Analysis of Load Profiles with Dynamic Loads, External Consumption and Added PV Generation

George S. Milushev

***Abstract* — The Examination of Load Profiles is powerful method for specifying problematic loads in installations. The examiner experience plays a significant role in reaching the proper conclusions and deciding the next actions to mitigate negative effects, disconnection, replacing or removal of the problematic loads. Usually, an examiner gains experience over time as they encounter various cases throughout their career. A way expedite the process of obtaining better experience is by sharing and studying complex cases documented by other experts from the engineering community. The present paper aims to share an experience of analysis of load profiles of a client with very dynamic own loads, additional external consumption out of his own premises, and installed PV generation for internal needs only.**

***Index Terms* — Energy efficiency, Load management, Photovoltaic systems, Power engineering, Power generation**

I. Introduction

An applied approach when examining load profiles [1, 2, 3, 4] in a complex multipoint distribution system is to examine several points over the same period in order to uncover any malfunctions or issues. The following case is a study of real one-week profiles aiming to identify the reason for exceeding the active power limit of the trade contract of a company. According to the trade contract, the consumption of the company is limited to 55 kW peak power. The regulations specify the client as a "small" – the trade point is on low voltage (LV) connection of the client's installation and the billing is according to a flat tariff, calculating active energy only.

Fig. 1 shows the single line schemas of the connection of the loads. The trade electricity meter is mounted on the MV/LV transformer panel outside the client's premises. The trade company bases on the monthly load profile obtained from the trade electricity meter and claims that in some moments the power exceeds the contracted power limit.

The client's installation powers some outdoor rental units in the boundary of the property. Initially, one of the potential reasons for overloading leads to the outdoor (external) loads.

A Photovoltaic (PV) generation power was installed for a partial compensation of the load of outdoor rental units and the internal load during the working day. It is not supposed to trade the overcompensated energy from PV generation even if the grid could accept it.

This work bases on the onsite inspection experience of UNITECH CONTROL accredited inspection body type A in Electrical Safety, Power Quality, Energy Efficiency and Load Profiles with BAS accreditation No 243 OKA.

G. S. Milushev is an Associate Professor in the Department of Electrical Measurements, Faculty of Automatics, Technical University of Sofia, 1000 Sofia, Bulgaria (e-mail: gm@tu-sofia.bg).

The indoor (internal) load consists of:

1) presumably small loads from internal rental units with full week working time and
2) dominant load from own consumption.

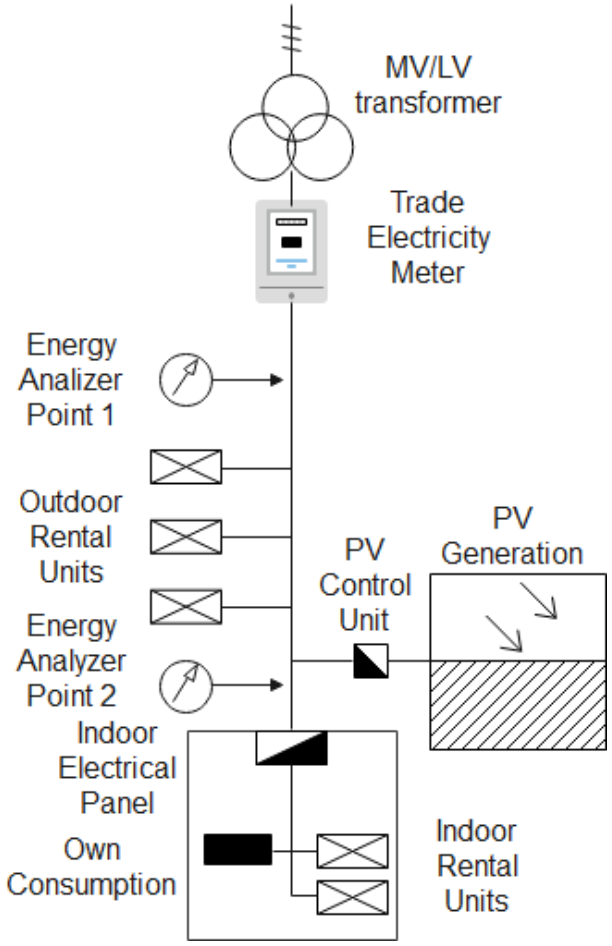

Fig. 1. Single line schemas of the connection of the loads

To add further complexity, the various types of consumer devices formed their own consumption, for example: an area with industrial trade refrigerators, own car service, office consumption etc. The diversity of devices requires additional analysis of the load profiles.

Initially, the client defines the refrigerator's area also as a potential reason for overconsumption.

II. Preparing the Inspection Plan

The inspection shall answer to following questions:

1. What is the power consumed by the outdoor external loads?

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2. In comparison to the power baseline is this power significant enough to exceed the power limit?
3. Is the refrigerator's area able to cause significant loads?
4. Shell the loads from internal rental units with full week working time take into account as potential reasons for power exceeding?
5. What is the influence of the PV generation over the power baseline and is there a negative impact?

The inspection shall answer these and other related questions having a limit of time and measuring instruments. Optimizing the resources, a one-step plan with two simultaneously working power analyzers connected before (inspection point 1) and after (inspection point 2) the outdoor (external) loads was chosen (Fig. 1.). In case the obtained information after executing the plan is not enough, the plan could be transferred to a two step plan changing one or more inspection points.

III. Electrical Connection and Instrumentation

The electrical connection in the two inspection points is the same and depends on the type of installation. The selection of the electrical connection type according to the instrument abilities [5] is shown on Fig. 2.

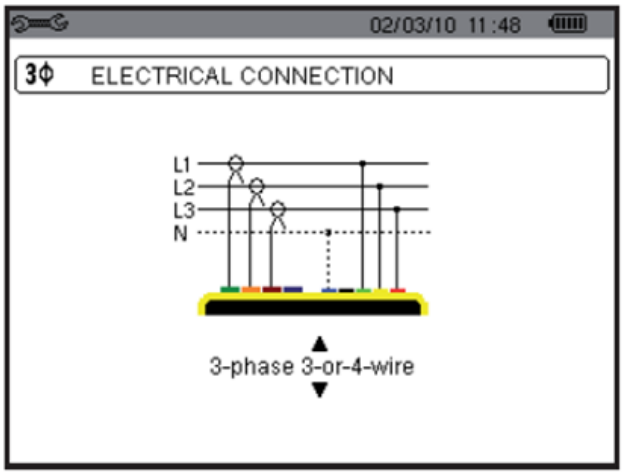

Fig. 2. Schemas of the electrical connection [5]

Two identical power analyzers calibrated with different current probes are used to record the power profiles. The model of the analyzers is Chauvin-Arnoux CA 8335 respectively:

Point 1 C.A 8335 with ID № 204838FLH with current probes type Rogovsky coil MA 193

Point 2 C.A 8335 with ID № 204839FLH with clamp current probes MN93A

Software used is PAT 2, freely distributed by the producer Chauvin – Arnoux for a series of analyzers.

IV. Inspection Results for a Week

The next figures Fig. 3 and Fig 4 show the weak power profiles at Point 1 (P1) and Point 2 (P2). The figures are in sequence to make a better comparison between them.

The analyzers record all the parameters related with the power: reactive, apparent, distorted powers; currents, voltages, harmonics, unbalance, Flicker; energies etc. Subject of interest here is only the active power because of the parameters of the supply contract.

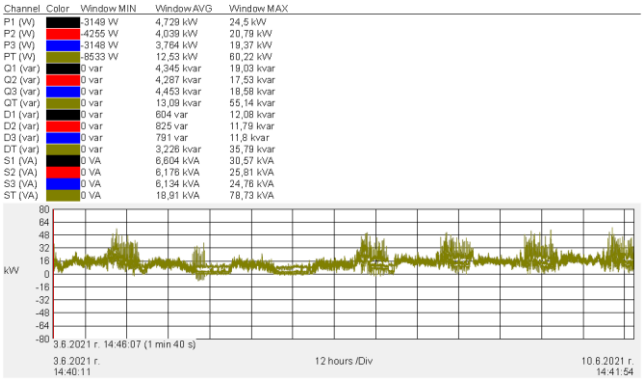

Fig. 3. Week profile at Point 1 (Total power)

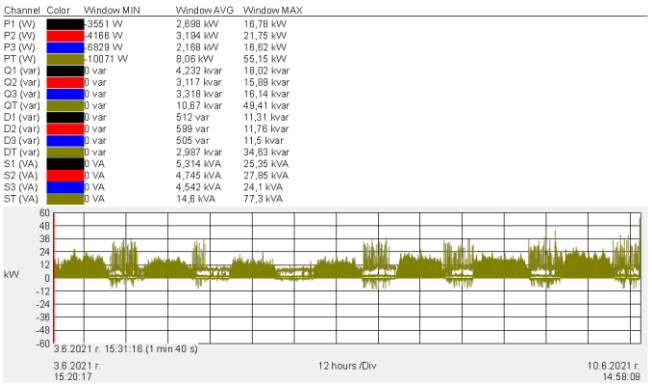

Fig. 4. Week profile at Point 2 (Indoor + PV generation)

The week profile at Point 1 on Fig. 3. presents the total power next to the meter point. The record starts on Thursday 03.06.2021 afternoon. The day profiles workday/holiday are definitely separated.

The week profile at Point 2 on Fig. 4. presents indoor consumption and PV generation. The PV generation compensates partially and in some moments fully the indoor load. The effect of the PV is more evident than on Fig. 3.

The details are visible much better on the daily profile based on the same records.

V. Daily Inspection Results

The next step of the investigation is the extraction of the daily profiles, to compare and analyze them day by day.

The time segment of each record at P1 exactly fits to the respective daily record at P2 because of the advance synchronization of the time clocks of analyzers to the world time. To center the activity of the PV generation during the day all the records are fixed to the astronomic time.

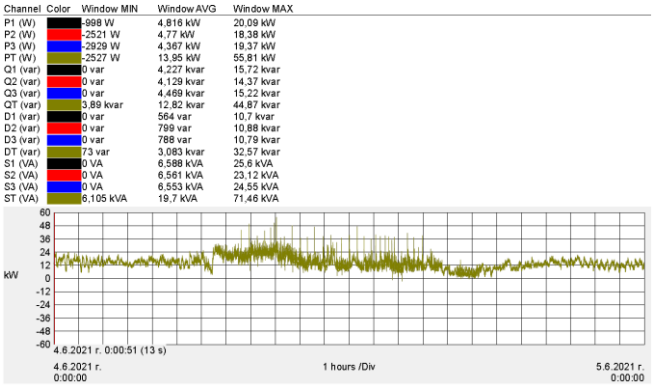

Fig. 5. Friday 04.06.2021 P1 Daily Profile

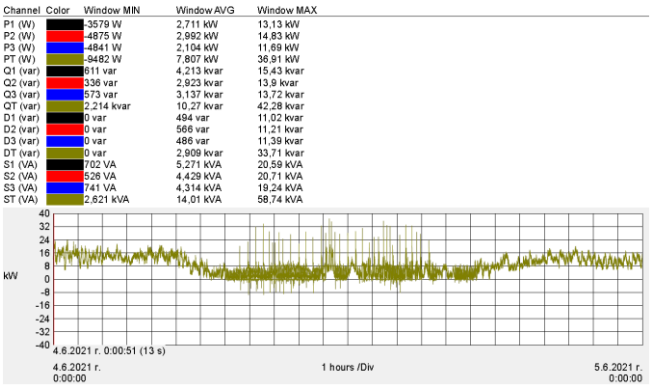

Fig. 6. Friday 04.06.2021 P2 Daily Profile

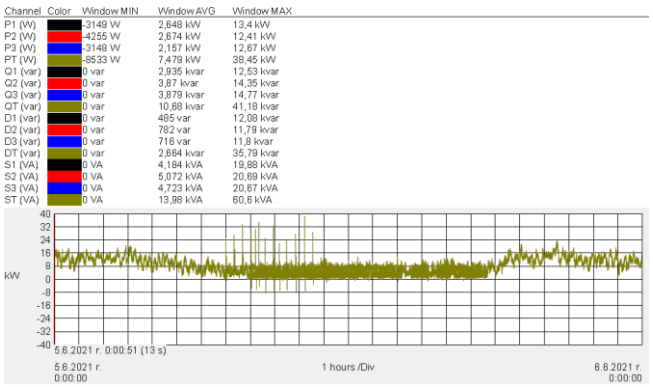

Fig. 7. Saturday 05.06.2021 P1 Daily Profile

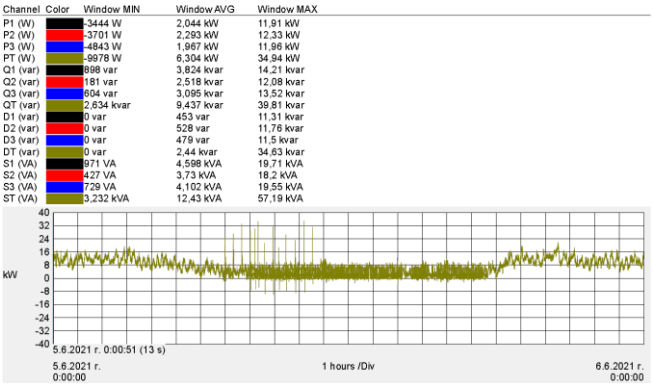

Fig. 8. Saturday 05.06.2021 P2 Daily Profile

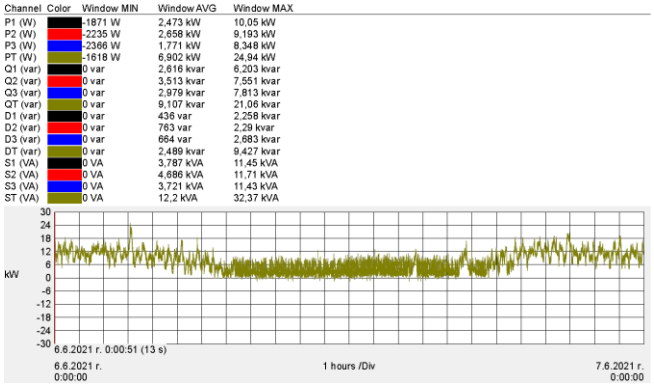

Fig. 9. Sunday 06.06.2021 P1 Daily Profile

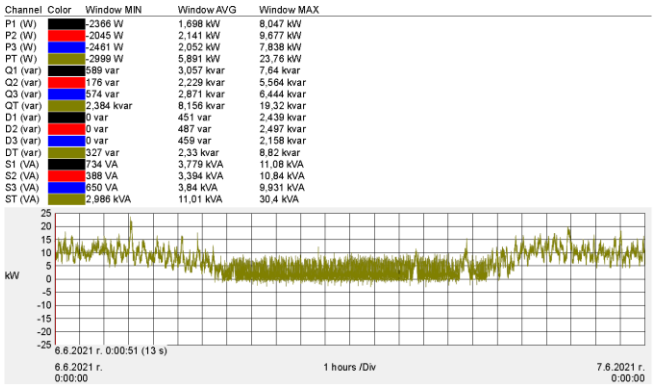

Fig. 10. Sunday 06.06.2021 P2 Daily Profile

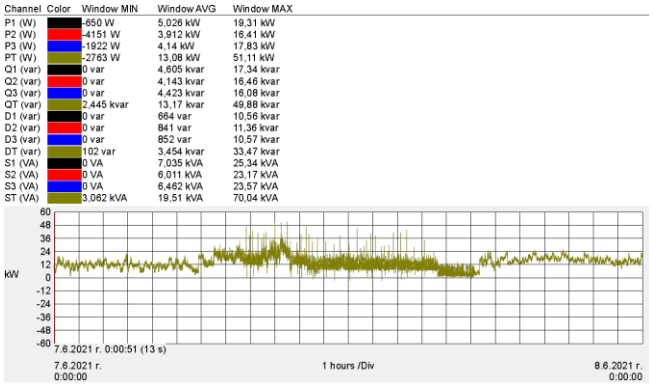

Fig. 11. Monday 07.06.2021 P1 Daily Profile

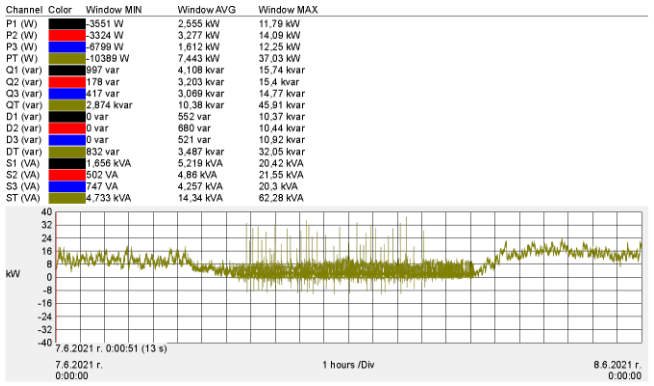

Fig. 12. Monday 07.06.2021 P2 Daily Profile

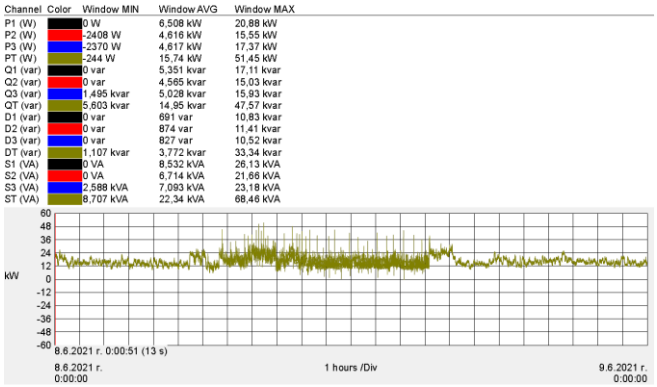

Fig. 13. Tuesday 08.06.2021 P1 Daily Profile

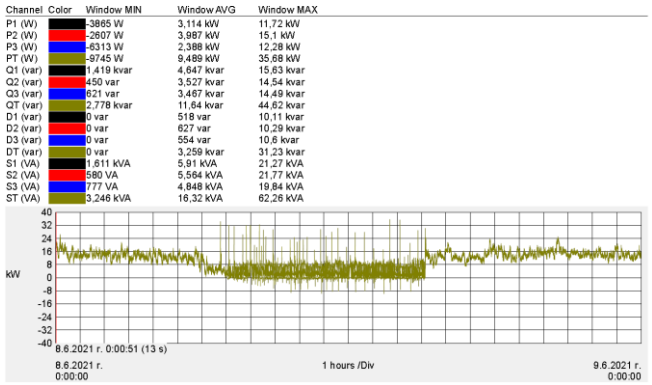

Fig. 14. Tuesday 08.06.2021 P2 Daily Profile

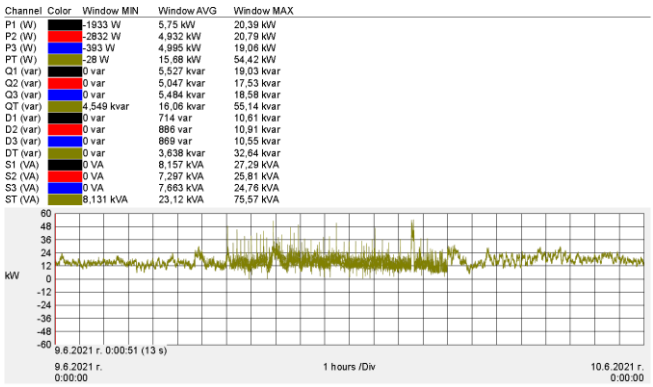

Fig. 15. Wednesday 09.06.2021 P1 Daily Profile

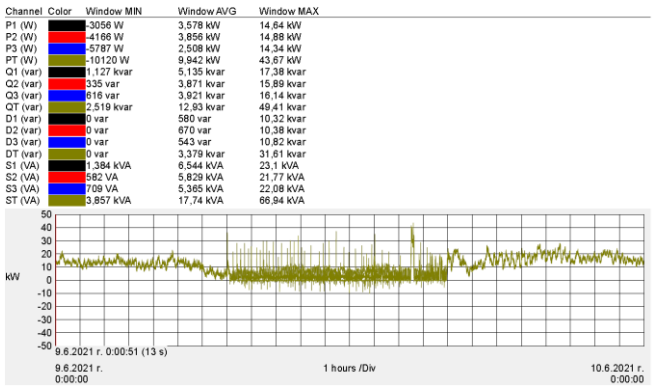

Fig. 16. Wednesday 09.06.2021 P2 Daily Profile

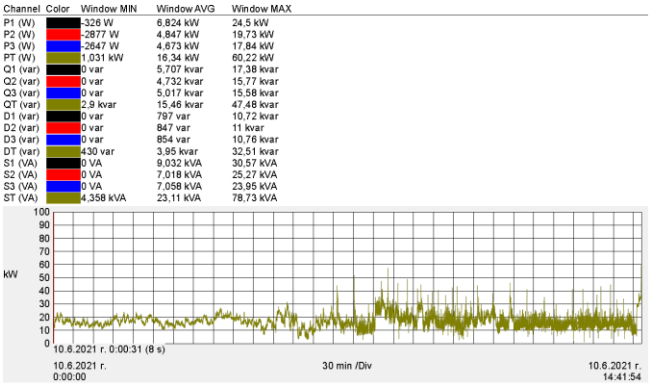

Fig. 17. Thursday 10.06.2021 P1 Daily Profile

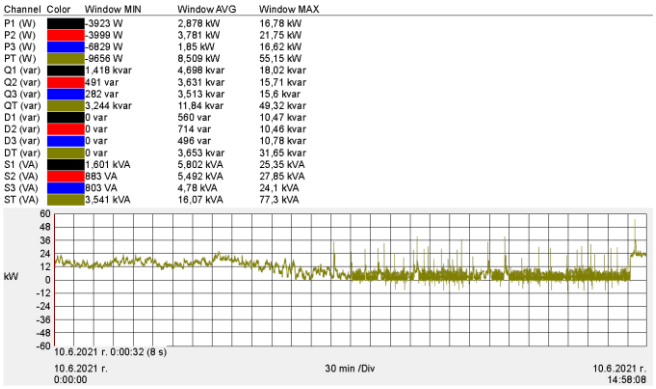

Fig. 18. Thursday 10.06.2021 P2 Daily Profile

On Fig. 5 to Fig. 18 it is evident that the highest consumption has a peak character with high values during a very short time. The intensity of the peak load increases at the end of the week. It appears on Saturday morning yet does not appear on Sundays.

Atypical losses of PV generation appear on 08, 09 and 10 between 15:30 and 17:00 h. A potential reason could be the protection level adjusted in the PV control unit.

High similarity of the profiles of the total and internal consumption is observed during the weekend.

The weekend profiles do not confirm the assumption that the refrigerators and the consumption of the indoor rental units can bring a significant load.

VI. Impact of the Outdoor Load

Estimation of the impact of the outdoor load is based on the differences between the registered power at P1 and P2. The differences are calculated in Table 1 (Average Power Difference) and Table 2 (Peak Power Difference)

TABLE I
Average Power Difference

Period\ Load	Total, kW	Indoor, kW	Difference, kW
04.06.21 Fri	13,95	7,81	6,14
05.06.21 Sat	7,48	6,30	1,18
06.06.21 Sun	6,90	5,89	1,01
07.06.21 Mon	13,08	7,44	5,64
08.06.21 Tue	15,74	9,49	6,25
09.06.21 Wed	15,68	9,94	5.74
10.06.21 Thu	16,34	8,51	7,83
Weekly	12,53	8,06	4,47

The differences between the total and the indoor load in average show relatively permanent outdoor load between 5 and 8 kW during the working days.

TABLE II
PEAK POWER DIFFERENCE

Period\ Load	Total, kW	Indoor, kW	Difference, kW
04.06.21 Fri	**55,81**	36,91	18,91
05.06.21 Sat	38,45	34,94	3,51
06.06.21 Sun	24,94	23,76	1,18
07.06.21 Mon	51,11	37,03	14,08
08.06.21 Tue	51,45	35,68	15,77
09.06.21 Wed	54,42	43,67	10,75
10.06.21 Thu	**60,22**	**55,15**	5,07
Weekly	**60,22**	**55,15**	5,07

The differences in the peak consumption between the total and the indoor load suppose the peak consumption to be caused by devices in indoor load.

VII. INSPECTION CONCLUSIONS

1. The highest consumption has a peak characterized by high values during very short time.
2. The intensity of the peak load increases near the end of the week. It appears on Saturday morning but does not appear on Sundays.
3. High similarity of the profiles of the total and internal consumption is observed during the weekend.
4. The outdoor load stays relatively permanent between 5 and 8 kW during the working days.
5. The refrigerators do not cause significant peak load.
6. The indoor rental units do not add any significant load.
7. Non typical losses of PV generation appear accidently at late afternoon with a potential reason - the protection level adjusted in the PV control unit.
8. The peak consumption comes from devices in the indoor load with a potential reason – the starting currents of rotary machines in the car service

VIII. RECOMMENDATIONS OF THE INSPECTION

1. Identification, replacement or disconnection of the indoor devices with peak consumption.
2. Analysis of the preset protection levels of PV control unit eliminating the false switching off.
3. Optimization of the permanent loads in rental units.

IX. CONCLUSIONS

1. An approach to examination of load profiles in a complex multipoint distribution system by parallel examination of load profiles in several points over the same period is applied.
2. The applied approach in real case with active power issues shows a significant potential to focus the study to uncover the real sources of malfunctions.
3. The approach can be applied on one, two or more steps, depending on the available time and apparatuses till precise specifying of the problematic loads.

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