Commercial Solar Projects with AEE Solar

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San Diego, CA
Discussion Topics

- **Tax Credits – ITC Extension and MACRS Depreciation**  
  - Example of value of Tax Credits, including MACRS
- **Considering 60-cell vs 72-cell modules for Commercial PV**
- **Trends and developments for Commercial PV Systems**  
  - Sizing arrays with regards to Inverter capacity  
  - Optimal tilt of arrays on Commercial Projects
- **NEC 2014 Rapid Shutdown for Commercial Projects**
- **Trends and developments for ballasted systems**
- **Ballasted Racking from Aerocompact**  
  - Example of maximizing output of a ballasted commercial PV system
- **Carport and Canopy Solar Racking from Schletter**
- **Commercial Ground Racking Solutions**  
  - Considerations for inverter placement for commercial Ground Mounts
Federal ITC and MACRS Depreciation Tax Credits

• Federal Investment Tax Credit (ITC)
  – 30% tax credit through 2019.
  – 26% in 2020
  – 22% in 2021
  – 10% from 2022 on (no expiration for commercial ITC)

• Modified Accelerated Cost Recovery System (MACRS)
  – 5-year accelerated depreciation for solar assets
  – Additional tax savings represent nearly 10% of system cost

• NOTE: See that your end-customer reviews these options with an accountant or tax attorney
MACRS Depreciation Example

• Consult your tax professional about IRS Form 4562 in calculating the allowed MACRS depreciation for the 6 year period.
  – 85% of the net PV install costs are eligible for depreciation
  – Depreciation Schedule for year 1 to year 6
    • 20% / 32% / 19.2% / 11.52% / 11.52% / 5.76%
    • Determines the ‘deduction’. Actual value depends on the Corporate Tax Rate

• Example: 40kW PV array, $100,000 total system cost, and 30% corporate tax rate
  – Year one ITC Federal Tax Credit - $30,000 tax credit
  – Tax savings per year resulting from calculating MACRS Depreciation
    • Year 1 - $5100
    • Year 2 - $8160
    • Year 3 - $4896
    • Year 4 - $2938
    • Year 5 - $2938
    • Year 6 - $147

• Net PV system install cost over 6 year period after ITC & MACRS
  – $100,000 - $30,000 - $24,179 = $45,821 net system install price
  – System costs drop to $1.15/watt, ~50% of project offset by tax credits
  – This is independent of the value of the energy provided!
60-Cell vs. 72-Cell Modules

60-Cell modules should be considered for Commercial scale projects
- Industry has standardized on the 60-Cell format for residential applications
- 72-Cell module may not be as available as 60-Cell equivalents
- 60-Cell modules are often similar cost per watt than 72-Cell modules
- Array power densities can be higher using 60-Cell modules

<table>
<thead>
<tr>
<th>Power Densities of modules available through AEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-Cell Modules</td>
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<tr>
<td>Hanwha</td>
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<tr>
<td>REC</td>
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<tr>
<td>Solarworld</td>
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</table>

- 72 cell module frames are thicker, so larger modules can be heavier per watt
- Two people required to handle 72-Cell modules
- More aesthetic options available with 60-cell modules

60-Cell Modules
- Poly – 260-290 Watts
- Mono – 290 to 315 Watts
- High Efficiency Mono – up to 350 Watts

72-Cell Modules
- Poly – 320 to 340 Watts
- Mono – 330 to 350 Watts
Commercial PV Array Trends

Higher DC to AC inverter load ratio becoming more common
- <125% DC:AC has been typical in industry
- 130% to 135% is becoming more common
- Some inverters capable of higher loading, especially with East/West ballasted arrays and using multiple MPPT circuits
- Inverters reach peak output earlier in the day, and minimal clipping during high irradiance is allowed
- More overall kWh are generated at the site with lower BOS and inverter costs

Tilting PV arrays to the South at latitude may not always be ideal
- High tilt angles facing south result in larger inter-row shading
- Majority of net-metered solar production is during summer months
- Lower tilt angles allow for larger PV arrays to be installed, with higher overall energy production
- East/West orientations eliminate inter-row shading, maximizing energy density on a given area, and provide a more consistent output throughout the day
- Design Programs are available to help with production estimation
Rapid Shutdown Considerations

• Under NEC2014 690.12, inverters located on the roof within 10’ of the array are generally considered compliant
  – 3-phase string inverters can be mounted on custom designed racking, or on ballast racks or sleds
  – 3rd Party or Custom Built inverter ballast racks available
  – SMA has a rack specific for the SMA Tripower inverter series

• Separate remote disconnects can also be used to meet Code
  – Innovative Solutions 1,000 VDC rated universal rapid shutdown
  – SMA, ABB, Fronius & Ginlong have branded RSD solutions for 600VDC systems, but currently do not have a 1,000 VDC solution
  – Ginlong is developing a universal 1000 VDC Rapid Shutdown Solution that could potentially be used for any inverter system.

• Outback Proharvest and SolarEdge inverter systems are inherently compliant in most cases
  – Outback Proharvest inverters mount under panels
  – SolarEdge systems deactivate optimizers, and cut DC power at source
NEC2014 Rapid Shutdown Adoption by state

NEC® in Effect
1/1/2017

http://www.electricalcodecoalition.org/state-adoptions.aspx
## NEC2014 Rapid Shutdown Adoption by state

<table>
<thead>
<tr>
<th>State</th>
<th>Currently Adopted NEC® (Effective Date)</th>
<th>2017 NEC Adoption Status (Effective Date)</th>
<th>Georgia</th>
<th>2014 (1/1/15)</th>
<th>Adoption process underway (1/1/18)</th>
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<tbody>
<tr>
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<td>Colorado</td>
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<th>State</th>
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<td>Tennessee</td>
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<td>New York City</td>
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Typical configuration of the Innovative Solutions 1000 Volt DC Rapid Shutdown Box
- Up to 4 DC Strings, both positive and negative per box
- Other larger enclosures are available, which include more terminals.
- Ground level reset, no need for roof access to reset
- Powered by transformer installed and powered from ground
- Allows for separate E-Stop Button Activation if required
NEW! Outback Proharvest Truestring Commercial Inverters

- For both 480 VAC and 208 VAC installations
  - PRO480-8k
  - PRO208-5k75
- Two MPPT circuits with direct MC4 inputs
- Lightweight – 24 lbs. per unit
- Two DC String Inputs with dual MPPT Tracking; with Monitoring over Powerline Communications
  - Integrated MC4 Connectors, speeds installation time
  - Arc Fault Detection for each individual DC String
- Robust Waterproof NEMA6 enclosure
  - Mounted under array
- Inherently compliant with NEC2014 Rapid Shutdown requirements
- Outabck Proharvest Designed AC Splice Boxes
  - Combines output of three inverters
  - One combined output circuit - 40A 3P-480 VAC breaker
- Made in USA options available
SMA ReadyRack 2.0 Ballasted Inverter Mounts

**SMA ReadyRack 2.0**
- Includes CU1000 combiner/disco
- For SMA Tripower inverters
- Factory assembled unit is shipped direct to job site, and lifted in place
SMA Core1 50kW Inverter

- Six MPPT Inputs, two strings each
- Integrated AC/DC Disconnect
- Free standing – Place next to array for Rapid Shutdown Compliance
- High DC/AC loading – up to 70kW DC in some Situations
- Suitable for Roof, Carport, or Ground Mount Applications
Commercial Rooftop Racking

• Flat-roof arrays using ballasted racking solutions
  – Quick to design using software tools
  – Installs quicker than a penetrating rail based system
  – Fewer materials than rail-based systems
  – Minimizes or eliminates roof penetrations
    • Avoids re-sealing
    • Easier servicing of roof
    • Less roof warranty issues

• Limitations of ballasted systems
  – Seismic-related building codes may mandate penetrations
  – Not suitable for roofs with greater than 5° slope
  – Not suitable for roofs over 60’ high
  – Wind exposure drives ballast and module tilt limitations
    • Be sure that designer and/or supplier uses correct wind loads
Penetrating vs. Ballasted

**Penetrating Racking**
- Roof penetrations into roof structure anchors PV array
- Roof penetrations must be properly sealed for array life
- Higher tilt angles possible to increase array efficiency
- Can be installed on pitched or flat roof surface
- Lower array weight than ballasted, less roof dead load
- Roof maintenance requires removal of array racking and re-installation of penetrations

**Ballasted Racking**
- Weight of array plus ballast anchors PV array
- Few to no roof penetrations required to anchor array
- Tilt angles typically kept <10° to minimize wind effects
- Pitch of roof limited depending on racking
- Higher roof loading due to ballast weight, higher dead load
- Array can be more easily removed and reinstalled for roof maintenance
Hybrid Ballasted Racking Systems

• Minimally attached system can offer best of both worlds
  – Majority of array quickly installed
  – Roof anchor and penetration points made in key areas of array
  – Fewer penetrations to install and flash, array still removable
  – Lower ballasting requirements can allow systems to be installed where roof loading is a concern

• Optimize tradeoffs between penetrations and ballast
  – Less penetrations require more ballasting and vice versa

• Combination of penetrations and ballast can be best way to meet site specific wind and roof load requirements
  – California and some other jurisdictions always require some penetrations for seismic considerations
Aerocompact 2.1 Ballasted Racking System

- Landscape Format – connects to module frames to connect racking arrays
  - South Facing 5°/10°/15° tilt
  - East/West 10° tilt - maximizes module density and lowers ballasting requirements
- 25 year warranty. Wind Tunnel tested to 150 mph
- UL2703 integrated grounding and fire code compliance
- Aerotool Design Software
  - Full layout, ballasting plan, material list, and engineering reports.
  - Wet-stamp support for all 50 states.
  - Final engineering and quotes
  - Light Version available for initial layout planning
- Pre-attached EPDM rubber pads on supports to protect roof surface; ballast trays when required
- Fast installation with single tool
- Support for penetrations to lower ballasting or for Seismic requirements. UL Listed Frame mounts available for microinverters or optimizers.
- Over 100MW of installed projects in 2016
Example – More solar per roof possible with lower tilt arrays

Aerocompact 15° South
- 160’ x 300’ area
- 1,245 (280-W) modules
- 348.6 kW (569 MWh)

Aerocompact 5° South
- 160’ x 300’ area
- 1,430 (280-W) modules
- 400.4 kW (620 MWh)
- 15% (9% kWh) increase

Aerocompact 10° East/West
- 160’ x 300’ area
- 1,586 (280-W) modules
- 444.1 kW (673 MWh)
- 27% (18% kWh) increase
Examples using Aerocompact South and East/West Ballast Rack

15° South Tilt Ballasted Racking
- 1,244 modules, 348.6kW DC Array
- Using 8x SE33.3kW inverters and P600 optimizers
- Array would produce estimated 569 MWh of power in year 1
- 3.22 psf roof dead load, needing 3,270 ballast blocks

5° South Tilt Ballasted Racking
- 1,430 modules, 400.4kW DC Array
- Using 9x SE33.3kW inverters and P600 optimizers
- Array would produce estimated 620 MWh of power yr1 (+9%)
- 2.80 psf roof dead load, needing 2,389 ballast blocks

10° Tilt East-West Ballasted Racking
- 1,586 modules, 444.6kW DC Array
- Using 10x SE33.3kW inverters and P600 optimizers
- Array would produce estimated 673 MWh of power yr1 (+18%)
- 2.35 psf roof dead load, needing only 910 ballast blocks
- Racking cost per watt can be up to half that of 15 degree racking, as it uses less materials, and does not require wind screens.
Schletter Park@Sol Carports

- Several carport options
- Commercial and Residential applications
- Cast in place concrete, concrete pillars, or micro-pile foundations.
- Single and double row vehicle arrangements can be designed, either with a south tilt or an East/West orientation, with up to a 20° tilt.
- Compatible with most module types, and are constructed of corrosion resistant aluminum. Purloins can accommodate spans of up to 30 ft.
• Medium sized systems can be completed with conventional ground mount racking
  
  – SnapNrack Series 200 Ground Mount can be competitively employed for arrays up to about 150 kW DC.
    • One rack of 100 280-watt modules with 25 rows of 4 high in landscape would result in a 28.0kW DC array, suitable for use with Fronius Symo or SMA Tripower 24kW inverter, or three HiQ 8kW Truestring Inverters
    • Ten 3’ deep front piers and ten 4’ deep back piers for many locations
    • 4 racks → 112 kW DC / 96 kW AC array field
    • This array could fit in a 100’ x 150’ space
    • Cost roughly $0.16-0.18/watt, plus galvanized piping and concrete
  
  – Pile driven systems may require special engineering studies and specialized equipment rentals that can add too much cost for smaller projects
SnapNrack Series 200UL

- Optimal solution for small to medium sized ground mount arrays
- Four Module High Landscape orientation, typical
  - Three high landscape is also available.
- High module/power density for a given area achieved
- UL2703 Listed – Only one grounding point per subarray required
- On-line configuration tool to determine BOM and engineering requirements
- Specialized equipment is not required for installation
- Locally sourced Schedule 40 1-1/2” galvanized pipe lowers shipping costs
- Residential installers can easily utilize a known solution for larger projects
NEW! Schletter FS Series Commercial Racking

- Large Commercial or Utility Projects
- Can accommodate uneven terrain
- Two high portrait design typical to maximize number of panels per post
- Posts are typically pile driven; cement piers and ground screws available
- Designed for exceptional value for cost driven projects
- Soil sampling is required as part of the project planning process
- Aluminum extrusions, integrated grounding components, and component pre-assembly allow this commercial racking system to be quickly installed.
- Integrated grounding to UL2703 for lower install time and component count
NEW! Aerocompact G and G+ Series Ballasted Ground Racking

- Commercial and utility ground mount installations
- Quick install times, without the need for piles, concrete or large machinery.
- Install as Completely ballasted, or with optional soil anchors.
- Up to 1 MW of racking can ship to a jobsite in a single truck load.
- Ideal for areas that have soil issues like landfills or brownfields, areas that cannot support deep piles or excavation due to rocks, or for areas of sensitive ecological nature where excavation is discouraged.
- Fleece mesh can be supplied to prevent vegetation growth around the module field. This ground mount system can be designed with either a South 15°-20°-25° tilt, or with a 10° tilt East/West Configuration.
Inverter Locations on Ground Mount Arrays

• Inverters for Ground Mount Arrays can be located behind the panels on the ground racks to save space and simplify installation
  – NEMA 4 enclosures of typical inverters allow for outdoor mounting

• AC vs DC voltage drop considerations
  – Most 480VAC-3P inverters allow for 1,000 VDC max wiring
  – Locating inverters close to point of connection will allow typical 600-800 VDC operation for array to inverter wiring
    • 277 VAC Line-to-Neutral is 2-3 times the voltage drop and system losses vs. 600-800 VDC

• Mounting inverters under array may avoid extra DC disconnects

• Monitoring may be easier if inverters are centralized
Questions and Answers

Any Questions?
Photos of Ballasted Racking Aerocompact 5° South
Photos of Ballasted Racking
Aerocompact 10° South
Photos of Ballasted Racking
Aerocompact 10° East-West