Built to Survive

How We Designed & Built a Sustainable, Secure & Survivable Custom Home

by

Joe Ordia

Foreword by Joel Skousen

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Dedication

To my wife Rachel, who has always supported my dreams and goals and without whom none of this would have been possible.

About the Author

Joe Ordia is the co-founder and President of Solar Surge, the mid-Atlantic region's leading provider of residential solar power systems with energy storage. Since starting his career in solar, Joe has helped more than 500 households achieve greater levels of energy independence by utilizing clean solar energy and battery storage technology. He is committed to getting as many households as possible self-sufficient and energy independent.

Joe and his wife Rachel married in 2011 and have five children: Grace, Lydia, Michael, Isabella, and Gianna. In 2011, the Ordias made the decision that they wanted to be prepared as a household. During a time of crisis, whether it be a natural disaster, economic collapse, cyber-attack, or war, they did not want to be dependent on the government or any other institution to take care of them. Simply put, they wanted to be able to take care of themselves. The Ordias currently reside in Central Virginia in the custom home that is the subject of this book. Joe & Rachel are followers of the Lord Jesus Christ.

A note from Joe: My approach to strategic planning and emergency preparedness was highly influenced by the following two books: *How to Survive the End of the World as We Know It* by James Wesley Rawles (Plume, 2009) and *Strategic Relocation: North American Guide to Safe Places* by Joel Skousen (Self-published, 2011). I highly recommend both of these resources to anyone who is serious about household preparedness or is planning to build off-the-grid. Both are available on Amazon.com.

If you would like to stay updated about our experience and new developments in the pursuit of self-sufficient living, please follow us on Facebook and subscribe to our YouTube Channel. Here are links to each:

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FOREWORD

by

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The High Security Shelter

We live in increasingly dangerous times. Not only is our political situation more divided and divisive than ever, leading to government inaction in both border security as well as defense, but we face increasing existential threats from major nuclear powers Russia and China who are building huge arsenals of high tech aircraft, missiles and warships. Clearly they are arming for a future war with the West.

Military experts agree that both nations will have completed the majority of their rearmament in high tech weapons by the middle of the coming decade (-2025). That doesn't mean they'll strike then, but a start of WWIII is less likely before then, depending on what they use for a trigger event.

North Korea is that likely triggering event, so the lack of progress in getting North Korea to actually disarm should be a major concern to all of us. In my analysis, they are unlikely to ever disarm and will continue to lie and deceive in order to buy more time.

And, while energy supplies are now abundant, all of our distribution systems are vulnerable to disruption during war or a collapse of the electric grid—which remains unprotected, and largely *unable to restart power* after a grid down event. Both Russia and China have developed anti-Satellite and nuclear Electro Magnetic Pulse weapons (EMP) which are designed to take down our electric grid, internet and GPS system, bringing a halt to all communication, navigation and economic commerce within a day.

While government is concerned about and studying the problem, the wheels of change move slowly, and considering the cost of upgrading the grid, plus dealing with the objections of hundreds of individual utility companies, it is unlikely to get fixed in time.

During the crises of the next decade our biggest problem will be the fact that most of us live in high population density areas.

People do so, and suffer through the traffic and pollution problems, because that's where the jobs are. But even though most cities will NOT be struck by nuclear weapons initially (the Russians and Chinese intend to hit US military targets first, and attempt to blackmail the nation into capitulation) all will suffer the results of a prolonged grid down nightmare and nuclear fallout from afar because the Russians and Chinese intend to destabilize our ability to respond by launching an EMP strike a few minutes prior to the physical strike on military targets.

In the first day, all food deliveries will stop. All sewer treatment plants stop functioning. City water supplies lose power, and there's no electricity to assist in repairs. Backup generators in cell phone towers, hospitals, and grocery warehouses have only enough fuel for a couple of weeks, but even those will not operate if they aren't protected from the EMP surge rushing down the power lines and through all the unprotected wiring in houses and buildings.

I predict that within 3 days, all food supplies and fuel supplies at gas stations will be exhausted and mass social unrest will commence in the cities. It will certainly happen earlier in inner city

areas. It will be less in rural areas, and that's why in my book *Strategic Relocation*, I advise people where safer places are and how to develop retreat plans to get out of town before these severe upheavals begin.

But as author Joe Ordia writes, it isn't practical for most people to move far from cities when their financial livelihood depends on urban areas. Instead, as he has done, they can move out to rural or semi-suburban areas close enough to the cities to commute for work. That's the strategy I've long recommended in *Strategic Relocation*. Those that can't move out of urban areas definitely need a retreat plan, even if simply making arrangements to live with family or friends outside of town.

Social unrest will tend to move outward from the urban areas, and so living at the outer edges of suburbia buys you time to get ready, as suburban areas closer to town absorb much of the pillaging. Remember, however, that most elements of security and self-sufficiency necessary to weather a prolonged crisis without food, water and electricity require installation in advance.

Fortunately for those of you who had the wisdom to buy Joe Ordia's book *Built to Survive*, you will find that he's made it easy

for you. I've designed custom high security residences and retreats for over 40 years and it's a complex process. But Joe has removed most of the complexity and found several systems that fit most people's needs for self-sufficiency in power generation (using a combination of solar and a small generator), heating, cooling, and water reserves. It's affordable and saves energy costs in the long run.

The only suggestion I would add to his fine work is the need for a small concealed safe room inside each house. This allows you to hide your family in a secure place rather than confront intrusions or social unrest that may threaten your family and your preparations. If properly concealed, it also allows you to hide valuables that you don't want stolen. Lastly, having a safe room helps you avoid having to secure the entire home.

If you're building a new home, I always recommend putting in a basement foundation where feasible, not only to get extra room, but to allow for a basement shelter or safe room. It's easier to conceal in a basement and has the added advantage of being able to be built with a lowered masonry ceiling that provides you with fallout protection in the likelihood of nuclear war. For those

of you who live with the threat of tornados, it also serves as a tornado shelter and is fireproof. It's the least expensive way to get fire, tornado and fallout protection inside the home. If interested, my book *The High Security Shelter* has detailed plans on how to do this project in an existing basement.

Whatever you do, remember that you still have time to prepare. Resolve to start now to *do something,* even if you can't afford to do all at once. *Built To Survive* will help point the way.

Preface

This Book's for You

This book is for those who want to enjoy the fruits of their labor and be prepared for what may come, but others will benefit from reading it as well.

Imagine a cyber attack by a rogue nation or terrorist group or a natural disaster such as the one in Puerto Rico in September 2017 results in a blackout lasting not hours, not days, but months or even years. Those unprepared may find themselves with no running water, no sewage, no refrigeration, no heat or air conditioning, and no electric lights. This could happen. A major cyber attack on America's power grid is not only possible, it is likely according to many experts. For example, retired United States Army general and commander of United States Central Command (CENTCOM), Lloyd James Austin III has been quoted as having said, "It's not a question of if, it's a question of when." An attack on just one of the nation's three electric power grids could cripple much of the nation's infrastructure, and in this age of cyber

warfare, a laptop is the only weapon required. Many in positions to know agree that the United States is shockingly unprepared and that means it's up to each individual or family to prepare, which is why my wife Rachel and I embarked on the adventure of designing and building a sustainable, secure, and survivable custom home.

We knew at the outset we were doing something truly unique. Unlike many so-called "preppers," we were not prepared to give up a normal lifestyle and retreat to a cabin in the Northwest wilderness or any other wilderness for that matter. With a rapidly growing family, we wanted a home that would provide what most would consider a normal middle-class quality of life for our children and ourselves, but at the same time, we wanted a home that would also serve as a survival retreat capable of supporting a comfortable lifestyle during a time of crisis, including a prolonged outage of the electric grid. If you are a minimalist who wants to build a residence capable of providing a place to live indefinitely off the grid in a way that harkens back to the American frontier days, you may learn a few things and get some good ideas from this book, but it is not written specifically for you. If, however, you are some-

one who wants to enjoy today's normal creature comforts such as central heating, air conditioning, automated clothes washing, drying, and dishwashing, but you also want to have a residence that will allow you to survive and to continue to have those things through an extended period while the grid is down, you have picked up a book that was written with you in mind.

What led us to decide to have a home built that can operate off the grid? Around 2011, we came to the conclusion the country was on shaky ground politically, financially, and spiritually, and we decided we wanted to be prepared for whatever might happen up to and including a cyber attack on the power grid, an electromagnetic pulse (EMP), a natural disaster, or an attack by a foreign power or terrorist organization. We felt we were living in dangerous times and that the country was on a path that would take the nation outside of God's protection. We realized that one day we might wake up and find ourselves at war or under attack, and we did not want to be victims in whatever might come. As a result, we decided to take action.

One of the first things we did was buy a portable generator, but as I began to do more research and think about possible long-

term scenarios, such as what would happen if power went out for a month, or six months, I realized that a traditional generator would not be the best solution. We would need to be sustainable from a renewable energy source. So we decided to use solar power to back up our home's critical systems. Initially we started with just the well pump because that's the most critical system. You have to have running water and to be able to flush the toilet. We did some research, pulled together all the components (mostly ordered from eBay) and figured out how to put all the pieces together. Having studied electrical engineering in college, I was familiar with the basic concepts of electricity, but this was the first time I put these skills into practice for my own home's energy needs.

A while after the system was up and running, we decided to see what would happen if we advertised the package we had developed on Craig's List. Well, the phone started ringing, and it quickly became clear there was demand for what we were able to offer. Other people were also looking for long-term backup, and solar was the perfect solution in our part of the country. Suddenly we were in business. Now, six years after that first Craig's list ad, we have a thriving solar business with plans to open additional offices.

Something that has helped our business grow is that a number of banks have developed programs to allow homeowners to finance the purchase of solar power systems. You see, a whole-house solar system typically costs anywhere from $20,000 to $50,000 and most people are not in position to stroke a check for that amount. Now they don't have to since a number of banks are willing to finance a solar system over a 20 or 25-year term. This has put a solar system in the realm of possibility for just about every homeowner. By taking advantage of the option to finance, homeowners can essentially trade an electric bill for a lower solar bill, and with the solar bill, they are paying themselves back in the form of debt reduction. How so? With the advent of solar and other renewable energy sources, utilities have incorporated bidirectional metering programs. Basically this involves an electric meter that measures electricity flowing both ways. It has long been the case that consumers can purchase electricity coming into the house from the electric company. The meter tracks how much power is purchased. With bidirectional metering, the homeowner can push power back onto the grid, which causes the electric meter's wheel to turn in the opposite direction. When this hap-

pens, credits are earned. In other words, grid-connected solar power systems make it possible to power a home and sell electricity back to the power company, and it happens automatically. Meters spin backwards during daylight hours. At night, when the sun is down, power is purchased from the utility, using the credit built up during the day.

The most consumer-friendly bidirectional metering arrangement is true 1-for-1 net-energy-metering. In this configuration, the utility purchases the excess solar power at the full retail price. Under most net-metering arrangements, once an electric bill is zeroed out completely, the utility is not required to pay the homeowner. Please note that not all electric utilities are required to offer a true 1-for-1 net-metering program. Another common bidirectional metering arrangement is known as "avoided cost". In this case, the system owner gets full retail price credit for solar electricity that is directly consumed within the house, however all excess solar electricity is sold back to the utility at a discounted wholesale rate (usually less than half the retail rate). In our part of the country, we find that the avoided cost method is more popular with nonprofit electric cooperatives and municipal utilities.

On the west coast, some utilities have adopted "zero export" policies, which allow solar to be consumed within the house but forbid any solar sell-back to the grid. Be sure to check your local policy before deciding on your solar financing approach.

Many consumers are able to offset their electric bills completely while at the same time having a stand-alone, emergency back up system to use during power outages. The results are that the homeowner's house is likely to increase in value along with the peace of mind in knowing a backup system is in place if disaster strikes, both with no cash outlay required.

What follows will lead you through the thinking and the decisions we made while researching, designing, and building a luxury custom home capable of operating off the grid over an extended period of time. Every major design decision had to take into account the often-conflicting priorities of our desire for personal comfort verses the need to survive and operate during a time of crisis. We wrote this book to capture the entire experience so that others may benefit from the lessons learned during our journey.

In summary, this book is written for people who wish to enjoy the fruits of their labor and provide a comfortable house for their

family as well as those who also value their self-sufficiency and emergency preparedness. If you are interested in retrofitting your home to be able to run independent of public utilities, or if you are planning on building an off-the-grid home then this book is a must-read for you. We hope that by sharing our experiences, both the successes and the pitfalls, you will be better enabled to make the best decisions with respect to your project, and that ultimately you are able to achieve the highest level of self-sufficiency possible for you and your family.

One more thing: We hope homebuilders who plan to engage in the building of energy-neutral and off-the-grid homes will also benefit from reading this book. Sustainable homes present unique requirements and design challenges. We have done our best to give homebuilders insight into prospective homeowners' priorities and to help better prepare them to meet homeowners' expectations. We hope that with the knowledge gained, they will realize a higher level of success.

We are writing this book throughout the initial design, construction, and post-construction phases of the project. This approach will give you an opportunity to understand our thinking as

it goes into the endeavor, the challenges and issues that arose during the execution phase, and our experience with the final product, which we now occupy as our primary residence.

Summary

- Our society has become almost totally dependent on infrastructure that could fairly easily be destroyed by an adversary or by a natural disaster.
- A standby electric generator offers only a temporary solution if a grid-down situation turns out to be long term.
- Solar energy offers a long-term solution.
- There are banks willing to finance solar installations, making it possible to trade an electric bill for a lower solar loan payment by selling excess energy back to the electric company.

Chapter One

Location, Location, Location, Where to Build?

Selecting a location: What to consider and why we built where we did

There are parts of the country serious preppers consider the best places to live. For those making a strategic relocation decision, it is almost universally agreed that the best part of the country is the northwestern United States. Survivalist author and blogger, James Wesley Rawles, cited this region a number of years ago and called for a political migration movement known as "The American Redoubt." Rawles, author of a best-selling book on the subject, How to Survive the End of the World as We Know It: Tactics, Techniques, and Technologies for Uncertain Times, pointed to the states of Idaho, Montana, Wyoming and adjoining portions of Oregon, and eastern Washington due to their low population density, lack of military installations, and an abundance of natural resources such as farmland, game, and clean, uncontaminated water. If a person had to survive off the grid that might well be the best place. But things haven't come to that in our opinion.

A number of factors combine to keep us in the part of the country where we now live, closer to civilization, including our business, our church, and the schools our children attend.

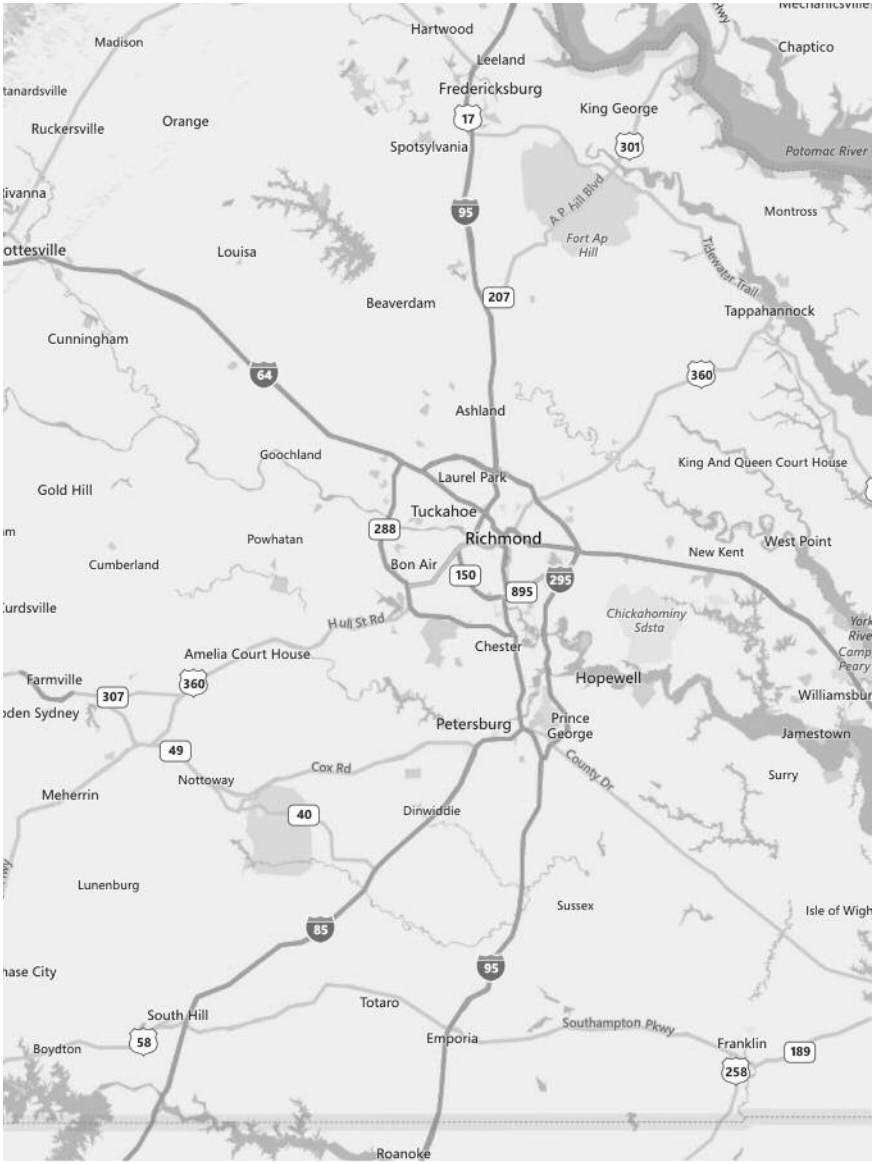
My wife Rachel and I chose to build our home just outside the Richmond, Virginia metro area. Perhaps unfortunately, we happen to live in a part of the country where there are many military installations that would likely be targeted by a hostile adversary. Before moving here, we lived a little more than an hour up the road in Northern Virginia, just outside of Washington, D.C., not far from the Pentagon. Down the road to our east is Hampton Roads and the Norfolk-Virginia Beach area, home to the largest concentration of naval bases and war ships in the world. Fort A. P. Hill is just north of us, a large helicopter base where a lot of flight training takes place. There's a nuclear facility in Lake Anna, not far away. Because of factors such as these, it made sense for us to move southwest away from the city center in the direction of the mountains of West Virginia.

Most survivalists agree that it is most important to be in a safe place when disaster strikes, rather than to have to retreat to a safe place. Once the choice is made for a family or individual, the ques-

tion becomes, how to make the place of residence one that can sustain itself. Supplies and provisions will be needed that will last over a lengthy period of time, or alternatively, the property will need to be such that it will provide food and water to sustain a family or an individual for an indefinite period. The property will also need to be secure enough that it can be defended against marauders that might spring up following the catastrophic event. It will need a renewable energy resource to provide power for refrigeration, water pumping, lights, and communication. It will need communications gear that can operate independent of the commercial telecom infrastructure. You will need the skills, training, and medical supplies to be your own doctor and dentist and to do all the other things you may have to do for yourself. You may need firearms and ammunition. In other words, if society, the economy, and public utilities turned off, what would you need for your household to survive? This will be discussed in Chapter Eight.

When choosing the location for our new home, Rachel and I had to balance several conflicting priorities. On the one hand, we wanted our home to be in a safe, remote location far from popu-

lation centers and centralized critical infrastructure like a power plants, water treatment facilities, and military bases.



On the other hand, we wanted to be close to our place of business, our children's school, our church, and our friends. We had to find a good balance that gave us the privacy and security that we valued and also allowed us to continue to participate in our community and local economy.

We began by looking at a map of the Richmond metropolitan area, where we have resided for the past six years. Rachel and I were pretty much set in the decision to stay put in the greater Richmond area, but we did not want to live in the city or in the close-in suburbs. The goal of building a home to survive is to eliminate dependence upon public infrastructure and public utilities, and the closer a person or family lives to an urban or suburban area, the more dependant on public infrastructure and utilities their lifestyle is likely to be. Moreover, as has been mentioned, survivalists agree that when a crisis hits, it's best to be as far away from population centers as possible. This makes perfect sense because densely populated areas are likely to generate a large number of refugees, which is a recipe for things to turn into chaos as people grow desperate and in an effort to survive, resort to looting and other forms of violence.

As a result, the first question in my mind was in which direction were we going to travel from the city center. Picture a 75-mile diameter circle with the City of Richmond at its center. I analyzed our options roughly as follows:

Northeast: Traveling northeast from the center of Richmond, you will find the suburb of Mechanicsville about 15 miles out. Mechanicsville was a bit too population-dense for us. We wanted more space and more distance from the city. Continuing out along this trajectory, you hit rural King William County and eventually King and Queen County. Although these communities offered plenty of land and privacy, they were too far from our church, schools, and place of business.

Northwest: We liked our options northwest of the city. Rachel and I had lived in western Hanover County for several years and we really did enjoy the area and the people there. It was close enough to our church, shopping and our office. However, just a bit further along this path lies the Lake Anna nuclear power plant, which I did not like from a strategic perspective.

North: Moving north from Richmond along US Route 301, we run into Fort A.P. Hill US Army Base. This was a large military

target that I wised to avoid. Following Interstate 95 North, we first hit the town of Ashland, a small college town about 15 miles north of Richmond. Continuing up I-95, we would eventually hit the City of Fredericksburg, another large population center that is an outer suburb of the Washington, DC/Northern Virginia metro area. There was simply too much congestion moving north.

Southeast: Moving southeast from the city would take us along the I-64 corridor towards Williamsburg. This was a large commercial and tourist area that we also wanted to avoid. Continuing along I-64 we eventually hit the Hampton Roads metropolitan area. This region includes several large population centers and military installations including Langley Air Force Base and US Naval Base Norfolk. These military bases protected the nation's capital and so were considered strategic targets during a time of war. There was too much risk here and I wanted to avoid this area at all costs.

South: Moving directly south from Richmond along I-95, we run into the cities of Colonial Heights and Petersburg. Colonial Heights is a small commercial area just outside of the Fort Lee US Army Base. There is a large military population here. Peters-

burg is an old industrial city with a weak local economy and high unemployment. I also knew through some business associates that even the city government was having trouble paying its bills. If there was going to be a major economic collapse, Petersburg would be facing a refugee crisis. I didn't want us anywhere near there.

West: Travelling along I-64 west of Richmond, there were some nice areas in Goochland and Louisa counties that could have suited our needs. I liked the idea of being able to take I-64 into Short Pump, which offered several options for shopping and plenty of available office space for our expanding business. Travel to our church would also be convenient coming from this direction. However, getting our daughters to school in the morning would be a challenge. I also didn't like the idea of being depending on the interstate highway system, which would likely become overloaded during a time of crisis or mass evacuation. Furthermore, moving too far west would take us into the Charlottesville metro area and the University of Virginia. I preferred to have a more private location with the ability to evacuate to a permanent survival retreat without using interstate highways. The reason is

simple. If things begin turning chaotic in a population center, the government will most certainly respond by imposing more control. I saw this firsthand in Iraq. By the time I arrived there, it was no longer a force-on-force, conventional war, but rather, it had become a policing situation. We were operating out of fixed buildings, patrolling pre-defined routes and zones much as a police department would in the United States.

I saw firsthand how a force goes about controlling a large population. It is accomplished by controlling the leverage points, which means the electric power, the telecommunications, travel, arms and weapons, and the money supply. With those five levers, the population can pretty much be brought under control. They are the levers that will be brought to bear if things ever become chaotic here, such as rioting and looting – in other words, a lot of hungry people that have become desperate.

It's clear to me that the first thing the government will to do is impose travel restrictions, using travel curfews and checkpoints. But the government will not have enough manpower to police every back country road. Rather, manpower will be allocated to those places where it will have the most effect, and that will be the

highest traveled thoroughfares, starting with interstate highways and followed by major state roads. An example of this from the not distant past is Hurricane Katrina in 2005, when the National Guard was deployed to keep people from evacuating New Orleans in order to stem a growing tide of refugees.

Southwest: Finally, I looked at the options southwest of Richmond. I could draw a line on a map starting in downtown Richmond and extend southwest 120 miles before hitting another major city or population center. About 15 miles outside the city were the close-in suburbs of Midlothian and Chesterfield, which offered ample shopping and office space. However, moving further southwest took us into Powhatan and Amelia counties, mostly rural areas that included cattle and tobacco farms.

We chose to build in the Oak Leaf Estates community in Powhatan County. Routes 711 & 288 would give us quick access to the I-295 beltway and I-95 south. Our commute to and from the kids' school would only be 20 minutes. Our church would also be about 30 minutes away and I could make it to the office in less than 40 minutes. Most importantly, when we completed our future 100% off-the-grid survival retreat, we would be able to evac-

uate to that location without using any interstate highways or passing through any major population centers.

Summary

1. It is best to be in a safe place when disaster strikes, rather than to have to retreat to a safe place.
2. For serious preppers, the places considered best are the states of Idaho, Montana, Wyoming and adjoining portions of Oregon, and eastern Washington due to their low population density, lack of military installations, and abundance of natural resources.
3. If society and public utilities essentially are switched off, you will need your place of residence to be one that can sustain itself, plus supplies and provisions and a source of water to sustain you for an indefinite period.
4. The property will need to be secure so that it can be defended against marauders.

5. You will need communications gear that can operate independent of the commercial telecom infrastructure.
6. You will need the skills, training, and medical supplies to be your own doctor and dentist and to do all the other things you may have to do for yourself.
7. It will be wise to have firearms, ammunition, and the training to use them.
8. We selected a location southwest of Richmond because it was away from population centers, military installations, Interstate highways, and on a line that extended southwest for 120 miles before coming to another major city or population center.

Chapter Two

Our Dream Home and Builder

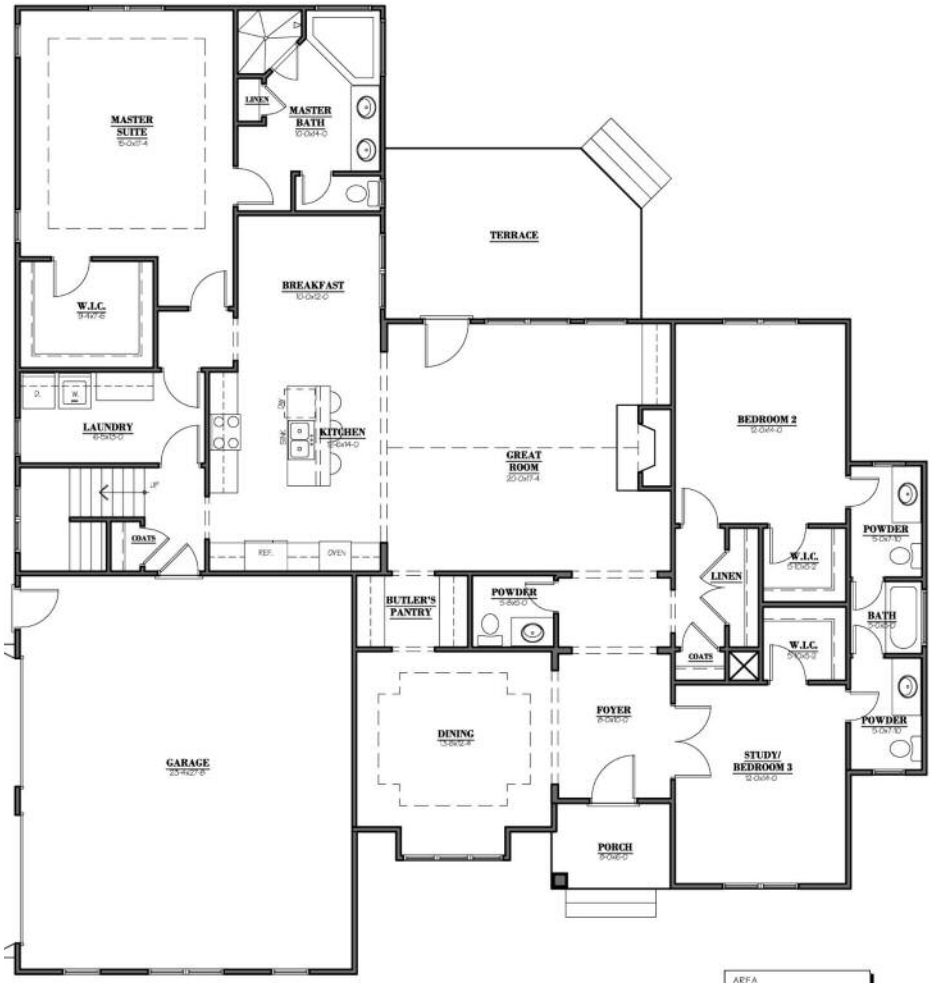
Choosing a builder, planning and designing the house

Rachel and I met Mike Dumont in October 2017. He was showing his model home, which had just won another gold medal on the 2017 Richmond Parade of Homes. The home being exhibited was a four bedroom with three-bathroom design. It was a beautiful craftman-style home with clean finishes and an open modern layout. The exposed wooden beams added to the home's unique character and welcoming feel. I noticed the gold medal award placards prominently displayed on the thick granite countertops in the model kitchen. We were impressed!

By this time, Rachel and I had looked at more than 25 homes and none had quite matched our needs. When we began our home search in mid-2016, I told Rachel I had an amount in mind we were willing to spend, but over the months of home shopping, that amount had progressively increased to the point that by the time we met the builder we decided to select, I had already accepted that we would probably spend nearly twice what I originally had in mind.

When shaking Mike's hand, Rachel and I immediately felt at ease. We knew that we were in the presence of a true professional who had mastered his craft. He didn't have to say much, but he did make a few comments to me about the building methods and materials used on some of the design features. This man knew what he was talking about! He could speak about the construction at such a fine level of detail that only another builder could fully appreciate it.

The following week, Mike introduced us to his son and business partner Christian, who had recently finished leading the construction of the company's premier model home in the award-winning Hallsley neighborhood, about 20 miles from where we were planning to build. Rachel laid out our requirements, and he assured us that he could deliver. About one week later, he presented us with a proposal to build the Ordia Residence using a modified and expanded Magnolia floor plan. Our new home would be built just across the street from the model home that had initially impressed us. Rachel would be responsible for the functional and aesthetic design while I focused on the energy efficiency improvements, preparedness, and sustainability.



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Dumont Homes, LLC

· THE MAGNOLIA ·

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After some brief deliberation, we accepted the proposal and dropped a deposit. The builder was able to provide builder financing for the project. All that was required of us as the buyers was a 5% deposit to start lot clearing and permitting and another 5% prior to breaking ground on the foundation. Rachel and I would then purchase the home using a conventional mortgage once construction was complete. Christian agreed to get started on engineering and permitting right away. We were one step closer to realizing our vision.

When all was said and done, we ended up at a figure nearly double our original budget. I simply underestimated how much it would cost to give us a home with the required space, custom floor plan, design, and high-quality workmanship we desired. Also driving up the price were preparedness-related requirements, such as LED lighting as opposed to standard lighting, a 1000-gallon propane storage capacity that we will discuss in an upcoming chapter, and the super-high efficiency HVAC system with variable speed control that you will learn about in Chapter Four. Those things and more contributed to elevate the price towards our breaking point. However, despite the additional financial

stress, I felt confident in our decision to build with Dumont Homes, a top-tier firm that could deliver everything we wanted.

I also liked the idea of being in an up-and-coming neighborhood. There's an old piece of real estate wisdom that says it's better to be the poorest guy in an affluent neighborhood than to be the most affluent guy in a poor neighborhood. I valued being in an environment with people who had already advanced further in their careers. These folks could serve as excellent mentors and advisors to us as Rachel and I grew towards the apex of our careers.

After settling on the neighborhood, our next task was to choose our home site from the available lots. We wanted enough cleared yard space for our children and dog to play outside without creating too much yard work for me. I also preferred to be towards the back of the subdivision, not visible from the main road leading into and out of the community. Finally, we wanted to live on a road with no pass-thru so that traffic would be minimal and it would be safe for our kids to ride their bikes.

We chose a lot just across the street from the model home where we first had met the builder. The lot was just shy of four acres and rectangular in shape. We would have two acres of

cleared yard in the front with another one and three-quarters acres of woods in the rear.

Our house would be situated with the front side facing north towards the road and the rear of the house facing south towards the woods. This orientation allowed us to keep the entire solar panel array facing south for optimal energy production and remain hidden from street view. The builder would also clear 100ft of backyard from the rear of the house to the tree line. Rachel and I planned to install a pool sometime in the near future and this additional clearing would give us ample space. Furthermore, the 100-ft buffer zone would allow more sunlight to hit the solar panels on the rear of the house with minimal shading impact. Finally, a few trees on the east and west property boundaries would provide privacy from our neighbors when we were entertaining in the back yard.

Before making the decision to build, my wife Rachel and I looked at several existing homes that we liked, but just weren't quite right for us. We wanted a house with five bedrooms: the master suite, two rooms for the girls to share, plus one room for our son Michael, and finally a guest room and office. We also

wanted the house to be functional, both for our family and for guests. Rachel and I have always wanted to be able to host church small groups as well as entertain family and social visits. I also eventually wanted a functional home office. We also wanted a private space for quiet reflection—a prayer closet.

Rachel has a lingering knee injury from playing soccer that has progressively worsened over the past ten years. As a result, walking up and down the stairs is painful for her and so we wanted to minimize the frequency of this activity. With so many young children that require active supervision, we needed at least three bedrooms, including our master suite, on the first floor. We also wanted some separation between the kids' space and the common space for family time and entertaining.

We decided to use the Magnolia floor plan as our starting point for the design. The Magnolia already incorporated a first-floor master with two additional bedrooms on the first floor. Each of the bedrooms has its own full bathroom. Rachel and I liked the idea of keeping our youngest children on the first floor with us, but letting them do their bathing and grooming away from our master suite. In our previous home, the children would often use the master bath to brush teeth in the morning and take emer-

gency baths after the several accidents during potty training. We were excited to get our "sanctuary" back!

Still, we had to make this floor plan our own. Having a place for quiet reflection, a prayer closet, has always been a desire of ours. We also wanted a place for our newborn Gianna to sleep close to us for her first twelve months. Mike offered to add on a 10' x 10' sunroom off the west side of the master suite. The solution was elegant and it met both of our requirements. Better yet, the impact on project cost was minimal at $12,500. The sunroom would serve as Gianna's nursery until she was old enough to move in with her big sister. After that, we would convert the sunroom to the adults' prayer room.

Architect's Rendering

On the upper level, the original Magnolia design provided a 4th bedroom and a large bonus room. Given our large family—five children at the time of this writing- we decided to go for a fifth bedroom. Christian was able to split the bonus room into two bedrooms and leave the original 2nd floor bedroom as a guest room/office space with some common area workspace. The final home design, including all modifications, came in at just over 3,800 finished square feet.

Summary

- It is important to choose a builder that has demonstrated the ability to produce quality work as well as one you are confident you can trust.
- It makes sense to locate on a road with no pass-thru so that traffic will be minimal and it may be easier to defend.
- It makes sense to select a lot on which your house can face north toward the road so that the solar panel array can face south for optimal energy production and be hidden from street view.

The foundation of our new house has just been laid.

Chapter Three

Powering Up

Electrical power, what's needed, alternatives, batteries and backup

I'd like to begin this chapter by discussing energy conservation actions you may wish to take before installing a solar energy system. You see, conservation is the key to getting the most out of your solar investment because it is much more economical to reduce the amount of energy you are using, and therefore the amount of energy you need, than to throw a lot of solar power at a home that isn't energy efficient. Often times, people reach out to my company because they are receiving electric bills that are $300, $400, or $500 a month, and naturally, they want to eliminate that huge bill. What they need to understand is that, without conservation, a larger electric bill means more solar power will need to be installed, and the higher the cost of that installation will be. Therefore, the first step ought to be to figure out what can be done to reduce the amount of electrical energy the home is consuming. You can start by reviewing your electric bill, which is something we do for every client we help become energy

independent. Your electricity invoices over a period of time will show month by month by month how much electricity your home is consuming.

Sometimes people ask if we can design a system based on the square footage of a house, but unfortunately, that by itself is not enough information to design a solar system. Energy consumption has to do with lifestyle and the appliances in the house, particularly heating and cooling appliances. By looking at the raw numbers on a utility bill we can determine how many kilowatt hours (kWh) are being consumed per month. For example, one home in Virginia we converted to solar a year or so ago was using 2,100 kWh of electricity per month. Here's how we determined how much solar was needed to offset that amount of usage. In Virginia there are on average 150 ideal sunlight hours per month. We divided that amount into the 2,100 hWh. We then divided the result by an efficiency rating of 85 percent, which gave us 16-kilowatts (kW) of solar panels we would need to completely offset that electric bill. Here's the formula:

2,100 kWh divided by 150 ideal sun hours, divided by 85% = 16kW

It turned out, however, that this house was able to accommodate only 13 kW of solar panels due to the limited amount of south-facing space on the roof. We were able to make 13 kW sufficient, however, by taking conservation steps that reduced the amount of electricity consumed by the house.

How can any homeowner do the same? Start by considering if there are appliances that may need to be upgraded. For example, there may be an old refrigerator or freezer with an inefficient compressor that runs more frequently than it needs to. There may be an old dishwater, an outdated hot water heater or other appliances that can be upgraded to state-of-the-art, EnergyStar-rated models.

Not long ago, I interviewed a client of mine for my *Prep Experts* YouTube video series, Mark Strickland, who is an expert on preparedness and off-grid survival. Mark worked for twenty years in emergency preparedness for the U.S. government and now has his own company, Building Security Associates, that consults with businesses and individuals on how best to prepare for and survive an extended off-grid event. He shared a number of ideas he employed in a home he had built for himself and his wife in the Blue Ridge Mountains of North Carolina.

One big savings in energy Mark was able to realize was accomplished by using LED bulbs for lighting throughout his house. For example, an LED bulb that uses 14-20 watts typically will generate as much light as a 100-watt incandescent bulb. Not only do they use only twenty percent or less electricity, LED bulbs have a general life expectancy of 50,000 hours versus 750-2,000 hours for the incandescent variety.

Something else Mark did to save energy was install a hybrid hot water system using a mini heat pump and inline propane water heater. A standard electric resistance hot water system typically draws anywhere from 2,700 to 4,400 watts. Mark's hybrid system only draws 480 watts. It employs a hot water heat pump to preheat water from 50 degrees Fahrenheit when it comes out of the ground to 100 degrees. It is then kept at that temperature in a 100-gallon holding tank, and when the time comes for hot water to be used, it is heated on-demand by propane from 100 to 120 degrees. This not only saves electricity, it saves on propane consumption since much more energy, and therefore much more propane, would be used to raise to the water's temperature all the way from 50 degrees when it comes out of the ground up to 120 degrees when it is used.

Mark went on to say that electric heat pumps are also an energy efficient way to heat a home as long as the outside temperature stays above 45 degrees Fahrenheit to 50 degrees Fahrenheit, which is why he has one. However, they becomes less efficient as the temperature drops. In typical heat pump systems, when the outside air temperature is very low, an auxiliary electric resistance heater typically kicks in and consumes a large amount of electrical energy. To avoid this, Mark replaced the electric resistance backup heater with a propane heating element. Mark also had a gas (propane) clothes dryer installed and a gas (propane) cook top. Both use far less electrical energy than standard appliances. Best of all, the cooktop requires zero electricity and will remain in service indefinitely if and when the grid does go down.

Phantom loads are something else to look out for as you take an inventory of electric usage by your home. These are devices that use electricity even when not in use. One example is a desktop computer that might be left on all the time even though it's used only a couple of hours a day. The cable or satellite box also may be on around the clock and yet used only for a few hours in the evening.

Other areas to consider have to do with cooking, hot water, heating and cooling. I advise everyone who wants to be able to build a home that can run entirely off grid – or perhaps to retrofit a home to run a portion of it off the grid – to use something other than electric resistance for heating and cooking. You might consider a heat pump as Mark Strickland did, for example, but you'll want the auxiliary heat backup to use an alternate fuel source. Usually, that's oil, natural gas, or propane. Wood and pellet stoves are also viable alternatives for home heating. Why? Traditional electric resistance backup heating elements requires a good deal of electricity, particularly at night when the sun isn't shinning and temperatures drop to the lowest levels. Using propane or some other source will reduce the home's electric energy consumption significantly. This is particularly important during a power outage when solar and battery are the only sources of electricity. Along the same line, an electric clothes dryer can be swapped for one that uses natural gas or propane.

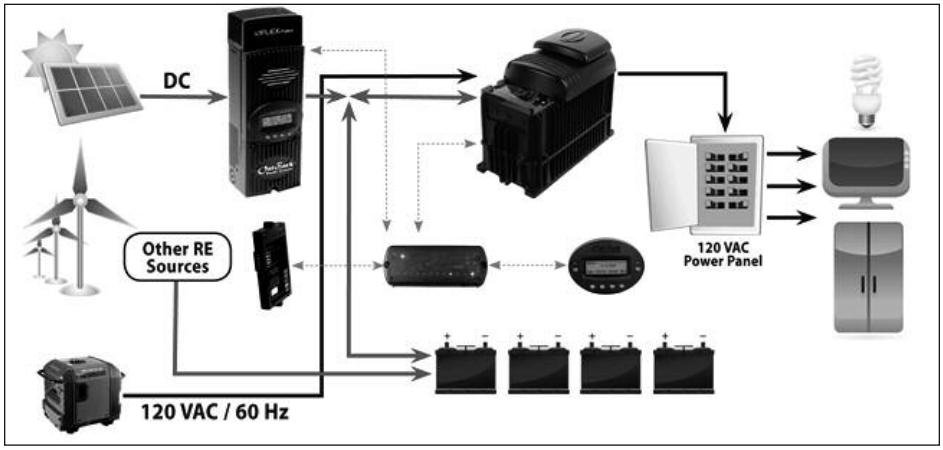
Finally, you might want to think about installing timers on appliances, particularly refrigerators or freezers that have a compressor set to run on an automatic cycle. For example, if a freezer

is not going to be opened overnight, it would make sense to have it power off say at ten p.m. – or whatever bedtime is – and power it back on at seven or eight the next morning. This is especially true in a grid-down situation when solar and battery back up are the primary sources of electrical energy.

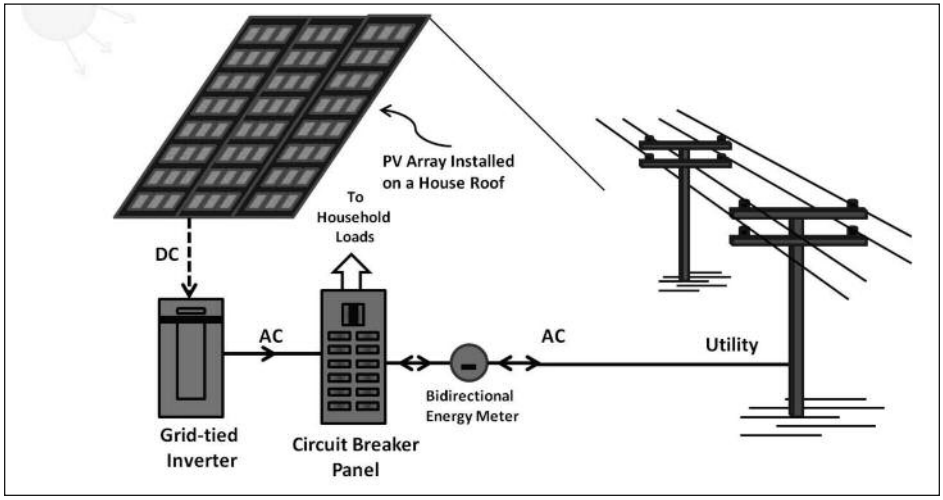
What Kind of Solar Power System Do I Need?

What kind of solar power system do you need? I'm going to describe the three types of systems, starting with one that will allow part or all of your home to run independent of the electric utility: the "off-grid solar system". Its number-one purpose is to provide secure backup power to a residence when the electric grid goes down. Such a system can also be used to power a building that has no access at all to a public utility, such as a hunting cabin in the woods.

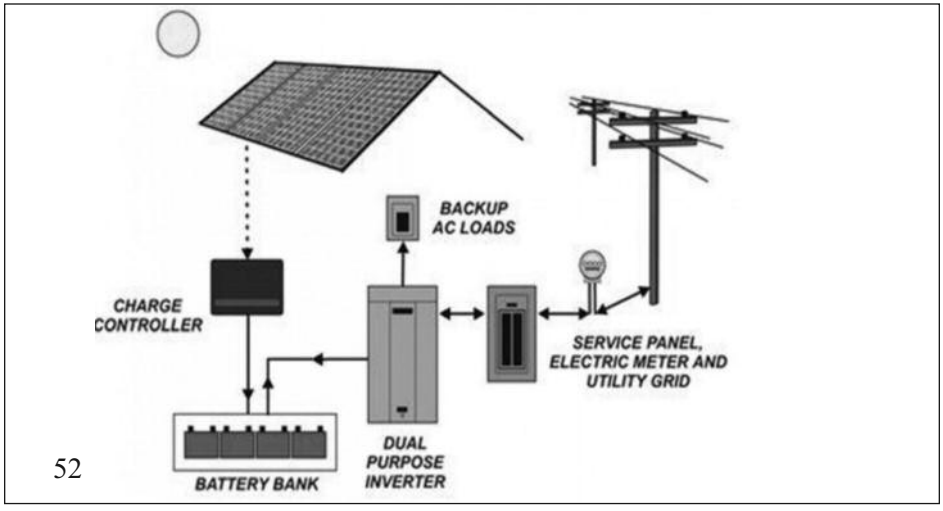
Since getting a generator is the first thing that may come to mind for someone who wants backup power, let's take a look at why that is not the best solution. There are a couple of reasons. Generators have to be maintained, and they require fuel. In fact, the warrantee on most generators is 500 hours. Think about that.



Off-Grid System



Grid-Tied System



Hybid System

If the grid goes down and a generator has to run all day, every day, those 500 hours will be used up in less than a month – actually, in three weeks – 21 days when running 24 hours a day. In addition, imagine how much fuel it would take to run a generator that length of time, much less indefinitely. As will be discussed, you will probably want to have a generator as a way to recharge your battery bank if that is ever needed because of an extended period when there is little sun due to inclement weather, but recharging batteries should require only a few hours of operation if or when that's necessary. What you do not want is to have to rely on a generator as your only power source. You may not be able to get the fuel you need, and even if you can get it, the sound of a generator motor running constantly will call attention to you and your location. After a period of time, as people run out of food and water, things are likely to get out of hand as societal norms break down. Desperate people will begin doing desperate things to survive. If they hear your generator running, they may decide to follow that noise in order to see what you have that they can try to take. On the other hand, energy is generated silently by an off-grid solar system, and that energy will be renewed each day whenever the

sun is shinning. That means there should never be the need to leave home to attempt to obtain fuel during a crisis.

Let me walk you through the components of an off-grid system. It starts with a solar panel array that coverts energy from the sun in to direct current (DC) electricity. This electricity then flows through a device called a "charge controller." The charge controller's job is to regulate the amount of solar energy allowed into the system to charge the batteries. This is because once batteries reach full charge, they can be damaged by overcharging. So, the proper and optimal amount of energy comes out of the charge controller and flows into the bank of batteries. You might think of this bank as your energy storage tank, where power is kept for use whenever the sun isn't shinning.

The battery bank is connected to a special electrical transformer called an inverter. The inverter converts low voltage DC electricity from the batteries into high voltage alternating current (AC) electricity that is then fed into the home's critical-loads circuit-breaker panel. From there, the current goes out to power appliances and equipment in the house that have been selected to be on this panel. This would normally include any necessary medical

equipment, the water pump, interior lights, the refrigerator, and perhaps the water heater. As you will see, we will be able to run just about everything one would find in a normal home in the house we have under construction as I write this. Our critical loads list includes all of the above plus air conditioning, the clothes washer and the propane furnace.

In addition to the equipment as just described, there is the option to integrate a generator into the mix. As was touched upon earlier, this is a good idea because, depending on the climate where you live, it's possible a number of overcast, rainy or snowy days in a row may deplete the backup battery system to the point solar energy production has not been able to keep up. When that happens, a generator can be fired up and run for a few hours to recharge the batteries. Using a generator in this way makes sense because it will not require nearly as much fuel, and the wear and tear on the generator will be much less than if it is used as the primary source of power when the grid is down. An additional possibility for back up is to integrate non-solar, renewable energy sources such as wind power or hydropower into the system.

A System to Reduce or Eliminate Your Electric Bill

An off-grid backup solar system as described above generally costs less than the other two I am about to tell you about, and it can help reduce an electric bill at least somewhat by powering selected circuits on a daily basis. It's a good place to start if you do not already have a backup system in place. However, the most popular system nationwide is called the "grid-tied solar system." (See Schematic of Grid-Tied System on page 52.)

The grid-tied solar system has solar panels that feed directly into an inverter that converts DC to AC power, which is then fed into the circuit breaker panel to power appliances, lighting and so forth, in the house. Typically, more power is produced during daylight hours than needed. The excess power causes the electric meter to run backwards, building up credit – in effect selling excess electricity to the utility in a process called "net metering." During the evening hours when there is no sun, energy is drawn into the house from the electric utility. The meter then turns in the other direction, using credit built up when the sun was shining. The goal of a grid-tied system is to have enough solar generation to completely offset a home's electric bill.

A grid-tied system is middle-of-the-road in terms of cost, and financing options exist that make it possible to have one installed without putting any money down. In this way, a monthly electric bill can usually be traded for a slightly lower solar loan payment.

The only downside to this system is that the homeowner and the house remain dependent on the electric utility. If the electric grid goes down, the system is going to deactivate itself as a safety measure to protect the utility's linemen who may be working on the grid from electric shock. Therefore, even though the solar panels are capable of producing electricity, they will not be able to provide backup power to the house.

The third type of system is called the "hybrid solar system" or "grid-tied with battery backup." This is the one we are putting into our new home because it is able to operate in both modes – off-grid and grid-tied. (See Schematic of Hybrid System on page 52.)

Like the grid-tied system, if the electric utility is in operation, the hybrid system will power the house and route excess electricity back to the power company, earning credit to offset an electric bill. In the event of a utility outage, however, the hybrid option

can run as a fully stand-alone system. In some cases, such as the home we have under construction, it can run the entire house using solar and battery power only. At this writing, however, the majority of hybrid systems are configured to power only the "critical loads" – meaning those things most necessary to have in an emergency, such as the water pump, refrigerator, medical equipment, interior lighting, and so forth. The hybrid system is the most expensive of the three options, but it is the only one that provides total energy independence and the ability to sell energy to the electric company.

The hybrid system starts with the solar array, which can be mounted on the roof or on the ground. This converts sunlight into DC electric current that is fed through a charge controller and into a bank of batteries. As mentioned earlier, the battery bank can be thought of as an energy storage bank.

The battery bank is connected to a hybrid inverter, which has two alternating current (AC) outputs. The first one powers the critical loads panel, supplying secure power to all of the home's critical systems. The second output goes into the main circuit breaker panel so that other circuits in the house can use that elec-

tricity. Once the entire needs of the house are met, any excess electricity will be sold back to the power company through the process previously described called "net metering."

As is the case with the off-grid system, it is possible to integrate a fuel burning generator with the hybrid system to provide an additional way to charge batteries. This may be important to have during winter months, for example, when solar production is at its lowest point. For those building to run completely off the grid, I highly recommend having some sort of a generator backup, even if it is simply a portable gasoline generator.

As already noted, a hybrid system is not the cheapest option and is not likely to offset an electric bill to the point it can be traded 1-for-1 with a solar loan payment. After converting to hybrid, a homeowner is likely to end up paying anywhere from $20 to $40 more a month overall to power the home than had been the case with the old electric utility bill. I consider that amount an insurance premium on energy because I see the hybrid solar system as an energy insurance policy. If the grid goes down, you and your household can continue moving forward.

Can I Afford to Install Solar Power on My House?

A lot of people wonder if they can afford a solar power system. The truth is, most homeowners can have one without putting any money down and can actually reduce the money they pay each month for electricity by having one installed. Let's look at the numbers based on a 10.0 Kilowatt system. That's enough electric power to offset about a $165 electric bill each month.

At the time of this writing, our fully-installed cost of a system of that size is $20,930 after the 30 percent government rebate is applied, based on my company's pricing. That may sound like a lot, but think about this... If solar panels are not installed, over the next twenty-five years the homeowner is going pay the electric company about $52,500. Moreover, that monthly payment will continue indefinitely and the money will be gone. However, as mentioned previously, there are banks that will finance a solar system purchase. By structuring the term of the loan over 20-25 years, a $165 per month electric bill can be exchanged for a $140 per month loan payment based on this example. The homeowner will own the solar panels outright and be reducing debt with each loan payment. Moreover, he or she will be entitled to the 30 per-

cent federal tax credit, and depending on where the home is located, state and local tax credits and incentives that may be available as well.

Getting Your Tax Credit

How can a homeowner get the 30 percent tax rebate for solar? This is important because it is often possible to structure a loan such that this tax credit can be used as the down payment on a solar system purchase, thus reducing the monthly payment even further.

Form 5695 for residential energy credits will need to be filed with the homeowner's Federal tax return.

The homeowner's name and social security number needs to be entered at the top of the form, and the total cost of the solar system, including labor and equipment, is entered on line number one. In this example, we are using a 10.0 kilowatt system.

The next three lines can be left blank. They are for solar water heating, wind energy and geothermal, which do not apply.

Line five is the sum of lines one through four, and so in this case it will be the same as line one.

Form **5695**

Department of the Treasury
Internal Revenue Service

Residential Energy Credit

► Go to *www.irs.gov/Form5695* for instructions and the latest information.
► Attach to Form 1040 or Form 1040NR.

OMB No. 1545-0074

2018

Attachment Sequence No. **158**

Name(s) shown on return

Joe Solar

Your social security number

1 2 3 4 5 6 7 8 9

Part I **Residential Energy Efficient Property Credit** (See instructions before completing this part.)

Note: Skip lines 1 through 11 if you only have a **credit carryforward from 2017.**

1	Qualified solar electric property costs	1	29900
2	Qualified solar water heating property costs	2	
3	Qualified small wind energy property costs	3	
4	Qualified geothermal heat pump property costs	4	
5	Add lines 1 through 4	5	29900
6	Multiply line 5 by 30% (0.30)	6	8970
7a	Qualified fuel cell property. Was qualified fuel cell property installed on, or in connection with, your main home located in the United States? (See instructions.) ►	7a	☐ Yes ☐ No
	Caution: If you checked the "No" box, you cannot take a credit for qualified fuel cell property. Skip lines 7b through 11.		
b	Print the complete address of the main home where you installed the fuel cell property.		

Number and street — Unit No.

City, State, and ZIP code

8	Qualified fuel cell property costs	8			
9	Multiply line 8 by 30% (0.30)	9			
10	Kilowatt capacity of property on line 8 above ► . x $1,000	10			
11	Enter the smaller of line 9 or line 10			11	
12	Credit carryforward from 2017. Enter the amount, if any, from your 2017 Form 5695, line 16			12	
13	Add lines 6, 11, and 12			13	8970
14	Limitation based on tax liability. Enter the amount from the Residential Energy Efficient Property Credit Limit Worksheet (see instructions)			14	
15	**Residential energy efficient property credit.** Enter the smaller of line 13 or line 14. Also include this amount on Schedule 3 (Form 1040), line 53; or Form 1040NR, line 50			15	
16	Credit carryforward to 2019. If line 15 is less than line 13, subtract line 15 from line 13	16			

For Paperwork Reduction Act Notice, see your tax return instructions. Cat. No. 13540P Form **5695** (2018)

For line six, multiply five by .30 (30%) to get the number. In this example, the total system cost is $29,900, and so the thirty percent rebate is going to be $8,970.

The middle section, which deals with fuel cell technology, can be skipped, but be sure to include your complete address where your system is installed.

Dropping down to line thirteen, enter the thirty percent rebate of $8,970. The only time this would be different from line six is when there are credits from a previous year being carried over.

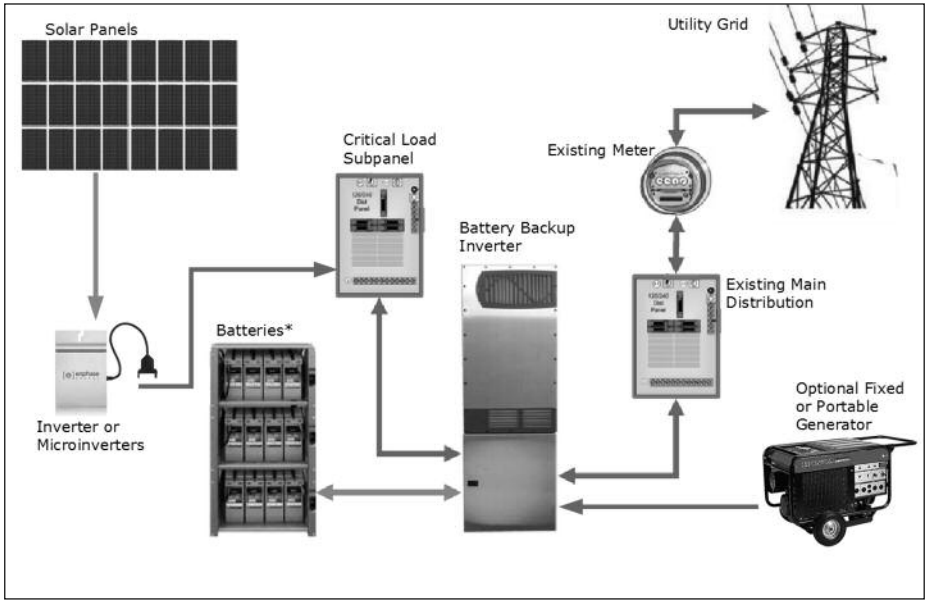
The next part is critically important in order to get an accurate idea of how much money will be coming back to you in the first year.

Line fourteen will vary depending on the tax liability of each taxpayer. This is the money the government is holding after all tax deductions have been applied. In order to get the entire solar rebate in the first year, the taxpayer must have a tax liability that is equal to or greater than the thirty percent rebate. In this example, the taxpayer would have to have a tax liability of $8,970 in order to get that amount in year one. If, for example, the taxpayer had only paid

in $5,000, then that is the amount he or she will get back this year. The difference can be carried forward to the following year.

How to Add Backup to an Existing Solar Power System

People who have an existing solar power system often ask how they can add battery backup to it. This often happens after the grid has gone down because of a storm and they find that without batteries, the solar system they have does not provide power during an emergency. Fortunately, there is a way to add battery backup with minimal impact.



Grid-tied system with battery backup

The technique we use at our company is called AC coupling. Very simply, this means we are going to make a connection on the AC side of the system between an existing grid-tied solar system and a new battery backup system. The existing system includes solar panels that are mounted on a roof or on the ground. The DC power coming from the panels will either be directly converted to AC power using micro inverters under each solar panel, or in many cases, DC power comes off the panels to a central string inverter where the conversion is made from DC to AC power.

As discussed in the section above on hybrid systems, a critical loads panel needs to be created in order to direct power to critical systems within the house during a utility outage. Then AC power can be diverted from the main circuit breaker to this critical loads panel, and a battery backup inverter that is stand-alone-capable added to the system. The inverter must be stand-alone capable so that it can send battery power into the critical loads panel in a grid-down situation and so that it can recharge the batteries using AC power coming from the grid-tied solar inverter(s). Finally, it must be utility interactive so that excess power can continue to be sold back to the electric utility during normal, daily operation.

The advantage to upgrading an existing system this way is that modifications to the solar panels are not required, whether the panels are on the roof or on the ground. The system can remain in place, and new components added to create a fully-functioning grid-interactive battery backup system that continues to allow power to be sold back to the electric company. A fully functioning stand-alone system will be created that will supply secure power during an emergency. Moreover, as with the hybrid system described earlier, a gas generator can be added as well to recharge batteries if need be when solar production may be inadequate due to overcast or inclement weather.

The Hybrid System for Our New House

Ever since we moved to our first house in the country, Rachel and I have had some sort of solar power system for emergency backup. Having lived on an independent well water and septic system for the past five years, we considered having a backup power system a necessity. Our previous homes required electricity for both running water and the ability to flush toilets. We also had enough solar capacity to run the fridge, freezer, and wood stove

blower during a utility outage using solar and battery power only. For the new house we are building, we wanted to take our energy security to the next level. This new home would have a solar electric system capable of running the entire house off-the-grid during a utility outage. I wanted our home to be a model for those who wish to live in modern comfort while having the highest level of energy security.

In order to fully understand the energy requirements of a home, we must know the peak power demand, measured in Watts, and the total energy consumption over the entire year, measured in kilowatt-hours. To achieve this, we must conduct a detailed load analysis, which consists of a listing of all electrical loads including their power rating and running time. Once we know the peak draw and total energy consumption, we can properly size the

Electrical Load Details

Qty.	Item	Avg. Draw (Watts)	Item Total (Watts)	Running Time (hours / day)	Running Time (days / weeky)	Total Energy Consumption (kWh / day)
1	Upright Fridge/Freezer (EnergyStar rated)	360	360	8	7.0	2.9
1	Chest Freezer	240	240	8	7.0	1.9
1	Well Pump	2,000	2,000	0.25	7.0	0.5
1	LED TV w/ Accessories	250	250	6	7.0	1.5
1	Fireplace Blower	75	75	8	7.0	0.6
10	LED or CFL Light Bulb	10	100	8	7.0	0.8
1	Microwave	1,200	1,200	0.25	7.0	0.3
1	Laptop Charger	65	65	8	7.0	0.5
1	Cell Phone Charger	10	10	8	7.0	0.1
Total Consumption		**Max Load**	**4,300 Watts**		**Total Energy Consumption**	**9.1 kWh/day**

renewable energy system and energy storage unit (batteries). Let's look at an example.

How much a homeowner is able to run on a solar power system depends on the specific loads being powered. The worksheet on page 67 lists all of the home's critical loads. As you know, many solar power systems are set up to run a portion of a home using solar and battery power only, systems deemed the most important ones to have during a power-outage emergency. The load calculation here lists all of those deemed as such in this particular home: The refrigerator, the chest freezer, the well pump, a flat screen LED television with accessories, the blower fan on the fireplace, ten light bulbs, a microwave, and chargers for a laptop and cell phone.

We need to look at how many watts each uses when running and how many hours per day the appliance is typically going to be used. Let's look at the refrigerator on the first row. It draws about 350 watts of power when the compressor is running, and it runs on average about one-third of the time – about eight hours during a twenty-four hour period. So, multiply the wattage when it's running times the running hours per day and divide by 1000

and that gives the total energy consumption of that appliance in kilowatt hours (kWh). It's important to understand there's a difference between instantaneous power, measured in watts, and total energy consumption, measured in kilowatt (kWh) hours. An electric bill typically shows kilowatt hours, which is total energy consumed over a period of time.

One purpose of the load analysis is to get a good idea of what the total power draw on a system will be if everything is running at once. If everything in the example shown here is running at the same time, the total draw will be 4,300 watts. Keep this number in mind as we will refer back to it later. The next thing to determine is the total energy consumption over a typical 24 hour day. Adding everything in this example results in a total of 9.1 kWh per day.

Why are these two numbers (total draw in watts, and total energy consumption in kilowatt hours per day) important? Number one, the solar inverter's power rating needs to meet or exceed total draw. If it doesn't, it will not be possible to power on all the items listed at the same time. The homeowner would, for example, be in a situation to have to turn off the water pump so the mi-

crowave could be turned on. Obviously, it's best to have the renewable energy system large enough so the inverter's power rating can handle everything operating at the same time.

The total power consumed over a 24-hour period is important for two reasons. First, there needs to be enough solar power generation in a typical day to meet the needs of the critical loads. To put that another way, the solar energy harvested by the system must exceed the energy that will be consumed by your home's appliances.

The second reason has to do with the battery reserve calculation. Off-grid, the solar panels power the loads during daylight hours while energy is simultaneously being stored in the batteries for use during evening hours. Between sundown and sunrise, the loads must be met solely by energy that was stored in the batteries. Knowing the total energy consumption over a typical 24-hour day makes it possible to compare different battery configurations,

Battery Reserve Calculations

Qty.	Type	Volts	Amp-Hours	Total Energy (kWh)	Depth of Discharge	Reserve Hours
1	LG Chem Resu10H	400	25	9.8	80.0%	18.6
1	AGM Deep Cycle Battery Bank 220Ah 48V	48	220	10.6	80.0%	20.1
1	AGM Deep Cycle Battery Bank 390Ah 48V	48	390	18.7	80.0%	35.5

sizes, and types to what the energy demands of the critical loads will be.

The chart on the opposite page shows three different battery configurations based on different battery technologies to see how they match up to the needs of the critical loads. The LG Chem RESU10 is a 400 volt 25 amp hour lithium ion home backup battery. This is a good battery for a home that does not have heavy loads to power, providing 9.8 kWh of reserve. However, in the example shown here, the 9.8 kWh running the battery down 80 percent only gives 18.6 reserve hours. When we design a system, we want battery storage to provide at least 24 hours of power because we know the extra time may be needed during periods when overcast conditions inhibit solar power production. As a result, the LG Chem RESU10 is somewhat undersized.

The second option shown is an AGM maintenance-free battery bank at 48 volts, 220 amp hours that yields total energy of 10.6 kWh. You can find this type of battery bank in most electric golf carts. This one provides only 20 hours of running time.

Option three is also a maintenance-free AGM battery bank using the larger 390 amp hour batteries. These batteries are sim-

ilar to what you might find in a forklift or commercial floor scrubber. This configuration will provide 35.5 hours of running time. Of the three options shown, this is the one I would recommend to a client.

Solar Power Generation Calculations

Qty	Type	Power (Watts)	Ideal Sun-hours/Day	Energy per Module (kWh)	Total Energy Harvest (kWh)	Meets Requirement
9	Hanwha Q-Cell 300W	300	5.0	1.5	13.5	126.8%

DC-AC Derating	
Solar Panel Nameplate De-rate	95.00%
Inverter Efficiency	90.00%

Next are the solar power generation calculations. With a whole house solar power system, the size of the solar array often will be based on the total consumption shown on the home's electric bill. If the solar array will cover the total energy consumption of the home, then it will certainly be enough to cover the critical loads. However, when designing an off-grid or partial coverage battery backup system, it's important to know just how much solar generation would be needed to cover critical needs when the grid is down. To calculate solar energy harvest, we need to consider the number of solar panels, their power rating in watts (this example has 300 watt panels), and the average hours of sunlight per day. This will vary depending on the part of the country where the installation is located. Where we are located in the mid-At-

lantic, there are on average about five hours of ideal sunlight per day. So we take the number of panels, times the watts per panel, times the average hours of ideal sunlight, times the power factor (efficiency), then divide it by 1000. This gives us the average energy harvest measured in kilowatt-hours (kWh). This figure needs to meet or exceed the total energy consumption from the loads.

On-Going Energy Monitoring

If we were going to stay within our energy budget, we felt we needed a way to see how our energy was being spent. Rather than waiting until the end of the month to view our home's electric bill, I wanted to be able to track in real-time energy coming in via solar or utility and energy being consumed by the various appliances and home circuits. In order to help us make better decisions about how we spend our energy, It was important to be able to measure our consumption down to the per-appliance and per-room level. Therefore, we needed an intelligent home energy monitoring system. Dozens of energy monitoring systems are available on the market today. The two I would advise anyone to look at today are Curb and Sense.

After evaluating several options, including those two, I chose to install Sense. The Sense system includes a single pair of current sensors that fit around your electrical feed lines and are very easy for your electrician to install. The unit has an intelligent signal processor that can differentiate between electricity being drawn from each major appliance, allowing us to measure energy consumption on dedicated circuits including the refrigerator, chest freezer, washer, dryer, well pump, HVAC compressors, water treatment system, septic pump, and various indoor lighting circuits.

Renewable Energy System and Storage

In our part of the world, solar modules operate best when oriented facing south. In this position, the modules will receive both morning and afternoon sunlight throughout the year. The rear of the house provided just enough south-facing roof space to install 42 pieces of 295-Watt solar modules, for a total system power of 12,390 Watts (12.4kW). A system of this size would be capable of producing in excess of 1,800 kilowatt-hours (kWh) of usable electricity per month. That equates to an approximate $200 per month electric bill. If we were going to power a 3,800+ square foot

home with an energy budget of 1,800 kilowatt hours per month, then we were going to have to do everything we could to maximize the energy efficiency of the home.

We decided to install a full hybrid solar power system using the 42pcs of Hanwha Q-cells 295W solar panels and 29kWh of energy storage capacity. I selected the Outback Radian 8048 hybrid inverter as the main power unit because of its multiple AC inputs (utility and generator), online monitoring capability, and its ability to handle the required load. Depending on the size and scope of the house being built and the projected power usage, however, some readers may wish to consider other less powerful, and therefore, less costly options. For example, for our clients today who are content with a backup system that will power the basic essentials such as the refrigerator, the water pumps, the lights and a few electric outlets, we are using a system called "StorEdge" along with a compact and efficient rechargeable lithium ion battery from LG Chem that is guaranteed for 10 years. At the time of this writing, the LG Chem 400V high-voltage unit is compatible with several other DC-AC inverters on the market, including SMA Sunny Boy Storage.

However, the higher power output and energy harvest provided by the Outback Radian 8048 hybrid inverter and 12.4kW solar array will allow us to power the house during daylight hours using solar power and earn credit by selling excess solar electricity back to the utility. We would still have the ability to use utility power during the evening so we would not have to ration our energy usage. During a utility outage, we would have the ability to use all available solar and battery power to energize the home. The Radian 8048 has a peak load of 9,000W and will surge up to 12,000W for 5 seconds. The system was designed to meet all of the home's energy needs, including central heating (using propane) and air conditioning, when running independent of utility power.

Here are a few things to consider when selecting the inverter unit for your home's renewable energy system:

1. If all critical loads are powered on simultaneously, how much power (Watts) is required? Your inverter should have a continuous power rating of at least this amount.
2. Do you need both 120V and 240V AC power?

Most modern hybrid inverters provide 120/240V "split-phase" power, just like the utility service. However, if only 120V power is needed, a smaller, less expensive, and more energy efficient inverter may be used. For example, the Outback Power GVFX3648 is a great 120V inverter offering up to 3,600W of power at 93% conversion efficiency. The GVFX3648 is only half the cost of a Radian 8048.

3. Always use a "pure sine wave" inverter. The lower cost "modified sine wave" inverters are likely to damage your sensitive electronics like microwaves, audio-video equipment, computer equipment, and printers.
4. Are you planning to offset the cost of your solar system by selling excess electricity back to the utility? If so, be sure to select an inverter that is grid-interactive.
5. Do you want the option of charging your batteries using a traditional generator? I advise all

of my clients purchasing off-grid or hybrid systems to have a generator hookup. Be sure that your inverter has separate, dedicated inputs for both utility power and generator power.

What Type of Batteries Should I Use?

Three main types of batteries are being used for solar systems today. The first type is the traditional, flooded, lead acid batteries, sometimes called "wet cell" batteries, which are comprised of lead plates and sulfuric acid. Distilled water has to be added from time to time to keep the electrolyte level up because it is important to keep the lead plates completely submerged. There are two advantages to "wet cell" batteries. Compared to the other two types, they are inexpensive relative to the amount of energy they store. Secondly, they have a longer cycle life, meaning they can be charged and discharged more times before they are no longer able to hold a charge. They also have two downsides. They require maintenance – distilled water to be added – and they may require special ventilation because "wet cell" batteries give off hydrogen gas when being charged or discharged, and of course hydrogen gas

is flammable. This can be a concern if the gas is allowed to build up in high concentration. Wet cell batteries must be placed somewhere that has adequate ventilation.

The second type is the AGM (Absorbent Glass Mat) battery. This is the type we most often use in our installations. The battery acid, which is in liquid form in the "wet cell" battery, is absorbed and immobilized in a fiberglass mat between the lead plates in an AGM battery. That means there is no liquid sloshing around inside. These batteries don't require the watering service or maintenance. Nor do they have the same ventilation requirements as wet cell batteries because the amount of hydrogen gas coming off them is significantly less. They are also more efficient than "wet cell" batteries. The typical "wet cell" battery is about 80 percent efficient, whereas an AGM battery is about 90 percent efficient. A drawback to AGM batteries is that they do not last as long as the other two types. They can be charged and discharged about 1200 to 1500 times, which means they will last around four years when used every day. For this reason, AGM batteries are typically used for stand-by and backup service only, meaning they are only going to be used when electric utility service is not avail-

able. In a building that is going to be using an off-grid system every day, such as a cabin in the woods, we will typically recommend "wet cell" batteries be used.

At the top of the battery heap are lithium-ion batteries, which as of this writing have recently come on the market for backup use and in off-grid systems. Basically, they are giant cell phone batteries that are built into large, stainless steel cabinets meant to be wall-mounted. Lithium-ion batteries are the most efficient with about 95 percent efficiency, and they require zero ventilation or maintenance. Another advantage is a longer cycle life. They will last between 3000 and 6000 cycles, or between eight and sixteen years if used every day. The downside, however, is that the cost is very high – as of this writing, perhaps two or three times higher per unit of energy compared to the AGM. So a homeowner will pay two or three times the cost of an AGM battery storage unit upfront for one that will last two or three times as long. Depending on the amount of backup an off-grid system will require, and therefore the size and cost of the backup energy storage unit, lithium-ion batteries may make a lot of sense.

Something else to be aware of: only deep-cycle batteries should be used for a solar system. Sometimes people think they ought to be able to use car batteries, but there is an important difference between batteries made to start engines and deep-cycle batteries. Automotive batteries generally have very thin lead plates with holes in them. This is to maximize the surface area between the lead plates and the electrolyte liquid. This is done to provide the quick surge of energy needed to start a car's engine. Deep cycle batteries are designed with lead plates that are solid and thicker to make them more durable. As such, they are able to provide power over a period of one to three days and then be fully recharged, a cycle that can be repeated thousands of times.

For battery storage for the house we have under construction, we chose to use 100% maintenance-free AGM deep cycle batteries. In our previous home, we had used traditional flooded lead acid, "wet cell" batteries. I decided I didn't want the maintenance headache that came with this sort of battery at our new house. Although I was initially attracted to the newer and more efficient lithium-ion batteries, they simply did not provide enough storage capacity to run our entire house during a period of prolonged in-

clement weather at a cost that made sense to me. AGM batteries, on the other hand, provided plenty of storage capacity, a lower initial price point, and the ability to increase capacity incrementally over time as my energy requirements evolve.

Summary

- Before designing and installing a solar system, the first step ought to be to determine what can and should be done to reduce the amount of energy a home is consuming.
- Some or all appliances may need to be upgraded.
- LED bulbs for lighting ought to be used throughout the house.
- Electric heat pumps are also an energy efficient way to heat a home as long as the outside temperature stays above 45 degrees Fahrenheit.
- Electric resistance heater backup systems for heat pumps should be replaced with a propane or other fuel-burning heating system.

- Consider propane or natural gas for cooking, hot water, and clothes drying.
- Consider installing timers on appliances, particularly refrigerators or freezers that have a compressor set to run on an automatic cycle.
- There are three types of solar energy systems:
    - Off-grid systems that can power a home independent of the utility
    - Grid-tied systems that can reduce or eliminate an electric bill
    - Hybrid systems that can do both
- Grid-tied systems can be upgraded to hybrid systems fairly easily.
- An electric generator may come in handy to charge a battery storage bank if needed during an extended period of overcast or inclement weather.
- The government offers a 30% tax credit that can be used as the down payment toward the cost of a solar system installation.

- Three types of batteries are used in solar systems today:
    - Traditional flooded lead acid batteries, which require maintenance and ventilation.
    - AGM (Absorbent Glass Mat) batteries, that do not require the watering service or maintenance, and they are more efficient.
    - Lithium-ion batteries, which require zero ventilation or maintenance and are highly efficient and long lasting but cost more upfront.

The framing timbers for our new house have been delivered.

Chapter Four

Water, Water, Everywhere

Because You'll Want to Drink

Wells, streams, cisterns, pumps, septic systems, toilets -

what you need to know and what we decided would work best for us

It's a fact potable water is absolutely essential to survival. No wonder the number one priority in a grid-down situation has got to be emergency power for water pumping. Each of our previous two homes had an independent well and septic system, so Rachel and I were already accustomed to dealing with wells and septic pumps before starting construction on our new home. Simply put, we knew if we lost power, we would also loose running water and the ability to flush toilets. Believe me, you don't want that to happen. Things can get messy in a hurry.

In our first country home, I rigged up an off-grid solar power and battery system that allowed me to manually switch the well pump and refrigerator/freezer circuits to solar power during a utility outage. In our current home as of this writing, we have a larger off-grid solar power system wired into a whole-house generator

transfer switch. A challenge we had to overcome is that both the well pump and septic pump require electricity to operate and, often, both the well and septic pumps fire simultaneously. For example, when we flush the toilet, the septic pump kicks in to evacuate the wastewater while the well pump would fire to refill the toilet reservoir.

Traditional AC motors have a high start-up surge demand and both pumps firing simultaneously had the potential to overload our emergency power system. For the new house, I want to avoid the possibility of this scenario altogether. Our new battery-inverter system has a peak load of 9,000W, which has the ability to cover the entire house, including HVAC. My goal is to minimize the power requirement of the water system as much as possible. That's why I decided to install a Grundfos 3/4HP soft start well pump. The soft-start feature minimizes the peak draw hitting the solar inverter, leaving more capacity available for other circuits in the house. Avoiding large start-up surges also should prolong the life of the inverter and help avoid any brown-out's, i.e., low voltage and the dimming of lights, when running on backup power.

Something else to strongly consider is having a manual pump backup to your electric well pump. In Chapter Eight we will discuss what could happen if an electromagnetic pulses occurs. The explosion of a nuclear device at high altitude can cause this, or it can occur naturally because of a solar flare or a Coronal Mass Ejection [CME], which is a cloud of magnetized solar material erupting from the sun's atmosphere. Any of these three types of events has the potential to essentially "fry" electronic devices as thoroughly as if they had been struck by lightning. If that happens to your electric well pump, no amount of backup power is going to bring it back to life.

The type of manual water pump you will need depends on the depth of your well. Put "manual well pump" into the search bar on Amazon and a host of options will appear. An old fashion hand operated pump like those you might see in an old western movie will work with a shallow well. Some of them claim to be operable for a well as deep as 150 feet. Deep wells, on the other hand, will require a different kind of manual pump. Bison makes one that is supposed to work for a well of up to 350 feet in depth.

The Rainwater Collection Option

If your home now gets water from a municipal source, what happens if the grid goes down indefinitely and the city, town, or county waterworks is no longer operational? You'll need water from somewhere. If ground water such as a pond or a creek is not accessible, it is possible in most cases to construct a water collection system on the roof of your house to provide the drinking water you need.

And what if you want to build a homestead in a place where water is so far down in the ground the cost of digging a well would be prohibitive? According to my research, digging a well typically costs between $15 and $30 per foot of depth, and that can rise to $50 per foot in difficult terrain. In one story I know about, a man bought a piece of property on a mountain, had a well drilled down eight hundred feet, but never struck water. He had to walk away from that property with nothing to show for it. After consulting a hydro geologist, the same man bought another piece of property and had drilling done in several different places before water was finally found six hundred feet down. But, as it turned out, the soil was very sandy and he had to pay for more than four hundred

feet of screen and casting in order to keep the well from caving in. He now has his well, but he spent more than $60,000 to get it. Perhaps the man should instead have considered a rainwater collection system integrated with his home's gutters.

When we first decided we wanted to be able to live off the grid if it became necessary, we used rainwater for drinking and cooking for six months just to see if we could do it and how it would work. We rigged our gutters to collect rainwater from the roof and direct it to above ground barrels. We also set up a desktop water filtration system to put the water through in order to take out particles that were picked up during the runoff process. After about 3 weeks of following this routine, we noticed a greenish color appear in the filtered water. After about 3 weeks of following this routine, we noticed a greenish color appear in the filtered water. I recalled that survivalist Jim Rawles stated that 1/4 teaspoon of unscented chlorine bleach could be used to treat two gallons of drinking water so I began doing this for each two-gallon portion. The bleach took care of the discoloration right away!

It's important to know, however, that bleach has a limited shelf life. Once a bottle has been opened, it will last only about six months before its effectiveness starts to decline. So, it will be useful in the beginning weeks of a collapse, but not for the long term. Fortunately, there is something you can use, and have on hand, that will last: calcium hypochlorite, also known as "pool shock." Calcium Hypochlorite is one of the best chemical disinfectants for water, better than bleach by far. It destroys a variety of disease causing organisms including bacteria, yeast, fungus, spores and viruses.

You'll need and want to avoid purchasing shock that has other chemicals in it. Look for and purchase 100 percent calcium hypochlorite. Pool shock is great for long-term use because so little goes so far. A single pound of calcium hypochlorite will disinfect about ten thousand gallons of water.

Using pool shock involves a two-stage process. First you will need to produce what is essentially a form of bleach, then add that to the water you want to disinfect. To do so, add one teaspoon of pool shock to two gallons of water and mix it using a wooden spoon. Why wooden? Because metal will quickly be corroded by

this solution. Then add the solution to your water in a ratio of one to one hundred parts. This means adding one pint of solution to twelve and one-half gallons of water.

By the way, if you don't have fairly fresh household bleach on hand and cannot get your hands on some pool shock, you can always boil water before drinking or using it for cooking. It may taste flat after doing so, but you can solve that issue by pouring it back and forth several times between two containers to aerate it.

Returning to our experiment with capturing rainwater, the only disadvantage to our system was water flow. It took the small, desktop filtration unit we had about four or five hours to treat two gallons of water. Obviously, more water than that may be needed for drinking and cooking, depending on the number of occupants in the household, and so for larger households, it will make sense to have more than one desktop filtration unit, or one much larger than our desktop system. Fortunately, such a system can be created using empty two-liter plastic bottles. Cut off the bottoms, so what's left look like large funnels. Turn them upside down so the threaded spout is at the bottom.

Here's how to turn them into water filters. Put coffee filters in the inverted bottles. Add a couple inches of activated charcoal, which you'll find at any pet store. Then, add a couple inches of grain sand directly on top of the charcoal. Most hardware stores and farm supply outlets will have this typically labeled as "Play Sand." Finally, put a layer of pea gravel or similar size rock on top of the sand.

To test out each filter, add food coloring to tap water and run it through the filters It should come out pretty clear.

A Cistern System for the Long Haul

The water collection system we built for ourselves would have been enough to get us through a relatively short period of time that the grid might be down. A potential problem is, what if you live in an area where digging a well is not practical or even possible, and there is no stream, river, or spring nearby you can tap into? According to the U.S. Geological Survey of the U.S. Department of the Interior, the average person uses around 80-100 gallons of water per day. That's a lot of water, and although you can probably cut down the amount by using conservation techniques,

it suggests that above ground rain barrels may not be enough to hold the volume you will need to be totally independent of the city or county water works. That being the case, you may want to consider installing an underground cistern that will hold several times the volume of rain barrels. A quick Google search indicates that many different types of prefabricated cisterns for underground placement are on the market, ranging in size from 1,500 to 10,000 gallons and made from either plastic, PVC, fiberglass, or pre-cast concrete. Think of one as an underground pool that will supply all the water you'll ever need because it is resupplied and refilled every time it rains.

As is the case with a cistern made up of above ground barrels, gutters and downspouts direct the rainwater that lands on the roof to an underground storage cistern. Experts say a metal roof is best, such as those seen on many old farmhouses, but just about any type will work if you have a way to separate dirt and debris from the water run off. Various materials including cinderblock, reinforced concrete, precast concrete, fiberglass, or steel can be used to form the underground cistern, which will supply water to the house through the same sort of electric plumbing and filtration system you would have for a well.

You may be wondering how to make sure the water in your cistern is safe to drink, but rest assured, rainwater cisterns can provide water of adequate quantity and quality if proper steps are taken in the planning and construction stages, and periodic maintenance is performed. First is to ensure the water captured from the roof is clean of debris and other contaminants. This involves allowing rain to wash the roof clean before the runoff is directed into the cistern. Known as "roof-wash diverters," commercial units are available from a variety of suppliers.

It's important to have a roof washer because dust and debris collect on roof surfaces between rainstorms. This may include particles of lead and other atmospheric pollutants as well as bird droppings.

The first water to come off the roof at the beginning of a rainstorm is the most contaminated. The degree of contamination will depend on several things including the length of time since the last rainfall, proximity to a highway or other local source of airborne pollution, and the local bird population. A roof washer diverts this initial, likely contaminated water away from the cistern. Once the roof's surface has been washed adequately, the water is

routed to the cistern. According to one source, the first 0.01 inch of rainfall is usually considered enough to remove most of the dust and dirt. As previously stated, roof washers and filters are available commercially. An automatic roof-wash diverter does not require anyone's presence to operate because a certain quantity of contaminated roof water is collected in a vessel at the beginning of a rainstorm. Once that vessel is filled, the roof's surface has been rinsed and water is re-routed to the cistern.

Rainwater cisterns are not new. The ancient Greek and Roman civilizations used them, and they are still widely used in some parts of the world today such as islands in the Caribbean that lack sources of fresh water. Assuming the annual rainfall is sufficient, cisterns make sense for those who live in areas where groundwater and surface water are unobtainable or unsuitable for use. If you are retro-fitting a house that has already been built, the roof area to be used as the collection surface will be what you have to work with. If, however, you are planning a rainwater collection system for a house that's not yet built, it will make sense to calculate the size roof required to deliver the water you will need while still in the planning stage.

The size of your household will determine the number of gallons likely to be used daily. That, along with the average rainfall in your area, are the data points needed to calculate the amount of water to be collected. Published figures suggest an amount between 73,000 and 110,000 gallons a year for a family of four.

Where we live in Virginia, annual rainfall averages around 46 inches, according to U.S. government figures, and at least some rain falls 116 days each year on average. During drought years there may be as little as 30 inches, while wet years may produce more than 50 inches of rainfall. Evaporation, snow, ice, and roof-washer losses, will eliminate about one-third of the amount of rainfall actually available for storage in the cistern. Designing a collection and storage system based on two-thirds of the drought-year figure being available would seem to be enough to ensure you'll have an adequate amount of water, even in the driest years.

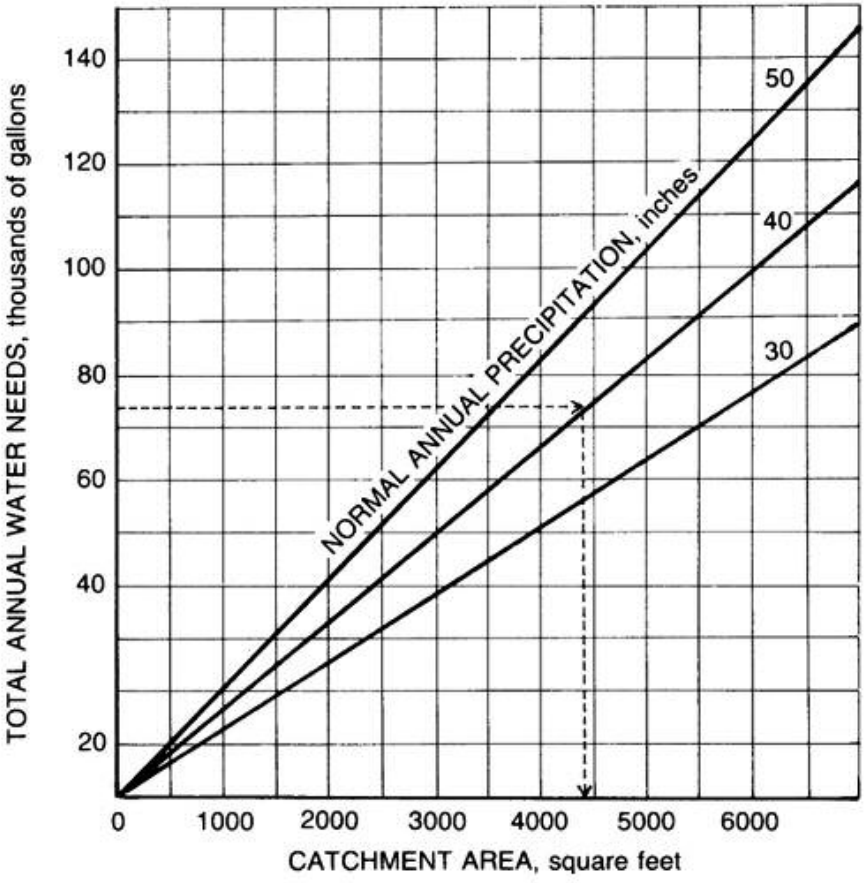
A cistern should have sufficient storage capacity to carry the household through extended periods of low rainfall. A three-month supply of water, or one-fourth of the annual yield of the catchment area, is generally adequate in areas where rainfall is distributed fairly evenly over the course of the year.

Cistern Location and Construction

Cisterns should always be located upslope from any sewage disposal facilities and at least ten feet away from watertight sewer lines and drains. They should be at least fifty feet away from non-watertight sewer lines and drains, septic tanks, sewage absorption fields, vault privies and animal stables, and at least one hundred feet away from sewage cesspools and leaching privies.

They also should be located as close as possible to the house, or wherever the water is to be used, and they can be built above or below ground, but below-ground cisterns are recommended in colder climate areas to avoid freezing during the winter months. Underground cisterns also have the advantage of providing relatively cool water even during the warmest months of the year. Moreover, a cistern should be located where the surrounding area can be graded to provide good drainage of surface water away from the cistern, which will reduce the chance of storm runoff contaminating the water in the cistern.

Cisterns can be constructed from a variety of materials including cast-in-place reinforced concrete, cinderblock and concrete, brick or stone set with mortar and plastered with cement



(Source: Midwest Plan Service, Iowa State Univ. 1968. Private Water Systems. p. 13.)

The above graph shows the catchment area required to meet a family's water needs based on annual precipitation. As an example, suppose the average annual precipitation or your area is 40 inches. You have determined that your family of four requires 200 gallons a day or 73,000 gallons annually. Based on the chart above, the needed catchment area is determined to be 4400 square feet.

on the inside. As mentioned earlier, a number of different types of prefabricated cisterns for underground placement are on the market, which is without a doubt the least expensive way to go and should do the trick. However, experts tend to agree that cast-in-place reinforced concrete is considered best. However, cinderblock-walled cisterns with concrete floors are common for below-ground construction and typically cost less than all-concrete cisterns.

If cinderblock or concrete block is used for the walls of the cistern, all hollow cores should be filled with concrete and reinforcing rods should be placed vertically to add strength to the structure. Service openings should have a watertight curb with edges projecting several inches above the level of the surrounding surface. The edges of the opening covers should overlap the curb and project downward at minimum a couple of inches. Openings ought to be placed near a corner or an edge of the structure so that a ladder can be lowered into the cistern and braced securely against a wall. This access is necessary for the periodic maintenance tasks.

The interior walls and floor of the cistern should be smooth to make cleaning easier. Typically, cement plaster can be spread over the interior, depending on how rough the basic construction is. Vinyl liners may be used to prevent leakage in some cisterns, but they are often troublesome. They are expensive, prone to puncture, and they prevent the use of cleanout drains and other accessories inside the cistern.

Cisterns ought to have at least one overflow pipe, and they should be vented as well in order to allow fresh air into the storage compartment. And, of course, all outside openings including vents and overflow pipes should be screened to keep critters out. It will make sense to have vent openings face in the direction of prevailing winds, west in most cases, to maximize ventilation and, obviously, the water line from the cistern to the house or other place of use should be buried below the frost line. In addition, the intake head to the water line ought to be effectively screened and it should be elevated a minimum of one foot off the floor of the cistern so that sediment will not be drawn into the distribution system.

Summary

- Potable water is absolutely essential for survival, making emergency power for water pumping the number one priority in a grid-down situation.
- Traditional AC motors have a high start-up surge that can overload our emergency power system but soft start well pumps are available.
- Have a manual well pump as backup in case something happens to render your electric pump inoperable.
- If digging a well will be impractical or extremely expensive, consider putting a rainwater collection system on your home's roof along with rain barrels to store the water.
- If above ground rain barrels will not hold the volume needed, consider installing an underground cistern that will hold much more and supply the house through an electric plumbing

and filtration system like you would have for a well.

- Prefabricated cisterns for underground placement are available and are typically much less expensive than those that are custom built.
- Water collected from streams, ponds and so forth, can be made potable by filtering it and adding a small amount of bleach.
- Bleach has limited shelf life, making calcium hypochlorite, also known as "pool shock," a good substitute to have on hand for the long-term.
- Boiling water will make it suitable for drinking or cooking, and pouring it back and forth several times between two containers will aerate it to restore a palatable taste.

Our new house is out of the ground.

Chapter Five

Climate Control

HVAC considerations, heat pumps, propane, wood, and what we decided

For a modern home, heating and cooling is the number-one consumer of energy. I knew that efficiently heating and cooling a 3,800+ square-foot home was not going to be cheap or easy. However, I was committed to being able to run this home, including HVAC, if we were limited to solar and battery power only. I had to do everything I could to minimize the heating and cooling energy requirement so that we would stay within our energy budget and be able to maintain our standard of living during an emergency. One way to keep heating and cooling energy usage to the minimum possible, of course, is to have the best insulation possible, but going into this project, I didn't know much about insulation other than what I had learned in the process of installing solar power on already energy-efficient homes. I had several clients that had success using spray-in foam insulation in their walls and attic. One client went a step further and installed a conditioned crawl space, essentially treating the crawlspace as addi-

tional living space with insulation and HVAC service. I knew that running our new 3,800+ sq-ft home on an energy budget of 1,800kWh per month was going to be a challenge, so if I could save some energy by upgrading the insulation, I was interested.

I asked Christian what he would recommend and he informed me that current building codes for new construction homes required us to use what would be considered high-efficiency insulation just a few years ago. For the time being, we would build using the standard insulation package offered by the builder. However, I wanted an option to invest more in the insulation should my needs change in the future. A larger concern for my family was mold. Rachel is highly allergic to mold, and we didn't want to take any chances here. We decided to invest in the conditioned crawl space, which would provide a barrier to mold-causing moisture and increase the home's heating/cooling efficiency because we wanted a high level of control over how energy was spent in the heating and cooling of the house. If energy was to be spent, I wanted it done in the most efficient manner. Additionally, if I had to operate the air conditioner during a utility outage, I did not want a unit that drew a high start-up surge capable of overloading

the solar-battery inverter system. That's one reason we decided to install Trane 18 SEER (Seasonal Energy Efficiency Ratio) variable speed heat pump units. They start up gradually, rather than with a surge as most air conditioning units do. That surge, which pulls a large amount of electric energy all at once, has the potential to overload a solar and battery system, making the slow start an important feature. Anyone who owns a whole-house standby generator knows the importance "load shaving" to avoid overloading the generator when running on emergency power. We are having two of the Trane XV18 units installed. As you likely know, the higher the SEER rating, the lower the amount of electrical energy required to power an appliance. Each of them will pull about 2,000 watts in the air conditioning mode, which is low enough to make it possible for both to operate using our solar and battery system in a grid down situation.

As discussed in Chapter Three, I knew that heating the home with an electric heat pump with only an electric resistance heater backup unit would not be practical when running on emergency power. Heat pumps work much like a refrigerator in reverse to move heat from one place to another by taking heat out of the

air. Because of how they work, they are most efficient in parts of the country that do not experience extreme cold for long periods. In summer, they move heat out of a house to the outside. So, if it's 90 degrees outside and the thermostat is set at 70 degrees inside, the heat pump has to move 20 degrees of heat to the outside. That's not a huge task, which makes heat pumps an efficient way to cool a house in summer. On top of that, the biggest demand for electricity for cooling is typically when the sun is also the most intense, making solar an efficient way to provide that power. The situation is different in winter when the heat pump has to work in reverse. Also, temperature extremes tend to be larger in winter. If it's 30 degrees outside and the goal is 70 degrees inside, that's a 40-degree difference, twice the difference in the summer example above. What will happen, of course, is that the electric resistance heater unit will kick in and draw a huge amount of electric current. As you recall, Mark Strickland, in Chapter Three, was able to eliminate this problem by installing a propane heating system as backup when the outside temperature dropped below 45 degrees.

Another issue is that the need for heating is most intense at night when there is no solar power coming in and all the power has to come from batteries. That's why, like Mark Strickland, we decided to use propane as a back up source of heat in winter.

When designing a home to be able to run off the grid, it's always best to minimize the electricity requirement before adding solar and battery capacity to the equation. One of the easiest ways to do this is to do all of your heating with an alternative fuel source like propane. Heating, cooking, and hot water are huge energy consumers and we could do all of them by using propane instead of electricity to help stay within our budget. Better yet, propane-heating appliances draw very little electricity when operating. So, they can run smoothly even when operating on emergency power. I chose to install 1,000 gallons of propane storage capacity so that we could maintain a reserve of a year's worth of fuel – just in case we ended up in prolonged grid-down situation.

I decided on the Trane XV variable speed system with two compressor units, one for each floor. The ground-floor unit is a dual-fuel model capable of heating via electric heat pump or propane gas packs. The top-floor unit is an electric heat

pump/compressor that operates only when utility power is up. The ground floor unit would effectively be able to heat both floors as long as we were willing to spend the fuel. And, of course, intelligent temperature control software would give us the ability to select which areas of the home we wanted to heat, giving us maximum control over our fuel consumption as opposed to the more traditional all-or-nothing approach.

In the winter, it is not uncommon to have periods of prolonged overcast weather lasting a week or more. In this scenario, we could not expect the solar panel production to provide adequate energy to keep up with our normal usage. One way to conserve energy during the winter is to heat the home with an open fire or wood stove. Using this approach, we would not have to spend any electricity to run the central air handler, which could draw 700-1800 watts of power.

In our previous two homes, we had a wood stove fireplace insert that served as our worst-case scenario heating solution. The stoves each included a small electric blower fan to circulate hot air around the chassis and heat the surrounding room. The wood stove fan also included a variable speed control, allowing us to

throttle fan speed and energy consumption as needed. At full throttle, the stove fan pulled a max of 75 watts, compared to the central air handler that could exceed 1,500 watts. If energy got really scarce, we could always bring the family to gather near the fireplace and forego use of the central air handler all together.

It was relatively easy to acquire and store one to two cords of firewood to run the wood stoves through the winter season. However, burning wood required quite a lot of time, energy, and attention. Tasks included: cutting, splitting, storage, seasoning, and manually feeding the fire. On the one hand, if things got really bad and firewood was no longer available for sale, I liked the idea of being able to harvest endless amounts of the wood using my chainsaw and a wood splitter. However, if economic conditions got so bad that even firewood couldn't be purchased, we would likely have to evacuate our primary residence and fall back to a true survival retreat in a more remote location. Furthermore, Rachel was allergic to red oak firewood.

Ultimately, we decided to go with an open propane fireplace as our last-resort heating option. The fireplace could be run with zero electricity and, with 1,000 gallons of fuel reserve in the

ground, we could run it for a year without exhausting our fuel supply. Even better, the propane fireplace is 100% maintenance-free. There would be no mess and nothing to keep up with in terms of ongoing chores or maintenance. Rachel could also breathe easy, as the gas fireplace is completely smoke- and scent-free.

Summary

- Heating and cooling consume more energy than anything else in a modern home.
- We decided to invest in a conditioned crawl space for a barrier to mold-causing moisture and to increase the home's heating/cooling efficiency.
- We decided to install variable speed heat pump units that start up gradually to avoid surges that have the potential to overload a solar and battery system.
- We installed a propane heating system to back up the heat pumps that will come on when the outside temperature drops below 35 degrees F.

- Intelligent temperature control software gives us the ability to select which areas of the home to heat, which will give us maximum control over fuel consumption.
- A 100% maintenance-free open propane fireplace serves as our last-resort heating option.
- A 1,000-gallon in-ground propane tank will give us a supply of fuel for heating, cooking, and hot water that will last a year.

Our new house is under roof.

Chapter Six

Modern Conveniences

Appliance considerations

As previously discussed, one of the best ways to control your electricity demand is to do all of your heating-related activities with an alternate fuel source. We chose propane for our new home. Propane is abundant, affordable, and clean. We would also have the ability to store a year's worth of fuel so there would be no need to purchase additional fuel from the marketplace during a time of crisis.

Cooking

In our most recent home, we had grown very fond of the five-burner gas cook top. I enjoy cooking for the family almost every morning and I have grown to value the precise temperature control that the gas cook top allows. Better yet, the gas range consumes virtually no electricity so we would have full operation of this appliance even if we had to conserve energy during a utility outage.

Choosing the gas cook top was probably the easiest and least expensive of the appliance selection decisions that we would make during the project.

Hot Water

The second easiest decision was probably the selection of the propane on-demand water heater by Rinnai. Our previous home used the same water heating solution and it had performed flawlessly for the previous three years. The Rinnai's electricity draw was minimal. All the heating is done burning gas, so the only components requiring electricity were the igniter, exhaust fan, and control panel (about 150 watts at max draw). I did briefly consider installing one of the new hybrid heat pump water heaters. Heat pump water heaters use electricity to drive a compressor that moves heat from one place to another instead of generating heat directly with an electric element as traditional electric water heaters do. In other words, the heat pump pulls heat out of the ambient air and transfers it into the water tank. As a result, they can be many times more energy efficient than conventional electric resistance water heaters. The drawback is that it is a slower

process. A heat pump will typically take 20 to 30 minutes to heat a tank of water, whereas a heater using an electric element, or one using propane, may take only five minutes. The bottom line is that speed of recovery is traded for a smaller draw of electricity. A traditional hot water heater uses 4400 watts compared to a heat pump water heater compressor that draws about 450 watts.

If someone who has declared energy independence does not have an alternative fuel source such as propane or wood to heat water, a heat pump water heater makes a good deal of sense. We ultimately chose against a heat pump hot water heater, however, due to the higher electricity demand, increased complexity, and risk of failure. Besides, we had already made the investment in being able to store 1,000 gallons of propane so we might as well use that fuel source for all of our heating needs.

Lighting

Going into the project, it was my intention to install all energy-efficient LED lighting. Although LED bulbs were more expensive ($1-5 per bulb) than traditional light bulbs, they made up for that difference in longer service life and much lower energy consumption. Given our limited energy budget, I considered the

decision to go with the highest efficiency lighting, a no-brainer.

A traditional light bulb consumes 60 Watts of power compared to an LED bulb, which consumes about 10 Watts of power for the same amount of illumination. Power consumption is measured in Watts and illumination is measured in Lumens. It is often helpful to look at a light bulb's lumens-per-Watt ratio to determine its energy efficiency. Any light bulb with a rating of 200 lumens per Watt or higher is considered highly efficient. As of the time of this writing, GE, Phillips and Cree have such bulbs on the market.

However, energy efficiency was not my only consideration in choosing lighting for our new home. I wanted to have light bulbs and fixtures that could be easily replaced at the local hardware store or electrical supply store in the event that something blew out. I did not want to have to special order bulbs from an out-of-state supplier, which may not be available during a time of crisis or on short notice. As such, I chose to go with standard lighting fixtures and socket types.

Refrigeration

Rachel and I like to keep a traditional fridge/freezer combo unit in the kitchen and a chest freezer in the garage for medium-long term storage. For the daily use fridge, I wanted something modern with Internet connectivity, allowing me to check grocery status from my mobile phone. I also wanted to be able to sync our grocery shopping list across Rachel's and my mobile phones. Finally, as with everything else in the house, I wanted a very energy-efficient unit that would perform well when running on solar/battery power only.

According to the US Energy Information Administration (www.eia.gov), the typical US home spends 9% of its energy on refrigeration and freezers. Based on our budget of 1,800kWh per month, my usage goal for refrigeration and freezing was 1,400kWh per year or less. We ended up going with the Samsung Family Hub 22.2 cubic foot French door stainless steel refrigerator. This unit consumes only 662kWh per year and it includes a broad range of intelligent features. My favorite is the ability to see inside the fridge remotely in real time using my smartphone.

Clothes Washing

We have five children and it seems that the laundry runs almost constantly in our house. According to the EPA, the average American household washes 295 loads of laundry per year. In our house, that number is closer to 700 loads per year. If I could save a few kWh of energy by installing a modern EnergyStar-rated washer, then we would do that. We decided to go with the Samsung Activewash 5.2 cubic feet 13-cycle high-efficiency top-loading washer. This unit averages only 165 kWh per year energy consumption. Rachel also had the builder install a laundry chute for convenience and it's been wonderful.

Clothes Drying

Based on our laundry cycle of 700 loads per year, you can bet that we are spending a lot of energy drying laundry. The typical electric clothes dryer draws 3,000 Watts (3kW) of power while running. Doing the math here: 700 loads/year x 1 hour per load x 3kW = 2,100 kWh per year. That's a lot of energy! Based on today's energy price of $0.13 per kWh, we are spending $273 per year just to dry clothes. Given our energy budget of 1,800kWh per month,

keeping the electric clothes dryer would consume 9.7% of our available energy. This was a high price to pay for convenience.

The conventional wisdom here would be to install a gas-fired clothes dryer to minimize the demand for electricity. After all, we did have a 1,000-gallon propane storage capacity. However, considering that our family does more than twice as much laundry as the typical household, I had some concerns about running the gas burners so frequently. I wanted some more time to research the safety of using a gas dryer under such heavy load.

We decided to proceed with construction planning for an electric clothes dryer as our primary. However, Christian would give me an option to have a gas shut-off valve installed in the laundry room so I had the ability to switch to a gas dryer in the future. To get started, we chose the Samsung 7.4 cubic-foot electric clothes dryer in white to match our washer.

Summary

- A gas or propane range consumes virtually no electricity and is operational during an electrical utility outage.

- A propane on-demand hot water heater by Rinnai draws very little electricity. All the heating is done burning gas, so the only components requiring electricity are the igniter, the exhaust fan and control panel, totaling 150 watts at maximum.
- LED bulbs cost more ($1-5 per bulb) than traditional light bulbs but last much longer and consume only a fraction of the energy.

Chapter Seven

Be Prepared

Why We Prepare

As you begin this chapter, stop for a moment and think about the state of the world and consider what bad actors ranging from Russia, Iran, China, North Korea, and Islamic terrorists in general, would like to do to the United States and our allies. No matter your religious beliefs, you must conclude that the threat of a cyber or nuclear attack that could knock out the grid is very real. I mention religious beliefs because six or seven years ago Rachel's and mine led us to begin preparations for what we thought might be coming. As we started along that path, we ultimately felt led to pursue what we now believe is our true calling, which is to provide others with the means to achieve energy independence and to be a source of information concerning survival strategies and techniques. Bear with me as I explain how we came to this, prior to discussing tangible actions to consider that will increase your chances of survival.

Rachel and I both believe the most important survival technique is to look to God for guidance in all important decision-making. One for us was where to locate our new home. In Chapter One I gave a strategic analysis of how we selected the location, but facts and logic in that case were only part of the picture. At best we humans can see only a small part of the big picture. That's why we believe that in addition to a hard-nosed assessment based on logic, one needs to pray, and to ask God to show the best way forward. Make your decision based on what you feel is coming through to you at a gut level, and once you do, if something just doesn't feel right, the Holy Spirit is likely trying to tell you to change course.

Rachel and I believe we are all God's children and that every one of us has a role to play in God's plan. Therefore, where we chose to live and all other major life decisions should be made in consideration of God's calling on our life.

Rachel and I have not always felt this way. Prior to my decision to dedicate my life to Christ, I was researching how the world works – the political and banking systems in particular – because I was an ambitious young businessman who wanted to make a lot

of money and felt I needed to know how the game worked. My research led me to fall down the rabbit hole, so to speak. As my eyes were opened, I came to the undeniable conclusion that there is a real battle going on in this world between the forces of good and evil. For example, as I key these words into a computer, the front-page, lead story in this morning's newspaper says the armed forces of the United States, Great Britain, and France rained rockets down last night (April 13, 2018) on parts of Damascus. This could not help but bring to my mind the Prophet Isaiah's prediction's about what will occur as the end times approach: "An oracle concerning Damascus. Behold, Damascus will cease to be a city and will become a heap of ruins.'" (Isaiah 17:1, ESV)

You see, I was raised mostly by grandparents who took me to church every Sunday, but once I went away to college and was on my own, like many, I rebelled against the Church and organized religion. Nevertheless, a Bible has always been on my bookshelf, and never for a minute did I forget that it was there. Many times I was tempted to open it but was afraid to do so. Somewhere deep down in my spirit, I knew that reading and absorbing God's word would cause me to reevaluate my beliefs and behavior. Suf-

fice it to say that my sudden revelation about the ongoing battle between good and evil awakened within me a deep desire to know the truth, and I called out to God, asking that it be revealed to me. Afterwards, people were put in my path who were able to point to Scripture that showed God had revealed things relevant and insightful about those issues a long, long time ago. Ultimately, I became confused and befuddled – there was so much conflicting information out there. In time, however, it became clear to me the only coherent paradigm was the Christian paradigm. For perhaps the first time I understood that God is real, Satan is real, and each has players on the field actively contending for the souls of men.

While this was going on, my personal life and fortunes hit rock bottom. I had a business that at the outset had enjoyed extraordinary success, but it had nosedived and failed. I had to close the business, and the $1.5 million I'd raised from investors was lost. My cars were repossessed. I had to short sell my house and move into a one-bedroom apartment. Selling technology to the government, which I thought would make me millions, was obviously not the right path for me. It's difficult to see how my situa-

tion could have been worse. I was at rock bottom financially and spiritually. Alone, in tears, I knelt down on my living room floor. I knew I was a sinner who needed saving, but somehow, I also knew I was redeemable. And so, I said the sinner's prayer.

At first, I felt guilt and I felt shame . . . then love and acceptance reached out to embrace me. Fantastic love – unconditional acceptance. Despite the mess I'd made, I knew in that moment I was saved. I also knew that I would have to reevaluate my entire life, my career, my relationships – everything – and the first thing I prayed for was that God would send me the right companion. I met Rachel ten days later.

Strange as it may seem, my poverty actually worked to my advantage because, instead of taking her out to dinner, which I could not afford to do, I told her I wanted to cook for her and invited her to dinner at my place. It was comforting to her and it made her feel cared for.

My routine at the time was to cook a chicken every so often because I'd have leftovers to eat for a week. It was a way to save money. But since Rachel was coming, I decided to upgrade. I cooked a turkey dinner instead, along with mashed potatoes and

gravy. She liked it, was impressed with my culinary skills, and I still had leftovers to eat for about a week.

Much later, after comparing notes, we think that the very night I pledged my allegiance to Jesus, Rachel went through something similar. Rachel, however, was already a believer. She grew up in church, totally involved. But she had drifted away after leaving home, moving to northern Virginia and becoming totally immersed in her career.

Living in and navigating the Washington, D.C. area and dealing with its incredible traffic is a draining experience all by itself, and on top of that, Rachel had been working 70-80 hours a week and was successfully climbing the corporate ladder. However, there was a huge void within her. She focused so much on being successful at work and earning a high income that she neglected to consider the possibility of a future family. She was feeling so alone and in such emotional despair, that she broke down, got on her knees, and prayed, "Lord, I have tried this my way and it isn't working. Please prepare me for my husband."

After that, things started falling into place.

Looking back, it all makes sense. Even at the time, I somehow knew God was taking away my material possessions because when I rebuilt I would have to recognize that everything that came to me from that point forward had come from Him. But even though what I had built up doing things my own way had come to naught, my work up to then, and the experience I gained, had by no means been a waste. Working as a government and military contractor, I learned a great deal that prepared me for my true calling, particularly what I learned in Iraq during the war. The Army had purchased a software system called Command Post of the Future, which I had helped build. It was a program that might be compared somewhat to Google Maps that was used to manage the battlefield. My job there was to provide on-site training and support. As a result, I worked in a division command post where I was able to watch the war, the occupation, and policing by the military happen on a big screen. I saw firsthand how desperate people in a populated area can become when the electric grid is no longer reliable, and basic services, such as sanitation and trash removal, have lapsed. Whenever we left our base, we would fly in a Blackhawk helicopter as close as possible to the ground in order

to avoid being a target for surface-to-air missiles. It sometimes would be 120-130 degrees Fahrenheit outside. We flew with the doors wide open and I could look down and see the conditions in the streets. Trash was everywhere, and it stunk so badly it would take our breath away.

The United States military was doing all it could do to improve the situation and to restore services, but it became clear to me that if a foreign military ever invaded the United States, it would be fairly easy for them to use food and water, the electric grid, roads, and telecom infrastructure to exercise control, which is why it later became clear to me that if I am able to play even a small role in helping people prepare for what is likely to be a horrific, incomprehensible time, my life will have been worth living.

Looking at the types of events and the scenario we are preparing for, it's clear that having equipment to generate power and provide water will be vitally necessary, but equipment alone will not be all that's needed to get through it. In this modern age, so much depends on the electric grid, the ability to transport goods, and communications – from Just-in-Time inventory, to interstate and intercontinental travel and transportation – that without the

massive infrastructure required, our civilization will rapidly dissolve in to chaos and mayhem. Simply put, people are not going to be able to drive to Wal-Mart and swipe their credit cards to get food. According to a 2008 report by the U.S. Senate Committee on Homeland Security & Governmental Affairs, if and when a large electromagnetic pulse (EMP) or geomagnetic disturbance (GMD) event occurs, there are essentially two realistic estimates concerning how many people would die from hunger, from starvation, from lack of water, and from social disruption. One estimate says that within a year or so, two-thirds of the United States population will be dead. The other is worse: 90% of the U.S. population will die.

We believe that at all times, but particularly during such a horrific event, we each will need to have God as a partner, to seek to do His will, to be His arms and hands in this world, and thereby under His protection in order to make it through.

First, Get Right with God

Rachel and I are convinced we each have a purpose and the key is to find that purpose and to take steps toward living the pur-

pose. The first step is to ask God, "What is it that you have for me to do?" and then, to be attentive and to listen. In doing so, it makes sense to ask yourself, "What skills and talents do I have?" You might take an aptitude or career preference test. What do you like to do? Think back to a time when you were doing something and hours passed but it seemed like minutes. What would you do even if you were not being paid for it? What can you do better than 90 percent of the population? With all that in mind, what do you feel in your heart needs to be done that would put those skills and talents to work?

When Rachel and I first began along the path we are now on, we wondered whether we might be a little crazy for thinking that our modern way of life might be in serious jeopardy and end suddenly. But as time went by and we learned more and talked with others, we realized we are far from alone in our thinking. We started a group called "Preparedness Experts Group." We had a water purification division, a food preservation division, and of course, the solar energy division. We wanted to be experts in all those areas, and so we conducted research. For example, we experimented with such things as harvesting rain water and purify-

ing it. As you know from an earlier discussion, we actually lived on it for several months just to prove to ourselves it was possible. We also learned how to can vegetables and meat, and of course, how to harness solar power in order to become energy independent. We raised rabbits for meat and chickens for eggs, and we shared what we learned by reaching out and speaking to any and every interested group of people who would sit still long enough to hear us out.

We felt reaching out was important for a couple of reasons: 1) An important part of our calling is to alert others and to help them prepare; and 2) it will be important for like-minded people to band together in a spirit of cooperation to share, to trade goods and services, and in general to help one another if the unthinkable comes to pass. After giving this a good deal of thought, I believe it would be very difficult for a single family to survive on its own for an indefinite period. Having a support group and a survival system with assignments worked out will be important, which is why we have established a group of families that is ready to band together if it is clear after an event occurs and some time has passed that things are not going back to normal. Some will be

adept at growing crops and raising animals, others at hunting, others at building and carpentry, and still others at defense. To borrow the Boy Scouts motto, we want to "Be Prepared."

One of the first things we plan to do once we move into our new home is to get to know our neighbors. We plan to host an open house and show them our backup energy system and other built-in features. We don't want to frighten anyone, but we probably will explain some things they may not have thought about and suggest some they may want to consider, such as not going the traditional generator route. One thing we all will have in common are wells and septic systems. If the power goes out, that means there isn't going to be any running water, and the toilets aren't going to flush. At the very least, I suspect that by itself will motivate them to consider a backup power system.

Now that our primary business is helping others become energy independent, it has become increasingly obvious that many, many others feel as we do. Like it our not, the threats are real. If you feel in your heart you need to begin taking steps to prepare, you definitely are not crazy, you are totally, one-hundred percent sane – more sane, I would say, than those whose heads remain buried in the sand.

Even so, we don't want to come across as doomsday alarmists. We don't think the time has come to move to a cabin in the northwest wilderness. Life goes on, and we want to live it. Rachel and I have both come to the conclusion it's important not to get so caught up in end-of-the-world thoughts and possible scenarios that we turn our backs on civilization. As it says in Matthew 24:39, "But about that day or hour no one knows, not even the angels in heaven, nor the Son, but only the Father." Until that day, whenever it may be, life goes on, and we believe it's important to get on with life. The kids need to get to school, we need to provide for ourselves and our families, and we must extend the effort to make a good, stable home. We also need to remain grounded and calm in the assurance that we are in God's hands, knowing that having accepted Jesus as Lord, everything over the long haul will eventually turn out all right. Meanwhile, however, we are convinced we each need to do our part, first by remaining faithful that God is in control, but nevertheless, by taking whatever action we can in order to do our part to have a positive impact on the imperfect world in which we live.

The action Rachel and I are now taking is to prepare for a full-year of off-grid living. If things get so bad that the economy is not

back and functioning within a year, before the end of that year we will have evacuated to a more permanent, truly off-the-grid survival retreat. That's the reason, as was mentioned in Chapter One about selecting a location, we chose a place where it will be possible to escape further south and west, away from population centers, without having to use interstate highways. Once we are in the new house now under construction, we will begin looking for a spot to build a retreat with land enough to farm and raise livestock. Together with the support network we have formed, we will build a residence or compound large enough for all of us that will be capable of sustaining indefinitely in terms of food, energy, and physical security.

Summary

- The treat of a cyber or nuclear attack that could knock out the grid is very real.
- Look to God for guidance in all important decision-making.

- The location we select, and all major life decisions, should be made in consideration of our calling.
- For some, hitting rock bottom may be what is required for them to wake up and get on the right path.
- Without the massive infrastructure we have become dependent upon, our civilization will rapidly dissolve in to chaos and mayhem.
- People in a populated area can become extremely desperate when the grid is no longer functional, and so to borrow the Boy Scouts motto, one must "Be Prepared." Have sufficient supplies and the training to use them.
- In a long-term crisis, it will be important for like-minded people to band together in a spirit of cooperation to share, to trade goods and services, and so you may benefit from establishing such a group now.

- If possible, have a plan of what to do and where to go if things aren't back to normal within a predetermined period of time such as a year.

Chapter Eight

Survival Considerations

Food, Medical, Communications, Defense, Security, and Entertainment

In addition to energy independence, my company offers clients a six-month household emergency package designed to provide the basics that will be needed for survival in a grid-down situation. It includes a six-month supply of long-term, storable food, which comes in individual, freeze-dried packets that have a twenty-five year shelf life. Boiling water is all that's needed to make each packet into a meal.

The package also includes a Big Berkey desktop water filter. If a client finds his or her family in a situation when water has to be harvested from a nature source, such as a creek or a pond, this will come in handy. The Berkey filter removes pathogenic bacteria, cysts and parasites and extracts harmful chemicals such as herbicides, pesticides, VOCs, organic solvents, radon 222 and trihalomethanes. It also reduces nitrates and unhealthy minerals such as lead and mercury. As mentioned in the previous chapter, Rachel and I used a similar filter for our drinking water for six

months just to see if this was possible, and it worked. The first step we always took to remove visible debris was to do some basic filtering using, for example, a cotton t-shirt. Then we would run the water through the carbon-ceramic filter system. As a further precaution, I also recommend that drinking water be treated with a quarter teaspoon of unscented chlorine bleach for each two gallons in order to kill any bacteria that might remain.

Finally, our six-month survival package also includes a The STOMP Medical Kit, which is almost identical to what Navy SEAL medics carry with them in the field. It has a variety of contents and contains many Velcro and zippered compartments for easy access to over three hundred items inside. In a prolonged grid-down situation, professional medical and dental care may not be available, and that means we will all have to do what we can for ourselves, our families, and our friends. Much has been written on the topic of survivalist medicine, and so it will make sense to take advantage of what's available by having on hand a good book on the subject. One that has received excellent reviews is *The Survival Medicine Handbook: THE essential guide for when medical help is NOT on the way* by Joseph Alton, M.D. and Amy Alton,

A.R.N.P. (known in the prepping community as "Nurse Amy & Doctor Bones") Having a proper first-aid kit will be crucial, but knowledge will be needed to put it to good use. Having such a book will help and, of course, as is the case with courses related to food preparation, gardening, canning, and other things you will want to know as much about as you can, Red Cross and CPR courses are available at local community centers.

The STOMP Medical Kit we offer our customers has in it just about everything you might possibly need, but it retails for nearly $400, and that may be more than your budget will allow. Nevertheless, you will want to have at least some basic medical supplies on hand. Here are the general categories I've come across: an assortment of bandages from gauze to Band-Aids, medications such as ibuprofen and Benadryl, antibiotic ointment, instruments including tweezers and a thermometer, and finally personal protection items such as gloves, hand sanitizer, and CPR masks.

Beyond typical first-aid supplies, you might want to think about your family's particular needs. If any member has a chronic condition, you will want to have the necessary supplies on hand to take

care it. You may also need to have undergone whatever training may be required to care for him or her if that becomes necessary.

Dentistry is something else to think about. Obviously, without the right equipment, and dentists' offices usually have plenty, it would be rather hard to perform the majority of dental procedures even if you knew how. For this reason, Rachel and I have committed ourselves and our children to a proactive dental hygiene regiment. In addition to your typical brush-floss-rinse routine, we feel it's important to limit our sugar intake and to immediately take care of any dental issues that may arise so that we don't find ourselves with an infection or other serious problem when it may not be possible to see a dentist.

There are several useful books dedicated to survival techniques in an extreme grid-down situation. As mentioned earlier, one of my favorites is *How to Survive the End of the World As We Know It,* techniques and technologies for uncertain times by James Welsey, Rawles. The author lists in great detail the exact food and supplies, and the quantities of each, one should stockpile in order to be prepared for an indefinite grid-down situation. I found it to be very helpful and recommend it highly for anyone who wants to

be fully prepared for whatever might happen. For our purposes, however, as previously mentioned, Rachel and I have decided to maintain an amount of food and supplies our family would need to live for one year in the new home we now have under construction. If the grid fails, we will monitor the situation, and if after a time passes it appears services will not be restored, and things are not going to return to normal, we will activate Plan B. That will mean getting in touch with members of our support group and heading southwest to the long-term retreat compound we plan to have ready and waiting.

Food

When designing your self-sufficient home, it is important to allocate space — a room if possible — to store food. This will be your family's "larder." The amount of space you will need depends on the size of your family. Since Rachel and I have five children (and they won't always be little), we need a room on the larger size. When the home construction is complete, our larder will be over 100 square feet.

It is important that this room be kept cool and dry. A root cellar room underground will keep your food at an ideal 55 degrees and will not direct electricity from other areas of your home should an emergency make it scarce. If you are unable to keep your larder underground, you will be able to regulate the larder's temperature with solar energy as described in Chapter Five. In our new house, the larder will simply be a climate-controlled room on the second floor.

A non-intimidating way to begin stocking up on food is to simply start increasing the amount of canned goods you have on hand that you and your family already consume on a regular basis. If your family already consumes a number of cans of beans or vegetables each month, it may make sense to slowly start bringing in additional cans each time you go to the store. This method of buying a few extra each time you go to the store can ease the financial strain of storing enough food for at least a year. Beans in particular are a great food to have on hand in quantity because of their nutritional value, so even if you do not now regularly consume beans, it probably makes sense to start stocking up on them. If meat is not available, beans are an ideal alternative for protein.

Moving beyond canned foods you already consume, it might be helpful to next identify what the gaps in nutrition you may have. All boxes of the food pyramid exist because our bodies need something from them, and in an event where food is more scarce, the nutritional content of each food becomes even more critical. While some folks may try to avoid fats and sugars in their daily diet now, they are essential to our health and should not be neglected if food becomes scarce.

For complex carbohydrates, most sources recommend rice, wheat, and dehydrated corn. For our family, rice is certainly a good idea, and dehydrated corn adds some variety. Wheat in the form of pasta also makes sense for some families. Rachel, however, is gluten intolerant and so we will stock rice and corn and forego wheat. Whole wheat is only practical if you grind it and bake it into bread. Additionally, because of the additional ingredients one must have on hand and the complex process in making and baking bread, you as well may want to think twice about wheat storage. For some folks, there is nothing like fresh bread; if you think you might like to have bread in the event of an emergency, then of course stock up on wheat, bread pans, and other necessary in-

gredients for survivalist bread baking. You may want to take the time and make the effort to learn how to bake bread in these conditions so that should a grid failure persist, you will have several sustainable methods for acquiring and preparing carbohydrates.

As far as storing these grains and starches, it will be important to buy airtight, waterproof bins. Galvanized trashcans with airtight lids work just fine. Storing your food this way may increase the shelf life, though simply storing the food in the factory packaging may also be alright if your larder is protected from outside weather, flooding (especially if it is underground) and spills.

For protein for the year beyond canned beans, it's a good idea to stock up on canned meats. In addition, a sufficient number of MREs (Meals, Ready to Eat) are great to have on hand, again stored in a cool, dry place. While MREs are sometimes criticized because they are more expensive and not particularly sustainable, they are a great short-term solution, and therefore meet Rachel and my purposes.

In order to have enough fats for a proper diet in the case of an emergency, I've found a balance of canned butter, olive oil, and peanut butter will do the trick. Peanut butter has a dual purpose

of fat and protein, and since my children love it, we have decided to keep a large quantity of it in our house. Sugar, too, is important for a well-rounded diet, and I believe honey is the best way to take care of your body's need for sugar. Canned butter, olive oil, peanut butter, and honey all have a shorter shelf life than some of the other foods I've mentioned, so it is important to keep up to date on when they will expire and refresh your larder when appropriate. Again, the climate conditions of your larder will have a big effect on this.

Rachel and I do not plan to have a garden adjacent to our new home, though our long-term retreat will be designed to produce the food we and our support group will need. For this reason, the best way for our family to obtain short-term fruit and vegetable provisions is through canned or freeze-dried goods. Once we move into our new home, we will begin slowly stocking up on enough canned and freeze-dried fruits and vegetable for our family for a year. While they may not have quite the taste of fresh fruits and vegetables, we decided that the immediate need they will fill in the case of an extreme emergency makes them sufficient for our family, and in choosing pre-packaged fruits and veg-

etables, Rachel and I can direct our daily attention away from gardening now and use that time for more immediate and fulfilling work at the moment.

Canning, however, is a worthwhile skill to learn, and most Mormon churches conduct canning classes. Rachel and I believe the most essential tangible thing we can do to prepare for a long-term grid-down situation is to acquire skills that we can later apply in order to be safe and self-sufficient. Canning, gardening, hunting or raising livestock, as well as first aid and other medical, dental, communication, and defense procedures I will go into in the next chapter are important skills for us to learn now, even while we may not use them immediately or at all. Our goal is to be able to adapt to different conditions should they arise. Many courses across these subjects are offered at local community centers, as well as through churches, clubs, and community colleges nearby where we live.

Before we leave the subject of food storage, l would like to mention that it will make sense to use the First In, First Out (FIFO) method of storing and using your canned goods and other items that do not have a twenty-five year shelf life. For example,

move the row of older cans of beans forward and place newly purchased canned beans at the back of the storage shelf behind them, and always take from the front. This is the best way to avoid having the food in your larder go past the "best-used-before" date on each can or package.

Communications

Communications is a category that warrants attention for anyone who wants to be prepared for the worst. If the grid goes down and stays down, including the cell phone network, it will be important to have a way to communicate with your support network locally, or an extended support network that may not be in the same neighborhood. For this reason, we also store short-range radios – Walkie-Talkies – and we have an HF "ham" radio, and I am a licensed operator. There is no official nationwide prepper group, but there are groups in different locales that have agreed to support one another in the event of an emergency. There is also a group in the United States and Canada called ARES (Amateur Radio Emergency Service) which is a group of trained amateur radio operator volunteers organized to assist in public service and

emergency communications. ARES is sponsored by the American Radio Relay League, which is the ham radio governing body, and the Radio Amateurs of Canada and has regularly-scheduled calls to test the lines of communication. Any ham radio operator can become part of this. Details can be found on the ARRL website (http://www.arrl.org).

Precautions Against an EMP

A nuclear electromagnetic pulse [EMP] can be generated two ways, one by a nuclear weapon and the other by the sun. Each have the potential to destroy anything that uses electricity.

An EMP is caused by a nuclear warhead detonated tens to hundreds of kilometers above the Earth's surface and is known as a high-altitude electromagnetic pulse (HEMP) device. Effects of a HEMP device depend on factors including the altitude of the detonation, the energy yield the explosion, gamma ray output, interactions with the Earth's magnetic field, how far you happen to be away from the blast, and the electromagnetic shielding of targets. We know nuclear explosions cause EMPs because they were experienced during the 1950s and 60s when nuclear bombs were being tested.

A solar electromagnetic plus is caused either by a solar flare, which is a sudden flash of brightness that can be observed near the Sun's surface, or by a Coronal Mass Ejection [CME], which is a cloud of magnetized solar material erupting from the sun's atmosphere that is ejected into space at high speed.

The first-observed solar flare occurred on September 1, 1859, and is now referred to as the Carrington Event, or the solar storm of 1859. It took down parts of the recently created US telegraph network, started fires, and shocked some telegraph operators. On March 9, 1989, a coronal mass ejection occurred, and on March 13, 1989, a severe geometric storm struck the Earth, causing power failures in Quebec, Canada and short-wave radio interference.

Solar panels and batteries should be fairly resilient to an electromagnetic pulse. It's the small, microprocessor-based control units that are most vulnerable. In an off-grid solar system, that includes such components as DC charge controllers, the inverters, battery management system, communications card, and the system's control panel. The first line of defense is to make sure everything is properly grounded. The next step is to install whole-house DC and AC surge protectors. This will provide basic protection

against lightening strikes as well as power surges that might hit the electric grid.

A second line of defense, and the way to be sure it will be possible to bring your solar equipment back into operation following an EMP or HEMP is to have spares of all of your sensitive electronics enclosed in a grounded, electromagnetically shielded case, called a Faraday cage. A simple way to create one is to use a galvanized metal trash can, which you can get for about $25 at most hardware stores. You will need to line the inside of your Faraday cage with something to serve as insulation so that it will not conduct electricity from the outer shell to the inside protected area. An expert I interviewed about building a Faraday cage suggested using foam rubber yoga mats. The idea is that the EMP will strike the metal and travel to the ground, leaving the electronics inside the protected area unscathed.

What should you have stored inside your Faraday cage? I suggest you have spare charge controllers, a spare inverter, and a spare system control panel. You might also want to store other electronics you may need in an emergency such as a ham radio, walkie-talkies, and medical equipment if someone in the family has a special need.

Defense

It's important to have a security plan ready to go in the event that a grid-down situation continues for an extended period, chaos has taken over, and law enforcement cannot be counted upon. Sensors around your property can help, but keep in mind that once a threat has arrived close to your home in may be too late to avoid disaster. That's why your security plan and procedure ought to extend well beyond your property line, meaning it will be important to know your neighbors and to have worked out a plan with them, perhaps to include neighborhood patrols. Do not forget that you will need a way to communicate, perhaps with walkie talkies as mentioned above, because cell phone service may be nonexistent.

As will be discussed, it will also make sense to be armed and able to operate your weapon of choice instinctively. Research by the military and law enforcement indicates the winner of a firefight is usually determined within seconds of the beginning of an engagement. That means it will be important to be well trained and ready to take the most effective action possible almost without having to think what to do.

How can you learn how to react instinctively? You may wish to conduct a Google search to see if training courses are available in your area. Mark Strickland, our client and the founder of Building Security Associates, offers a series of courses that cover how best to handle a wide range of scenarios, from firefights to home invasions. As mentioned earlier, I have interviewed Mark, who is located in the Blue Ridge Mountains of North Carolina, for our YouTube video series on preparedness. It may be helpful to watch some of these.

At least one firearm is something you are going to wish you had if things really get bad, and if you have never owned one, the first question to ask and answer, is what kind should you get? No doubt, it will be to defend yourself and perhaps your home and family, and so the best firearm to select will depend at least in part on where you live. If you live in a rural area, you will probably want a shotgun or a rifle. That way, you will be able to use it for hunting if that becomes necessary. On the other hand, if you live in an urban area, a pistol may be more appropriate because it will be easier to take with you in order to defend yourself when you must venture outside your home.

If you decide to purchase a handgun, it will make sense to get some training unless you are already proficient with one, and you will want to do this before you actually buy a pistol. A basic 101-type class will help you decide what kind of handgun will be best for you. Depending on your area of the country, a Google search should turn up classes and courses being offered in your area. These typically include how to operate revolvers and semi-automatic pistols, safe gun handling, pistol parts and operation, types of ammunition, loading, and of course, shooting fundamentals. When it comes time to start shopping for a pistol, I have found the 9mm Glock models 17 & 19 easy to use, simple to maintain, and very reliable. Rachel and I own each of these models.

Pistols are particularly good and appropriate for personal defense, but you may want to add a long gun to your arsenal if you have a house and family to defend. Again, you would do well to take a class to see what works best for you before you make a purchase. You might decide on a shotgun. Go skeet shooting to see how you like one. The Mossberg 500 and the Remington 870 are two pump-action shotguns that are relatively inexpensive and well regarded. Or, perhaps a rifle makes more sense for you. I prefer

the AR 15. It's an easy-to-use, highly accurate, lightweight semi-automatic rifle based on the Colt AR-15 design. After Colt's patents expired in 1977, a number of manufacturers began producing their own versions. Unlike big-gauge shotguns, AR 15s are low recoil, making them a good choice for female shooters. They are also easy to disassemble and clean. The National Shooting Sports Foundation refers to them as modern sporting rifles, and the National Rifle Association refers to the AR 15 as, "America's rifle." I believe every prepared homeowner should have an AR15 and the proper training to use it effectively.

Once you have a weapon or weapons, it will make sense to practice using them. Marksmanship is a skill, and like any skill, practice makes perfect. Moreover, once you feel you are up to speed, do not stop practicing, at least every once in a while. Like most skills, proficiency in marksmanship will decline over time if not reinforced. I'd say it will make sense to go out to the shooting range once a month, or perhaps once every three months, in order to maintain your skill level.

Security

If you really want to feel safe and secure, you are going to want your house protected by a security system, including glass-break and motion detectors and perhaps video cameras. The important question to answer, of course, is where to place these devices. The answer is, "At every possible point of entry." I advise you to take a fresh look at your house by regarding it as if you were a criminal who wanted to gain undetected access. For example, is part of your house near a wooded area? Is part of it deeply shaded and very dark, particularly at night. If so, you might want to strongly consider adding sensors to along the perimeter of your property to warn you of intruders as well as an ample amount of outdoor lighting, perhaps activated by motion detectors. Thieves definitely shy away from light.

Is there a fence that someone might climb up in order to gain access to a balcony or a window? These are the vulnerable spots that will most certainly need to be addressed with motion detectors, cameras and perhaps with additional lighting.

If you are going to do your own installation, you should probably give some thought to the drawbacks of a wireless system.

Certainly, wireless will be easier to install than a wired system, but the problem is, some wireless devices can be jammed, and it may also be possible for some to be hacked. Shop around and make sure safeguards against hacking and jamming are built in. Read the online reviews. Often, they can tell you a great deal. The best, highest-quality systems will likely cost more, but the peace of mind they can bring will likely be worth it.

Wireless systems typically come with a keypad that plugs into a wall socket and devices such as motion detectors that are powered by batteries. Batteries wear out, and so all around your house, you will have devices that after time may no longer be working as they should. You will want a system with a keypad that will instantly alert you to this. Make sure that will be the case. Moreover, most do-it-yourself systems only have one line going out of the house to a monitoring station. This typically will be via the Internet. The Internet can go down. To be totally safe, it will make sense to have a redundant way to communicate, such as a system with a cell phone backup.

Of course, if you can afford it, it will probably make sense to purchase a system from and have it installed by professionals. De-

signing and installing security systems is something they do every day, and so they know what to look for and what can go wrong. Moreover, like many things, the devil is typically in the details. Going the professional route may save you the headache of reading complicated directions and trying to sort out the various parts, components, and complexities of a DIY system.

In addition to saving you time, effort, and headaches, a professional system will likely be a wired system, and a wired system is more dependable and secure than a wireless system. Wireless systems may depend on the Internet and most likely will go down in a grid-down situation. Information travels faster over wire than over the air and such a system is less likely to be hacked, jammed, or scanned to gain access to security codes. Hardwired systems also generally have much higher video quality. Think of the case where you might need to ID a suspect using facial recognition. Moreover, a well-done professionally installed security system will have battery backup in the event utility-supplied electricity goes out, and such a system will have more than one way of communicating with the monitoring station. Think about it. A thief who really wants to gain entry may cut the phone line to your house.

This will render inoperative outgoing communications from a security system with no backup. But a well-designed system will have cell phone backup. Cell phones, by the way, are typically much more reliable than the Internet because there tend to be multiple cell phone towers in most parts of the country, which makes for even more redundancy.

Entertainment

Entertainment is the final thing I'll mention in this chapter on survival. With our solar panels and bank of batteries, we will be able to run our television set, our DVR and other electronic equipment if the grid is down. Unfortunately, there will likely be no Internet, and no cable or broadcast TV to provide content. This suggests that it will be prudent to create an electronic library of DVDs, MP3 audio and MP4 video files and such to pull from on long, cold, and boring winter nights. Imagine how much entertainment you would be able to fit on just one terabyte (TB) external hard drive. Also, be sure to have offline digital backups of your preparedness skills training videos as you may need these for reference during a grid-down event. Of course, it will also make

sense to have additional entertainment items on hand such as board games the family will enjoy playing together and, of course, a small library of good books, assuming you like to read. Fortunately, our children love to play outside and those old enough do love to read, so the sports equipment we already have coupled with additional books for both the children and Rachel and me will be just what the doctor ordered.

Summary

- We can provide clients a six-month household emergency package designed to provide the basics:
    - Freeze-dried packets of food
    - A desktop water filter
    - A medical kit
- It will make sense to have books on hand related to emergency medical aid, food preparation, gardening, canning, and other things you may need to know.

- It is important to have sufficient space in your home, a room if possible, to store food.
- Consider building up your supply of food gradually by increasing the amount of canned goods you have on hand that your family already consumes on a regular basis.
- While some may try to avoid fats and sugars, they are essential to good health and ought not be neglected if food becomes scarcer.
- Peanut butter is good to have because it contains both fat and protein.
- Don't forget to store an ample amount of canned fruits and vegetables.
- Keep the food in your larder fresh by using the First In, First Out (FIFO) method of storing and using canned goods.
- Have a way to communicate with your support network that may not be in your neighborhood, such as a ham radio.

- Consider joining a group called ARES (Amateur Radio Emergency Service), which consists of trained amateur radio operator volunteers organized to assist in public service and emergency communications.
- An electromagnetic pulse [EMP] has the potential to destroy anything that uses electricity.
- The first line of defense against an EMP is to make sure everything is properly grounded. The next step is to have spares of all of your sensitive electronics enclosed in a grounded, electromagnetically shielded case, called a Faraday cage.
- At least one firearm is something you are going to wish you had if things really get bad.
- Consider making sure your house is protected by a security system, including glass-break and motion detectors and perhaps video cameras.
- In a prolonged grid-down situation there will likely be no Internet, and no cable or broadcast TV to provide content.

- Consider creating an offline digital library of DVDs, MP3 audio and MP4 video files for entertainment and skills training.

All done and ready to move in.

Chapter Nine

Looking Back Now that the Work Is Done

What we would have done differently if we had to do it over again

We like our new house and are happy with the end product. The rooms are spacious and the ambience is exceptional. We are happy with the look and feel, and after a few months, are beginning to feel at home. It's great living space, but arriving where we are today was not as easy or as pleasant a journey as it might have been because there were a number of unexpected bumps and detours along the way.

We selected a builder because he exuded confidence and had a stellar track record. That made sense, and I would suggest you do the same but take one additional step. Be sure that you fully understand the risk you are taking with respect to schedule and budget. First, our move-in date was delayed by more than a month, but that was minor compared to other issues that caught us off guard. As the process went along, we were hit with a number of big surprises that probably could have been avoided. Perhaps the biggest among them had to do with our water system.

The well had to be dug deeper than we expected. Water was finally hit more than four hundred feet down. Fortunately, there was enough money set aside in the construction budget to cover that. The biggest surprise was that the iron content was six times the normal amount, and this led to an even bigger, unexpected expense.

Water in a recently drilled well is subject to contamination by the drilling operation, and so new wells are typically treated with chlorine before the water is used for drinking. When this was done, the iron in the well reacted with the chlorine. As a result, we had ugly, brownish-orange rust water coming out of our faucets. Fortunately, we had a Big Berkey desktop water filter on hand like the one previously mentioned. We had to use it to treat the water coming from our well for a full week after we moved in.

To solve this problem, we had to have a heavy-duty water treatment system installed, which includes a water softener and silica treatment. We also bought and had installed separate reverse osmosis filters for each of two drinking-water outlets: one for the kitchen sink and the other for the refrigerator icemaker and water dispenser. The elaborate filtration and softening sys-

tem added significant resistance to the water lines, thus reducing pressure at the faucets. To remedy this, we chose to add a re-pressurization pump, which also wasn't in our budget, to bring the water pressure up to par. The additional cost for all the water-related items amounted to more than $8,000 that we had not planned on spending and was not in our budget. Thank goodness, the overall water quality now is good, and water from the drinking spouts actually tastes good. Now that all is said and done, we have ended up with an abundant water supply that can operate independent of the grid, but it cost a good deal more than we expected. We purchased our whole-house water treatment system from Kinetico Advanced Water Systems of Richmond, VA and we couldn't be happier with the quality, service, and fast turn-around time.

However, that is not the only problem that came about as a result of the initial water problems. The warrantee is now void on our Rinnai on-demand propane water heater. As you recall, water is fed through the unit and then rapidly heated by an internal propane fire. The copper pipes within the unit were subjected to a high level of iron prior to the installation of the water filtration

system, and running hard water through the on-demand water heater invalidated the warranty. The reason is that the iron can react with the copper piping used to heat the water. This is something you need to be aware of if you decide on such a system. Do not use the hot water heater until a filtration system is installed, or you are certain the mineral content of the water will not void the warranty.

These were not the only surprises to do with water. The other big one had to do with the septic system. As you probably know, septic systems treat wastewater and are typically found in rural areas without centralized sewer systems. They use a combination of nature and technology to treat household wastewater that exits from bathrooms, kitchen drains, and washing clothes. A typical septic system consists of a septic tank and a drain field, or soil absorption field. The water initially flows into the tank, which has openings that allow the water to seep into the field.

As has been said a number of times, if you want to be able to live comfortably off the grid, it makes sense for the appliances you select and the home's mechanical systems to be designed and constructed so that they use as little electrical energy as possible.

That being the case, it makes sense to have a 100 percent gravity-fed septic system so there will be no additional electricity required for wastewater pumping. Such a system eliminates an electric load the solar system would otherwise have to power. For that to be possible, household wastewater has to come from a higher elevation than the septic tank so that gravity is what causes the water to flow into septic tank and drain field. That's what we thought would be the case when we purchased the lot for our new home. The plan was for the septic tank and drain field to be located on lower ground behind our house. As it turned out, however, the system could not be located in the backyard and had to be put in front of the house, which is higher ground. Why? The backyard didn't perc.

The word "perc" comes from "percolation rate," which is the speed at which wastewater will be able to flow through the soil. You cannot put a septic field on land that doesn't have a high enough rate. Unfortunately, our backyard did not.

You might wonder why the front yard would perc and the backyard would not. From what we can determine, it had to do with fill dirt. The front yard of our new home was open land when

we bought it, and the backyard was forested. When the trees were removed, there were holes and uneven ground where the roots had been. These were filled with dirt and the land was graded with the result that the backyard did not have a sufficient percolation rate for a drain field to be placed there. Since the front yard is slightly higher than the house, an electric pumping system had to be purchased and installed to evacuate wastewater and move it to the septic tank. This not only added to the electric power requirements of our house that will have to be covered in an off-grid situation, it cost an additional $3,800 we had not planned on spending.

The final lesson learned that would have changed our design has to do with propane fuel consumption. As I am writing this, we have been living in the new house for five months. During that time, I have observed the rate of fuel consumption and determined that our 1,000-gallon tank will support our lifestyle for a maximum of twelve and a half months on a full refill. My original intent was to have at least two years of fuel reserve, so we missed the mark by one full year. In the future, we may add a second 1,000-gallon tank connected in parallel to the existing tank.

The cost of an additional tank is approximately $3,500 and the fuel to fill it costs an additional $1,750 at today's market prices. I would advise that you plan for this additional expense if having a robust fuel reserve is a priority for you.

Here is the bottom line: If we had to do it all over again, we would have spent more time and effort understanding the land and the possible pitfalls connected with it rather than focusing solely on the house itself and associated systems. The lesson learned is that it is important to thoroughly understand the terrain, the geology of the ground, and how the related factors may impact systems and electric power requirements. Also, be sure to understand what budget risk you're taking as the homebuyer versus what risk the builder is taking. Water quality wasn't even on my radar as a potential liability. Perhaps if we had done more research on the homebuilding process in general, we would not have had those big surprises. As the old saying goes, "Live and learn."

They say that as time goes by, people remember the good and forget the pain they endured. We hope this will be the case because Rachel and I really do like our new house and are comfortable in the knowledge we are now prepared for whatever the

future may bring. To illustrate that, what follows is a recap of some of the major features.

As discussed previously, we had the electric control panels and wiring set up so that all the critical systems of the house are on automatic secure backup with the option to send emergency power into other parts of the house as needed by manually flipping some switches. This was planned out with our electrician before construction began so, unlike an existing home that already has the electric system in place, it wasn't necessary to move things around. We simply decided in advance which systems to put on the critical loads panel and which would go on the other, non-critical one.

The panel on the left has the entire home's critical systems. This includes the well pump, the propane furnace, the heat pump

and variable speed air-conditioning unit for downstairs, the refrigerator, living room, kitchen and other common areas as well as downstairs bedroom receptacles, the freezer, the on-demand propane water heater, the microwave, the septic pump. If utility power drops off, every circuit in the left panel is going to remain energized automatically. Solar power will be used, assuming sunlight is available. Otherwise, power will be pulled from stored energy in the batteries. This way we can still live normally without any disruption during an outage.

On the right side are the non-critical loads. They include things that are nice to have but aren't necessarily needed during an outage such as the garbage disposal, dishwasher, clothes dryer, and electric oven, which tend to produce heavier draws. We haven't put them on the automatic backup because we don't want to drain the batteries too fast, but we do have the option to manually switch these circuits to backup power one at a time if we decide for any reason that we want to. So far, that hasn't been necessary.

Pictured on the next page (pg. 174) is the FLEXpower Radian. It includes the hybrid-inverter, the central engine of the renew-

able energy system, which integrates four different power sources. They include solar panels on the roof, stored energy within the battery, the gasoline-powered generator if needed, and utility power. And, of course, the utility power connection is bi-directional, which means we can sell power to the utility when we have excess available, and purchase power from the utility during evening hours when there is no solar available. The equipment allows us to configure and monitor all of this. For example, we can see what our solar power production was during the day, what the battery status is, what the draw of the different loads are, and where the energy is coming from, i.e., whether from solar, battery, or from the grid.

Our deep cycle battery bank shown on the facing page is comprised of OutBack EnergyCell AGM grid-hybrid batteries. The

design was taken from commercial telecom batteries. Most cell phone towers and telecom switching centers typically use banks of batteries very similar to ours. They are what keep our telecommunications systems running during power outages.

The racks the batteries go on were designed and manufactured for this size and shape of battery, all the battery terminals are in the front and all the pre-connection cables and wiring is pre-cut, which makes installation and service easy. The batteries also come with a protective black cover, so that once the connections are made, you don't have to worry about accidently short-circuiting

the terminals. There is also independent switching on each string or row of batteries so that individual strings can be isolated or the entire power source cut off if the need arises.

Shown above is the load center or switchgear. It's where all four power sources come in. Based on how we program it, the hybrid converter is able to determine which power source to use and in which priority. Generally, the way it is configured is to use solar power first, followed by utility power, stored battery power, and finally, gasoline engine generator power.

Below we have an Ethernet interface similar to the one that might network computers. It allows all the devices in the house to communicate with one another and work together harmoniously.

So, for example, the charge controllers can determine what the optimal voltage is to keep the batteries one-hundred percent fully charged while still allowing the inverter to direct the excess power to be sold back to the electric company for credit on our electric bill. All that coordination happens seamlessly. The device is also

internet enabled, which makes it possible for me to access and configure or reconfigure it on my laptop from any location that has wifi.

In an earlier chapter I discussed the wisdom of having a backup generator to use to power the house and charge batteries during a prolonged period of overcast or inclement weather. The unit we selected produces 7500 watts, which is more than enough to handle all the critical loads in this house while also charging the batteries at a high rate of speed.

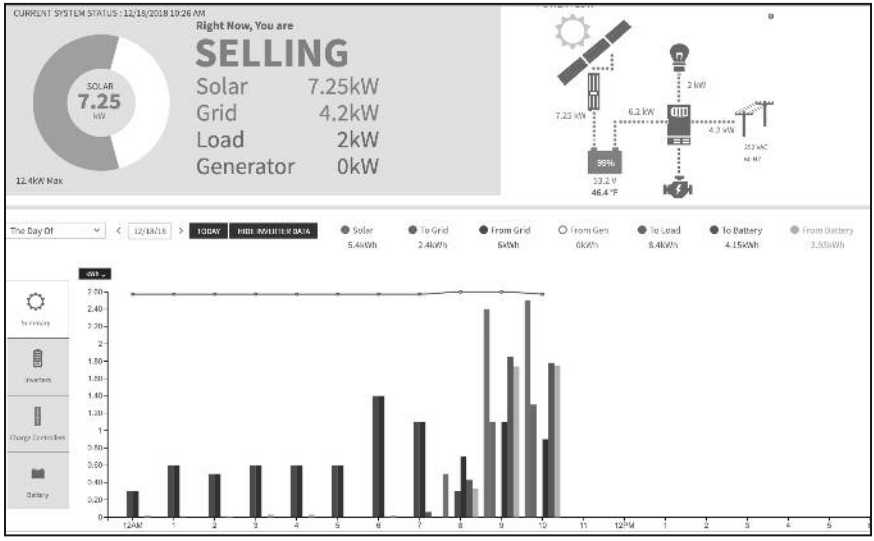
In fact, because we were able to plan things out before construction began and purchase only the most energy efficient devices, the amount of energy this house uses is amazingly small.

The optics application pictured below shows exactly how much is being used at any given time. When this particular image was taken, it was mid-morning and solar production was over 7kW, and the load in the house was 2 kilowatts, or 2,000 watts, the equivalent of twenty 100-watt bulbs. It was 40 degrees outside at

the time and the propane furnace was on plus the TV and all the lights in the kitchen and common area. Of course, if we were to turn on the hot water and activate the well pump and the on-demand hot water the load may increase slightly. Having observed the system for several months now, we've found that the resting load for the house is typically 800 watts or less.

As discussed previously, our gas log fireplace serves as a backup heating system. So, if and when a situation arises that it makes sense because, for example, we are running on battery

power, instead of running the furnace, we have the option of turning on the fireplace and putting the HVAC system on circulate to move the heat throughout the house. We have tried this and found that it actually does work. Moreover, the air handler by itself draws only about 400 watts, and when used in combination with the fireplace, which draws no electricity, the entire house is heated to a comfortable temperature.



The OpticsRE software platform enables solar system performance monitoring.

In closing let me say that all the energy systems and devices are performing exactly as we wanted them to and hoped they would in terms of energy usage. As discussed at the beginning of this chapter, if we had done a better job of understanding the lay of the land, we might have been able to avoid having to have a powered septic pump and an expensive water softening system with its own separate pump. But even though those unforeseen issues arose, we have been able to achieve our goals without having to compromise any quality or comfort.

Thank you for taking this journey with us. We hope that by sharing our experiences and letting you know what we learned, you will be far ahead of where we began as you move ahead to accomplish your goal of being able to live comfortably independent of the utility grid. If you would like to stay updated about our experience and new developments in the pursuit of self-sufficient living, please follow us on Facebook and subscribe to our YouTube Channel. Here are links to each:

https://www.facebook.com/UnitedSolarSurge

https://www.youtube.com/UnitedSolarSurge

Glossary

Ampere – the standard unit of measure for electrical current or flow

Battery – an electrical device that stores electricity as chemical potential energy

Charge controller – an electrical device that limits the amount of solar electricity allowed to pass through to a battery bank. Prevents overcharging the batteries.

Circuit breaker – A reusable device that automatically interrupts ("breaks") an electrical circuit when the current limit is exceeded

Cistern – a reservoir, tank, or container for storing or holding water

Current – Volume of electron/electricity flow

Deep Cycle Battery – A battery that is designed to be discharged over a prolonged period of time between recharges

Energy – the ability to do work

Inverter – a special type of electrical transformer that converts direct current (DC) electricity to alternating current (AC) electricity

Joule – the standard unit of measure for energy

Kilowatt-hour (kWh) – A unit of measure for electrical energy. The amount of energy expended when running a load of 1,000 Watts for a period of 1 hour

Photovoltaic – Electricity from light. Solar electric

Power – the rate at which energy is expended or transferred

Solar panel – an electrical device that converts sunlight into DC electricity

Switchgear – A collection of switches and circuit breakers that allows the solar equipment to be bypassed or disconnected.

Volt – the standard unit of measure for electric potential or electromotive force

Watt – the standard unit of measure for power. 1 watt = 1 Joule per second

Work – exertion or effort directed to produce or accomplish something