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Power quality measurement campaign at a Jordan LV grid and determination of the influence of a large PV plant



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Source: UNHCR

AGENDA

1. Project Background

2. Measurement Campaign

3. Power Quality Analysis

4. Conclusion

1. Project Background



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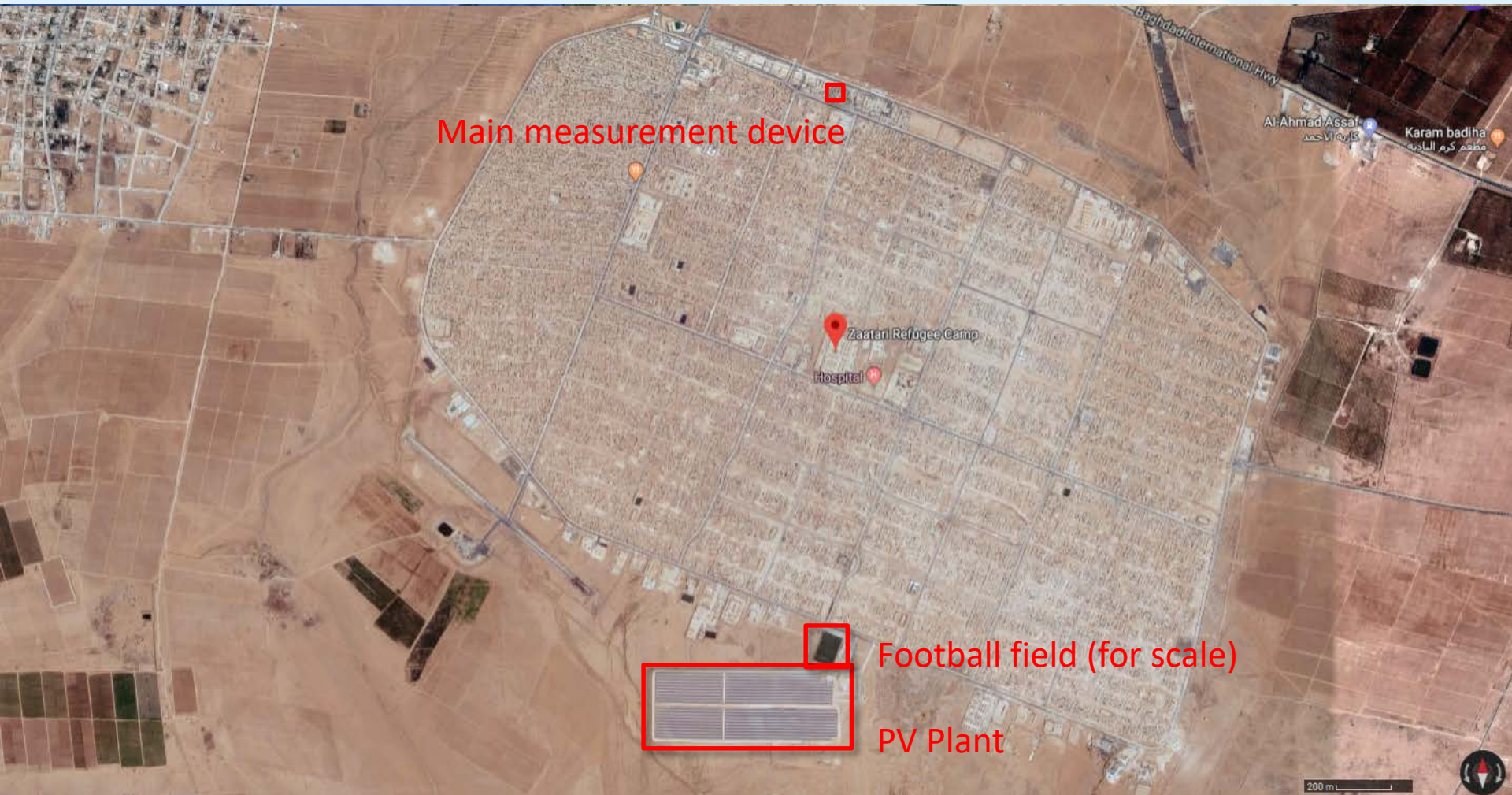
1. PROJECT BACKGROUND

- As a result of Syrian civil war many refugees fled to Jordan and Lebanon
- Large refugee camp „Al Zaatari“ was erected in Jordan close to the Syrian border and is operated by UNHCR, accomodating approximately 70 000 people
- Electricity supply of Al Zaatari is challenging regarding budget
- To reduce electricity bill refugees only have few hours electricity supply during night
- As remedial measure a 12.9 MWp PV plant was built next to the camp, funded by KfW
- Applying net metering, the electricity bill is reduced and thus more hours of available electricity are possible, which improves the living standard of the people
- The here described measurement campaign was conducted to determine the **influence of the PV plant on power quality** in the LV grid of the camp

1. PROJECT BACKGROUND



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Source: Google Maps



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1. PROJECT BACKGROUND

Al Zaatari refugee camp



Source: UNHCR

2. Measurement Campaign



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2. MEASUREMENT CAMPAIGN

- **Main objective:** Determination of the influence of the PV plant on power quality of the LV grid of the camp
- Besides, consumption of refugees is observed, so UNHCR can determine possibilities to save energy
- The camp is divided into 12 districts, each district has its own MV/LV transformer (630 to 1000 kVA) with power supply only during night
- In each district 1 measurement device was installed at LV side of transformer, mainly used to observe consumption
- There is continuous power supply at registration of UNHCR (and other facilities, such as hospitals)
- 1 measurement device installed at registration in **July 2017** (class S PQA)
- Mainly used for power quality analysis, all data shown here are from this device

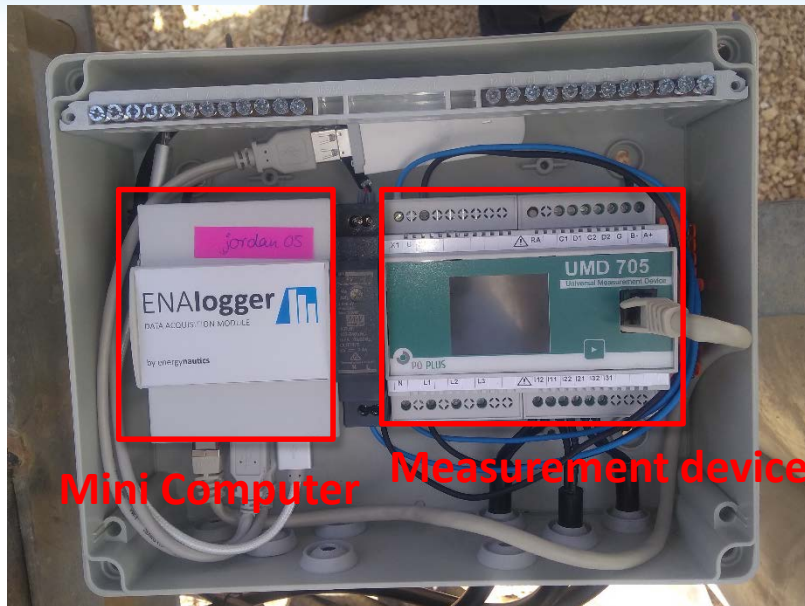
2. MEASUREMENT CAMPAIGN



Local electrician supporting us with the installation

- There were concerns, that the devices might overheat
- PQA is installed at north side of busbar housing in as shady place as possible
- No problems with heat observed so far

2. MEASUREMENT CAMPAIGN



Measurement setup

- Mini computer is used for
 - Internet connection for monitoring and data transfer via secure VPN tunnel
 - Backup data storage on USB stick
- In-house development by Energynautics



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2. MEASUREMENT CAMPAIGN



Measurement device after 1 year

- Huge amounts of dust
 - Bird excrements on some housings
-
- Good housing is essential!
 - IP 65 is recommended

3. Power Quality Analysis



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3. POWER QUALITY ANALYSIS

- Power quality was analyzed according to EN 50160:

Quantitiy	Requirements
Voltage magnitude	95 % of values within ± 10 % of rated voltage 100 % of values within +10 % / -15 % of rated voltage
THD	95 % of values below 8 %
Unbalance	95 % of values below 2 %
Flicker (P_{It})	95 % of values below 1

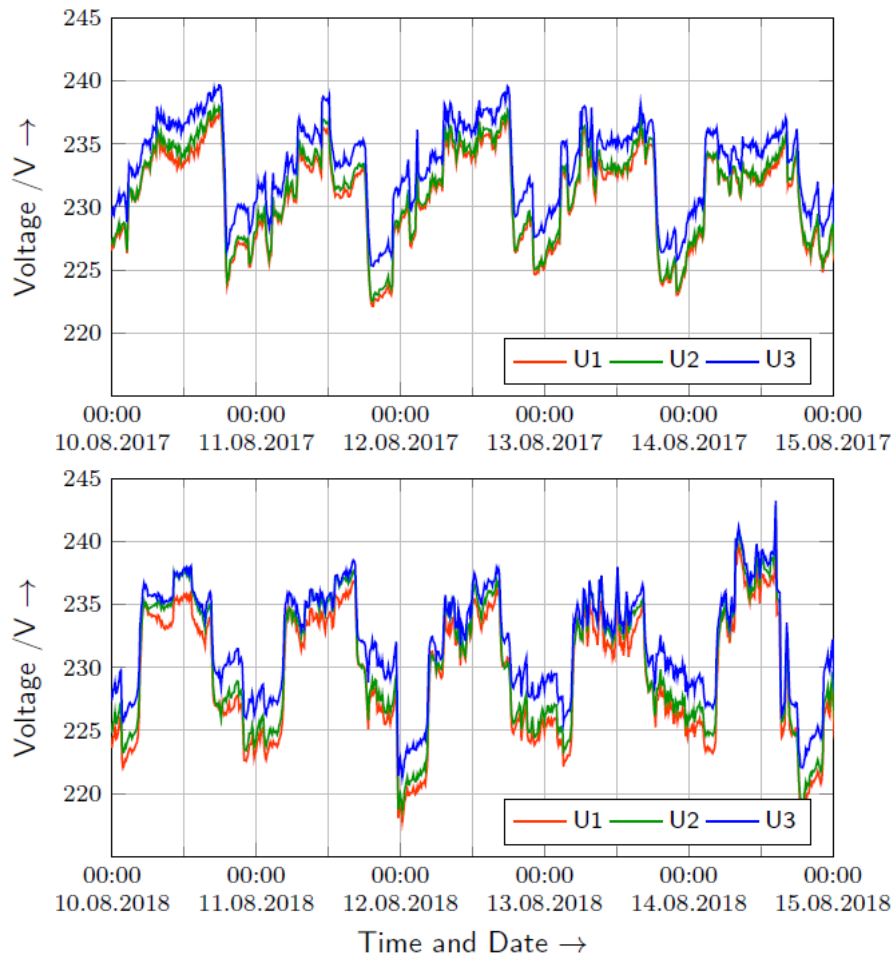
- 10 min average values for one week are used for the evaluation
- All these quantities are compared before and after the installation of the PV plant
- Additional analyses, such as average, maximum and minimum value calculation have been done



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3. POWER QUALITY ANALYSIS

Voltage magnitude:



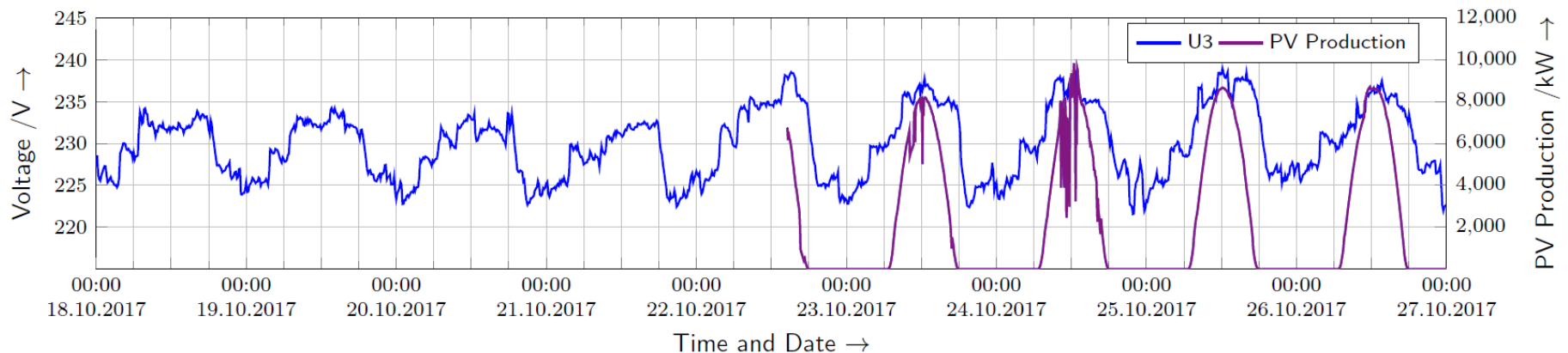
- Voltages fluctuates a lot
- Voltage is higher during the day even before connection of PV plant
 - Influence of the load of the camp
- Increased supply duration in 2018
 - Longer periods of low voltage
- Requirements of EN 50160 (+/-10 % for 95% of the time) fulfilled



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3. POWER QUALITY ANALYSIS

Voltage magnitude:

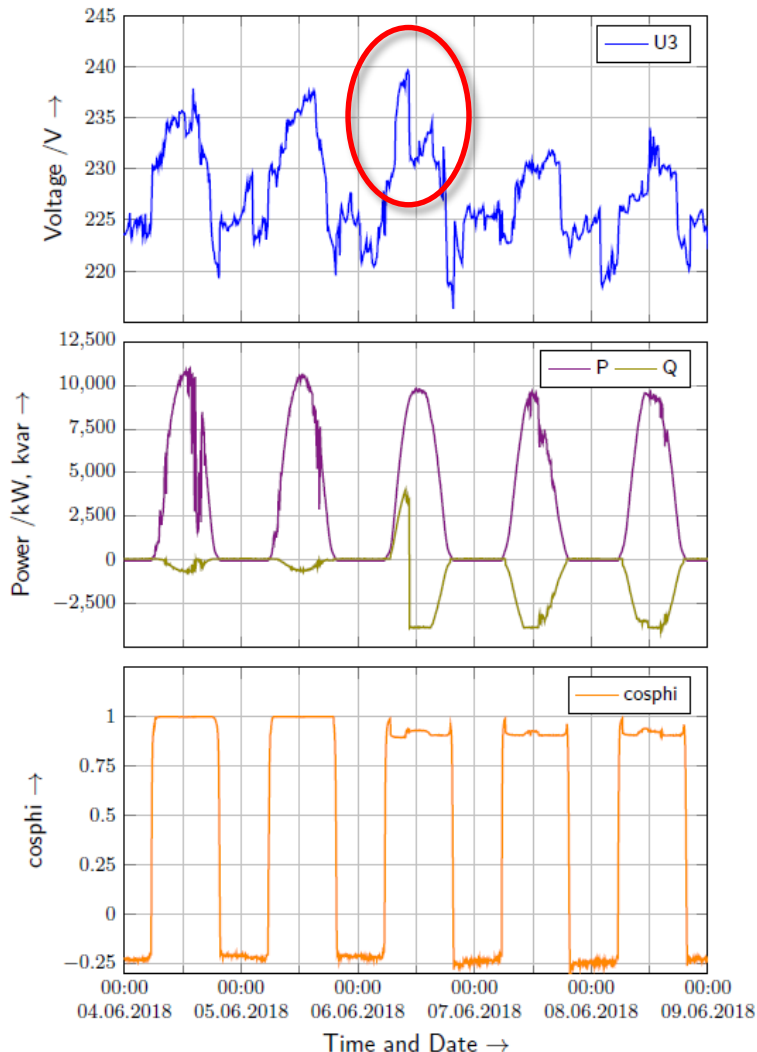


- Voltage immediately rises by ca. 4V at the moment the PV plant is connected
- Higher magnitudes in the days after connection
- Complaints by consumers about overvoltages in the LV grid
 - Operation mode was changed to $\cos\phi_i = 0.9$



3. POWER QUALITY ANALYSIS

Voltage magnitude:

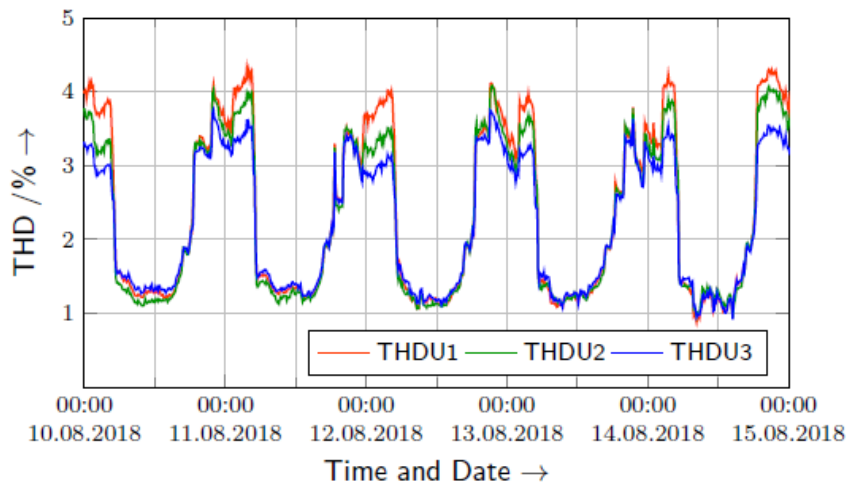
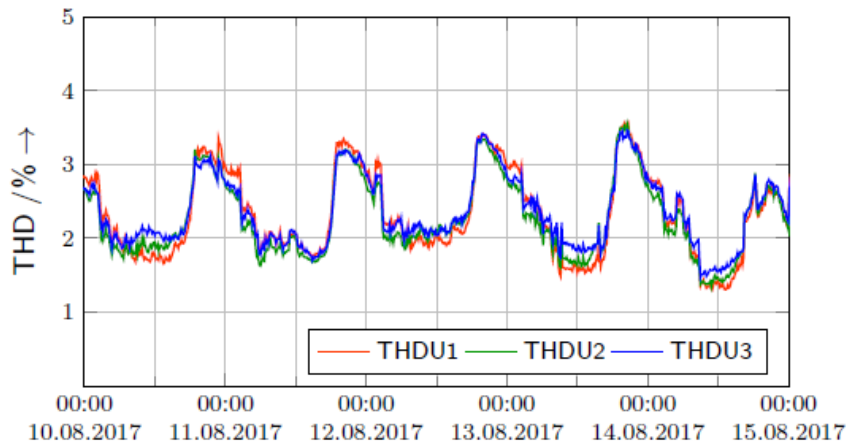


- Accidentally, PV plant first operated overexcited instead of underexcited
 - Extra high voltage peak
- When the mistake was corrected voltage immediately dropped by approximately 8 V
 - Controlling voltage with reactive power is certainly effective
 - Disadvantage: less active power is dispatched due to inverter current limits



3. POWER QUALITY ANALYSIS

Total harmonic distortion (THD)

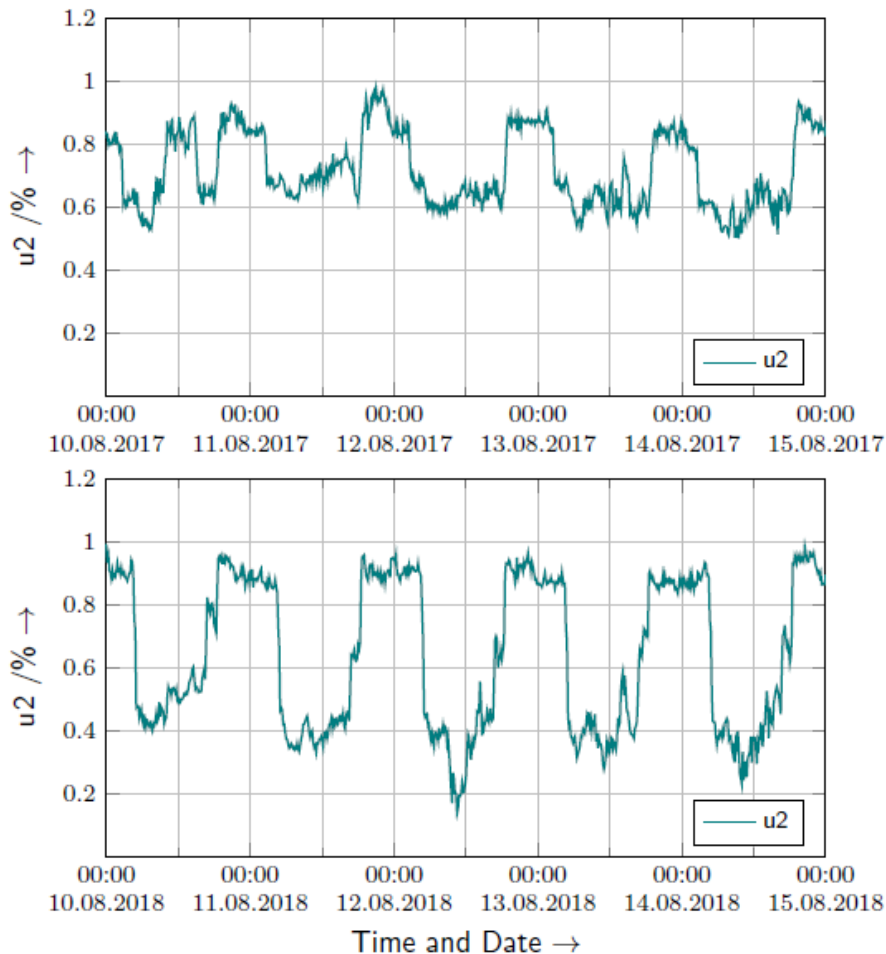


- Higher THD during the night than during the day
 - Probably due to many LED lamps in the camp, which have high harmonic emissions
- No influence of the PV plant is observed
- Requirement of EN 50160 (THD below 8% for 95% of the time) fulfilled



3. POWER QUALITY ANALYSIS

Unbalances

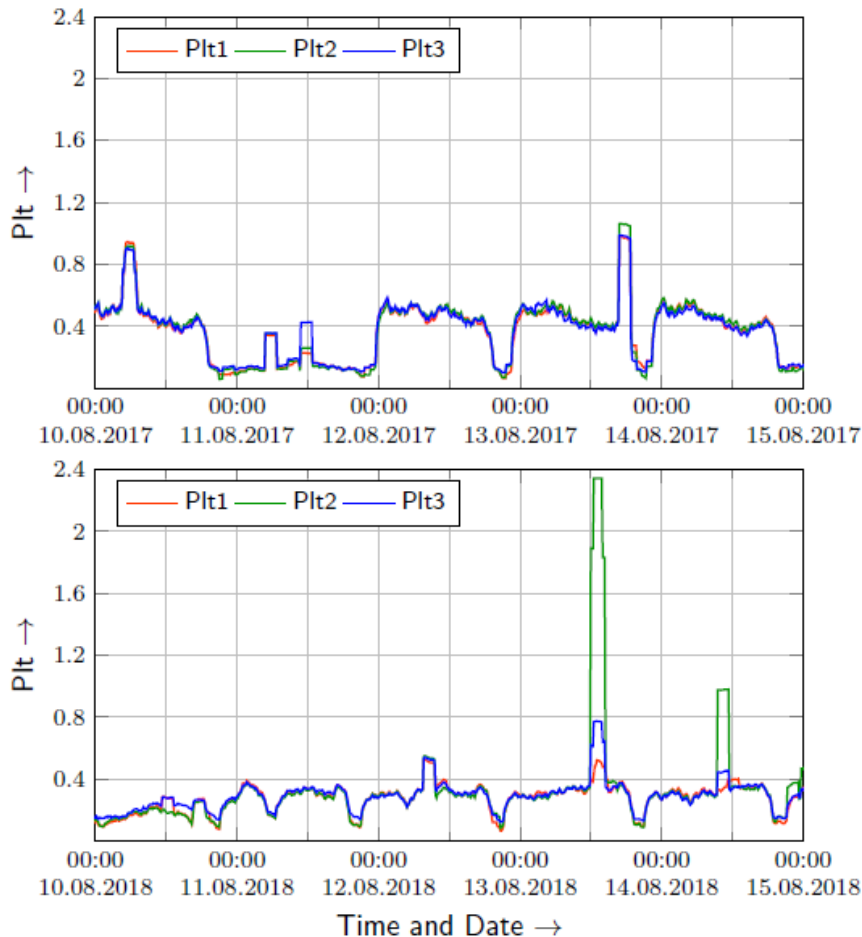


- Higher unbalances during the night than during the day
 - Correlation with power supply of the camp is likely
- No influence of the PV plant is observed
- Requirement of EN 50160 (unbalance below 2% for 95% of the time) fulfilled



3. POWER QUALITY ANALYSIS

Flicker



- There seems to be a periodic behavior, but not as clear as for the other quantities
- No influence of the PV plant is observed
- Requirement of EN 50160 (flicker below 1 for 95% of the time) fulfilled

4. Conclusion



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5. CONCLUSION

- Power Quality has been measured in a LV grid in Jordan to determine the influence of a large PV plant on power quality in that grid
- It was observed that the PV plant lifts the voltage, when dispatching power
 - Operation at power $\cos\phi_i = 0.9$ inductive compensates the voltage increase
- There was no influence of the PV plant on THD, flickers or unbalances observed

THANK YOU FOR YOUR ATTENTION!



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