

Santerno Reliability: Case Study And Benchmark

NOVEMBER, 2013

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This study is aimed at comparing the behavior of 480 Santerno solar inverters over more than 3 years in respect to a case study published by Client #1 in 2011.

Units analysed:

- No. 406 TG145, 100 kWac w/ LV transformer
- No. 74 TG385, 300 kWac w/o LV transformer

Total power installed: **63 MWac**

Santerno & PV Plants analysed in Spain

1. Plant #1
2. Plant #2
3. Plant #3
4. Plant #4
5. Plant #5
6. Plant #6
7. Plant #7
8. Plant #8

The Benchmark:



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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The data collected support the following:

- Santerno inverters **Service Rates** are substantially better than Client #1 suppliers.
- **Design Service rates** (MTBF) are validated.
- **Designed Repair Time** (MTTR) is validated

91 repair calls have been recorded on the sample population from September 2008 to date, with over 1400 combined years of inverter operation.

	A	B	E	F	G	H	I	J
1	DATE	Richiesta n°	Code Material	Material description	Q	OLD s	SENT FROM SP	TRANSPORT C
54	16/10/2009	090-EES-SEI-CO-2468	ZZ0101061 MY242	Sinus P-F 150-162	1	804258	SENT 18/11/2009	AL 055-09 18/11/20
55	16/10/2009	090-EES-SEI-CO-2469	ZZ0101061 MY242	Sinus P-F 150-162	1	804247	SENT 18/11/2009	AL 055-09 18/11/20
56	21/10/2009	090-EES-SEI-CO-2591	RL0200961	RELE	1		SENT 04/11/2009	AL 052-09 04/11/20
57	21/10/2009	090-EES-SEI-CO-2590	RL5001999	ZOCOLO X DIN RELAY	1		SENT 04/11/2009	AL 052-09 04/11/20
58	22/10/2009	090-SRO-SEI-CO-2517	ZZ0101094 RY242	RY242 SUNWAY 385-800V	1	8000540	SENT 04/11/2009	AL 052-09 04/11/20
59	28/10/2009	090-EES-SEI-CO-2633	ZZ0095620	ES848/2	1		SENT 04/11/2009	AL 052-09 04/11/20
60	03/11/2009	090-EES-SEI-CO-2679	ZZ0069008,3200	SUNWAY M XR 5300	1	68511	SENT 18/11/2009	AL 055-09 18/11/20
61	04/11/2009	090-EES-SEI-CO-2715	AC1832701	FILTRO	1		SENT 04/11/2009	AL 052-09 04/11/20
62	04/11/2009	090-EES-SEI-CO-2716	XXRL00084	TEMPORIZADOR	1		SENT 04/11/2009	AL 052-09 04/11/20
63	04/11/2009	090-EES-SEI-CO-2717	ZZ0085906	ES768	1		SENT 04/11/2009	AL 052-09 04/11/20
64	04/11/2009	090-EES-SEI-CO-2714	ZZ4080905	ES809	1		SENT 04/11/2009	AL 052-09 04/11/20
65	17/11/2009	090-EES-SEI-CO-2835	ZZ4500520	DATA LOGGER	1		SENT 18/11/2009	AL 055-09 18/11/20
66	18/11/2009	090-EES-SEI-PR-2842	ZZ0101094 RY242	RY242 SUNWAY 385-800V	1	815654	SENT November 2009	
67	05/01/2010	100-EES-SEI-CO-0003	ZZ0101061 MY242	Sinus P-F 150-162	1	800032	SENT 12/01/2010	AL 063-10 12/01/20
68	20/01/2010	100-EES-SEI-CO-0090	ZZ4080905	ES809	1		SENT 16/03/2010	AL 070-10 16/03/10
69	26/01/2010	100-EES-SEI-CO-0143	RL5001999		2		Given 10/02/10 to Laura / Bedeschi	
70	26/01/2010	100-EES-SEI-CO-0142	XXRL00109		2		Given 10/02/10 to Laura / Bedeschi	
71	01/02/2010	100-EET-SEI-CO-0509	XXCE00311	Interruttore sezionadore	1		SENT 16/03/2010	AL 070-10 16/03/10
72	08/02/2010	100-EET-SEI-CO-0511	ZZ0101061 MY242		1	800250	SENT 01/04/2010	AL 074-10 01/04/10
73	22/02/2010	100-EES-SEI-CO-0397	ZZ0101085 HO242	Sunway 135 - 600V	1	900772	SENT 16/03/2010	AL 070-10 16/03/10
74	04/03/2010	100-EET-SEI-CO-0510	XXCE00095	SGANC.APERT PER S3-S4-S5	1		SENT 16/03/2010	AL 070-10 16/03/10
75	04/03/2010	100-EET-SEI-CO-0701	ZZ4500520	ES851	1		SENT 16/03/2010	AL 070-10 16/03/10
76	04/03/2010	100-EET-SEI-CO-0704	ZZ4500520	ES851	1		SENT 16/03/2010	AL 070-10 16/03/10
77	09/03/2010	100-EET-SEI-CO-0702	XXVN00031	Griglia Ventilazione	1		SENT 16/03/2010	AL 070-10 16/03/10
78	15/03/2010	100-EET-SEI-CO-0703	ZZ0101061 MY242	Sunway 145 - 800V	1	800210	SENT 01/04/2010	AL 074-10 01/04/10
79	22/03/2010	100-EET-SEI-CO-0512	XXRL00109	Rele	1			AL 067-10 08/02/10
80	06/04/2010	100-EET-SEI-CO-0847	RL0200807 • RL5001	Rele CR-M024DC4LG ER 595	1-1		SENT 3/05/10	AL 082-10 3/05/20
81	06/04/2010	100-EET-SEI-CO-0848	RL0200807 • RL5001	Rele CR-M024DC4LG ER 595	1-1		SENT 3/05/10	AL 082-10 3/05/20
82	06/04/2010	100-EET-SEI-CO-0850	ZZ0101061 MY242	Sunway 145 - 800V	1	804117	SENT 8/04/2010	AL 077-10 08/04/10
83	15/04/2010	100-EET-SEI-CO-0889	XXRL00024	CONT.TRI.A 145-30-11	1		SENT 1/06/10	AL 099-10 31/05/10
84	15/04/2010	100-EET-SEI-CO-0887	ZZ0069044 32001	SUNWAY MPLUS 6400	1	916127	SENT 3/05/10	AL 082-10 3/05/20
85	23/04/2010	100-EET-SEI-CO-1198	RL0200807	Rele CR-M024DC4LG ER 595	1	802442	SENT 3/05/10	AL 082-10 3/05/20
86	23/04/2010	100-EET-SEI-CO-1199	RL0200807	Rele CR-M024DC4LG ER 595	1	802297	SENT 3/05/10	AL 082-10 3/05/20
87	23/04/2010	100-EET-SEI-CO-1200	RL0200807	Rele CR-M024DC4LG ER 595	1	802277	SENT 3/05/10	AL 082-10 3/05/20
88	23/04/2010	100-EET-SEI-CO-1197	ZZ4080905	ES 809	1	802294	SENT 3/05/10	AL 082-10 3/05/20
89	28/04/2010	100-EET-SEI-CO-1201	TR0113200	TRANSF 1F. 500VA 230-400V	1	802306	SENT 1/06/10	AL 099-10 31/05/10
90	28/04/2010	100-EET-SEI-CO-1000	WV0030530	Sonda PT100 TESAR TRP-100	1		SENT 3/05/10	AL 082-10 3/05/20
91	28/04/2010	100-EET-SEI-CO-1017	XXVN00051	TORRINO VENT TB25000220	2		SENT 1/06/10	AL 099-10 31/05/10
92	28/04/2010	100-EET-SEI-CO-1016	ZZ0101061 MY242	Sunway 145 - 800V	1	810304	SENT 1/06/10	AL 099-10 31/05/10
93	30/04/2010	100-EET-SEI-CO-1656	ZZ0101085 G0242	Sunway 135 - 600V	1	711808	SENT 3/05/10	AL 082-10 3/05/20
94	04/05/2010	100-EET-SEI-CO-1655	ZZ0101061 MY242	Sunway 145 - 800V	1	700650	SENT 24/05/10	AL 097-10 24/05/10

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6 out of 100 inverters get a service call every year.

480 Inverters

Data Collection Period: 8/26/08 – 10/14/11

→ 1,113 days = 3.05 years

Total Inverter Years = $480 * 3.05$

→ 1,464 Inverter Years

10 working hours day means

→ 4,800 Hours

Total Up Time in 1113 days

→ 5.342 kWh

Total Service Cases

→ 91

Cumulative Service Probability = 91 Events/480 Inverter

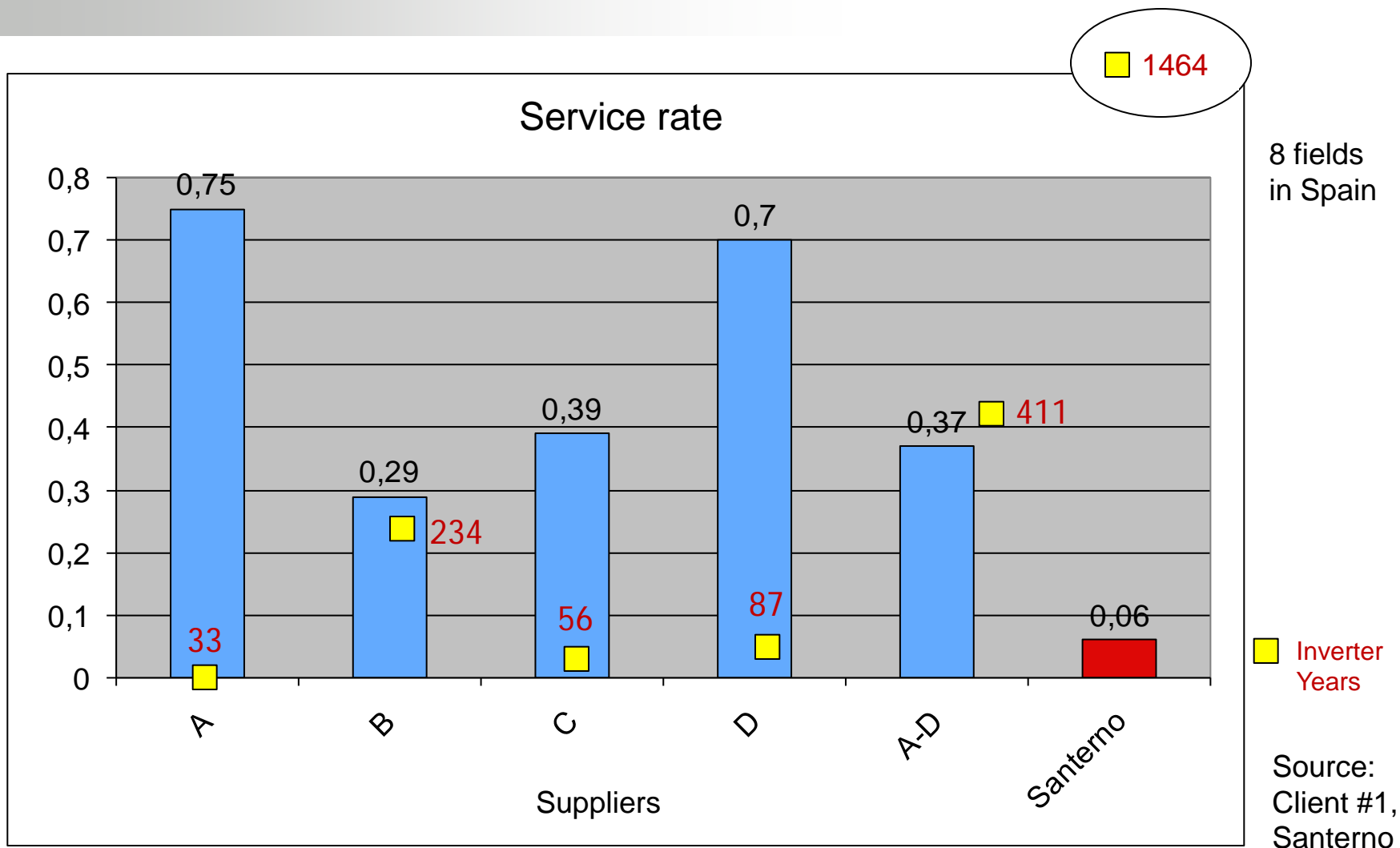
→ **0.19**

Service Rate (per Inverter-Year) = $91/1464$

→ **0.06**

Client #1 fleet vs **Santerno**

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MTBF and MTTR value for solar inverters

Models	MTBF [h]	MTTR [h]
SUNWAY TG	150k	1.05
SUNWAY TG TE	150k	1.05

- **MTBF** has been proven by failure rates over the all installed products.
- **MTTR** is the repair time in hours from when a trained person arrives in front of the inverter with spare parts to when the inverter is repaired.

Cumulative actual service probability = 0.19

→ the actual MTBF is 127kh.

Calculation details:

Actual MTBF = 127,000 h

X = 3.05 Years = 26,718 h

1/λ = 126,000 h

Actual probability = $1 - \exp(-\lambda * x)$ = $1 - \exp(-26,718h/127,000h) = 0.19$

Design MTBF = 150,000 h

X = 3.05 Years = 26,718 h

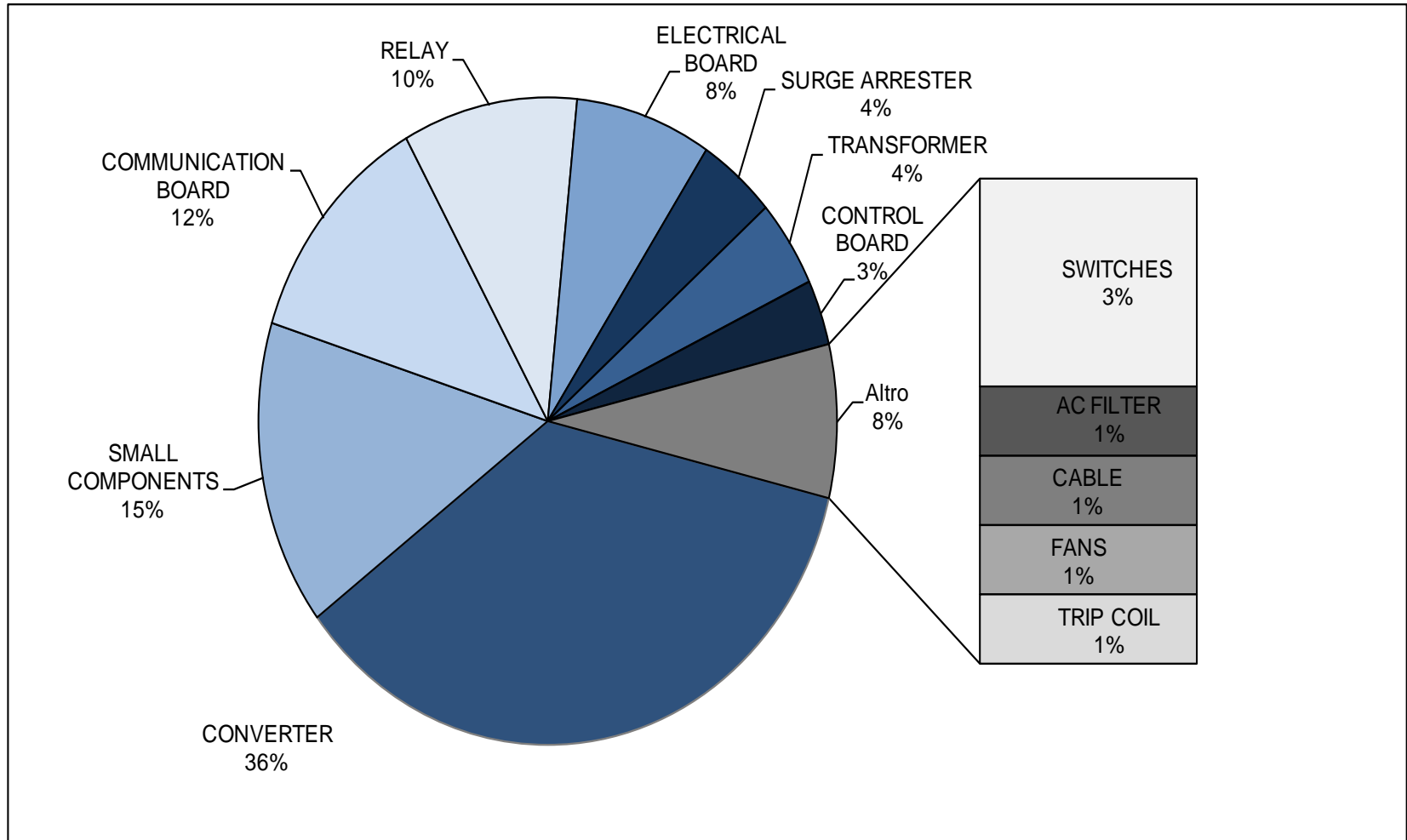
1/λ = 150,000 h

Design probability = $1 - \exp(-\lambda * x)$ = $1 - \exp(-26,718h/150,000h) = 0.16$

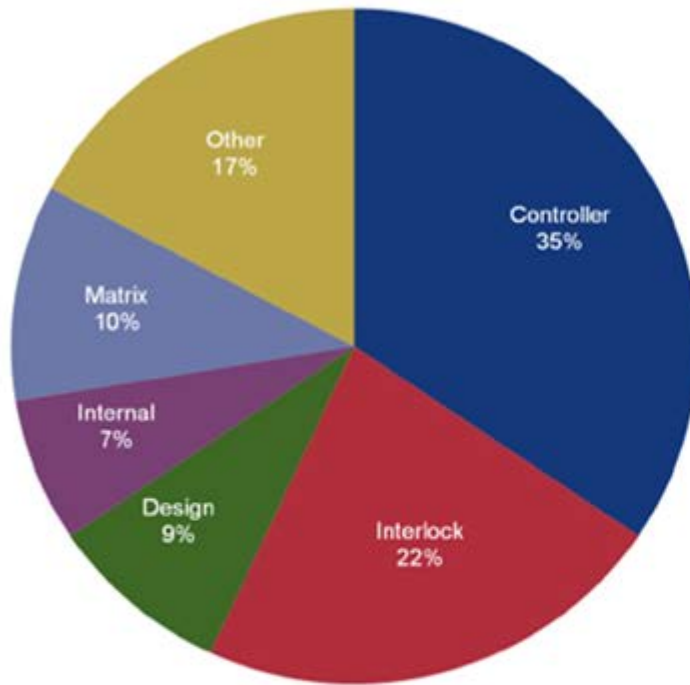
http://en.wikipedia.org/wiki/Exponential_distribution

Santerno: Calls for inverter repairs

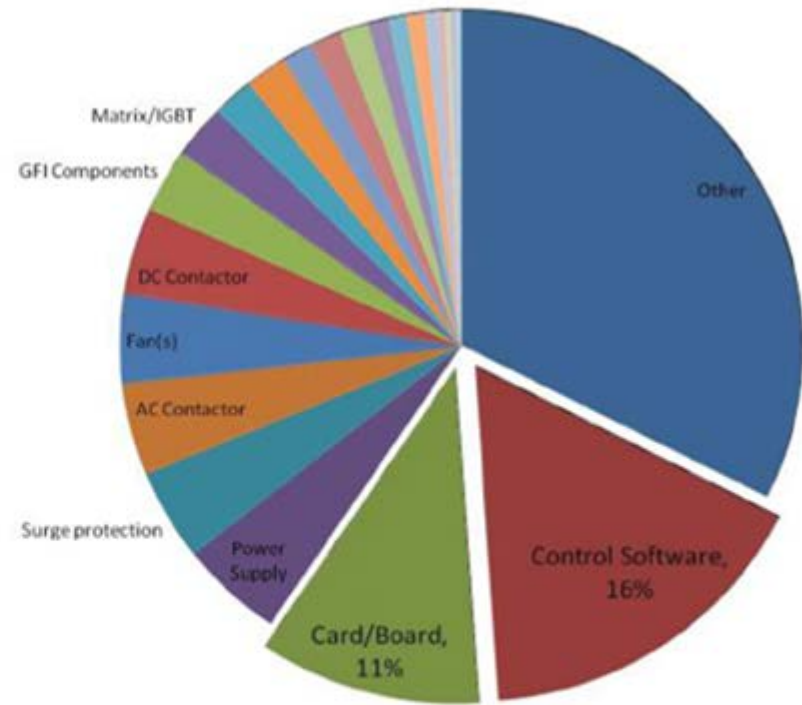
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Client #1: Calls for inverter repairs



Source: Sandia National Laboratories



Source: Client #1

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Santerno design MTBF:

- The actual validated value is MTBF = 127 kh.
- This is several times better than the best supplier in Client #1 fleet.
- The Santerno MTBF implies an uptime of 99.9% in case service calls are closed within 72 hours.
- The above conclusions were reached by analyzing a population of 460 machines in operation for 1,464 inverter years.

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