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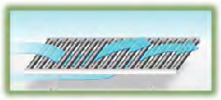
PV Modules

What You Need To Know In A Rapidly Developing Market



Presented by:
Jeff Spies
President SOLARSPIES
NABCEP Secretary

Webinar starts at 9AM Pacific (12 Noon Eastern)

Webinar Instructions

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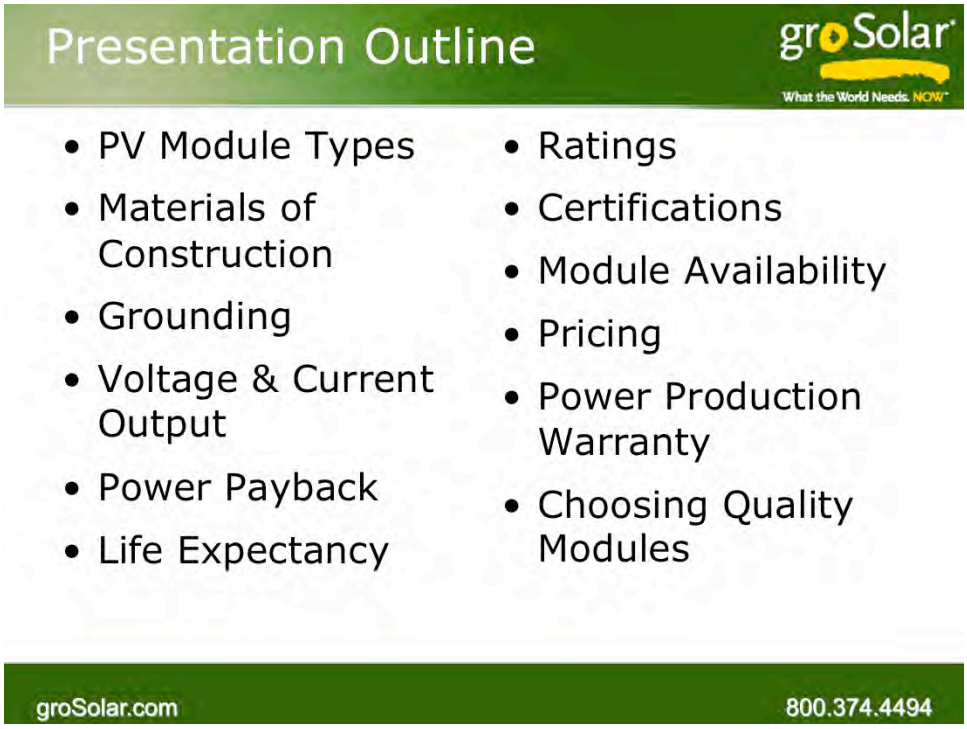
- **Audio options**
  - Telephone - Refer to email for phone number
  - Computer speakers or headset
  - Move close to router or use a wired connection
- **Q & A**
  - Chat - Type your question into chat window and host will read question to presenter
  - Questions addressed based upon time
- Download entire presentation with presenter notes at groSolar.com/training



Module Types

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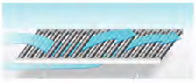
- Crystalline Silicon Modules

- Thin Film Modules

- Specialty Products



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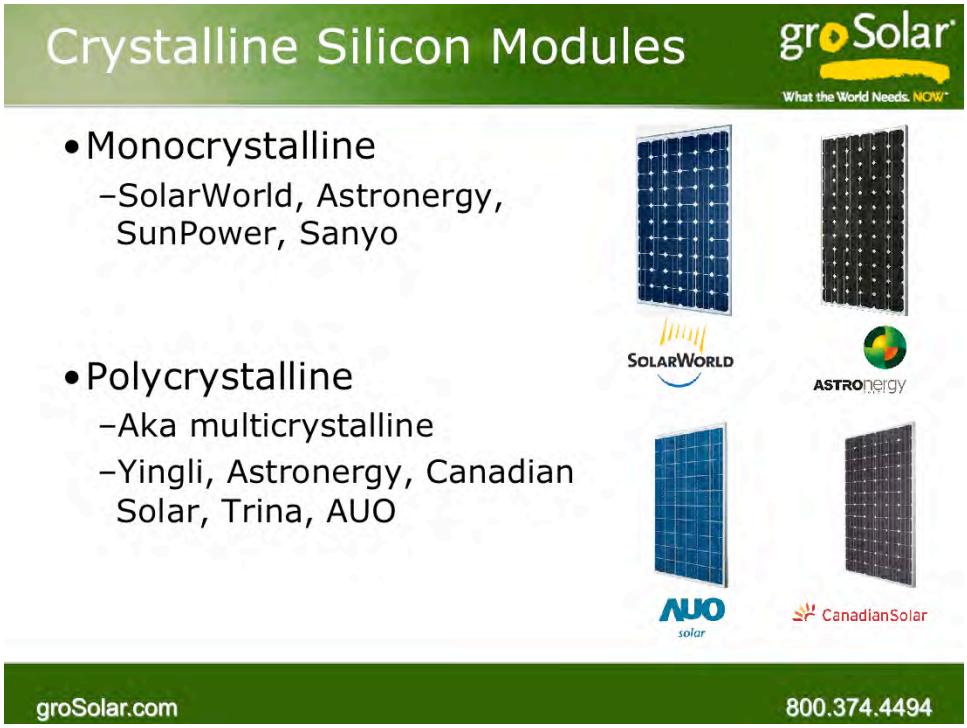


•**Monocrystalline** SolarWorld, (SunPower, Sanyo)

- •Highest efficiency
- •Less power loss in high temps
- •Back contact modules from SunPower result in high efficiency, but positive grounding is required

•**Polycrystalline** is slightly less efficient than mono, but difference is marginal

•**Price per watt** tends to be main deciding factor for most jobs.

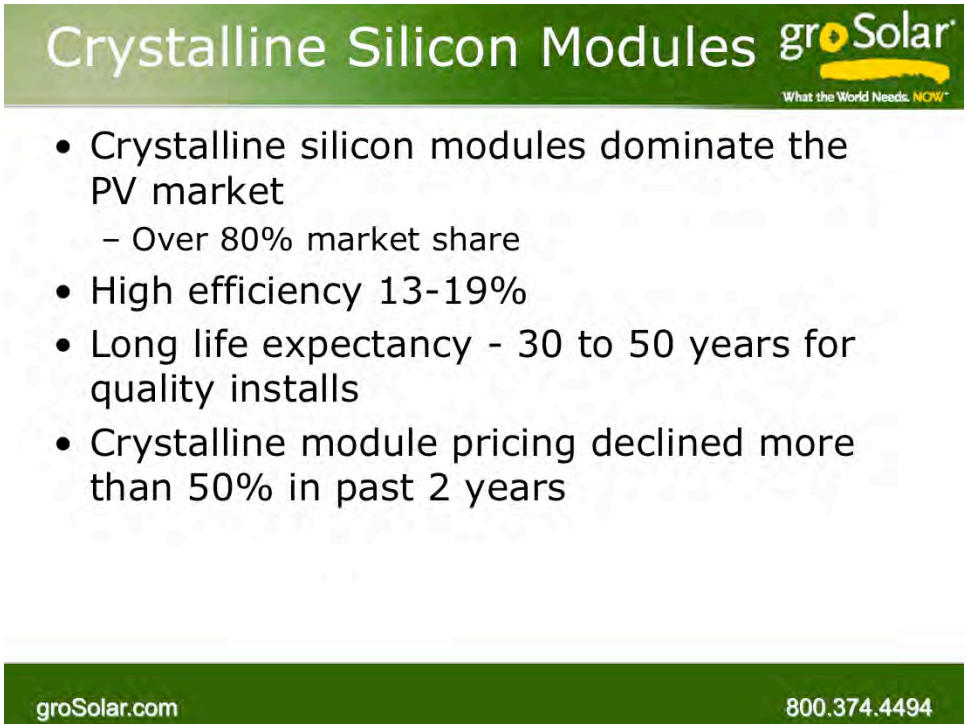
•Highest Efficiency is the SpectroLab Three-junction (2-terminal, monolithic) gallium arsenide cells

•Poly easier to ramp up production at plant

•Sanyo Hetero Junction Interface technology increases efficiency

•Sunpower back contacts makes for more area for PV exposure

•Stacking processes helps increase efficiency

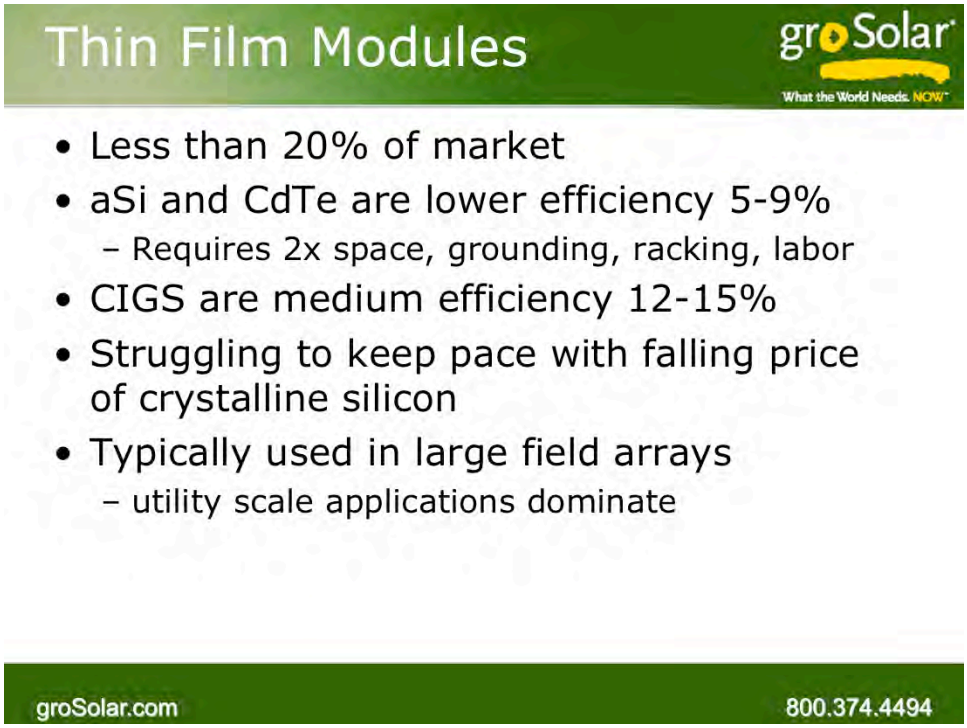


•30-50 years is the common life estimate assuming **quality modules, proper designed, proper installation**

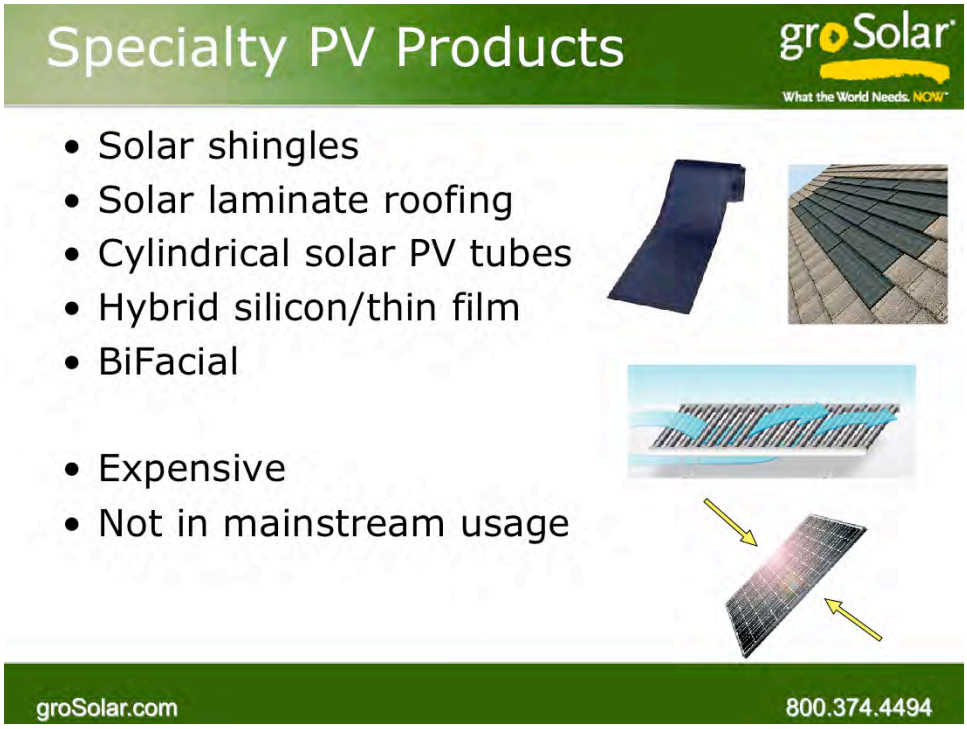
•**Market reports:**

- •**SolarBuzz** reports that 80% of the market is cSi and 20% is thin film
  - •http://www.solarbuzz.com/Technologies.htm
- •**Greentech Media** forecasts thin film to capture 28% market share by 2012
  - •http://www.greentechmedia.com/articles/read/the-future-of-thin-film-beyond-the-hype/
- •Price decline due to wafer thickness
- •Polysilicon is very expensive
- •Grams/watt has decreased to save cost
- •300 microns down to 150-200 microns
- •Kerf (saw cut thickness) has been minimized
- •Manufacturing efficiencies help reduce cost

- **Amorphous Silicon** - aSi
  - UniSolar, Astronergy, Dupont Apollo
- **CIGS** Copper Indium (Gallium) DiSelenide
  - Stion, Miasole, Solyndra, TSC
  - CIS modules are similar to CIGS modules but do not use Gallium
- **Cadmium Telluride** - CdTe
  - First Solar CdTe modules use cadmium which is a toxic heavy metal, necessitating recycling after 25 years
  - Cadmium and Tellurium may face supply shortages in coming years
  - Telluride is 5th rarest metal on earth
  - Indium may run out in 30 yrs



- **Thin film modules produce more kWh/kW** due to ability to harvest sunlight more hours of the day
- Thin film does **have good potential to lower installed costs** in the future
- Most thin film arrays must **cover twice the area** to give same power output compared to crystalline silicon array
    - Requires **twice the racking, install labor, and grounding hardware**
- **Lower efficiency products** include
    - Unisolar aSi modules
    - First Solar CdTe modules (First Solar dominates the thin film market)
- **Medium Efficiency 12 – 15% CIGS modules include**
    - Solyndra, Stion, Miasole
    - Cigs modules have only a small share of thin film market
- Thin Film allows more broad spectrum light absorption , so more production in cloudy weather or earlier and later in the day
    - Allows more some advantage in the cloudier areas



- **Solar Shingles**
  - Many module interconnects
  - Less power due to poor ventilation (5% for thin film materials is common)
  - 40-80% more expensive
  - Most solar shingle ventures have failed, but new ones are planned
  - Kyocera, UniSolar, & Open Energy have discontinued their solar shingle business
  - Dow introducing new solar shingle in 2011
  - Most require new construction and cannot match color of other shingles easily
- **Solar laminate roofing**
  - Metal roof application – new roof typically required
  - 20-30% more expensive than crystalline silicon
- **Cylindrical solar PV tubes**
  - Solyndra CIGS modules designed for flat white roof
  - 20-30% more expensive than crystalline silicon
- **Hybrid silicon/thin film modules**
  - Sanyo HIT modules use CIGS material on top of monocrystalline silicon cells for higher efficiency
- **BiFacial**
  - Sanyo PV cell front and rear of module to harvest reflected light

Materials of Construction

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- Cells
- Glass
- Encapsulant
- Backsheet
- Frames
- Electrical Connection

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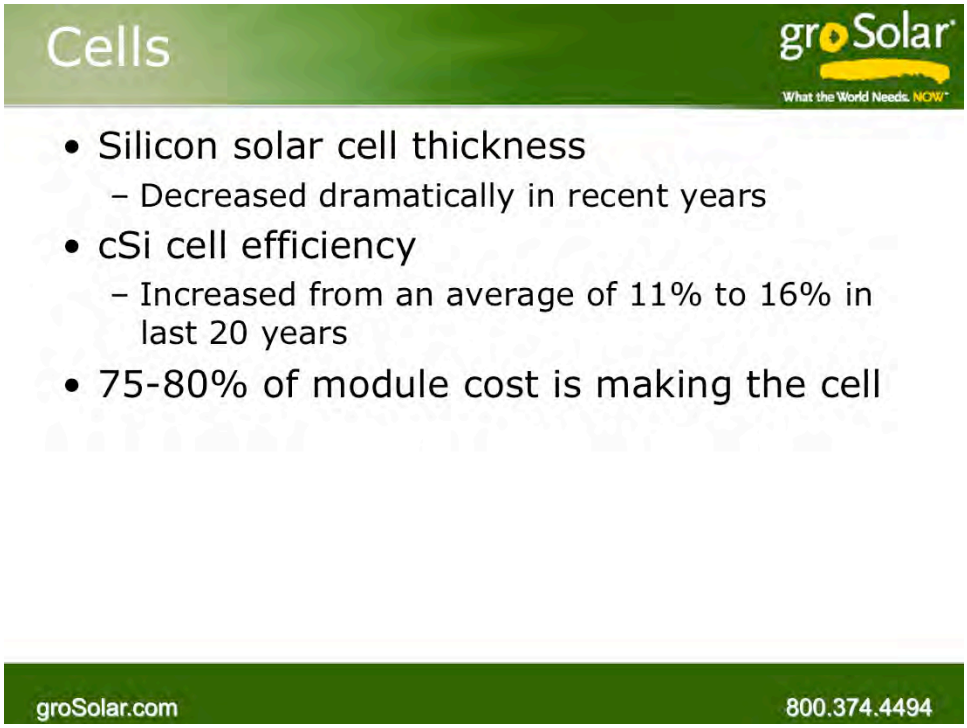
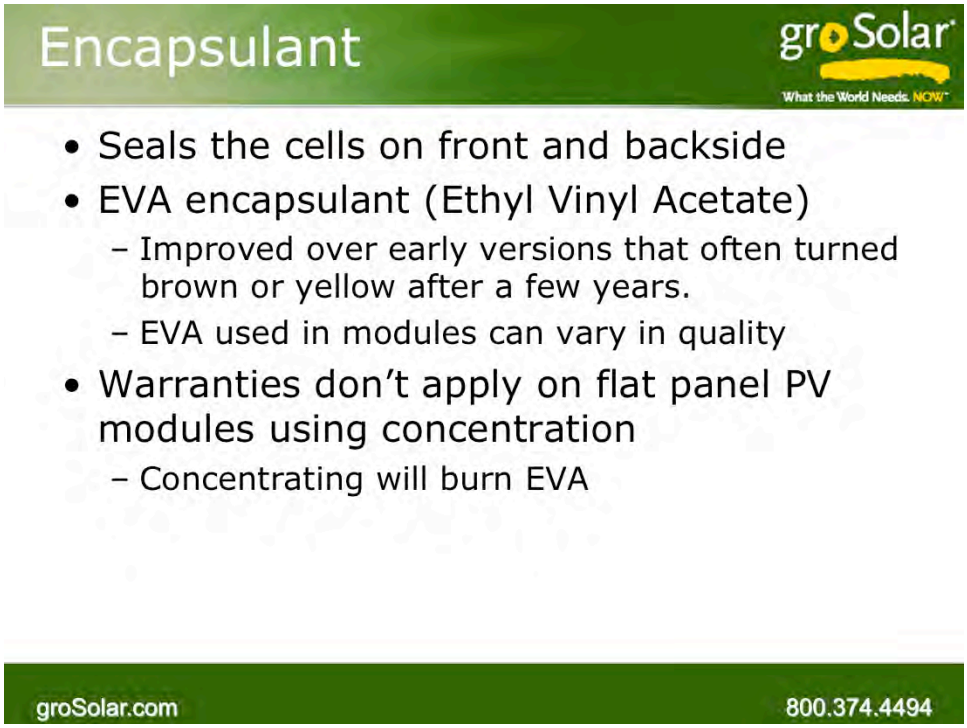


•In 1998 75 W panels were the norm

- •120W panels soon debuted due to improved efficiency
- •By 2010 module output was 200-250 watts due to larger modules and increases in efficiency

•Cells currently sell for $1.15 to $1.30/watt so they comprise the majority of the cost of a module

- **Tempered safety glass** used in most framed modules
- **Very low iron content** to minimize reflection
- **Anti reflective coating** applied or baked in
  - Directs light straight into the cell instead of at an angle
  - Some coatings have peeled off, but those problems were addressed effectively
- Thinner glass requires that you **DO NOT walk across the modules!**
- Modules must pass **hail damage resistance tests** - performed after wind tests
  - Severe Hail Damage Resistance Test
    - steel ball 45 mm, 358 g dropped from 5.4 m onto sample 10 times.
    - impact energy of 19 J
  - Moderate Hail Damage Resistance Test
    - test is performed after wind tests.
    - steel ball 51 mm, 737 g dropped from 1.5 m onto sample 10 times
    - impact energy of 10.8 J.
  - Conditions of acceptance
    - Voltage output of the PV module after simulated hail damage must be at least 95 percent of the module voltage output prior to testing.
    - PV module shall show no signs of cracking or splitting.



•**Solar concentration** uses lens, mirrors, or reflectors to shine more sunlight on a PV module

- •Concentrating systems **require tracking systems**

•Tracking systems have noticeably **higher initial and maintenance costs and tend to not be cost effective due to the dramatically lower prices for crystalline modules**

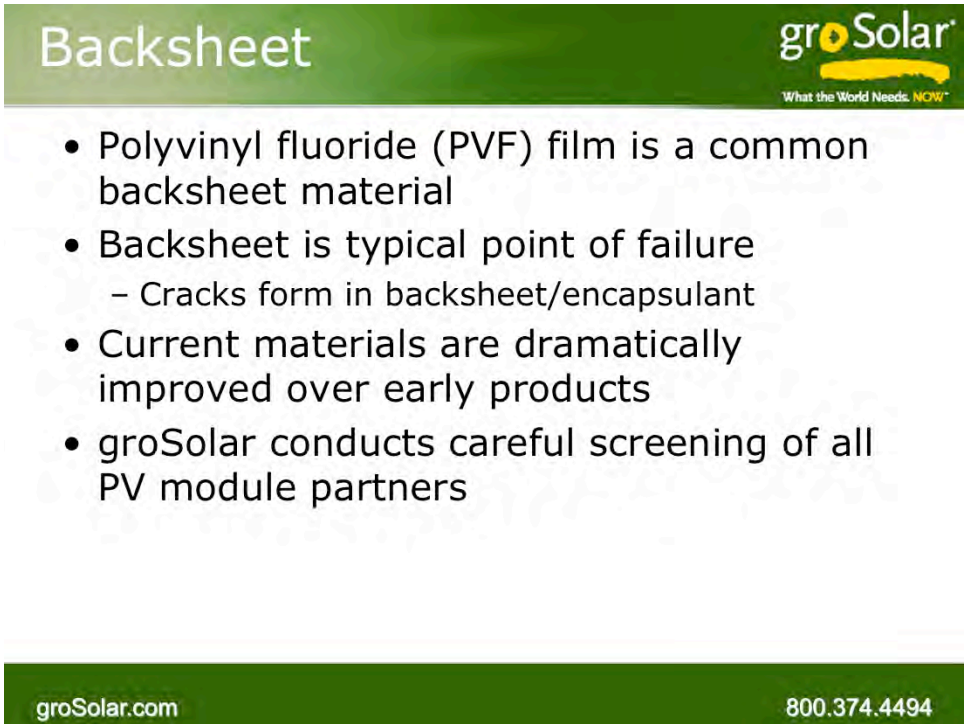
- •**Better cost strategy is to put up more modules in a static array**

•Sandwich is made from glass, EVA , cell, EVA , & backsheet

- •EVA melts to form clear hermetic transparent seal over front and back of cell

•EVA quality control is important

- •groSolar validates all module manufacturer EVA sources and certificates
- •Need to keep in climate controlled areas
- •Sealed in good bag
- •Use within 24 hours of opening bag
- •Those that don't follow this protocol do not get recommended



•**Dupont Tedlar® polyvinyl fluoride (PVF)** film is the most popular backsheet material

•Polyester backsheet used in some backsheets (shinier)

•Cracks in backsheet and encapsulant allow incursion of **moisture eventually leading to corrosion of electrical pathways** and ultimately failure of module

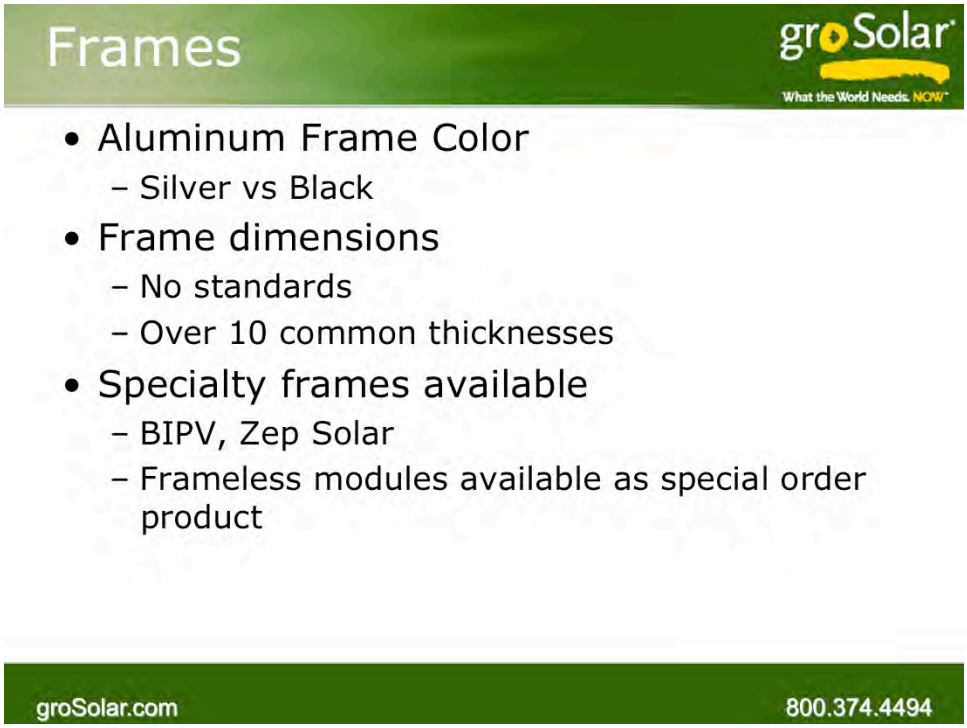
•Care must be taken to not damage backsheet

•Damage can easily occur when using screwdriver or sharp tools

•Current backsheet materials are dramatically improved in past decade **allowing longer life than modules made 30 years ago**

•**groSolar conducts careful screening** of all PV module partners to verify use of top quality backsheet materials

•Backsheet materials must be carefully handled at module manufacturing plant similar to EVA (see previous page)



•**Frame color -** silver frames are the norm

- •Black frames are becoming more available
- •Black frames are susceptible to scratches

•**Frame dimensions -** no standards Over 10 common frame thicknesses **requires careful racking clamp selection**

•**Frameless modules** – common in larger scale thin film installation

- •Glued to mounting rack or clipped to rack
- •Sometimes used in utility scale solar arrays

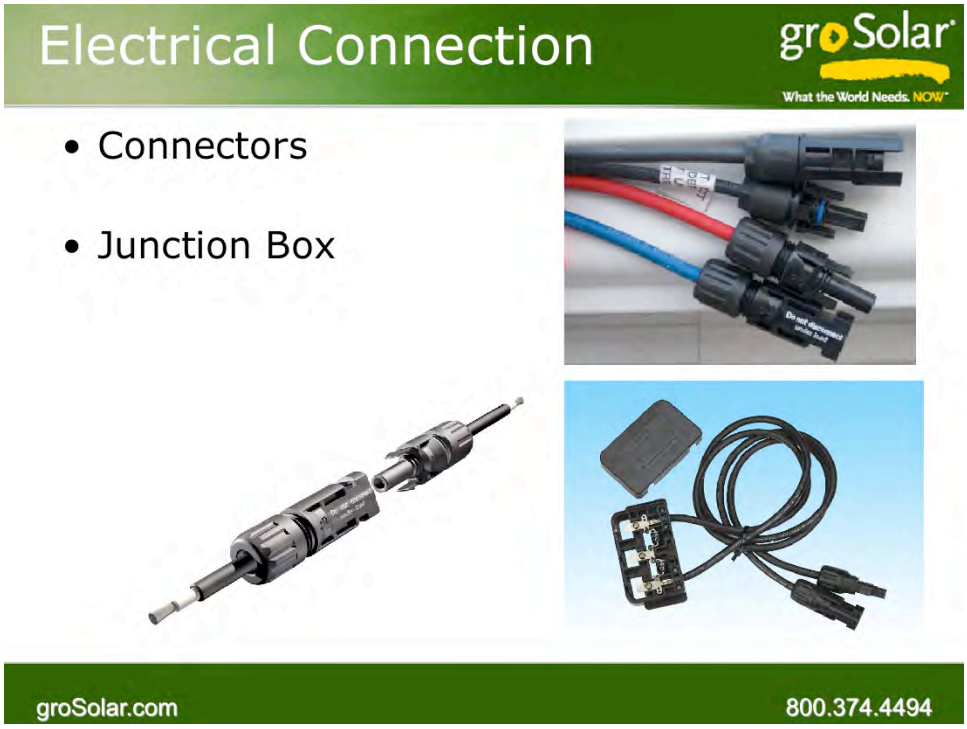
•**Fiberglass** frames coming to the market soon

- •Grounding of these modules is thought to be less problematic, but manufacturers still validating grounding and structural issues of arrays that would use fiberglass frames.

•Frame costs $.05 - .10 per watt

•Under heavy loads glass can bows up to 2” (high winds or snow load)

- •Backsheet can rub on rails
- •Frame needed to keep glass as stiff as possible and limit the flexing of the glass



- **Connectors**
  - Tyco and MC dominate
  - New players on the horizon
- **Junction Box**
  - Serviceable J-Boxes are now uncommon
  - Must take care to not damage cabling within 12 inches of J-Box
  - Modifying the cables voids the Listing
  - J box silicone sealed to backsheet
  - Must be firmly secured in flexible fashion to accommodate for temperature flexing
  - Make sure you have proper adapter and connector
  - Pull test performed on wires to ensure robust connection

Crimp Tools

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- Solar cableset crimping tools available from MC, Tyco, & Rennsteig
  - Rennsteig tool comes with interchangeable dies to make all common cable connectors
- Carrying a variety of pre-made wires can be an effective strategy

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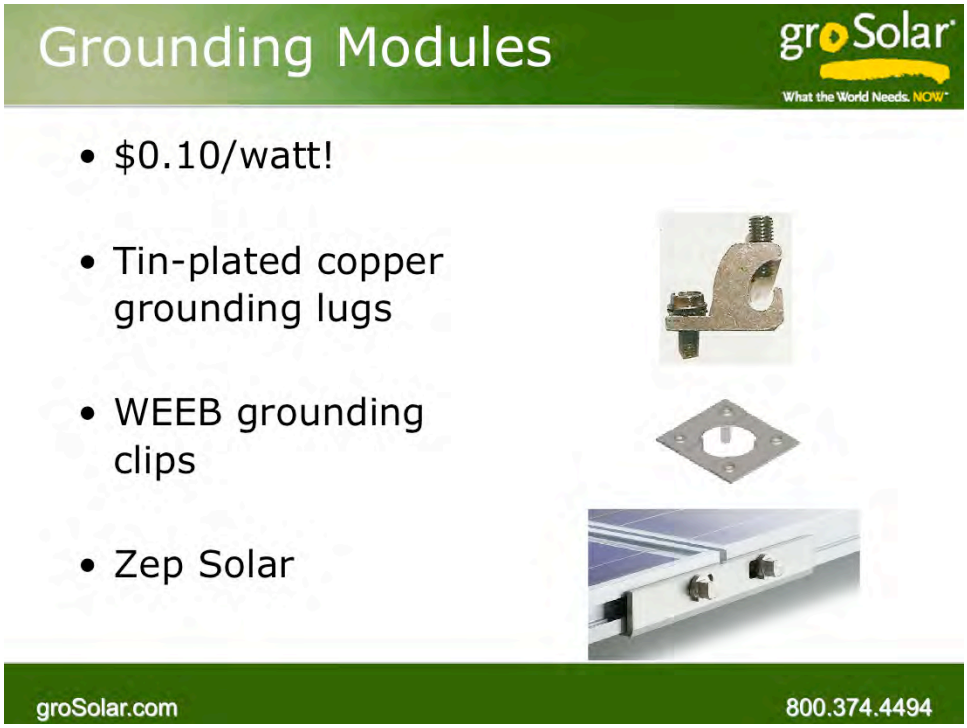
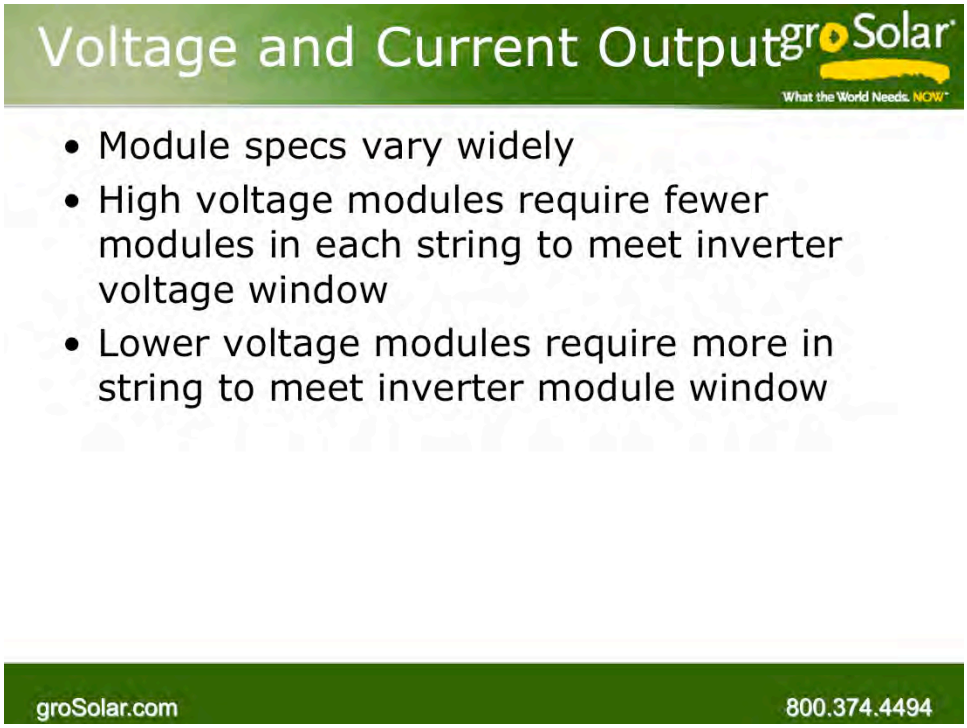
•Making your own cable sets may not be the best cost strategy

- •Can be expensive and problematic if the crimping operation is not performed precisely
- •Incorrectly crimped connectors can pose an undesirable liability issue for the installer

•groSolar recommends purchasing varying lengths of cable sets and making your own cables only if you don't have the proper cables or adapters to finish a job.



- **Tin-plated copper grounding lugs**
  - Industry standard method to ground aluminum frame to mounting rack
  - $.05/watt hardware cost and $.05/watt labor cost
- **WEEB grounding clips**
  - Simplify grounding & reduces installation time/cost
  - Documentation available at http://www.we-llc.com/index.html
  - Check with local inspector for approval before design
  - May not be approved to UL 1703
    - Grounding officially manufacturer recommended grounding process is may not include weeb clips
    - Getting UL 1703 listing requires expensive testing and many module mfg'rs opt to not incur this expensive
- **Zep Solar**
  - Integrates rugged grounding system into mounting rack for cost effective grounding
  - Currently available on Canadian Solar modules
  - Expect 3-4 other modules manufacturers to offer ZEP mounting system in 2011

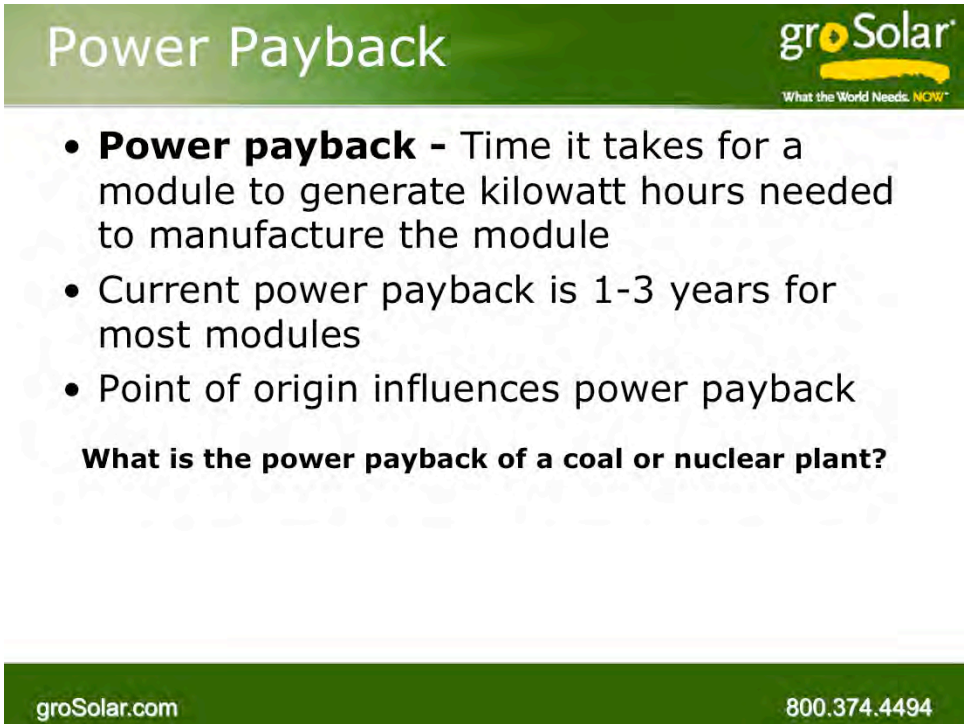


•**High voltage modules** require fewer modules to meet inverter voltage window

- •Wiring challenges (more strings, more fuses)
- •Most do not work with micro inverters
  - •Especially true with many thin film & some specialty crystalline modules

•**Lower voltage modules** require more in string to meet inverter module window

- •Might limit application in smaller arrays
- •More watts on a single pair of wires can reduce wiring costs



•**Power payback -** The time it takes for a module to generate the kilowatt hours required to manufacture the module

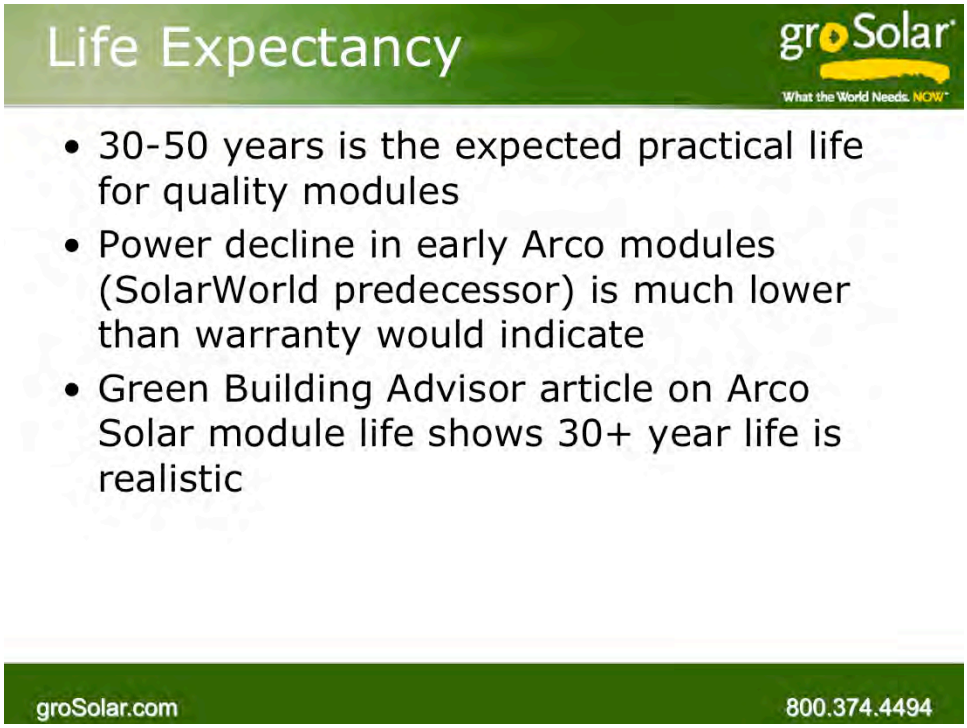
•**2005 NREL reports showed power payback** between 1-4 years http://www.nrel.gov/docs/fy99osti/24619.pdf

- •Current estimates are now 1-3 years due to higher energy efficiency cell manufacturing
- •Silicon module mfg process now more efficient

•**Point of origin influences power payback**

- •Some module manufacturers use hydropower to make modules improving carbon impact like SolarWorld

•Thin Film modules have less power per watt to make the modules



- **Article on Arco Solar module life shows 30+ year life** is realistic
  - http://www.greenbuildingadvisor.com/blogs/dept/musings/testing-thirty-year-old-photovoltaic-module

- Some manufacturers now extending the power production warranty to represent real world power production findings (Suntech 35 module power production warrantee)

Life Expectancy

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- Backsheet/Encapsulant is the normal point of failure
  - Encapsulant and glass cracks make a module slowly fail
- Power decline affected by environment
- Initial power decline can be steep for some modules
  - Light Induced Degradation up to 3% within a few days of light exposure

Ratings of Modules STC vs PTC

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- STC Standard Test Conditions
  - AKA "nameplate rating"
- PTC Performance Test Conditions
  - Slightly less than STC
  - Intended to represent real world performance, but does not
  - PTC ratings take into account everything including loss from wires, etc…
  - Does not account for rating tolerance

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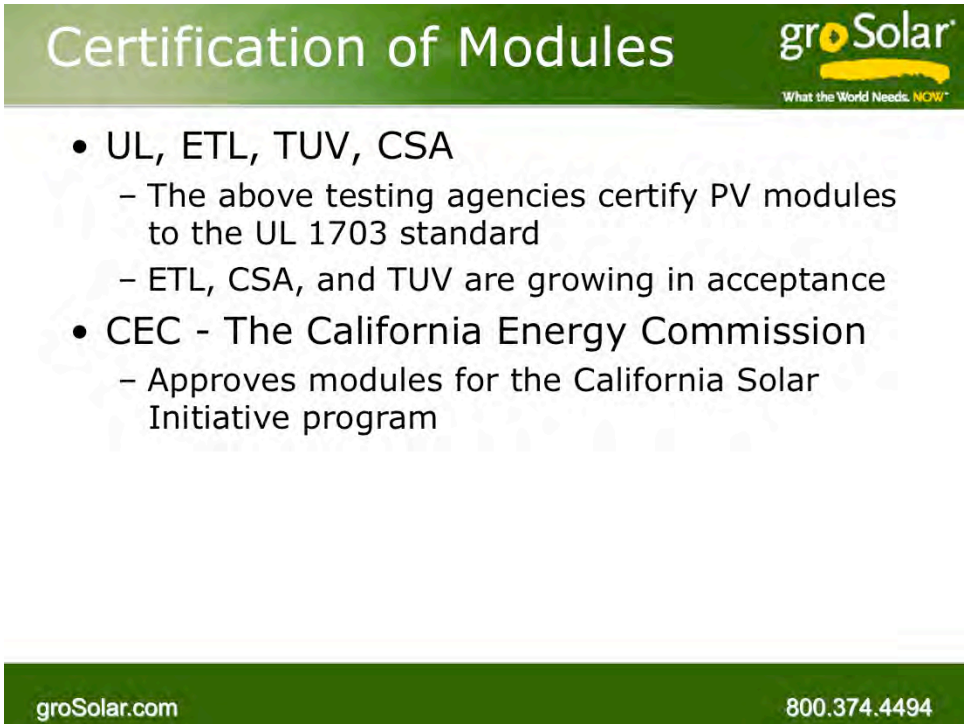
•**200-watt STC** rated module may produce **180 Watts using PTC** conditions



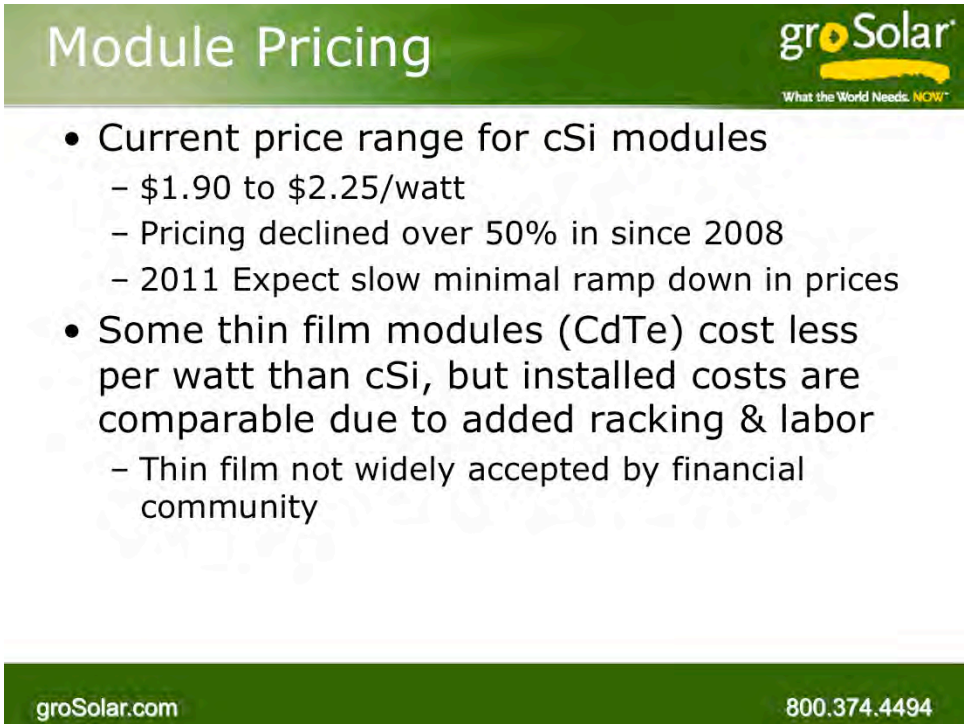
•**UL 1703 is industry standard** for electrical safety

•ETL, CSA, and TUV are growing in acceptance **but not as universally accepted as UL testing**

•Many **state and local incentive programs use the CEC approved module list** for their program

•It is not legal in almost all municipalities to install modules that meet UL 1703.

•Using C modules in a residential or commercial installation can open up a huge liability concern for the designer/installer company



•**Will price decline keep pace with incentive declines?**

•Some thin film **(CdTe) pricing is 25-40% lower** than crystalline silicon modules

•**Thin film modules require extra** space, racking, labor, and grounding make installed cost comparable for smaller arrays

•Italy is now increasing dramatically in PV consumption and taking the lead over Germany in PV Module consumption

Module Availability

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- US module availability fluctuates month to month
- European market has major influence on US availability
  - US is tip of the tail, can't wag the dog
- Consult your groSolar sales manager to determine PV modules with the best availability when you expect the job to be approved

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•**Huge incoming module allocation** for groSolar modules

•World market

- •13.5-16 GW forecast in 2010
- •17-23 GW

•US market

- •1.2 -1.5 GW in 2010
- •2-3 GW in 2011

Quoting Modules for Projects

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- Sell watts not module manufacturer
  - Quote system without listing module manufacturer
  - Allows for use of modules with best availability when the project is approved
- Incentive programs often require specifying module at time of incentive application
  - Understand process to change out modules after approval

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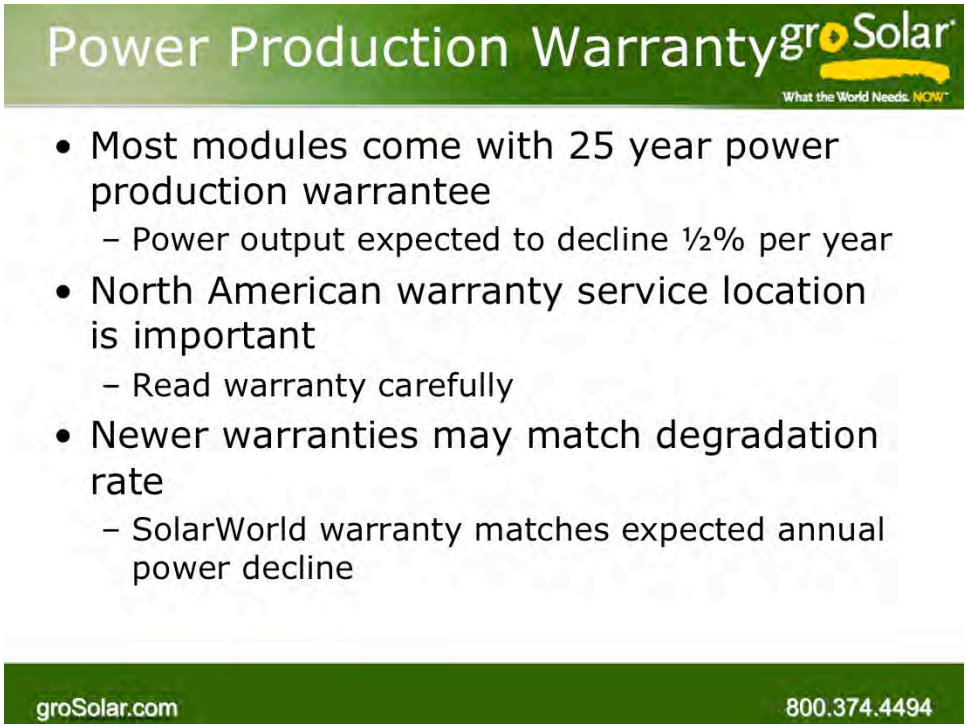
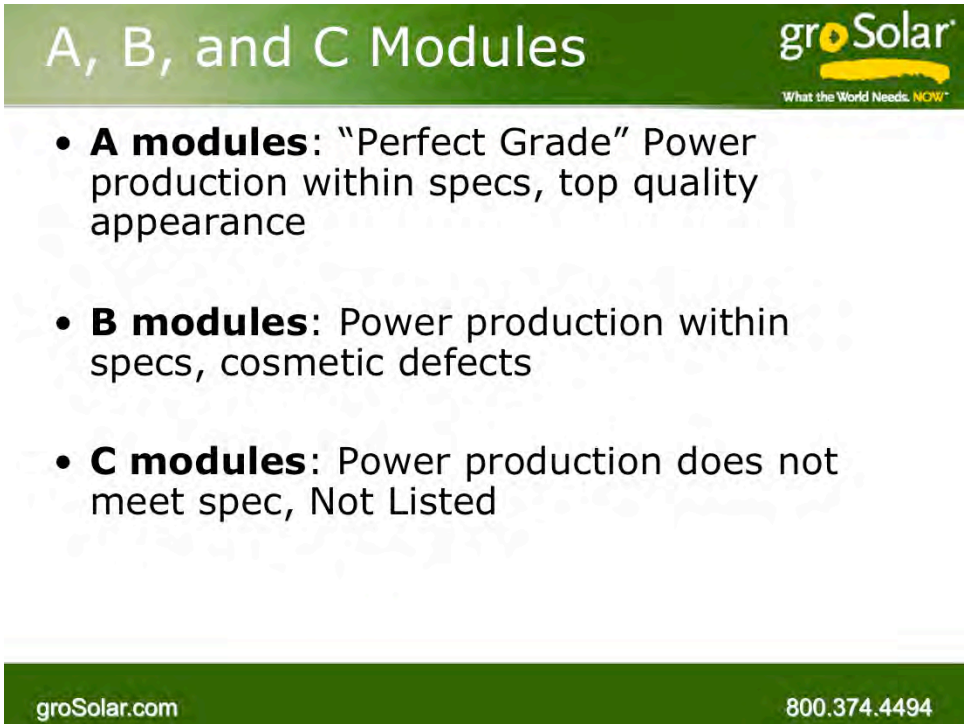


•**Read warranty carefully** and be aware if service facility is overseas

•**Out of country service locations can make warranty repairs inconvenient and very expensive** if shipping costs are not covered

•Many module manufacturers have had problems - the **good manufacturers stand behind their product and repair or replace it**.



- **A modules**: Power production within specs, top quality appearance
- **B modules**: Power production within specs, cosmetic defects
  - Limited availability
  - Make too many ➔ go out of business
  - B modules can be a "best buy" if cosmetic appearance is not important
- **C modules**: Power production does not meet spec, Not Listed
  - Power production warranty does not apply
  - Dealer has liability for selling non-Listed product
  - C modules are typically only advisable for off-shore off-grid
  - Modules advertised for very low prices on the internet are often C modules

Choosing Quality Modules

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- There are hundreds of module manufacturing companies worldwide
  - Look for module manufacturers with financial backing & stable history or warranties that are backed by large 3rd party insurance companies
- Tier-one products are the best bet for long life and warranty backing
  - We visit plants to assure Tier One status

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•**Major industry consolidation** anticipated

•Choose manufacturers that will be **around longer than your warranty**

"gro" your solar business with groSolar

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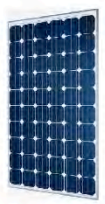
- Quality products you can trust
- Large inventory in Maryland & California
- Excellent customer service

We call our customers back!



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Satcon

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enphase ENERGY

solaredge architects of energy

Schletter

UNIRAC

AET Rayport Racking

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Quick Mount PV