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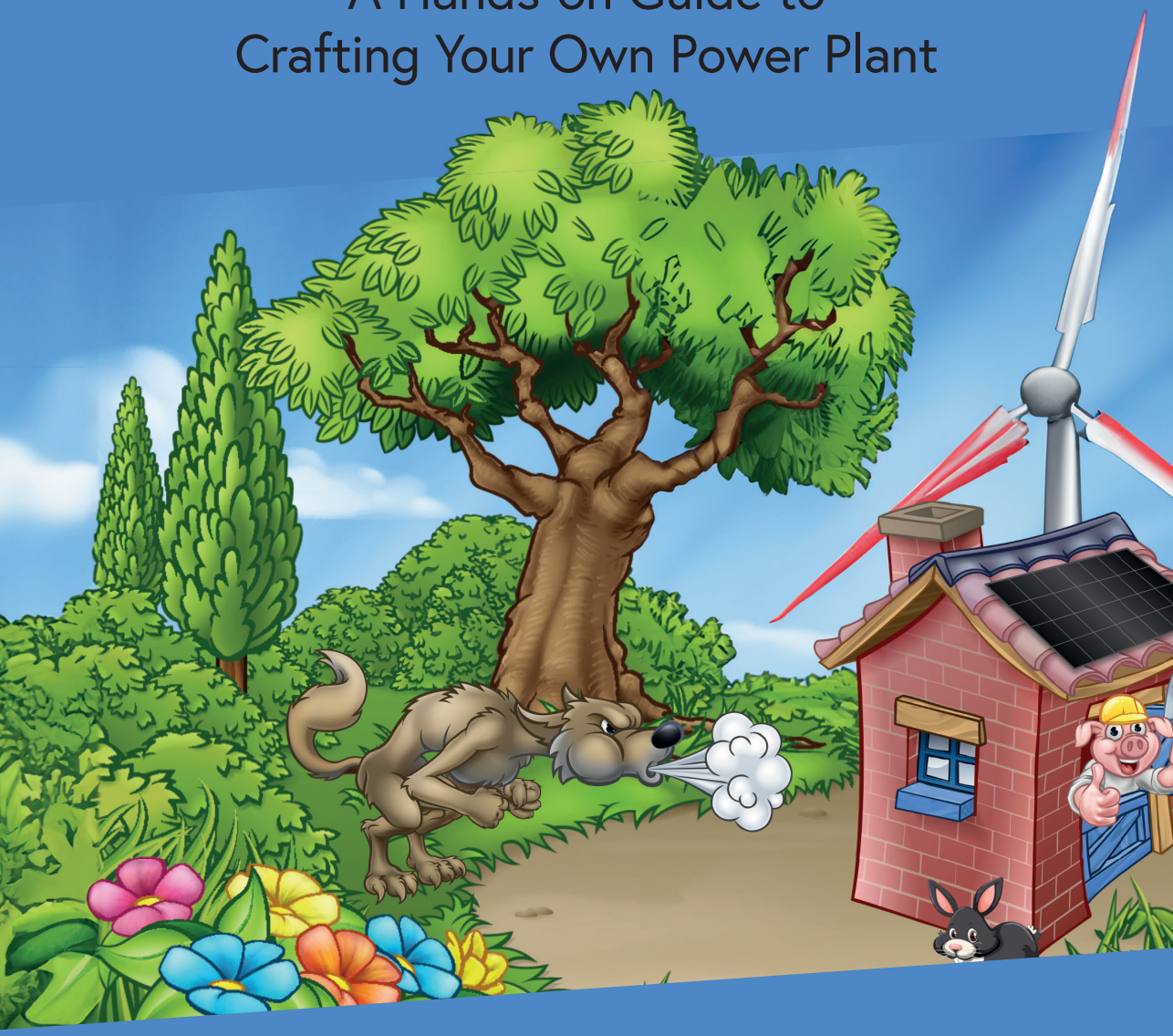
Renewable Energy at Home

A Hands-on Guide to Crafting Your Own Power Plant



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Contents

For Whom is This Written?

Many books have already been written about various aspects of renewable energy, *e.g.*, economic, political, etc. In addition, there are also books for the DIYers claiming to guide creating an off-grid solar energy powered house. The book you are reading now was written while we created a garage and a deck "power plants" from scratch. We present actual steps and considerations relevant to establishing your own energy independence together with some revealing experiments along the way.

We speak to the experimenters and geeks who would like to play with their renewable energy setup, learn fundamentals experimentally and ultimately build their own unique solution. The readers are encouraged to follow the projects described here and produce their own variations specific to their locations / circumstances. Some of the experiments and projects may sound like reinvention of a wheel, however we firmly believe that it is okay to re-invent and make a couple of wheels in someone's lifetime if it provides the experience and in-depth understanding of the subject.

Finally, our intention was not to simply rephrase information from various sources to fill up the pages, but rather create a new hands-on experience that will grow on its own. Where appropriate, we provide references to published literature and stable (hopefully) web resources for additional information for those who are interested.

Tools, Skills, and Supplies

Learn CAD

Creating your own renewable energy power plant requires serious attitude and attention to details. Even if you are not an engineer, you will have to become one, at least partially. Hence, planning your design will require some CAD work. We are not talking about thousands of dollars CAD software, rather there are wonderful CAD products like DesignSpark Mechanical (DSM). There are multiple video tutorials bringing you up to speed with CAD. For any DIY engineer, CAD is simply indispensable. All designs described in this book are accompanied by DSM files.

Data Logger

We will be evaluating the performance of our solar and wind setups in terms of voltage and current output. Also, we will monitor the amount of solar light as a function of time in our specific location. Moderately sophisticated charge controllers will provide data logging, some of which will even allow online monitoring. Nevertheless, monitoring the wind turbine performance or measuring the amount of solar energy requires a separate data logger. There are professional expensive data loggers providing several channels for voltage and current logging. Here we suggest a cheaper and more creative solution based on Raspberry Pi single board computer (https://www.raspberrypi.com/). Specifically, we used Raspberry Pi Zero 2W, which is a very small single board computer with Wi-Fi. Further in the book we provided details about setting up and deploying the data logger. Before that, learn some basics of Linux!

Tools

One wise man's words: "with appropriate tools one could achieve virtually anything". We highly recommend investing in a set of tools. There is nothing more frustrating than working with inadequate equipment. Please, do not attempt assembling a project holding parts in the air or with your feet! Get yourself a drill press, hand drill with a hammer mode, impact driver, a set of "number" drill bits, tap, die, jigsaw, angle grinder, belt grinder and a circular saw. All of these can be purchased over time from a home improvement stores relatively inexpensively.

Suppliers and Supplies

Home improvement stores like Home Depot, Lowe's (USA) or Bauhaus (Germany) are filled with great items like pipes, fasteners, metal angles, sheets and rods, conduits, wires as well as tools and consumables. Besides the usual online shopping, *e.g.*, Amazon, also consider industrial suppliers such as McMaster-Carr, Grainger, Online Metals (ThyssenKrupp AG). These suppliers have an incredible assortment of fasteners, wires, raw materials, chemicals, and tools. For the electronic components, consider Digi-Key, Mouser and Conrad Elektronik.

References

There is a very useful "Pocket Reference" book (1) that provides invaluable information on fasteners and corresponding hole sizes, ampacity of wires, material properties, etc. It is best to avoid the choice of materials and fasteners based on feelings, rather than on

well-established standards. These standards came about through trial and error, and in this case the re-invention of the wheel is not helpful. After all, inadequate fasteners may corrode or be not strong enough resulting in a collapse of your solar or wind energy setup.

Book Organization

The fist chapter of the book proposes two DIY instruments, which we will use while building our renewable energy system. These instruments perhaps may be replaced with the off-the shelf analogs, however building, and using our own may enrich the whole experience. The following chapter is devoted to photovoltaics, from theory to the actual garage "power plant". The fourth chapter deals with wind energy and a small wind turbine, which can be placed on the roof or deck. Another chapter describes curious power sources and suggests building a microbial cell battery based on rabbit manure. The manure battery is quite weak, however playing around with such power sources may be inspirational for curious researchers. The last chapter discusses technical aspects of wiring and battery recovery.

Abbreviations

ABS – acrylonitrile butadiene styrene
Ah – ampère-hour (capacity)
ADC – analog to digital converter
AM – air mass coefficient
FET – field effect transistor
JAE – Japan Aviation Electronics
I – current
MPP – maximum power point
PV – photovoltaic
RPM – revolutions per minute
SMPSU – switch mode power supply unit
V – voltage

Chapter 1 • Helpful DIY Instruments

Pi-logger

A data logger can be very helpful to investigate the performance of our power plant, whether it is a microbial power source, solar panels, or a wind turbine. Specifically, the data logger is used for measuring the amount of solar radiation (*i.e.*, insolation) by a pyranometer, as discussed in the photovoltaics chapter. Also, the wind turbine presented in the following chapter can be optimized based on the measurements obtained by the logger. There are many professional data loggers available on the market, which are capable of measuring voltage and current across several channels. These solutions are quite expensive and do not seem to offer a "1-wire" interface, which is used for temperature measurements among other things. Here we propose a data logger, the "Pi-logger" based on Raspberry Pi Zero 2W single board computer, featuring Wi-Fi as well as several analog and digital inputs. The schematic of the Pi-logger along with actual implementation is shown in Figure 1.

The Pi-logger runs Linux operating system (OS). Raspberry Pi web pages provide step by step instructions about the installation and configuration of the OS. Briefly, a microSD card must be loaded with a bootable Linux ISO image using the Rufus software. There is also a Raspberry Pi imager software that serves the same purpose. The Linux image may be obtained from the Ubuntu or Raspberry Pi web sites. Choose the Linux installation without the desktop because the Pi-logger works with text-based interface, while graphics pose unnecessary complications. During the installation, it is important to have the keyboard and monitor connected to see the progress, to create an admin account and provide Wi-Fi settings. After the installation, the Raspberry Pi will be used "headless", *i.e., only using the terminal software over the network. To make the system up to date, run*

```
sudo apt update
sudo full-upgrade
```