



## SOLAR ENERGY SERVICES AS RELIABLE AS THE SUN



### **Owner/Operator Perspective on Reliability Customer Needs and Field Data**

***Sandia National Laboratories  
Utility-Scale Grid-Tied PV Inverter Reliability Technical  
Workshop, January 2011***

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# What we monitor/operate

## Monitored by SunEdison:

More than 400 projects totaling more than 230 MWp across the globe  
(USA, CAN, ITA, ESP, IND)

## Built *and* operated by SunEdison:

<i>Numbers are approximate</i>	Any inverter size	Inverter > 200 kWac
# of Systems	340	140
MWp	220	180
# of Inverters	1200	340
System-Years	700	260
Inverter-Years	1650	420

# Overview of service components



## SEEDS

SunEdison Energy & Environmental Data System

## Renewable Operations Center (ROC)

## Operations & Maintenance

## Billing & Reporting



- Maintain uptime
- Meet or exceed production targets
- Minimize O&M cost



- Energy consumer
- Investor & PPA provider
- PPA Provider



# Analysis of performance and service events

Energy &  
Monetary  
Impact

- unrealized production
- unrealized revenue
- service (truck-roll) cost

Failure Areas &  
Root Causes

- affected system component
- root cause

Continuous  
Improvement  
Process

- Feedback to
  - Engineering
  - Construction
  - Procurement
  - Finance
  - Vendors



# Two input sources for analysis

## 1. Continuous feeds from the SEEDS™ gateway

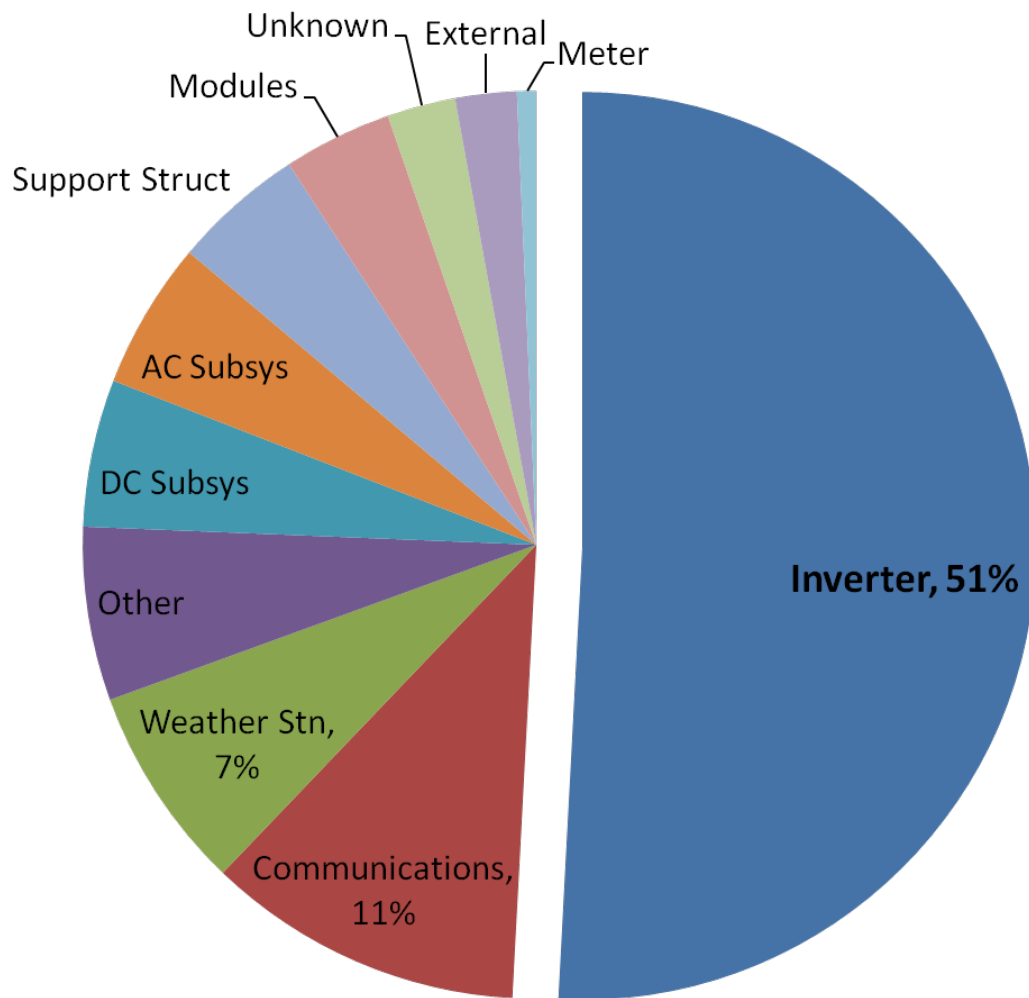
- » Meter feeds
- » Inverter feeds
- » Weather station feeds

## 2. Input from Field and ROC Service Technicians

- » Textual description of issue & resolution
- » Initial and final identification of
  - » Affected Area (General and Specific) -- *what*
  - » Root Cause (General and Specific) -- *why*

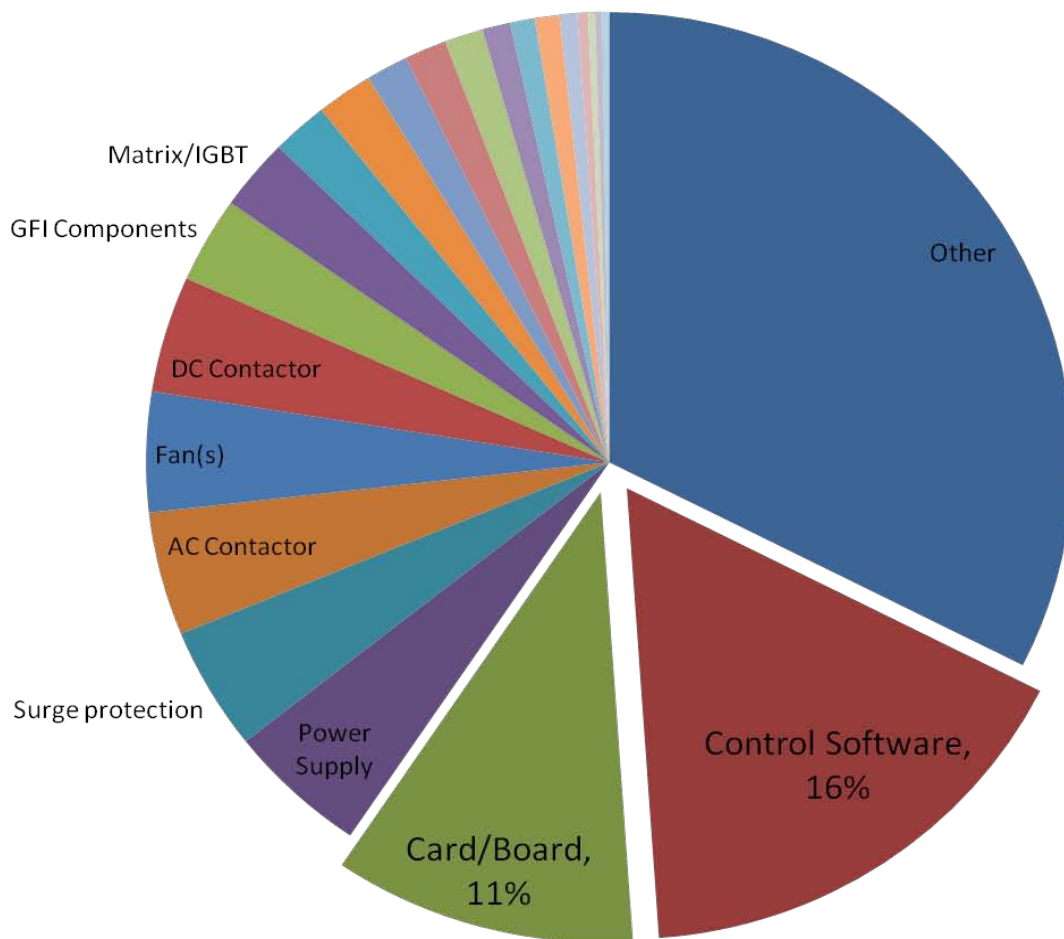


# Tickets per Affected Subsystem: 2008-2010



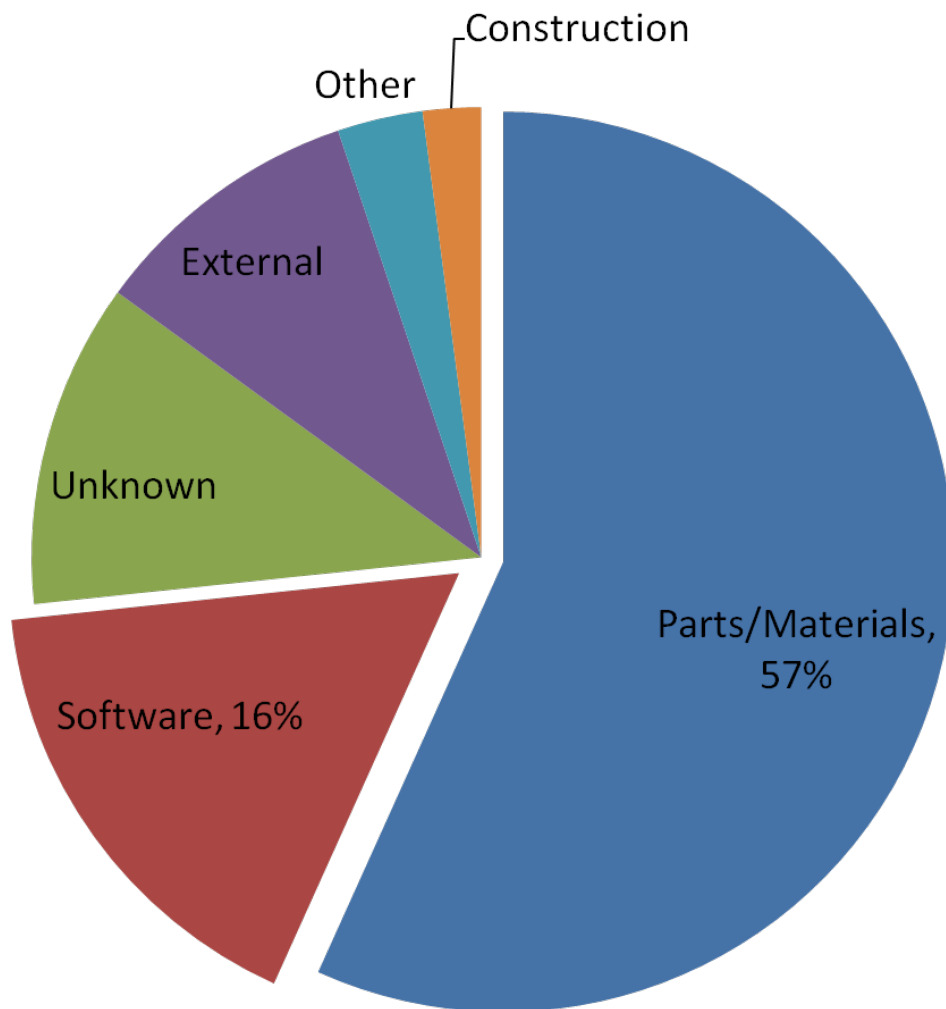


# Tickets per Affected Inverter Component: 2008-2010





# Inverter Tickets per Root Cause: 2008-2010

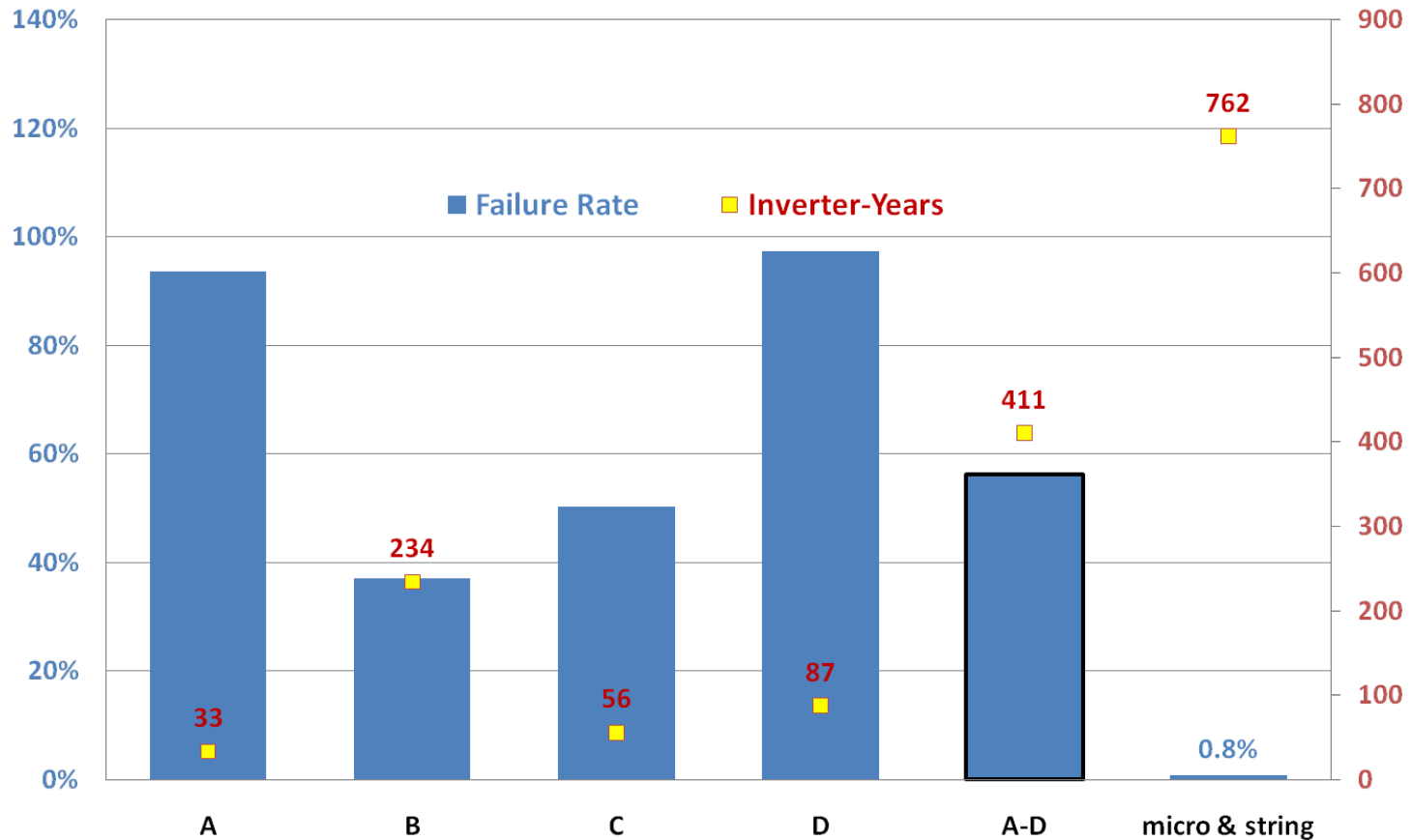






# Reliability as a function of architecture

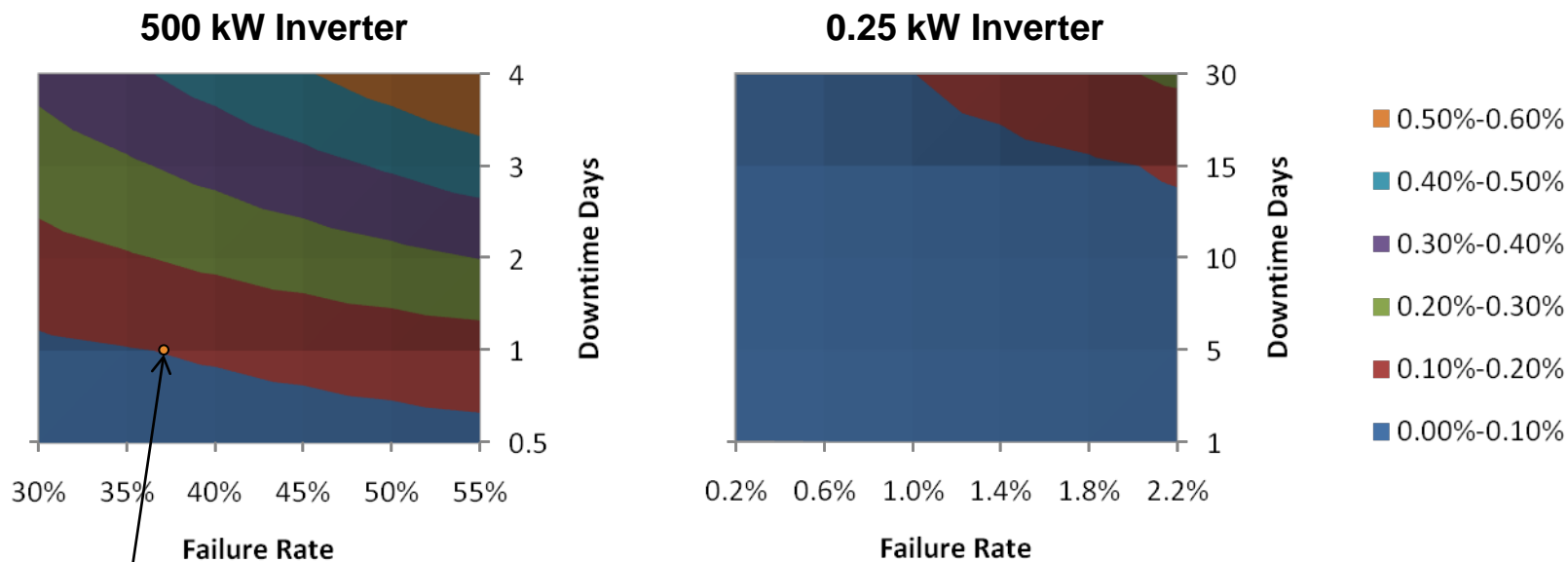
**Failure Rate & Inverter-Years**  
for 4 utility-scale inverter vendors and 2 micro/string inverter vendors  
*based on tickets with definitive affected area (no 'Other'/'Unknown')  
and root cause identified as 'Parts/Materials' or 'Vendor S/W'*





# Reliability, O&M schedule, Availability

Non-availability based on Failure Rates and Downtime for a 30 MWac plant



Plausible scenario for utility-scale plant based on current data



# Reliability, Availability and O&M Economics

**For a fleet owner/operator:**

## **Reliability = No reason for alerts**

- Every alert has to be dealt with
- Some alerts have to be acted upon via local presence (“truck roll”)

**Many S/W issues and some H/W issues can be resolved within the same day**

- Limited impact on availability and O&M cost (single “truck roll” for DG)

**Many H/W issues will require extended downtime and a repeat visit**

- High impact on availability and O&M cost (double “truck roll” for DG)

**DG is much more sensitive to reliability:**

**For constant availability**

**the O&M cost is determined by the frequency of serviceable alerts**



# Reliability and Inverter Procurement

**“Reliability at any cost” is not the answer**

**Traditionally, capital cost, including the warranty cost, has been the most important factor in the inverter procurement process**

**However, total cost of ownership, as reflected in the LCOE, is a more accurate metric, and includes the effect of the inverter reliability**

**Other factors that are important in selecting a vendor:**

- 1. Responsiveness**
- 2. Established Quality Systems**
- 3. Engagement in Continuous Improvement Procedures**
- 4. Flexibility in Service Agreements**
- 5. Support in Communications Development**



## Conclusions

- **“Central” or “Utility-scale” inverters: most frequently impacted subsystem**
- **PCB subassemblies and Software/Firmware: most frequent culprits**
  - better quality control of components and assembly processes
  - more thorough debugging
  - more effective test platforms(\*) and methodologies
- **Frequency of events (“tickets”) impacts economics in addition to availability**
- **Operators and Vendors need to engage in Continuous Improvement across the supply chain**

(\*) SunEdison may authorize physical and remote access to vendors' units under well-specified attack plans