Solar Panels

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June 2017

2017: Fold-Out Portable USB (5 volt) Panels

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With the advent of the highly portable, relatively inexpensive, Asus Transformer Book (T100HA) and similar notebook computers (see Notebook Section), we suddenly have a host of fold-out portable panel solutions that back-packer and outdoor camping types like to use to re-charge their tablets and mobile phones. As we will see that not all panels are made alike and worse one must carefully match the panel with the device or devices you wish to charge, if you want optimum performance. But this section is an attempt to share the research we have already done in the field.... so you don't have to.

The best tested panel in the lab to date has been the relatively inexpensive 20 watt fold-out panel by X-Dragon. It is superior to many in that it has great low-light performance, and it doesn't seem to suffer from any kind of "return to maximum" charge problems, as found with some other panels when clouds come and go. This phenomina is not fully understood, but some products "down-shift" when the incident sunlight falls momentarily and then power to the device **fails to return to maximum output later**. This means your device might continue to recharge still... but at a **much slower rate** than expected. You might be disappointed at the end of the day, to find your phone or tablet or transformer book, not fully recharged.

USB Ports are *Not* all the Same:

You might be thinking. Yes, I know all about USB v2.0 has maximum output capability of 1.1 amps and the new USB 3.0 spec can be up to 2.4 amps, but life is never so easy really. There is a new specification out called the **USB Power Distribution** spec and it outlines the various modes that allows for USB charging all the way to 100 watts! That's enough to cause fires, shock hands, and burn up devices if improperly wired, but that's progress. But the striking news is that the new PD spec is not just for USB 3.0 devices but **can be applied to new USB 2.0 devices**. That's exactly what we see with the Asus T100HA model (see Notebook section) where the standard tiny power brick (the module you plug into the wall socket) can up-shift to the next highest charge rate of 9 volts out, and 2 amps. So it might look like a standard micro-usb port on that box, but it's not really. That's why recharging (so far) is faster using the AC power brick, in comparison to using these fold out USB solar panels (at 5 volts)... but maybe someday we will find such a panel that accomodates some of the USB PD charging modes. We are still searching.

Also specified is a data communication protocol for power transfer between the source and target devices.

For more on this **PD topic** see here: USB Power Distribution Specification

USB PD rev. 2 source power rules[102]

Source output power (W)	Current, at: (A)			
	+5 V	+9 V	+15 V	+20 V
0.5–15	0.1–3.0	No	No	No
15–27	3.0 (15 W)	1.7–3.0		
27–45		3.0 (27 W)	1.8–3.0	
45–60			3.0 (45 W)	2.25–3.0
60–100				3.0–5.0

But for the purposes of our work on the field, any combination that allows for two hours of use on the device, and requires a one hour recharge rate, is considered acceptable. This is the unofficial "2 for 1" rule and is the situation we now have with the Asus Transformer Books and the X-Dragon (and other) type panels. For today, this panel at least, is highly recommended.

Amazon: X-Dragon 20 Watt fold-out panel US$ 50 (Tested)
Amazon: Sokoo 22 Watt US$ 50 (Consider)
Amazon: Anker 20 Watt US$ 60 (Consider)

Typical of these panels, the X-Dragon comes with three solar sections under a clear transparent window and water-tight PET nylon cloth-like coverings. The sealed electronics and connectors are hidden behind one panel flap and as such would protect the ports and cable connections from rain. There is even a pocket back there to protect small devices such as a phone, or USB power bank (a battery storage device), but for larger tablets and transformer books, one should just place underneath the entire panel assembly. These panels claim to be water-proof, but I would consider them water-resistant. You don't really want to throw these into a lake and fish them out and expect them to work immediately after that.

How about the 15 watt variants of these panels by the same manufacturers? Not recommended. If you live in sub-Sahara Africa where the sun shines almost every day of the year, with blue sky weather, then you might consider even a 10 watt panel... but for the rest of us, you want a panel that simply works during the early dawn hours of the day, or very late afternoon sun, or when it's heavy overcast. In PNG one could have heavy overcast for an entire week. You want a panel that simply "always works" especially if the user is less tech savvy, but well trained in the Bible Translation and Language Develiopment tasks. You want something simple for when there is no advisor around to work out any problems.

The Power Bank Option

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The “Direct Connect” solar approach does have at least one caveat as represented by the Asus Transformer Book (see Notebooks section). Recharging procedures change somewhat. The Asus Transformer Book style notebooks can run easily around 12 hours, but the average work-day is designed to be 8 hours only. This means that daily there should be a recharge during the daylight hours, and preferably between 10:00 a.m. and 2:00 p.m. So far, the fold-out style panels only supply about 1.1 Amps and therefore a fast recharge is not possible. Nonetheless a good rule of thumb is about 2 hours of work, for 1 hour of recharge (even in overcast conditions). So to sustain 8 hours of work, expect a 4 hour recharge period using these panels.

However, a good **option** to consider is an auxiliary USB “power bank"; a small Li-Ion rechargeable battery pack with USB ports. With the extra investment of a power bank unit, the user can now leisurely connect solar panel to small power bank and recharge anytime in the day, while working on the computer anytime day or night. The noon-time period is not wasted for work, if so desired. Then before sleeping at night (a period where no work is performed obviously) the user can easily recharge the Asus transformer book back to full charge for the next day. So, although “direct connect” is possible, it is probably a good idea to add the cost of a small power bank. It’s just a versatile setup, and remember that the longest USB cables only run about 2 meters in length anyway, so we are not in the original scenario of "solar panel on the roof, and 10 meters of cord down into the village office". USB cords do not run 10 meters.

For this scenario, we would recommend a power bank of twice the recommended energy storage of the Transformer Book, so for 30 Wh, then we want a 60 Wh power bank, more or less. So a quick check of amazon.com here: ($25-$30)

Amazon.com Anker PowerCore 10000 would be fine. Simple power indicator LEDs.

Amazon.com ToHLo 20000mAh unit is more precise with it's digital energy display.

Amazon.com RAVPower 16750mAh with higher current output.

We consider RAV of the quality of Anker unit which has bar power display, and the potential for a true 2 Amp recharge rate. It also has flashlight LED. But the Asus T100HA may not allow for a faster recharge and self-limit to 1.1 Amp anyway.

But we don't really need all the "bells and whistles here" If the user were simply going to sleep at night, closing the computer for the day, and then recharging the Asus while they slept.... the least expensive Power Bank would do the trick. **Fancy options like a flashlight just means that it's going to be borrowed, battery drained, and not returned right away by a neighbor.** Better to not tempt anyone with extra functional usability.

2016: You live in the Third-World? Where to Purchase for the "Big" panels.

This section is for the "time-challenged" workers among us, who are typically supporting others in a third-world context. These are the ones who say: "I don't care about the details... just tell me what to purchase and where to purchase." Obviously the recommendation we give here, will not be the only option and lots of excellent stores can be found on-line via Amazon.com and eBay.com. **But the problem, invariably is how to ship the parts and complete solar systems to where you are on the planet.**

Primary Recommendation: GTIS Powermon store: Home Page

Specifically for Solar Panels: GTIS Solar Panels

This can be your "one stop" shop, since they sell parts and complete kits specially designed to support computer systems in the field. The Purchasing and Shipping department is a certified DHL world-wide shipping agent, and therefore if DHL is available in your country, they can ship to you, directly by air freight. If you want to do surface transport (slower and less expensive) that is an option too. You simply have to declare "how" you want your parts shipped and by what method. So the major advantage here is that GTIS Powermon store is highly experienced in shipping parts anywhere in the world.

The least expensive solar panels, by watt are the **Solartec** line as seen here: GTIS PowerMon Store



These aluminum frame 15 watt panels are a steal at US$18 (SIL Discount) and are of a granularity that is perfect for various applications. You want to power a tablet? Fine, start with one Solartec 15 watt panel. You want to power all day and 4 hours into the night, a modern year 2016 Notebook? Fine, start with 2x the Solartec 15 watt panel. You want to power an old style notebook, say a 9 watt Lenovo x140e model? Fine, work with 3x Solartec 15 watt panels. You have a very old (2014) Dell 6420 model to power running at maybe 12 watts? Fine, you purchase 4x Solartec 15 watt panels (60 watts total). You won't do better, pricewise anywhere else, but you can substitute more flexible options that are handy (see next section) but are more expensive per watt.

The very handy, portable, lightweight, but more expensive **Bioenno Panel** is perfect for ease of transport, say in a major hiking situation and you are powering a 2016 "Bay Trail" notebook (see Notebook section).



This is built upon the latest thin-film technolgies and folds up nicely. You could purchase two of these for the near 60 watt scenario above. See: GTIS PowerMon Store

Note that in this picture is the handy, extremely light-weight, "Half-Pint" battery bank with controller, but please see the appropriate section for more details on that very useful LFP battey pack.

Different Solar Technologies

The maximum energy we could ever expect from average solar radiation to the ground (or insolation) would be around 1,000 Watts/m2 on the earth's surface perpendicular to the Sun's rays at sea level on a clear day. But of course that would be in the ideal since there are many other factors involved where one is located. Insolation from the words "incident solar radiation" is often expressed regionally on maps as kilowatt-hours per square meter per day (kW·h/(m2·day)).[1] Look for insolation maps for your region

which can be quite helpful for planning purposes. Obviously this has a bearing on photovoltaic (PV) or “solar” panels, but solar panels are never 100% efficient.



Monocrystalline technology. The highest efficiency ratings have been achieved on monocrystalline silicon cells (c-Si) which are normally expensive to produce since one must grow silicon crystals in cylindrical “boules” and sliced into thin wafers. Hence such panels made from such cells often have an array of circular cells mounted on a substrate. The highest recordedcommercial efficiency appears to be around 23%. Note that due to the extreme competition from the more modern technology, somehow, manufacturing costs continue to fall, and c-SI panels stay quite competitive in the marketplace, even in the year 2016.

Thin Film technologies can sometimes reach 18% and “multiple junctions” higher than that. Most of the commercial production of thin film solar is based upon another compound, CdTe with an efficiency of 11%. These are of interest today because of greatly reduced manufacturing costs, and you notice their rectangular nature when placed on a substrate of some kind, or perhaps mounted on a flexible roll. But "thin-film" can also be mounted under glass and placed on a substrate surround by a heavy aluminum frame, using the same manufacturing techniques for monocrystalline. The difference is easily spotted by the pattern of the cells presented to the sun. Because of the sealed glass and rigid aluminum frames, these panels can be as heavy as 12 kg or more.

The selected materials of thin film are all strong light absorbers and only need to be about 1 micron thick, so materials costs are significantly reduced. The most common materials are amorphous silicon (a-Si, still silicon, but in a different form), or the polycrystalline materials: cadmium telluride (CdTe) and copper indium (gallium) diselenide (CIS or CIGS).

Each of these three is amenable to large area deposition (on to substrates of about 1 meter dimensions) and hence high volume manufacturing. The thin film semiconductor layers are deposited on to either coated glass or stainless steel sheet.”[2]

Thin Film Flexible Technology

Originally (2010) we saw examples of thin-film technology by the One Laptop Per Child group (OLPC) and their flexible, lightweight 10 watt panels were produced by Gold Peak (GP) solar. They were sold to a captive audience and therefore the GP technology was not generally available for purchase. However, they produced these by the thousands and distributed all around the third-world.

However, today in 2016 there are other suppliers of flexible thin-film panels and available for easy shipment around the world. Consider the SunPower 100 watt: GTIS PowerMon Store flexible panel (SIL members: 20% discount). A 100 watt panel is more than sufficient for certain late model laptops (2014 and older) that were sold by Dell, Lenovo and Asus at the time.



In the past, we have managed to get a few custom GP 20 watt solar panels made for us, and shipped to Papua New Guinea for solar experiments. They proved to be great "low light" performers, yielding great results in overcast or early mornings. However, after years of service, sometimes a noticable sunlight etching or frosting occurred on the surface of these, that was easily restored to transparancy by a thin layer of spray-on clear laquer paint. We cannot say today what will happen to the newer SunPower technology shown at the left. It might do better.

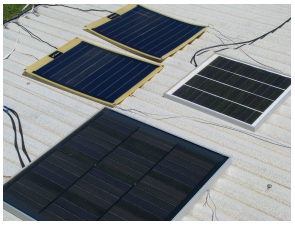
Wondrously light weight (1.8 kgs), these 100 watt panels are very easy to ship by small aircraft. They have grommet holes suitable for permanent mounts, but some users are considering raising and lowering these during the day via ropes to increase security from theft in the village context by night.

As we will see later, the SunPower panels come at the "perfect" size of **30 watts** as well, and are therefore smaller, lighter and less expensive. A perfect size for the new 2016 notebooks (5 watts or less) to power all day and in the rainy weather weeks. (See the "Notebooks" section.) The Powermon store sells these 30 watt panels as well: GTIS PowerMon Store

Note: Most modern panels want a standard MC4 connector type on the cable ends for easy modular attachment and interchangeable parts. MC4 parallel connectors are easily available for combining panels in parallel for more power. The older style MC3 connector is fine, but going away in most designs.

CIGS Solar Panels

Another promising technology are the new CIGS panels, or Copper Indium Gallium diSelenide technology. This is considered in the class of “poly-crystalline thin film”.



We have been experimenting with the Global Solar 30 watt panel model GSE-30 shown here.[3] The MPP (Maximum Power Point) appears to be 1.7 A at 17.5 volts, and the unit weighs 11 lbs. Dimensions 25 x 25 x 1.3 inches

This panel is relatively heavy, but ruggedly built and the active elements appear to be mounted behind glass, and within a solid aluminum frame. Designed specifically for “off grid” use, these panels are designed for high reliability in very rural applications. Just what we would want. The relative costs is always excellent, but the monocrystalline manufacturers always seem to meet the competion and also lower their prices accordingly. In short, purchase whatever is the proper size for your solar system in watts, and that you can ship affordabilty to your location. Look for suppliers with good long warranties behind their products, which means that at least at the time of manufacture, the company was planning to support their design for a long time. Don't expect to actually "cash in" on the warranty over 25 years. Many solar companies in business two years ago, are now defunct. Competition in this market is fierce.

We have found these CIGS panels to be excellent “low light” performers as well. For a given wattage, you may find that an old-style monocrystalline panel is actually smaller in size and weight.