

RPSEA 2010

Power Conversion for Distributed PV Solar Systems

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Power Generation

- Historically centralized in multi-GW plants
 - Fossil fuels, nuclear, etc
- Renewable energy sources, wind and solar, introduce new degrees of freedom
 - Wind still naturally suited to large-scale “farms”
 - Non PV Solar also mandates a large “plant”
 - PV Solar, uniquely, can be implemented two ways
 - Large, centralized “utility scale” farms
 - Distributed roof top systems

Power Conversion for Solar

- Distributed generation via roof-top PV should become a major element of solar power
 - No environmental trade-offs
 - No mega-project finance
 - No transmission lines or right of ways
 - Inherently more secure
- Should make for a huge market opportunity, BUT
 - Customer experience must be made better
 - Overall economics, LCOE, must improve

The Metrics

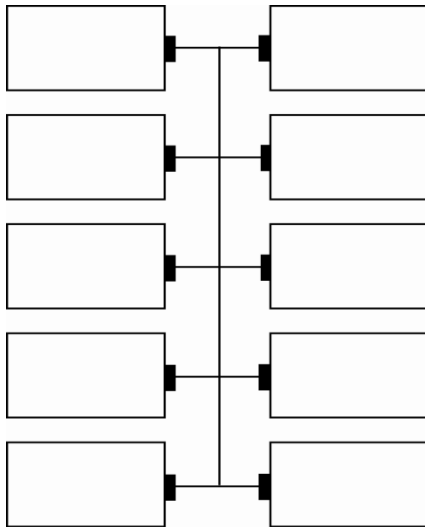
- LCOE = Levelized Cost Of Energy
 - Total energy generated
 - Total cost
 - Both over service life of the system, typically 25 years
- Largest element of system cost is still the solar panel itself, but has been falling rapidly
- Power Conversion impacts 3 other key metrics
 - Energy Harvest
 - Installation Cost
 - Operating Cost

Problems with DC-based Central Inverter PV Systems

- DC panels are all connected in series, which leads to numerous limitations in energy harvest
 - Low output from one panel impacts whole string
 - Panels have to match within 3 % to work well together
- Complicated design and install
 - Many interested sites get disqualified
 - Requires separate centralized inverter
- High Voltage DC on rooftops leads to real safety issues
 - Fire risk due to arc faults, “system off” is not “HV off”

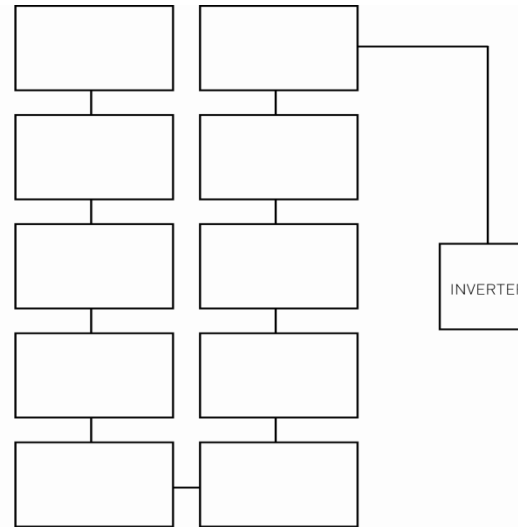
**Current technology not well suited
for residential or light commercial applications**

AC vs DC Array Comparison



Microinverter :

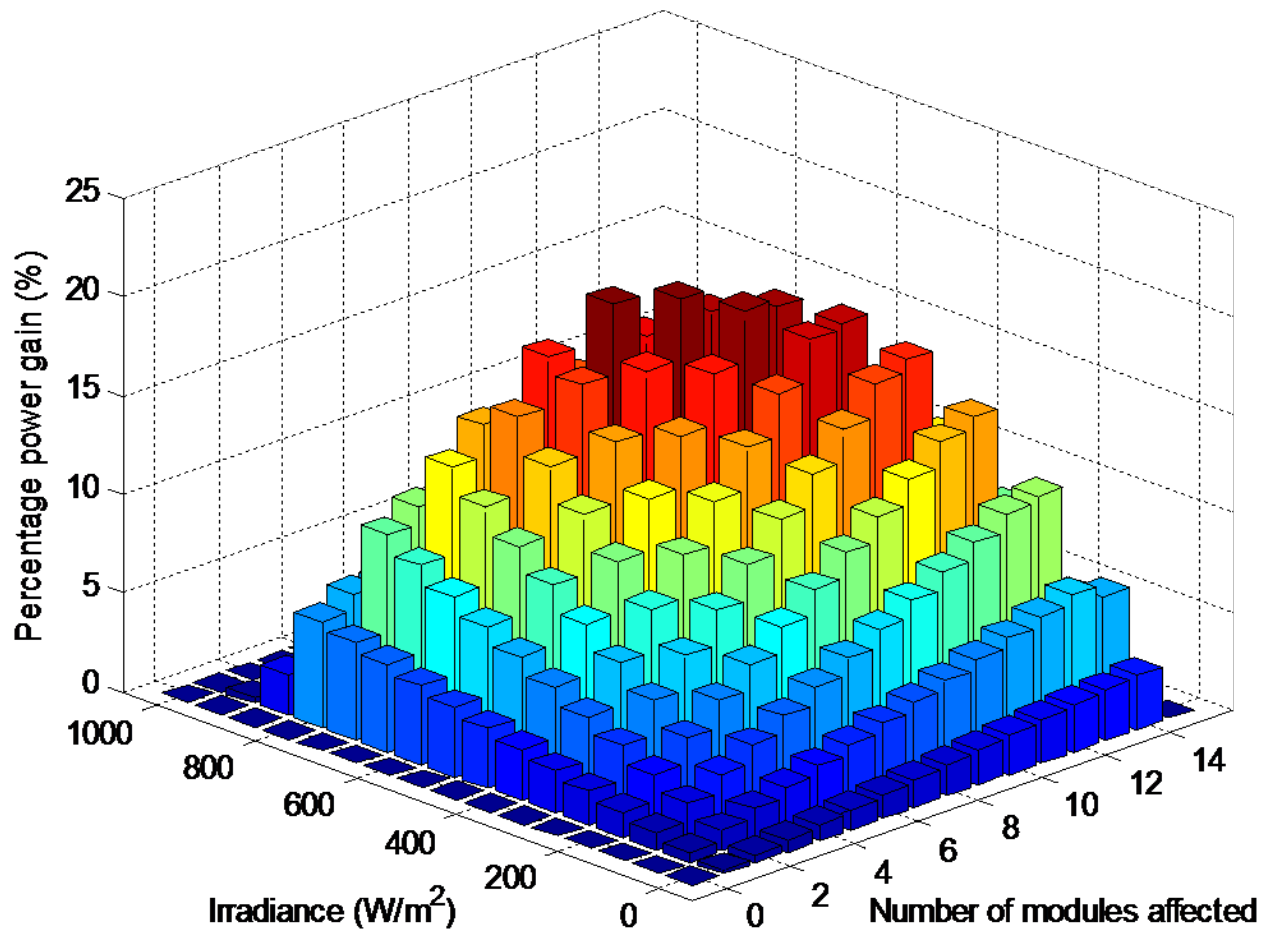
- MPPT performed at module level
- No single point of failure
- No DC wiring
- Information on individual panel performance available



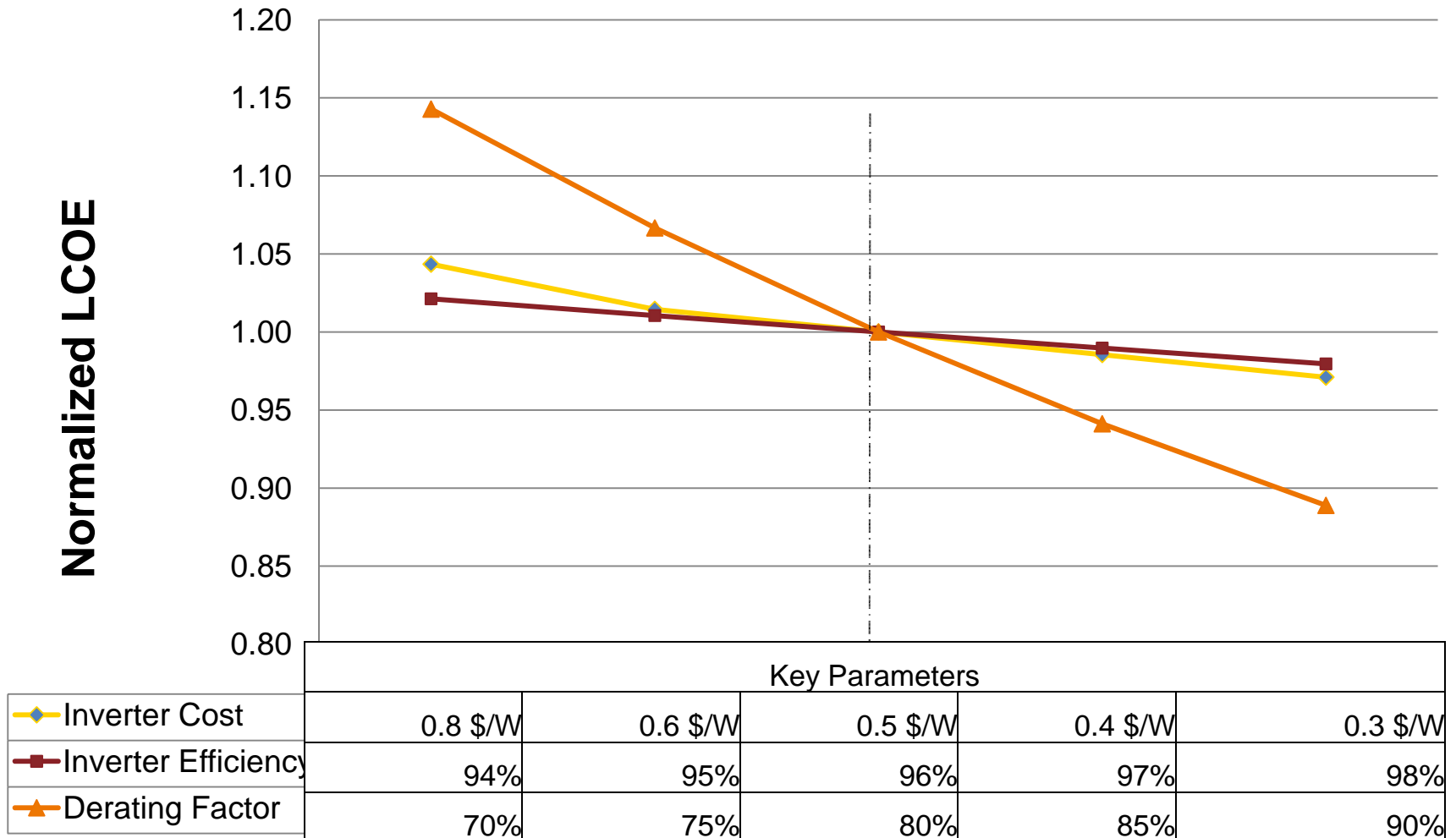
Traditional Inverter:

- MPPT performed at inverter level (sub-optimal performance)
- When inverter fails, system output is zero
- Includes DC wiring, circuit breakers, disconnects
- Performance information at string or inverter level only

Power Gain with ACPV : Shading Factor Only



Inverter Factors in LCOE Reduction



Moving Beyond Centralized DC Systems

- Distributed DC-DC “optimizers” are not enough...
 - Net increase in system cost
 - Still have HV DC wiring
 - Still have a central inverter
- Distributed, but detached, DC to AC conversion is not enough...
 - High installation costs
 - High replacement costs

- **Gains in Energy Harvest are Necessary, but Not Sufficient**
- **Must Also Leverage Up-Front Costs and Operating Costs**

Integral AC PV – The Category

- Energy harvest gain of module-level MPPT AND...
- Goes to market as natural “AC Module” expansion of product offer from Solar Module companies
 - Attaches securely to back of solar panel
 - No special frame requirements
 - Functional final test with panel
 - Ships in standard packaging
 - Backed by an integrated 25 year warranty
- Arrives at job site ready to go
 - Pre tested combo of PV+power conversion
 - Only standard AC wiring to service panel is required
 - No inverter(s) to install (on rack or on ground)

Integral AC PV – The Benefits

Module Company Value:

- Greater Share of Total System Value
- Increased Sales & Contribution Margin
- Differentiation Relative to Commodity Magnet

Installer Value:

- Reduced Design Costs and More Sites Qualify
- Reduced Installation Coats with Less Specialized Skills
- Turn More Jobs with Same Size Crew

End-User Value:

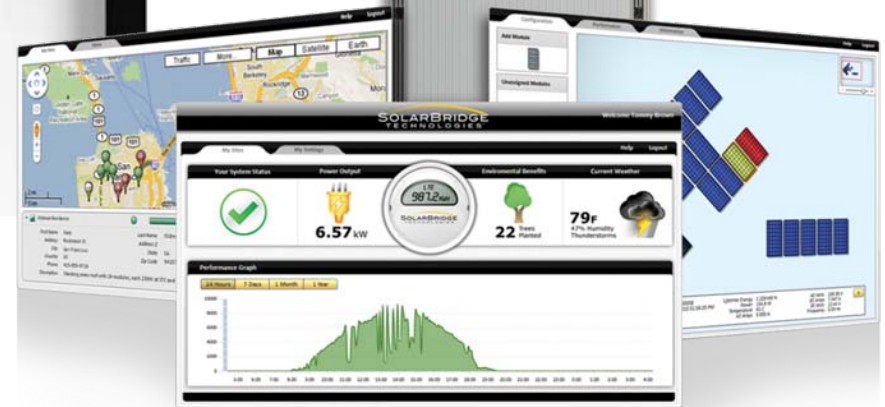
- Significant LCOE Reduction
- 25-Year “Integrated System” Warranty
- Increased Safety (Std 240/208 VAC)

SolarBridge AC Module System

Integrated Pantheon™ microinverter
PV-Dock™

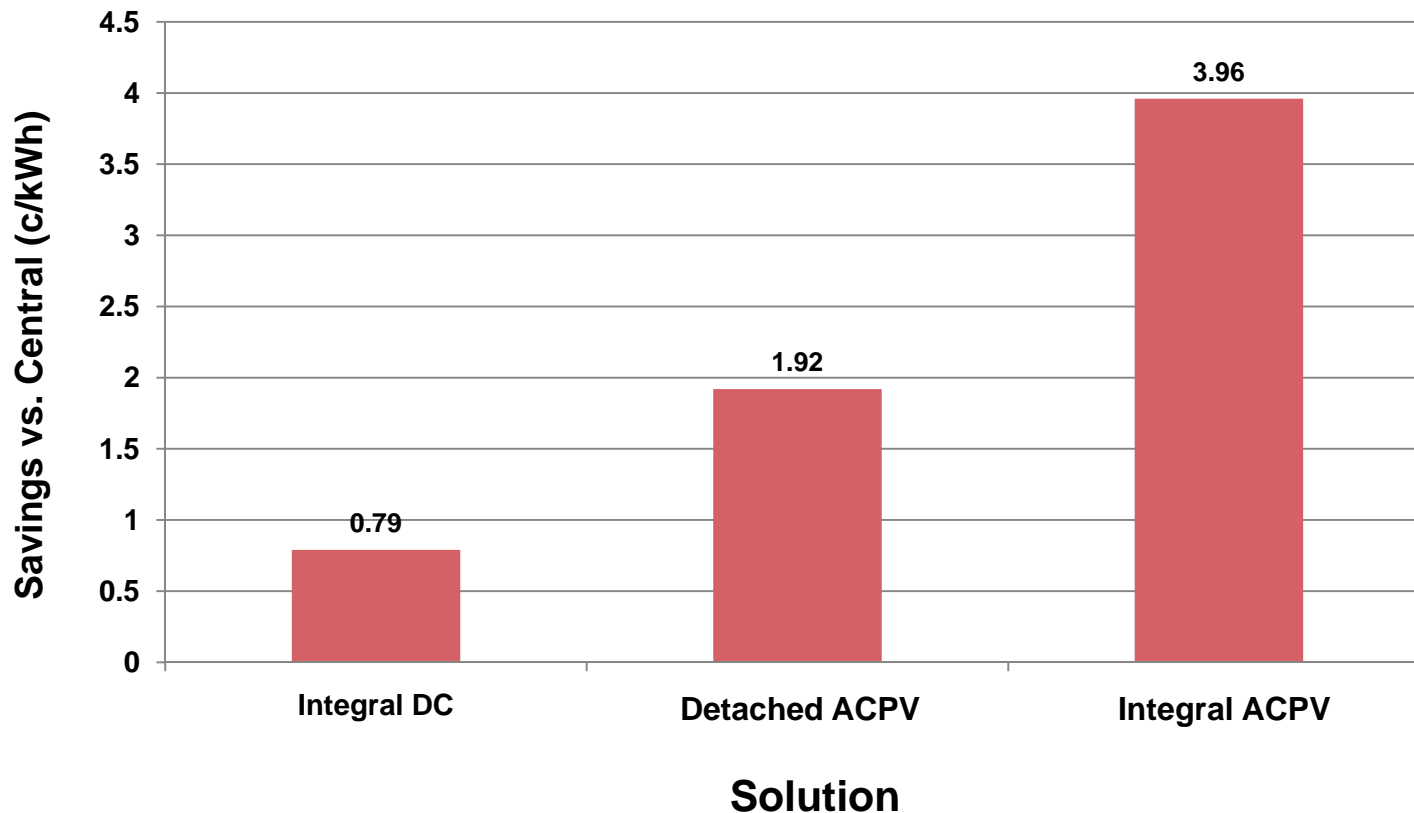


Power Manager



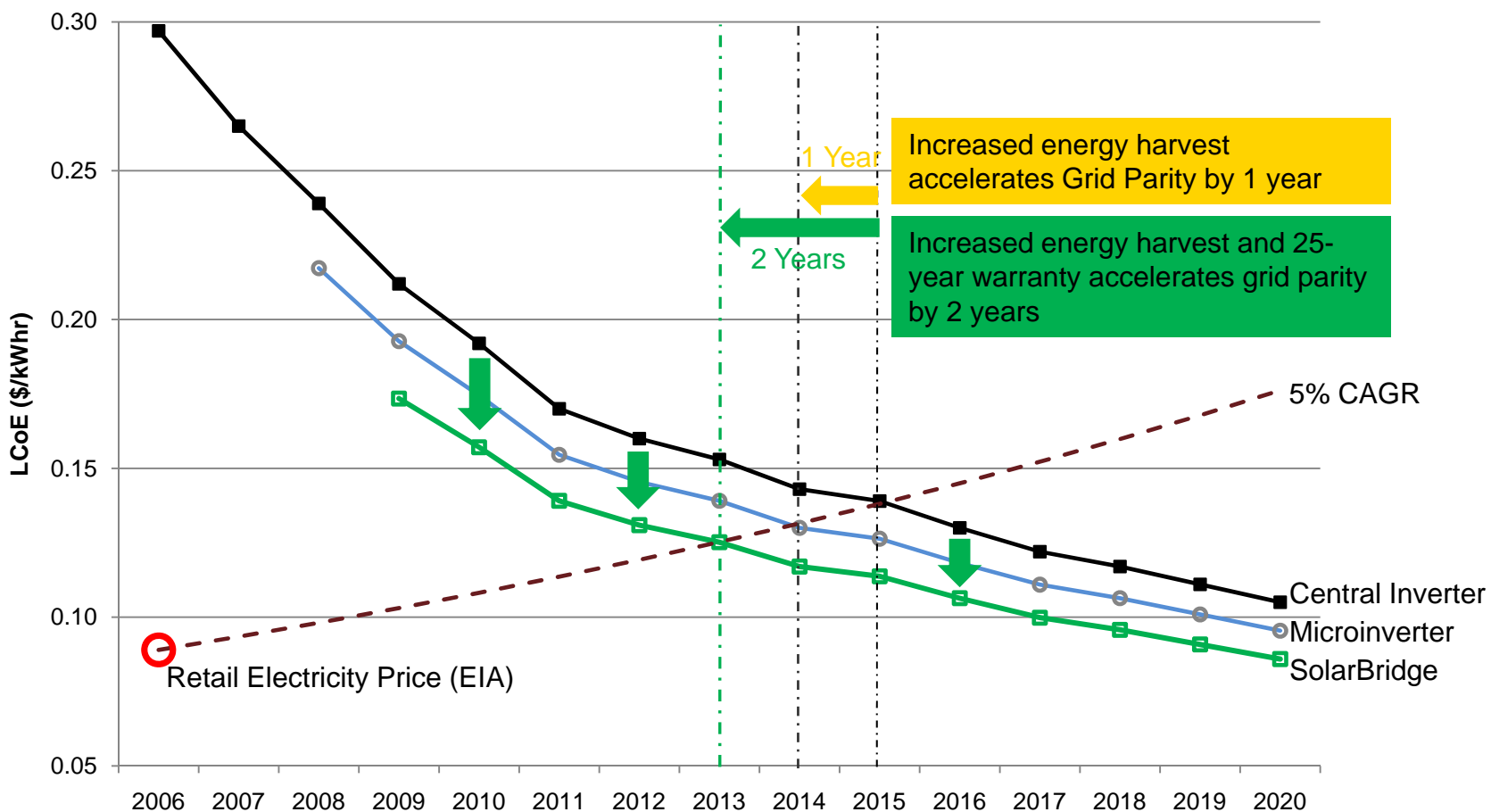
Power Portal

Savings vs. Central Inverter (5kW Residential Installation)



**Integral ACPV has: 5x the LCOE benefit vs. Integral DC-DC
2x the LCOE benefit vs. Detached ACPV**

Accelerating Grid Parity



DG PV : Four Phases of Progress

- Phase 1 – Series DC to Parallel AC systems
 - Gains in energy harvest and safety
- Phase 2 – Detached to Integrated Electronics
 - Reduced installation cost
- Phase 3 – AC Modules with integrated warranty
 - Eliminate inverter replacement cost
- Phase 4 – PV Dock : Industry standard for module-integrated electronics
 - Accelerate mainstream market conversion
 - Ultimate long-term cost advantages

DG PV : Usage Progression

- Direct adoption by end-users
 - Flexible, can be expanded in stages, safest solution
- New business models : Lease or PPA
 - Naturally modular and lowest LCOE
 - Full monitoring, command/control capability
- Utility sponsored deployment
 - Satisfy RPS and stay in control
 - Inherently Smart Grid ready
 - Some microinverters enable VAR management
 - Assist in regional power factor optimization

Summary

- Distributed Generation is an important part of PV Solar Deployments
- Residential and light commercial applications much better served by moving beyond systems based on HV DC and central inverters
 - Energy harvest, design flexibility, safety
- Integral ACPV enables full economic potential
 - Leverage installation and replacement costs
 - Reliability by Design is Crucial
- PV Dock SIG will enable industry standards
- Reducing barriers to utility-sponsored deployment