Report No.	:	64.290.16.03931.01
Rev.	:	1.0
Issued Date	:	2016-08-12
Project Engineer	:	Tom Cai
Project Reviewer	:	Cavic Wu

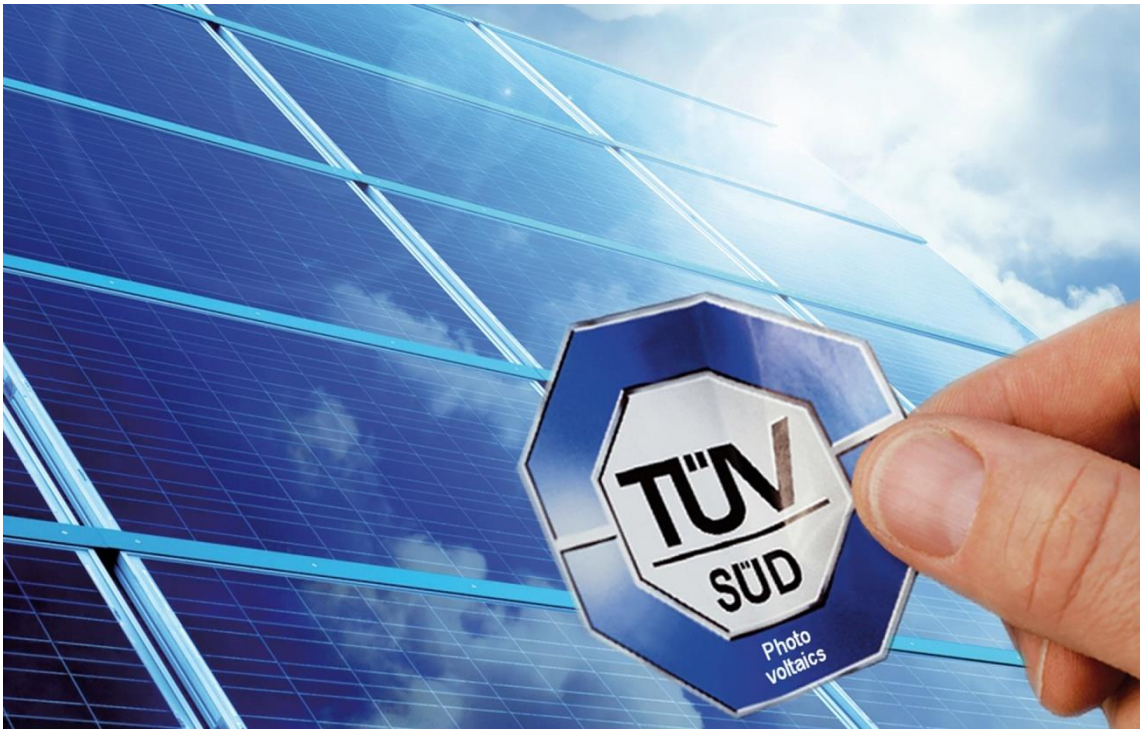
HUAWEI

TÜV SÜD Greater China

Choose certainty. Add value.

Technical Report

Technical Due Diligence Report on Huawei Inverters Operation and Performance Technical Indexs in 220MW PV Plant



TÜV SÜD Certification and Testing (China) Co., Ltd. Guangzhou Branch

5F, Communication Building, 163 Pingyun Rd, Huangpu West Ave

Guangzhou 518048, P.R. China

Client information				
Client Name	:	Huawei Technologies Co., Ltd.		
Client Address	:	Shenzhen, P.R. China		
Contacts	:	Name	:	Mr. William Wong
		Tel.	:	+86 18507558709
		E-mail	:	wangliyuan1@huawei.com

Revision Record		
Issued Date	**Issued Date**	**Summary**
V0.0	2016-08-11	Draft

Project Engineer	:	Tom Cai	Tom Cai 2016.08.12 <Date and Signature>
Project Reviewer	:	Cavic Wu	Cavic Wu 2016.08.12 <Date and Signature>

Contents

1 Executive Summary

1.1 Scope of Work

Huawei invite TÜV SÜD, as an independent third party, to assess the inverter technical characteristic such as Huawei Inverter Failure Rate, Availability and Array Yield, by reviewing the operation and maintaining record of the 220MW PV plant in Golmud.

The operator of the PV plant, one of the biggest PV Plant investor in China, offered the operation and maintenance record to help us finish this report. The TÜV SÜD engineer reviewed the O&M records on site of the PV plant during the day 2016/08/01 – 2016/08/09, and assessed the inverters operation and performance technical index, including the below.

- Failure Rate
- Availability
- Array yield (Y_A)

1.2 Project Brief

Golmud grided PV Plant, whose installed capacity currently is 590 MWp, located in Photovoltaic park of Golmud exit east, in a desert where is 30 km far awary from Golmud city.

The Golmud PV Plant is consisted of Station Phase I 200 MWp, Station Phase II 100 MWp, Station Phase III 200 MWp, Station Phase IV 60MWp and Station Phase V 30MWp. Total 228 MW PV inverters were installed in these PV Plants, including 8MW for Station Phase II, 130MW for Station Phase III, 60MW for for Station Phase IV and 30MW for Station Phase V.

Fig. 1.1 Golmud grided PV Plant, 590MW

1.3 Executive Summary

The usage and the dates of grid of the Huawei PV inverters in 590MW Golmud PV Plant is below:

- Station Phase II, used 200 sets of inverter SUN2000-20KTL and 8 sets of inverter SUN8000-500KTL, 8 MW in total, and grided since 2013-12-17.
- Station Phase III, used 4939 sets of inverter SUN2000-28KTL, 83 MW in total, and grided since 2014-12-27.
- Station Phase IV, used 1790 sets of inverter SUN2000-40KTL, 64.4 MW in total, and grided since 2016-01-11.
- Station Phase V, used 700 sets of inverter SUN2000-50KTL, 33.3 MW in total, and grided since 2016-06-01.

During the running period, Huawei inverters performance indexs are as follows:

- **Failure Rate of PV Inverter**
  a) Station Phase II, during the 963 running days, the Inverter SUN2000-20KTL annual failure rate is $\lambda_{(SUN2000\text{-}20KTL,\ year)} = 0.189\%$;
  b) Station Phase III, during the 583 running days, the Inverter SUN2000-28KTL annual failure rate is $\lambda_{(SUN2000\text{-}28KTL,\ year)} = 0.252\%$;
  c) Station Phase IV, during the 207 running days, the Inverter SUN2000-40KTL failure rate is $\lambda_{(SUN2000\text{-}40KTL,\ 207days)} = 0.390\%$.

- **Availability of PV Inverter：**
  a) Station Phase II, during the 963 running days, the Inverter SUN2000-20KTL availability is $A_{(SUN2000\text{-}20KTL,\ 963days)} = 99.998\%$;
  b) Station Phase III, during the 583 running days, the Inverter SUN2000-28KTL availability is $A_{(SUN2000\text{-}28KTL,\ 583days)} = 99.996\%$;
  c) Station Phase IV, during the 207 running days, the Inverter SUN2000-40KTL availability is $A_{(SUN2000\text{-}40KTL,\ 207days)} = 99.996\%$.

- **PV Array Yield：**

The PV Array Yield (Y_A) for 4MW PV Array of Station Phase II used inverter SUN2000-20KTL is as below:
  a) 2014 annual Energy Yield is $Y_{A(SUN2000\text{-}20KTL)2014} = 1855.2$ h;
  b) 2015 annual Energy Yield is $Y_{A(SUN2000\text{-}20KTL)2015} = 1869.3$ h;
  c) 2016 Energy Yield during period between Jan. and Jul. is $Y_{A(SUN2000\text{-}20KTL)2016} = 1189.9$ h;
  d) The PV Array Energy Yield (Y_A) ratio between string inverter and central inverter is **$Y_{A(SUN2000\text{-}20KTL)} / Y_{A(SUN8000\text{-}500KTL)} = 102.02\ \%$.**

1.4 Important Remarks

1. Since China Northwest output capacity of high-voltage cable is limited, some PV power plant is limited to grid electricity, of which the photovoltaic power plants Station Phase III, Medium-sized Station and Station Phase IV is to be limited the grid power of 40 to 50%. TÜV SÜD would not assess the Array Yield (Y_A) of these PV plant.

2. Due to inconsistency of the different plant location, the annual amount of radiation, operation and maintenance level, it is no sense to assess a single Array Yield (Y_A) as one performance index of the inverter. So that we introduce the other inverters in the plant of the same design for comparison.

3. Because of restrictions on electricity generating, the energy yield of each inverter is random. So the definition of less than 80% of the average defined as unavailable of inverter would not be taken to assess the Inverter Availability. We TÜV SÜD assessed the Inverter Availability by calculated the amount days of inveter downtime and service time.

4. Because it is not more than one year from PV power plant Station Phase IV grided, the failure rate of equipment belonging to the early period, we would not assess inverter annual failure rate of Station Phase IV.

5. Data evaluated from the running PV plant O&M record, does not exclude the PV power plant operator statistics omission.

2 Definitions and Abbreviations

2.1 Terms and definitions of PV plant

Net energy from array ($E_{A,\tau}$), in kWh, electrical energy that is measured to have been generated by a PV array. Refer to IEC 61724:1998 for detail.

Net energy to utility grid ($E_{TUN,\tau}$), in kWh, electrical energy that is measured to have been generated by a PV system and upload to utility grid. Refer to IEC 61724:1998 for detail.

Array yield (Y_A), in hours, is the daily array energy output per kW of installed PV array:

$Y_A = E_{A,d} / P_0 = \tau_r \times (\Sigma \text{ day } P_A) / P_0$

The symbol Σ day denotes the summation for the day. This yield represents the number of hours per day that the array would need to operate at its rated output power P_0 to contribute the same daily array energy to the system as was monitored (which equals Tr × (Σday P_A)).

Refer to IEC 61724:1998 for detail.

Power rationing, in %, = Limited energy yield /（Actual yield+ Limited energy yield）*100%.

Inverter availability, in %, is an important target to assess the quality of products and services.

The calculation formula is as below:

$$A = (1 - \frac{T1 + T2 + \cdots + Tn}{N * T}) * 100\%$$

A(%) is the Inverter Availability.

N(pcs) is the total amount of inverters used in the PV plant.

T(days) is the total number of days in operation in a year.

Tn (days) is the amount of down-time days of No. “n” inverter in a year.

Refer to “Statement of Huawei Inverter Availability For Recurrent” version July, 2016 for detail.

Failure rate, in %, is the frequency with which an engineered system or component fails, expressed in failures per unit of time. It is often denoted by the Greek letter λ (lambda) and is highly used in reliability engineering.

λ(t)= r / (n*t)； r is the failures number, n is total number in used, t is the interval.

2.2 PV Inverter Technical Specifications

The main technical parameters of Huawei PV inverter used in the assessed PV plant as below.

Table 2-1 Huawei PV String Inverter Main Technical Parameters

Inverter Model	SUN2000-20KTL	SUN2000-28KTL	SUN2000-40KTL	SUN2000-50KTL
Max. DC Usable Power (W)	22500	28200	40800	53500
Max. Input Voltage (Vdc)	1000	1000	1000	1100
Max. Current per MPPT (A)	18	18	23	22
Max. Short Circuit Current per MPPT (A)	25	25	32	30
Min. Operating Voltage (V)	200	200	200	200
Rated Input Voltage (V)	620	680	680	750
Full Power MPPT Voltage Range	480V～800V	480V～800V	580V~800V	200V~1000V
Max. Number of Inputs	6	6	6	8
Number of MPP Trackers	3	3	3	4
Rated AC Active Power (W)	20000	27500	36000	47500
Max. AC Active Power (cosφ=1) (W)	22000	27500	40000	52500
Rated Output Voltage (Vac)	3×230V/400V+N+PE 3×220V/380V+N+PE	3×277 V/480 V+PE	3×277 V/480 V+PE	3×288 V/500 V+PE
Max. Output Current (A)	3.4	33.5	48	54.9
Rated AC Grid Frequency (Hz)	50Hz/60Hz	50Hz/60Hz	50Hz/60Hz	50Hz
Max. Efficiency	98.6%	98.7%	98.8%	99%
Protection Rating	IP65	IP65	IP65	IP65
Topology	Transformerless	Transformerless	Transformerless	Transformerless

2.3 PV Plant Technical Specifications

Golmud grided PV Plant, whose installed capacity currently is 590 MWp, located in Photovoltaic park of Golmud exit east, in a desert where is 30 km far awary from Golmud city. At present the installed capacity of photovoltaic power plants is 590MWp, and its Technical Specifications is as below.

Table 2-2 Golmud PV power plant main technical parameters

Identification of PV Station	Station Phase I	Station Phase II	Station Phase III	Station Phase IV	Station Phase V
Grid date	N/A	2013-12-17	2014-12-27	2016-01-11	2016-06-01
PV Plant Nominal capacity (MW)	200	100	150	60	30
Huawei inverter model * Use Number	N/A	SUN8000-500KTL * 8; SUN2000-20KTL * 200	SUN2000-28KTL * 4939	SUN2000-40KTL * 1790	SUN2000-50KTL * 700
Huawei Inverter Rated AC Active Power in total (MW)	N/A	8	130	60 (100%)	30 (100%)

3 Failure Rate of Inverter

Inverter failure, defined as beyond the planned operation and maintenance of PV plant, is the incident that inverter because of itself hardware or (and) software causes it suddenly shutdown or off-grid.

Annual failure rate of the inverter, in the running time of the year, is the ratio of number of faulted inverters in PV power plant and the total used number of units.

During the day 2016-08-01 to 2016-08-09, TÜV SÜD engineer checked and verified the operation and maintenance record on site of 590MW Golmud PV plant which used 220 MW Huawei inverters, verified the number of failed or replaced inverters, and calculated the failure rate of station phase II, station phase III and station phase IV. The station phase V is in the commissioning phase for 2016-06-01, we would not take it for reviewing.

3.1 Inverter Failure Rate of Station Phase II _λ (SUN2000-20KTL, year)

The Station Phase II installed capacity is 100 MWp, whose 4 MW used 200 sets of Huawei inverter model SUN2000-20KTL.

3.1.1 PV inverter failure statistics of Station Phase II

TÜV SÜD counted the failure quantity of Huawei inverter SUN2000-20KTL from the grided date 2013-12-17 to now, by reviewing the O&M record of Station Phase II. The statistics is listed as below table. Statistical data are not included inverters downtime caused by the PV array and the planned downtime.

Table 3-1 Huawei inverter failure statistics in Golmud PV Station Phase II

No.	SN of PV inverter	Failure
1	II-51-31	Inverter system failure

3.1.2 PV inverter failure rate calculation of Station Phase II

According to the formula λ(t)= r / (n*t), TÜV SÜD calculated annual failure rate of Huawei inverter SUN2000-20KTL used in PV Station Phase II, from the date 2013-12-17 to 2016-08-06 (963days in total).

$\lambda_{(SUN2000\text{-}20KTL,\ year)} = (1 / (200+1) * (963/365)) * 100\% = 0.189\%$

3.2 Inverter Failure Rate of Station Phase III_λ (SUN2000-28KTL, year)

The Station Phase III installed capacity is 200 MWp, whose 130 MW usied 4939 sets of Huawei inverter model SUN2000-28KTL.

3.2.1 PV inverter failure statistics of Station Phase III

TÜV SÜD counted the failure quantity of Huawei inverter SUN2000-28KTL from the grided date 2014-12-27 to now, by reviewing the O&M record of Station Phase III. The statistics is listed as below table. Statistical data are not included inverters downtime caused by the PV array and the planned downtime.

Table 3-2 Huawei inverter failure statistics in Golmud PV Station Phase III

No.	SN of PV inverter	Failure
1	3E-#38-N45	Residual current fault
2	3E-#42-N37	Abnormal DC circuit
3	3E-#08-N38	Machine always shows the Irradiation detecting, and can not grid
4	3E-#20-N27	Machine always shows the Irradiation detecting, and can not grid
5	3E-#68-N01	Machine always shows the Irradiation detecting, and can not grid
6	3E-#52-N13	Relay burnt inside the machine
7	3E-#38-N20	Inverter alarms and shows abnormal inverter circuit
8	3E-#07-N46	Inverter alarms and shows abnormal inverter circuit
9	3E-#31-N27	Inverter alarms and shows abnormal inverter circuit
10	3E-#03-N32	Residual current fault
11	3E-#08-N47	Power circuit board burnt inside the machine
12	ZE-#05-N41	Internal short circuit power circuit board
13	ZE-#06-N22	Abnormal DC circuit
14	ZE-#17-N13	Internal short circuit power circuit board
15	ZE-#18-N08	Abnormal inverter circuit
16	ZE-#24-N39	Machine always shows the Irradiation detecting, and can not grid
17	ZE-#22-N38	Three-phase cable burnt inside the machine
18	ZE-#30-N38	Relay burnt inside the machine, Power circuit board shorted
19	ZE-#14-N03	Abnormal inverter circuit
20	ZE-#05-N07	Part of AC side burnt inside the machine

3.2.2 PV inverter failure rate calculation of Station Phase III

According to the formula λ(t)= r / (n*t), TÜV SÜD calculated annual failure rate of Huawei inverter SUN2000-28KTL used in PV Station Phase III, from the date 2015-01-01 to 2016-08-06 (583days in total).

$\lambda_{(SUN2000\text{-}28KTL,\ year)} = (20 / (4939+20) * (583/365)) * 100\% = 0.252\%$

3.3 Inverter Failure Rate of Station Phase IV_$\lambda_{(SUN2000\text{-}40KTL,\ 207days)}$

The Station Phase IV installed capacity is 60 MWp, which all used 1790 sets of Huawei inverter model SUN2000-40KTL.

3.3.1 PV inverter failure statistics of Station Phase IV

TÜV SÜD counted the failure quantity of Huawei inverter SUN2000-40KTL from the grided date 2016-1-10 to now, by reviewing the O&M record of Station Phase IV. The statistics is listed as below table. Statistical data are not included inverters downtime caused by the PV array and the planned downtime.

Table 3-3 Huawei inverter failure statistics in Golmud PV Station Phase IV

No.	SN of PV inverter	Failure
1	South_Array37_#29	Inverter system failure
2	South_Array 36_#3	Inverter system failure
3	South_Array 28_#20	Inverter failure
4	South_Array 1_#34	Abnormal inverter circuit
5	South_Array 4_#28	Insulation fault
6	South_Array 33_#15	Abnormal voltage of phase A caused the inverter to restart frequently
7	South_Array 3_#17	Abnormal inverter circuit

3.3.2 PV inverter failure rate calculation of Station Phase IV

According to the formula λ(t)= r / (n*t), TÜV SÜD calculated annual failure rate of Huawei inverter SUN2000-40KTL used in PV Station Phase IV, from the date 2016-01-11 to 2016-08-05 (207days in total). Since the PV Station Phase IV running less than one year, we just calculated the inverter running period, not for annual value.

$\lambda_{(SUN2000\text{-}40KTL,\ 207days)} = (7 / (1790+7)) * 100\% = 0.390\%$

4 Availability of Inverter

Inverter availability is an important target to assess the quality of products and services.
The calculation formula is as below:

$$A = (1 - \frac{T1 + T2 + \cdots + Tn}{N * T}) * 100\%$$ .....Formula 4.1

- A(%) is the Inverter Availability.
- N(pcs) is the total amount of inverters used in the PV plant.
- T(days) is the total number of days in operation.
- Tn (days) is the amount of down-time days of No. "n" inverter.

During the day 2016-08-05 to 2016-08-07, TÜV SÜD engineer checked and verified the operation and maintenance record on site of 590MW Golmud PV plant which used 220 MW Huawei inverters, verified the amount of down-time days of failed inverters and the total number of days in operation, and calculated the strings Inverters Availability of station phase II, station phase III and station phase IV. The station phase V is in the commissioning phase for 2016-06-01, we would not take it for reviewing.

4.1 Inverter Availability of Station Phase II_A (SUN2000-20KTL, t)

The grid date of Station Phase II is 2013-12-17, it was running for 963 days. And we will take it for the calculation period.

4.1.1 PV inverter down-time days statistics of Station Phase II

Some as the clause 3.1.1, the down-time record is as below.

Tabel 4-1 Huawei inverter down-time statistics in Golmud PV Station Phase II

No.	SN of PV inverter	down-time day	Failure
1	II-51-31	4 (2015-07-27 / 30)	Inverter system failure

The tatal number down-time of all failed inverters is as below (in units*days).

$\sum T_{n\ (days)} = 4$

4.1.2 Total number of days in operation of Station Phase II

According to the O&M record, the total total number of days in operation of Station Phase II is as below (in units*days).

$\sum T_{days} = 963 * 200 = 192600$

4.1.3 Calculation of Inverter Availability of Station Phase II

According to the formula 4.1， the Inverter Availability of Golmud PV Station Phase II from 2013-12-17 to 2016-08-06 (963days) is as below.

$A_{(SUN2000\text{-}20KTL,\ 963days)}$ = (1 - 4/192600) * 100% = 99.998%

In which,
The Inverter Availability of 2014 is 100%, the inverter down-time record is 0 Unit*day.
The Inverter Availability of 2015 is 99.995%, the inverter down-time record is 4 Units*days.
The Inverter Availability of 2016 is 100%, the inverter down-time record is 0 Unit*day.

4.2 Inverter Availability of Station Phase III_A (SUN2000-28KTL, t)

Part of the inverter SUN2000-28KTL grid date of Station Phase III is 2014-12-27, and till 2015-01-01 all the 4939 sets of inverters SUN2000-28KTL connect to grid from Station Phase III. We calculated the operation day from 2015-01-01, and the total running days is 583 days.

4.2.1 PV inverter down-time days statistics of Station Phase III

Some as the clause 3.2.1, the down-time record is as below.

Tabel 4-2 Huawei inverter down-time statistics in Golmud PV Station Phase III

No.	SN of PV inverter	down-time day	Failure
1	3E-#38-N45	1,(2015-03-08 ~ 2015-03-08)	Residual current fault
2	3E-#42-N37	1,(2015-03-09 ~ 2015-03-09)	Abnormal DC circuit
3	3E-#08-N38	13,(2015-03-10 ~ 2015-03-22)	Machine always shows the Irradiation detecting, and can not grid
4	3E-#20-N27	1,(2015-03-11 ~ 2015-03-11)	Machine always shows the Irradiation detecting, and can not grid
5	3E-#68-N01	12,(2015-03-11 ~ 2015-03-22)	Machine always shows the Irradiation detecting, and can not grid
6	3E-#52-N13	7,(2015-03-16 ~ 2015-03-22)	Relay burnt inside the machine
7	3E-#38-N20	8,(2015-05-05 ~ 2015-05-12)	Inverter alarms and shows abnormal inverter circuit
8	3E-#07-N46	1,(2015-05-15 ~ 2015-05-15)	Inverter alarms and shows abnormal inverter circuit
9	3E-#31-N27	1,(2015-05-16 ~ 2015-05-16)	Inverter alarms and shows abnormal inverter circuit
10	3E-#03-N32	3,(2015-07-26 ~ 2015-07-28)	Residual current fault
11	3E-#08-N47	4,(2016-02-20 ~ 2016-02-23)	Power circuit board burnt inside the machine
12	ZE-#05-N41	1,(2015-02-10 ~ 2015-02-10)	Internal short circuit power circuit board
13	ZE-#06-N22	1,(2015-02-10 ~ 2015-02-10)	Abnormal DC circuit

14	ZE-#17-N13	1,(2015-02-10 ~ 2015-02-10)	Internal short circuit power circuit board
15	ZE-#18-N08	1,(2015-03-08~ 2015-03-08)	Abnormal inverter circuit
16	ZE-#24-N39	9,(2015-03-08 ~ 2015-03-16)	Machine always shows the Irradiation detecting, and can not grid
17	ZE-#22-N38	1,(2015-03-13 ~ 2015-03-13)	Three-phase cable burnt inside the machine
18	ZE-#30-N38	46,(2015-03-25 ~ 2015-05-09)	Relay burnt inside the machine, Power circuit board shorted
19	ZE-#14-N03	13,(2015-07-16 ~ 2015-07-28)	Abnormal inverter circuit
20	ZE-#05-N07	4,(2015-11-15 ~ 2015-11-18)	Part of AC side burnt inside the machine

The tatal number down-time of all failed inverters is as below (in units*days).

$\sum Tn_{(days)} = 1+1+13+1+12+7+8+1+1+3+4+1+1+1+1+9+1+46+13+4= 129$

In which,
The tatal number down-time of 2015 for all failed inverters is 125 units*days.
The tatal number down-time of 2016 for all failed inverters is 4 units*days.

4.2.2 Total number of days in operation of Station Phase III

According to the O&M record, the total number of days in operation of Station Phase III is as below (in units*days).

$T_{days} = 583*4939 = 2879437$

4.2.3 Calculation of Inverter Availability of Station Phase III

According to the formula 4.1， the Inverter Availability of Golmud PV Station Phase III from 2015-01-01 to 2016-08-06 (583days) is as below.

$A_{(SUN2000\text{-}28KTL,\ 583days)} = (1 – 129 / 2879437) * 100\% = 99.996\%$

In which,
The Inverter Availability of 2015 is 99.993%, the inverter down-time record is 125 Units*days.
The Inverter Availability of 2016 is 99.999%, the inverter down-time record is 4 Units*days.

4.3 Inverter Availability of Station Phase IV_A (SUN2000-40KTL, t)

The grid date of Station Phase IV is 2016-01-11, it was running for 207 days to the reviewing date. And we will take it for the calculation period.

4.3.1 PV inverter down-time days statistics of Station Phase IV

Some as the clause 3.31, the down-time record is as below.

Tabel 4-3 Huawei inverter down-time statistics in Golmud PV Station Phase IV

No.	SN of PV inverter	down-time day	Failure
1	South_Array 37_#29	2	Inverter system failure
2	South_Array 36_#3	2	Inverter system failure
3	South_Array 28_#20	2	Inverter failure
4	South_Array 1_#34	2	Abnormal inverter circuit
5	South_Array 4_#28	2	Insulation fault
6	South_Array 33_#15	2	Abnormal voltage of phase A caused the inverter to restart frequently
7	South_Array 3_#17	2	Abnormal inverter circuit

The tatal number down-time of all failed inverters is as below (in units*days).

$$\sum T_{n\,(days)} = 2*7 = 14$$

4.3.2 Total number of days in operation of Station Phase IV

According to the O&M record, the total total number of days in operation of Station Phase I is as below (in units*days).

$$\sum T_{days} = 358 * 207 + (1790-358) * 199 = 359074$$

4.3.3 Calculation of Inverter Availability of Station Phase IV

According to the formula 4.1， the Inverter Availability of Golmud PV Station Phase IV from 2016-01-11 to 2016-08-05 (207days) is as below.

$$A_{(SUN2000\text{-}40KTL,\ 207days)} = (1 - 14 / 359074) * 100\% = 99.996\%$$

5 Array yield

Due to the limited transmission capacity of high-voltage transmission lines in Golmud, and the poor local electrical energy consumption, the local PV power plant were widespread seted a limit of energy to utility grid. 590MW photovoltaic power plants, except the 200MW station phase II, the power rationing of which were set to 40% to 50%. And in the process limited power, the actual output of each inverter is random, which is not suitable for Array yield evaluattion.

In summary, TÜV SÜD deep considered and selected the station phase II for Array yield calculation.

5.1 Array Yield (Y_A) of Station Phase II

5.1.1 Configuration of Station Phase II

8MW Huawei inverter were used in Golmud PV Plant station phase II 100MW, which installed as follows.

Table 5-1 Configuration of Station Phase II

Array No.	III_49	III_50	III_51	III_52	II_49	II_50	II_51	II_52
Inverter model	SUN8000-500KTL	SUN8000-500KTL	SUN8000-500KTL	SUN8000-500KTL	SUN2000-20KTL	SUN2000-20KTL	SUN2000-20KTL	SUN2000-20KTL
Rated PV module power (Wp)	255	255	255	255	255	255	255	255
QTY of module	4000	4000	4000	4000	4000	4000	4000	4000
Module capacity (kWp)	1020	1020	1020	1020	1020	1020	1020	1020

Reviewing of drawings, we verified that the type, quantity, installation tilt angle of PV module and the azimuth angle of each array are consistent. Without considering errors caused by construction, we believe that each 1MW PV array is the same unit. Since SUN8000-500KTL and SUN2000-20KTL in the same array design, we can compare the total enengy yield.

5.1.2 Array Energy Yield of Inverter (E_A) of Station Phase II

TÜV SÜD checked and compiled statistics of the Huawei inverter historical output energy data of Golmud PV plant station phase II, sourcing from monitoring and control system of Golmud PV Plant station phase II. The array energy yield data were counted from January 1, 2014 as follows.

Table 5-2 Array Energy Yield of Inverter (EA) of station phase II

Array Energy Yield (kWh)	III_49	III_50	III_51	III_52	II_49	II_50	II_51	II_52
2014-01	140630.2	142851.4	146524.6	148576.3	154340.1	152709.8	154047.1	154201
2014-02	132578.0	125599.7	131564.3	131389.3	133250.6	132530.9	132493.4	133287.2
2014-03	177687.6	176829.7	175804.5	176974.5	179918.8	180045.3	177159.9	180322.6
2014-04	167798.5	170500.3	169561.5	171307.2	172673.6	162503.3	154907.8	172735.3
2014-05	182166.4	181049.6	177056.5	178027.5	182383.7	182430.1	174876.0	187629.9
2014-06	154483.2	153017.5	105188.8	144537.3	145056.8	151954.7	153732.2	155225.2
2014-07	176634.5	175935.2	175603.8	175646.3	180086.7	180557.5	180051.6	179949.3
2014-08	172785.1	172894.8	172146.9	172590.6	170320.0	170177.4	173343.8	174691.9
2014-09	162046.2	162668.0	162214.8	162735.7	164228.4	164148.9	163581.3	164277.3
2014-10	132233.4	131984.7	131742.7	132086.3	133526.4	133573.2	132749.2	133018.0
2014-11	148531.8	148210.1	147895.9	148464.7	151013.2	151042.3	150159.2	151033.7
2014-12	125516.9	125250.5	124624.3	124344.9	126672.6	126855.0	126284.5	127293.0
2014 Annual	**1873092**	**1866792**	**1819929**	**1866681**	**1893471**	**1888528**	**1873386**	**1913664**
2015-01	129332.4	128936	129249	129163.9	132729.0	132230.9	131645.6	132793.5
2015-02	106571.0	106250.9	101382.1	107945.4	114901.0	113193.7	113077.1	113918.5
2015-03	165320.7	165173.3	167288.0	166199.0	167222.6	166088.3	166369.1	167620.7
2015-04	175411.7	174748.4	175506.0	176340.4	176902.0	176125.2	175708.3	176992.7
2015-05	183787.9	182032.9	182534.1	182070.7	184779.7	184652.8	183091.5	184741.8
2015-06	114551.9	113541.7	121636.2	118511.7	125098.3	125081.7	124208.0	125162.8
2015-07	179352.9	177249.8	177630.1	176594.9	180380.5	180038.4	178303.0	179714.9
2015-08	185856.3	184013.0	184490.0	183248.8	187551.9	186659	183077.2	186505.8
2015-09	151844.4	150927.7	149794.1	150299.9	153072.7	152676.3	151787.0	152545.8

2015-10	183043.9	182036.6	182025.7	181901.5	185801.7	185232.0	181160.1	183882.3
2015-11	150314.8	149643.1	149838.2	149949.5	151469	151202	151100.1	151523.1
2015-12	152849.8	152248.5	152940.2	151967.9	154752.9	154498.8	154677.1	154969.2
2015 Annual	**1878238**	**1866802**	**1874314**	**1874194**	**1914661**	**1907679**	**1894204**	**1910371**
2016-01	164649.0	163603.5	164479.2	164102.3	165943.4	165433.1	165153.6	165884.1
2016-02	163021.3	161628.0	161715.9	162356.1	166799.5	166447.1	164879.4	166242.8
2016-03	182012.8	180276.3	184278.5	186240.0	183149.9	182492.6	186556.5	188212.9
2016-04	178699.3	176904.8	178481.1	178275.4	181602.7	181449.4	179795.9	181277.4
2016-05	167583.9	166683.9	167453.9	167577.1	171599.9	171446.2	169964.6	171402.1
2016-06	160406.2	159629.5	174459.9	159852.9	174542.5	174489.9	175276.3	176171.4
2016-07	165047.3	164182.3	164682.5	165592.3	170085.8	169996.8	168698.6	169913.0
2016 (Jan.-Jul.)	**1181420**	**1172908**	**1195551**	**1183996**	**1213724**	**1211755**	**1210325**	**1219104**

5.1.3 Array Yield (Y_A) from inveters of Station Phase II

According to the formula $Y_A = E_{A,d} / P_0$， the statistics of Array Yield(Y_A) from inveters AC side is as below table.

Table 5-3 Statistics of Array Yield (Y_A) from inveters AC side

	III_49	III_50	III_51	III_52	II_49	II_50	II_51	II_52
Inverter model	SUN8000-500KTL	SUN8000-500KTL	SUN8000-500KTL	SUN8000-500KTL	SUN2000-20KTL	SUN2000-20KTL	SUN2000-20KTL	SUN2000-20KTL
Array rated capacity (kW)	1020	1020	1020	1020	1020	1020	1020	1020
Annual energy, yield 2014 (kWh)	1873092	1866792	1819929	1866681	1893471	1888528	1873386	1913664
Y_A, 2014 (h)	1836.36	1830.19	1784.24	1830.08	1856.34	1851.50	1836.65	1876.14
Annual energy, yield 2015 (kWh)	1878238	1866802	1874314	1874194	1914661	1907679	1894204	1910371
Y_A, 2015 (h)	1841.41	1830.20	1837.56	1837.45	1877.12	1870.27	1857.06	1872.91
Energy yield, 2016 (Jan.-Jul.) (kWh)	1181420	1172908	1195551	1183996	1213724	1211755	1210325	1219104
Y_A, 2016 (Jan.-Jul.) (h)	1158.25	1149.91	1172.11	1160.78	1189.93	1188.00	1186.59	1195.20

The above table shows that,

From 2014-01-01 to 2016-07-31, each 4MW array AC energy yield (E_A) counted from central inverters SUN8000-500KTL and strings inverters SUN2000-20KTL are as below.

$E_{A(SUN8000-500KTL)}$ = 19653917 kWh

$E_{A(SUN2000-20KTL)}$ = 20050872 kWh

Array yield (Y_A) counted from 4MW central inverters SUN8000-500KTL is

$Y_{A(SUN8000-500KTL)}$ =19653917 kWh / (4*1020 kW) = 4817.1 h

In which, $Y_{A,2014}$ = 1820.2 h； $Y_{A,2015}$ = 1836.7 h； $Y_{A,2016(Jan.-Jul.)}$ = 1160.3 h.

Array yield (Y_A) counted from 4MW strings inverters SUN2000-20KTL is

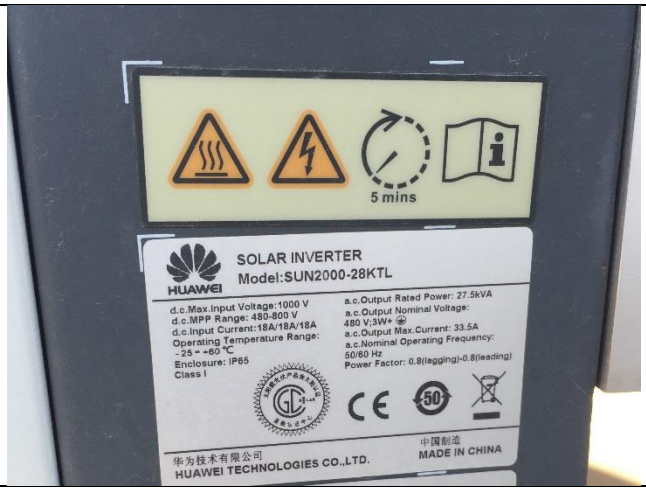
$Y_{A(SUN2000-20KTL)}$ =20050872 kwh / (4*1020 kW) = 4914.4 h

In which, $Y_{A,2014}$ = 1855.2 h； $Y_{A,2015}$ = 1869.3 h； $Y_{A,2016(Jan.-Jul.)}$ = 1189.9 h.

The ratio of Array yield between strings inverters SUN2000-20KTL and central inverters SUN8000-500KTL is below.

$Y_{A(SUN2000-20KTL)}$ / $Y_{A(SUN8000-500KTL)}$ = 4914.4 / 4817.1 = 102.02 %

Appendix Photo Documentation

P1. PV Plant	P1. PV Plant
	
P3. SUN2000-20KTL	P4. SUN2000-20KTL
	
P5. SUN2000-28KTL	P6. SUN2000-28KTL
	

P7. SUN2000-40KTL	P8. SUN2000-40KTL
	
P9. SUN2000-50KTL	P10. SUN2000-50KTL
	

End of Report