Living Off The Grid

The information provided here on “Living Off The Grid” is from my books on aquaponics.

I am providing it to you at no cost.

If you are interested in learning more, I would encourage you to check out one of books at:

http://www.farmyourspace.com/new-book-releases/

Thank you

David Dudley

CHAPTER 22

Alternative Energy Options & Operating Off-The-Grid

Alternative Energy Overview

Renewable energy is clean, affordable, domestic, and effectively infinite. It produces no emissions and results in cleaner air and water for all. Energy prices are rising rapidly and fuel oil prices are breaking records on an almost daily basis. With the economy slowing down, the increasing cost of food, gas, utilities, and taxes consuming more of our budget, consumers are spending less on non-essentials. It is no surprise that many families and business owners are wondering how they will survive. One strategy is to lower energy consumption by becoming more energy efficient or by using alternative energy sources.

In recent years, a lot of attention has been given to biomass as an alternative fuel source (ethanol, aka corn). With many Americans having to sustainably curtail their food budget and hundreds of millions around the world starving, U.S. lawmakers have adopted an insane policy of burning up our food supply in the form of a corn-based ethanol fuel mandate. What is really crazy is that ethanol-laced fuel gets much worse mileage than gasoline; you have to buy more of it to get where you're going. It is a policy that has never made much sense, but adopted because of lobbyists, Big Agriculture, and political favors. Obviously, growing corn for ethanol reduces the available farmland to grow food crops. Furthermore, a recent Congressional Budget Office report concluded that the increased use of ethanol accounts for 10-15 percent of the increase in food prices, thus one of the reasons food prices continue to rise, despite more efficient farming practices being implemented and more land being converted to agriculture..

This chapter will focus on solar and wind energy. These are alternative energy options that not only make good sense, but are relatively affordable and easy for most people and small businesses to put into place.

Economics of Electricity

The cost of electricity can be somewhat challenging to determine, as most utility companies have different rates for summer and winter months, and for peak and not-peak usage. With the development of so called 'smart meters', utility companies are able to determine exactly when and how much electricity you are using.

Before we see how much electricity costs, we have to understand how it's measured. When you buy gas, they charge you by the gallon. When you buy electricity, they charge you by the *kilowatt-hour*

TABLE 25. **Electricity Costs**

DEVICE	WATTAGE	HOURS USED	kWh
Medium Window-Unit AC	1000 watts	one hour	1 kWh
Large Window-Unit AC	1500 watts	one hour	1.5 kWh
Small Window-Unit AC	500 watts	one hour	0.5 kWh
42" Ceiling Fan on Low Speed	24 watts	ten hours	0.24 kWh
Light Bulb	100 watts	730 hours (all month)	73 kWh
CFL Light Bulb	25 watts	730 hours	18kWh

(kWh). When you use 1,000 watts for 1 hour, that's a kilowatt-hour. See table 25 on the following page.

To get kilowatt-hours, take the wattage of the device, multiply by the number of hours you use it, and divide by 1,000. (Dividing by 1,000 changes it from watt-hours to kilowatt-hours.) Here's the formula to figure the cost of running a device:

wattage x hours used ÷ 1000 x price per kWh = cost of electricity

For example, let's say you leave a 100-watt bulb running continuously (730 hours a month), and you're paying 15¢/kWh. Your cost to run the bulb all month is 100 x 730 ÷ 1,000 x 15¢ = $10.95.

If your device doesn't list wattage, but it does list amps, then just multiply the amps times the voltage to get the watts. For example:

2.5 amps x 120 volts = 300 watts

(If you're outside North America, your country probably uses 220 to 240 volts instead of 120.)

Watts vs. Watt-Hours

- Watts is the *rate* of use at *this instant.* In other words, Watt is a measure of work.
- Watt-hours is the total energy used over time.
- We use *watts* to see how hungry a device is for power. (i.e., 100-watt bulb is twice as hungry as a 50-watt bulb.)
- We use *watt-hours* to see how much electricity we used over a period of time. That's what we're paying for.

So, just multiply the *watts* times the *hours used* to get the *watt-hours.* (Then divide by 1,000 to get the kilowatt-hours, which is how your utility charges you.) Example: 100-watt bulb x 2 hours ÷ 1,000 = 0.2 kWh.

The national average rate for electricity is useless for two reasons:

1. **Electricity rates vary *widely.*** They vary not only by region (i.e., an average of 7.5¢ in Idaho vs. 36¢ in Hawaii), but they also vary from the same utility. As a matter of fact, rates can range from 12¢ to 50¢ per kWh from the same provider. The only way to know what you're actually paying is to check your bill carefully.
2. **Electric rates are usually *tiered,*** meaning that excessive use is billed at a higher rate. This is important because your *savings* are also figured for the highest tier you're in. For example, let's say you pay 10¢/kWh for the first 500 kWh, and then 15¢/kWh for use above that. If you normally use 900 kWh a month, then every kWh you save reduces your bill by 15¢ (technically, once you get your use below 500 kWh, then your savings will be 10¢ kWh, but you get the point).

For simplicity in determining a 'rough' cost for an item, use a rate of 15¢ per kWh. This isn't a "typical" rate, since there's no such thing as typical when it comes to electricity rates. And it's certainly not average. It's just a *reasonable expectation.* Your

own rate could be dramatically higher or lower than 15¢ per kWh

Table 26 shows the typical cost of electricity. As of 2014, where I live the in northern California, the cost of electricity averages about $0.14/KWH, with annual increases planned for the next four years. What is NOT shown are the fees and taxes that are also imposed upon us in addition to our base electrical charges. It is easy to see how even a small solar powered system can help alleviate some of this financial burden, whether it be used for aquaponics or for other purposes.

TABLE 26. ***Electricity Costs***

COST PER kWh	12-HOUR DAYS		18-HOUR DAYS	
	Day	Month	Day	Month
$0.05	$0.60	$18.00	$0.90	$27.00
$0.06	$0.72	$21.60	$1.08	$32.40
$0.07	$0.84	$25.20	$1.26	$37.80
$0.08	$0.96	$28.80	$1.44	$43.20
$0.09	$1.08	$32.40	$1.62	$48.60
$0.10	$1.20	$36.00	$1.80	$54.00
$0.15	$1.80	$54.00	$2.70	$81.00
$0.20	$2.40	$72.00	$3.60	$108.00
$0.25	$3.00	$90.00	$4.50	$135.00

Electrical Definitions

- Watt'—a measure of work.
- Kilowatt (kW or kw)—a unit of power, equal to 1,000 watts.
- Kilowatt-hour (*kWh* or kW·h)—a measure of electrical energy equivalent to a power consumption of 1,000 watts for 1 hour.
- Ampere (amp)—a measure of electricity in motion.
- Volt—a measure of electricity under pressure.

Grid Connection

Depending on local regulations and laws, so-called net-metering systems can be installed that allow your electricity meter to run 'backwards' when your power generator is producing more than you need. In some locations, excess power delivered to the grid will result in additional reimbursements. In many states, electrical utilities are mandated to purchase a specific percentage of their energy from 'green' or renewable sources and welcome special arrangements with energy producers.

Solar Energy Fundamentals

Solar power is one of the fastest growing sectors in the U.S. The price of solar panels has dropped by 30 percent since 2010 and costs continue to fall. This is not just a trend in America, the rest of the world is also moving in the same direction. As a matter of fact, the United States was a net exporter of solar products in 2010 by $2 billion.

While plants convert sunlight into biomass production, photovoltaic (PV) panels convert it into electricity. The conversion efficiencies of PV panels have increased over the years to as high as 17 percent at maximum light intensity. Some experimental PV cells have achieved efficiencies of 40 percent.

PV panels should be mounted for maximum light interception. In the Northern hemisphere, panels can be attached to south-facing roofs, other support structures, or on a tracking device that follows the position of the sun across the sky.

PV panels generate DC power that can be converted to AC power to operate lights, pumps, and other household/small business equipment. PV systems can be interconnected with the local electrical grid, ensuring that electrical power is always available. In a grid-connected system, excess power from the solar installation can be sent to the grid. Interconnection requirements vary from state-to-state and utility-to-utility.

Off-grid PV systems require some form of electrical storage to provide power during periods of little or no sun. Typically, banks of batteries are installed for this purpose. Off-grid systems are best suited to applications where there is no nearby electrical grid or for standalone systems, such as aquaponics.

A significant portion of sunlight reaches the surface of the Earth as heat radiation. This energy can be used to heat water. Typically, not much water is needed for washing and cleaning purposes, but aquaponic operators can use warm water to heat the greenhouse. The most solar energy that can be collected is during the middle of the day, so storing the warm water for use during the night is a good strategy to reduce the use of heating fuel. The fish tank can serve as an efficient means of regulating temperature in a greenhouse or other enclosed area. The rise in heating prices makes long-term storage of warm water more attractive.

There are also many other technologies for converting incoming solar radiation into heat. The most common systems are flat plate collectors that allow water or other fluids to flow through a panel that is oriented toward the sun. Very simple flat plate collectors are often used for heating swimming pools, but can and are used for many other applications. Flat plate collectors are very efficient. Other systems for converting sunlight into heat include evacuated tube collectors and parabolic reflectors. These products are capable of generating higher temperatures, but are significantly more expensive and are often dependent upon a tracking systems to maintain an optimal orientation.

Other solar technologies are passive. For example, big windows placed on the sunny side of a building allow sunlight to heat-absorbent materials on the floor and walls. These surfaces then release the heat at night to keep the building warm.

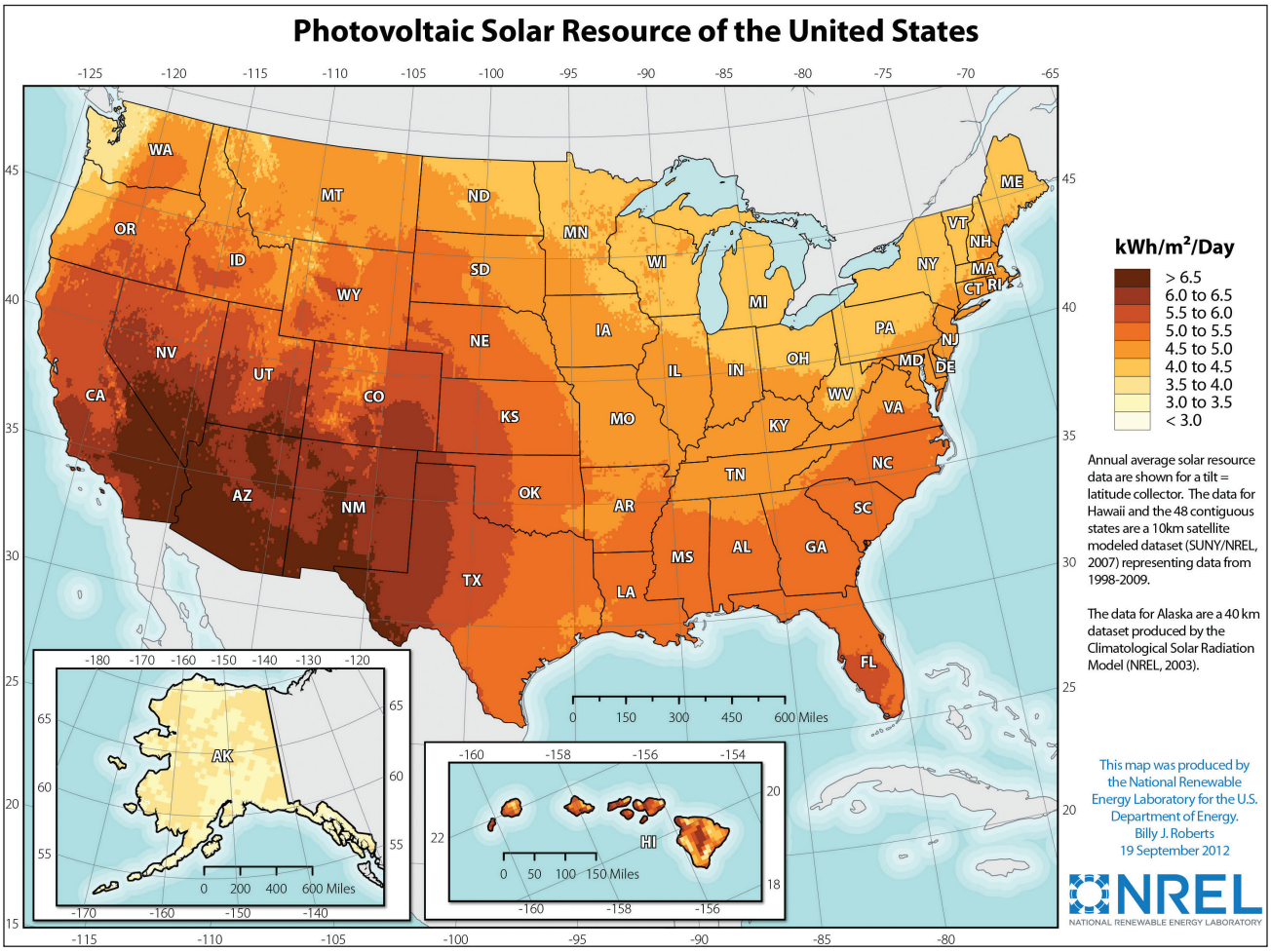


FIGURE 118. The American Solar Energy Society provides additional information on their web site: (http://www.ases.org/)

Benefits of Solar Energy Summarized

- Feel good about saving energy and the environment.
- Helps promote a model for sustainable living.
- Save tens of thousands of dollars over the life of your solar energy system.
- Allows you to put current utility bill money to better use.
- Use all your appliances without feeling guilty.
- Helps the U.S. get one step closer to energy independence.
- Doing something good for future generations.
- Solar energy is an inexhaustible fuel source that is pollution and noise free.

Average Daily Solar Radiation per Month at Your Location

Figure 116 shows the general trends in the amount of solar radiation received in the United States and its territories.

Steps to Integrating Solar Energy

1. Review your power needs.
2. Look for ways that you can conserve power (i.e. more efficient lighting, temperature control, etc.).
3. Calculate the savings over time, and consider how those funds could be better spent.
4. Calculate the cost of installation.
5. Remember that it is an investment, and that there is a good probability that you can sell the system (thus receiving a portion of your money back) in the future if you ever decide to go a different direction.
6. Obtain free advice from solar energy equipment vendors regarding your operation.
7. Educate yourself on solar energy equipment.
8. Compare cost.
9. Installation.
10. Maintenance (cleaning the panels periodically).

Solar Energy Grants, Loans, Tax Incentives, and Other Resources

- Energy Technology Inc. has solar powered equipment, supplies, and accessories for homeowners and small businesses: http://personal-solar.com
- Solar Resource Calculator at: http://solar.ucsd.edu/SolarApp.html
- The Solar and Energy Loan Fund (SELF) provides low cost financing options and energy expertise to help homeowners and small business owners lower energy bills and implement alternative energy systems, such as solar equipment:
- http://cleanenergyloanprogram.org/how-it-works/homeowners
- The USDA Rural Business and Cooperative Programs has a wide array of programs, as well as grants and loans, for increased energy efficiency and alternative energy systems: http://www.rurdev.usda.gov/Energy.html
- Check with your electric utility company to see if they have other resources as well as provide solar energy conversion benefits.
- With tax incentives, solar electricity typically pays for itself in five to ten years.

Wind Energy

The United States has some of the best wind resources in the world, with enough potential energy to produce nearly 10 times the country's existing power needs. Wind energy is now one of the most cost-effective sources of new-generation power technology, often having a significant competitive advantage over the coal, gas, and nuclear power technologies. Its cost has dropped steadily over the past few years, as wind turbine technology has improved. Currently, over 400 American manufacturing plants build wind components, towers and blades.

Using wind to pump water and generate power is not a new idea. Before the start of rural electrification in 1936, wind energy was widely used across the U.S. During the last ten years, technological improvements

and rising energy prices have significantly increased the number of wind energy installations. In many cases, large installations have occurred on farmland, but often the farmers are not the main users of the generated energy, nor do they own the equipment. Many farmers only receive a land lease payment for the area used by wind turbines.

The success of wind energy installations depends on site-specific wind conditions. Wind maps have been compiled for all regions of the U.S. and these maps are useful for a first approximation of the average wind speed at a given location (links provided at the end of this section). However, local topology, vegetation, and building structures significantly affect the average wind speed. Where possible, use local wind speed measurements to determine whether a site is appropriate for wind generation. Currently, an average wind speed of 9 mph for small wind generators and 13 mph for large generators (measured at 100 ft above the ground) is considered necessary for the economical use of wind power.

Even small wind generators can be used to operate a fairly large size aquaponic system. Such a system can be operated off-grid, but a connection to the grid is prudent. Grid-connected-systems have the advantage of having power available when the wind system is not functioning at full capacity, and does not require batteries for electrical storage.

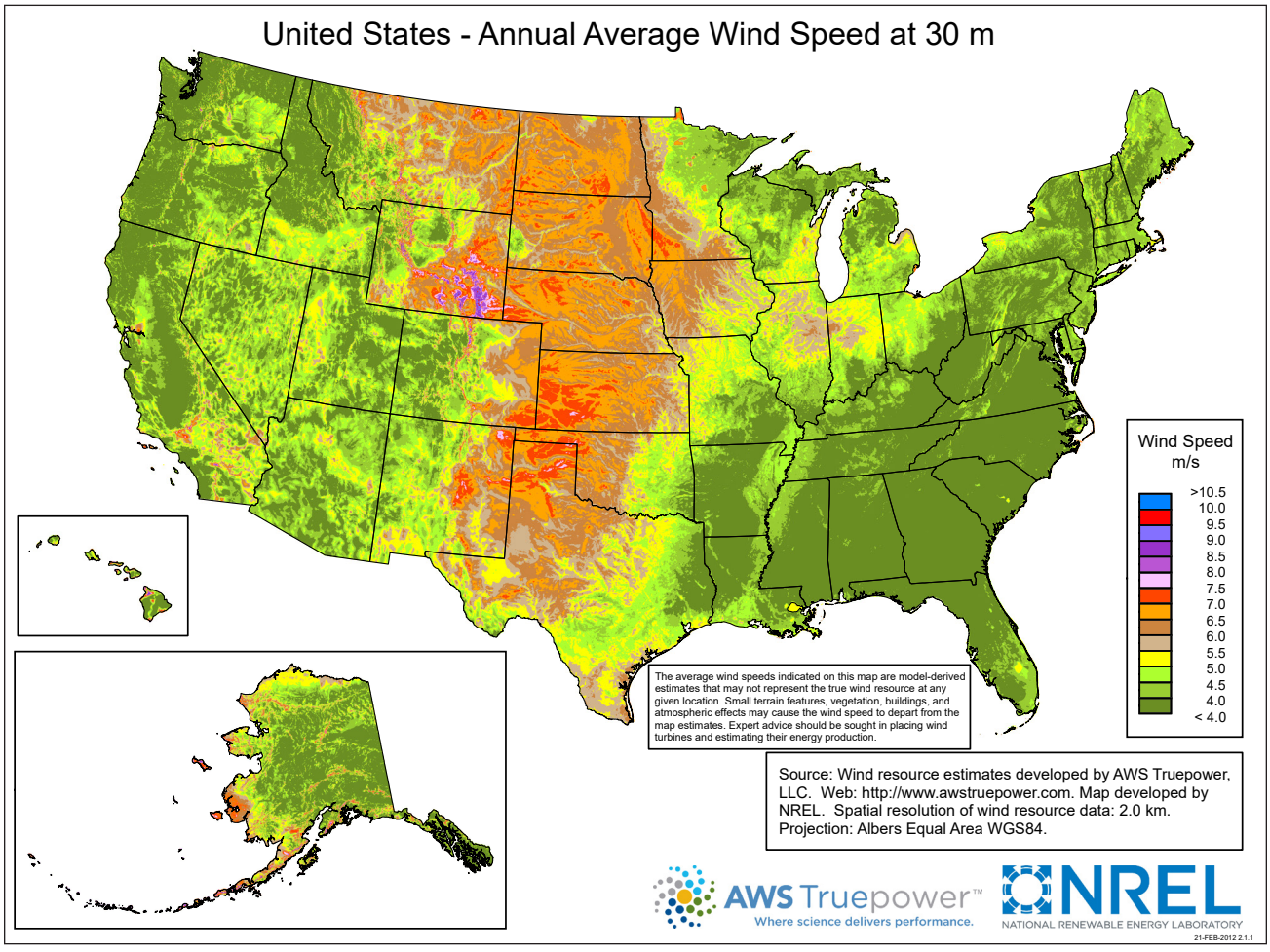


FIGURE 119.

Wind Energy Helpful Resources

- Very interesting current wind map of USA: http://hint.fm/wind
- A collection of helpful worldwide wind and climate maps: http://www.climate-charts.com/World-Climate-Maps.html
- The U.S. Department of Energy provides an 80-meter (262.5-ft) height, high-resolution wind resource map for the United States with links to state wind maps. States, utilities, and wind energy developers use utility-scale wind resource maps to locate and quantify the wind resource, identifying potentially windy sites within a fairly large region and determining a potential site's economic and technical viability. http://www.windpoweringamerica.gov/wind_maps.asp

Grant, Loan and Rebate Programs

Local utilities, as well as state and federal organizations, offer a variety of grants, loans, and rebate programs for alternative energy installations. Each of these programs comes with its own set of requirements and often entail cost-sharing. Nevertheless, these programs can reduce the investment costs and/or reduce the pay-back period. Many of these programs are announced on web sites, requiring some effort to learn about them. In some states, energy regulating commissions, such as the Board of Public Utilities or state energy agencies, have programs for renewable energy systems. Your local utility and county extension service, state departments of agriculture, the USDA, and the NRCS are good places to start investigating the various opportunities.

Renewable Energy Certificates

Some states administer renewable energy certificate (REC) programs that allow certified producers of eligible renewable energy to sell these certificates that represent proof that 1,000 kWh of electricity was produced. Thus, in addition to reducing your electric power consumption from the utility grid (i.e., by lowering your monthly electricity bill or receiving payment for excess electricity you exported to the grid), the RECs generated by your system can provide additional income when sold (i.e., to a power company that was mandated to deliver a certain percentage of its total output as renewable energy). While prices for RECs fluctuate, REC programs provide additional financial incentives for renewable energy production (http://www.eere.energy.gov/greenpower/markets/).

Energy Conservation

Before you consider a solar or wind system for your aquaponic operation, the first step in any renewable energy project is ensuring that the existing system is functioning efficiently. The reason is quite simple: the cost of implementing energy efficiency measures is less than the cost of installing renewable energy technologies to compensate for inefficient use of conventional energy sources.

Energy Conservation Resources

- An excellent energy conservation guide full of valuable ideas and practical techniques has been produced by the U.S. Dept. of Energy and can be found at http://energy.gov/sites/prod/files/2013/06/f2/energy_savers.pdf.
- The State of California Consumer Energy Conservation Department has a list of energy conservation and efficiency tips for your home, office, business, vehicle, and other areas, located at: http://www.consumerenergycenter.org/tips/index.html
- A useful reference source is the book titled "Energy Conservation for Commercial Greenhouses", published by NRAES.
- Some of the many ways to achieve better energy performance in greenhouses include using thermal curtains, where possible, and checking that

they seal properly (i.e., form a continuous barrier), verifying that environmental control systems are doing what they are supposed to, and sealing glazing leaks through unintended openings in your walls and roofs.

- Most local utility companies have a brochure and/or webpage showing you many ways on how you can better conserve energy in your home and business.

Living or Operating Off-The-Grid

A growing trend, especially within the United States, is being "off-the-grid". This term can conjure up many different meanings for people, ranging from a peaceful community of folks who still travel by horse-and-buggy to groups preparing for the end of the world and are of anti-everything. While these groups can fall under the basic definition of off-the-grid, the general term is simply people who are not connected to a public utility. Their reasons for choosing to live in such a way varies from one end of the spectrum to the other. For the most part, off-the-grid folks are not connected to their local electrical system; they are a stand-alone-system.

Off-The-Grid Alternative Energy Source

Electricity, however, is just the main aspect of being off-the-grid; it can also relate to all energy sources. For instance, off-the-grid homes are autonomous; they don't depend upon the municipal water supply, sewer, natural gas, cable or internet services, or similarly related utility services. What the author would consider a true off-the-grid house is one that is able to operate completely independent of all traditional public utility services.

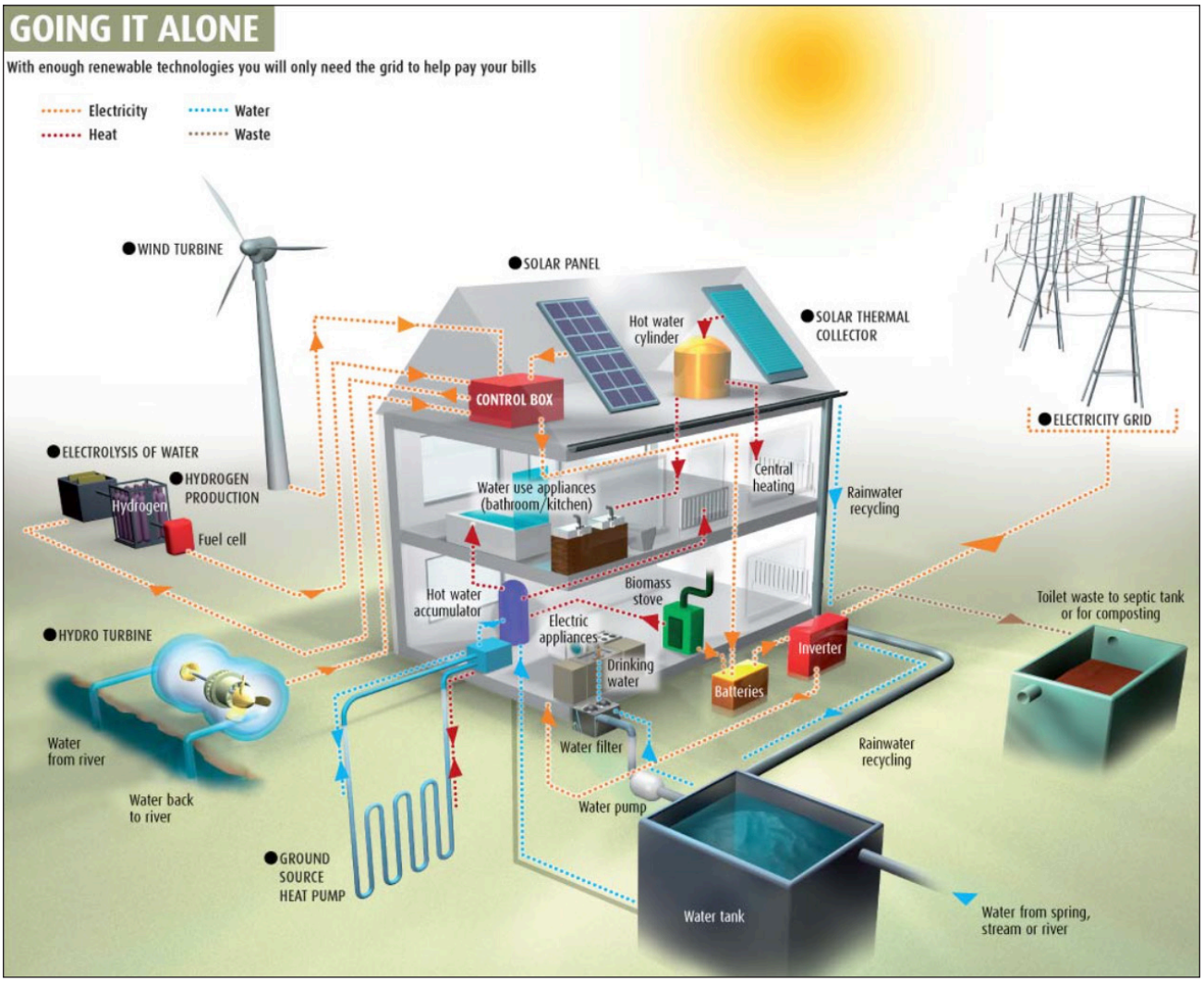
Although there are many different types of alternative energy sources (such as geothermal), the ones that are most applicable to the topic-at-hand are wind, solar, biofuel, ethanol, and water (well, creek, or pond). Of these, solar polar is by far the most commonly used alternative energy source in aquaponics.

The initial set-up costs for living off-the-grid are a bit high, turning many away from considering alternative energy. However, most find that the initial price tag is compensated through time as they are free from the monthly financial drain as well as government mandated taxes and regulations. In addition, many have peace of mind knowing that they are generating a non-polluting energy source and that they won't have the deal with as many outages and shortages. Lastly, they take comfort in knowing that they are no longer financially supporting and sanctioning the fossil and nuclear fuel industries.

Alternative Food Source

Many who live off-the-grid have taken to growing their own food as well. Compared to taking the jump into an alternative energy source, growing your own food will require constant dedication and a lot of hard work; the end results are always worth it, though. Through aquaponics yields are much greater than traditional gardening for equal areas. Growing your own food has many advantages, such as:

- **Receiving the nutrients your body requires.** Much of the food we eat today has been modified and changed with chemicals and preservatives. Anyone that does even ten minutes of research online will quickly learn that what we are purchasing from the grocery store just isn't healthy to consume. Most of the chemicals used in farming were approved by the Environmental Protection Agency without any research into how these chemicals could harm individuals. Currently, the EPA considers 60 percent of all herbicides, 90 percent of all fungicides, and 30 percent of all pesticides as carcinogenic (cancer-causing). In 1987, a study by the National Academy of Sciences found that pesticides may contribute to an additional four million cancer cases in the United States alone. Imagine what that number might



be today! Our body craves particular minerals, nutrients, and vitamins; growing and eating your own organic crops helps meet this need. Bonus: the food tastes better than anything you'll buy from the store.

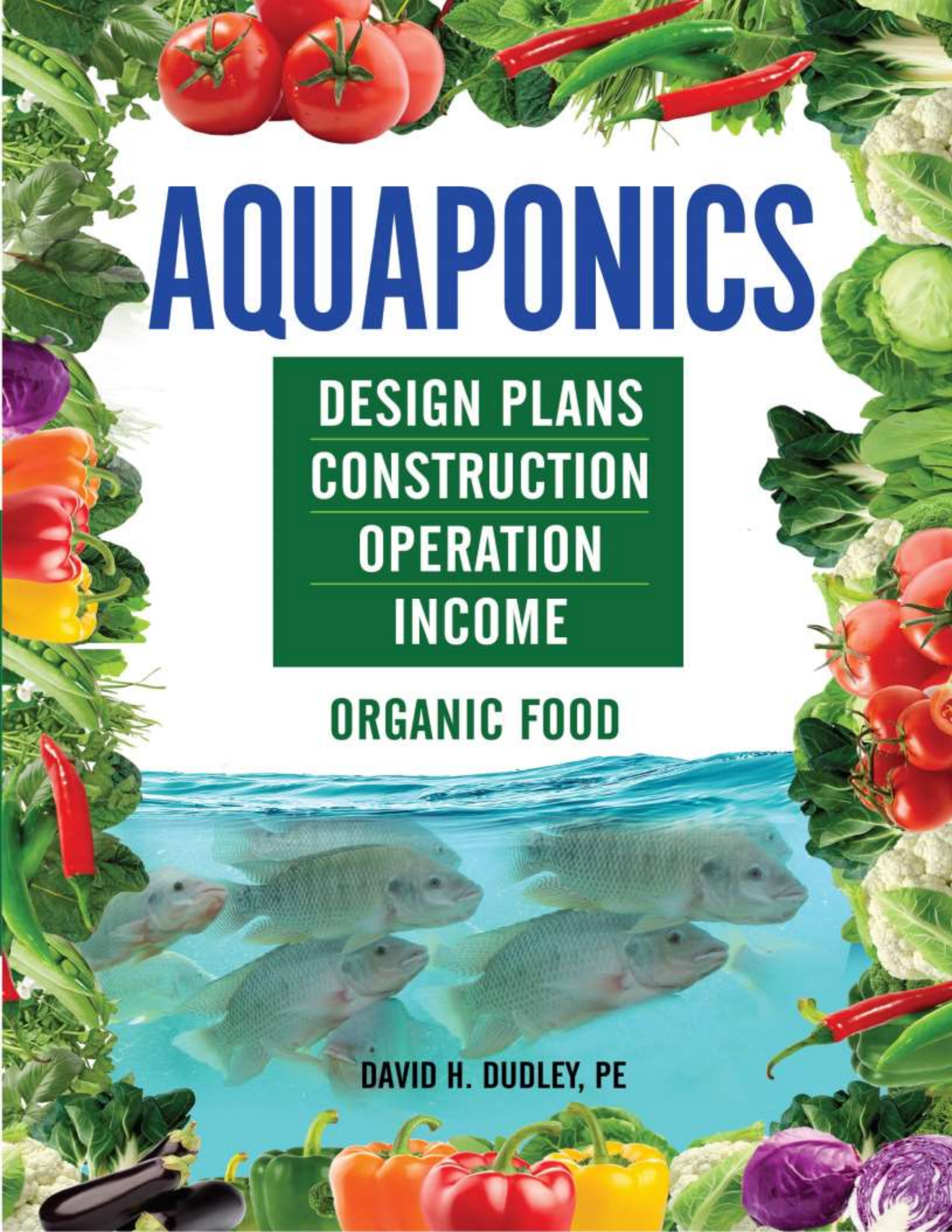
- **It will save you money!** The math is simple: if you are no longer spending money every week at the grocery store, but are growing your own food to consume, then you are saving money that will rapidly add up over time. If you decide to sell some of it to neighbors, family, and friends, then you just created an additional cash flow as well.
- **Stops soil erosion.** According to The Soil Conservation Service, over three billion tons of topsoil are eroded each year from the U.S.'s croplands; or about seven times faster than it is being built-up by mother nature.
- **Better water quality.** Due to most crops across the United States being sprayed with an array of chemicals (such as pesticides), at least 38 states have reported that their groundwater has been contaminated. A possible outcome of drinking such water is cancer. Growing your own crops, free of pesticides and other chemical agents, helps prevent the polluting of your own groundwater (which you may be drinking if you are truly off-the-grid).
- **Saves energy.** Most crops you buy at the store today are grown on mega-farms. In order to keep up with production, many farmers are forced

to use petroleum (more than any other single U.S. industry). This energy is used to create the synthetic fertilizers as opposed to growing healthy crops.

- **Emergency Supply.** Should a disaster ever strike your family or community, whether that be from a storm or something worse, you will have a ready-supply of food to consume. Many know what a grocery store looks like right before a major storm system hits; shelves are emptied in a hurry leaving you with few options if you didn't arrive first (and if you did, you may have left with multiple bruises and a higher blood-pressure). The old Boy Scout motto of "always be prepared" is a good one to remember here.

While it takes a lot of work, time, and effort, the benefits of being off-the-grid and supplying your own power and food far out-weight the negative. Upfront costs for setting up are quickly reimbursed, and there is a peace-of-mind that simply cannot be purchased when you are no longer dependent upon local utility companies, stores, and certain government regulations.

Friendly Reminder: As mentioned previously in this chapter, one should be sure that making alternative energy changes and/or implementing a farm (i.e. adding solar panels, harnessing the wind, growing a garden, etc.) doesn't violate any local laws, will not void your home owners insurance, will be tolerated by your local utility companies, and is conformance with your homeowner association (if applicable).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CONTENTS