14th Annual PQSynergy™
International Conference and Exhibition 2014

Solar Plant in Thailand and its impact on Power Quality

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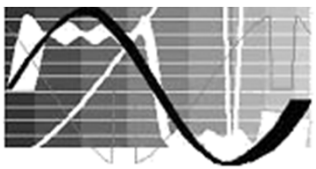
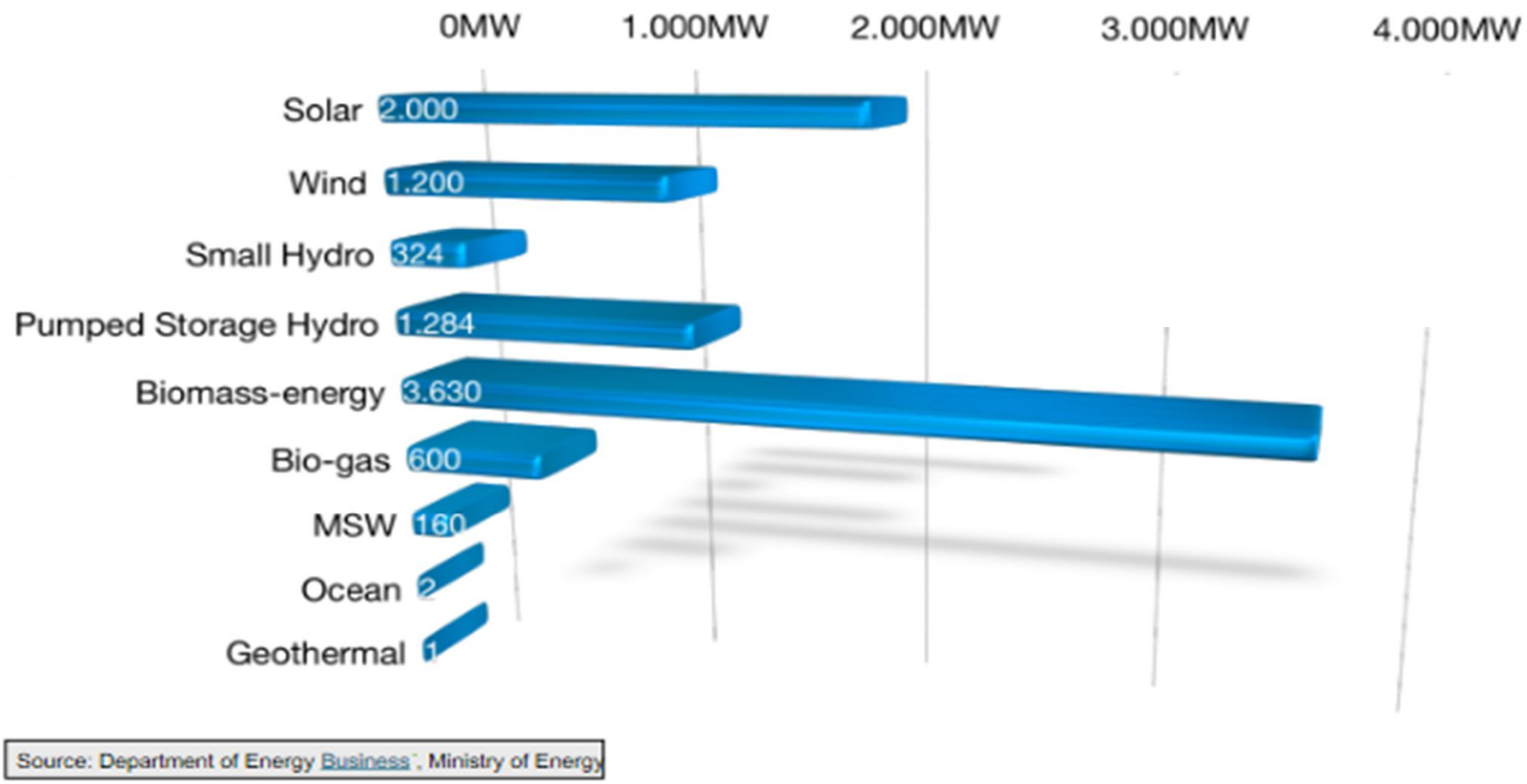
Power Quality Engineer



Power Quality Thailand LTD.

Thailand Development Plan 2012-2021



Source: Department of Energy Business", Ministry of Energy

Thailand Factors for One of the Best Locations on Solar Power Project – Except its Sun

- Thailand was one of the first Asian countries with comprehensive feed-in tariff/adder program.

Type of RE	Unit: US Dollars per kWh					Years Supported
	2007 Adder Rate	2009 Adder Rate	2010 Addder Rate	Special Adder for Diesel Replacement	Special Adder for Three Southernmost Provinces	
Biomass						
Installed Capacity ≤ 1 MW	0.010	0.017	0.017	0.033	0.033	7
Installed Capacity > 1 MW	0.010	0.010	0.010	0.033	0.033	7
Biogas						
Installed Capacity ≤ 1 MW	0.010	0.017	0.017	0.033	0.033	7
Installed Capacity > 1 MW	0.010	0.010	0.010	0.033	0.033	7
Waste						
Landfill and Digestor	0.083	0.083	0.083	0.033	0.033	7
Thermal Process	0.083	0.117	0.117	0.033	0.033	7
Wind						
Installed Capacity ≤ 50 kW	0.117	0.150	0.150	0.050	0.050	10
Installed Capacity > 50 kW	0.117	0.117	0.117	0.050	0.050	10
Small/Micro Hydro						
50 kW <Installed Capacity < 200 kW	0.013	0.027	0.027	0.033	0.033	7
Installed Capacity ≤ 50 kW	0.027	0.050	0.050	0.033	0.033	7
Solar	0.267	0.267	0.217	0.050	0.050	10

Thailand Factors for One of the Best Locations on Solar Power Project – Except its Sun

- This program is successful by 1,000 MW already connected and selling power to the grid.
- Thailand had about 8,000 MW of renewable energy projects in the pipeline seeking adder.
- Even though, renewable energy share only 5% of energy resource, gas (66%), coal (20%).

The Major Players in Thailand Energy Market

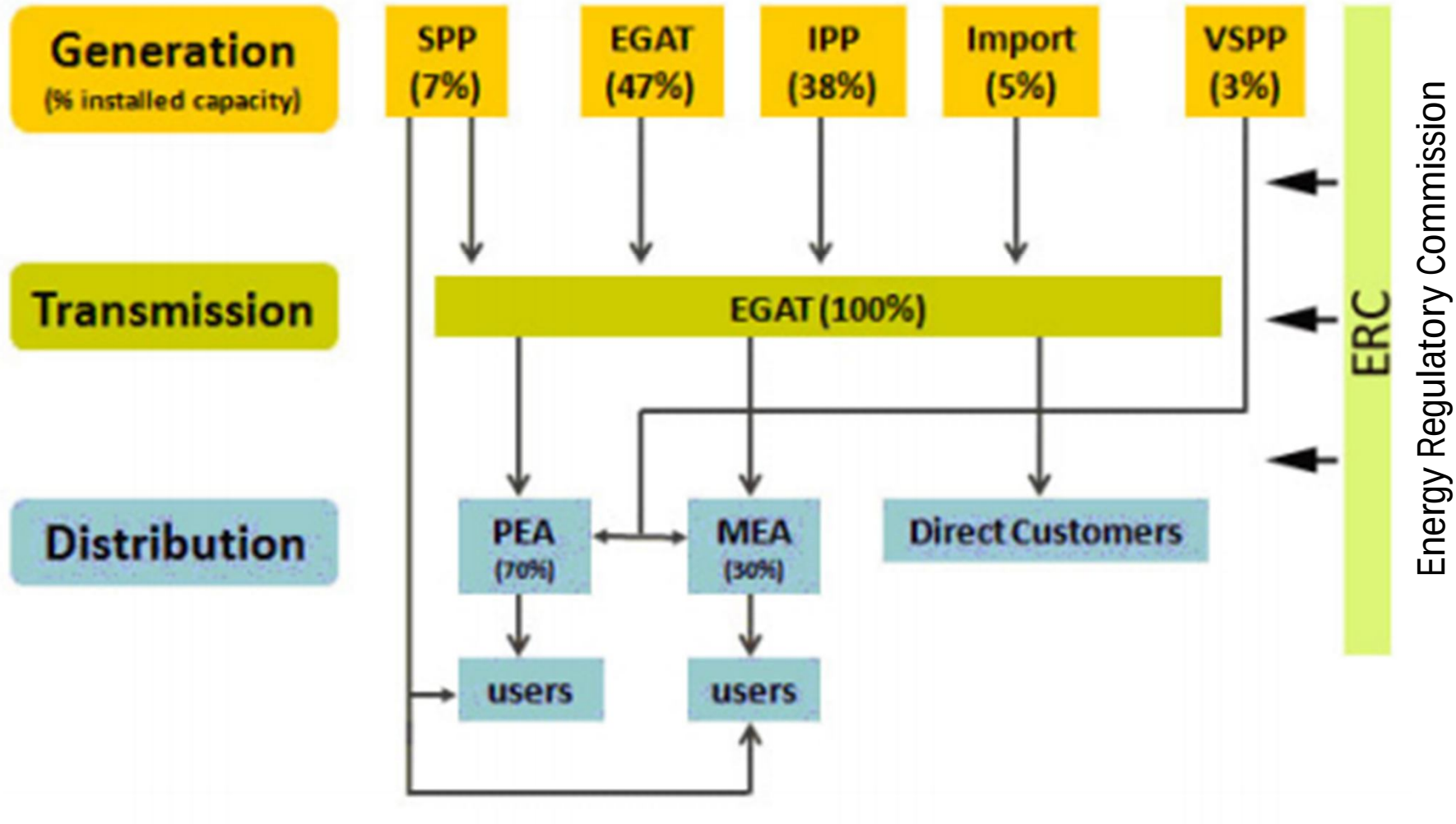
EGAT Electricity Generating Authority of Thailand is a state-owned company which controls 48.5% of the generating capacity, but 100% of the transmission system

EGAT generates and supplies electricity to the MEA and PEA for further distribution to consumers.

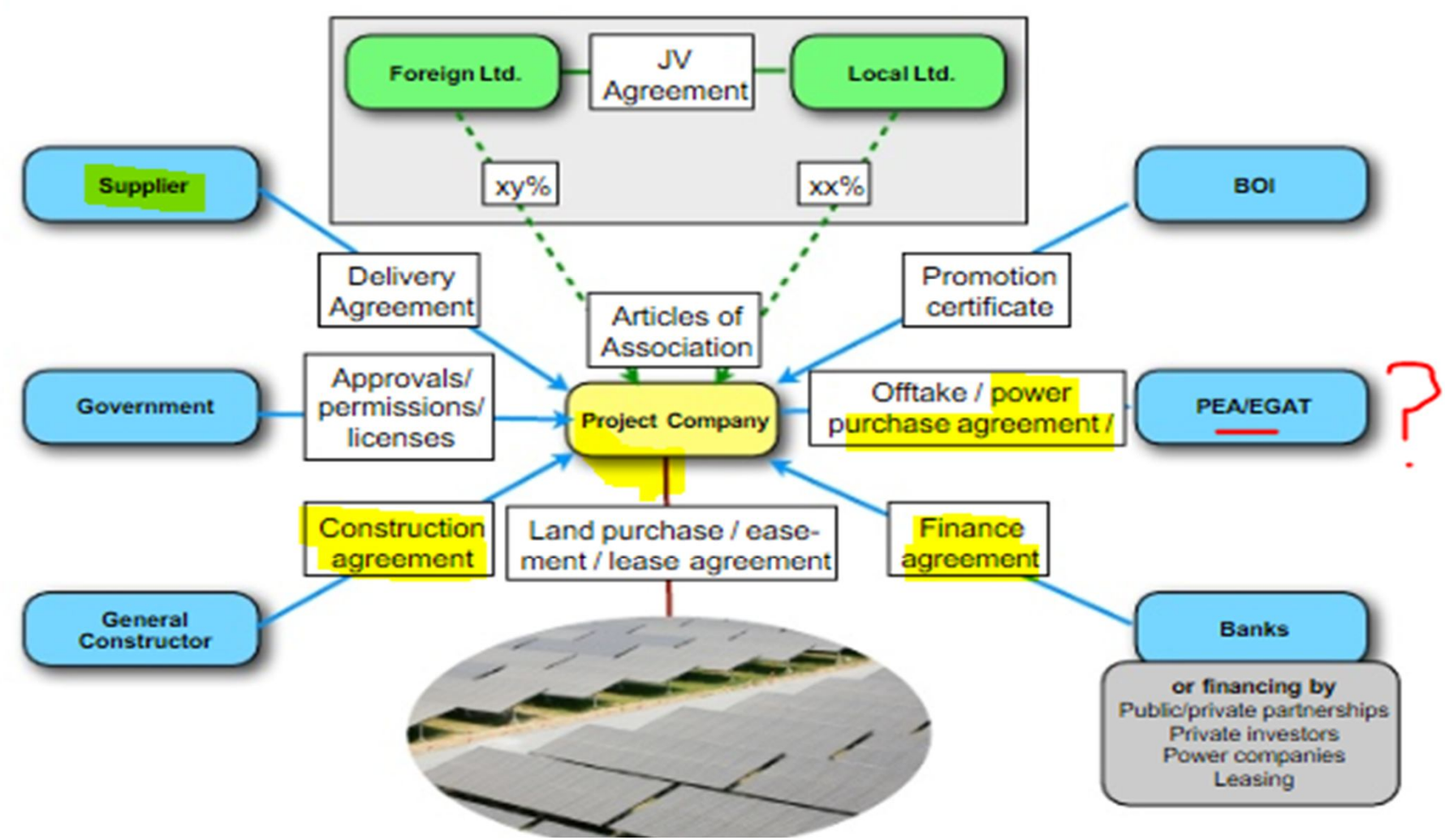
PTT Petroleum Authority of Thailand, PTTEP PTT Exploration and Production and Bangchak Petroleum are the three other major energy-related state enterprises, primarily in the oil and natural gas sector.

The IPP Independent Power Producer EGCO Electricity Generating Company and Ratchaburi Electricity Generating Holding are private sector competition in the power generation. 24% of the shares in EGCO are held by the Dutch TEPDIA Generating B.V., a joint venture between Tokyo Electric Power Company and Mitsubishi Corporation.

Structure of Thailand's Electric Power Industry

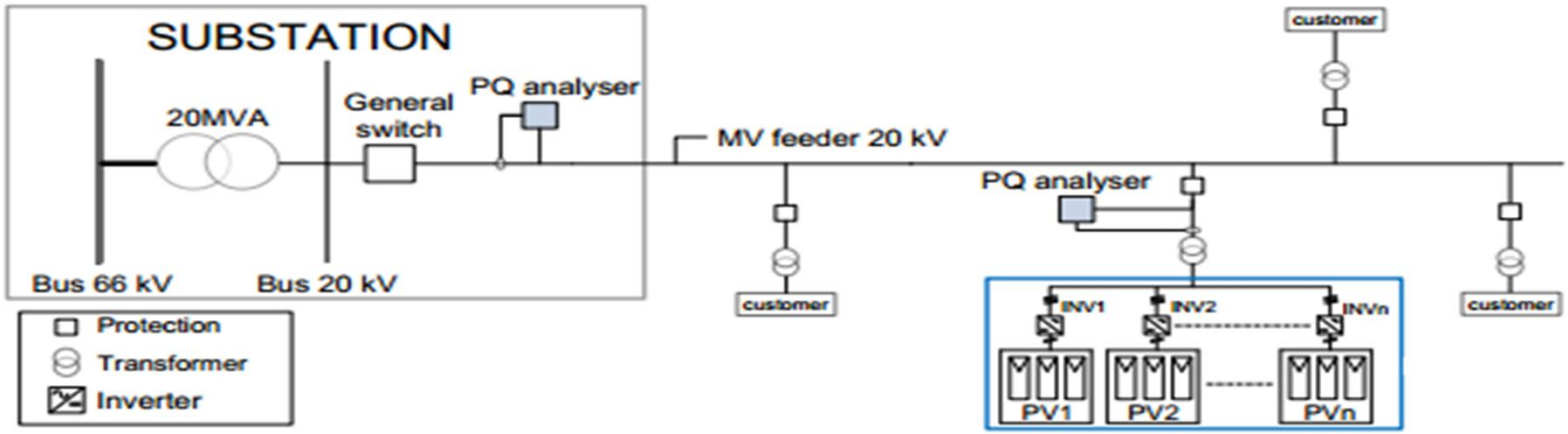


Simplified Contractual Structure for a Solar Power Plant Project in Thailand



Thailand Utility Regulation for Solar Power Plant

- MUST be installed PQ meter at connected point of common coupling.



- Quality of Supply checking
  - Voltage - Current
  - W, Var, VA - PF
  - Harmonics V, I - THD, TDD
  - Flicker - Unbalance

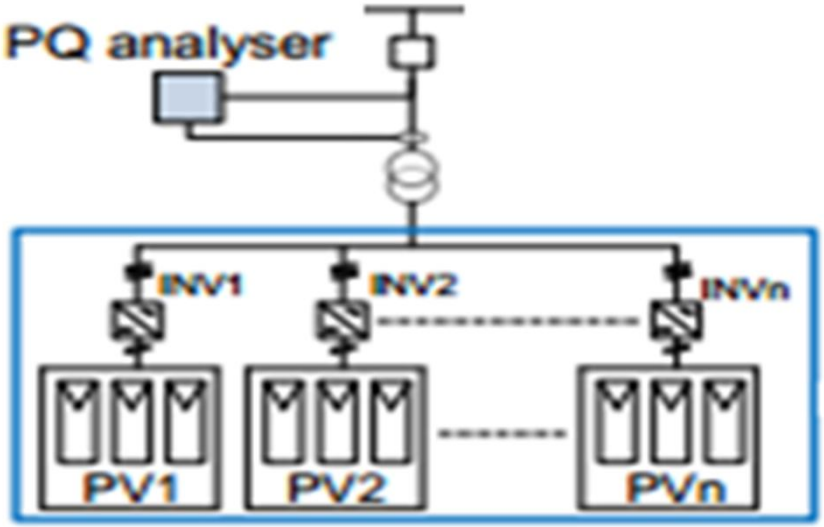
PQ Monitoring plays Important Rules for Solar PP

- High-penetrated grid-connected PV systems require more PQ monitoring on voltage fluctuation, voltage flicker, power factor, harmonic and events.

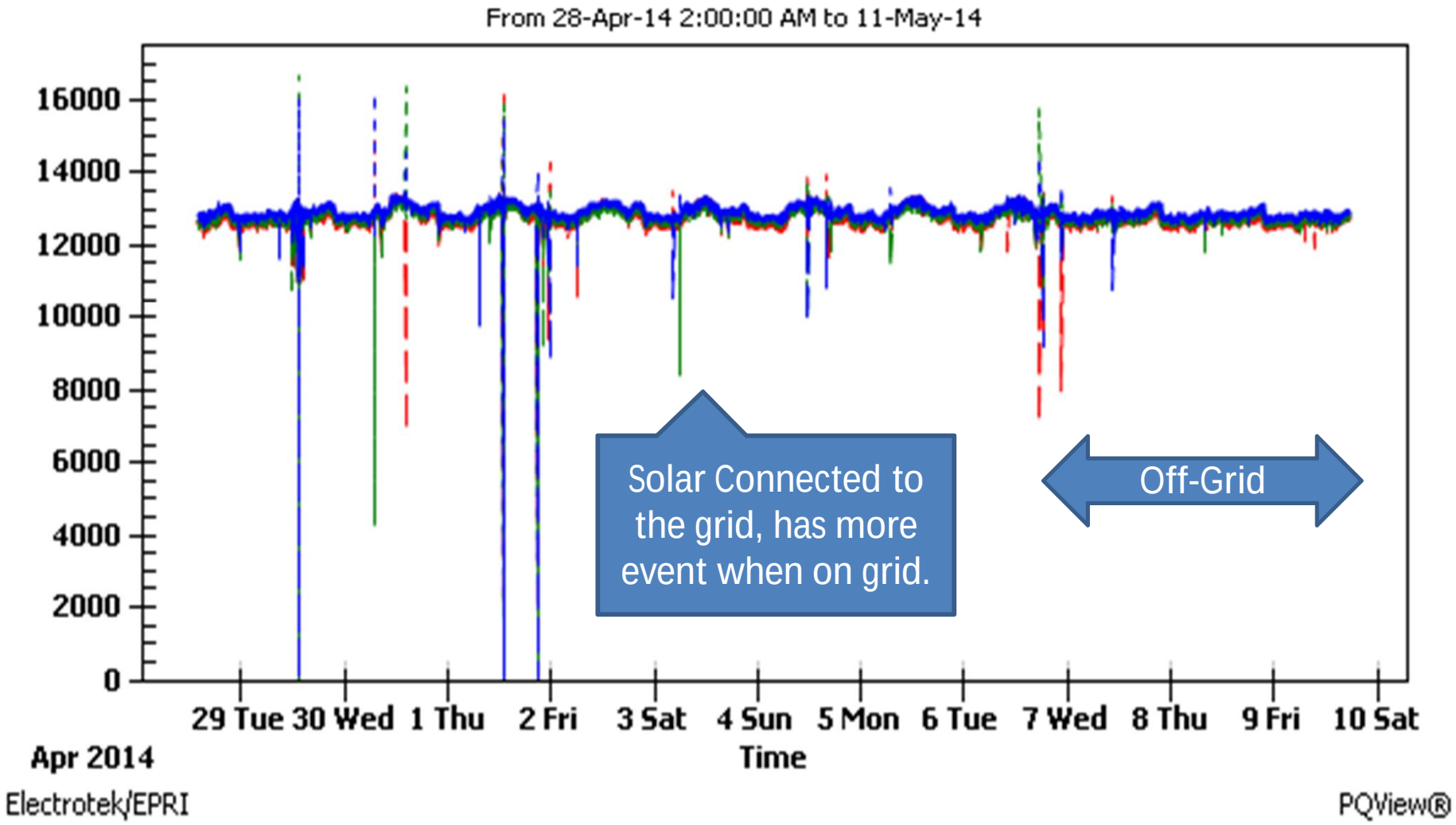
- Causing heat in electrical component, equipment failure or miss-operation then impact on cost of maintenance, repair, replace, time and manpower.

Case study from Solar Plant

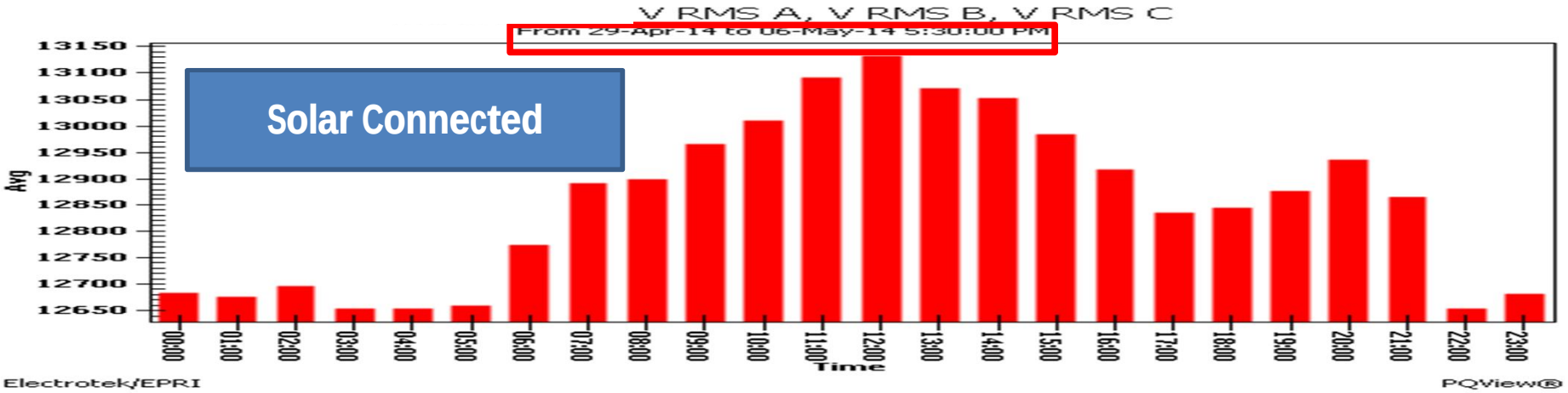
- Effect of On-Off gird Solar power plant 8 MW connected at 22kV.
  - **On-Grid:** 28 Apr 2014 – 6 May 2014
  - **Off-Grid:** 6 May 2014 – 9 May 2014

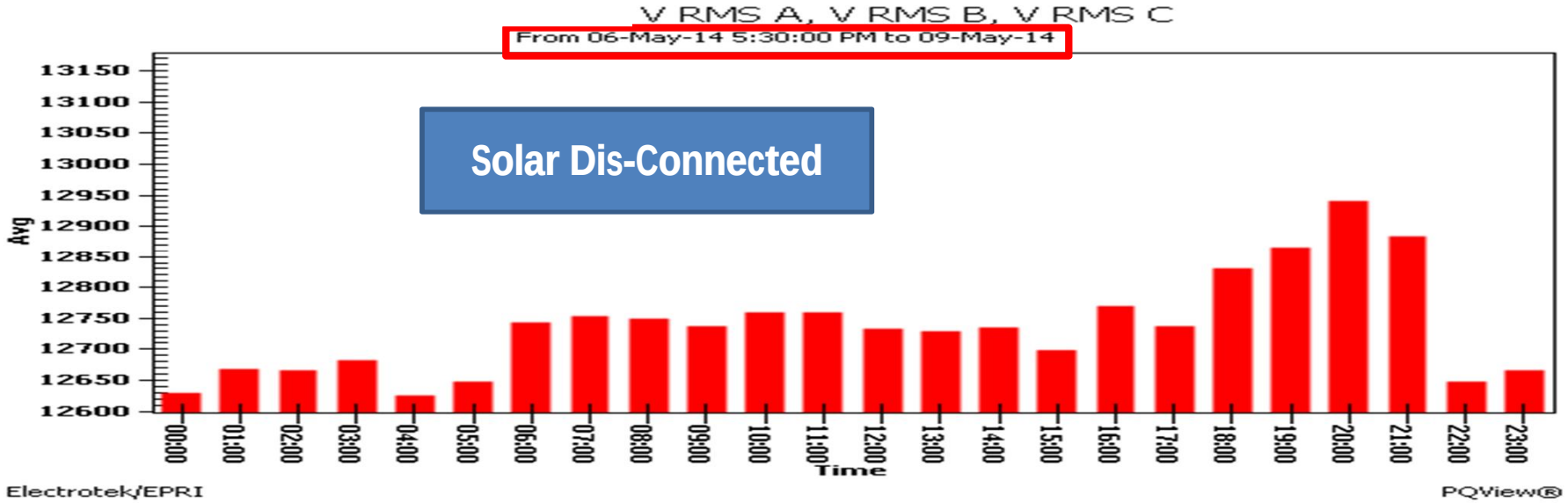


Voltage Profile

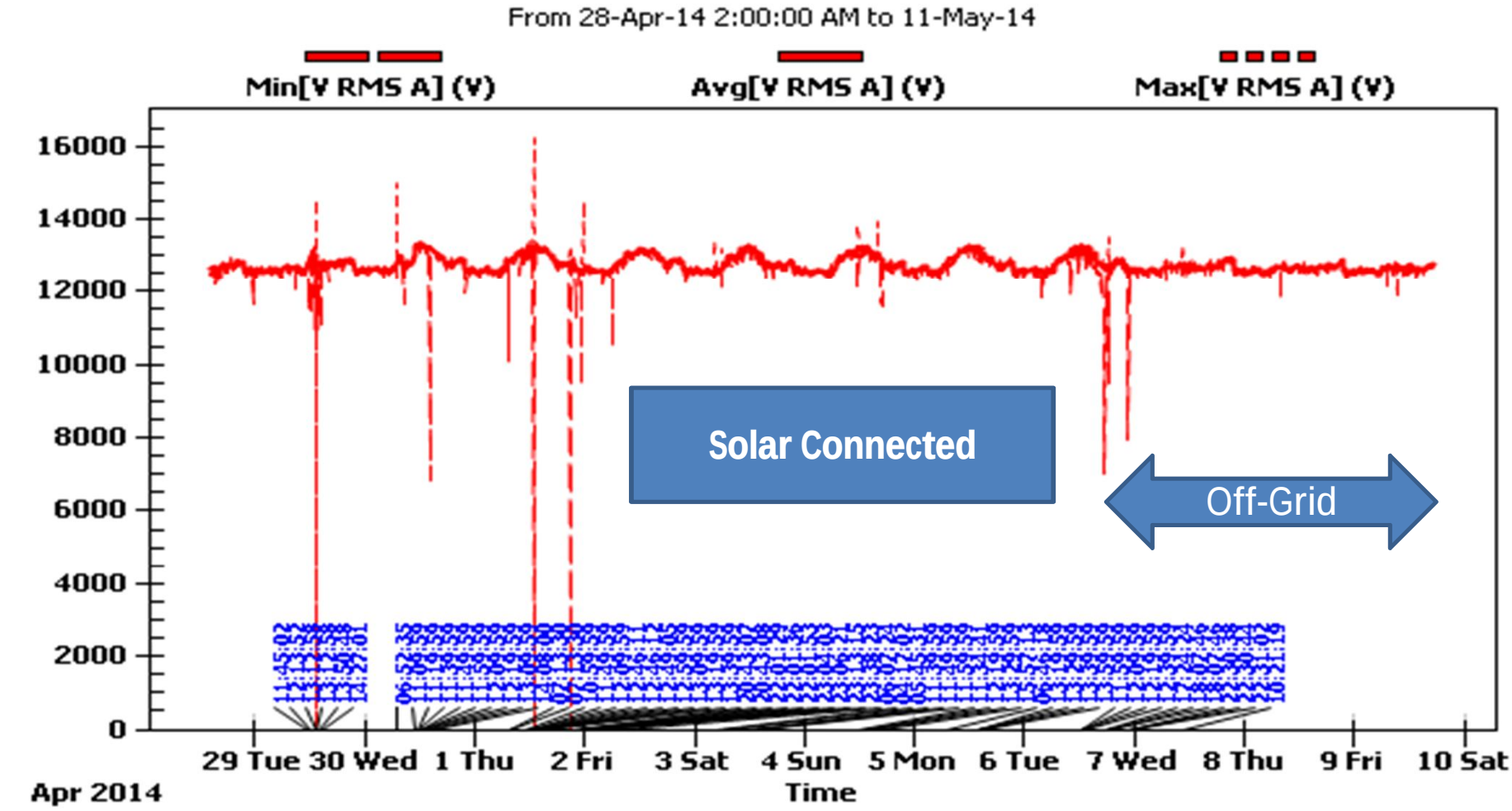


Voltage Profile

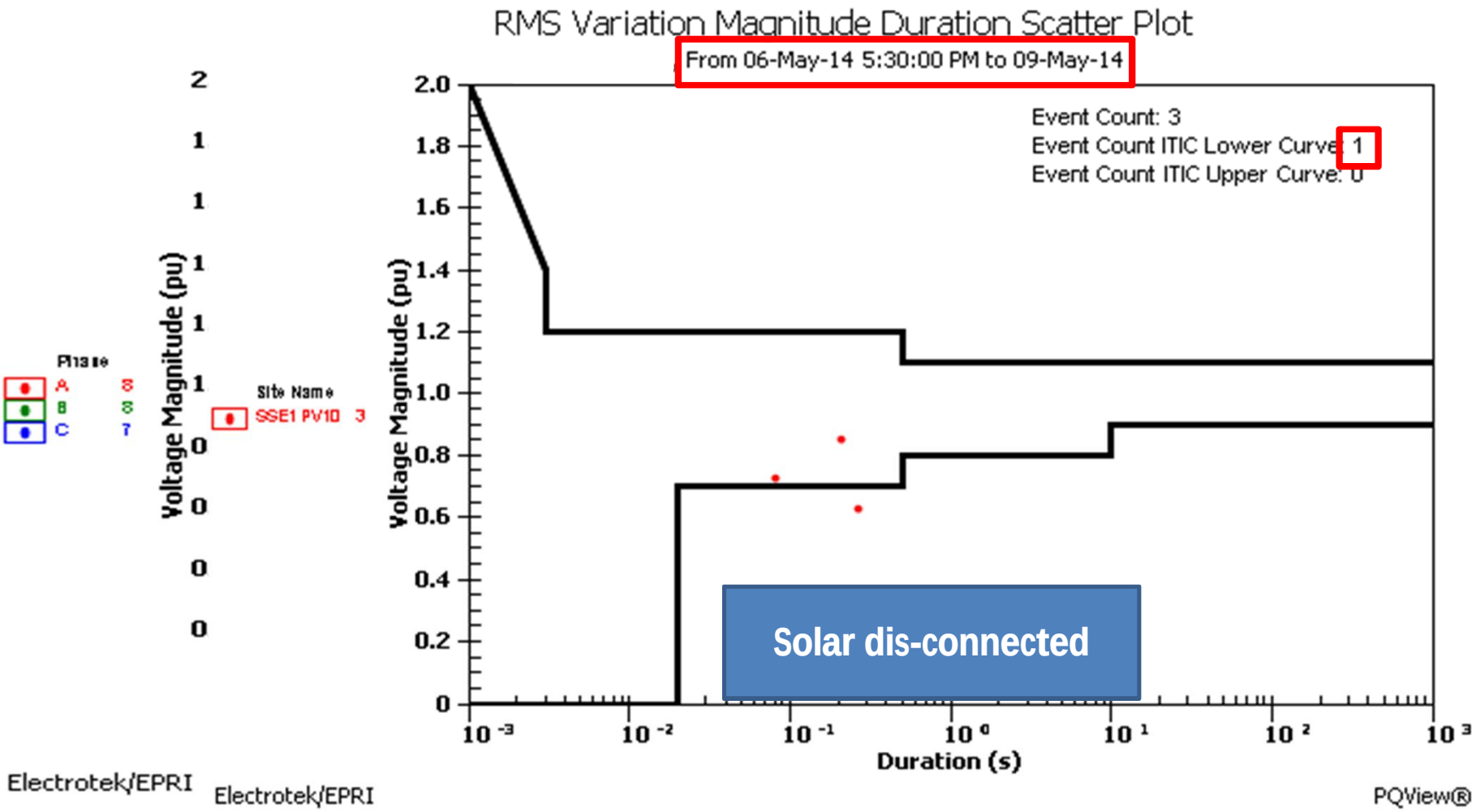




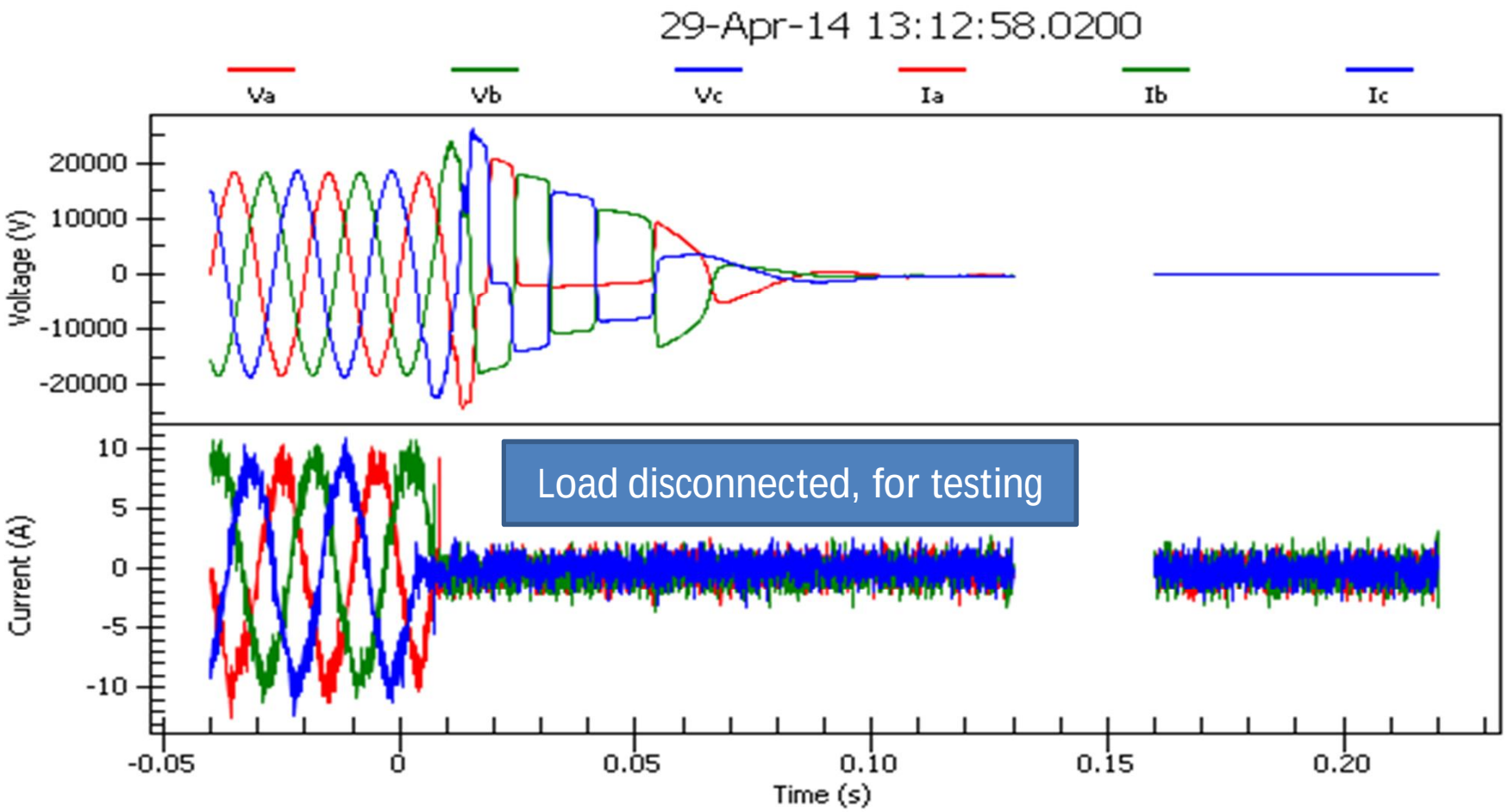
Events Trigger



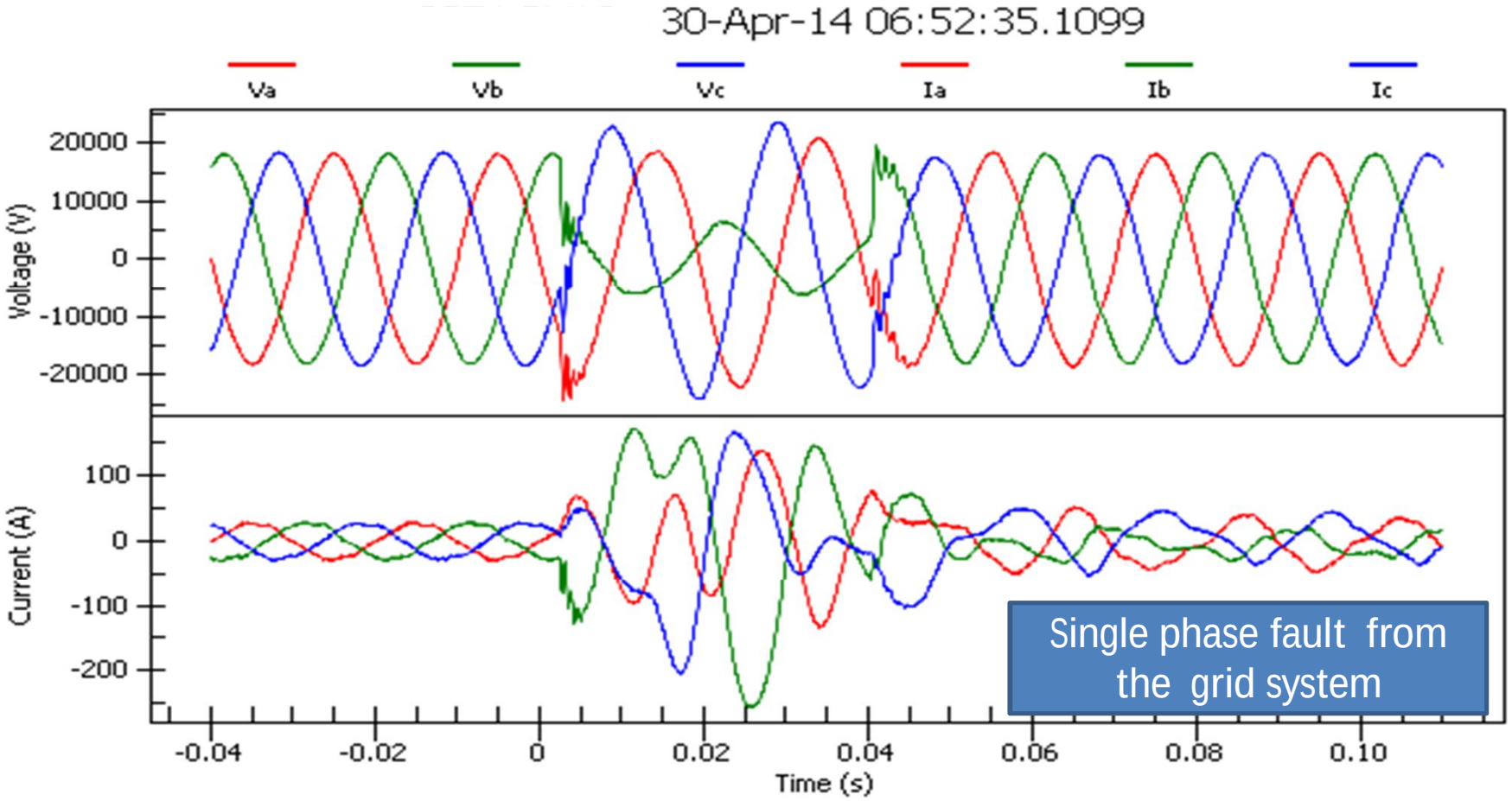
ITIC Chart Sensitivity Curve



Data Captured by PQ monitor Showing Solar Plant Response when Load Disconnected



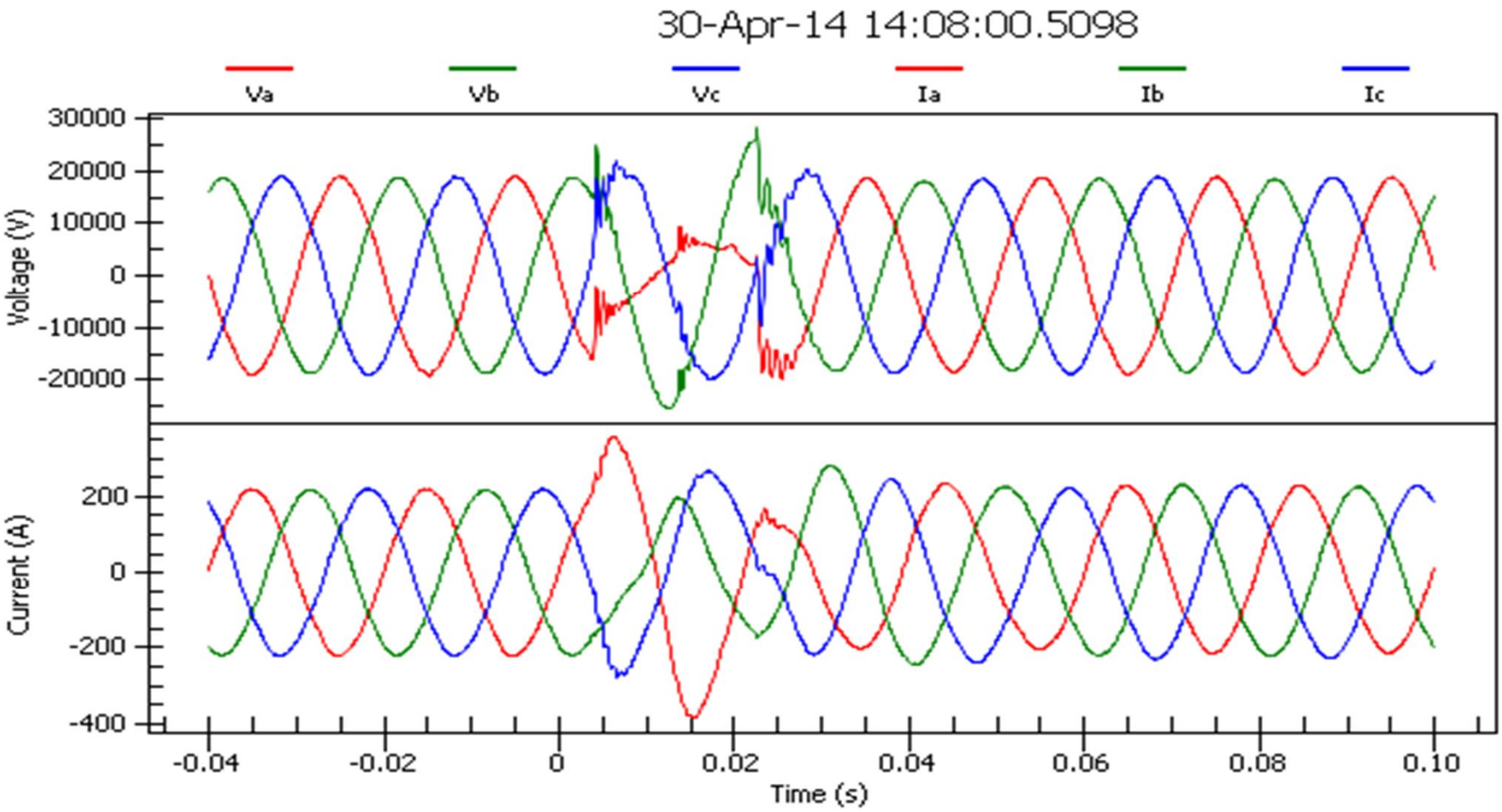
Data Captured by PQ monitor Showing Solar Plant Response to Fault



Event ID = 254
Electrotek/EPRI

System Event ID = 0
PQView®

Data Captured by PQ monitor Showing Solar Plant Response to Fault

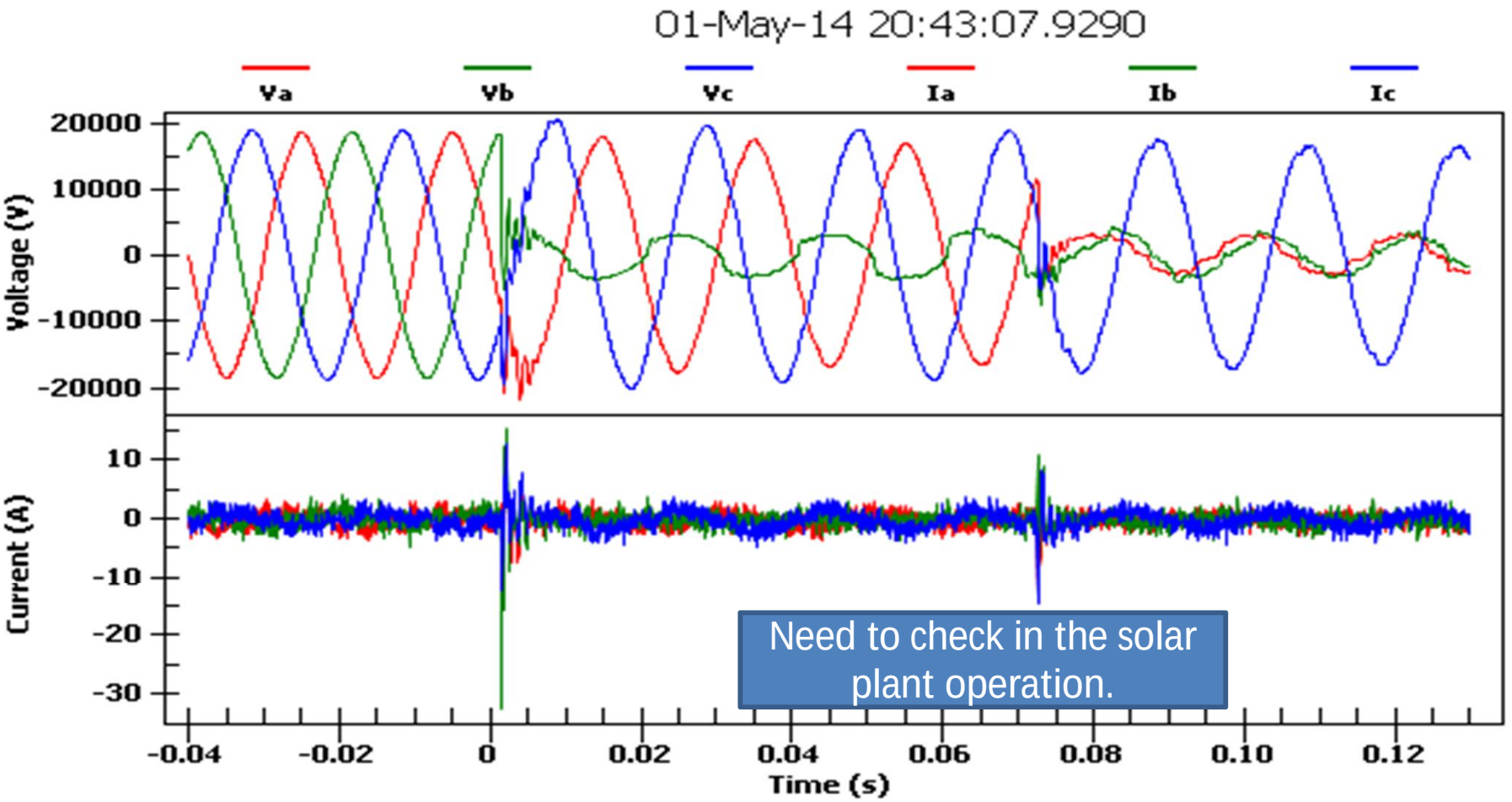


Event ID = 298
Electrotek/EPRI

Single phase fault from the system

stem Event ID = 0
PQView®

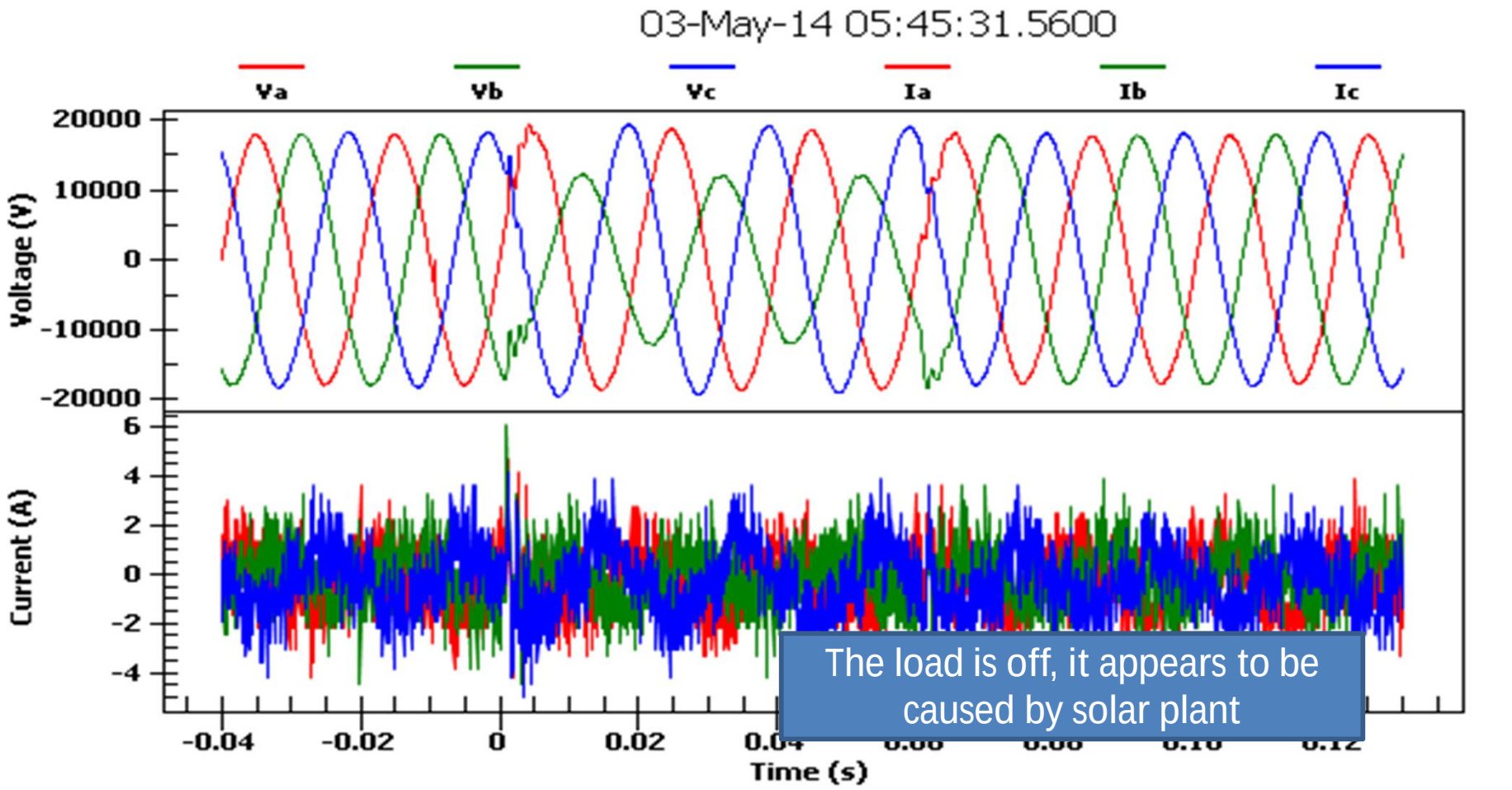
Power Quality Impact from Solar Power Plant



Event ID = 488
Electrotek/EPRI

System Event ID = 0
PQView®

Power Quality Impact from Solar Power Plant



Event ID = 697
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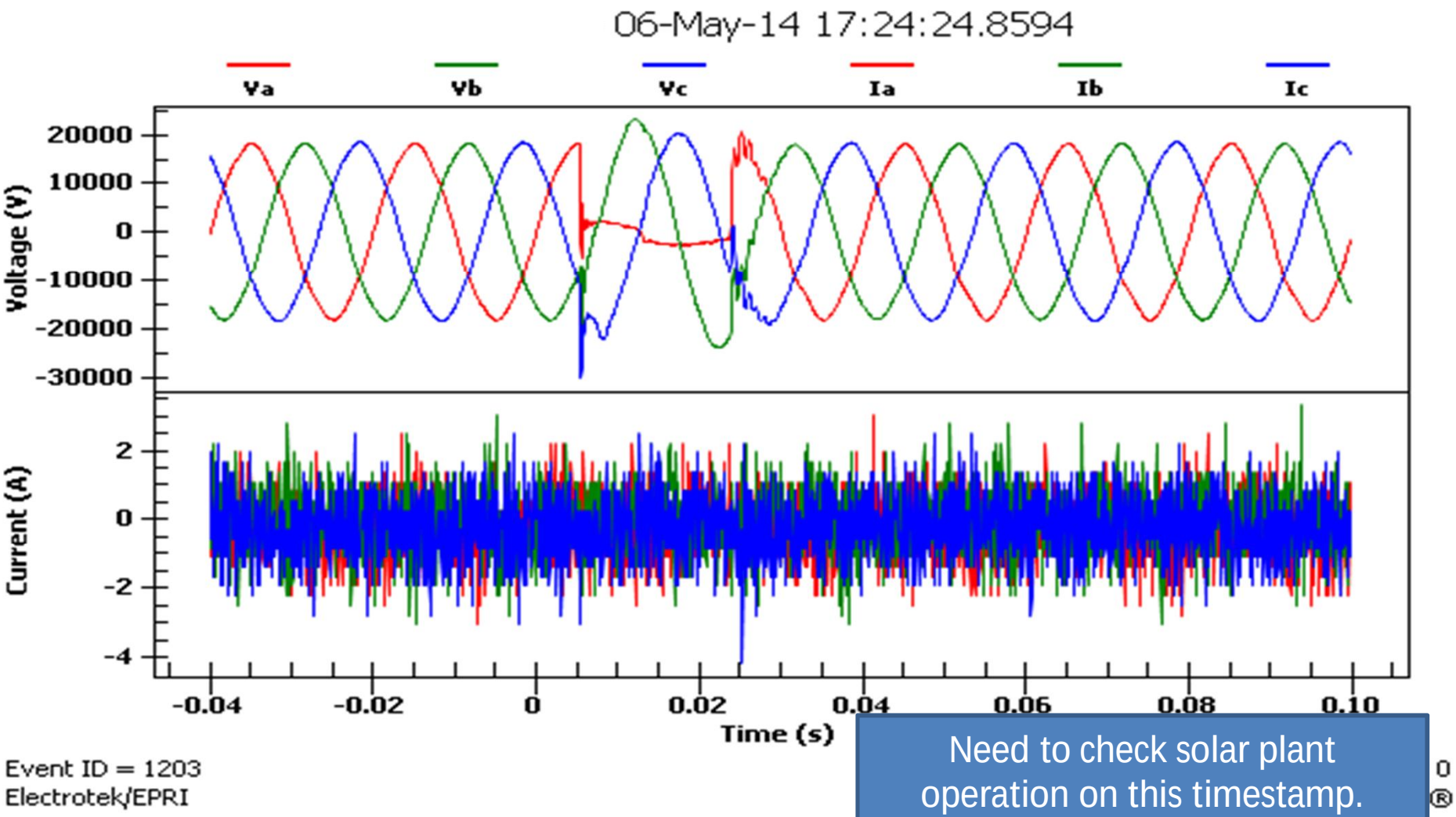
System Event ID = 0
PQView®

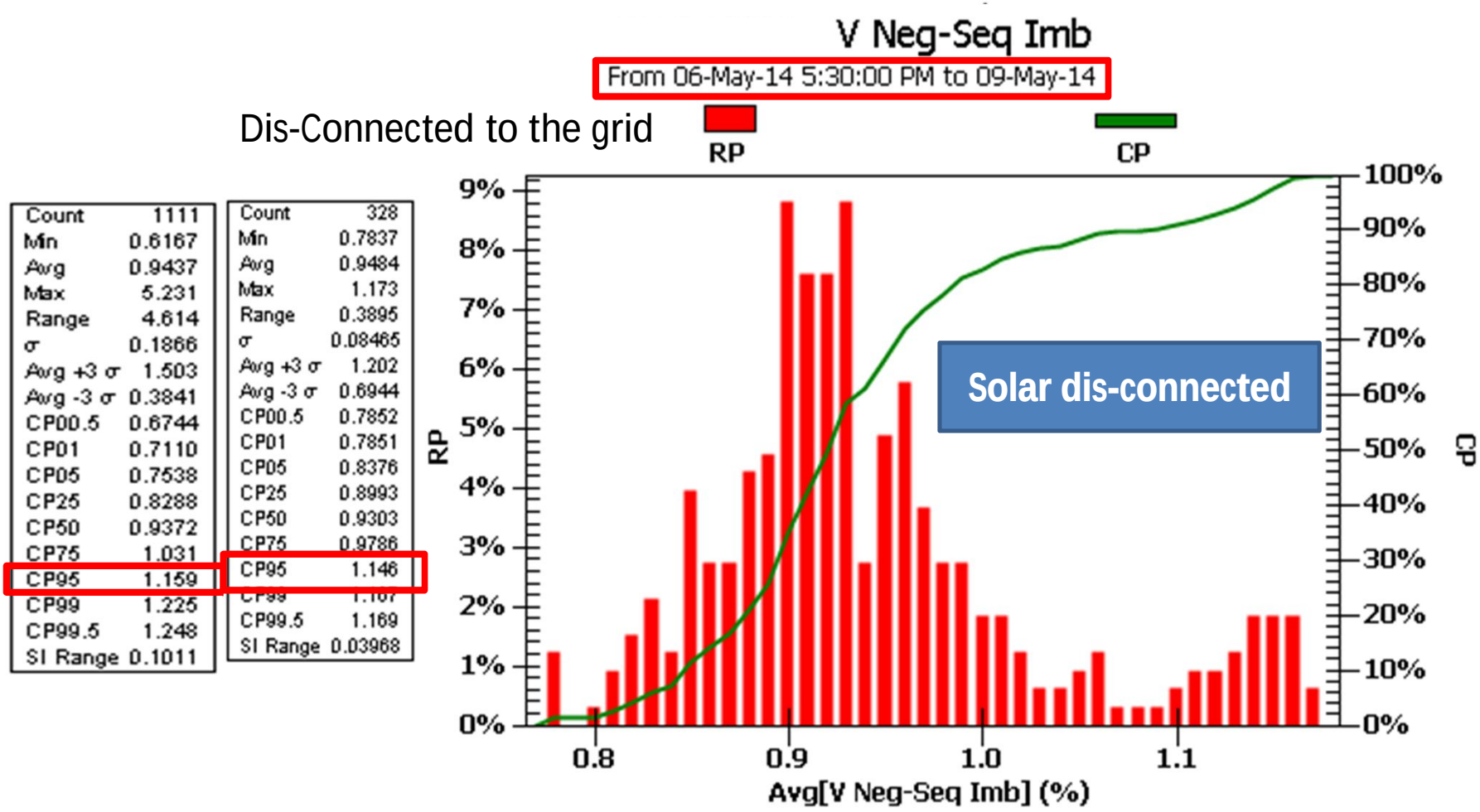
Power Quality Impact from Solar Power Plant



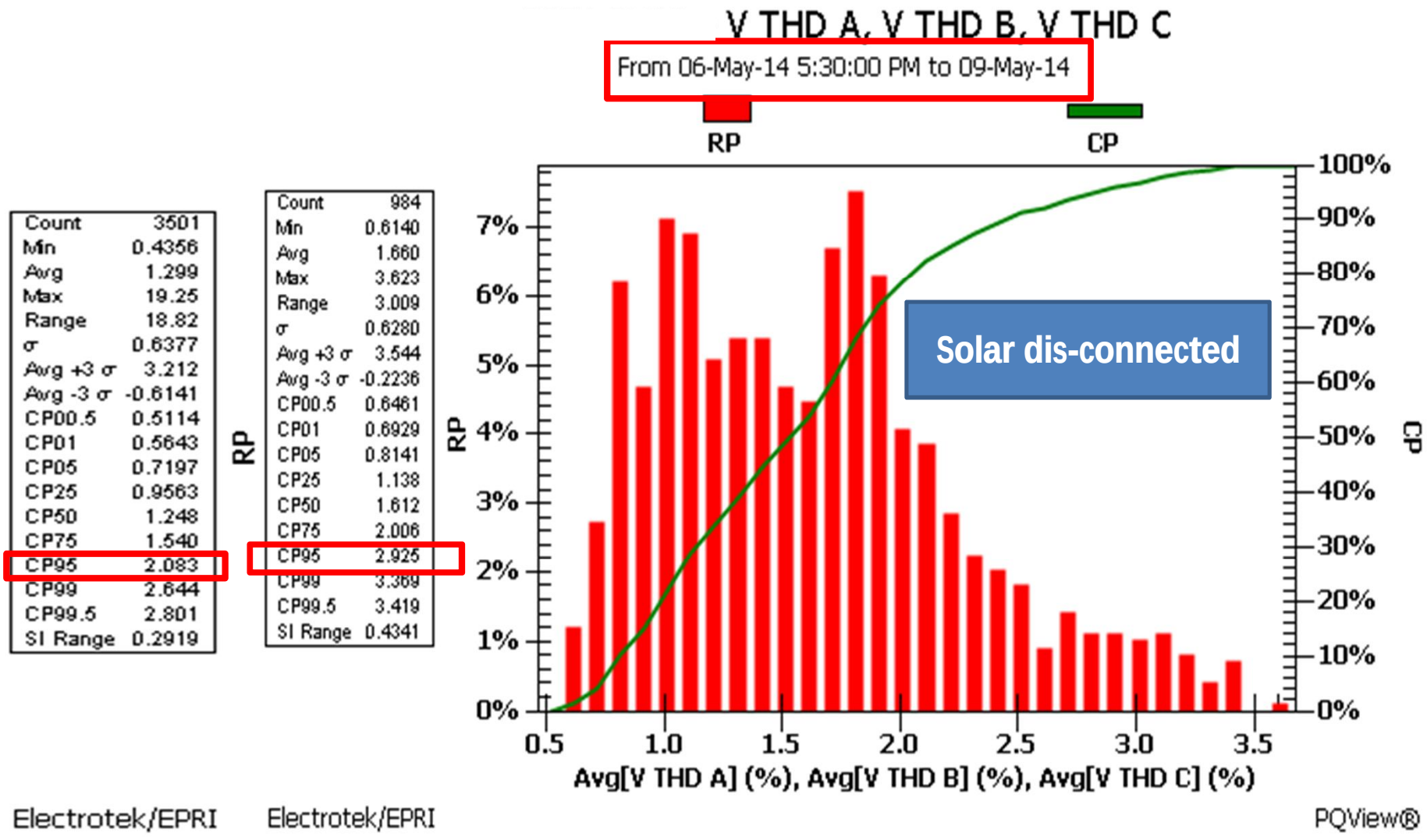
Need to check solar plant operation on this timestamp.

Unbalance

Dis-Connected to the grid



VTHD



RP	
Count	3501
Min	0.4356
Avg	1.299
Max	19.25
Range	18.82
σ	0.6377
Avg +3 σ	3.212
Avg -3 σ	-0.6141
CP00.5	0.5114
CP01	0.5643
CP05	0.7197
CP25	0.9563
CP50	1.248
CP75	1.540
CP95	2.083
CP99	2.644
CP99.5	2.801
SI Range	0.2919

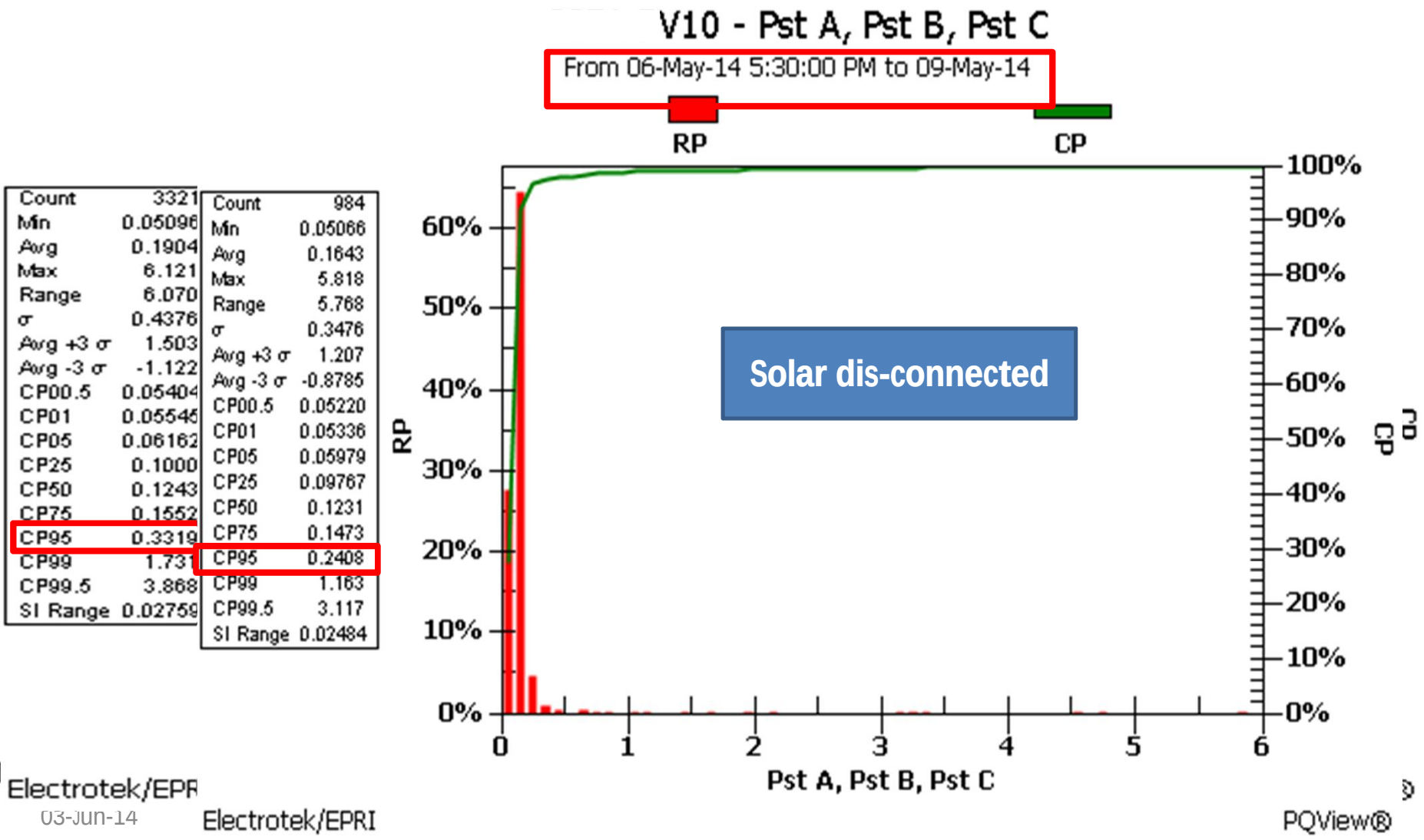
Electrotek/EPRI

CP	
Count	984
Min	0.6140
Avg	1.660
Max	3.623
Range	3.009
σ	0.6280
Avg +3 σ	3.544
Avg -3 σ	-0.2236
CP00.5	0.6461
CP01	0.6929
CP05	0.8141
CP25	1.138
CP50	1.612
CP75	2.006
CP95	2.925
CP99	3.369
CP99.5	3.419
SI Range	0.4341

Electrotek/EPRI

PQView®

Flicker: Pst


V10 - Pst A, Pst B, Pst C
From 06-May-14 5:30:00 PM to 09-May-14
RP
CP
Count 3321
Min 0.05096
Avg 0.1904
Max 6.121
Range 6.070
σ 0.4376
Avg +3 σ 1.503
Avg -3 σ -1.122
CP00.5 0.05404
CP01 0.05545
CP05 0.06162
CP25 0.1000
CP50 0.1243
CP75 0.1552
CP95 0.3319
CP99 1.731
CP99.5 3.868
SI Range 0.02759
Count 984
Min 0.05066
Avg 0.1643
Max 5.818
Range 5.768
σ 0.3476
Avg +3 σ 1.207
Avg -3 σ -0.8785
CP00.5 0.05220
CP01 0.05336
CP05 0.05979
CP25 0.09767
CP50 0.1231
CP75 0.1473
CP95 0.2408
CP99 1.163
CP99.5 3.117
SI Range 0.02484
Solar dis-connected
RP
CP
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
5
6
Pst A, Pst B, Pst C
Electrotek/EPR
03-Jun-14
Electrotek/EPRI
PQView®

Conclusion

- Solar is very interesting investment in Thailand.
- Thailand utility has regulation for quality of supply from Solar power plant.
- Continuous PQ monitor is critical for both the solar farm and the utility to monitor the performance of the generation and the fault activity of the grid.

Recommendation

- Monitoring background should monitor before connect solar to the grid with the same time period.

- PQ monitoring should be installed at solar PCC at utility and in utility substation in order to see the impact of events.

Thank You

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