



Interconnection of Distributed Generation

12/04/2009

Bryan Gernet
Sr. Engineer

Kyle Woolfolk
Sr. Engineer

History

- Increase of Grid Tied Systems (last 10 years)
- 1999 – 35
- 2007 – 300
- 2008 – 780
- 2009 – 3000 ??



History

Standardizing the Requirements

- APS, SRP & TEP req's very similar
- Interconnection on transmission system covered by FERC – approved process
- FERC may even get into act at distribution level if you engage in sale for re-sale.



12/04/2009 - 3

Incentive Program

Types of Interconnected Incentives

- Up front Incentive (UFI) [Capped at \$75k]
 - one time rebate check based on rating
- Performance Based Incentive (PBI)
 - Paid quarterly per kWh for the next 10, 15 or 20 years



12/04/2009 - 4



Incentive Program

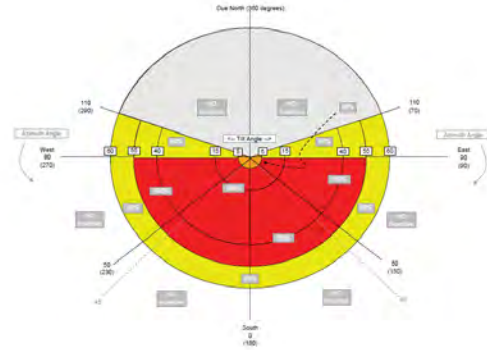
De-rated UFI Incentive ?

Measured from True South (not Magnetic)

Azimuth ~
90deg West
to 90deg East

Tilt ~ 5deg to 55deg
above Horizontal

Shade Factor ~
1.0 to 0.75, or
about 25% annual shading



12/04/2009 - 5



Incentive Program

Incentive Process

1. Submit Reservation Application and/or Agreement
2. Receive Reservation Confirmation and/or Agreement
3. **Submit Interconnection Application***
4. **Receive Preliminary Approval***
5. Obtain Local Permits
6. Proceed with Installation
7. Receive AHJ Clearance
8. **Request APS Inspection***
9. Submit Proof of Clearance, Acceptance and Installation Certification Form, & Paid Invoice



12/04/2009 - 6



Topics

Requirements

- Must meet the Program guidelines filed with ACC, Incentives vary per technology & may be de-rated if applicable
- Interconnect Requirements Vary based on the generator type, size and scope of the system installed.
- Address the alternating current (AC) side of the system.
- All applicable NEC and Authority Having Jurisdiction (AHJ) requirements must be followed.
- APS Electric Service Requirements Manual (ESRM)
- Our requirements are in addition to the National Electrical Code (NEC).



12/04/2009 - 7



Topics

Purpose of the Requirements

- Primary focus is Safety.
- Utility worker safety, and equipment protection (both utility and customer)



12/04/2009 - 8



Topics

Interconnection Requirements Manual (rev 6.2)

- Sec 4 – DG Types
- Sec 8.2 – Utility Disconnect
- Sec 9 – Metering
- APPENDIX A –
Interconnection Application for NON-Residential



12/04/2009 - 9



Topics

- (Emergency) Stand Alone w/
Transfer Switch = Minimum req's
- Closed transition
- Parallel Operation – Interconnected w/ Utility
- Various Types: Inverters, Induction,
Synchronous

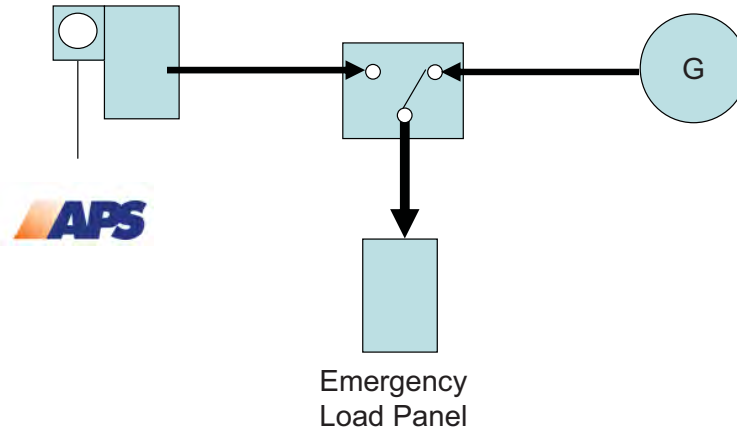


12/04/2009 - 10



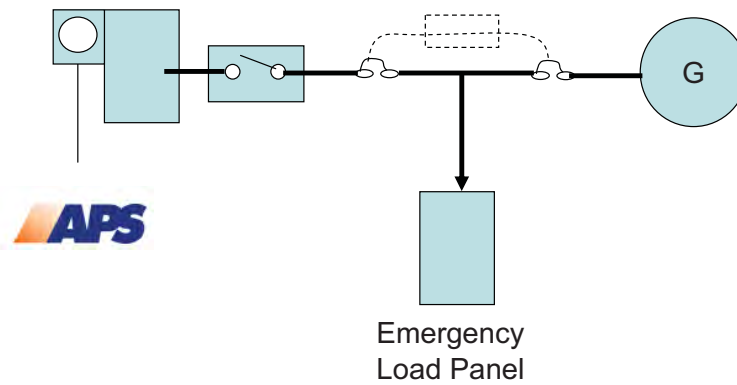
Topics

(Emergency) Stand Alone w/ Transfer Switch



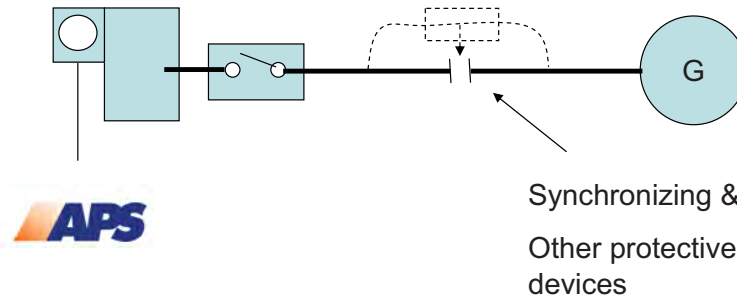
Topics

Closed transition



Topics

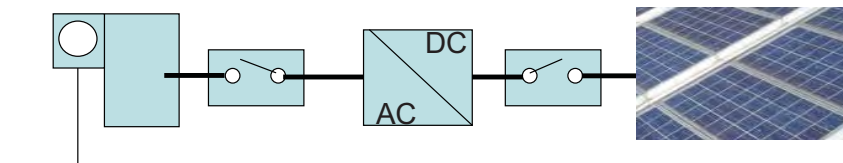
Parallel



12/04/2009 - 13

Topics

Parallel - Inverter



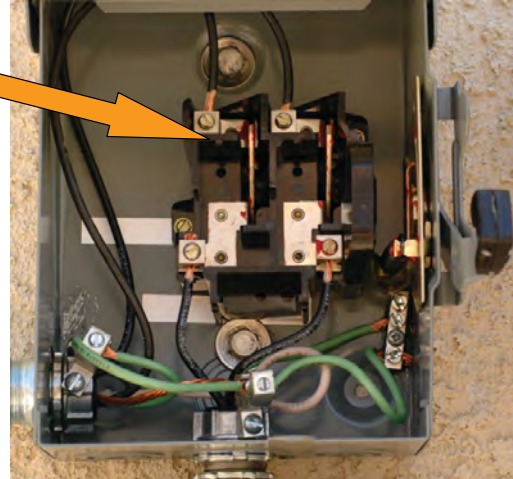
12/04/2009 - 14



Topics

• *Utility Disconnect Switch*

- * *VISIBLE – OPEN*
- * *Lockable in the OFF position*
- * *Don't use as a Raceway*
- * *Line & Load Wiring separated*
- * *Blade Direction (also applies to DC switch)*
- * *Don't switch Neutral !*
- * *Lockable Cover*
- * *Cover Clasp - 3/8" hole for APS lock*



12/04/2009 - 15



Topics

Photovoltaic System Meter ~

*aka "Dedicated Photovoltaic System kWh Meter",
"Inverter Output Meter", "R.E.C Meter"*

To record the total output of your system,
for the life of the system.

→ Non-Incentive Systems
Meter not Required

Don't use as a Raceway

Per APS ESRM

Ring Type Enclosure

Height & Working Clearance



12/04/2009 - 16

Topics

Photovoltaic System Meter ~

Meters "Form #" and voltage shall match the output of the Inverter.

~ 1S, 2S, 9S, 12S, 15S, 16S, etc.

→ Battery backup 240V systems require (2) **Two** 12S meters

→ For PBI systems and/or rates;

* Dedicated **phone line**(s) required by Customer

* Meter and/or CT's are provided by APS



12/04/2009 - 17

Topics

Rates

If you are interconnected in parallel, the excess energy (electricity produced by the system but not immediately used at the customer location) can be transferred to the APS grid.

- **EPR-2** Net Billing
- **EPR-5** Net Metering (replaced)
- **EPR-6** Net Metering & Net Billing



12/04/2009 - 18

Reference

www.aps.com/DG



12/04/2009 - 19

Topics

Residential ~ (602) 328-1924

Renewables@aps.com

Residential Interconnection Application

* **DIAGRAMS** ~ may qualify for SFT set
~ may require 3-line also

• **Commercial ~ (602) 371-6160**

Commercial-Renewables@aps.com

APPENDIX A – all Non-Residential

* **DIAGRAMS** ~ requires FULL-Set



12/04/2009 - 20

Topics

• Residential Criteria for SFT

(Super Fast Track) Application & Site Plan Diagram



Rule of Thumb is:

A new PV or Wind system installation that contains One (1) Inverter connected to a backfed breaker in the SES, by which the Main is not de-rated.

* Excludes: Single Branch Circuit Micro-inverter systems,
Note: careful with EGC / GEC [later]

* FULL SET for anything else, Including but not limited to -
System Expansions, Sub-panels, Combiners, Batteries, Back up Generators, Hybrid Systems, etc.



12/04/2009 - 31



Topics

Residential

Commercial



RESIDENTIAL INTERCONNECTION APPLICATION

OVERVIEW AND APPLICATION PACKET INSTRUCTIONS

Thank you for your involvement in the APS Renewable Energy Incentive Program. Because the system you will be installing will have interconnectivity to the APS distribution grid, we have created an application procedure that will provide the necessary information for APS to provide a preliminary review of the renewable energy system design to determine if it appears to be in conformance with APS' Program and Interconnection Requirements. Please carefully review the APS Interconnection Requirements and Sample Diagrams posted to our website at www.aps.com/colado. Note that our website also has an FAQ specifically pertaining to interconnection related questions. If you have any questions, you would like to talk with us about directly, please call 800-371-1914 for assistance. Please note that APS will provide preliminary written notification that your system design, as documented in this interconnection application packet appears to be in conformance with APS' Program and Interconnection Requirements.

APS will provide final written notification that your system design, as documented in this form appears to be in conformance with APS' Interconnection Requirements. This notification will not be sent until we have completed our interconnection inspection. Our notification to you of your System's compliance does not represent our approval of your system's design, nor is it an assurance that your installed system complies with all applicable electric codes, laws, regulations and requirements applicable to its installation and operation. It is also important to remind you that you may not interconnect your system and operate it until we issue you our notification that your system complies with our requirements, as mentioned above.

Please also ensure that you understand what is required for the system design, including NEC codes and manufacturer's requirements (also known as Authority Having Jurisdiction or "AHJ" requirements), including equipment labeling. Also note that the APS Interconnection Inspection is in addition to, not in lieu of, an AHJ inspection. Proof of AHJ clearance will need to be provided to APS prior to our scheduling the APS Interconnection Inspection.

A complete Interconnection Application Packet for a PV or Wind System consists of:

1. A signed and completed Interconnection Application
 2. A Site Plan diagram - (see page 5 for diagram requirements)
 3. A 3-Line Diagram (WPP) - (see page 5 for diagram requirements)
 4. Equipment cut sheets for the Inverter(s) and Module(s) or Wind Turbine(s), depending on the technology
- *Note: For Wind - A 3-Line is not required if the system design has only ONE (1) Inverter and 1 WPP's system operation and connects to the Service Entrance (not a sub-panel) through a backfed breaker in accordance to NEC 690.64(B)(3). www.nec.org has the Energy Back up manual. If the Wind system Controller is external to the service entrance.

- A Site Diagram when it appears to be necessary to do so in order to make a preliminary determination as to compliance with the APS Interconnection Requirements.
- Wind systems only: A copy of the Civil Engineering structural drawing and/or report, stamped by a Registered Professional Engineer (PE), stating that the Wind tower was designed and installed by individuals familiar with local geoscientific conditions.

Please submit the Interconnection Application described in the above box to:

Renewables@aps.com

or
APS Renewable Energy Incentive Program
PO Box 20830, MS 3361
Phoenix, AZ 85071-3833
800-371-1914



Adobe Acrobat Document

APPENDIX A INTERCONNECTION APPLICATION

Note: Residential installations participating in the APS Renewable Energy Incentive Program must complete the residential application located at <http://www.aps.com/colado> and not the application(s) included in this document.

Non-residential installations need to complete all items on the attached Interconnection Application (Static Inverter or Rotating Machinery) and forward to APS along with all Supplementary Information requested.

APS will then review the application submitted to determine if the design appears to be in conformance with APS requirements.

APS notification that the system design appears to be in conformance with APS Interconnection Requirements does not represent APS approval of system's design, or is it an assurance that your system complies with all applicable electric codes, laws, regulations and requirements applicable to its installation and operation. It is also important that systems not be interconnected or operated in parallel with APS' grid until APS has inspected the system and issues written notification that the system is in compliance with APS' requirements.

Note that the APS Interconnection Inspection is in addition to, not in lieu of, an AHJ inspection. Proof of AHJ clearance or Letter-in-Lieu of Electrical Clearance will need to be provided to APS prior to our scheduling the APS Interconnection Inspection.

If you have any questions please call 800-371-1914 for assistance.

Please submit all documentation electronically in pdf format to: Commercial.Renewables@aps.com

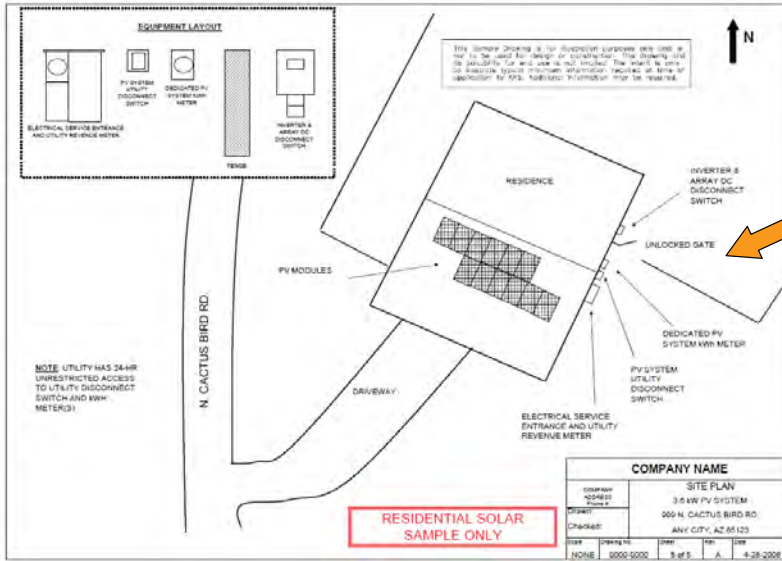
Include Customer name in subject line of email.



12/04/2009 - 32



Topics



Show Fences, Gates, etc

12/04/2009 - 23



Topics



Residential

Commercial

APS Renewable Energy Incentive Program RESIDENTIAL INTERCONNECTION APPLICATION OVERVIEW AND APPLICATION PACKET INSTRUCTIONS

Thank you for your involvement in the APS Renewable Energy Incentive Program. Because the system you will be installing will have interconnectivity to the APS distribution grid, we have created an application procedure that will provide the necessary information for APS to provide a preliminary review of the renewable energy system design to determine if it appears to be in conformance with APS' Program and Interconnection Requirements. Please carefully review the APS Interconnection Requirements and Sample Diagrams posted to our website at www.aps.com/colloids. Note that our website also has an FAQ specific only pertaining to interconnection related questions. If you have any questions, you would like to talk with us about directly, please call 602-371-1214 for assistance. Please note that APS will provide preliminary review notification that your system design is documented in this interconnection application packet appears to be in conformance with APS' Program and Interconnection Requirements.

APS will provide final review notification that your system design, as documented in this form appears to be in conformance with APS' Interconnection Requirements. This notification will not be used until we have completed our interconnection inspection. Our notification to you of your System's compliance does not represent our approval of your system's design, nor is it an assurance that your installed system complies with all applicable electric codes, laws, regulations and requirements applicable to its installation and operation. It is also important to remind you that you may not interconnect your system and operate it until we issue you our notification that your system complies with our requirements, as mentioned above.

Please also ensure that you understand what is required for the system design, including NEC codes and manufacturer's requirements (also known as Authority Having Jurisdiction or "AHJ" requirements), including equipment labeling. Also note that the APS Interconnection Inspection is in addition to, not in lieu of, an AHJ inspection. Proof of AHJ clearance will need to be provided to APS prior to us scheduling the APS Interconnection Inspection.

- A complete Interconnection Application Packet for a PV or Wind System consists of:
1. A signed and completed Interconnection Application
 2. A Site Plan diagram - (see page 5 for diagram requirements)
 3. A 3-Line Diagram (WPI) - (see page 5 for diagram requirements)
 4. Equipment cut sheets for the Inverter(s) and Module(s) or Wind Turbine(s), depending on the technology
- Notes for Review: A site is not required if the system design fits only ONE (1) of the two and is NOT a system application and connects to the Service Entrance (not a sub-panel) through a bonded breaker as accordance to NEC 690.64(B)(3). www.nec.org has NEC Energy Risk up available at the Wind system chapter is central to the article.

- Notes for AHJ compliance:
- A 3-Line Diagram when it appears to be necessary to do so in order to make a preliminary determination as to compliance with the APS Interconnection Requirements.
 - Wind systems only: A copy of the Civil Engineering structural drawing and/or report stamped by a Registered Professional Engineer (PE), stating that the Wind tower was designed and installed by individuals familiar with local geotechnical conditions.

Please submit the Interconnection Application described in the above box to:

Renewables@aps.com
or
APS Renewable Energy Incentive Program
PO Box 20830, MS 3361
Phoenix, AZ 85071-3833
602-375-1214

APPENDIX A INTERCONNECTION APPLICATION

Note: Residential installations participating in the APS Renewable Energy Incentive Program must complete the residential application located at <http://www.aps.com/colloids> and not the application(s) included in this document.

Non-residential installations need to complete all items on the attached Interconnection Application (Static Inverter or Rotating Machinery) and forward to APS along with all Supplementary Information requested.

APS will then review the application submitted to determine if the design appears to be in conformance with APS requirements.

APS notification that the system design appears to be in conformance with APS Interconnection Requirements does not represent APS approval of system's design, or is it an assurance that your system complies with all applicable electric codes, laws, regulations and requirements applicable to its installation and operation. It is also important that systems not be interconnected or operated in parallel with APS' grid until APS has inspected the system and issues written notification that the system is in compliance with APS' requirements.

Note that the APS Interconnection Inspection is in addition to, not in lieu of, an AHJ inspection. Proof of AHJ clearance or Letter-in-Lieu of Electrical Clearance will need to be provided to APS prior to our scheduling the APS Interconnection Inspection.

If you have any questions please call 602-371-1214 for assistance.

Please submit all documentation electronically in pdf format to: Commercial.Renewables@aps.com

Include Customer name in subject line of email.



Adobe Acrobat Document

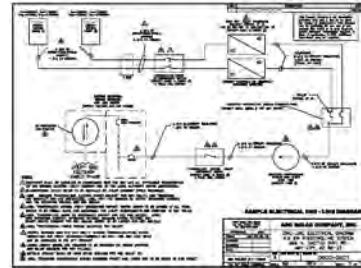


12/04/2009 - 24

Topics

Diagram Requirements – FULL Set

- **One-Line**
- **3-Line**
- **Site Plan**
- **Plant Location**



Adobe Acrobat
Document

Use APS Sample Diagrams



12/04/2009 - 25

Topics

Diagram Requirements – FULL Set

In General

- ***Per Samples, Format and Level of detail***
- ***Computer Generated, no hand drawn***
- ***No color ~ photocopy / scan***
- ***No Copyrights***
- ***NOTES***
- ***No extra “Construction” calculations, dimensions, structural, etc.***

Title Block with

- ***Installation Address***
- ***Total Inverter AC output (not DC)***
- ***Update Rev #'s on corrections submitted***
- ***Installer Company Name and Phone #***



12/04/2009 - 26



Topics

Diagram Requirements – FULL Set

One & 3-lines

- Reference **NOTES** where applicable
- Show all wiring, no “empty boxes”
- Utility Disconnect Switch Make, Model, Rating (non-fused) or (fused)
- System Meter FORM # and Rating
- Equipment Ratings
- Breaker/ Fuse ratings
- Represent panel as “All-in-One”, show multiple Bus’ and Mains, Show all ratings (Solar Ready Panel also)
- GEC and/or Building Steel
- Location of equipment when scattered among several buildings
- When there are multiple switches, label 1/x, 2/x, etc.



12/04/2009 - 27



Topics

Diagram Requirements – FULL Set

Site Plan

- North Arrow
- Road, Driveway, Parking, etc.
- Drawn, not Maps from Google, MSN, etc.
- Show all Equipment, Label with “Arrows” as it is referenced on the One & 3-Line
- Show APS Lock Boxes
- Reference Gated Community “codes”
- Reference Security Posts, or “front desks”

Plant Location

- Draw Simply, not Maps from Google, MSN, etc.
- North Arrow
- Reference Gated Community “codes”
- Reference Security Posts, or “front desks”
- APS Easements



12/04/2009 - 28

Topics

- ***Inverter –***

Proof of testing to the UL standard of 1741

- ***PV Modules –***

Proof of testing to the UL standard of 1703



12/04/2009 - 29

Topics

- ***Access – 24 hour***

- ***Dogs***

- ***Locked gates***

- ***Fences***

- ***Etc.***



12/04/2009 - 30

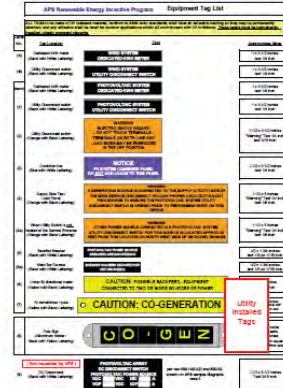
Topics

- **Labeling** - Several labels (engraved in plastic) are required per the NEC and APS to identify equipment or post warnings as to the presence of a power source.

[Don't have to follow colors]

Including but not limited to...

- * System Meter
- * Utility Disconnect Switch
- * Combiner Panel (AC)
- * Back-fed Breaker(s)
- * Location of System at SES
- * Main Breaker De-rate
- * 2008 NEC –
“... Do not relocate OCPD”
- * etc.



The image shows a table titled "APS Renewable Energy Incentive Program Equipment Tag List". The table lists various equipment types and their corresponding tag colors and symbols. A red box highlights a "CAUTION: CO-GENERATION" tag with a lightning bolt symbol. Below the table, there are several electrical symbols for different types of equipment, including a lightning bolt in a circle, a lightning bolt in a square, and a lightning bolt in a triangle.



12/04/2009 - 31

Topics

- **NEC 690.64**
“...(B) or not to (B), that is the question?”

This question is on the Residential Interconnection Application.

- **Load Side Connection [NEC 690.64(B)]**
7.68kW limit ~ 240V
 - * 200A service/200A Main
 - * 40A/2P backfed breaker

- **De-rate Main ?**

- **Facility size limitation (kWh, etc)**
including EPR-6 qualification 125% max demand



12/04/2009 - 32



Topics

- **Supply Side Connection [NEC 690.64 (A)]**

1. A line (supply) side tap constitutes a new service as defined by the National Electric Code (NEC), and is subject to all applicable NEC requirements and/or requirements adopted by the Authority Having Jurisdiction.

2. Any line side tap shall be made without any modifications to any factory installed and/or factory listed equipment or components, unless such tap is expressly authorized by the manufacturer and/or listing agency, and performed in strict accordance with the manufacturers directions and specifications.



Topics

- **Supply Side Connection [NEC 690.64 (A)]**

- **All-in-One : Letter from Manufacturer to modify panel bus**
- **Separate Meter Can / Load center ~ OH vs UG**

- **“Solar Ready” Panels ~ Verify they are on APS ESRM Pre-Approved List**

- **Load Side ~ N/A ?**



Topics

Grounding



- **GEC**
- **EGC**
- **EGC / GEC per 2008 NEC (w/ Grounding Bushings)**
- **Micro-Inverters (EGC from GEC)**



12/04/2009 - 35

Topics

Inspection

- *APS will inspect the system using the Documents and Diagrams supplied*
- **APS must inspect and approve any system connecting to the grid** prior to operation
~ whether applying for incentives or not.
- The inspector will simulate a loss of Utility power to ensure the system shuts down within one second.



12/04/2009 - 36



Topics

- *Gutter / Raceway – Separation*
- *Totalized Metering*
- *Network System*
- *Letter-in-Lieu*
- *Multiple installs behind a billing meter ~ (Master agreements / Schedules)*



12/04/2009 - 37



Topics

- *Single Phase Inverters – 3 Phase service*
- *“Open Delta” – 3 Phase service*
- *Inverters w/ no Neutral*
- *Sunny Island – battery back up*
- *Don’t switch grounded Conductors*



12/04/2009 - 38



Reference

Interconnections - Brian Driscoll, Larry Jones

Commercial – (602) 371-6160

Rick Welch, Gay Zerkel, Bryan Gernet , Kyle Woolfolk

Residential – (602) 328-1924

Scott Duplessis, Gary Ellars, Susan Lipe, Diane Maltis, Beth Pope



a better tomorrow
starts today

a better tomorrow
starts today

a better tomorrow
starts today

a better tomorrow
starts today

a better tomorrow
starts today

Questions ?

a better tomorrow
starts today

a better tomorrow
starts today

a better tomorrow
starts today

a better tomorrow
starts today

