

# PV INVERTERS – THE OTHER HALF OF A PV SYSTEM (PART II)



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**1**

**What different inverter technologies are available?**

**2**

**What applications is each inverter technology best suited for?**

**3**

**Reliability of PV inverters**

**4**

**Questions**



# WHO OR WHAT IS SMA?



Best  
**efficiency** worldwide

**99%**

Global manufacturer of

**inverters**

More than **1,000**  
professionals

**in R&D**

Founded in Germany

**1981**

**Over 41 GW SMA**

installed globally

Sales 2015 (exp)

**€975 million**

**1 in 3** inverters on the planet is SMA

**1 in 4** inverters in Australia is SMA



WHAT DOES SMA STAND FOR?

# System Mess Anlagentechnik

Computer Control +  
Measuring Technology +  
Plant System Technology



1981



1988



1990



2008

# GLOBAL #1 FOR SOLAR INVERTERS FOR OVER TWO DECADES



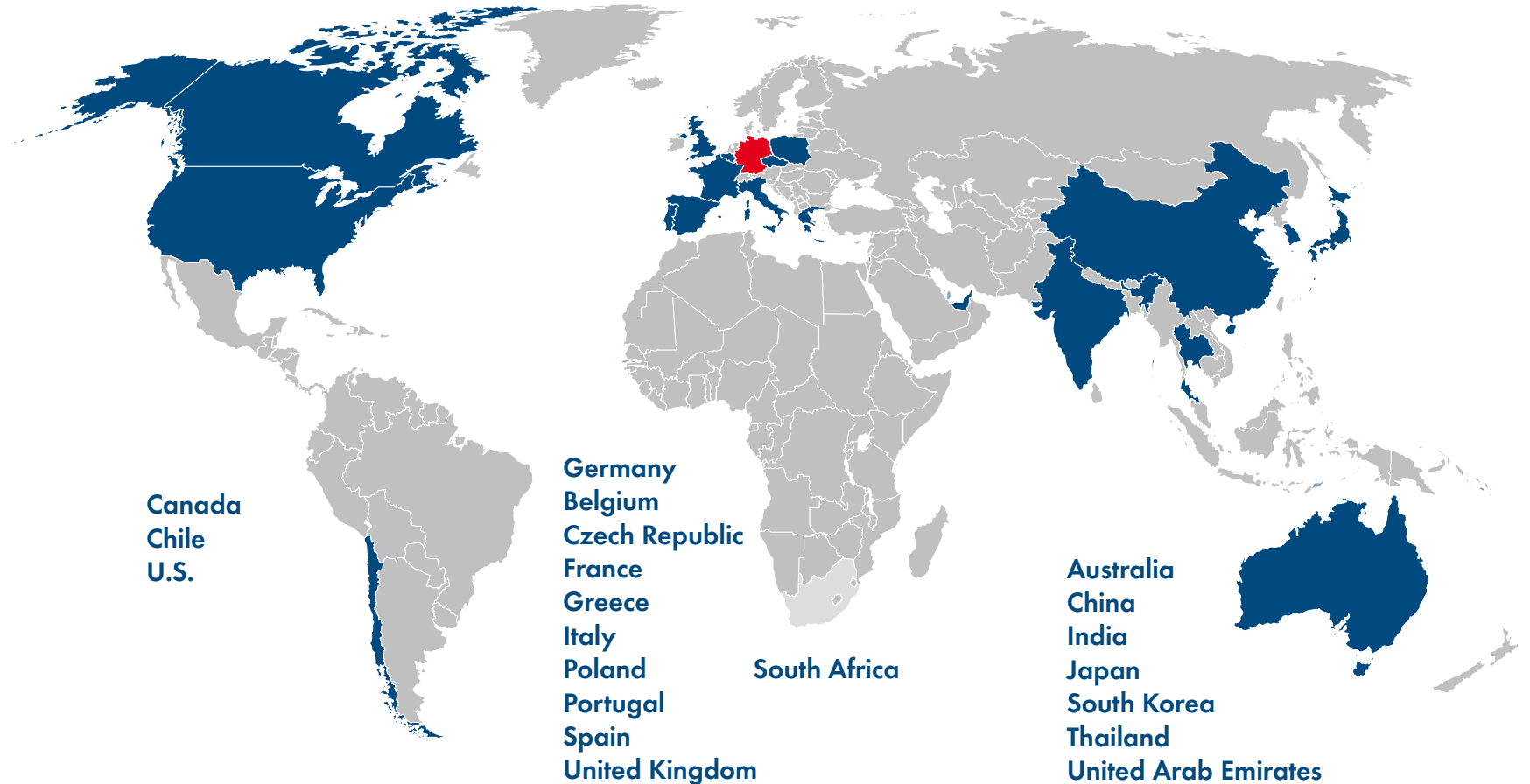
## Unmatched product and service portfolio and global presence

- > Over 30 years of experience
- > Innovative solutions and strong system know how in grid management and storage
- > Key technologies for the energy transition
- > Complete product range, proven technology and game-changing new products
- > Global presence with strong sales and service infrastructure and local networks
- > Service excellence



- > **SMA is the only specialized PV manufacturer with a complete portfolio, global reach and a high innovation rate with 21 new products introduced in 2014 alone.**

# STRONG PRESENCE IN 21 COUNTRIES ALL OVER THE GLOBE



> More than 41 gigawatts installed SMA inverter power worldwide.





# RECAP FROM PREVIOUS SPREE SEMINAR

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- > Main tasks of a PV inverter (MPPT and Sine-wave, Autonomous or Synchronised)
- > PV Inverter Efficiency (how its defined, what's typical)
- > Mass Production of PV Inverters (how, what, when, where)
- > Development of inverter technology over past 25 years  
(Transformer, Power classes, Power Electronics, Transformerless)
- > Inverter functionality to facilitate Smart Grid
- > **Watch previous seminar here:**

<https://www.youtube.com/watch?v=hrdVuV5plno>



# WHAT DIFFERENT INVERTER TECHNOLOGIES ARE AVAILABLE?

# WHAT ARE THE DIFFERENT TYPES OF INVERTERS?



	Residential	Commercial	Utility
On Grid	 	 	 
Off Grid	 	 	 

# WHAT ARE THE DIFFERENT TYPES OF INVERTERS?



## MICRO

- > Each PV module is connected to its own inverter and MPP tracked
- > Alternate is DC optimiser (fewer components) with string inverter
- > Power range < 300W



## STRING

- > PV modules series connected (PV String) then connected to inverter
- > String is MPP tracked, Multiple string inputs and MPP trackers
- > Power range 1.5kW  $\Rightarrow$   $\sim$  60kW



## CENTRAL

- > Multiple PV strings connected in parallel, normally to single MPP tracker
- > High Voltage DC input
- > Power range  $\sim$  0.5MW  $\Rightarrow$  2.5MW

# WHAT APPLICATIONS IS EACH INVERTER TECHNOLOGY BEST SUITED FOR?

# MICRO INVERTERS

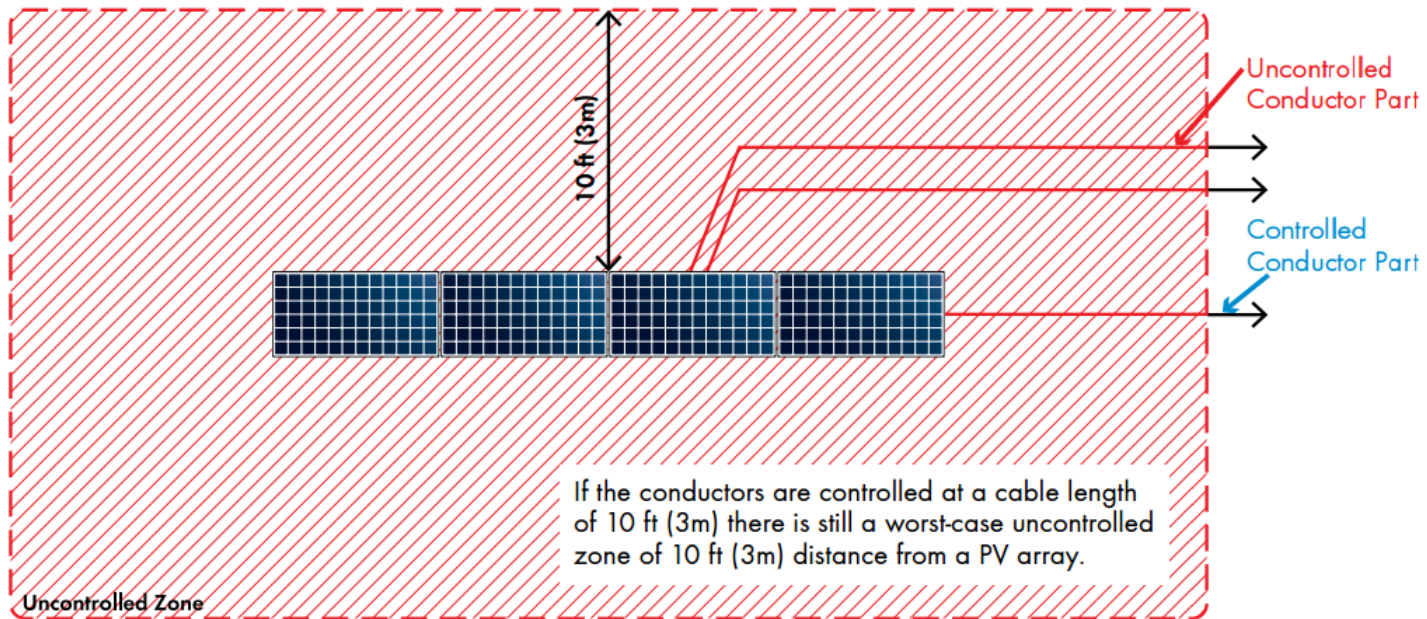


# APPLICATIONS SUITED FOR MICRO INVERTERS



> Regulatory landscape / DC voltage risk issues

- USA, NEC section 690.12





# APPLICATIONS SUITED FOR MICRO INVERTERS



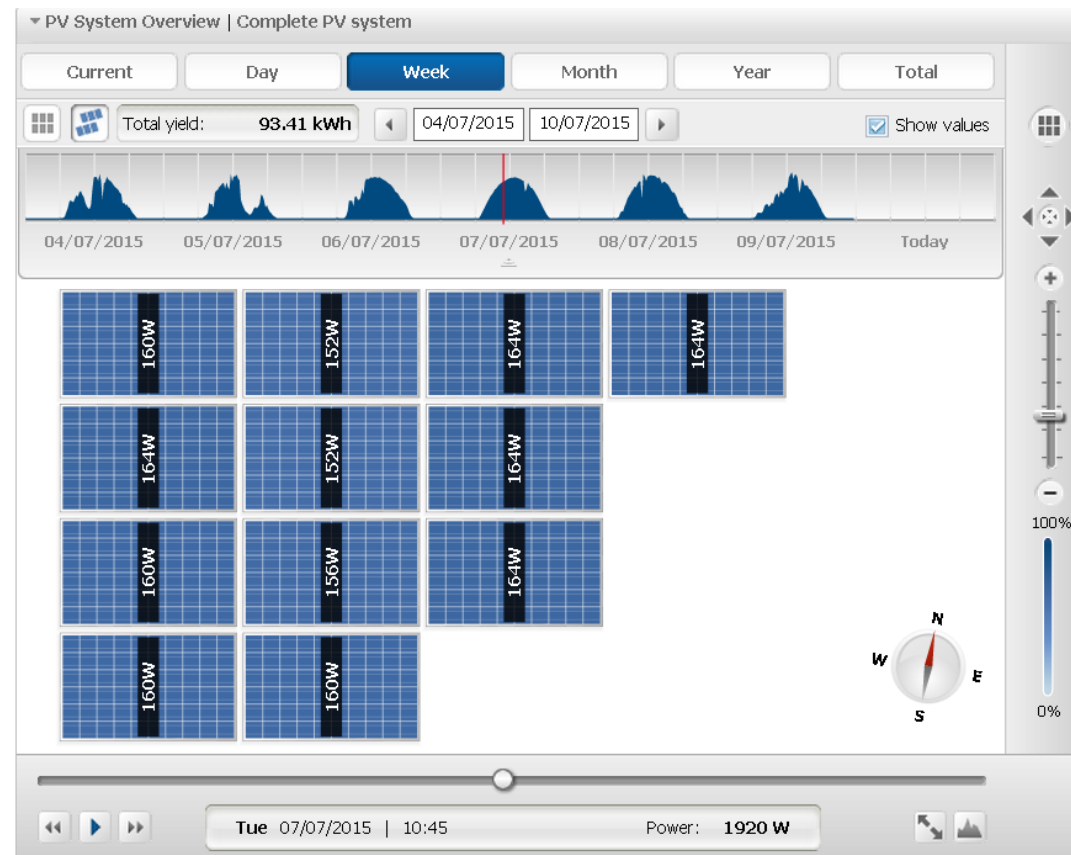
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- > Difficult roof structures
  - Separated strings, non-uniform array planes



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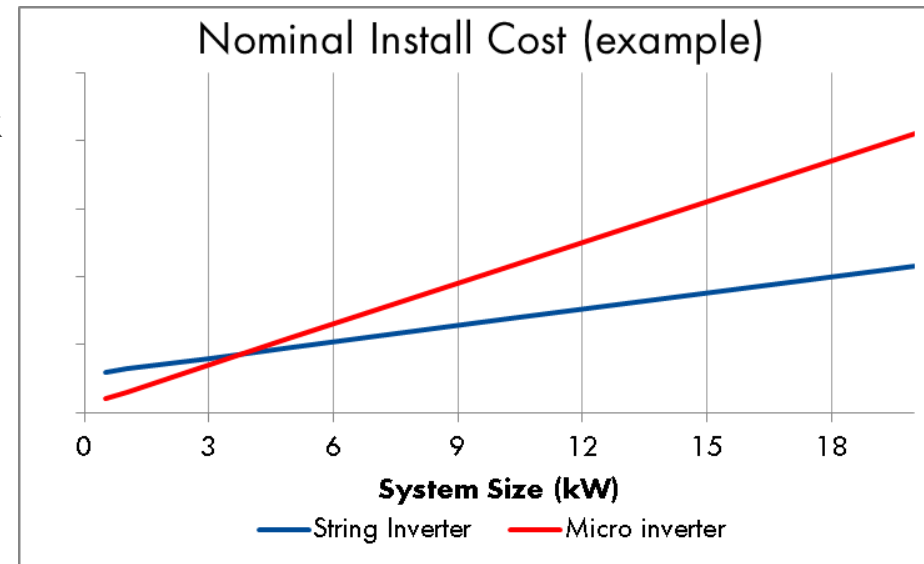
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- > PV panel level monitoring
  - Product differentiation, commissioning validation



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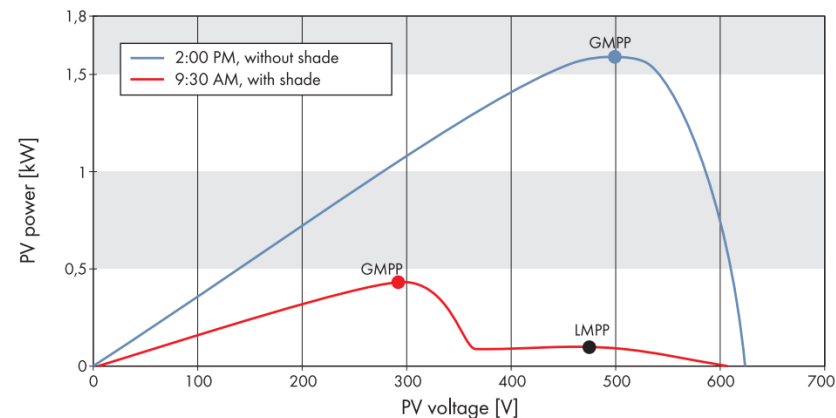
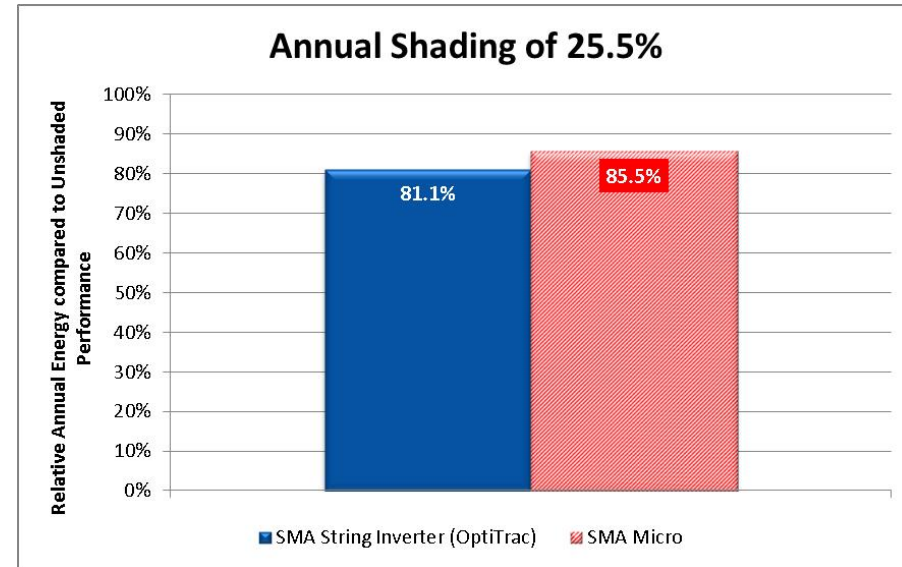
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  - Reduction of some components, increasing risk with larger systems



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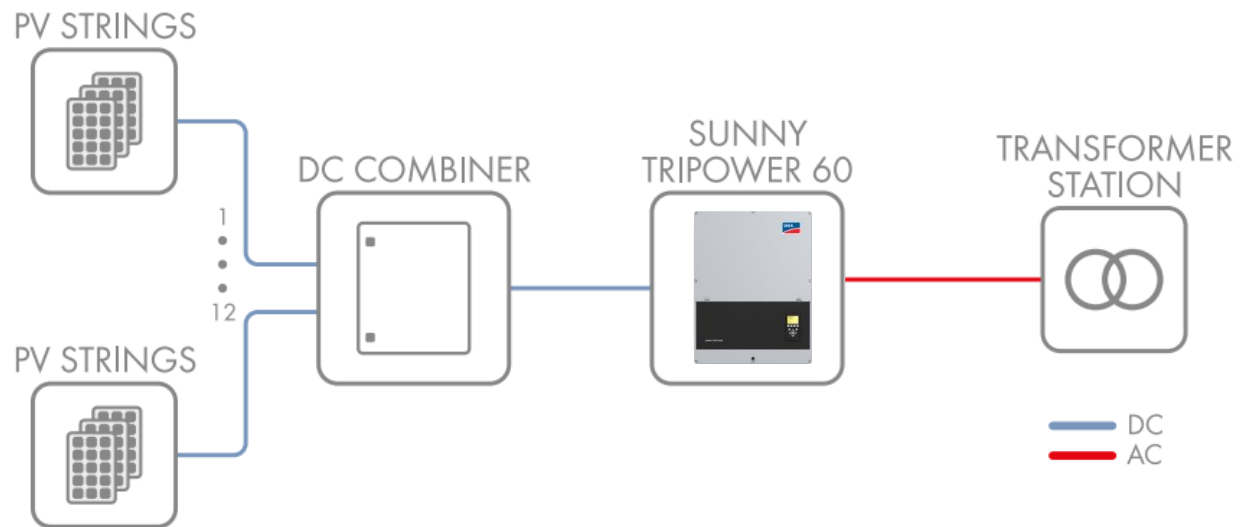
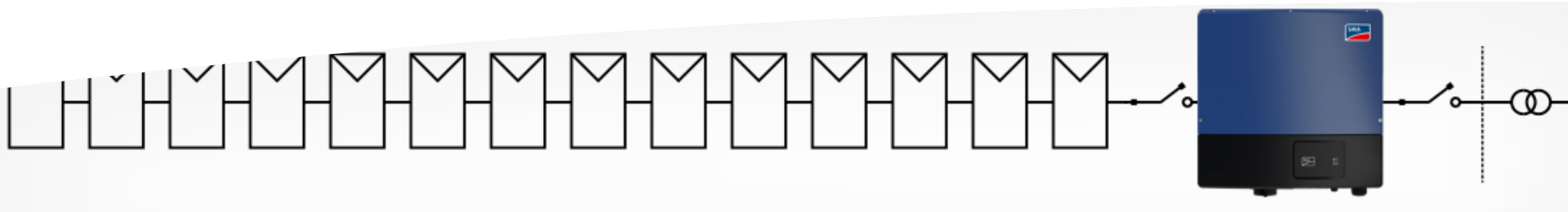
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- > PV panel level monitoring
  - Product differentiation, commissioning validation
- > Smaller PV systems
  - Reduction of some components, increasing risk with larger systems
- > Heavy shading
  - Greater than 25% fixed annual shade (*but should you really install solar in the shade?*)  
<https://www.youtube.com/watch?v=bxli4GiZakE>



GMPP: Global Maximum Power Point, LMPP: Local Maximum Power Point

> Cost will typically result in the lowest \$/kWh and risk for a micro system below 3-4kWp (varying)

# STRING INVERTERS

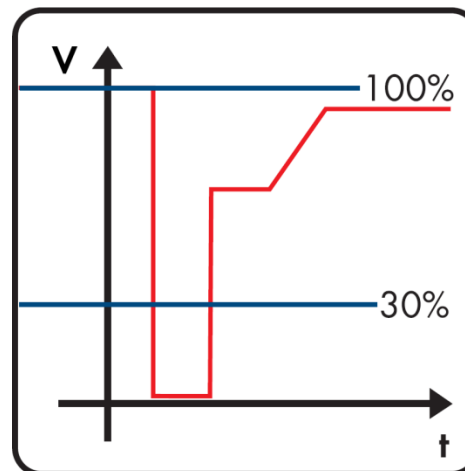
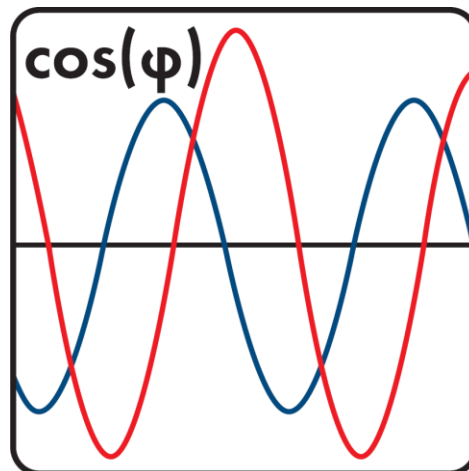
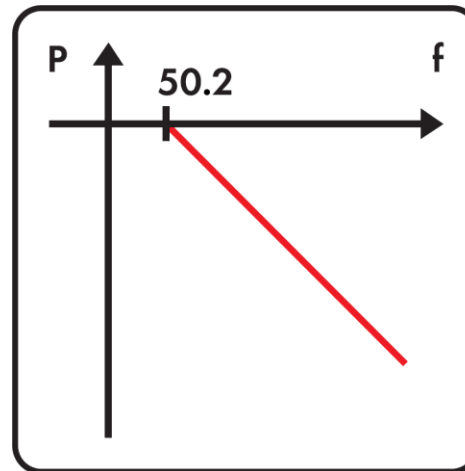
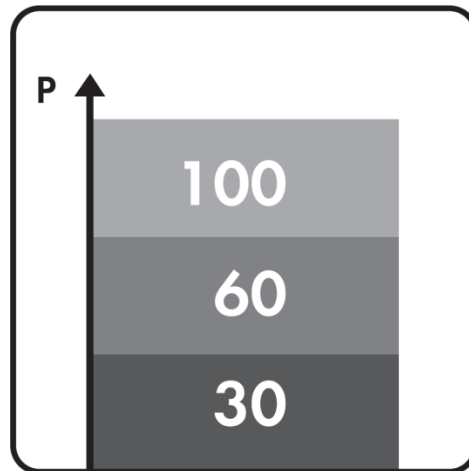


# APPLICATIONS SUITED FOR STRING INVERTERS



## > Grid Support

- Volt/VAR, Cos( $\varphi$ ), Static; Dynamic; On-demand



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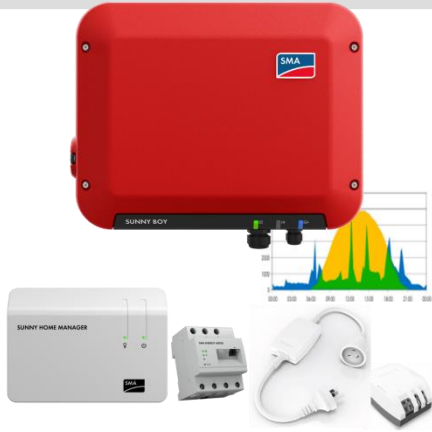



## > Grid Support

- Volt/VAR, Cos( $\varphi$ ), Static; Dynamic; On-demand

## > Larger Residential systems

- Battery back up, Smart Home

Solar System + Load Automation	Solar System + Backup Storage
Load Automation	Inverter & battery inverter
	

# APPLICATIONS SUITED FOR STRING INVERTERS



## > Grid Support

- Volt/VAR,  $\text{Cos}(\varphi)$ , Static; Dynamic; On-demand

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## > Commercial PV systems

- 10kW<sub>p</sub> up to 5MW<sub>p</sub>

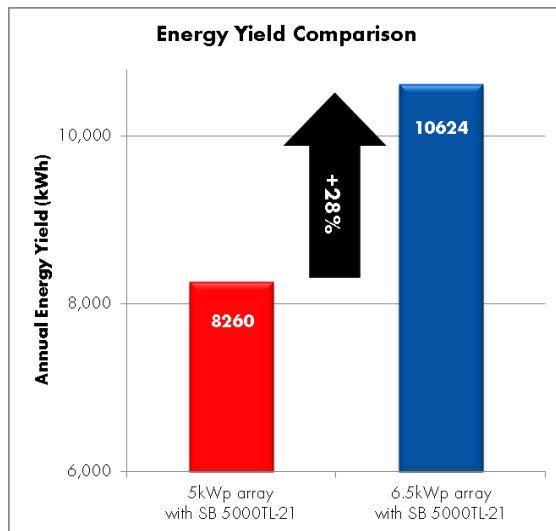
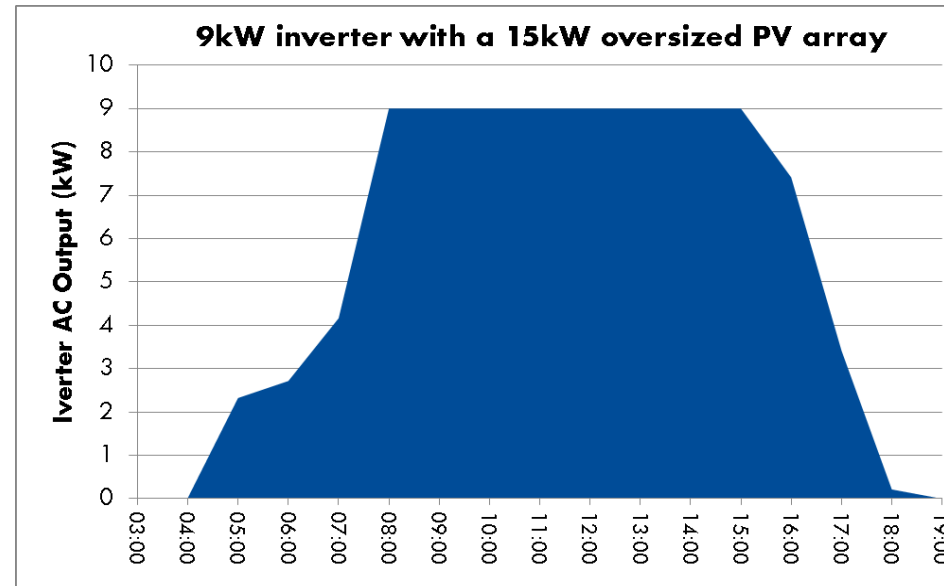




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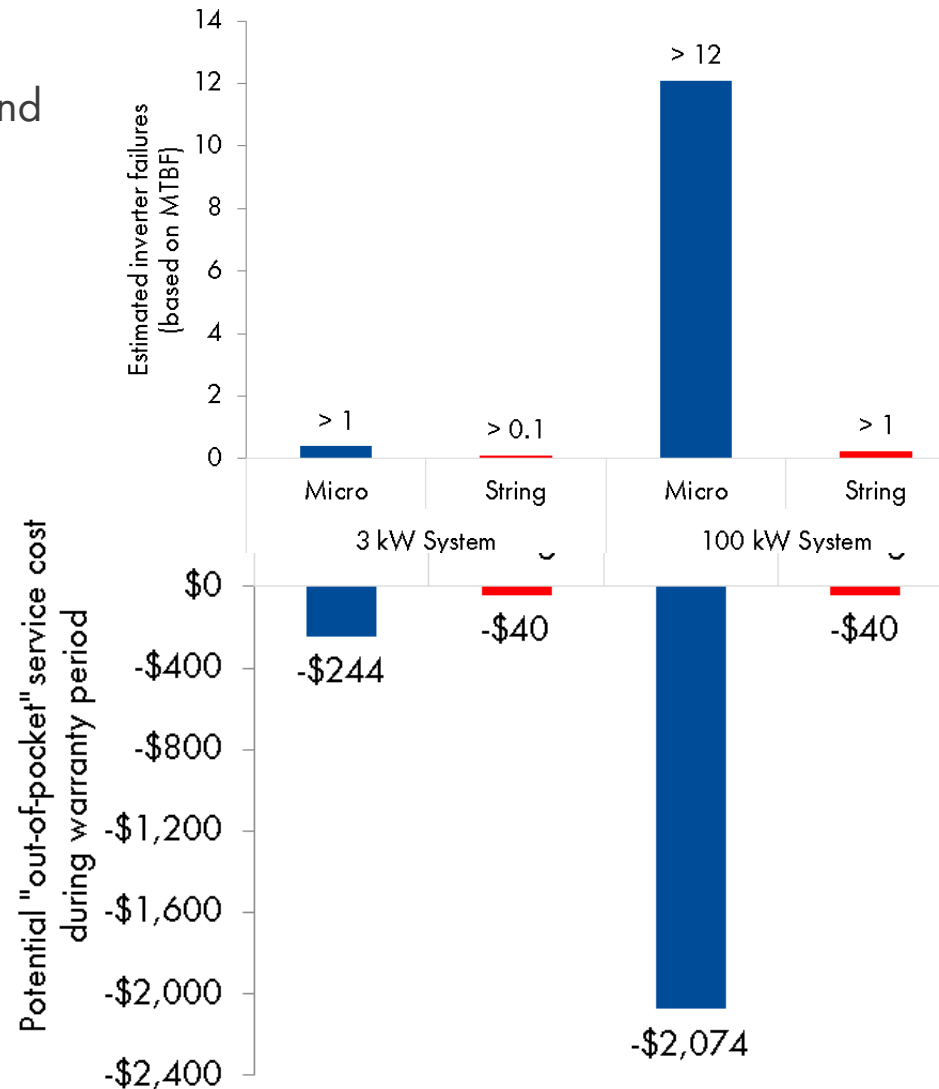
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  - Improving the utilisation of a plant,  $\downarrow$  \$/kWh



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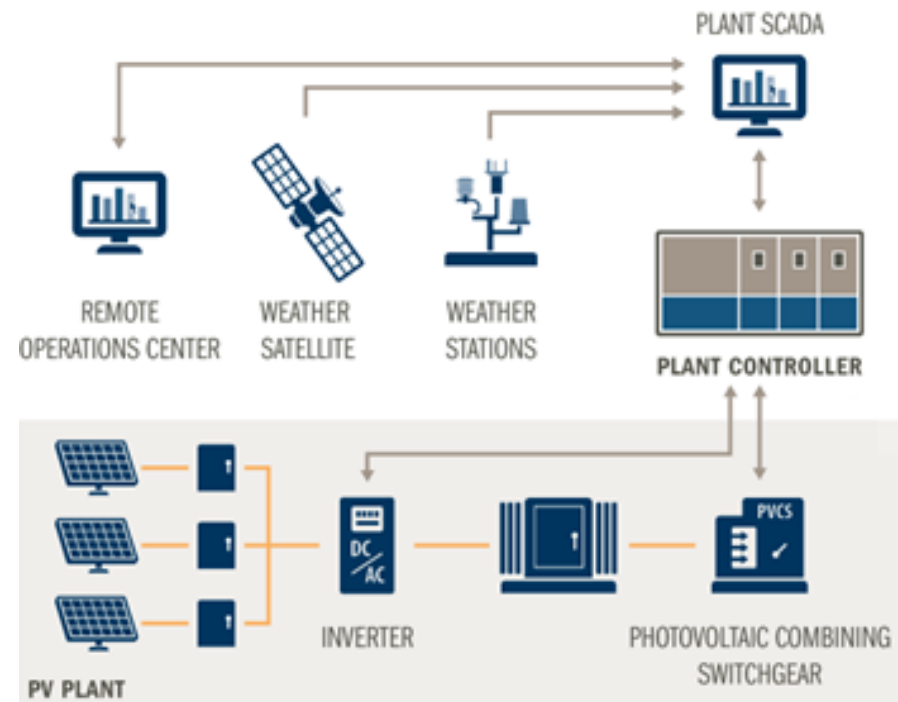
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  - MTBF dependant on # of components
  - Service cost dominated by onsite labour



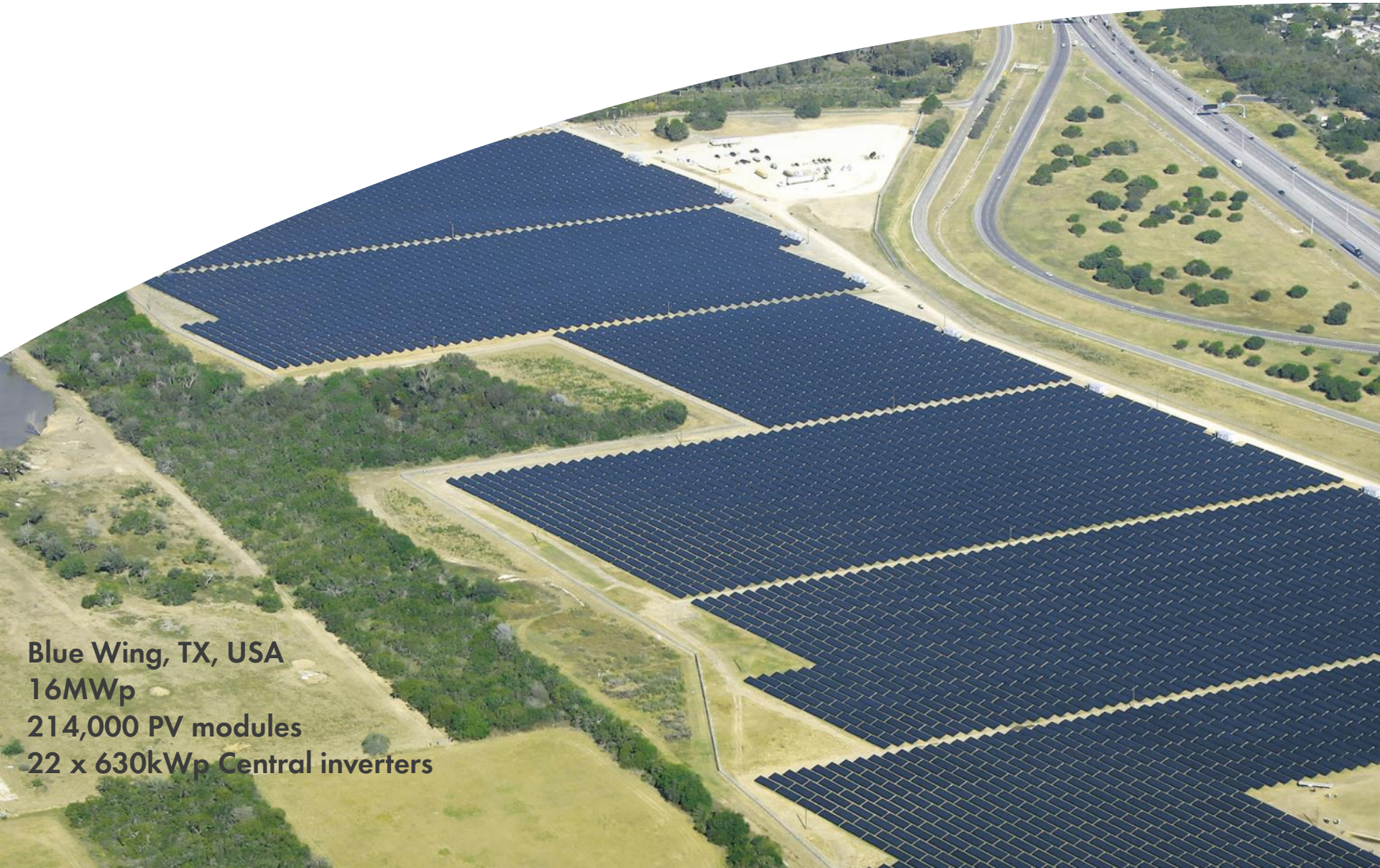
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  - MTBF dependant on # of components
  - Service cost dominated by onsite labour
- > Grid network SCADA integration
- > **Globally, once a system size exceeds 10kWp, string inverters are preferred until Utility scale PV plants**



# CENTRAL INVERTERS



Blue Wing, TX, USA  
16MWp  
214,000 PV modules  
22 x 630kWp Central inverters

# APPLICATIONS SUITED FOR CENTRAL INVERTERS



> Large PV systems / Utility scale Power Plants

- Greater than 5MWp



Greenough River, WA, AU  
10MWp  
150,000 PV panels  
16 x 720kW central inverters

# APPLICATIONS SUITED FOR CENTRAL INVERTERS



> Large PV systems / Utility scale Power Plants

- Greater than 5MWp
- to over 600MWp



Antelope Valley, CA, USA

579MW

1,720,000 PV panels

Over 600 inverters

# APPLICATIONS SUITED FOR CENTRAL INVERTERS

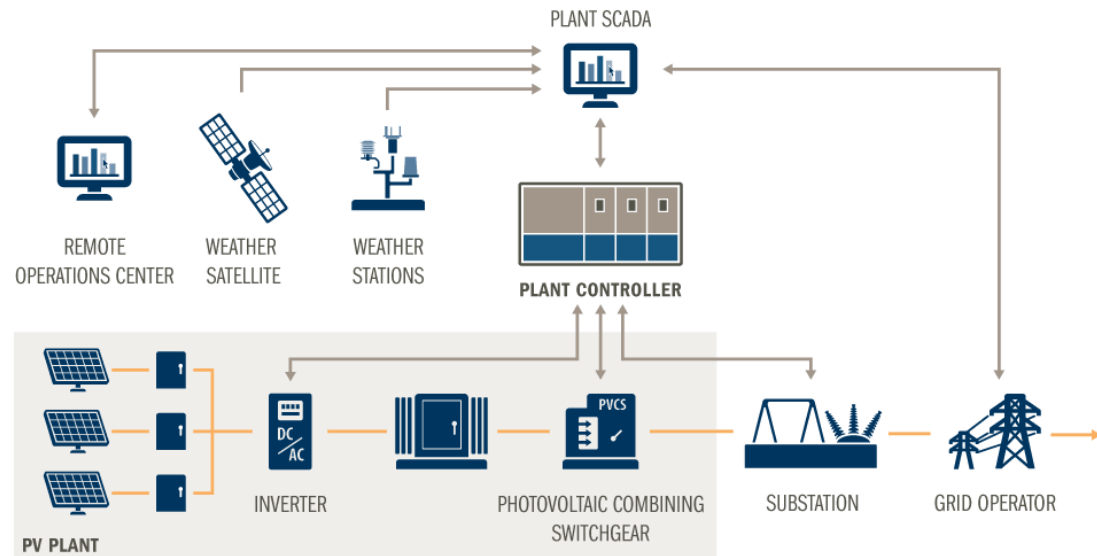


> Large PV systems / Utility scale Power Plants

- Greater than 5MWp
- to over 600MWp

> Grid network SCADA integration

- Full plant control / scheduling



# APPLICATIONS SUITED FOR CENTRAL INVERTERS



## > Large PV systems / Utility scale Power Plants

- Greater than 5MWp
- to over 600MWp

## > Grid network SCADA integration

- Full plant control / scheduling

## > Plant solutions

- Inverter, Transformer, Switchgear
- Certified for Arc Flash

> **Utility scale & very large Commercial PV plants make up the greatest proportion of Solar installed globally to date (expected to continue)**







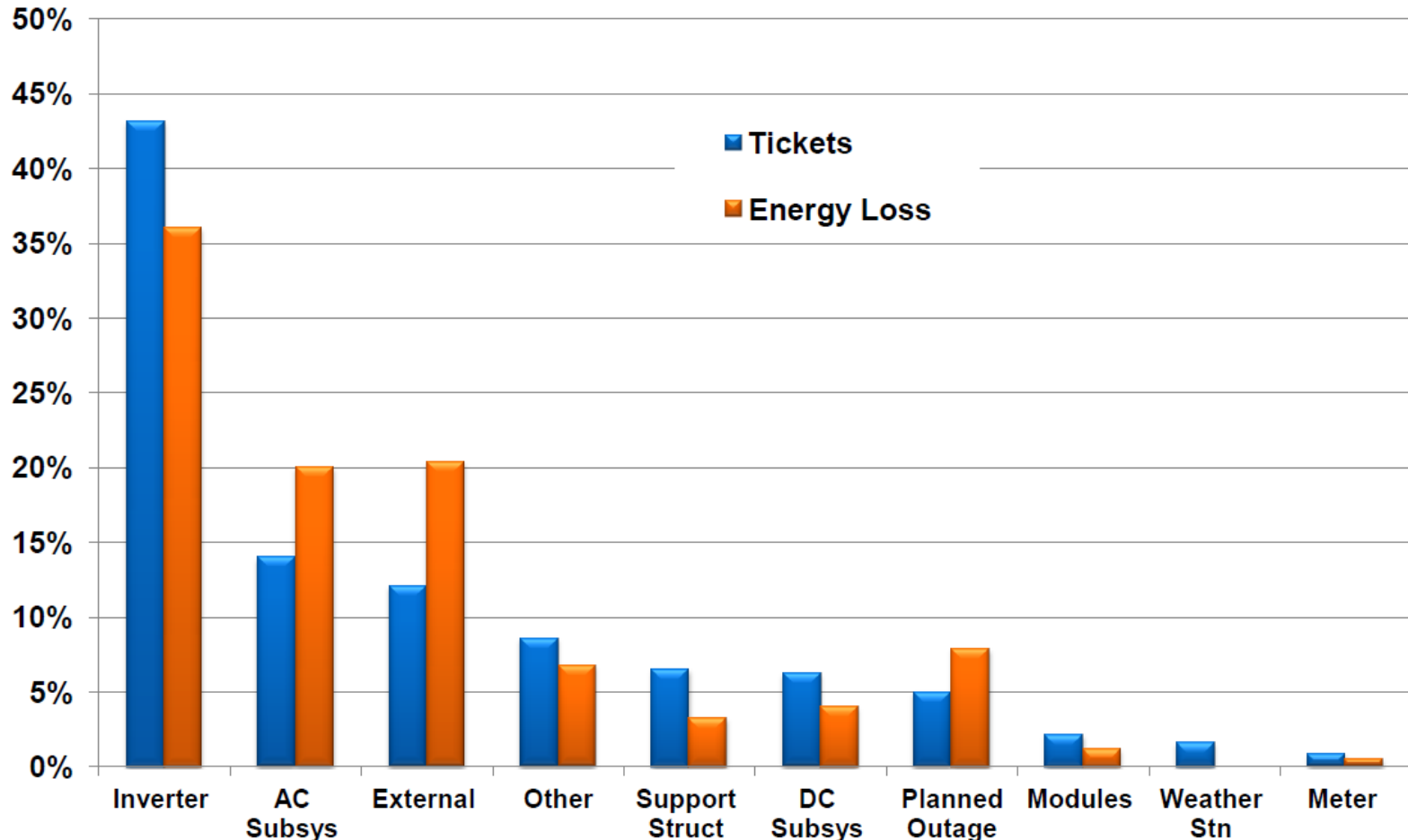
# RELIABILITY OF PV INVERTERS



# 3<sup>rd</sup> Party PV Plant Operator Experience & Data

# RELIABILITY OF PV INVERTERS

Frequency of Tickets & Associated Energy Loss for each General Failure Area



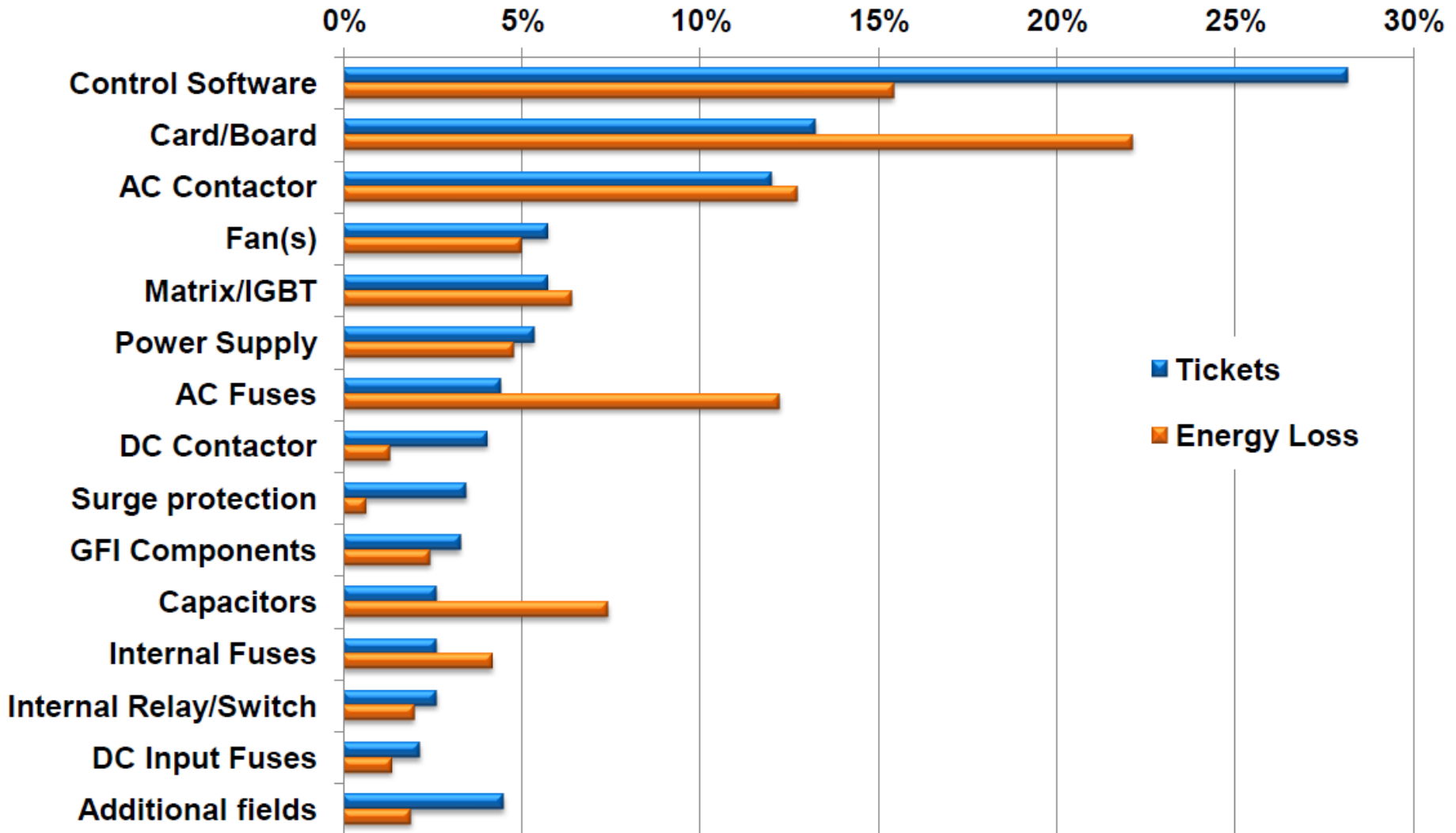
A. Golnas, June 2012

> Golnas, A, "PV System Reliability: An Operator's Perspective", IEEE Journal of Photovoltaics, Vol 3, Issue 1, pg 416-421, 2013

> Energy lost due to all tickets is estimated at  $\leq 1\%$  of total potential energy generation

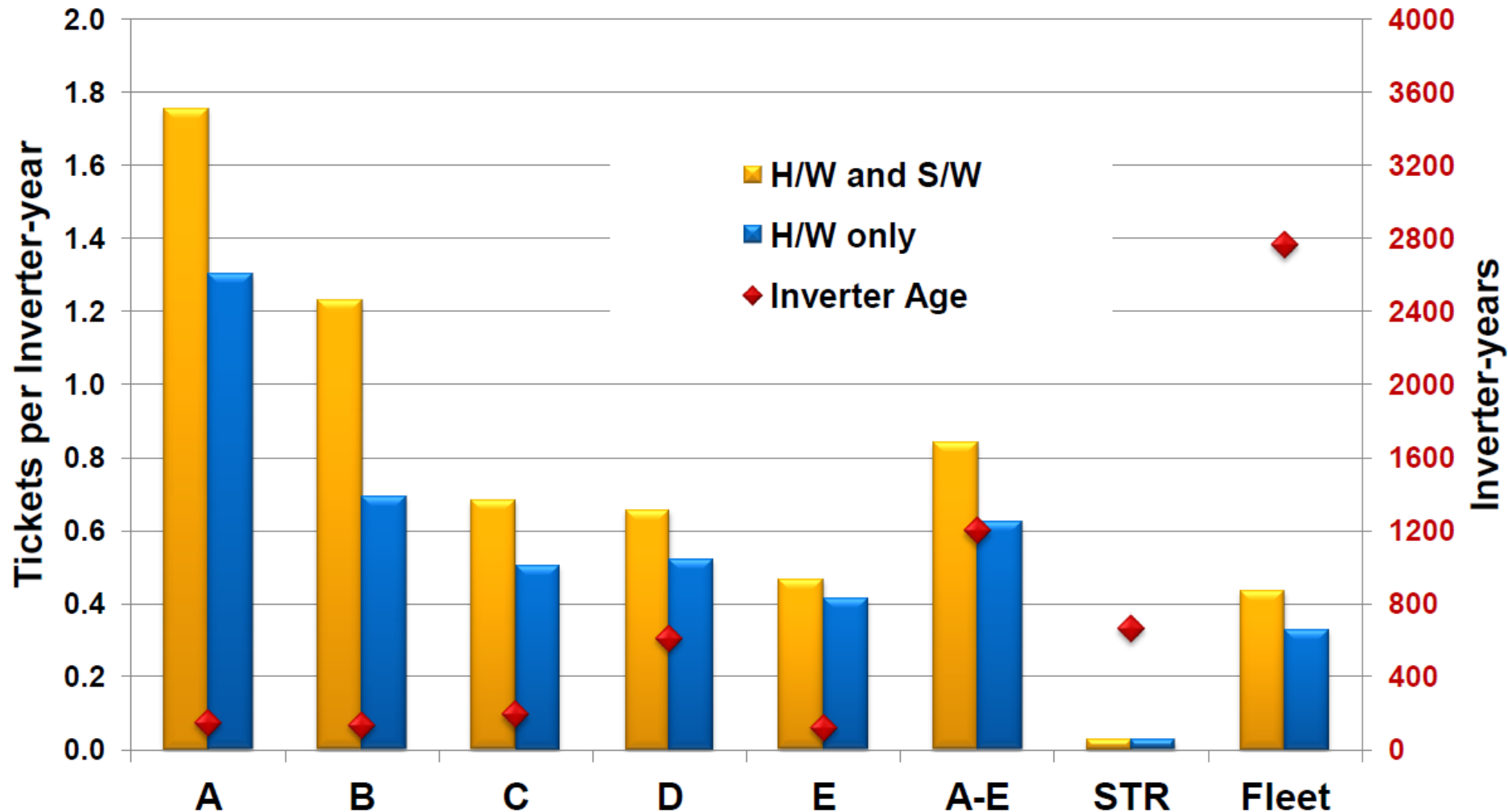
# RELIABILITY OF PV INVERTERS

Frequency of Inverter Tickets & Associated Energy Loss by Component



# RELIABILITY OF PV INVERTERS

Tickets per inverter-year for 5 central inverter manufacturers (A-E) and a string-inverter (STR) vendor

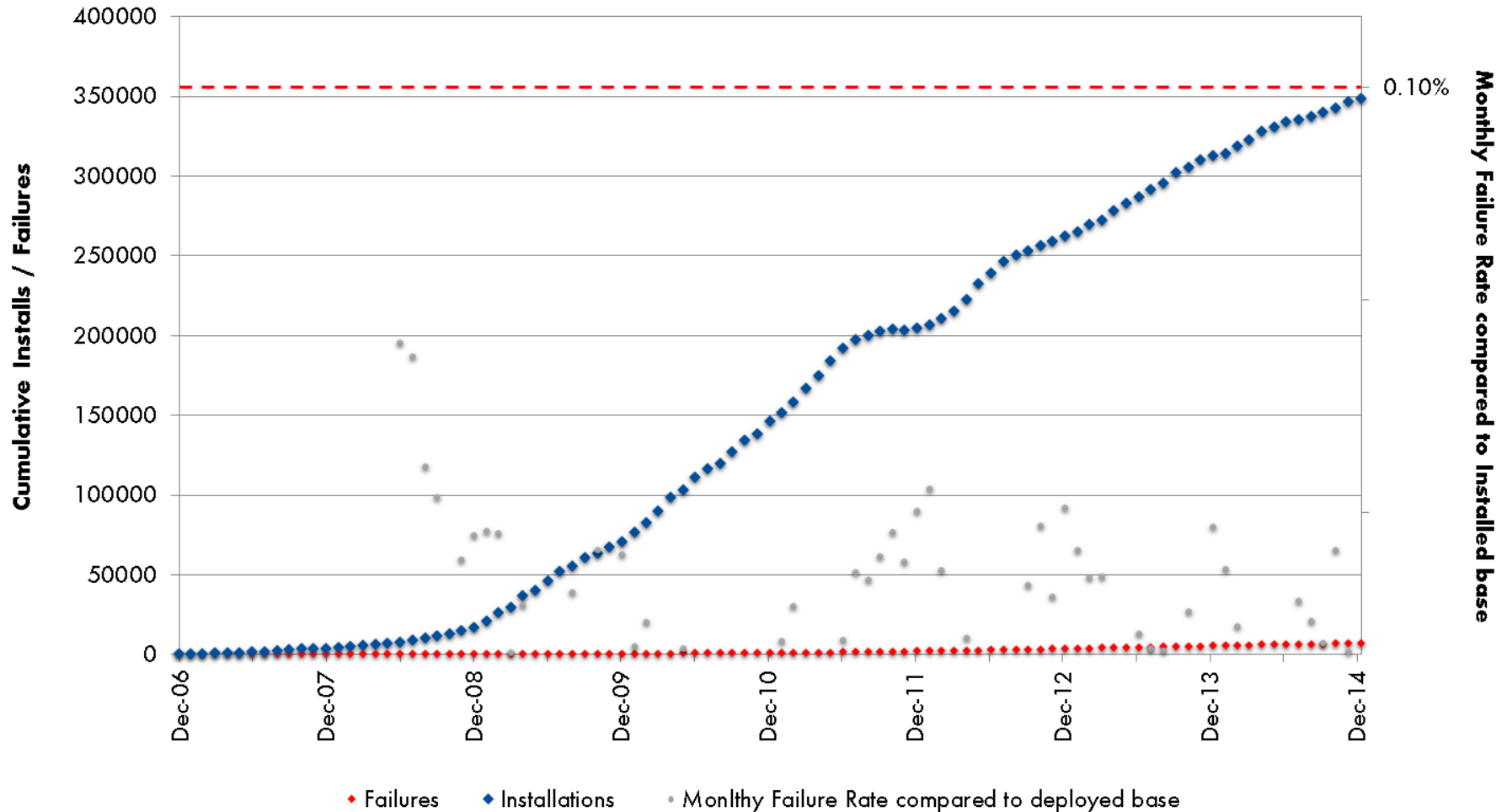




# SMA Australia Experience & Data

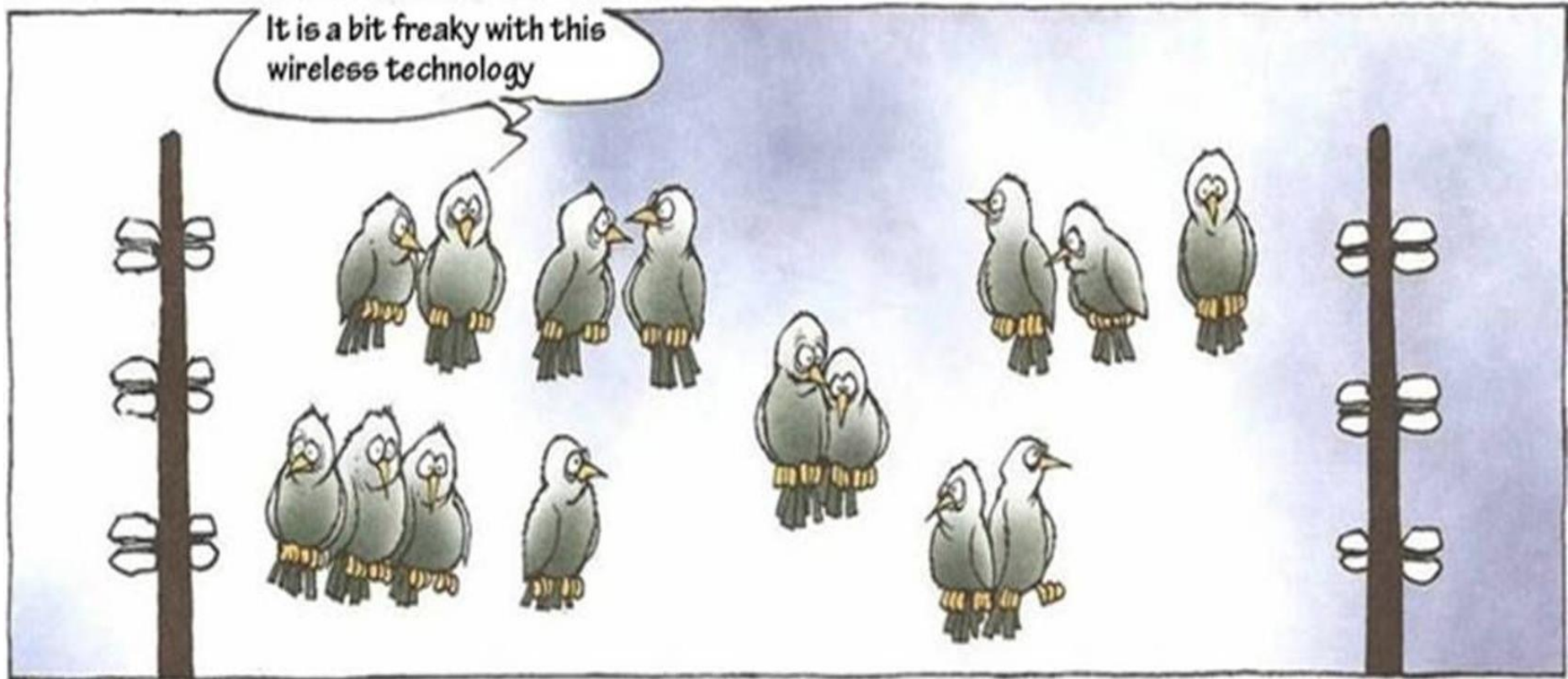


## Installations & Failures



> Not all warranty failures are “real” warranty failures

> New products typically see slight increases in failure rates un-related to “infant failures”  
(installation error, but cost absorbed due to premium brand and customer experience)



It is a bit freaky with this wireless technology

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QUESTIONS?

ENERGY  
THAT  
CHANGES



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