

By Jason Adams

INTRODUCTION 4
THINGS TO KEEP IN MIND ABOUT OFF GRID LIVING 6
NATURAL GAS AND PROPANE – KICKING THE HABIT 9
GETTING RID OF A GAS WATER HEATER 11
SOLAR WATER HEATING 12
FLAT PLATE COLLECTORS 14
INTEGRATED SOLAR WATER HEATING SYSTEMS 16
SOLAR WATER HEATERS IN COLD CLIMATES 17
THE FURNACE 18
PASSIVE SOLAR HEATING 21
ELECTRICITY AND THE GENERATION THEREOF 25
OFF GRID VERSUS GRID TIE IN 28
SOLAR POWER EXPLAINED 30
STEP BY STEP SIZING OF YOUR SOLAR SYSTEM 31
SIZING THE SOLAR PANELS 34
THE INVERTER 35
SIZING YOUR BATTERY BANK 36
THE MINIMALIST APPROACH 38
REFRIGERATION WITHOUT ELECTRICITY 40
ZEER POT 40
THE COOLGARDIE SAFE 42
CONCLUSION 44

Copyright 2013 OffGridSurvivalSystem.com

DISCLAIMER OF LIABILITY AND WARRANTY

This publication describes the author's opinions regarding the subject matter herein. The author and publisher are not rendering advice or services pertaining to specific individuals or situations. For specific advice, or if expert assistance is required, the services of a qualified professional should be obtained.

The author and publisher assume no responsibility whatsoever for the use of the information in this publication or for decisions made or actions taken based, in whole or in part, on the information in this publication. The author and publisher make no warranties, express or implied, regarding the information. Without limiting the foregoing, the author and publisher specifically disclaim and will not be responsible for any liability, loss, or risk incurred directly, indirectly or incidentally as a consequence of the use or misuse of any advice or information presented herein. Use this publication and information with good judgment and do the best you can in your particular situation.

You agree to indemnify and hold the author and publisher, and their respective officers, directors, agents, employees, contractors and suppliers, harmless from any claim or demand, including reasonable attorneys' fees, related to your use or misuse of this publication or the information contained therein. You further agree that you will cooperate fully in the defense of any such claims.

Notice: As the purchaser of this electronic document you are permitted to store it and print it for your own personal use only.

Otherwise, no part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise without the prior written permission of the copyright owner and publisher. It is illegal to make a copy of all or part of this publication for someone else, even if you do not charge for the copy.

COPYRIGHT

Those who have received or purchased the guide are neither authorized nor permitted to transmit copies of this guide to anyone without written permission. Giving away copies to people who haven't paid for them is illegal under international copyright laws and will submit you to possible legal action. Therefore, the utilization of this file is limited to personal use only.

TERMS AND DISCLAIMER

By using, viewing, and interacting with this guide, you agree to all terms of engagement, thus assuming complete responsibility for your own actions.

The authors and publishers will not be held liable or claim accountability for any loss or injuries. Use, view, and interact with these resources at your own risk.

All products from Jason Adams and its related companies are strictly for informational purposes only. While all attempts have been made to verify the accuracy of information provided on our website and within the publications, neither the authors nor the publishers are responsible for assuming liability for possible inaccuracies.

INTRODUCTION



The concept of living without any ties to modern utilities, otherwise known as *living off the grid* is a dream many preppers and survivalists have. It's a dream that is the pure embodiment of freedom – electric power without power bills and the oversight of big brother electric company. It's the freedom to be self sufficient, to be totally self reliant instead of being connected to the umbilical cord of society.

Unfortunately, most ideas relating to off the grid living usually include the purchase of a remote, inconvenient piece of land somewhere in the boonies. True off grid living is a utopian ideal that few can achieve, since it's so fundamentally hard to not live near a city or urban area, especially if your employment depends on it. The reason why land is so inexpensive out in the sticks is because no one wants it – to be perfectly honest. Unless you are independently wealthy and can build the custom off grid cabin in the woods, then you'll have to abandon the off grid living plan. *Or do you?*

We're here to tell you that it is entirely possible to live off grid in your average suburban house. Using a few simple and innovative technologies

from the past and a little ingenuity, it is possible to sever the link between you and your utility company. We recommend a hybrid approach; an approach that keeps you connected to the grid but not really using it, leaving it there as a backup.



What we're proposing is essentially a return to a simpler time, a time approximately a century ago when most houses had rudimentary power at best, perhaps a single electrical circuit supplying the home mainly for lights. A time when refrigeration did not mean a plug in refrigerator. A time when home cooling was accomplished by the careful placement of windows and a routine of opening and closing them at strategic times during the day.

What we are proposing is hardly radical. In fact, in the 19th century, what we are proposing was entirely commonplace in all but the largest cities. Back then, there really *was no grid to be dependent on*, and people got along just fine. Today, there are signs that there might not be a grid to depend on in the future. Consider that:

- The American power grid is heavily overburdened, splintered, antiquated, failure prone, and totally susceptible to terrorist attack.

- Threats like electromagnetic pulse loom over the country, threatening to send us all back to the stone ages due to the complete destruction of modern technology as we know it.
- The rising cost of electrical power generation is unpalatable to most people.
- The intrusion of the power company into our lives with devices like smart meters, and the logging and analysis of our power consumption habits is tantamount to an invasion of privacy.



The grid really is an umbilical cord to which we are all tied, unfortunately.

THINGS TO KEEP IN MIND ABOUT OFF GRID LIVING

Completely severing some homes from the grid and other utilities may not be possible; it really depends on what your goals are and what your current home looks like and how it is designed. Keep in mind that the average home today is several times larger than homes of the past, and that plays a big part in how dependent it is on utilities for things like heating and cooling.

Those with older homes will undoubtedly have an easier time of implementing some of our suggestions, since older homes:

- Are often smaller, and thus easier to heat.
- Were designed with natural ventilation in mind rather than forced air heating, ventilation, and air conditioning (HVAC).

The major advantage that newer homes have over older ones is *insulation*, plain and simple. The concept of R values and insulation technology in general was poorly understood even as early as 30 years ago. Today, we have newer and better materials for insulation, and we are able to insulate things like glass far better than ever before. To say that insulation has taken a quantum leap in homes is an understatement. Fortunately, most insulation technology is easily retrofitted to older homes, albeit at some expense.

The first thing you'll need to do is take an assessment of your current home, just as it sits, and from there define your goals. Here's what you need to do:



1. Grab your most recent power bill and scan it for the total amount of kilowatt hours (kWh) of electricity you used last month. The year to date total is even better, but it can also be extrapolated from your current bill.
2. Do the same for your natural gas bill, if applicable. What you're looking here is the cubic feet of gas you used last month.

3. Analyze any other utility bill you might have, such as propane, fuel oil, etc.

You'll notice we didn't mention water, as water is the one utility it is almost impossible to live without, unless a convenient source of water is nearby. Water accessibility in the suburbs is fairly low, mainly being piped through the city water network directly to your faucet. Complete removal from city water requires:

- Readily accessible and *legal* access to a large water supply such as a lake, river, or stream.
- The ability to treat or filter the water to remove pathogens. Surface water should never be considered safe to drink without treating, filtering or boiling.
- The ability to pressurize the water by means of a pump system.



Remarkably, there are many aquifers underneath cities and suburbs, yet most municipalities disallow the drilling of water wells within city limits. We cannot recommend anything illegal, but satisfy your water curiosity by speaking to a local expert; you may be pleasantly surprised at what lurks beneath your soil, and a water well is not outside the capability of the average person to drill.

Water independence can also be achieved in some climates with roof catchment systems, cisterns, and slow sand filters positioned underneath rain downspouts.

The big two utilities that we are interested in stopping in their tracks are:

- Natural gas or propane
- Grid electricity

Technically speaking, the term *the grid* really refers to the electrical grid, but while we're *off grid surviving in the burbs*, we might as well make a dent in gas as well. Let's take a look at gas first.

NATURAL GAS AND PROPANE – KICKING THE HABIT

Natural gas (NG) and propane are excellent, clean burning, and inexpensive fuels primarily used for home heating applications. Although natural gas has been around since the mid 1800s as a method of lighting street lamps (since the late 1700s in England), it wasn't until the '40s and '50s that NG was used to heat homes en masse.

Today, natural gas is used to power:

- Furnaces
- Ranges and cook tops
- Hot water heaters
- Pool and Jacuzzi heaters



- Gas barbecues

Propane is used similarly, mainly in applications where the plumbing of natural gas lines would be impractical, such as farms and ranches.

We'll discuss the two interchangeably, since they both are used in the same sorts of applications.

So why kick the habit on a fuel that is clean burning, cheap, convenient, and effective? Simple – *because you cannot make propane or natural gas*. Read that line again – should a disaster strike, or big brother decide not to make it available, you cannot make natural gas yourself. Electricity, you can make; natural gas is a total bust.

Firstly, you need to identify what appliances you have that run off NG, and secondly, what you use them for. We're not saying saw the pipes off and cap them, we're saying have a plan B to reduce or eliminate your dependence on NG, knowing that in a survival situation, it is often not available since the lines are failure prone, and even an EMP or similar act of terrorism can destroy the SCADA (electronic monitoring systems) that control the flow of NG.

First, let's address the appliances in a sample scenario that might use NG:

- Water heater
- Furnace

- Barbecue
- Gas range

Okay, so first off we can forget about the barbecue, because that can always be replaced with a charcoal grill. So that leaves us with a gas range, water heater, and furnace. Further drilling down to the low hanging fruit, consider replacing your gas range with an electric cook top.

This is sure to elicit gasps – it costs more to run an electric stove, it arguably cooks the food inferior to a gas stove, and it wastes power.

All of this might be true, *but we can show you how to manufacture solar power in abundance, but not natural gas!*

So that leaves us with the furnace and the hot water heater to deal with. Let's look at the hot water heater first.

GETTING RID OF A GAS WATER HEATER

We don't actually want to *get rid* of the heater, as we will see shortly – its body definitely has a purpose. We simply want to reduce our dependence on gas, and perhaps not use the gas heating feature when the weather is just right. Don't worry if you aren't getting it right now; we'll soon explain.

Hot water is quite literally what separated barbarians from civilized folk. The Romans' ability to not only make hot water but to plumb it into all sorts of buildings was legendary and ushered in a new era of civilization. We're definitely not suggesting that you try and live without hot water – we know we wouldn't want to!

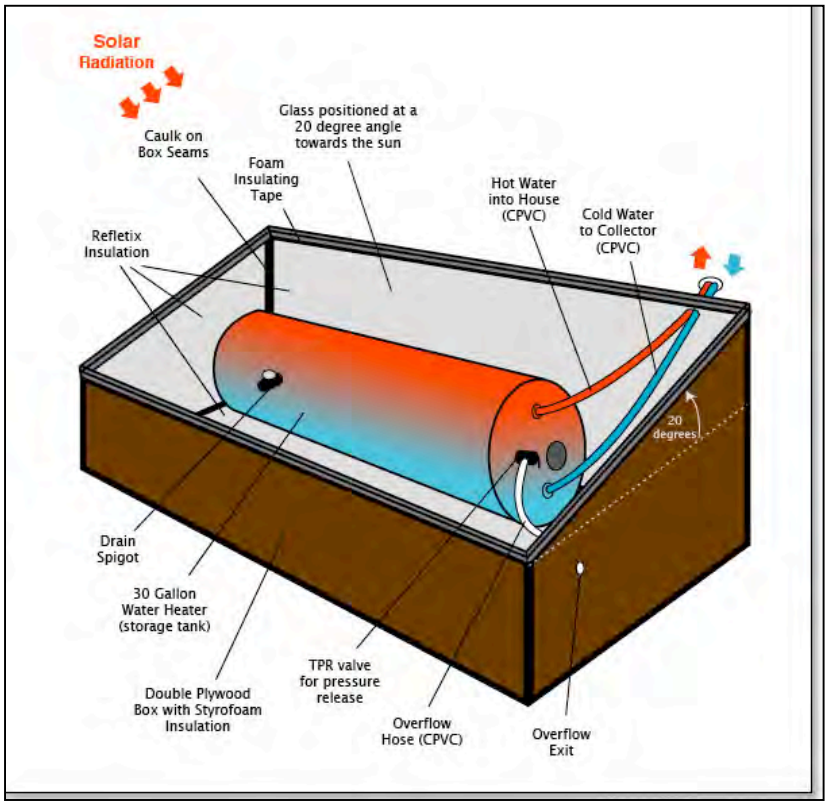


SOLAR WATER HEATING

You're already an expert on solar water heating, but you may not realize it. If you've ever felt how hot the water was inside a coiled garden hose that's been laying in the sun, you already understand solar water heating. Essentially, the light and heat of the sun is used to heat your water, and in many cases it can be a very effective system and reduce or eliminate your dependence on natural gas.

Solar heating is not a new system and has been around for over two millennia, providing reliable hot water wherever there has been sun, even in the winter months. Hot water temperatures can even exceed 150 degrees Fahrenheit and higher using a solar hot water system, so care needs to be taken to avoid scalding.

The first system we'll show you is the simplest – a batch style water heater.



A batch style water heater is the simplest and least costly water heating system available, and can be mounted anywhere where there is steady and constant sunlight. Here are some notes on the batch water heater:

- The heater tank itself can be made from an ordinary discarded hot water heater, many of which can be had for free.
- The water heater should be thoroughly cleaned, and painted *flat black*. This is important because flat black absorbs heat more than any other color.
- Construct an enclosure to house the hot water heater as shown, and line it with reflective foil insulation. This accomplishes two things: 1) insulates the compartment to avoid heat loss, and 2) reflects sunlight back onto the heater.

- *The whole assembly needs to be covered with a layer of plexiglass or lexan*. This is important because putting the whole assembly under glass raises the internal temperature, thus making the water faster.
- At night, cover the box with a thick blanket to avoid heat loss.

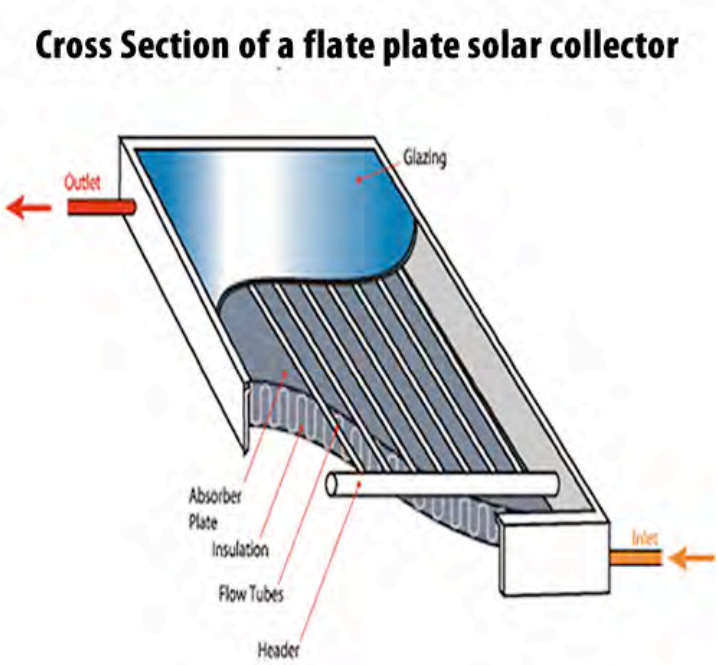
Batch water heaters such as the above can be made with discarded materials for almost no money, and are effective especially in the summer months in providing lots of hot water for free. They are a basic, rudimentary system for hot water making that can even be used in a rental home, since no modifications to the home need to be made other than a couple of small holes to plumb the unit. Depending on where you put the batch water heater, you may need a small electric pump to move the water back into the hot water heater, but mostly, the native water pressure of the home should be adequate to keep the water moving.

Note that this system does not replace your hot water heater – it feeds into it. As an added benefit, you get an additional water storage tank for emergency water, right on your property.

FLAT PLATE COLLECTORS

Where a batch water heater is impractical due to space or weight constraints, a flat plate collector can be used. Flat plate collectors are

nothing more than radiators, and they can be constructed out of common materials.

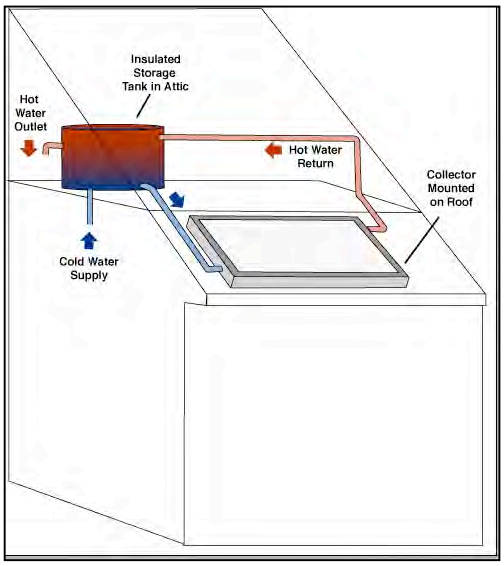


The one to the right is simply made using copper or PVC pipes, which are again painted flat black after assembly. The absorber plate is a piece of plywood or metal, also painted flat black, and backed by a layer of insulation underneath to keep heat in the box. A clear plastic cover is placed on top of the whole assembly to enhance the solar oven effect. Most of these units are sized between 20-25 square feet each, and are nominally 4' x 6' in size. Two such flat plate solar collectors are about right to supply the hot water needs of your average family of four. Buying versus building will be a personal choice, and pre-built units are readily available. Still, we think these are so simple to build that you can easily have two of them done in a weekend, for very little money. If you really have to have premade units, they are available, but cost more money since they are a manufactured item.

Copyright 2013 OffGridSurvivalSystem.com

INTEGRATED SOLAR WATER HEATING SYSTEMS

The flat plate solar collector, just like the radiator in your car, forms the basis of most solar water heating systems. If you're looking for an integrated hot water system that is fully tied into your hot water system, there are a few options available.

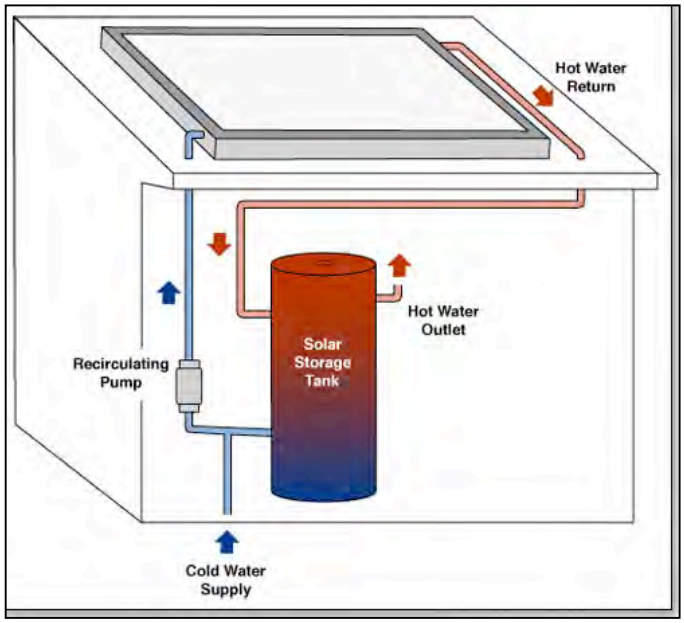


The system to the right uses a flat plate collector to warm the water, but places the accumulation tank inside the attic to combat one of the weak links of solar heating systems – night time heat loss. Night time heat loss is the bane of solar heat, because if the container where the hot water is housed is poorly insulated, the heat will bleed off during the night and the whole house will wake up to lukewarm water.

The attic based system resists heat loss because the accumulation tank is placed in a sheltered area – inside the attic – and heavily insulated, thus resisting temperature swings. If you were wondering how such a tank was going to make it into your attic, a 20 gallon cylindrical tank will fit through most attic vents with the louver removed. Another added benefit for homes that are concerned about lack of water pressure during a water outage is that the tank provides its own pressure through elevation.

Copyright 2013 OffGridSurvivalSystem.com

If an attic mounted water tank is impractical, the system on the right can be used. A flat plate collector is placed on the roof, and fed by a small recirculating water pump to get the water up to roof level. The hot water return is gravity fed, and is conveniently stored within the home's own water heater. This provides a couple of key advantages:



- The home's hot water heater is most likely already housed in a temperature controlled environment, and thus heat loss is not as much of an issue.
- While gas service is still available, the hot water heater can still be turned on, and in the middle of the night when the water starts cooling, the heater can kick on for a few minutes and maintain the temperature – even so, with the flat plate collector, the heater will work only a tiny fraction of the amount it did solely on natural gas.

SOLAR WATER HEATERS IN COLD CLIMATES

To say that solar water heaters are unaffected by cold weather is inaccurate; it's not so much the temperature drop that affects them as it is the lack of sunlight required to activate the collector. Cold temperatures don't affect solar performance as much as you think,

but lack of sunlight most definitely does. Since the sun is further away from the Earth during the winter months, its rays are weaker, and the tilt of the Earth means shorter days.

If you live in a cold climate such as that found in the Northeast, the best option would be to augment the flat collector with a tankless electric water heater powered by electricity. This will provide the added boost the water system needs to remain hot.

THE FURNACE

The angry air breathing monster you call the furnace is tough to get rid of and dispense with, mainly because modern homes in all but the Pacific Northwest (where they prefer radiant heat from baseboard heaters) use it for heat. Additionally, forced air homes usually contain a maze of rooms such that if there is a fireplace in the living room, there is no way that heat will make it back into the bedrooms.



There are a few things you can do to prepare for an extended off grid existence after or during a disaster in which your furnace is not available from lack of natural gas. Before you build anything in the following pages, before you hook up electric heaters or spend even a

dollar however, *it is imperative that you find and destroy all of the air leaks in your home.*



Realize that given a well insulated home with zero air leaks, it is possible to exist in the coldest of winters with not much more than a tiny space heater in each room. Okay, not many homes have zero air leaks, but here is what you can do to cut down on them:

1. Poorly fitting doors with gaps underneath, on top, or on the sill are the worst offenders for air leaks. If you can't solve every one by reapplying door flashing, put blankets or towels down to cover the air leaks.
2. Wherever possible, add insulation to your older home.
3. Thin, single pane windows that do not need to be opened in the winter can be made less leaky with clear plastic wrap duct taped into place. Heavy curtains also help.
4. If you have a fireplace, make sure your damper works or install a chimney cap to avoid losing heat from the chimney.

On the topic of fireplaces, what most homes currently have installed can hardly be called *true* fireplaces. First of all, your average masonry fireplace is only about 15% efficient. All that beautiful warm air goes straight up into the chimney and warms the sky rather than your living room.



For a true off grid scenario during winter months in the suburbs, we recommend a wood burning stove insert in your fireplace. These units are not fireplaces and they are not true wood burning stoves – they are a hybrid. The fit within your current masonry fireplace, and burn wood or pellets very efficiently, circulating the heat with an electric fan. The unit in the picture above can pump out an amazing 55,000 BTU in this manner, and heat a space up to 2500 square feet, no small feat. Some models of wood burning stoves can be had with grills or hot plate mounts on top so they can be used for limited cooking and water boiling applications.

Off grid winters in cold climates mean that the family must revert back to the way things were done in the old days, namely, that sleeping

bags and quilts need to be brought into the same room as the wood burning stove so that everyone can stay warm. A stove such as the one on the last page is more than capable of heating a home all year round during the winter in southern states, completely off the grid.

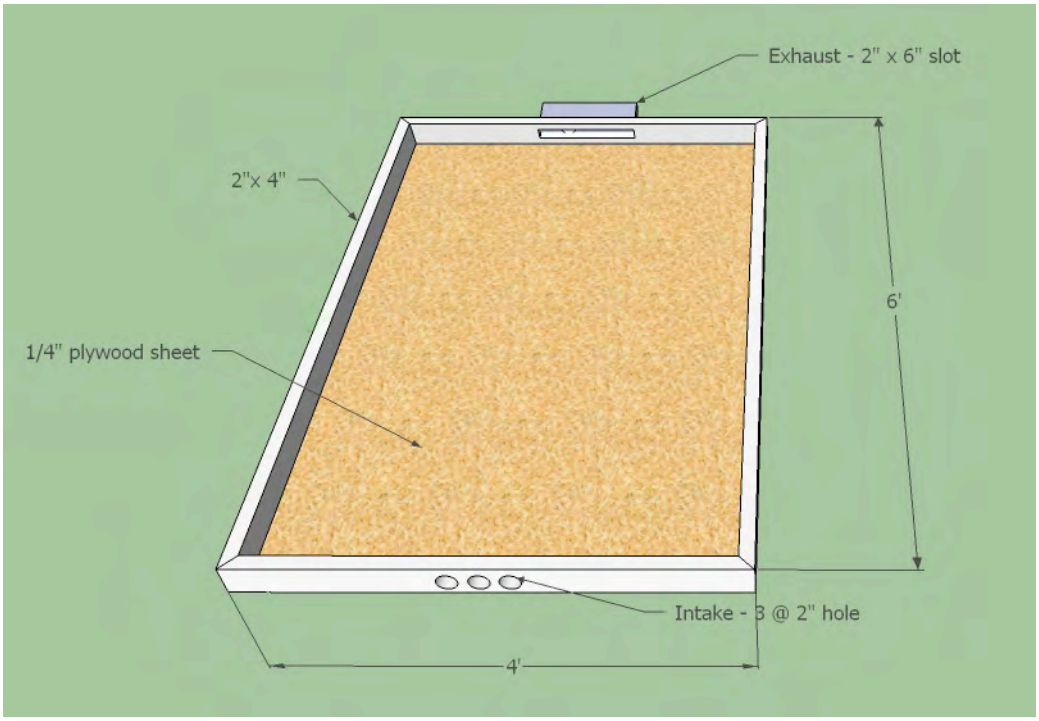
PASSIVE SOLAR HEATING

Wood burning stoves are great, and should be a prime consideration for heating your off grid suburban home, especially if you already have a fireplace. However, wood burning stoves have some undesirable features from an operational security standpoint, especially during and after a disaster, when your main survival strategy should be to not attract attention: smoke and smell. The distinctive plume of smoke from a wood burning stove can be seen for some distance, and its smell is also easy to discern, and both or either might attract unwelcome visitors. Additionally, a wood burning stove obviously requires the gathering of wood or wood pellets, which you should stockpile well in advance. It makes sense to come up with an alternate, noiseless heating method that once again harnesses the power of the sun, so that you can be freed up to do something other than feed the wood burning stove. A perfect tool for that is a simple passive solar heater, which can provide a remarkable amount of heat for a home while costing next to nothing, makes no noise or smoke, and can be built in a weekend by someone with less than average carpentry skills.

Passive solar heaters, also known as convection heaters, work under the pretty simple premise of convection, are amazingly effective, and can be constructed of scrap materials and garbage. Here's how:



1. Realize that these convection heaters can be as big or small as you want them to be. There's no hard and fast rule for how big they need to be. Obviously, the bigger they are the more heat they produce.
2. Using common 2 x 4 lumber, construct a simple tray with a ¼" plywood bottom.
3. Drill out exhaust and intake holes as shown on drawing (next page)
4. Insulate the box with standard Styrofoam insulation.



Remember, the box can be any dimension you want – these dimensions are just as an example.

5. Next, you will need to acquire aluminum beer or soda cans – how many you acquire depends on how big your heater is.
6. The principle of the heater is based on convection. Air must flow through the cans – and while they already have a hole on top, they require one on the bottom as well. Using a 1" hole saw on a drill, drill a hole on the bottom of each can. Discard the pull tab and flap on the top.
7. Arrange the beer cans so they lie horizontally within the array. If you size your array properly, the cans will fit tightly and require nothing more than some silicone caulk to hold them in place.

8. The beer or soda cans need to be stacked end to end as shown. Be sure to use a little silicone on the cans where they are joined. Simply butt the cans end to mouth with a little silicone between them to seal the whole arrangement, but do not plug the holes!



9. When all the cans are in place, it's time to spray paint the whole assembly black. The best types of paint to use are high temperature paints like barbecue or engine block paint. Matte black is the color they need to be for maximum heat transfer.

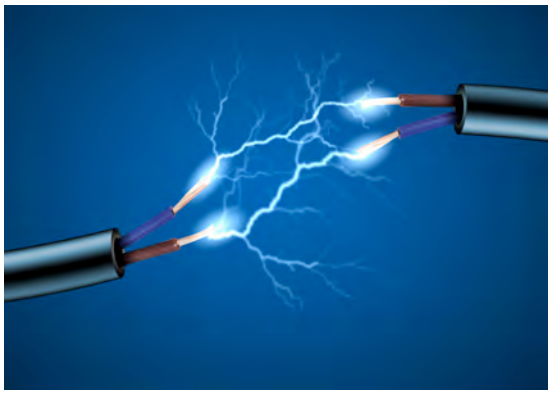
When this whole assembly dries, the final step is to lay a single piece of tempered glass on top of the whole assembly as shown in the first picture. Note that it does not have to be tempered glass as lexan or plexiglass will still work, but the advantage with tempered glass is that it will last for quite some time whereas plastic will grow more opaque with age, rendering the heater less effective.

Operation of the convective solar passive heater is simple – place the heater in direct sunlight. Cold air will naturally seep in the bottom through the holes, and as the cans begin to heat up, this cold air will be drawn up through the cans and become progressively hotter. This air will emerge from the top nozzle as super hot air – *over 140 degrees!* From

there, it can be routed up through a hose into the room you want to heat. This process is entirely passive, and will

push through quite a jet of hot air out, even in the winter. Builders of these heaters have recorded temperatures of over 160 degrees at the outlet– even in 40 degree weather. Convection is a powerful thing, and this heater can be used to silently heat your home. At that point, good insulation needs to take over and keep that heat within.

ELECTRICITY AND THE GENERATION THEREOF



So far, we've shown you a couple ways to replace your natural gas appliances with available solar technologies that in many cases, will work just as well. Now it's time to address the 800 pound gorilla – electricity. Now more than ever, the American home *needs* electricity. Not only is this need required to provide the comforts of life, it is also required in some cases to sustain life, like in the case of critical medical equipment such as oxygen machines.

Whether it's a need or a want, either way no one would really consider going for extended periods without electricity, and frankly, *neither would we*. Let's state one thing up front – if the funds are available, *you can replace every single watt of incoming power to your home with solar*

panels. That's right! The technology is there, and the technology is mature.

The only problem with this scenario, however, is:

- 100% replacement of your power with solar can often be prohibitively expensive.
- Some electronics and gadget laden homes consume more power than they can fit solar panels on their roofs, since after all, solar panels do take up space.
- If you want to replace every single watt, it can be done, but you're missing the point of off grid living.

The last one is really the clincher. Off grid living, even in the suburbs, is really about long term sustainability. Not only is it an environmental and green consideration, it is also a hedge against natural and manmade disasters, civil disturbance, and other catastrophe. It is about still being able to provide your family the rudiments of civilization even when others cannot. For this purpose, we don't really want to replace every single watt with solar, but if *you* want to, then go right ahead.

The average American home uses 1000 kilowatt hours (kWh) of power every month, or about 12,000 kWh per year. Analyze your own home for details of your own usage. Some of the power used is clearly for leisure and recreation, things such as:

- Watching television

- Playing video games
- Surfing the net
- Charging entertainment devices such as tablets.

Other power is used for things that in a pinch, you can really do without electricity. These are things such as:

- Opening the garage door
- Drying clothes
- Microwaving food
- Excess lighting where only a single bulb might be required

The point we are trying to make is that there is your typical monthly electricity usage, *and then there is your bare minimum survival usage.* Your solar system should be sized somewhere in between those two extremes capability-wise so as to provide a good balance between cost and performance.

So why solar? Why not other technologies? Pound for pound, nothing touches solar. Here are a few alternatives, however:



Generators: Portable generators are a short term solution at best, since you cannot safely tie them into your home's power system, they require frequent oil changes and regular maintenance not

to mention fuel, and they are loud, which is a tactical consideration. Whole home natural gas or propane generators are a better choice as they are tied into your home's power system, but they will only run so long as the gas keeps flowing. They too require frequent maintenance.

Wind generators: Wind generators are excellent on a large scale, such as a wind farm, and in an area that has regular and predictable winds. A single wind generator, however, won't produce much power and is not a good choice for true off grid living.



Solar power is the champ of power generation – it's clean, quiet, and most of all, ubiquitous. Prices on panels are slowly falling over time as well, and most anyone can afford a panel or two even if a whole home installation is not feasible. Additionally, panels can be acquired one at a time and joined to the home's system, so you really can build your system as you go.

Of course, some locales are better than others as far as access to reliable sunlight, but overall, solar power is a great choice for American homes.

OFF GRID VERSUS GRID TIE IN

Solar manufacturers usually make solar systems with two applications in mind – *pure off grid* and *grid tie in*. Off grid is just like what it sounds like – solar panels that provide 100% of a home's electricity without the home

having to be on the grid. By far the most common solar systems are grid tie in systems, the kind that millions of homes across America already have.

The two systems differ in one key point – *an off grid system has a way to store the power that it generates for when there is no sunlight, but a grid tie in system <u>does not</u>*.

This is a very important distinction, because one system (off grid) provides power even when it's dark or cloudy, whereas grid tie in systems become *useless* the second the sun sets. So why then are grid tie in systems so popular? Mainly because of the power bill reduction side – many homeowners generate enough power that they are able to sell it back to the power company and their meters will run backwards on super sunny days.

Grid tie in systems have one fatal flaw, however – they are all, by code, equipped with a failsafe system that locks out the solar panels from the grid in the event of a power failure. You heard that right – when the power fails, as it often does in natural disasters, your solar panels are dead as a doornail. This is for safety reasons; because your solar panels generate power whenever the sun is shining, power companies are worried that your panels will back feed into the grid and shock some unwary power line worker when the power is out.

While grid tie in solar is all well and good from a consumer standpoint, it is really a weak answer from a preparedness standpoint in that you're still basically on the grid and subject to the whims of the power company. We'll show you how to set up a system that isn't!

SOLAR POWER EXPLAINED

Here is how solar power is produced:



1. Solar panels absorb the rays of the sun.
2. Electrons within the silicon wafers become excited and produce electricity.
3. This electrical output is in the form of DC voltage. Realize there are two basic forms of voltage – direct current (DC), like in your car battery, and alternating current (AC) like in your wall plugs.
4. The solar panel's DC voltage won't power your household (unless you go all DC, discussed later), so you'll need an *inverter* to change the voltage to AC so your house can use it.

Some people aren't aware of the limitations of solar panels, and the way they work. Their output voltage changes all day long depending on the amount of sunlight available, so depending on the conditions, or whether

it's dark, your solar panel system's voltage will fluctuate. Basically, when it's dark, they don't produce a single volt of electricity, and when it's cloudy, overcast, raining or snowing, their power output levels are greatly reduced. Having said all this, solar is still a great choice.

STEP BY STEP SIZING OF YOUR SOLAR SYSTEM

Before we take you through sizing your solar power system, here is a handy reference that shows you the typical loads you'll find in your average suburban home, measured in watts. This will come into play later on.

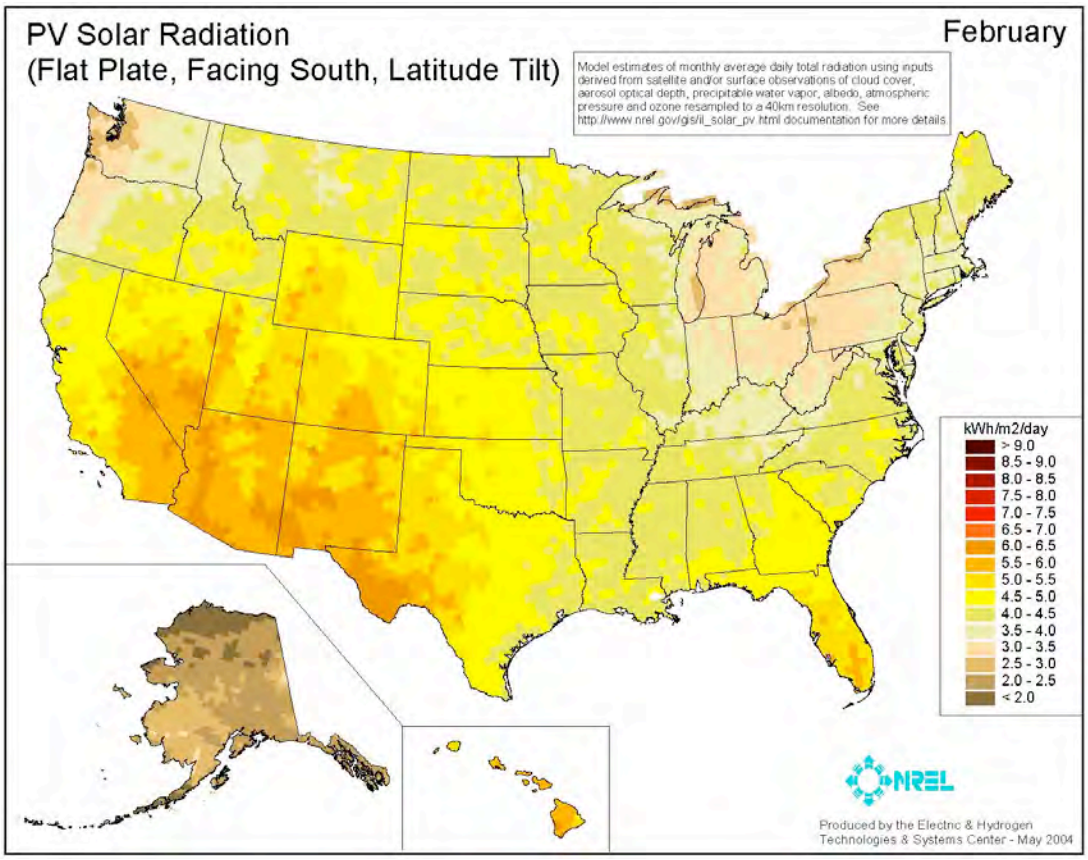
Aquarium = 50–1210 Watts
Air conditioner – central = 5000
Air conditioner – room = 1000
Clock radio = 10
Coffee maker = 900–1200
Clothes washer = 350–500
Clothes dryer = 1800–5000
Dishwasher = 1200–2400
Dehumidifier = 785
Electric blanket (*Single/Double*) = 60 / 100
Ceiling fans = 65–175
Window fans = 55–250
Central gas furnace = 750
Central oil furnace = 1500
Hair dryer = 1200–1875
Heater (*portable*) = 750–1500
Clothes iron = 1000–1800
Microwave oven = 750–1100
Computer CPU - awake / asleep = 120 / 30
Computer monitor - awake / asleep = 150 / 30
Laptop = 50
Radio (*stereo*) = 70–400
Refrigerator (*frost-free, 16 cubic feet*) = 725
Televisions (*color*)
- 19" = 65–110
- 27" = 113
- 36" = 133
- 53" - 61" Projection = 170
- Flat screen = 120

Toaster = 800–1400
Toaster oven = 1225
VCR/DVD = 17–21 / 20–25
Vacuum cleaner = 1000–1440
Water heater (*40 gallon*) = 4500–5500
Water pump (*deep well*) = 250–1100

Step 1: How much power do you need? As discussed earlier, it's impractical and unsustainable to replace every watt in your home with solar power, but you can if you want to. If you want to select individual loads, then use the chart above. If you want to replace

your entire power generation at the American average of 1000 kWh per month, we can do that too. Divide 1000kWh by 30, to get the amount of kWh per day: **1000/30 = 33.33kW per day**.

Step 2: How much sunlight does your home receive per day? Recall that solar power generation changes with the light, and the light is not constant. In order to find out how much your home receives, you must refer to a *solar insolation map* – yes, that's insolation *not* insulation. This is basically a sun map, and there are nationwide maps available on line. You can also find more detailed maps for your area.



The above maps are available at www.nrel.gov . Notice one thing about the map – first of all it is dated, and it is for a specific month. They also have yearly average maps, but the monthly maps are more specific and will tell you with greater detail what amount of sunlight you will get.

Also notice that the numbers are relatively conservative. For example, Southern California is shown as having only 5.5-6 hours of sunlight per day – the part you are missing, however, is that it is only 5.5-6 hours of *sunlight directly overhead* – the kind of light solar panels need. Check your area and follow along with our calculation. For our purposes, we'll go with 6 hours, but of course, it will change during different seasons.

Step 3: Calculate how large the solar system needs to be in kW. Based on the 1000 kW per month number we had before, we know that we need to generate 33.33kW per day, and we know from the solar insolation map above that we have *exactly six hours per day* to generate that power. **Therefore, the calculation is 33.33 / 6 = 5.55kW**. Our solar system needs to be able to generate 5.55kW per day in order to meet 100% of our energy needs per month.

Step 4: Account for system losses: Solar panels are nowhere near 100% efficient, and neither are inverters. From our above calculation, we need 5.55kW per day from the panels just to meet

the bare minimum of our needs. We need to add in a factor for inefficiency to our calculations. The industry accepted margin for error is a factor of 1.43. **Therefore, the calculation is 5.55kW * 1.43 = 7.94kW**

At this point, we know we need a solar panel system large enough to be capable of generating 7.94kW of power per day to meet our energy needs. Now, to size the panels.

SIZING THE SOLAR PANELS

Now we know that we need panels that will put out 7.94kW of power, and we need to select panels to do the job. Solar panels generally come in sizes of 50, 100, 200, 300, and 400 watt sizes, and weigh anywhere from a few pounds to close to a hundred pounds per panel. Most traditional gable roofs will have no trouble accommodating this weight, but when in doubt, consult a local engineer. There is no downside to using fewer larger wattage solar panels as opposed to using more numerous smaller panels, but the big ones may not fit on your roof. Following our example, here is the rest of the scenario:

THE INVERTER

Our sample system now is comprised of 20 solar panels, and this will power 100% of our daily electrical needs –but not by themselves! Recall that in their native state, solar panels output DC voltage, not AC voltage. We need an inverter to change the DC voltage over to something our home can use – AC power.

A sample panel we chose is a 400 watt solar panel. Its dimensions are 77.2" wide x 51.5" tall, by 1.57 inches

When sizing your inverter, you must take into account the *wattage of the devices you actually run in your home* as opposed to the output of the panels. Once again, this number is exactly what it says on your power bill. In our example, we determined that our daily power usage was 5.55 kW, and so in theory, a 6kW inverter would work well.

But wait – why have 7.94 kW of solar panels and feed that to only a 6kW inverter? Won't power be wasted? Yes and no. As we stated earlier, the increase in the panels over what we actually need was a fudge factor to account for bad weather and system inefficiencies. The one thing we do know, however, is that based on our example of 1000kW usage per month and 5.55kW usage per day, that a 6kW inverter would cover that nicely.

SIZING YOUR BATTERY BANK

Recall that the primary thing that differentiates a grid tie in system to a true off grid system is a way to store the energy. An off grid systems uses batteries to accomplish this goal, and that's why in the middle of the night the off grid solar user can turn lights on with abandon, and the grid tie in user must consume power from the electrical utility, as his system is *not currently producing power*. To calculate your battery needs, follow these steps:

Step 1: How much energy are you using daily? Our previous example revealed that we used 5.55kW worth of power per day.

Step 2: How many days without solar power can you run? Think about it for a moment- you will run a minimum of 12 out of every 24 hours *without solar power* because it's dark! Also, overcast skies or poor weather could degrade your solar panel's output. You can't have dead lights just because it's cloudy! For our example, let's suggest 2 days of running. This means we multiply 2 days by the average daily usage of 5.55kW, so 5.55kw * 2 days = 11.1kW. We will therefore need to store 11.1kW of power within our batteries.

Step 3: Account for discharge rates: We never want to discharge a battery to below 50% as it dramatically reduces the life of a (very expensive) battery. In our example above, if we only had 11.1 kW of storage space, and we ran for two days, our batteries would be run

down to zero. In this case, we need to make sure that the batteries do

not discharge past 50% after two days of drawing from them. This means you once again multiply by 2 – 11.1kW * 2 = 22.2kW. So what we really need are a set of batteries that can hold 22.2kW worth of electricity – this means that after 2 days of constant discharge, they will still have 50% of their capacity left.

Step 4: Convert to Amps: Batteries are sold in amps, not watts. The formula to convert to amps is simple – *amps = watts / volts*. In this case, we select the voltage we want the battery to have. For example, your car battery is 12 volt, your average golf cart battery is 6 volt, and your average heavy truck battery system is 24 volts. For a home solar system, 12 volts makes sense because the batteries are widely available, can be replaced in a pinch, and are relatively economical. Therefore, the calculation looks like this: amps= 22,200 watts / 12 volts= 1850 amps. Now your average 8D form factor battery contains 255 amps. If you divide 1850 by 255, you get 7.25 batteries required. Round up to 8 batteries, and that will store all the power you need for up to two days, plus leave a 50% reserve.

To recap, your average American home will need 20 – 400 watt solar panels, one 6kW inverter, and 8 – 255 amp 8D batteries to *completely remove itself from the grid* and be able to store power.

This system isn't cheap, but you can do much of the work yourself and prices are falling on the most expensive component, the panels themselves.

While a whole home solar system is a great way to go if you can afford it, it's best to start with a partial system that you can add on to, a couple of emergency use solar panels to power the essentials.

THE MINIMALIST APPROACH

While 20 panels and all that gear would be nice, this system will be cost prohibitive for most. The best strategy is to combine solar heating and solar water heating technologies with other methods of power reduction in order to reduce the number of panels you need. As we mentioned before – sure, you can power every watt in your home on solar, but why would you want to? Reduce the wasteful watts now, while you still have the chance to buy free gear at will. Mercilessly attack power wasters like:

- Incandescent bulbs
- Anything with an inductive load (heating coil) like ovens, electric stoves, refrigerators, and dryers.
- Make your home as air tight as possible so that your heating systems work more efficiently.

We've already shown how to cut out your water heater and furnace. There's still your clothes dryer, that 5500 watt monster that churns all day long. In an off grid situation, this is easily replaced with an outdoor or even indoor clothesline, so that's not a problem.

How then, do you go off grid with something like a refrigerator, which is usually 725 watts and can be much, much bigger depending on the size of the unit?

There are a couple of options here:

- You can go to a DC refrigerator of reduced capacity, which is entirely doable but will probably not impress with its size. DC refrigerators are usually meant for boats and motor homes, and thus are smaller, but their redeeming quality is that they take the power that panels make without any conversion, and thus can be powered by a couple of 400 watt panels with no need for an inverter.
- You can simply account for the refrigerator in your solar plan, and go with a larger system (like the example we presented a few pages back) to account for this extra load.
- You can go to some alternative food preservation system that does not need power to run...

The last point is one we will show you an example of.

REFRIGERATION WITHOUT ELECTRICITY

If you thought that mankind did not have a way to refrigerate food prior to the introduction of the refrigerator, you'd be very wrong. Mankind has been refrigerating food for thousands of years, all without electricity. We'll show you two methods of keeping your foodstuffs cool, without power.



ZEER POT

The zeer pot is an ingenious and simple method of refrigeration, and can most likely be made with materials you already have at home. It uses the scientific principle of evaporative cooling to operate; evaporative cooling is the effect that happens when water evaporates off of an object. The Zeer pot is a remarkably effective method of cooling; even though the outside temperature can be in the 90 degree range, Zeer pots have been demonstrated to cool to temperatures in the 40s, all without power. Zeer pots have been in use in some form or another for millennia, and are stupid simple to make and understand. Here's how to make one:

1. Obtain two terra cotta pots capable of nesting within each other, with approximately ¾" -1" space between them

2. Purchase or obtain clean sand; ordinary playground or construction sand will do just fine. Make sure the sand is clean.
3. You can use corks to plug the holes in the bottom of the terra cotta pots, or any other material like putty, so long as the bottoms are plugged.



4. Take the large clay pot and fill the bottom with an inch of sand, leveled out.
5. Place the second, smaller pot inside the first.
6. Next, fill the gap between the two pots with sand, leveling off the surface when it is full.
7. Your Zeer pot is now built and complete, now all you have to do is add water to it whenever you want to use it.
8. When you want to use the pot, dampen the sand by carefully pouring water over it until the sand becomes saturated with water. This will take a little time so do it carefully.

9. When the sand is saturated with water, you're ready to go. Put food within the zeer pot, and cover the whole assembly with a wet cloth over top.
10. Place the pot in a shaded but breezy location where a breeze will hit it.
11. Within 5-6 hours, the temperature will fall into the 40-50 degree range inside, regardless of how hot it is outside. Lift the wet cloth top sparingly as it lets the cold air out, and enjoy!
12. When is use, the Zeer pot will need to have water added to it a couple of times per day, or whenever the sand goes dry.

Zeer pots are a fantastic backup plan to off grid living, since refrigeration dramatically expands the shelf life of foods.

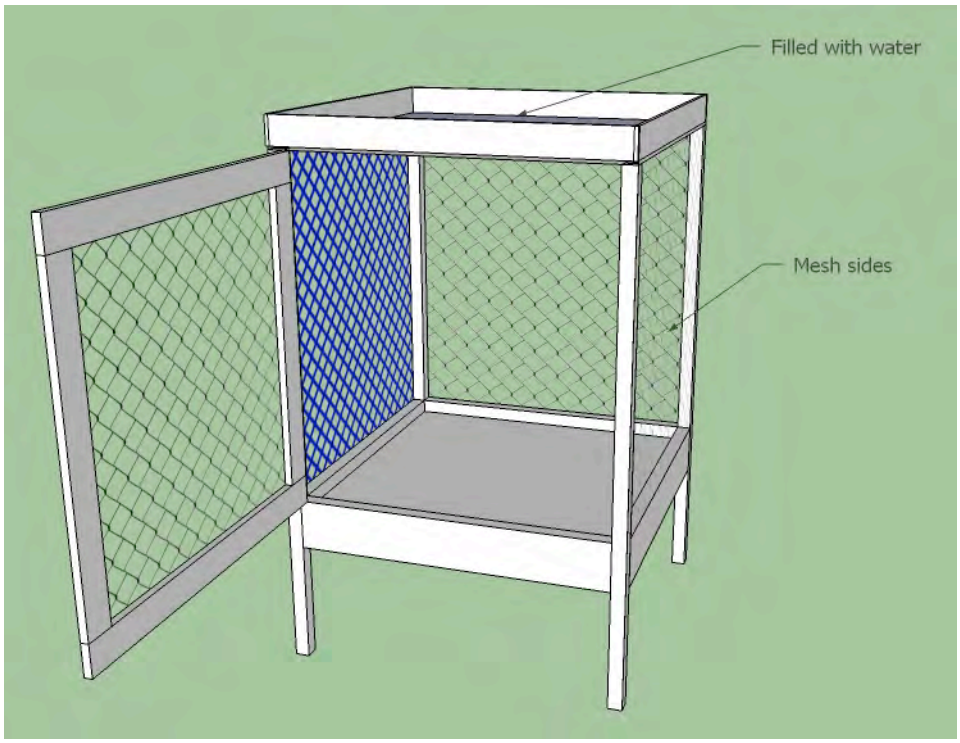
THE COOLGARDIE SAFE

The second method of refrigeration we'll show you works on a similar principle to the Zeer pot, but on a larger scale, and more closely resembles a conventional refrigerator. It's called the Coolgardie safe, and it's named after an Australian town called Coolgardie, a



mining town. A resident there in the late 1890s developed this clever device in response to residents needing a method to refrigerate food, and the Coolgardie safe was born. Remarkably, this device was so effective that it stayed in use as late as the 1940s and the advent of the modern refrigerator.

Coolgardie safes are easy to build with common materials, and you can build one yourself with minimal skills.



Construction of a Coolgardie safe is pretty simple, per the diagram, it's a wood framed box of the size of your choosing, but in any case, not too large. The one in the diagram is 36" tall by 24" wide and 24" deep, a good size without going overboard.

Construct the box as shown, and create a top tray to hold water. If you are so inclined this can be an epoxy lined tray that holds water, or alternately, it can be a metal tray that is glue to the top of the

box. The sides and door are mesh all the way around to allow airflow into the box.

Next, you need to cut pieces of burlap that are fastened to the sides of the box – *all four sides.* **Note: the burlap must start inside the water tray and cover all sides of the mesh enclosure, one strip per side, for a total of four sides.**

The way it works is easy. Pour water inside the tray, and capillary action will soon cause the burlap on all four sides to be damp all the way down to the bottom of the burlap. Place the Coolgardie safe in a place where it will catch a breeze, and soon enough the safe will become quite a bit colder inside than it is outside. It won't freeze food, but it will keep it at a nice low temperature without any power whatsoever, functioning on the principle of evaporative cooling much like the Zeer pot.

CONCLUSION

Living off grid in the suburbs is entirely possible, and in many cases, can be accomplished with as good a quality of life as you currently enjoy. Many old technologies, previously lost to history, are still valid methods of living, but we've forgotten them in our modern age.

Think of off grid living as a method of sustainable living, but also as a hedge against natural and man made disasters. Endeavor to learn the technologies of the past so that you don't get caught unawares by future events. Off grid living in the burbs is not only possible – how far you take it depends on how much you're willing to change; it's best to change now before the change is thrust upon you!