Solar Photovoltaic (PV) Design Considerations & Issues

By Paul M. Williams, President & CEO

NEC – Article 690
Solar Photovoltaic (PV) Systems

The article consists of eight chapters.
Chapters 2 through 4 most applicable
for solar array design

Article 690-Solar Photovoltaic Systems

I. General
II. **Circuit Requirements**
III. **Disconnecting Means**
IV. **Wiring Methods**
V. **Grounding**
VI. Marking
VII. Connection to Other Sources
VIII. Storage Batteries Systems Over 600 Volts

Article 690-Solar Photovoltaic Systems

II. Circuit Requirements

Voltage Correction Factor for Crystalline and Multi-crystalline Silicon Modules. Must correct for manufacturer's rated Voc (open-circuit voltage) for ambient temperature.

Article 690-Solar Photovoltaic Systems

II. Circuit Requirements

Circuit Sizing and Current– The maximum current shall be the sum of parallel module rated short-circuit currents multiplied by 125 percent. This 125 percent requirement is in addition to the 125 percent factor required by 690.8(B).

Article 690-Solar Photovoltaic Systems

III. Disconnecting Means

- Fused DC disconnects
- Visible load break of Positive and Negative at combiner box
- AC Disconnect at Interconnection

Solar PV projects may be complicated

Other trades may be necessary….

Structural – roof load

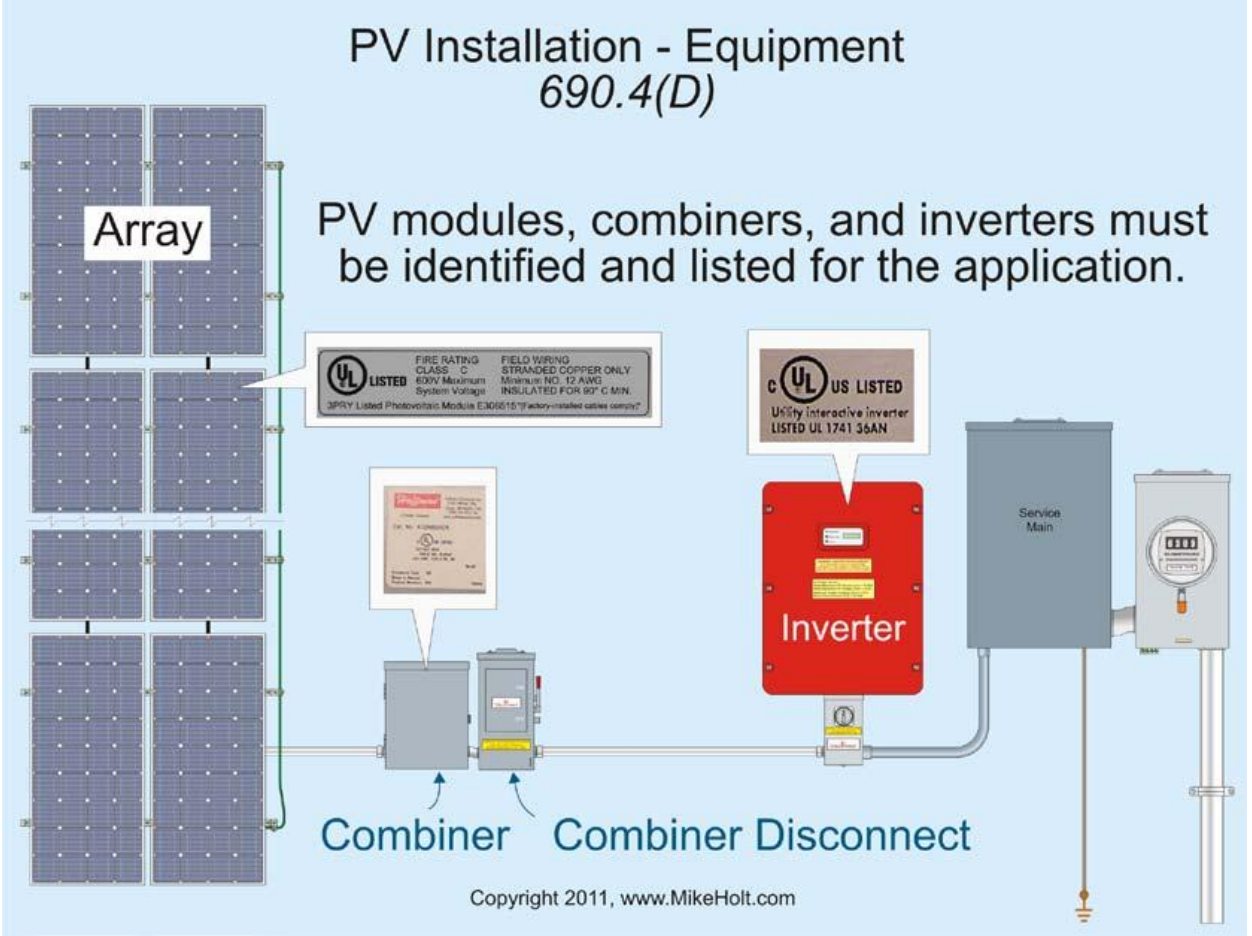
Mechanical – connections

Civil – ground mounted arrays

Architectural – aesthetics & design

Security – valuable assets

IT – Web monitoring, Data Acquisition System



Reference: http://www.mikeholt.com/instructor2/img/product/pdf/11SOLDVDQ100-1099-sample.pdf

Solar PV Basics

Solar PV Basics – DC to AC Derate factors

Component Derate Factors	Component Derate Values	Range of Acceptable Values
PV module nameplate DC rating	0.95	0.80 - 1.05
Inverter and Transformer	0.92	0.88 - 0.98
Mismatch	0.98	0.97 - 0.995
Diodes and connections	0.995	0.99 - 0.997
DC wiring	0.98	0.97 - 0.99
AC wiring	0.99	0.98 - 0.993
Soiling	0.95	0.30 - 0.995
System availability	0.98	0.00 - 0.995
Shading	1	0.00 - 1.00
Sun-tracking	1	0.95 - 1.00
Age	1	0.70 - 1.00
Overall DC to AC derate factor	**0.769**	

Solar PV Basics

- Solar module or panels
- Mounting – rail or racking
  I. Roof mounted
  II. Ground mounted
  III. Fixed tilt or tracking
- Strings – panels connected in series
- Combiner Box(CB) – strings connected in parallel

Solar PV Basics

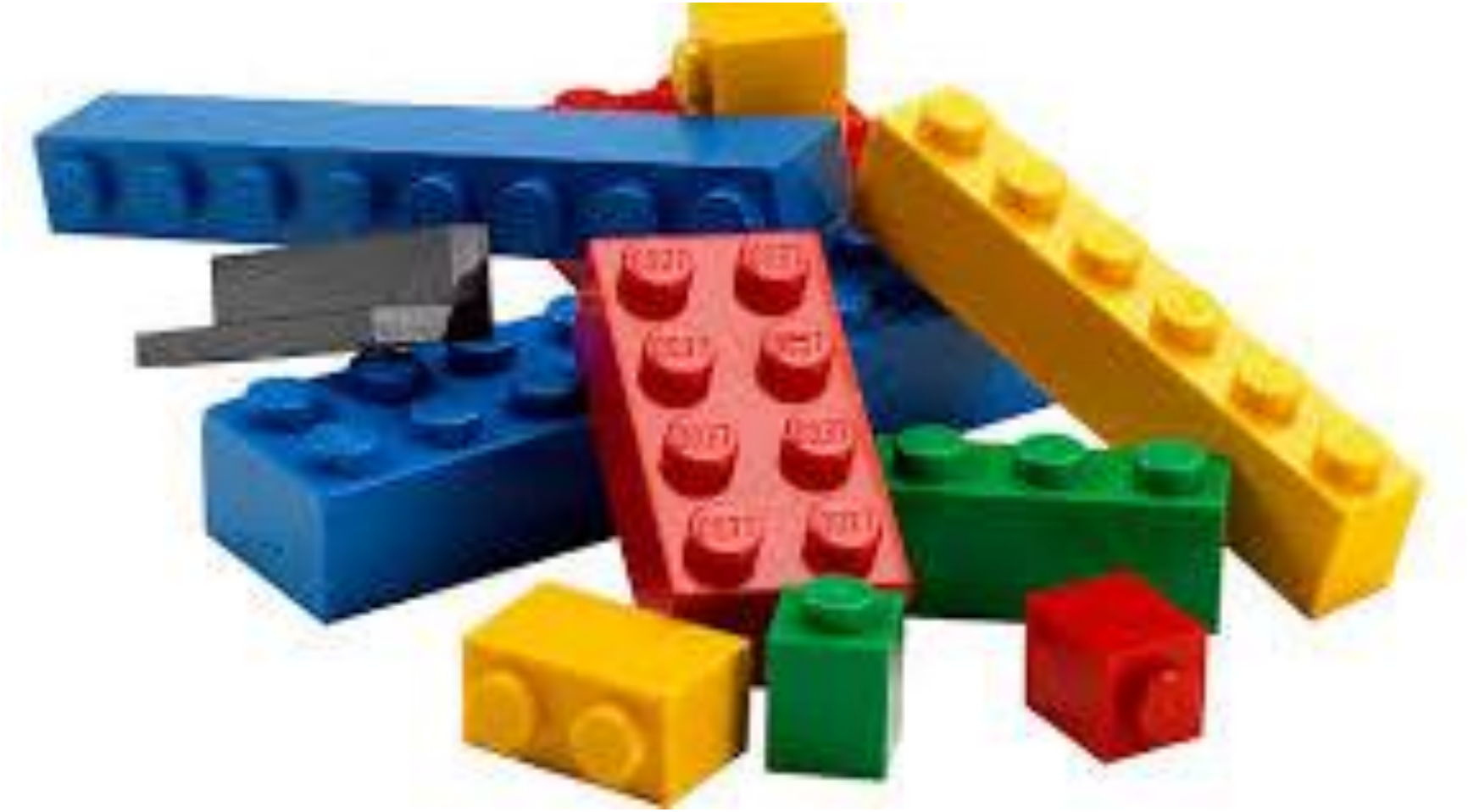
- Re-Combiner box – paralleling upstream CB
- Inverters – power electronics converting DC to AC.
  I. Grid Tied
  II. Off-Grid or Island
- Interconnection – Connection point to utility grid
- Battery banks

Solar PV Basics

- Site selection – large area
- Orientation – True South
- Tilt/Azimuth
- Shading?

  Shading causes panels to act as “short circuit” to prevent damage, therefore less power output.

“Lego designs”
Two Schools of Thought



Centralize Inverter Design

- Example of 500 KW Centralized Inverter
- Typical utility scale with interconnection voltage greater than 600 volts
- String Design
- Circuit sizing
- Combiner Box

This 500KW “Lego block” , or sub array, can be duplicated “x” times to increase PV array size.

IE: 2MW is four sub arrays interconnected

1.2 MW – Centralize Inverter

2.2 MW – Centralize Inverter

2.2 MW – Centralize Inverter

De-centralize Inverter Design

- Example using 10kW de-centralized Inverter
- Typical utility scale with interconnection voltage less than 600 volts (both single or three phase)
- String Design
- Circuit sizing
- Combiner Box

This smaller 10kW “Lego block”, or sub array, can be duplicated “x” times to increase PV array size.

IE: 2MW is 200 sub arrays interconnected

50 kW – de-centralize Inverter

2.2 MW, 382 SMA Sunny Boy 6 kW Inverters. Vermont Solar Farm,

Burlington, Vermont

De-centralize Inverter Design

- Microinverters

  - Potentially Less labor to install
  - Higher initial cost
  - Potentially higher 20 year maintenance cost
  - Monitor each module
  - Potentially higher energy yield

Mounting Issues – Ground

- Soil condition. Piles, footings or auger style
- Shading – adjacent buildings, trees, structures
- Fencing for safety and security
- Fix tilt or tracking

Mounting Issues –Roof

- Roof mounted issues - getting home runs from CBs to the Centralized inverter. Or several smaller runs from the de-centralized inverter. Minimize DC run, versus maximizing AC runs
- Flat roof, ballasted - require structural engineer to perform load analysis, roof condition, age?, etc.
- Tilted metal roof - standing seam: off-set using rail versus S-5! clamp Better ventilation/air flow; easier cable install
- Tilted metal rood - corrugated: rail to the peaks; minimize roof penetrations - ROOF PENETRATIONS! always an issue.
- Safety - safety barrier; maximum weight of personnel; designated walk-ways; two means of egress; skylights

Solar PV Market - Georgia

- Georgia Power – Advance Solar Initiative 210 MW
- IRS allows 30% Investment Tax Credit (ITC)
- Favorable treatment for depreciation. Accelerated 5 year depreciation, with 50% bonus in first year
- Georgia has plenty of annual sun! Approx 13% less than Southern California
- Land is cheaper than other parts of the country – SoCal or NJ.

Solar PV Market Trends

- Environmental – emissions
- Electric Vehicles – may increase residential use of power and grid impact
- Cost of power *increasing* versus Cost of PV *decreasing*
- *Increasing Demand*

Solar Photovoltaic (PV)

Questions?

By Paul M. Williams, President & CEO