

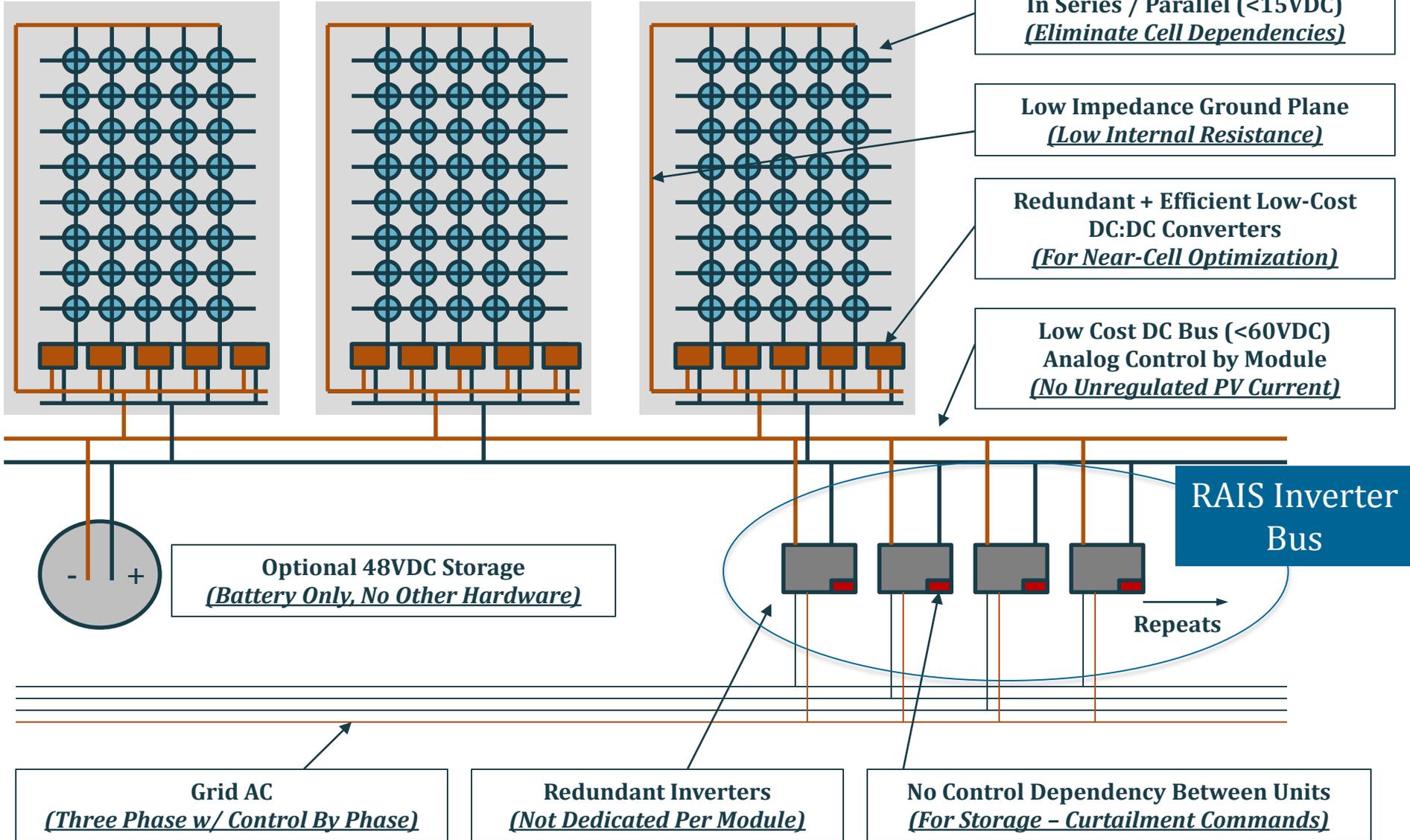
Highly Redundant Inverter Architecture

Tim Johnson

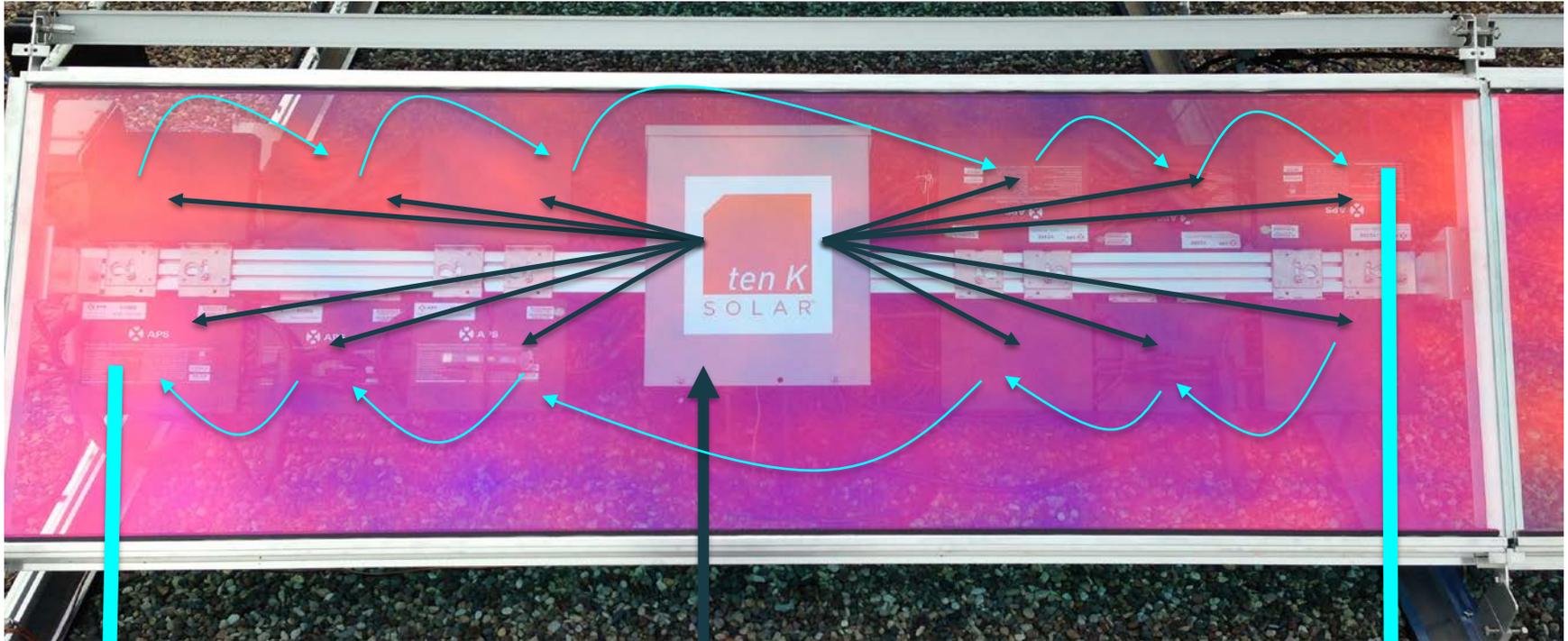


A Highly Redundant, Low-Voltage Solar Topology

Modules ($V_{oc}=0, J_{sc}=0$)
Redundant, Parallel DC Output



RAIS Inverter Bus



AC Out

DC In

AC Out



RAIS Inverter Bus: Unparalleled Inverter Reliability

Redundant Power Sharing Shatters Traditional Limits of DC/AC Reliability



500W and 1000W small inverters at low 50V bus voltage.

AC Power combines in 36 KW 3Φ blocks,
Very very low cost rooftop electrical installation

All units share load, only power on as Needed. Duty cycle cut by ½.

Inverters are warranted for 25 years, run cooler and ½ the time on the tenK bus. Shared power bus design means any individual failure has nearly no impact on output.



Parallel, But No Comm Between Devices

System Response Shown to Left

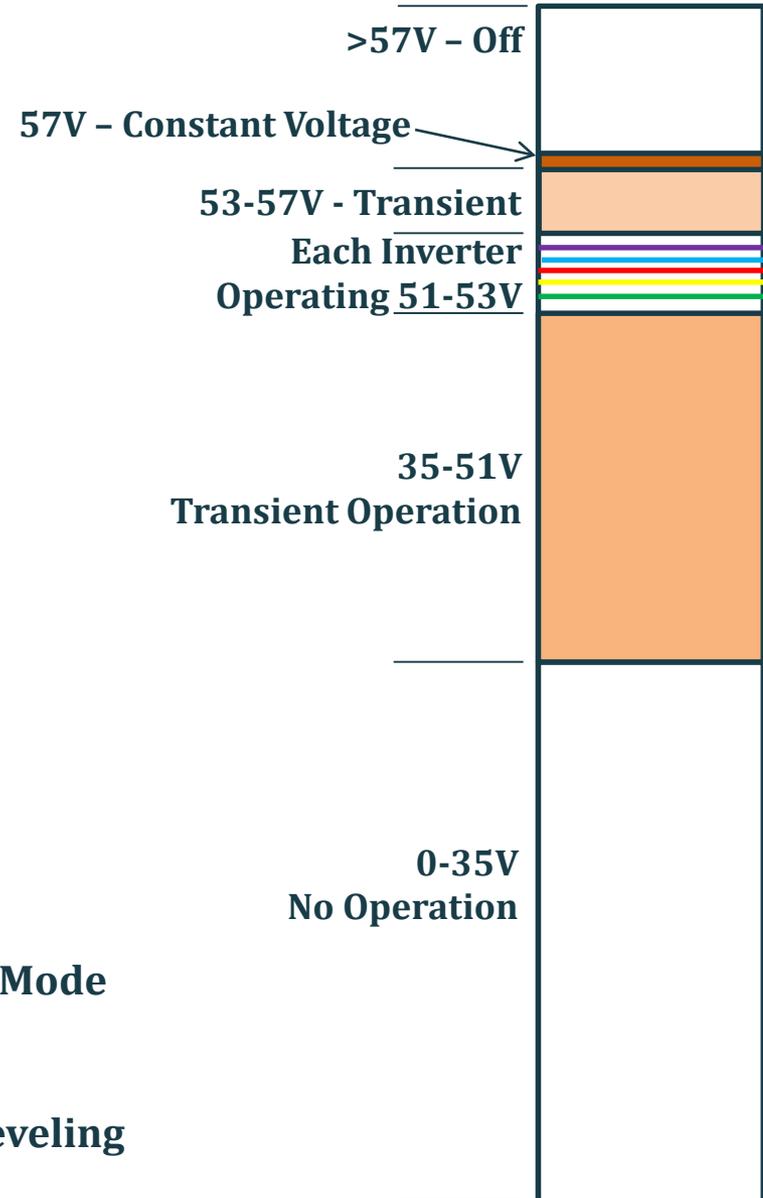
**Modules Self-Start in AM
Push System Voltage to 57V**

**One of Inverters on Bus
Lowest Voltage Setpoint of Group
Pulls Current From Bus
System Voltage Falls to Setpoint**

**Once First Inverter Reaches Limit
System Voltage Rises Slightly
Second Inverter Starts - New Setpoint**

**Repeats For Each Inverter Until All At Max
System Voltage Rises to 57V
Some Modules Drop Into Constant Voltage Mode
System Holds at 57V**

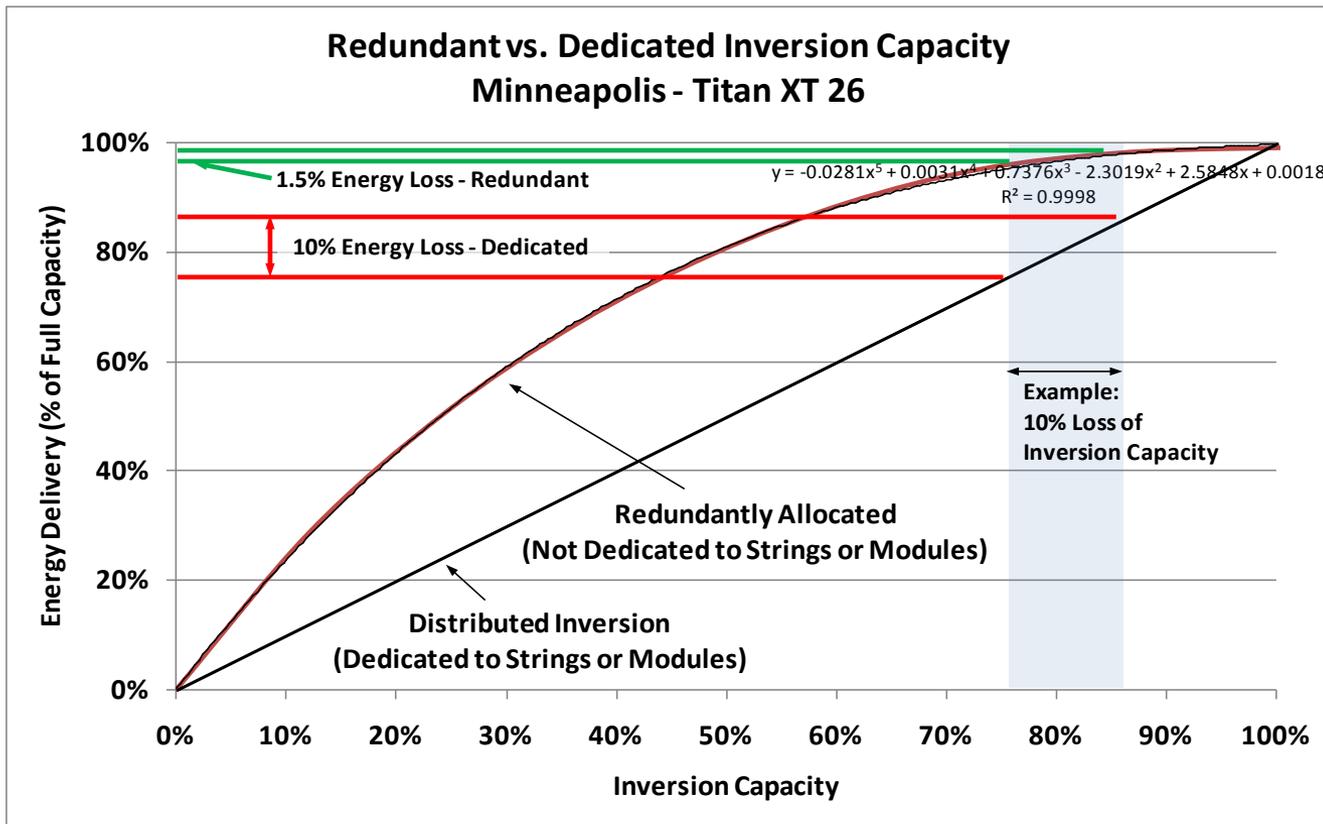
Randomize Inverter Setpoints Daily for Wear Leveling



Effect of Redundancy

First Consider Energy Loss Curve In Solar
(i.e., Energy Delivery vs. Inversion Capacity)

Shared power bus design means any individual failure has nearly no impact on output. Result → 88% or > energy guaranteed from system after 20 years with no maintenance.



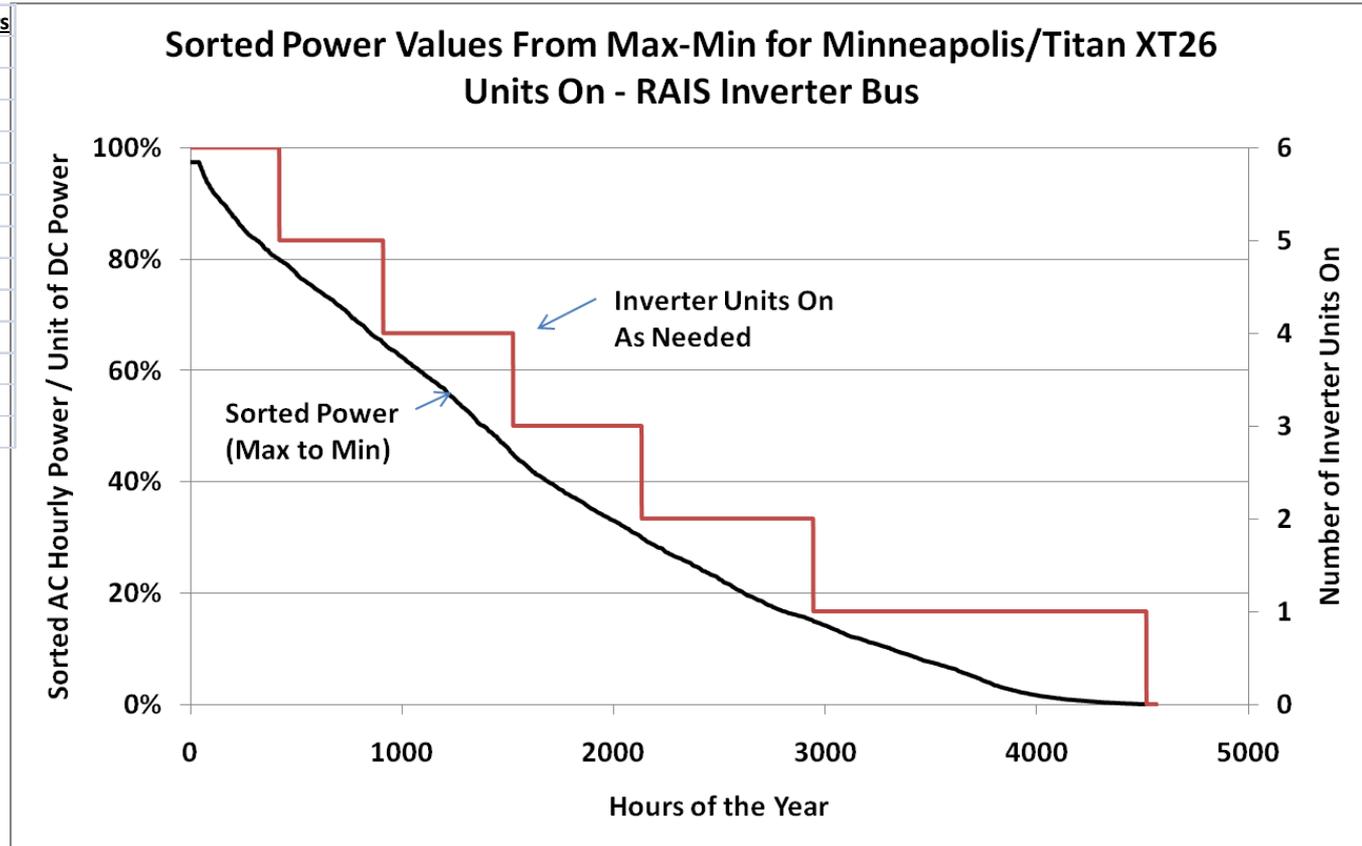


Duty Cycle Effects

**Data Below is Solar Power Production in MN
Sorted From Highest to Lowest Through One Year**

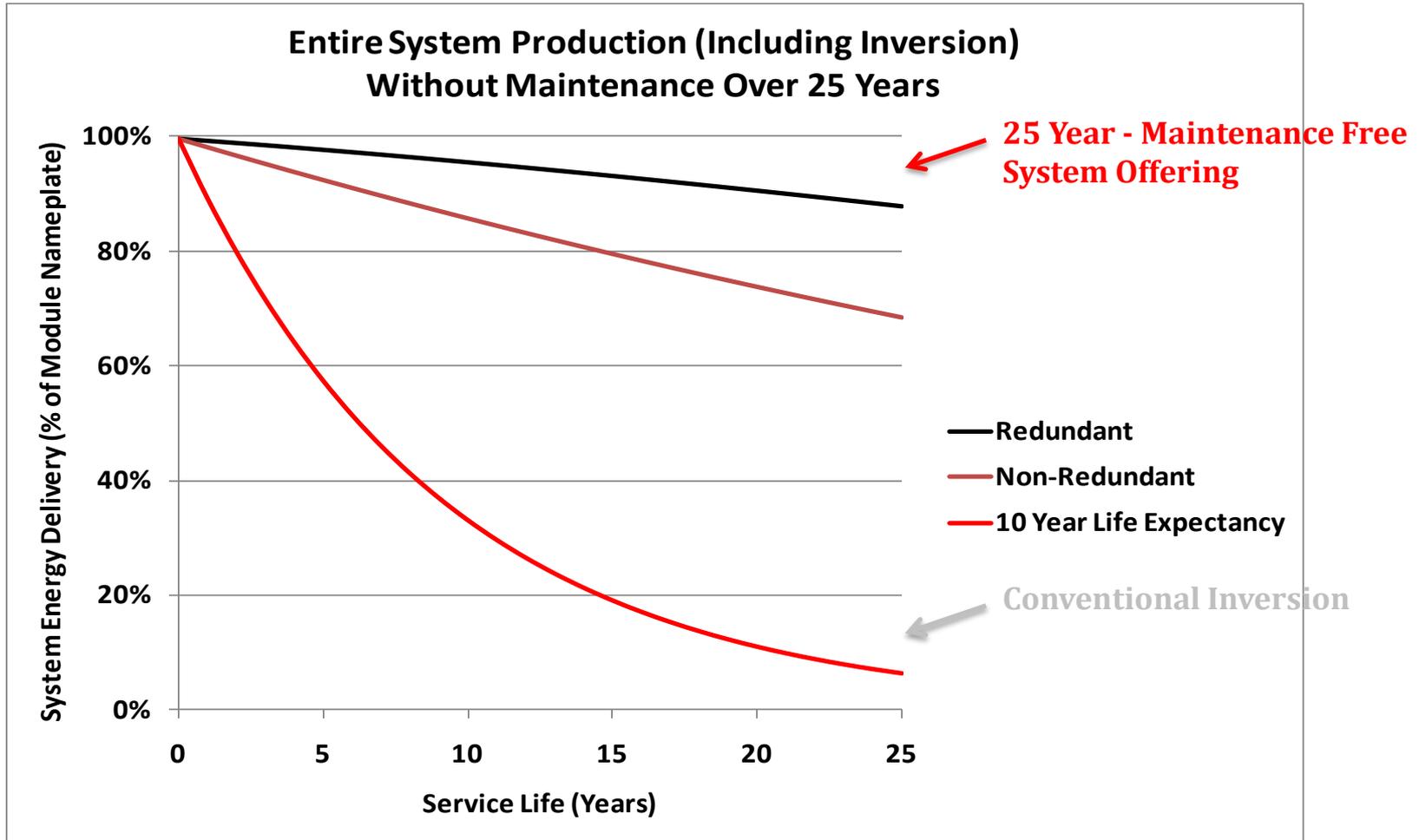
**By Powering On What is Needed: Duty Cycle is 23.7%
Powering On All Units When Sun is Available: 51.6%**

Units On	Hours	Units*Hours
6	421	2526
5	912	2455
4	1526	2456
3	2134	1824
2	2945	1622
1	4520	1575
0	0	0
Total		12458
Average Hours On		2076
Annual Duty Cycle		23.70%
Conventional (4520 Hours On)		51.60%



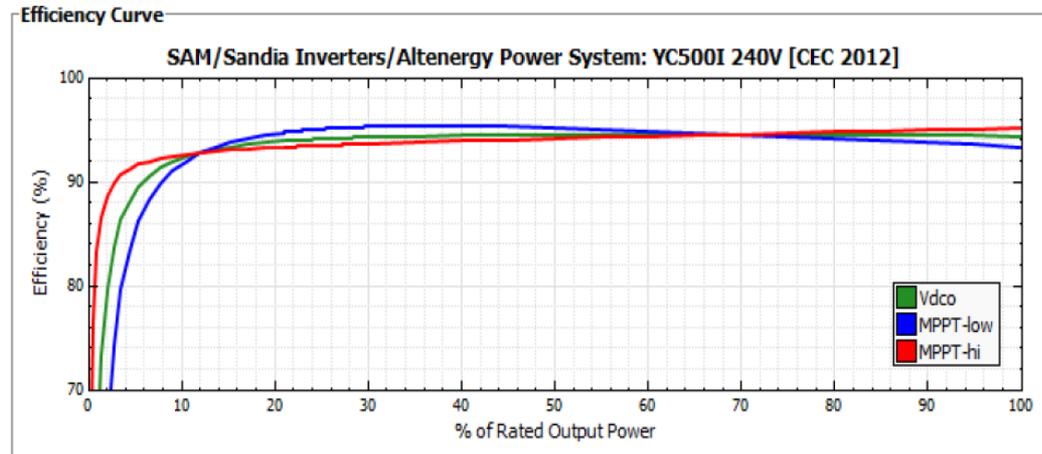
Effect of System Redundancy

1% AFR for Electronic Units (Module and Inverter)
and 0.2% / Year Module Degradation (Parallel Cell Interconnects)
(And Compared to 10 Year Life Conventional Inverter)

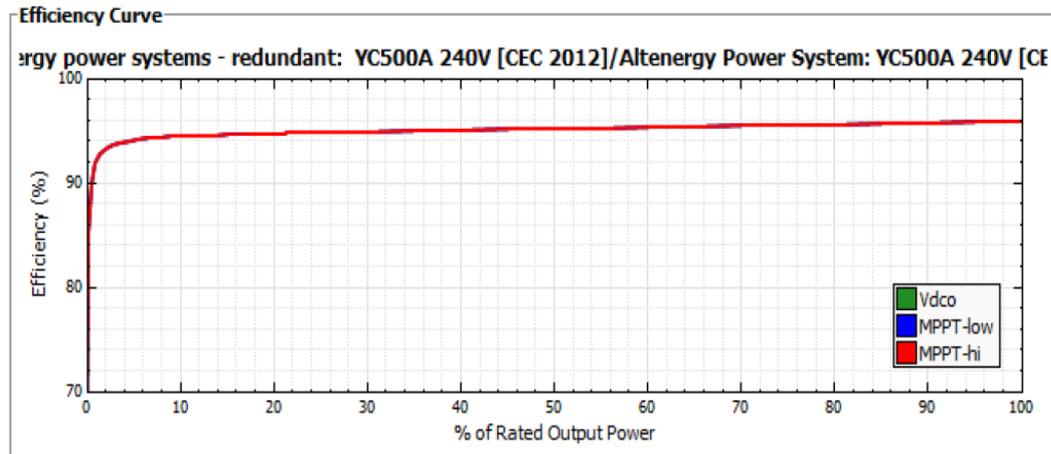


1% Higher Overall Efficiency when inverters share the load versus a Single Inverter Efficiency

Single
Inverter
Module



Multiple
Inverter
Modules
Connected
Via
Bus



RIB – Electrical and Mechanical

Today: 12 kW Kit Installer Snaps
Into Array – Single AC Connection
Pre-Kitted and Shipped by tenK

Q1-2014: 24 kW Kit –
Single AC Connection

