PV-INTEGRATED MICROINVERTERS IN HIGH-RELIABILITY ROOFTOP APPLICATIONS

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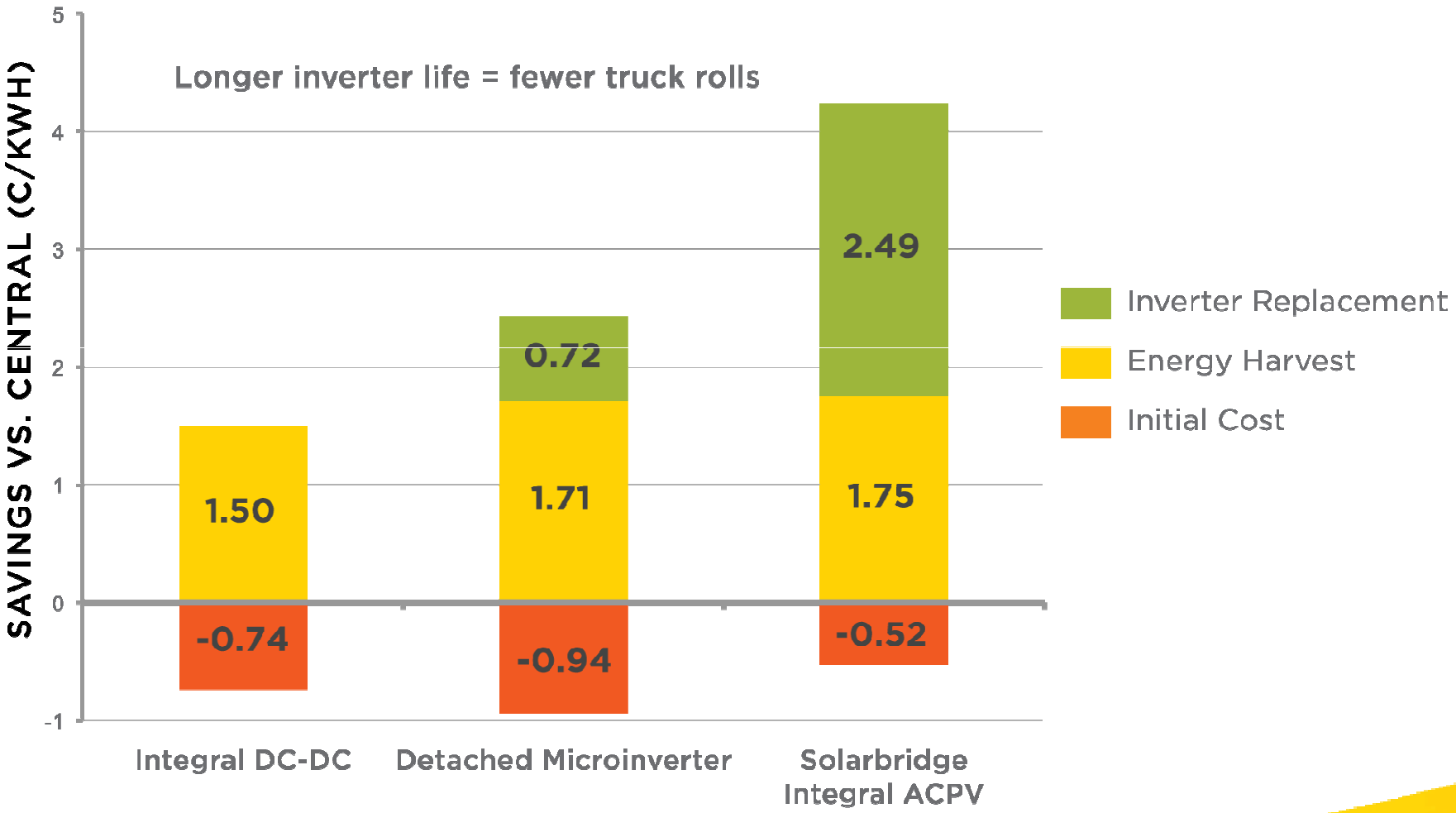
INTEGRAL ACPV: HIGHER RELIABILITY, LOWER LCOE



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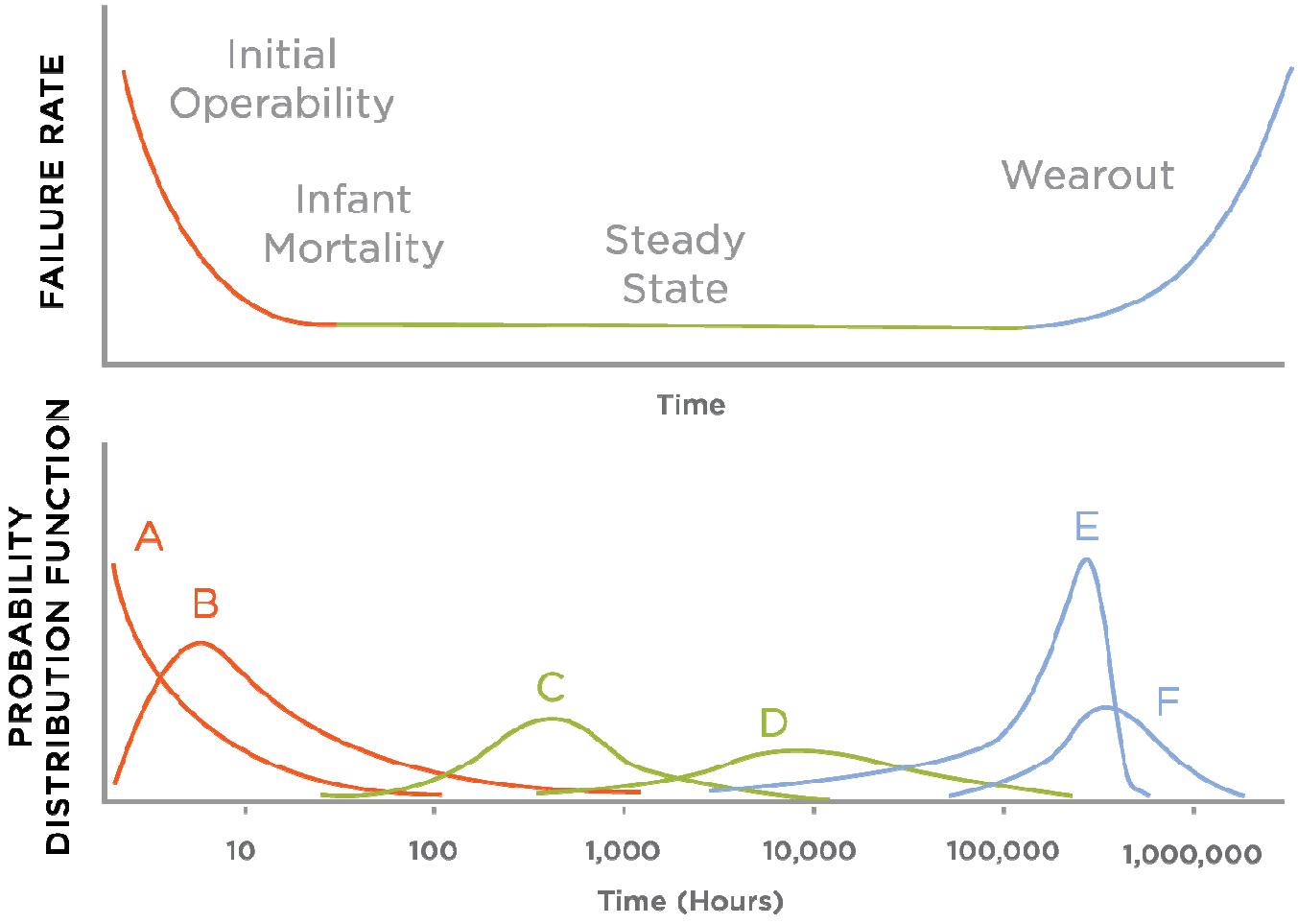
THE TRADITIONAL BATHTUB CURVE



Infant Mortality:
A. Weak Solder Joints
B. Cracked Ceramic Capacitor

Steady State:
C. FET Single Event Burnout
D. Corrosion

Wearout:
E. Electrolytic Capacitor Degradation
F. Non Compliant Solder Joints (BGA,etc.)

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DEFINING RELIABILITY: MTBF HAS NOTHING TO DO WITH LIFETIME

- MTBF only applies to useful life/steady state
- MTBF does not predict product wearout
- MTBF does not account for harsh use environments
- MTBF does not consider manufacturing variation

MTBF ≠ Lifetime

ACHIEVING 25-YEAR RELIABILITY

- Design For Reliability
- Test For Reliability
- Manufacture For Reliability

DESIGN FOR RELIABILITY: ELIMINATE TOP 5 RELIABILITY RISKS

Do not use:

- Electrolytic Capacitors (E-Caps)
- Optical-isolators
- Tantalum Capacitors

Minimize stresses on:

- Printed Circuit Board Vias
- Solder Joints

E-CAPS FAIL TO MEET PV RELIABILITY STANDARDS

CAPACITOR OPERATING LIFE

		T operating (Cap Core)	
Capacitor Description	**End of Life Failure Criteria**	**60**	**70**
5,000 Hour, 105C Rated e-caps	20% drop in Cap or 2x ESR	**8 Years**	**4**
10,000 Hour, 105C Rated e-caps	20% drop in Cap or 2x ESR	**16**	**8**
Film Capacitor (Industry Model)	20% drop in Cap	**1540**	**770**
VOLTAGE DERATING = 80% in all cases			

STEADY STATE FAILURE RATE (FIT)

Capacitor Description	Bellcore	CNET	HRD4	M217	Siemens
Aluminum Electrolytic Capacitor	**210**	**22**	**120**	**16**	**120**
Film Capacitor	**17**	**4**	**6**	**1**	**14**
FIt Ratio E-Cap / Film	**12.4**	**5.5**	**20.0**	**16.0**	**8.6**

Bellcore: Similar to Telcordia SR-332
CNET: National Center for Telecommunications Studies
HRD4: Handbook of Reliablity Data – Issue 4
M217: MIL HDK-217
Siemens: SN29500

Ref: Jones, et.al., “A comparison of Electronic Reliability Prediction Methods”, IEEE Trans. On Reliability, June 1999, p. 127-143.

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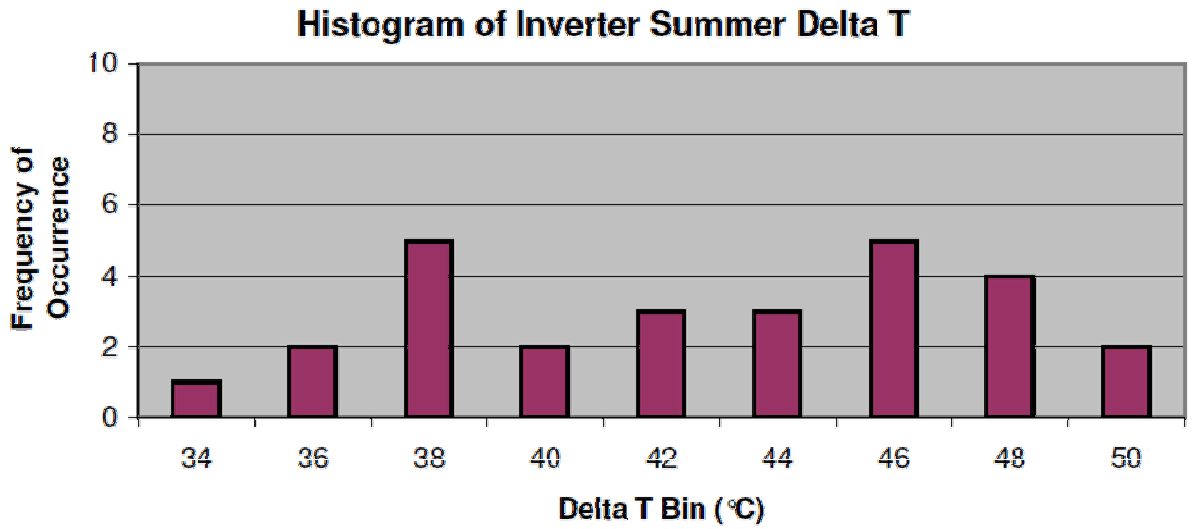
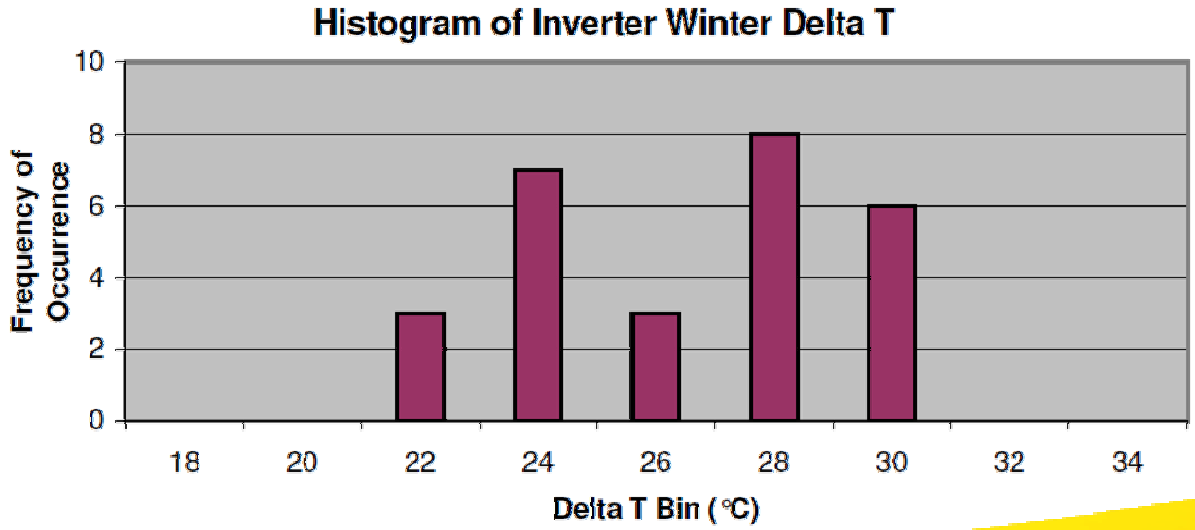
SUMMER/WINTER DESERT TEMPERATURE DATA





Component Daily ΔT statistics are applied to fatigue models to predict time to wearout

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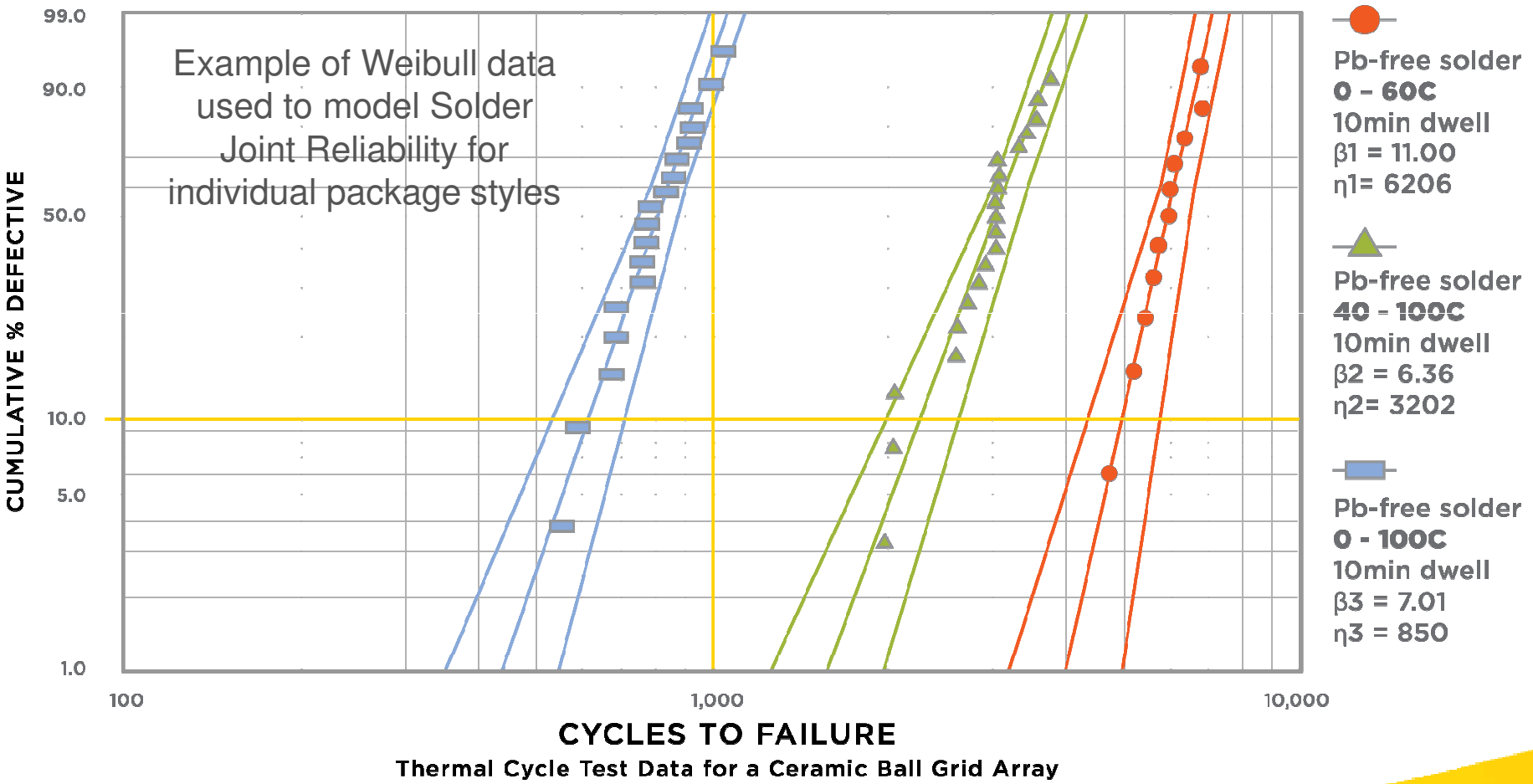
ACCELERATED TESTING: SOLDER JOINT RELIABILITY ACCELERATED WEIBULL ANALYSIS



Pan, et.al.," An Acceleration Model for Sn-Ag-Cu Solder Joint Reliability Under Various Thermal Cycle Conditions.", 2005 SMTAI, pp. 876-883.

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PREDICTING TIME TO WEAROUT