewell:

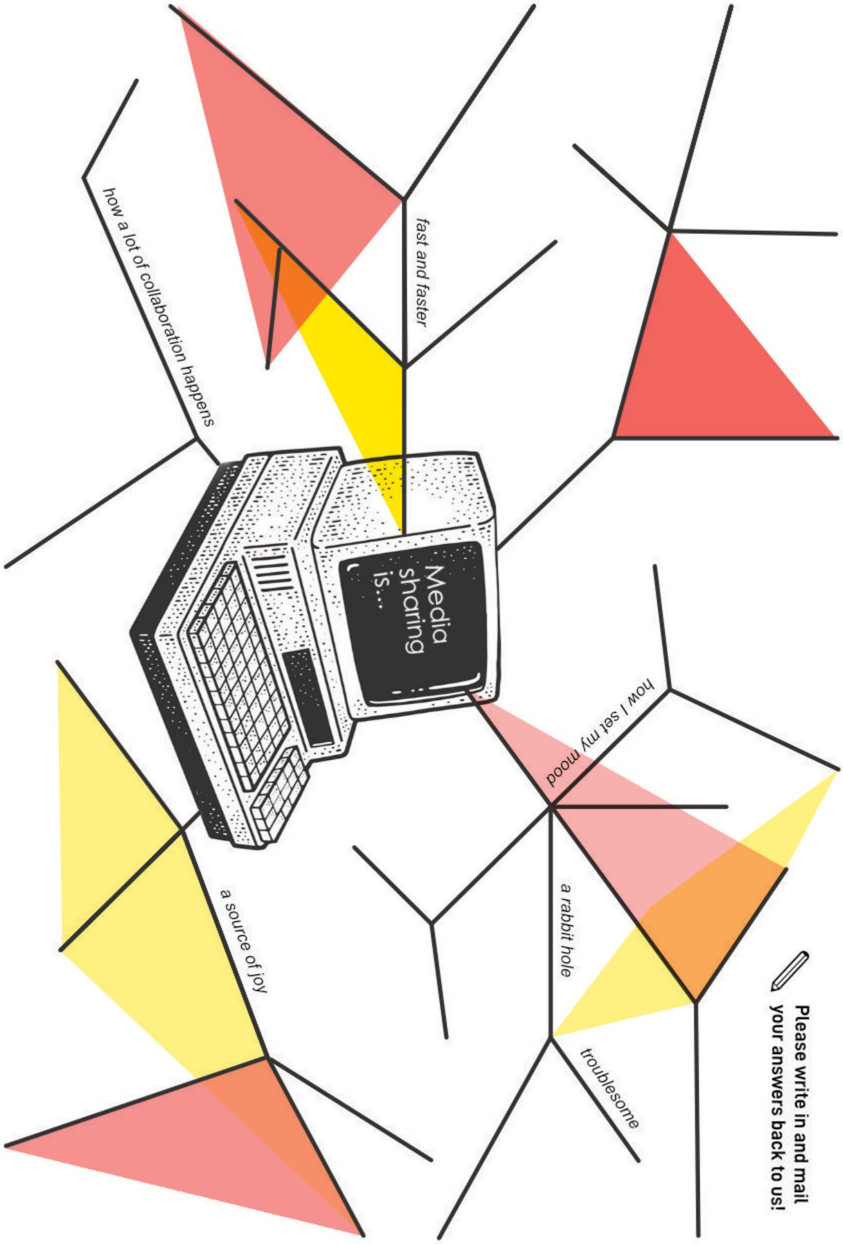
May your solar-powered media prefigure a different kind of network.

☼☼☼



(Print this page on something sturdy so you can cut out and mail the postcard)

(Cut out this safety reminder and stick it inside the enclosure for your system)



REMEMBER:

Connect in this order:

1. Battery
2. Charge controller
3. Solar panel

REMEMBER:

Disconnect in this order:

1. Solar panel
2. Charge controller
3. Battery