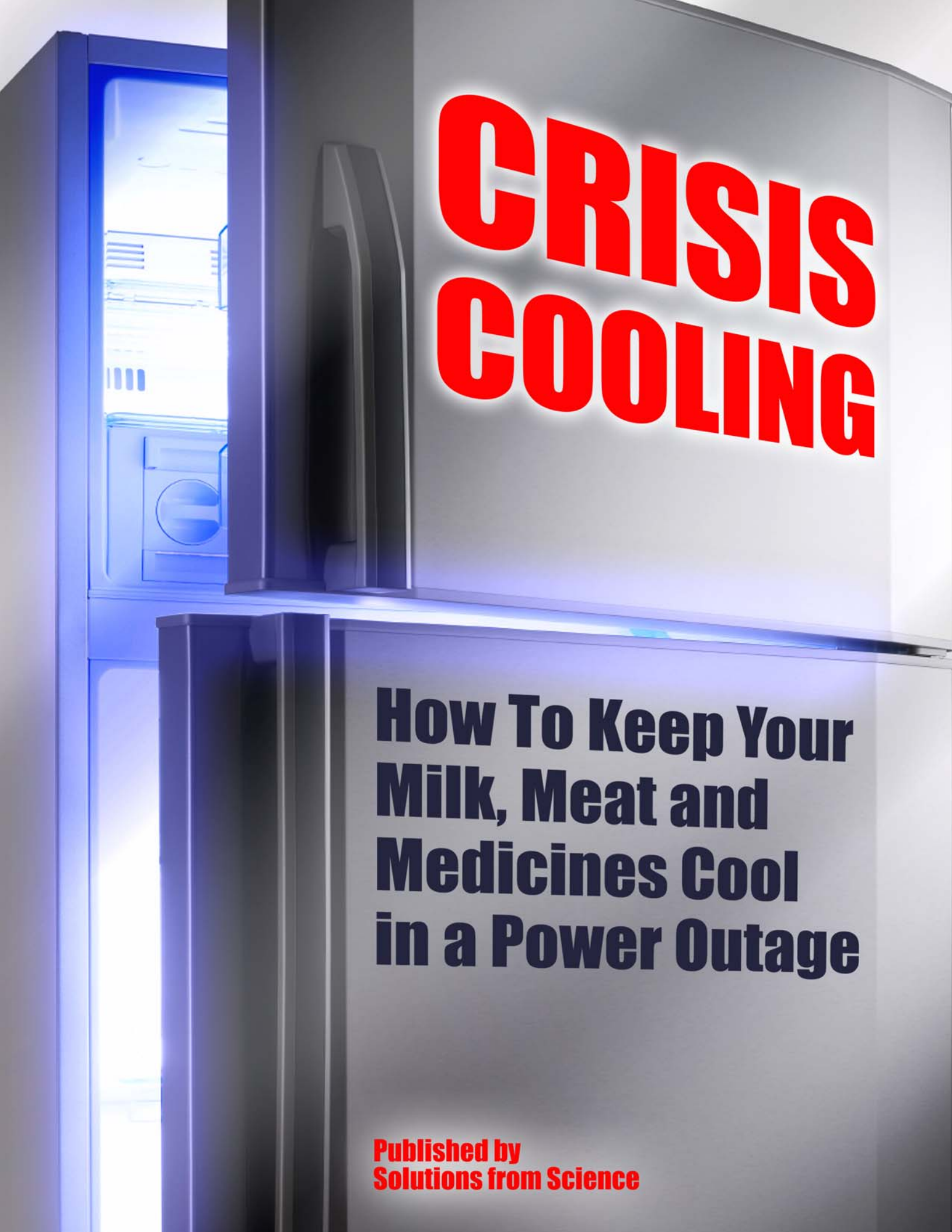

CRISIS COOLING

How To Keep Your Milk, Meat and Medicines Cool in a Power Outage

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Part 1:

Refrigeration 101

How To Keep Your Milk, Meat and Medicines Cool in a Power Outage

An Invention that Changed the World

One of the first models of refrigerators on the market.

The basic principles of refrigeration were mostly discovered and perfected during the 19th century, and in 1911 General Electric introduced the very first refrigerator specifically designed for home use.[1] In the 100 years since this invention first entered the marketplace, the refrigerator has become one of the most ubiquitous appliances in the world and at the present time. an astounding 99.5% of all American homes contain at least one of these invaluable machines.[2]

Refrigeration is wondrous because it allows people to store food for longer periods of time without spoilage, as the cold temperatures inside a refrigerator retard the growth and development of bacteria, fungi, or any other microbial agent that might be present inside of food. In addition to the direct benefits offered by the home refrigerator, the principle of refrigeration also makes it possible for foods to be shipped long distances, and makes it possible for retailers to stock foods in their stores for longer periods of time. Refrigeration has revolutionized the eating habits of people all over the world, and it is a testament to how spectacularly successful this technology has been that most people take its miracles completely for granted and could not imagine trying to get along without having a refrigerator in their home.

But in evaluating the importance of refrigeration, we must not forget that it is largely a symbiotic type of technology. That is, the kind of refrigeration we have become used to relies on electricity to function, and without this other astonishing miracle of science, refrigeration as we know it would quickly cease to exist. Fortunately for the companies that introduced electric refrigerators into the marketplace, once everyone's homes and apartments had been wired to the electrical grid, purchasing a home appliance that needed to be plugged in 24 hours a day presented no problem whatsoever.

To the average consumer, the preceding probably seems like a trivial observation. Electricity coming through wires to their homes, in the minds of most, is as automatic as breathing. But for those who have chosen to take their families off the grid, there is no such thing as automatic, especially not when it comes to electricity. Off-the-grid living is a satisfying and rewarding way of life, but it is also a complex amalgamation of self-sufficiency and sacrifice—you may be free from a system that imprisons you in many ways, but at the same time, you will no longer be able to ignore the limitations

and realities of nature. For those who have left the electrical grid behind, power is a precious commodity and a valuable resource. Whether they are relying on wind, solar, hydropower, or a personal generator to produce their electricity, its supply is neither unlimited nor 100% dependable. Of course, the power supply of those who are living on the grid is also fragile, especially in the long run, and those who assume their electricity will be there forever are living in a fool's paradise. But in the off-the-grid world, dealing with electricity as a scarce resource is a part of daily reality.

So for those embracing this way of living, the question must be asked: how does refrigeration fit into the bigger energy use picture? The answer is, it provides one of the biggest challenges that will be faced, because the refrigerator can be a prodigious user of precious power resources. By some estimates, an average conventional refrigerator can use between 3,500 and 8,500 watt hours of electricity per day, which makes it the highest energy consumer among all household appliances.[3] For those attempting to survive without depending on the grid, anything that uses this much energy is problematic, and it clearly behooves anyone in this situation to leave no stone unturned in the search for ways to reduce the amount of power they must use for refrigeration.

The other important big picture aspect of refrigeration is that it, unlike many ubiquitous technological innovations, really does serve an important purpose. Refrigeration allows for much more efficient storage and preservation of food supplies, and because off-the-gridders must practice efficiency in all things, trying to get by without a refrigerator may not be an especially attractive option. But nevertheless, the reality is that non-grid

power sources in most circumstances are inherently intermittent, and there may be times that the energy needed to continue running a refrigerator is simply not available. Also, in emergency situations, it may be necessary to divert power supplies for other, even more vital, uses. For each of these reasons, those practicing a survivalist lifestyle need to be prepared to go on without electrical refrigeration should that become necessary, possibly for a brief time, but maybe even permanently, if circumstances prove especially daunting. So, if there are alternatives to the electrical-powered refrigerator available, preppers should know about them and investigate them fully.

But before we look more closely at the options available for those who urgently need to save energy on refrigeration, let's take a brief look at exactly what is going on inside of those magical boxes that sit quietly in the corners of our homes, working tirelessly and relentlessly to make sure that our foods and drinks stay cold and fresh.

How Refrigerators Work: A Primer

Among other things, the Second Law of Thermodynamics tells us that when two surfaces with different temperatures come into contact, heat will always flow from the hotter surface to the colder until equilibrium in temperature has been achieved.[4] It is this inviolable law of nature that ultimately led to the invention of the refrigerator, which operates by facilitating the transfer of heat out of its inner compartments, where it can then be transported to the outside and vented into the open air.

The oldest type of cooling "technologies" took advantage of the Second Law of Thermodynamics and the heat transfer it describes by using ice or snow to keep foods cooler. This natural form of refrigeration worked quite well right up to point where the ice and snow would melt, after which it would need to be replenished in order for the process to keep on working. This most basic form of cooling has been around since time immemorial, and as anyone who has ever watched the classic TV show *The Honeymooners* knows, the old-fashioned ice box continued to be used right up into the mid 20th century.

In reality, however, the icebox and all of its crude predecessors were inconvenient, inefficient, and time-consuming to use. Fortunately, a scientific principle called the Third Ideal Gas Law, or Charles and Gay-Lussac's Law (in honor of the two 19th century French scientists who discovered it), provided the key that unlocked the door to a far superior form of cooling for the purposes of food preservation.[5]

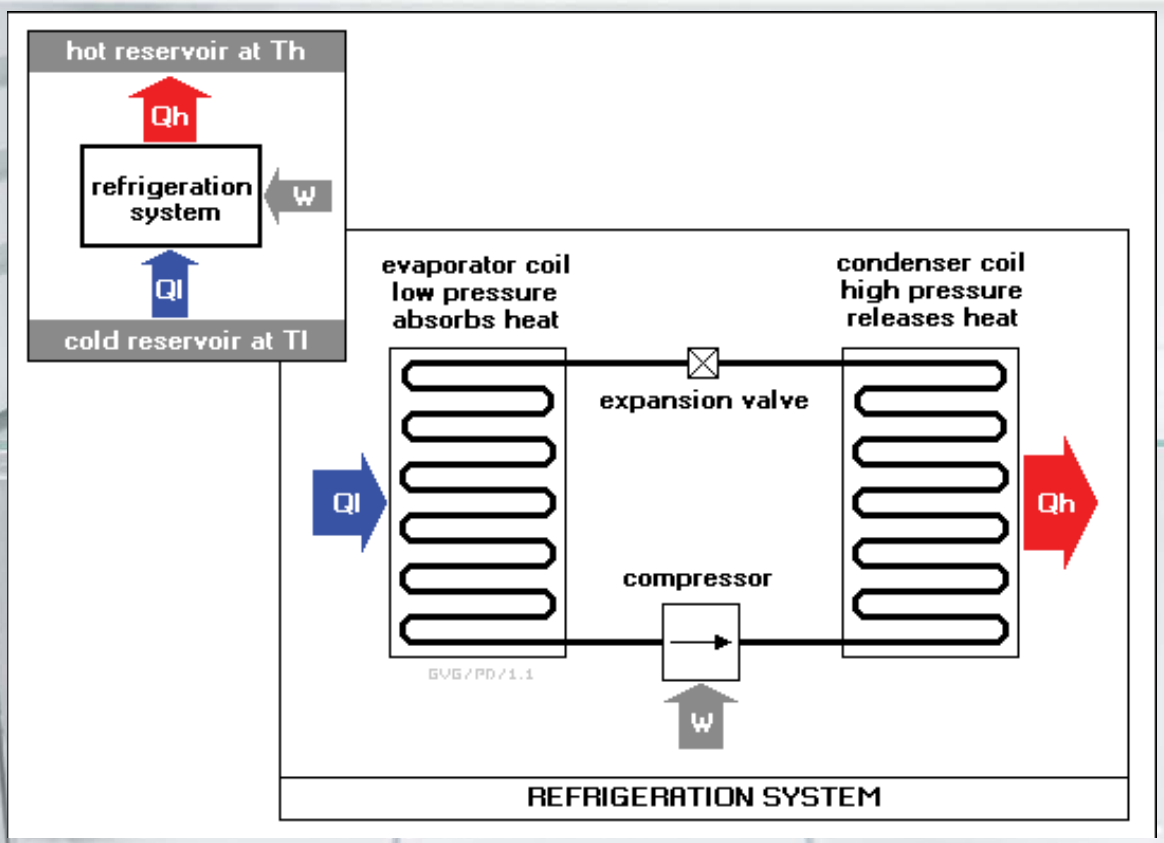
The Third Ideal Gas Law states that a gas will decrease in temperature as it decreases in pressure, and vice versa. What this means is that it is possible to create a natural cooling effect in a confined area simply by changing and manipulating the temperature of gases.

The physics of the refrigeration process is somewhat complex, but the important point is that the types of gases that boil at normal atmospheric temperatures and pressures can be heated and cooled and turned from liquid to gas and back again on demand. This property gives them the ability to cool warm spaces by removing heat and dumping it into the surrounding atmosphere efficiently and conveniently.

Refrigerators: An Inside Look

Without its refrigeration equipment, a refrigerator would be nothing more than an ordinary, rectangular, metallic box taking up space. In order to turn that box into a fully-functioning perpetual cooling machine, the following items must be provided and installed:

- A motorized compressor
- A system of refrigerator condenser coils
- An expansion valve
- A chemical that can be converted from gas to liquid and back again
- Electrical wiring
- The control switch
- A cooling fan
- A small amount of interior insulation



A diagram on the principle of refrigeration

The chemical gas used is, of course, the secret ingredient here. Without the proper gas, the mechanical system of the refrigerator would not be able to accomplish anything. Older refrigerators used a form of chlorofluorocarbon called *Freon*, which has now been phased out because of the alleged effects it has on the atmosphere's protective ozone layer when it leaks or is released. Newer fridges now usually use a chemical with the catchy name HFC – 134a (tetrafluoroethane). This chemical not completely harmless, but it supposedly causes less environmental damage than Freon.[6]

Regardless of which gaseous refrigerant is present, it will be made to circulate throughout the refrigerator's extensive coil system, which is a sort of continuous Mobius strip that winds from inside to outside and back again. When the chemical inside the coil moves from outside to inside it goes through a modulating device called an expansion valve, which reduces its pressure and allows its temperature to drop (remember the Third Ideal Gas Law). As this low pressure gas then circulates on through the interior of the fridge, it picks up heat from the inside compartments and carries it forward through the refrigeration system. At a certain point, the motorized compressor will begin to perform its duty, condensing all of the passing refrigerant into a tighter and tighter space until it heats up to a temperature that surpasses that of the outside air. This superheated coolant will then be sent on to the outside section of the coil, where the process of heat exchange takes over and excess heat is released into the surrounding atmosphere. And round and round we go, until the control switch senses that the desired amount of heat has been removed from the fridge interior, at which point it shuts off the compressor so the system can rest for awhile. Once temperatures on the inside begin to rise, however, the control switch will send a signal to the compressor letting it know it is time to go back to work, and the process will begin all over again.

All of this is very ingenious, but when you break it down, the technology involved is really not all that complex. In fact, the whole thing is simple enough that there are plenty of people out there who have figured out how to build their own fully functioning electrical refrigerators. Uncovering the secret science of refrigeration was the key breakthrough, and once the principles of electrical generation had been discovered and developed, the invention of the modern refrigeration systems that have changed our world and that we have all grown accustomed to was inevitable.

Part 2:

Finding the Perfect Refrigerator

How To Keep Your Milk, Meat and Medicines Cool in a Power Outage

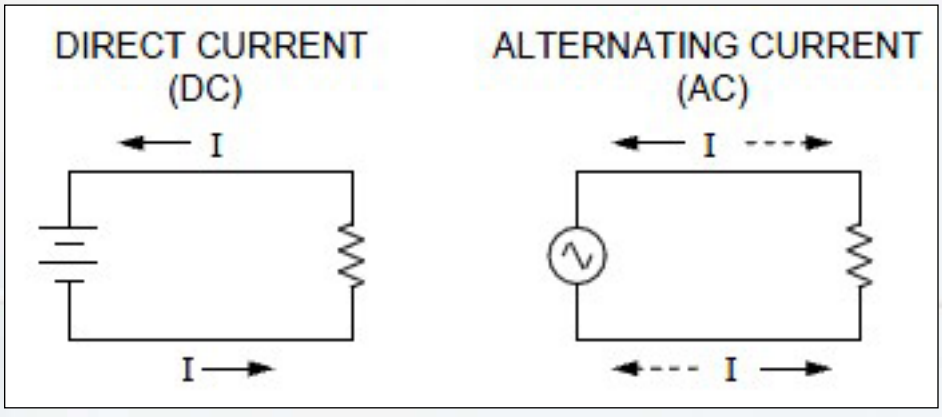
The Refrigeration Revolution

Most probably still remember those historic days of the late 1980s, when revolution in Eastern Europe ultimately led to the downfall of a Communist empire that had existed for more than 70 years. But just a few short years later, there was another revolution that most might have missed—the refrigeration revolution. While it can be hard to pinpoint an exact date when things changed forever, many have identified 1993 as the cut-off year that separates the era of the older, energy-gobbling refrigerator monsters from the new era of the sleek and efficient energy savers. But there is no question that at some point in the last 20 years a revolution did take place, and as a result it is now possible to buy a new refrigerator that uses only one-tenth as much energy as a model that was manufactured in 1990.[7]

The old obsolete models have not disappeared from the market completely. Used ones can still be found, and often at a bargain price. But in this case, the word "bargain" is relative, to say the least. In comparison to an energy-efficient 21st century model, it is estimated that a refrigerator manufactured in the 1980s and still in use now would increase electricity costs for the average consumer by more than $100 per year, while a model made in the 1970s would use $200 more a year worth of energy.[8] Needless to say, a new energy-efficient model will pay for itself in just a few years at the most, and of course, if we are talking about an off-the-grid living situation, then obviously reducing electricity usage is something valuable in its own right. So when you look at things from this broader perspective, it is clear that, just like international communism pre-1993, refrigerators should be confined to the ash heap of history.

AC or DC? Tesla vs. Edison Revisited

In the epic battle of the electric currents, Nikola Tesla's alternating current emerged as the clear winner over Thomas Edison's direct current. But there is something to be said for DC, which can be a simple, convenient, and efficient form of power in its own right.



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Most off-the-grid homes these days are making use of an inverter, which allows direct current tapped from battery banks to be changed into the alternating current that is necessary to run most household appliances. But inverters are not exactly perfect—they suffer losses, they have limited capacities, and they sometimes can fail completely, which can leave an all-AC household in quite a bind.

Fortunately, there are refrigerators available that run on DC exclusively, so any home that has a battery bank capable of putting out 12-volt or 24-volt DC power will have some extra options available. Granted, DC refrigerators are generally small, and these units are best suited for use on boats or in RVs, but larger units which run on direct current options are now starting to show up on the market. So while a traditional AC fridge is certainly an option for those who have inverters, it may not be necessary to go that route if AC demand is already tight.

Size Matters

Certainly everyone has a general idea that big refrigerators use more power than small ones. But if you are thinking this means getting the smallest refrigerator you can cram everything into is a wise decision, think again. You need a refrigerator that can hold everything you need it to hold comfortably, and cool everything you need it to cool efficiently, because this is what will save you the most money in the long run.

Refrigerators that contain between 16 and 20 cubic feet of space will deliver the most cooling bang for the buck for the average-sized family.

For warm air to flow smoothly and efficiently out of interior compartments, it must have room to do so, and when a refrigerator is packed tightly, it impedes the heat exchange process. Because heat takes longer to remove, the compressor will have a longer daily duty cycle (which is just the technical way of saying that it will be turned on more often and ultimately wear out more quickly).

A good rule of thumb is to try and select a refrigerator that will never be more than approximately half full. If each shelf or compartment has a square inch of empty space for each square inch of refrigerated food or drink, this is the ideal situation. Of course, if a refrigerator would only be filled beyond this point once in a blue moon, a smaller unit would probably be okay.

From the standpoint of pure energy efficiency, refrigerators that contain between 16 and 20 cubic feet of space will deliver the most cooling bang for the buck.[9] So when it comes time to purchase a new model, those who generally fill their fridges with about 8-10 cubic feet of stuff will be the ones who find themselves sitting in the cat bird's seat.

The Devil is in the Details

These days, a refrigerator is more than just a refrigeration box. It is also a freezer, an ice maker, a water dispenser, and it can now defrost itself automatically so all the fuss and muss that used to be associated with manual defrosting is largely a thing of the past.

But here's the thing: all of these wonderful extra amenities that add so much pleasure and joy to the modern refrigerator experience will also add plenty of extra watt hours to a fridge's daily log of electrical usage. This revelation is just common sense, really, since all of these processes obviously require extra work to be done, they will inevitably cause an increase in the amount of power required to keep a refrigerator humming along smoothly. So for off-the-gridders who plan to stick with conventional AC, it would be beyond wise to avoid these extra amenities if at all possible.

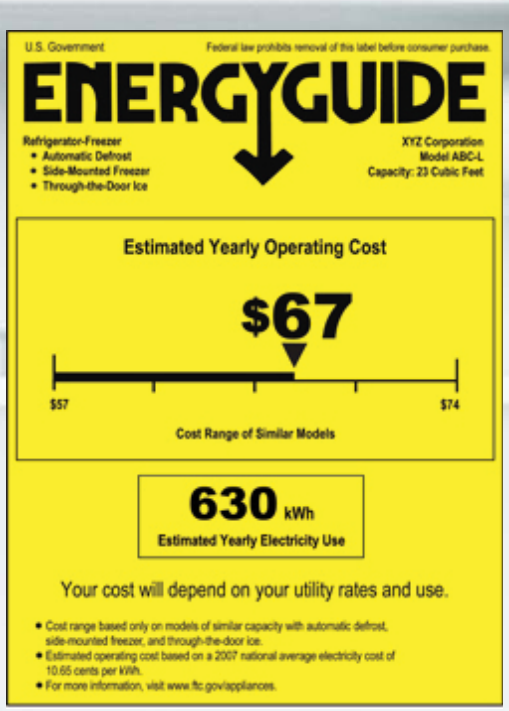
Unfortunately, it can sometimes be hard to find anything that does not have these features, especially automatic defrosting. It is unclear whether or not a self-defrosting unit can be safely disconnected without interfering with the normal operation of the machine, therefore only a trained refrigerator technician should be allowed to attempt this kind of modification. At the present time, only smaller refrigerators like those made for apartments or dorm rooms come with manual defrosting.

Twinkle, Twinkle Little Energy Star

Energy efficiency has become all the rage these days, which is a good thing for the environment but also a good thing for the consumer. Minimum federal standards for energy efficiency in home appliances have been around for awhile, but in 1993 the Environmental Protection Agency decided it was time to come up with something even more stringent and demanding—the ENERGY STAR qualification program.[10]

To put it simply, ENERGY STAR appliances use less energy than other types of appliances. In the case of refrigerators, energy used during normal operation must exceed minimum federal standards by 20% or more in order to qualify for an ENERGY STAR designation. This does not mean that all such fridges are created equal, however; the 20% reduction is in comparison to other refrigerators of similar types, so an ENERGY STAR machine with ice maker, water dispenser, state-of-the-art automatic defroster, and 24 cubic feet of cabinet space would no doubt still use more energy (possibly a lot more) than a non-ENERGY STAR fridge with smaller dimensions and fewer amenities. This means that anyone looking to purchase a brand new electric refrigerator, whether living off the grid or not, should view the ENERGY STAR label as an excellent starting point for their search, but that does not mean it is the beat all and end all in and of itself.

Looking for the EnergyGuide Label



Fortunately, there is something else mandated by the government that is even more useful for the refrigerator buyer than the ENERGY STAR program—the EnergyGuide label. Since 1987, all household refrigerators have been legally required to meet minimum standards for energy consumption as outlined in the National Appliance Energy Conservation Act (NAECA), and as a result of this legislative edict the EnergyGuide label was added to all new home appliances.[11] To put it succinctly, this bright yellow sticker basically tells potential consumers everything they ever wanted to know about electric appliances but were afraid to ask, and as such it is a vital and invaluable source of information for anyone who plans to buy a new or refurbished refrigerator.

If the appliance in question is indeed a refrigerator, the EnergyGuide label will contain the following important information:[12]

- The Basics – make, model, and size in cubic feet
- Key features included – water dispenser, ice maker, self-defrost, etc.
- Estimates of kilowatt hours used per year (for normal usage)
- Estimated yearly operating costs (based on the national average of electricity costs at the time the machine was manufactured)
- Energy cost ranges for similar models
- The ENERGY STAR logo, if applicable

For the purposes of comparison shopping, this is the information that every refrigerator buyer needs to know before they make their final decision. But obviously, even a lemon looks good before it is cut open and eaten, and just because a particular machine seems to have the right specifications, that is no guarantee it will actually work the way it is supposed to when it is put into use. Therefore, before purchasing any new refrigerator (or a used one, for that matter), the smart thing to do is to visit online forums and retail websites to read the reviews that users have been leaving about any fridge being considered.

Sun Frost: State-of-the-Art for Off-the-Grid

All Sun Frost models are available in 12 or 24 volt DC, or 110 or 220 volt AC.

One question will probably occur to many: are there certain brand names that are better than the others? Generally speaking, the answer to this question is no, the particular characteristics of a refrigerator are more important than brand name, especially when an ENERGY STAR label is present. However, there is one company selling a line of electric refrigerators that are just perfect for those who are trying to make things work off the grid—Sun Frost.

Sun Frost refrigerators and refrigerator/freezers are specially designed to work with home solar energy systems or other renewable sources of power. These refrigerators are the cream of the crop in energy efficiency, as most models use less than half of the energy that is required to run normal energy-efficient machines of similar dimensions.[13] While Sun Frost does have units available that work on either AC or DC, it is their 12- and 24- volt DC models that achieve the highest levels of energy efficiency, since direct current can go straight from battery bank to appliance without the intervention of an inverter, thereby reducing energy loss by up to 10%.[14]

There is really nothing revolutionary about the Sun Frost refrigeration system. What sets Sun Frost apart is just excellence, pure and simple. The manufacturers of these refrigerators have embraced the principles of sustainable design to the fullest and have

condensed and streamlined everything as much as possible. Sun Frost refrigerators generate little heat or noise, run much less frequently than other models, preserve food up to three times longer than conventional refrigerators by maintaining high humidity levels in the interior, and can last up to 60% longer than normal energy-efficient units.[15]

So is there a downside to Sun Frost? Yes, there is, and it is exactly the one you would expect. In life you get what you pay for, and the high-quality refrigerators produced by Sun Frost do indeed come with a hefty price tag. Even their medium-sized refrigerators or fridge/freezer combos sell for $2000 or more, and a full-size model can cost as much as $3500.[16] In all honesty, the money saved on electric bills for those living on the grid probably would not be enough to offset the cost of a new Sun Frost refrigerator, which is why it really is a better choice for people who have abandoned the grid and need to keep their energy usage down because supplies are so precious. Probably the best thing that can be said about Sun Frost refrigerators is that they represent the shape of things to come, as it is inevitable that some of the innovations that set them apart will gradually be adopted by other manufacturers looking to improve the design of their cooling machines. The fact that they are actually customized specifically to be used with solar photovoltaics or other forms of energy that rely on battery storage is especially exciting, since any imitators that come along are also likely to produce refrigerators that will work nicely in an off-the-grid setting.

There is no doubt that, at this point in time, preppers looking for an electric refrigerator will not be able to find a better option than a Sun Frost. Nevertheless, the strain on the budget that a decent-sized unit carrying this brand name is likely to cause will make these refrigerators unaffordable for many. One can only hope that more affordable machines which share Sun Frost's excellent features and design principles will be coming onto the market very soon.

Riding the Propane Train

While all who embrace the survivalist lifestyle strive for energy independence, because solar and wind energy set-ups are so expensive, many have been forced to rely on propane to meet at least some of their power-related needs. For this reason, propane has been referred to as the "dirty little secret" of off-the-grid living, as many have been forced to swallow their pride and turn to this natural gas byproduct to help them get by.[17]

Propane refrigerators have a well-established presence on off-the-grid homesteads, as many looking for an alternative to the electrical fridge have chosen this tried-and-true option. This is actually a better choice now than it was in the past, as the technology that supports propane-based cooling has advanced to the point where fuel costs are not normally prohibitive. Propane fridges have also been getting bigger, so preppers using propane no longer have to rely exclusively on smaller units that were designed primarily for use on boats or in RVs.

EZ-Freeze is one of several companies that manufacture propane refrigerators. EZ-Freeze is an Amish company which manufactures in the USA

But regardless of the advances that have been made, the fact remains that propane is off-the-grid in name only, as reliance on any kind of fossil fuel for energy production is just another kind of dependence that leaves us vulnerable to price spikes or the cut off of supplies during an emergency. Making things worse is the fact that a brand new, full-size propane refrigerator will cost as much as some Sun Frost models, even though in the end the amount of money spent on propane to make such a unit run will surpass the electricity costs of a normal AC refrigerator plugged into the grid by about a 2-to-1 margin.[18] Clearly, what we are talking about here is something far removed from real energy efficiency and independence.

As a final alternative, a propane refrigerator for off-the-grid use might be better than nothing. But in terms of cost and reliability, anything that relies on fossil fuels that must be produced and shipped from elsewhere is not likely to be of much help if and when troubled times arrive.

Part 3:

Maximizing Refrigerator Efficiency –

Giving the Cold Shoulder to Energy Waste

Energy efficiency in refrigeration starts with a good buying decision, but it definitely does not end there. While the refrigerator might seem like the quintessential "plug it in and let it go" technology, in reality this is far from the case. Or at least, it should be far from the case. With a self-defrosting model in particular, it is certainly possible to just plug a fridge in and let it run until it stops working, and since refrigerators are hardy machines you might be able to get a good 10-12 years out of it that way, if you are lucky. But this non-reflexive approach to refrigeration is a real loser, because like all complex beings either living or mechanical, refrigerators need maintenance, care, and attention if they are going to thrive and survive, and use energy efficiently.

There are a number of ways to maximize refrigerator performance so that each valuable kilowatt hour that is expended to keep it running is used as effectively as possible. Ultimately, the more intelligently a refrigerator is managed, the less frequently its motor will have to run, which will save money on energy, reduce the amount of energy infrastructure needed to meet power demands, and potentially extend a fridge's lifespan several years beyond the decade or so a neglected unit can be expected to last.

14 Terrific Tips for Perfect Refrigerator Performance

While rugged, sturdy, and dependable, a refrigerator is also a finely-tuned machine that requires consistent maintenance and smart usage patterns to keep it functioning at the highest possible level. The beautiful thing is that what is good for the refrigerator is also good for its owner, because when a fridge is performing at a peak level, its expenditure of energy and use of electricity will be minimized. This is what is most amazing about the technology behind refrigeration—it is actually designed to be lazy, in the sense that when it is working the best, it is actually working very little.

Since the manufacturers of energy efficient refrigerators were nice enough to provide people with machines that are designed to save them as much money as possible, it seems like the only fair thing to do in return is to give these cooling machines all the respect they deserve by taking steps to ensure that they remain in excellent working order. This is the honorable thing to do, and the fact that it will save money and cut down on energy usage is just a nice added bonus.

What follows, then, is a 14-point action plan that will help refrigerator owners everywhere make sure their energy-efficient machines are delivering the optimum in low-consumption cooling performance.

Tip #1 – Keep the Door Closed!

Generally speaking, a refrigerator with its door left open will use a lot more energy than one with its door closed, since an open fridge will essentially be trying to cool an entire

house. So keeping the door of a refrigeration unit closed is one of the very best ways to guarantee that it will be able to do its job properly.

We are being a little tongue-in-cheek here, obviously, but there is a method to this madness. For while it may sound silly to hear someone talking about the importance of keeping a refrigerator door closed, let's remember that, in point of fact, we *do* open our refrigerator doors and leave them open for a significant amount of time each and every day. Of course I am talking about the fact that we all open our refrigerators dozens of times each day to take things out or put things in, and if we ever bothered to add up the total number of minutes that a refrigerator door is open during the day, we would probably be surprised to see how big that number actually is. Because cold air sinks, every time we do this, a good portion of the refrigerated air that had been contained inside the fridge will immediately spill out onto the floor, and the compressor will have to kick on much sooner in order to make up for what has been lost.

According to an analysis performed by *Home Energy* magazine, about 7% of the energy used by a refrigerator can be traced to the extra load added by door openings.[19] But this assumes a normal pattern of behavior—another study from the University of Florida found that those with poor door opening habits could use as many as 100 extra kilowatt-hours of electricity each year, which could represent as much as 25% of the total annual power usage of a typical energy-efficient AC refrigerator!

Overcrowded refrigerators are less efficient because the air circulation required for heat removal is inhibited.

So needless to say, it is important to keep refrigerator door openings short and to the point. Well-organized refrigerators make it easier to find things, and refrigerator doors should never be opened on hunger-driven spec—if we know what we are going in there to get, we will be able to get in and out very quickly.

Tip #2 – Space Food Correctly

This is a point we have already touched on in our discussion of refrigerator size. But it must be reiterated that overcrowded refrigerators do not work efficiently because the kind of free and easy air circulation that is needed to remove heat from the fridge's contents is inhibited.

The half-full rule is a good one, and the food and beverages that are kept inside a fridge should be distributed evenly on however many shelves are provided. While drawers in refrigerators are a good way to organize things, they do set up

barriers that cut off air flow, so perhaps they should be used to hold food only if there is not enough room on the shelves or in the door compartments.

Tip #3 – Let Food Cool First

Refrigerators are excellent at removing heat from food, but the more work they have to do, the more energy they will have to use. So even though they have the ability to eventually cool down even the hottest foods, it makes more sense to let hot leftovers sit outside the refrigerator for as long as possible before putting them into cold storage.

It is true that food safety experts recommend putting freshly cooked, uneaten food into the refrigerator as quickly as possible to prevent contamination. But according to the FDA, it is okay to leave most kinds of hot foods out for up to two hours before they will need to be put into cold storage.[20] Two hours of cooling can make a significant difference, and most foods that are out for this long will be lukewarm at best by the time they are stuffed into the fridge.

The one exception to the above rule is if the temperatures in the kitchen or house are over 90 degrees. If food is exposed to this kind of heat, contamination can occur much quicker. In this instance, refrigeration should not be put off for more than an hour.[21]

Tip #4 – Defrost and Thaw Frozen Foods in the Fridge

It is true that when frozen foods need to be thawed out or defrosted, the process will go much faster if the foods in question are left in a warm room or soaked in hot water. But they can also thaw out perfectly well inside of a refrigerator, and the neat thing about doing it this way is that frozen foods will actually help to cool interior fridge spaces, thereby reducing the load on the compressor. And because it usually takes a long time for frozen foods to thaw out when it is done this way, the cooling effect can last for quite some time.

Tip #5 – Turn the Refrigerator into an Icebox

Putting frozen foods inside the fridge has an effect similar to what happens with ice inside an icebox. But for those who live at northern latitudes, the opportunity exists to take things one step further and partially convert a refrigerator into an old-style, old-fashioned icebox. During the winter months, snow can be collected in plastic bowls and stored inside the fridge, where it can provide a free cooling

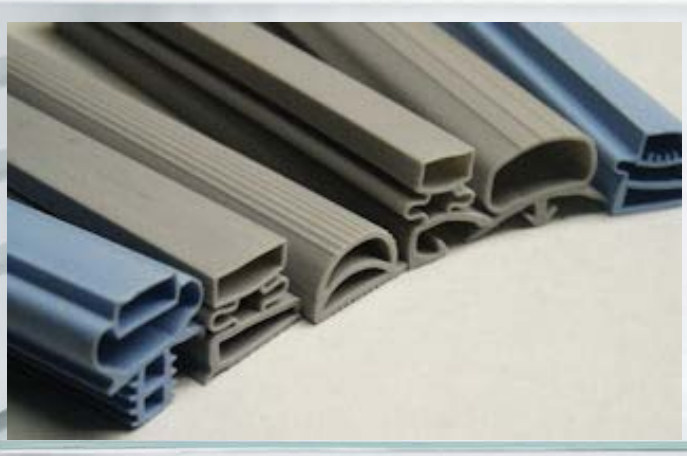
Decrease energy use by using ice or snow stored in the refrigerator compartment for a free cooling effect.

effect for as long as it takes the snow to melt, after which it can be replaced with a fresh supply of snow from outside. Alternatively, if temperatures are below freezing but the ground is dry, the bowls can be filled with water and put outside to freeze. Even better, people who have large freezers with extra room do not even have to wait for winter—they can make all the ice at home and use it to keep their fridge interiors well-stocked all year round.

Energy efficient refrigerators are designed to hold the cold in for a long time, so they actually can function quite effectively as an icebox. Of course this trick with ice and snow will only work if there is enough room in the refrigerator for these non-food items, but if the lower drawers are kept empty, it could be a good idea to put ice bowls in there so the rest of the refrigerator can be kept free.

Just so there is no misunderstanding, the idea here is not to turn an expensive refrigerator into a cheap ice box. Rather, we are just trying to show how ice and snow can be used as a supplement to the normal refrigeration process. It is a great idea to try this, if the ice and snow are actually available, because their natural cooling effects can decrease the duty cycle of a fridge's compressor enough to make a real dent in total energy consumption.

Tip #6 – Practice Gasket Maintenance



The long rubber strip that runs along the edge of the refrigerator door is called a sealing gasket. This item keeps the interior of the fridge airtight, preventing cold air from escaping and reducing the amount of time that the motorized compressor must run. If a gasket has been damaged in some way, or even if it has just gotten dirty, this can negate its sealing capacity and reduce its effectiveness dramatically.

The best way to check the gasket is to use the paper test. If a piece of paper inserted between the gasket and the refrigerator when the door is closed can be pulled out with little or no resistance, this is a sign that the gasket is defective. Fortunately, sealing gaskets are a replaceable part, and they can usually be purchased in any store that sells hardware or refrigeration supplies.

Refrigerator gaskets frequently suffer from extensive wear and tear, and this can cause a surprisingly significant amount of leakage. Unfortunately, this is exactly the sort of small

detail that most people will tend to overlook, simply because it never occurs to them that something like this could be a problem.

Tip #7 – Adjust the Thermostat

A refrigerator running 10 degrees colder than necessary can increase energy usage by as much as 25%.

One of the most common ways that people waste energy with refrigerators is when they keep the temperature inside turned down too low. Not only are overwhelmingly cold temperatures not necessary to protect food from spoilage, but extreme cold can actually damage food by causing it to lose all of its moisture. But for some reason, people have a tendency to turn their refrigerators down so much that ice frequently forms in the liquids that are being stored there. And from an energy use standpoint, this is not a trivial concern. It has been estimated that a refrigerator that is ten degrees colder than it should be may increase its consumption of electricity by as much as 25%.[22]

The only way to properly set a refrigerator thermostat is to experiment. Turning it down one number at a time (lower numbers equal warmer temperatures on a refrigerator thermostat) and then trying things out after a few hours to see if cooling is adequate, is the most reliable method of finding the right temperature. However, there is really no such thing as a "perfect" refrigerator temperature because there is an element of subjectivity and personal preference involved in the question that will never completely disappear. Keeping this in mind, a good general rule of thumb might be that refrigerator temperatures should be only turned up to the point where no one in the house is complaining because the cold foods they love so much are coming out too warm.

Tip #8 – Provide Room for Ventilation

The outer sections of a refrigerator's condenser coil system are called the heat dissipation coils. Specially designed to facilitate the passage of excess heat away from the refrigerator and into the surrounding atmosphere, these coils will get the job done quite efficiently as long as the free flow of warm air out of the fridge is not somehow obstructed. When this happens, the heat generated by the continuous electrical

refrigeration cycle will be trapped, and as a result it will inevitably feed back into the body of the machine to add an extra burden onto the workload of the compressor.

But surprisingly, refrigerators are usually designed in a way that makes this problem very difficult to avoid. The black zig-zagging grill of the heat dissipation coils will always be found on either the back or underneath the body of the refrigerator, where it is placed partially for aesthetic reasons and partly because dissipation coil emissions need to be funneled toward the rear of the machine so no one will get blasted by the heat they give off. But when refrigerators are pushed back directly against a wall, or nearly against a wall, air flow is impeded and the successful dumping of excess heat into the atmosphere will be inhibited.

Ideally, refrigerators should be placed no closer than about 18 inches from a back wall, and if it is possible to get it farther away, that would be even better. One option that some have tried is to maximize ventilation by cutting an opening in a wall and installing the fridge in the slot that has been created so that the back of the unit is completely exposed to the outside air. An overhang may need to be added to protect the fridge from the elements, but nevertheless, this is one way to help a refrigerator run more efficiently by aiding and abetting the heat exchange process.

If you're not familiar with building practices and structural frame members, however, get a licensed contractor to do this for you if you decide to utilize this option. You can't just go in and whack a hole in the wall without careful consideration of the impact on the structural integrity of the wall you're altering and other structural elements that wall supports.

Tip #9 – Find a Cooler Location than the Kitchen

High atmospheric temperatures cause a refrigerator to work harder. For every degree the ambient room temperature rises above 70 degrees Fahrenheit, a refrigerator will have to use up to 2.5% more energy to keep the interior properly cooled.[23] This means that a refrigerator located in a room kept at 80 degrees could end up using 25% more energy than the norm, while a unit placed in a room that reaches 90 degrees would have to increase its energy use by as much as one-half in order to meet the demands of its thermostat.

Given this fact, it is more than a little bit ironic that the refrigerator is almost always placed in the kitchen, which is the hottest room in the home. So, one of the best ways to cut down on the amount of energy required to make a refrigerator run is to move it from the kitchen to a much cooler place, such as a basement, garage, or outside on a sheltered porch. It may not be as convenient this way, but that could be a small price to pay for off-the-gridders in particular who need to shave every kilowatt off their electricity demand that they possibly can. One added bonus of making a move like this is that it will likely make it much easier to find a spot where a solid back wall won't interfere with ventilation.

One word of caution—while moving a fridge out of the kitchen is usually a good idea, care must be taken so that it is not relocated too close to another prolific heat source, such as a furnace, a washer/dryer, or a window that faces the sun.

Tip #10 – Defrost Frequently
(Manual Defrost Refrigerators Only)

It really is an absolute crying shame that manual defrost refrigerators are so hard to find these days. While the automatic style of defrosting uses heat and electricity, the old way of doing it placed no extra power demands on a refrigerator whatsoever.

Check frost buildup regularly in manual defrost refrigerators and clean when it has a thickness of 1/4" or more

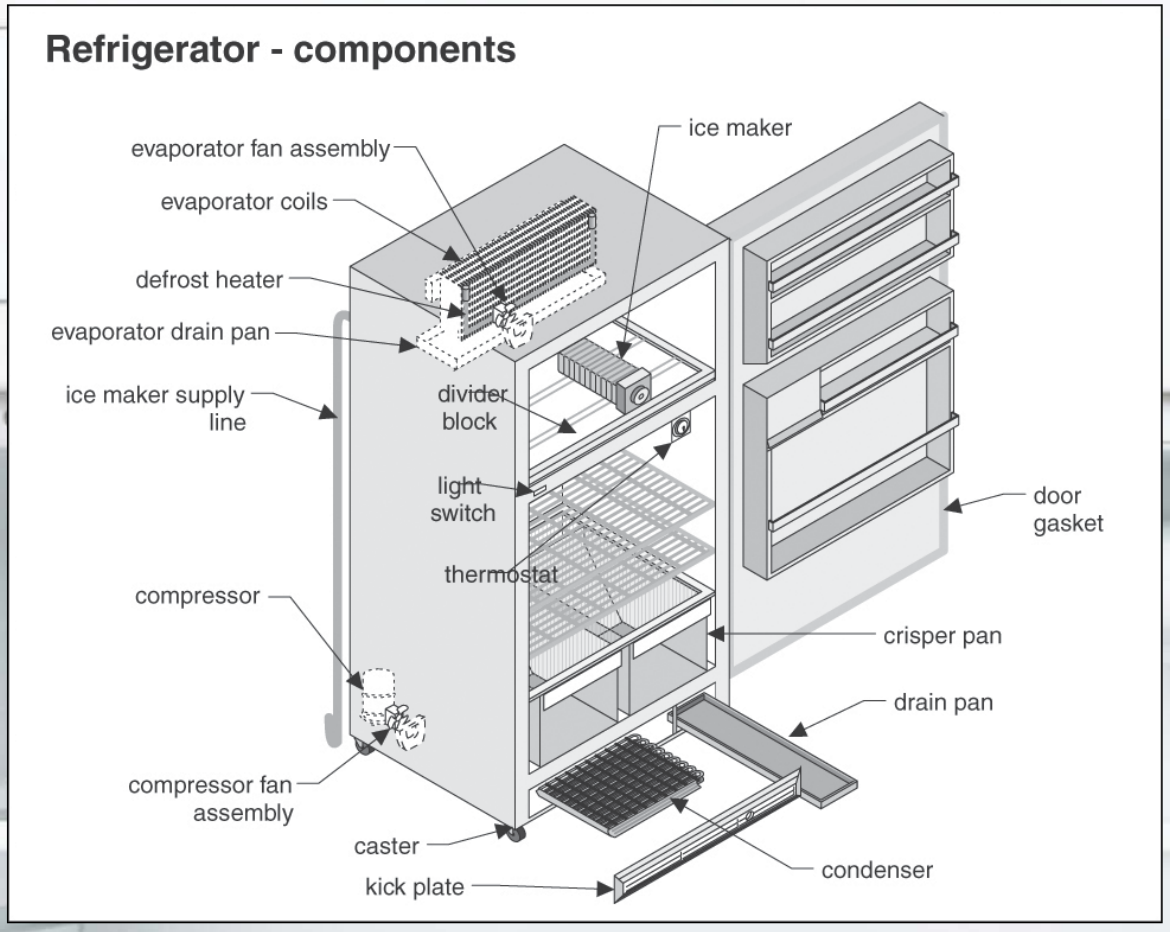
However, fridges with manual defrost (some newer Sun Frost models offer this option) do require their owners to pay more attention to what is going on inside them. The moisture brought in by food can cause frost to build up quickly on the interior coils, and once this happens, air flow is restricted and the refrigeration process will slow considerably, forcing the compressor to stay on for much longer periods of time. Therefore, frost buildup should be checked regularly, and when any section of the coils has become covered with layers of ice that have a thickness of one-quarter inch or more, that means a fridge is ready for defrosting.[24] Some refrigerator guidebooks will recommend that machines be defrosted at specified regular intervals, but the one-quarter inch test is a better standard to rely on because the coil system may not function as efficiently as a machine ages and frost may start accumulating much more rapidly at that stage.

For those who are especially serious about reducing the amount of electricity their refrigerator is using, it might be worth it to consult with a refrigerator repairman or technician to find out if the automatic defrosting unit can be disconnected without causing problems in the model of fridge they own.

Tip #11 – Clean the Coils

There's an old aphorism that states "out of sight, out of mind," and this most certainly applies to the back and the underside of a refrigerator. Without regular cleaning, dust, dirt, spider webs, and other mysterious stuff tends to accumulate rapidly in these areas, but rather than face this unpleasant reality many never even bother to look.

But as we have seen, a refrigerator is the ultimate heat exchange machine, and as such, maintaining clear and unobstructed air flow is vital for its proper functioning. All of those



The coils on your refrigerator can be located on the bottom, as in this diagram, or on the back of the refrigerator.

disgusting things that accumulate in the coils and around the compressor interfere with that air flow, and as a result a refrigeration system that is not kept clean will not be able to work the way it was designed to.

To clean condenser coils, a soft brush or mini-vacuum or both should be used, while the compressor can be vacuumed or wiped clean with a feather duster. Vacuuming and sweeping behind and beneath the fridge on a regular basis is also important, since the dust, cobwebs, and tiny bits of paper lying on the floor today could get sucked up into the refrigeration system tomorrow.

If refrigerator coils are cleaned thoroughly at least once every six months, it could potentially improve the efficiency of the refrigeration process by as much as 30%.[25] Before cleaning either the coils or the compressor, however, there is one very important thing that everyone should be sure to do first—unplug the refrigerator!

Tip #12 – Add More Insulation

While there are some exceptions to the rule, most refrigerators contain much less insulation than you might think. There just isn't that much room available for it on the inside, and insulation on the outside would detract from a fridge's appearance.

But extra insulation on the sides, top, and front of a unit could make a sizeable impact on its ability to hold in the cold. Rigid polyurethane insulation can do the trick quite nicely, and to lessen the potential aesthetic damage, decorative wood-faced paneling can be used to provide a surface cover. Because of the risk of damage to the intricate and delicate coil system that runs through the interior of a refrigerator, sheet metal screws should not be used to mount the insulation, but a high-quality tape or other kind of adhesive should be more than sufficient to get the job done.

Of course, insulation should not be installed where it will cover or obstruct the heat dissipation coils or the compressor in any way.

Tip #13 – Turn the Refrigerator Off When Not in Use

It is common sense that refrigerators should be emptied and turned off when people go on vacation. But there really is no reason to limit this strategy to only those times when no one is at home. Digital timer switches are available that can be programmed to shut appliances on and off on a predetermined schedule, and these handy little items can be used to turn off refrigerators during overnight hours while everyone in the house is sleeping. As long as a well-made, energy-efficient fridge is kept closed, it can keep its contents acceptably cool for up to 12 hours before it will be necessary to start using the compressor once again.[26] So as long as no one is getting up for a cold middle-of-the-night snack, it is perfectly safe to use a timer to shut the fridge down for a period of 8-10 hours. As long as the door is not opened during the night and a fridge's natural airtight seal remains unbroken, there is no reason to worry about a compressor being overstrained trying to catch up when the timer switches it on again in the morning.

Tip #14 – Relocate the Heat Dissipation Coils

The coil system in a refrigerator is a closed loop, and it must remain this way in order to continue performing its heat-removing magic. But because these coils are a closed loop, it really does not matter how extensive or long this loop is, just as long as it stays intact and interconnected. Because this is the case, it is theoretically possible to remove the heat dissipation coils from the back or bottom of the refrigerator and move them to an entirely different location as far away from the fridge as you would like. Refrigeration coil can be added as needed, and a refrigeration technician can then be called in to bleed the new line, add more refrigerant (this part should *not* be considered DIY optional) and finally check to make sure the system is up and running properly. The only limitation here is that the heat dissipation coils can't be placed in a location that is *too* cold,

because this can confuse the compressor and cause it to shut itself off because it thinks there is no more work to do. So at the very least, temperatures in the chosen location should be at least a few degrees above freezing.

But of course the question immediately comes to mind, why in the world would anyone want to do something like this? There are two good answers to this question. First, it can really facilitate an effective transfer of heat away from the refrigerator if the dissipation coils are located in a spot that is cooler. Remember, ambient temperature can have a big effect on the performance of a refrigerator's cooling system, and a part of the reason for this is that it allows the dissipation coils to shed heat faster and thereby shorten the duty cycle of the compressor.

The second good reason to consider something like this is because it may actually be possible to harvest the heat produced by a refrigerator to produce hot water. Since refrigerator coils themselves are not electrified, if the heat dissipation section is moved away from the electrical part of a fridge, it can be submersed inside a tank of water, where it can effectively produce enough heat to provide a decent supply of usable hot water. And an added bonus is that water is a superior conductor of heat in comparison to air, which means that the efficiency of a refrigerator's cooling system can gain a significant boost if its termination point is placed inside a tank of filled with H_2O.

So what we are talking about here in essence is a do-it-yourself water heater project. There is one problem with this idea, however, and that is the fact that refrigerator tubing can and does develop small leaks, and because the chemicals inside of a refrigeration cooling system are potentially toxic, they are definitely nothing anyone would want to be fooling around with. Therefore, the best way to handle a project like this is to use a double-wall heat exchanger which transfers the heat of the water in the dissipation coil tank to a secondary source of water that can then be used freely and without worry.[27] This may sound a little complicated, but a heat exchanger is a pretty straightforward device, and it is manufactured specifically to facilitate the harvesting of heat from any source for use in heating water.

Part 4:

Alternatives for the Do-It-Yourself Crowd

As we have seen, it is eminently possible to dramatically cut down on the amount of electricity needed to run a refrigeration system without compromising on performance. This information can be worth its weight in gold to off-the-gridders, who need to carefully monitor and conserve energy constantly if they hope to stay ahead of the game.

But so far, everything we have been talking about applies to powered processes of refrigeration, which require the consumption of other resources in order to produce a cooling effect. Fortunately, there are other methods of "refrigeration" available that do not need an outside source of energy to make things colder. This is because they work with nature directly to unlock the powers hidden everywhere all around us, powers that are capable of providing a bounty of gifts and riches that are limited only by our imaginations.

For the most part, the alternatives to electric forms of cooling are not in production and available on the market at the present time. But for those who enjoy doing things for themselves—and off-the-gridders are well represented on this list—these other options can make for exciting DIY projects. And if those who are worried about the future of our society and about the kinds of calamities and catastrophes that could be coming are right, then having alternatives for food preservation that don't require the consumption of precious power resources could be especially vital and invaluable.

Bringing Back the Icebox

Before there were refrigerators, there were iceboxes. This technology worked so well that iceboxes continued to be made well into the 20th century. But that is all over now, as the hegemony of electrical refrigeration is total and complete. The problem with iceboxes is that they must be replenished with ice and/or snow continuously, and in a society that values convenience above all else (or laziness, depending on your perspective), making that kind of effort and taking that much responsibility is no longer in fashion. But for those who have easy access to a steady supply of ice, either from outside or from a freezer, and who need to do everything they can to preserve power, an icebox could still come in very handy.

The nice thing about an icebox is that it is one of the simplest things in the world to construct. All that is required is an old chest-style freezer with an intact sealing gasket, sheets of insulation that can be attached to both the inside and outside walls, some

containers to hold the ice and snow, and some shelves or removable baskets that can be used to keep food separated from the melting ice.

While it is certainly possible to build a home-made box out of metal (or even wood), that can function effectively as an icebox, what makes a chest-style freezer work so perfectly is that it already has a door attached that was made to keep in the cold, and because it opens from the top instead of from the front, cold air will not be lost whenever someone lifts the lid to take something out. This is the one great design flaw in "normal" refrigerators—they must be stationed upright and supplied with a door that opens horizontally instead of vertically, even though this makes it impossible to prevent cold air from spilling out during regular usage. But iceboxes that open from the top are built to take advantage of the fact that cold air sinks and will not be lost just because the icebox door has been opened.

There is no way to tell ahead of time exactly how often ice might have to be changed in an icebox for adequately cold temperatures to be maintained. But food does not have to be kept ridiculously cold in order to be kept free from spoilage, and if the lid isn't opened too frequently it is entirely possible that the ice in a well-constructed icebox could last as long as 48-72 hours before it will have to be replenished.

Evaporation Cooling

We all know that when we sweat, this helps cool our overheated bodies. This is because the evaporation of water absorbs heat energy from the skin, causing the temperature of the body to decrease. This cooling effect always accompanies evaporation, and believe it or not, this effect can actually be harnessed for the purposes of refrigeration.

The pot-in-pot method has been developed to take advantage of the ability of evaporating water to cool items in its vicinity. The method works as follows: food is placed inside a pot, which is then covered with a moist cloth. Both the original pot and the cloth are then placed inside a larger pot, and a permeable substance of some type is added in the space between the two pots. This permeable material will be kept saturated with water at all times, and the wet cloth will be dipped into that material and left there so it can soak up more

Evaporation cooling will not work in a moist, humid climate. A dry, arid, desert-like climate is necessary for this concept to work.

moisture as it dries and thereby keep the process of evaporation going continuously. And from this, you will get a fully functioning refrigerator, and one that works extremely well at that.

The most common and probably most effective form of evaporation cooling device is called the *zeer*, which is the Arabic name for the type of large pots that are normally used in this particular evaporation refrigerator.[28] Developed in 1995 by a Nigerian teacher who wanted to help poor African families preserve their food, the zeer uses sand as the medium of saturation, and this refrigerator works so well that it can keep fruits and vegetables fresh for a period of up to 20 days—which is actually better than an electric refrigerator would ever be expected to do.[29]

The one stipulation with a zeer, or with any type of evaporation cooling system, is that the surrounding air must be dry enough to facilitate effective evaporation. Humid air makes evaporation impossible, and the zeer will not work if it is placed in a location where the air is moist. But for someone who lives in a desert climate in particular, a pot-in-pot cooling apparatus would work exceptionally well most of the time.

Evaporation coolers can be constructed from many different materials, and in many shapes and sizes. Really, the sky is the limit here for those who love to meet their personal needs by coming up with their own unique creations. All that is needed to make an effective evaporation refrigerator are two storage containers of different sizes, a cloth that can be kept moist, an insulating medium that can absorb water, and a location where the air can be kept dry.

Intermittent Absorption Refrigeration -

The Holy Grail of DIY Cooling Technology

Earlier, propane refrigerators were mentioned as an alternative to cooling units that run on electricity. It must be noted, however, that propane units work somewhat differently than electrical models that rely on motorized compressors—they are an example of what is known as an "absorption refrigerator."

Like their electrical counterparts, absorption refrigerators also exploit the Third Ideal Gas Law and the Second Law of Thermodynamics by using pressurization effects to manipulate the activities of gases with low boiling points. In this case, however, the cooling effect is caused by a more complex chain reaction of chemical events that is set off inside a closed system by the application of heat. Ammonia gas is the most commonly used refrigerant in an absorption refrigerator, and a mediating substance such as water or calcium chloride salt is also used to absorb, emit, and then re-absorb the ammonia, all of which affects the temperature level inside of an absorption refrigerator.[30]

There are two types of absorption refrigerators—continuous and intermittent.[31] The difference is that in the former, the heat must be applied continuously for the cooling

Absorption Refrigerator

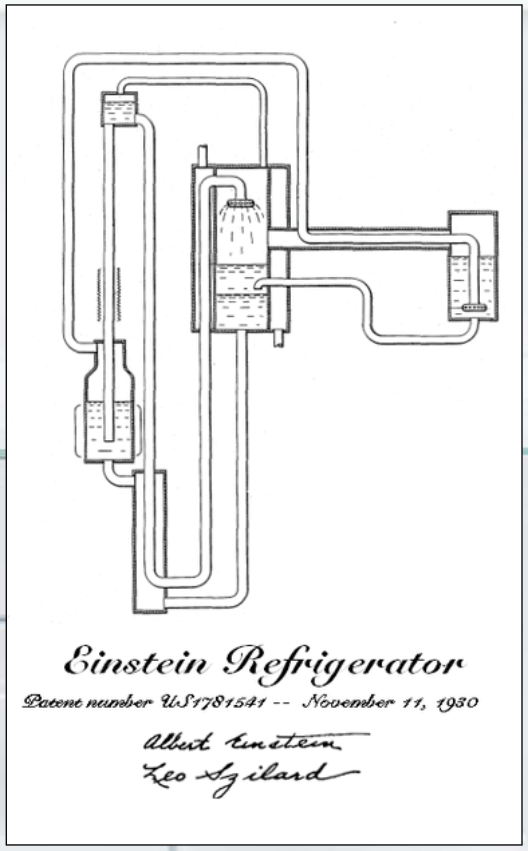
1. *Hydrogen enters the pipe with liquid ammonia*
2. *Ammonia+hydrogen enter the inner compartment of the refrigerator. Change in partial pressure causes ammonia to evaporate. Energy is being drawn from the surroundings - this causes the cooling effect*
3. *Ammonia+hydrogen return from the inner part, ammonia returns back to absorber and dissolves in water. Hydrogen is free to rise upwards*
4. *Ammonia gas condensation (passive cooling);*
5. *Hot ammonia (gas)*
6. *Heat insulation and separation of water from ammonia gas*
7. *Heat source (electric)*
8. *Absorber vessel (water + ammonia solution)*

process to work, while in the latter the heat will only need to be applied once per day to set off a cooling effect that can last for up to 18 hours.[32] Because of the superior efficiency of the intermittent absorption refrigerator, there have been a number of clever and inventive people who have turned their skills and attention in this direction. Success in these endeavors has proven elusive, however, in the sense that no intermittent absorption refrigerators have come on the market as of yet for sale to the general publc.

But this does not mean that working models have never been developed; on the contrary, a number of designs for intermittent absorption refrigerators have been created and tested successfully by industrious inventors over the years, and some of the machines they have built have even received patents. Do-it-yourselfers all over the world have also tried to construct this type of refrigerator at home for their own personal use, and some of the fridges they have built apparently work quite well.

All over the Internet, it is possible to find detailed plans for intermittent absorption refrigerators. Solar-powered intermittent absorption units are drawing the most interest and attention these days, although some older designs still call for an open flame to be used to provide the heat needed to set off the necessary cascade of chemical reactions. But the solar models appear to be especially promising, because all that is needed for them to work is a way to focus the energy of the sun onto a particular spot at a particular time, which is something that does not necessarily require an expensive or extensive photovoltaic array to accomplish.

Thanks to all of the online guidance and advice that is now available, and all of the information sharing that is taking place on various websites and on a multitude of Internet forums, any off-the-gridder who would like to try building their own intermittent absorption refrigerator will not find it hard to find the information they need to get started. A DIY unit of this type will require some time to set up, but the materials needed to make them are available in abundance, including the ammonia gas. If things are done one step at a time, carefully and in a logical order, it is very possible that an intermittent absorption refrigerator can be created at home that will actually end up working.



In short, it does not take an Einstein to plan out and construct an intermittent absorption refrigerator—even though Einstein himself is one of the inventors who once patented a design for one!

Part 5:

Coming in Out of the Cold – A Final Analysis

Do-it-Yourself with Electricity?

While we have just looked at some DIY alternatives to electrical refrigerators, anyone who prefers to do it themselves could just as easily construct a customized electrical unit at home on their own time. There is no guarantee ,of course, that a home-made electrical refrigerator will be able to match the energy efficiency of a top-of-the-line model purchased from a well-known dealer. But a high-quality electrical refrigerator is not an inexpensive item by any means, and there is no question that putting together a DIY unit would save a lot of money on the front end, since the materials needed would not be prohibitively expensive.

When you come down to it, the only real challenge for anyone taking this route is making sure the gas they choose as a refrigerant is handled correctly and safely. All of the possible options are toxic and dangerous, which is why many who have chosen to construct their own electric refrigerator have sought the advice and assistance of a qualified refrigeration technician to help them with this part of the process. But realistically, there is no reason why any off-the-gridder so inclined could not go ahead and build their own fridge with energy-efficient features included instead of buying one from an established retail appliance supplier.

Conscious Living through Refrigeration

To exist successfully off the grid, people need to assume that every little thing counts… because it does. Nothing can be taken for granted, and every contingency needs to be planned for and every possible scenario taken into account. One of the crucial things that all preppers must never forget is that energy is a precious resource, and it is a resource that cannot always be counted on to be there when we need it. Consequently, taking steps to conserve, preserve, and reduce the amount of energy used in whatever form it is available is vital for off-the-gridders whose very survival could some day come to depend on it.

Refrigeration offers a golden opportunity for people to reduce their daily consumption of energy down to more manageable and respectable levels. This is because most do not take the time to educate themselves about the realities of refrigeration and about how much energy their fridges might really be using. For those taking on the challenge of trying to survive off-the-grid, efficient living is an imperative rather than a choice, and simply plugging in an electric refrigerator and forgetting about it is not an acceptable response. Knowledge is power, as they say, and knowing how to manage power is exactly the kind of knowledge that off-the-gridders must possess in abundance.

Endnotes

1 http://www.whoinventedit.net/who-invented-the-refrigerator.html
2 http://www.nytimes.com/2009/02/05/garden/05fridge.html?pagewanted=all
3 http://www.oasismontana.com/refrigerator.html
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