ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

EE474 Distribution Systems and Smart Grid

Project Phase 2 Report

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Introduction

This project focuses on analyzing and optimizing the power dynamics at the Middle East Technical University (METU) campus using the SINCAL environment. The main goal is to understand how METU's power network performs throughout a day by simulating its behavior based on network topology, generation data, and load data.

The core of the analysis involves generating time-series power flow results to uncover how the network handles changing demands and generation patterns. The report aims not only to provide insights into METU's power network but also to highlight any issues encountered, with a focus on proposing thoughtful solutions.

The report will include crucial elements such as screenshots, detailed results, challenges identified, and suggested solutions. With inputs covering network topology, generation data, and load data, and the anticipated outputs in the form of time-series power flow results, this project aims to contribute valuable insights to improve the efficiency and reliability of the METU campus power network.

Network

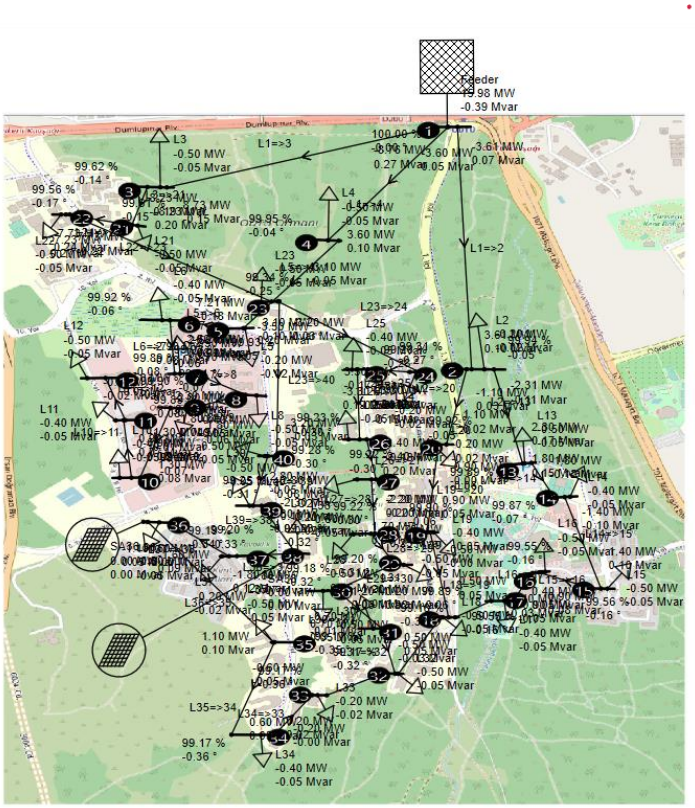

Figure 1. METU Network on PSS Sincal

In order to analyze the power flow on METU, the network information given in the Load_Generation_Data.xlsx and Topology.xlsx files in the ODTUCLASS are used.

Firstly, 3 load types are defined in Operating Point/Profiles section according to load types given load generation data. PV array is assumed as a load with negative power, and it is added as Solar Array load type. Load data are given in the Appendix.

After adding the load types, a network level with 35 kV line to line with 50 Hz frequency is defined and buses and the network feeder are added to the simulation. While adding the buses, the map of the METU is set as the background and buses are placed according to the map. Since the network level is defined previously, buses did not need any arrangements. Then, loads are added to the buses according to the buses section in the load generation data. Finaly, branches are added according to branch data section in the topology file. While adding branches, the length of all branches is assumed as 1 km and branches between the busses 17-18, 32-33 and 18-32 are marked as out of service. Moreover, B values are given in the topology file, these values are converted to capacitance values.

Results

Timeseries Power Flow analysis is done with the PSS Sincal. Node Results, Branch Results and Heat Map are investigated. There are 24*3 = 72 results. Results of the maximum power demand and minimum power demand time which are 02.00 and 14.00 are given in the following. All results can be seen in the uploaded .sin file.

Heat Map

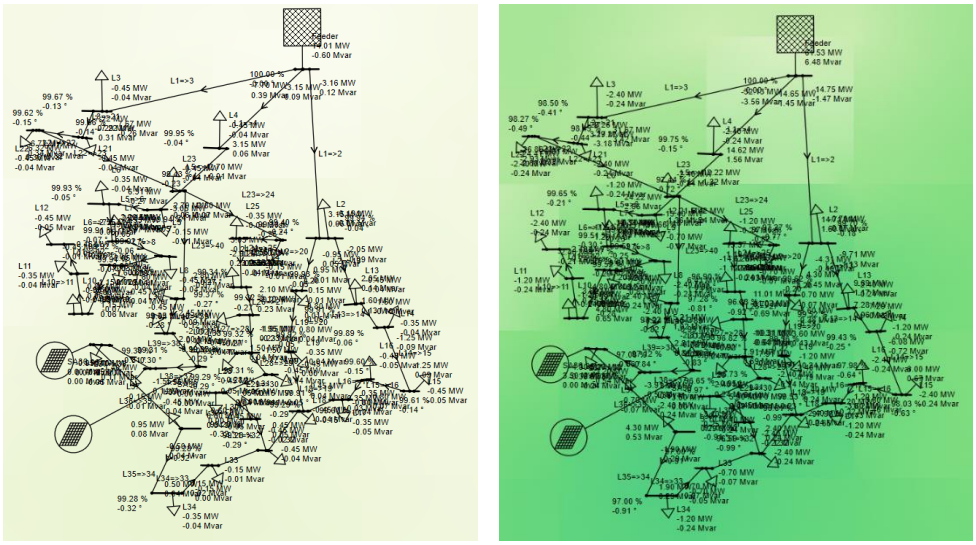

Figure 2. Heat Map of METU Network (Left at 02.00 and Right at 14.00)

Heat Map is generated according to the Node Voltage to Rated Voltage ratio. As the ratio decreases color of the map changes to green and as the ratio increases color of the map changes to red. As can be seen from Figure 2, at 02.00, bus voltages are close to the rated voltage. However, at 14.00, bus voltages are lower than the rated voltage. Detailed numerical results are given in the Node Results and Branch Results Section.

Node Results

Node	Network ...	P [MW]	Q [Mvar]	S [MVA]	V [kV]	V/Vn [%]
A1_Betun_Kab	Level	14.008	-0.598	14.021	35.000	100.000
ODTU_Kule	Level	-0.450	-0.045	0.452	34.984	99.953
Beton_Kabin	Level	-0.150	-0.015	0.151	34.981	99.944
GUMUS_BLK	Level	-0.150	-0.015	0.151	34.979	99.939
SILIKON_BLK	Level	-0.350	-0.045	0.353	34.977	99.934
REKTORLIK	Level	-0.150	-0.015	0.151	34.975	99.928
GALYUM	Level	-0.150	-0.015	0.151	34.975	99.928
IKIZLER	Level	-0.450	-0.045	0.452	34.973	99.922
MILSOFT	Level	-0.450	-0.045	0.452	34.971	99.918
BILGI_ISLEM	Level	-0.350	-0.045	0.353	34.971	99.916
ORTAK_BINA	Level	-0.350	-0.045	0.353	34.968	99.910
HIDROLIK	Level	-0.450	-0.045	0.452	34.968	99.909
Kultur_Merke	Level	-0.450	-0.045	0.452	34.968	99.908
TITANUM	Level	-0.350	-0.045	0.353	34.967	99.907
TURK_TLKM	Level	-0.450	-0.045	0.452	34.967	99.905
LOJMANLAR	Level	-0.350	-0.045	0.353	34.961	99.889
KAYNAK_TEK	Level	-0.450	-0.045	0.452	34.886	99.673
ISI_SANTRALI	Level	-0.450	-0.045	0.452	34.882	99.662
VAKIF_OKULU	Level	-0.450	-0.045	0.452	34.868	99.621
YURTLAR_OTU	Level	-0.450	-0.045	0.452	34.863	99.608
YURTLAR	Level	-0.450	-0.045	0.452	34.860	99.600
HAVUZ	Level	-0.350	-0.045	0.353	34.859	99.598
EGITIM_FKL	Level	-0.450	-0.045	0.452	34.800	99.430
IDARI_BLM	Level	-0.150	-0.015	0.151	34.790	99.399
MIMARLIK	Level	-0.350	-0.045	0.353	34.783	99.381
SIMMER	Level	-0.350	-0.045	0.353	34.781	99.375
GYM	Level	-0.450	-0.045	0.452	34.773	99.352
FIZIK	Level	-0.450	-0.045	0.452	34.768	99.336
TUBITAK	Level	-0.450	-0.045	0.452	34.766	99.330
FEN-EDBKIM	Level	-0.150	-0.015	0.151	34.763	99.324
ELE_IND	Level	-0.450	-0.045	0.452	34.763	99.323
ODTUKENT	Level	-0.150	-0.015	0.151	34.758	99.309
ARGE	Level	-0.450	-0.045	0.452	34.758	99.309
ODTUKENT2	Level	-0.450	-0.045	0.452	34.754	99.297
YANI_MAKINA	Level	-0.450	-0.045	0.452	34.753	99.293
KIMYA	Level	-0.150	-0.015	0.151	34.750	99.286
METALURJI	Level	-0.450	-0.045	0.452	34.749	99.283
GIDA	Level	-0.450	-0.045	0.452	34.749	99.283
HAVA_TR2	Level	-0.350	-0.045	0.353	34.749	99.282
HAVA_TR1	Level	-0.150	-0.015	0.151	34.748	99.281

Table 1. Node Results for Minimum Power Demand (02.00)

Node	Network ...	P [MW]	Q [Mvar]	S [MVA]	V [kV]	V/Vn [%]
A1_Betun_Kab	Level	61.532	6.483	61.873	35.000	100.000
ODTU_Kule	Level	-2.400	-0.240	2.412	34.913	99.751
Beton_Kabin	Level	-0.700	-0.070	0.703	34.895	99.700
GUMUS_BLK	Level	-0.700	-0.070	0.703	34.887	99.677
SILIKON_BLK	Level	-1.200	-0.240	1.224	34.878	99.652
REKTORLIK	Level	-0.700	-0.070	0.703	34.868	99.623
GALYUM	Level	-0.700	-0.070	0.703	34.867	99.620
IKIZLER	Level	-2.400	-0.240	2.412	34.857	99.590
MILSOFT	Level	-2.400	-0.240	2.412	34.849	99.569
BILGI_ISLEM	Level	-1.200	-0.240	1.224	34.848	99.564
ORTAK_BINA	Level	-1.200	-0.240	1.224	34.836	99.533
HIDROLIK	Level	-2.400	-0.240	2.412	34.834	99.526
Kultur_Merke	Level	-2.400	-0.240	2.412	34.833	99.524
TITANUM	Level	-1.200	-0.240	1.224	34.831	99.518
TURK_TLKM	Level	-2.400	-0.240	2.412	34.828	99.508
LOJMANLAR	Level	-1.200	-0.240	1.224	34.802	99.433
KAYNAK_TEK	Level	-2.400	-0.240	2.412	34.477	98.505
ISI_SANTRALI	Level	-2.400	-0.240	2.412	34.457	98.450
VAKIF_OKULU	Level	-2.400	-0.240	2.412	34.395	98.270
YURTLAR_OTU	Level	-2.400	-0.240	2.412	34.309	98.025
YURTLAR	Level	-2.400	-0.240	2.412	34.295	97.985
HAVUZ	Level	-1.200	-0.240	1.224	34.292	97.978
EGITIM_FKL	Level	-2.400	-0.240	2.412	34.105	97.442
SIMMER	Level	-1.200	-0.240	1.224	34.047	97.277
IDARI_BLM	Level	-0.700	-0.070	0.703	34.045	97.272
GYM	Level	-2.400	-0.240	2.412	34.027	97.220
TUBITAK	Level	1.100	-0.240	1.126	34.014	97.182
MIMARLIK	Level	-1.200	-0.240	1.224	34.007	97.164
ODTUKENT	Level	-0.700	-0.070	0.703	33.992	97.120
ODTUKENT2	Level	1.100	-0.240	1.126	33.979	97.082
GIDA	Level	-2.400	-0.240	2.412	33.952	97.006
HAVA_TR2	Level	-1.200	-0.240	1.224	33.951	97.003
HAVA_TR1	Level	-0.700	-0.070	0.703	33.949	96.998
FIZIK	Level	-2.400	-0.240	2.412	33.914	96.897
FEN-EDBKIM	Level	-0.700	-0.070	0.703	33.889	96.826
ELE_IND	Level	-2.400	-0.240	2.412	33.887	96.821
ARGE	Level	-2.400	-0.240	2.412	33.857	96.735
YANI_MAKINA	Level	-2.400	-0.240	2.412	33.828	96.650
KIMYA	Level	-0.700	-0.070	0.703	33.813	96.610
METALURJI	Level	-2.400	-0.240	2.412	33.807	96.592

Table 2. Node Results for Maximum Power Demand (14.00)

Branch Results

Node 1	Node 2	Element Name	Element Type	t [h]	P [MW]	Q [Mvar]	S [MVA]
LOJMANLAR	YURTLAR_OTU	L14=>15	Line	2.000	-1.253	-0.088	1.257
YURTLAR_OTU	LOJMANLAR	L14=>15	Line	2.000	1.250	0.086	1.253
YURTLAR	HAVUZ	L16=>17	Line	2.000	-0.350	-0.029	0.351
HAVUZ	YURTLAR	L16=>17	Line	2.000	0.350	0.045	0.353
YURTLAR_OTU	YURTLAR	L15=>16	Line	2.000	-0.800	-0.041	0.801
YURTLAR	YURTLAR_OTU	L15=>16	Line	2.000	0.800	0.074	0.803
HIDROLIK	BILGI_ISLEM	L18=>19	Line	2.000	0.450	0.045	0.452
BILGI_ISLEM	HIDROLIK	L18=>19	Line	2.000	-0.450	0.004	0.450
BILGI_ISLEM	REKTORLIK	L19=>20	Line	2.000	0.800	0.041	0.801
REKTORLIK	BILGI_ISLEM	L19=>20	Line	2.000	-0.800	0.008	0.800
Beton_Kabin	Kultur_Merke	L2=>13	Line	2.000	-2.054	-0.088	2.056
Kultur_Merke	Beton_Kabin	L2=>13	Line	2.000	2.054	0.141	2.059
KAYNAK_TEK	ISI_SANTRALI	L3=>21	Line	2.000	-7.223	0.307	7.230
ISI_SANTRALI	KAYNAK_TEK	L3=>21	Line	2.000	7.222	-0.292	7.228
ISI_SANTRALI	VAKIF_OKULU	L21=>22	Line	2.000	-6.772	0.337	6.781
VAKIF_OKULU	ISI_SANTRALI	L21=>22	Line	2.000	6.769	-0.318	6.777
VAKIF_OKULU	EGITIM_FKL	L22=>23	Line	2.000	-6.319	0.363	6.330
EGITIM_FKL	VAKIF_OKULU	L22=>23	Line	2.000	6.307	-0.271	6.313
EGITIM_FKL	SIMMER	L23=>40	Line	2.000	-2.803	0.071	2.804
SIMMER	EGITIM_FKL	L23=>40	Line	2.000	2.802	-0.074	2.803
EGITIM_FKL	IDARI_BLM	L23=>24	Line	2.000	-3.054	0.245	3.063
IDARI_BLM	EGITIM_FKL	L23=>24	Line	2.000	3.053	-0.213	3.060
SIMMER	GYM	L40=>39	Line	2.000	-2.452	0.119	2.455
GYM	SIMMER	L40=>39	Line	2.000	2.451	-0.088	2.453
TUBITAK	ODTUKENT	L38=>37	Line	2.000	-1.551	0.144	1.557
ODTUKENT	TUBITAK	L38=>37	Line	2.000	1.550	-0.100	1.554
GYM	TUBITAK	L39=>38	Line	2.000	-2.001	0.133	2.006
TUBITAK	GYM	L39=>38	Line	2.000	2.001	-0.099	2.003
ODTUKENT	ODTUKENT2	L37=>36	Line	2.000	-1.400	0.115	1.405
ODTUKENT2	ODTUKENT	L37=>36	Line	2.000	1.400	-0.021	1.400
ODTUKENT2	GIDA	L36=>35	Line	2.000	-0.950	0.066	0.952
GIDA	ODTUKENT2	L36=>35	Line	2.000	0.950	0.081	0.953
GIDA	HAVA_TR2	L35=>34	Line	2.000	-0.500	-0.036	0.501
HAVA_TR2	GIDA	L35=>34	Line	2.000	0.500	0.042	0.502
HAVA_TR2	HAVA_TR1	L34=>33	Line	2.000	-0.150	0.003	0.150
HAVA_TR1	HAVA_TR2	L34=>33	Line	2.000	0.150	0.015	0.151
IDARI_BLM	MIMARLIK	L24=>25	Line	2.000	-2.903	0.228	2.911
MIMARLIK	IDARI_BLM	L24=>25	Line	2.000	2.902	-0.202	2.909
MIMARLIK	FIZIK	L25=>26	Line	2.000	-2.552	0.247	2.564
FIZIK	MIMARLIK	L25=>26	Line	2.000	2.551	-0.189	2.558
FIZIK	FEN-EDBKIM	L26=>27	Line	2.000	-2.101	0.234	2.114
FEN-EDBKIM	FIZIK	L26=>27	Line	2.000	2.100	-0.216	2.112
FEN-EDBKIM	ELE_IND	L27=>28	Line	2.000	-1.950	0.231	1.964
ELE_IND	FEN-EDBKIM	L27=>28	Line	2.000	1.950	-0.229	1.964
ELE_IND	ARGE	L28=>29	Line	2.000	-1.500	0.274	1.525
ARGE	ELE_IND	L28=>29	Line	2.000	1.500	0.044	1.501
ARGE	YANI_MAKINA	L29=>30	Line	2.000	-1.050	0.001	1.050
YANI_MAKINA	ARGE	L29=>30	Line	2.000	1.050	0.044	1.051
YANI_MAKINA	KIMYA	L30=>31	Line	2.000	-0.600	0.001	0.600
KIMYA	YANI_MAKINA	L30=>31	Line	2.000	0.600	0.038	0.601
KIMYA	METALURJI	L31=>32	Line	2.000	-0.450	-0.023	0.451
METALURJI	KIMYA	L31=>32	Line	2.000	0.450	0.045	0.452
A1_Betun_Kab	KAYNAK_TEK	L1=>3	Line	2.000	-7.699	0.386	7.709
KAYNAK_TEK	A1_Betun_Kab	L1=>3	Line	2.000	7.673	-0.262	7.678
A1_Betun_Kab	ODTU_Kule	L1=>4	Line	2.000	-3.152	0.092	3.154
ODTU_Kule	A1_Betun_Kab	L1=>4	Line	2.000	3.151	0.057	3.151
GUMUS_BLK	ODTU_Kule	L5=>4	Line	2.000	2.701	0.064	2.701
ODTU_Kule	GUMUS_BLK	L5=>4	Line	2.000	-2.701	-0.012	2.701
GUMUS_BLK	SILIKON_BLK	L5=>6	Line	2.000	-2.551	-0.049	2.551
SILIKON_BLK	GUMUS_BLK	L5=>6	Line	2.000	2.550	0.068	2.551
SILIKON_BLK	GALYUM	L6=>7	Line	2.000	-2.200	-0.023	2.201
GALYUM	SILIKON_BLK	L6=>7	Line	2.000	2.200	0.049	2.201
GALYUM	IKIZLER	L7=>8	Line	2.000	-2.050	-0.034	2.051
IKIZLER	GALYUM	L7=>8	Line	2.000	2.050	0.061	2.051
IKIZLER	MILSOFT	L8=>9	Line	2.000	-1.600	-0.016	1.600
MILSOFT	IKIZLER	L8=>9	Line	2.000	1.600	0.043	1.601
MILSOFT	ORTAK_BINA	L9=>10	Line	2.000	-1.150	0.002	1.150
ORTAK_BINA	MILSOFT	L9=>10	Line	2.000	1.150	0.063	1.152
ORTAK_BINA	TITANUM	L10=>11	Line	2.000	-0.800	-0.018	0.800
TITANUM	ORTAK_BINA	L10=>11	Line	2.000	0.800	0.055	0.802
TITANUM	TURK_TLKM	L11=>12	Line	2.000	-0.450	-0.010	0.450
TURK_TLKM	TITANUM	L11=>12	Line	2.000	0.450	0.045	0.452
A1_Betun_Kab	Beton_Kabin	L1=>2	Line	2.000	-3.157	0.120	3.159
Beton_Kabin	A1_Betun_Kab	L1=>2	Line	2.000	3.155	0.057	3.155
Beton_Kabin	REKTORLIK	L2=>20	Line	2.000	-0.950	0.047	0.951
REKTORLIK	Beton_Kabin	L2=>20	Line	2.000	0.950	0.007	0.950
Kultur_Merke	LOJMANLAR	L13=>14	Line	2.000	-1.604	-0.096	1.607
LOJMANLAR	Kultur_Merke	L13=>14	Line	2.000	1.603	0.133	1.609

Table 3. Branch Results for Minimum Power Demand (02.00)

Node 1	Node 2	Element Name	Element Type	t [h]	P [MW]	Q [Mvar]	S [MVA]
LOJMANLAR	YURTLAR_OTU	L14=>15	Line	14.000	-6.083	-0.724	6.126
YURTLAR_OTU	LOJMANLAR	L14=>15	Line	14.000	6.001	0.673	6.039
YURTLAR	HAVUZ	L16=>17	Line	14.000	-1.200	-0.224	1.221
HAVUZ	YURTLAR	L16=>17	Line	14.000	1.200	0.240	1.224
YURTLAR_OTU	YURTLAR	L15=>16	Line	14.000	-3.601	-0.433	3.627
YURTLAR	YURTLAR_OTU	L15=>16	Line	14.000	3.600	0.464	3.630
HIDROLIK	BILGI_ISLEM	L18=>19	Line	14.000	2.400	0.240	2.412
BILGI_ISLEM	HIDROLIK	L18=>19	Line	14.000	-2.401	-0.192	2.409
BILGI_ISLEM	REKTORLIK	L19=>20	Line	14.000	3.601	0.432	3.627
REKTORLIK	BILGI_ISLEM	L19=>20	Line	14.000	-3.603	-0.384	3.623
Beton_Kabin	Kultur_Merke	L2=>13	Line	14.000	-9.706	-1.128	9.771
Kultur_Merke	Beton_Kabin	L2=>13	Line	14.000	9.689	1.171	9.760
KAYNAK_TEK	ISI_SANTRALI	L3=>21	Line	14.000	-29.274	-3.176	29.445
ISI_SANTRALI	KAYNAK_TEK	L3=>21	Line	14.000	29.259	3.173	29.431
ISI_SANTRALI	VAKIF_OKULU	L21=>22	Line	14.000	-26.859	-2.933	27.019
VAKIF_OKULU	ISI_SANTRALI	L21=>22	Line	14.000	26.813	2.925	26.972
VAKIF_OKULU	EGITIM_FKL	L22=>23	Line	14.000	-24.413	-2.685	24.560
EGITIM_FKL	VAKIF_OKULU	L22=>23	Line	14.000	24.218	2.661	24.363
EGITIM_FKL	SIMMER	L23=>40	Line	14.000	-6.419	-1.242	6.538
SIMMER	EGITIM_FKL	L23=>40	Line	14.000	6.410	1.231	6.527
EGITIM_FKL	IDARI_BLM	L23=>24	Line	14.000	-15.398	-1.179	15.443
IDARI_BLM	EGITIM_FKL	L23=>24	Line	14.000	15.372	1.194	15.419
SIMMER	GYM	L40=>39	Line	14.000	-5.210	-0.991	5.304
GYM	SIMMER	L40=>39	Line	14.000	5.207	1.018	5.306
TUBITAK	ODTUKENT	L38=>37	Line	14.000	-3.906	-0.571	3.948
ODTUKENT	TUBITAK	L38=>37	Line	14.000	3.904	0.612	3.952
GYM	TUBITAK	L39=>38	Line	14.000	-2.807	-0.778	2.913
TUBITAK	GYM	L39=>38	Line	14.000	2.806	0.811	2.921
ODTUKENT	ODTUKENT2	L37=>36	Line	14.000	-3.204	-0.542	3.250
ODTUKENT2	ODTUKENT	L37=>36	Line	14.000	3.203	0.630	3.264
ODTUKENT2	GIDA	L36=>35	Line	14.000	-4.303	-0.390	4.321
GIDA	ODTUKENT2	L36=>35	Line	14.000	4.300	0.527	4.332
GIDA	HAVA_TR2	L35=>34	Line	14.000	-1.900	-0.287	1.922
HAVA_TR2	GIDA	L35=>34	Line	14.000	1.900	0.293	1.922
HAVA_TR2	HAVA_TR1	L34=>33	Line	14.000	-0.700	-0.053	0.702
HAVA_TR1	HAVA_TR2	L34=>33	Line	14.000	0.700	0.070	0.703
IDARI_BLM	MIMARLIK	L24=>25	Line	14.000	-14.672	-1.124	14.715
MIMARLIK	IDARI_BLM	L24=>25	Line	14.000	14.657	1.137	14.701
MIMARLIK	FIZIK	L25=>26	Line	14.000	-13.457	-0.897	13.487
FIZIK	MIMARLIK	L25=>26	Line	14.000	13.421	0.932	13.454
FIZIK	FEN-EDBKIM	L26=>27	Line	14.000	-11.021	-0.692	11.043
FEN-EDBKIM	FIZIK	L26=>27	Line	14.000	11.014	0.704	11.036
FEN-EDBKIM	ELE_IND	L27=>28	Line	14.000	-10.314	-0.634	10.333
ELE_IND	FEN-EDBKIM	L27=>28	Line	14.000	10.313	0.635	10.333
ELE_IND	ARGE	L28=>29	Line	14.000	-7.913	-0.395	7.923
ARGE	ELE_IND	L28=>29	Line	14.000	7.906	0.694	7.937
ARGE	YANI_MAKINA	L29=>30	Line	14.000	-5.506	-0.454	5.525
YANI_MAKINA	ARGE	L29=>30	Line	14.000	5.502	0.493	5.524
YANI_MAKINA	KIMYA	L30=>31	Line	14.000	-3.102	-0.253	3.112
KIMYA	YANI_MAKINA	L30=>31	Line	14.000	3.100	0.289	3.114
KIMYA	METALURJI	L31=>32	Line	14.000	-2.400	-0.219	2.410
METALURJI	KIMYA	L31=>32	Line	14.000	2.400	0.240	2.412
A1_Betun_Kab	KAYNAK_TEK	L1=>3	Line	14.000	-32.129	-3.559	32.326
KAYNAK_TEK	A1_Betun_Kab	L1=>3	Line	14.000	31.674	3.416	31.857
A1_Betun_Kab	ODTU_Kule	L1=>4	Line	14.000	-14.652	-1.450	14.724
ODTU_Kule	A1_Betun_Kab	L1=>4	Line	14.000	14.620	1.558	14.702
GUMUS_BLK	ODTU_Kule	L5=>4	Line	14.000	12.212	1.361	12.287
ODTU_Kule	GUMUS_BLK	L5=>4	Line	14.000	-12.220	-1.318	12.290
GUMUS_BLK	SILIKON_BLK	L5=>6	Line	14.000	-11.512	-1.291	11.584
SILIKON_BLK	GUMUS_BLK	L5=>6	Line	14.000	11.509	1.306	11.583
SILIKON_BLK	GALYUM	L6=>7	Line	14.000	-10.309	-1.066	10.364
GALYUM	SILIKON_BLK	L6=>7	Line	14.000	10.306	1.088	10.363
GALYUM	IKIZLER	L7=>8	Line	14.000	-9.606	-1.018	9.660
IKIZLER	GALYUM	L7=>8	Line	14.000	9.604	1.042	9.660
IKIZLER	MILSOFT	L8=>9	Line	14.000	-7.204	-0.802	7.248
MILSOFT	IKIZLER	L8=>9	Line	14.000	7.202	0.826	7.249
MILSOFT	ORTAK_BINA	L9=>10	Line	14.000	-4.802	-0.586	4.838
ORTAK_BINA	MILSOFT	L9=>10	Line	14.000	4.801	0.649	4.844
ORTAK_BINA	TITANUM	L10=>11	Line	14.000	-3.601	-0.409	3.624
TITANUM	ORTAK_BINA	L10=>11	Line	14.000	3.600	0.446	3.628
TITANUM	TURK_TLKM	L11=>12	Line	14.000	-2.400	-0.206	2.409
TURK_TLKM	TITANUM	L11=>12	Line	14.000	2.400	0.240	2.412
A1_Betun_Kab	Beton_Kabin	L1=>2	Line	14.000	-14.751	-1.473	14.824
Beton_Kabin	A1_Betun_Kab	L1=>2	Line	14.000	14.712	1.601	14.798
Beton_Kabin	REKTORLIK	L2=>20	Line	14.000	-4.306	-0.403	4.325
REKTORLIK	Beton_Kabin	L2=>20	Line	14.000	4.303	0.454	4.327
Kultur_Merke	LOJMANLAR	L13=>14	Line	14.000	-7.289	-0.931	7.348
LOJMANLAR	Kultur_Merke	L13=>14	Line	14.000	7.283	0.964	7.346

Table 4. Branch Results for Maximum Power Demand (14.00)

Problems and Suggestions

During daytime there are voltage drops in the METU network related to the increases in the load demand. As the current passing through branches increases, voltage drops at the branches increase too which results voltage drops on the buses. These voltage drops can lead undervoltage problems in the network.

In order to eliminate or minimize this undervoltage problem, reactive compensation elements energy storage systems, increasing grid capacity and voltage control system can be used.

Reactive Compensation Elements: Implementing reactive compensation elements can effectively adjust the power factor, reducing current flow in the distribution grid. This alleviates cable loading and minimizes voltage drop along the lines.

Energy Storage Systems: These systems can store excess energy generated by photovoltaic arrays during low-demand periods and release it into the grid during high-demand periods. When coupled with power electronic interfaces like inverters, such as dynamic voltage restorers (DVR) and devices like static synchronous compensator (STATCOM) or static var compensator (SVC), voltage levels can be regulated, and current flow in the distribution grid can be adjusted through reactive power injection/absorption.

Increasing Grid Capacity: Upgrading power lines, adding new ones, or enhancing transformer capacity can increase the overall grid capacity. This helps in accommodating higher power demands and avoiding overcurrent issues.

Voltage Control: Installation of voltage control devices like capacitors or voltage regulators helps maintain voltage levels within an acceptable range, ensuring a stable power supply.

Conclusion

In summary, this project conducted a thorough power flow analysis of the METU campus power network, aiming to understand its performance throughout the day. The analysis, carried out using the SINCAL environment, revealed insights into the network's behavior, particularly concerning voltage drops during increased load demand. Key results, including time-series power flow outcomes and visual representations like the Heat Map, indicated potential undervoltage issues. The Node and Branch Results tables further highlighted fluctuations in bus voltages and branch parameters during different demand scenarios. To address these challenges, proposed solutions encompassed implementing reactive compensation elements, energy storage systems, grid capacity enhancement, and voltage control systems. These measures aim to mitigate undervoltage problems by adjusting power factors, regulating voltage levels, and enhancing overall grid capacity. In conclusion, this project provides valuable insights and recommendations to enhance the efficiency and reliability of METU's power network, emphasizing the proactive management of potential issues in educational institutions' power distribution systems.

Appendix

(none)
Load1
Load2
Load3
SolarArray

	t [h]	Curve	P [kW]	Q [kvar]
	0.000	Cont...	500.000	50.000
	1.000	Cont...	500.000	50.000
	2.000	Cont...	450.000	45.000
	3.000	Cont...	450.000	45.000
	4.000	Cont...	500.000	50.000
	5.000	Cont...	550.000	55.000
	6.000	Cont...	575.000	57.500
	7.000	Cont...	600.000	60.000
	8.000	Cont...	800.000	80.000
	9.000	Cont...	1200.000	120.000
	10.000	Cont...	1500.000	150.000
	11.000	Cont...	1700.000	170.000
	12.000	Cont...	2000.000	200.000
	13.000	Cont...	1800.000	180.000
	14.000	Cont...	2400.000	240.000
	15.000	Cont...	2000.000	200.000
	16.000	Cont...	1900.000	190.000
	17.000	Cont...	1700.000	170.000
	18.000	Cont...	2000.000	200.000
	19.000	Cont...	2400.000	240.000
	20.000	Cont...	1800.000	180.000
	21.000	Cont...	1200.000	120.000
	22.000	Cont...	700.000	70.000
	23.000	Cont...	500.000	50.000

Table 5. Load Type 1

(none)
Load1
Load2
Load3
SolarArray

	t [h]	Curve	P [kW]	Q [kvar]
	0.000	Cont...	400.000	50.000
	1.000	Cont...	400.000	50.000
	2.000	Cont...	350.000	45.000
	3.000	Cont...	350.000	45.000
	4.000	Cont...	400.000	50.000
	5.000	Cont...	400.000	55.000
	6.000	Cont...	450.000	57.500
	7.000	Cont...	450.000	60.000
	8.000	Cont...	700.000	80.000
	9.000	Cont...	1000.000	120.000
	10.000	Cont...	1000.000	150.000
	11.000	Cont...	1000.000	170.000
	12.000	Cont...	1200.000	200.000
	13.000	Cont...	1100.000	180.000
	14.000	Cont...	1200.000	240.000
	15.000	Cont...	1100.000	200.000
	16.000	Cont...	1200.000	190.000
	17.000	Cont...	1000.000	170.000
	18.000	Cont...	700.000	200.000
	19.000	Cont...	400.000	240.000
	20.000	Cont...	400.000	180.000
	21.000	Cont...	700.000	120.000
	22.000	Cont...	300.000	70.000
	23.000	Cont...	400.000	50.000

Table 6. Load Type 2

(none)
Load1
Load2
Load3
SolarArray

	t [h]	Curve	P [kW]	Q [kvar]
	0.000	Cont...	200.000	20.000
	1.000	Cont...	200.000	20.000
	2.000	Cont...	150.000	15.000
	3.000	Cont...	150.000	15.000
	4.000	Cont...	200.000	20.000
	5.000	Cont...	250.000	25.000
	6.000	Cont...	300.000	30.000
	7.000	Cont...	400.000	40.000
	8.000	Cont...	500.000	50.000
	9.000	Cont...	500.000	50.000
	10.000	Cont...	600.000	60.000
	11.000	Cont...	650.000	65.000
	12.000	Cont...	700.000	70.000
	13.000	Cont...	650.000	65.000
	14.000	Cont...	700.000	70.000
	15.000	Cont...	700.000	70.000
	16.000	Cont...	675.000	67.500
	17.000	Cont...	700.000	70.000
	18.000	Cont...	500.000	50.000
	19.000	Cont...	300.000	30.000
	20.000	Cont...	200.000	20.000
	21.000	Cont...	200.000	20.000
	22.000	Cont...	100.000	10.000
	23.000	Cont...	200.000	20.000

Table 7. Load Type 3

(none)
Load1
Load2
Load3
SolarArray

	t [h]	Curve	P [kW]	Q [kvar]
	0.000	Cont...	0.000	0.000
	1.000	Cont...	0.000	0.000
	2.000	Cont...	0.000	0.000
	3.000	Cont...	0.000	0.000
	4.000	Cont...	0.000	0.000
	5.000	Cont...	0.000	0.000
	6.000	Cont...	0.000	0.000
	7.000	Cont...	-100.000	0.000
	8.000	Cont...	-400.000	0.000
	9.000	Cont...	-800.000	0.000
	10.000	Cont...	-2000.000	0.000
	11.000	Cont...	-2500.000	0.000
	12.000	Cont...	-3000.000	0.000
	13.000	Cont...	-3000.000	0.000
	14.000	Cont...	-3500.000	0.000
	15.000	Cont...	-2800.000	0.000
	16.000	Cont...	-2500.000	0.000
	17.000	Cont...	-2000.000	0.000
	18.000	Cont...	-400.000	0.000
	19.000	Cont...	-100.000	0.000
	20.000	Cont...	0.000	0.000
	21.000	Cont...	0.000	0.000
	22.000	Cont...	0.000	0.000
	23.000	Cont...	0.000	0.000

Table 8. Load Type Solar Array