

Enerji Depolama Etkisi

(Türkiye 2018 verileri üzerinden bir benzetici çalışması ve sonuçları)

Barış Sanlı

barissanli.com/python

2 Nisan 2019

Hatırlatma

- İlgili çalışma : <http://barissanli.com/python/depolama.php>
- Kodlar: <https://github.com/barissanli/python-energy>
- Veri seti: <http://barissanli.com/python/2018-elektrik.xlsx>
- Çalışma tamamen deneme amaçlı olup, hiçbir resmi/akademik çalışmasının parçası veya çıktı hazırlayıcısı değildir
- Görüşler sadece kişiseldir, hiçbir kurum ve kuruluşa mal edilemez, bu kurum veya kuruluşların görüşüymüş gibi aktarılamaz
- Kod mükemmel değil, geliştirmek isteyenler için paylaşılmıştır. Dolayısıyla serbestçe bölüşülüp değiştirilerek kullanılabilir.

Benzetici (Simülatör)

- Soru: Depolama olsa sisteme etkisi ne olurdu?
 - Alt soru: Fayda-maliyet
 - Alt soru: Gerçekten güneş-depolama mı?
 - Alt soru: Gerçek değer nerede?
- Diğer çıkarımlar
- İçerik

Teknik Detay

- Veri seti: EPIAŞ (seffaflik.epias.com.tr)
- Jupyter/Python
- Lisanslı üretim+lisanssız üretim=genel toplam

17	3	36411.3	10108.9
16	3	39093.2	10587.5
17	3	40272.0	10911.3

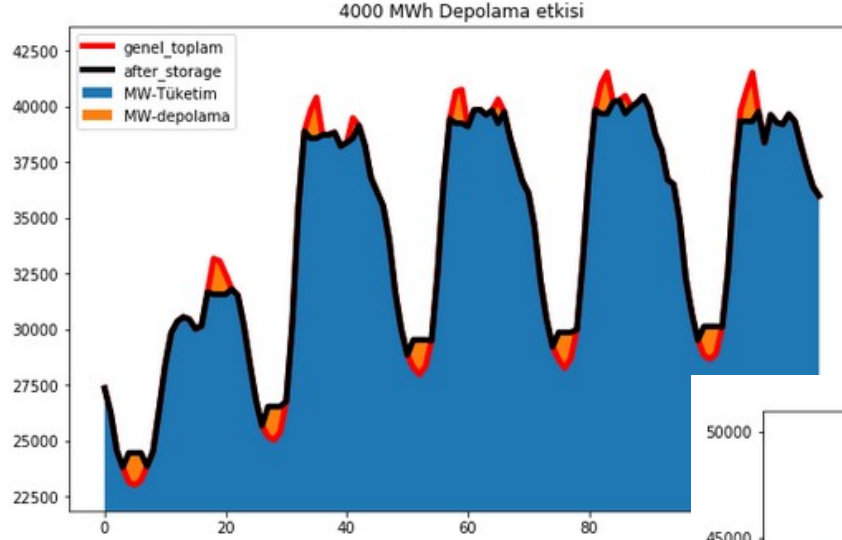
2018-saatlik
2018-gun

gun	ay	yl	saat	lisansli_uretim	lisansli_toplam	lisanssiz_uretim	lisanssiz_toplam	genel_toplam	lisansli_uretim	lisansli_toplam	lisanssiz_uretim	lisanssiz_toplam	genel_toplam	lisansli_uretim	lisansli_toplam	lisanssiz_uretim	lisanssiz_toplam	genel_toplam	lisansli_uretim	lisansli_toplam	lisanssiz_uretim	lisanssiz_toplam	genel_toplam	
1	1	2018	0	27429.7	7038.0	4933.6	5226.3	1897.1	5242.1	1179.5	0.0	176.6	891.1	278.2	189.5	230.0	26.2	0.0	297.0	26.2	0.0	27596.0	207.6	108.0
1	1	2018	1	26243.3	6995.6	3928.6	5277.2	1893.5	5653.6	1148.5	0.0	174.2	893.2	284.8	205.5	221.7	26.4	0.0	287.0	26.4	0.0	26289.6	205.3	142.0
1	1	2018	2	24653.3	6122.8	2722.0	5325.5	1697.5	5619.4	1216.4	0.0	177.9	894.3	278.2	201.5	218.9	26.2	0.0	269.0	26.2	0.0	24679.4	164.9	120.0
1	1	2018	3	23789.3	6020.5	2535.4	5265.9	1651.6	5123.4	1298.1	0.0	171.5	895.6	271.6	211.5	220.2	26.4	0.0	274.0	26.4	0.0	23815.7	154.5	120.0
1	1	2018	4	23113.7	5747.4	2473.7	5282.9	1687.6	4722.2	1231.9	0.0	165.0	895.0	273.8	207.5	224.3	26.2	0.0	263.0	26.2	0.0	23139.8	112.6	89.0
1	1	2018	5	22981.2	5630.3	2328.4	5198.4	1612.4	4990.7	1136.6	0.0	163.4	891.1	275.8	209.5	224.4	26.5	0.0	261.0	26.5	0.0	22911.8	105.0	85.0
1	1	2018	6	23198.3	5979.6	2364.8	5145.2	1577.6	4898.6	1194.4	0.0	163.6	898.4	271.6	203.1	224.1	26.0	0.0	263.0	26.0	0.0	23221.9	89.0	85.0
1	1	2018	7	23703.6	6027.5	2283.6	5174.1	1536.0	5052.4	1109.5	0.0	163.7	897.0	273.8	204.5	224.6	26.0	0.0	261.0	26.2	0.0	23658.0	119.9	89.0
1	1	2018	8	24206.4	7249.8	2183.9	5079.0	1720.0	4994.4	1154.0	0.2	179.9	895.2	278.2	203.5	219.8	1.6	346.0	252.6	0.0	24518.0	152.9	115.0	
1	1	2018	9	26724.0	7672.1	2499.9	5143.9	1943.2	5243.2	1480.3	1.5	175.1	891.1	282.6	204.5	225.7	0.0	1.9	234.0	694.1	0.0	26388.2	183.3	193.3
1	1	2018	10	27283.5	8899.0	2671.8	4959.4	2036.1	5489.0	1115.0	1.8	177.9	797.4	276.0	209.5	219.4	0.0	0.0	236.0	1117.7	0.0	26901.2	204.0	204.0
1	1	2018	11	28414.7	9438.4	3344.2	4991.1	2126.0	5497.0	1053.9	3.5	175.8	778.8	276.0	201.5	220.8	1.7	232.0	1432.1	0.0	28346.8	170.0	180.0	
1	1	2018	12	28757.8	9454.1	3575.2	4993.5	2097.1	5494.7	1058.1	4.2	180.4	787.0	273.8	213.5	222.6	0.0	1.7	245.0	1553.1	0.0	28799.9	145.0	174.2
1	1	2018	13	29031.3	10014.6	3499.6	4924.3	2183.9	5671.3	1031.3	3.7	177.2	799.7	274.8	202.5	225.6	0.0	1.7	231.0	1516.8	0.0	29255.0	170.0	176.1
1	1	2018	14	29160.5	10309.9	3275.9	4792.8	2191.0	5715.4	1059.5	3.5	204.5	799.9	271.6	200.5	227.1	0.0	1.8	230.0	1288.4	0.0	29448.0	170.0	178.1
1	1	2018	15	29151.4	9932.1	3215.4	4893.5	2078.4	5892.6	1105.8	1.9	205.5	747.9	276.0	213.0	219.6	0.0	1.7	268.0	872.2	0.0	29322.6	170.0	180.0
1	1	2018	16	29790.8	10109.5	3698.0	4890.3	1983.6	5777.0	1210.6	0.8	183.7	790.8	273.8	209.5	221.4	0.0	1.8	262.0	395.1	0.0	30153.9	184.9	185.0
1	1	2018	17	31575.8	10998.8	4492.6	4925.3	2207.8	5813.3	1475.7	0.1	177.6	775.8	289.5	201.5	228.2	0.0	1.7	257.0	98.9	0.0	31672.8	189.0	170.0
1	1	2018	18	31136.3	11161.7	5049.2	5044.1	2287.7	5813.4	1479.1	0.0	184.9	781.4	311.7	202.5	243.0	0.0	1.8	186.0	38.3	0.0	31174.7	203.0	215.0
1	1	2018	19	30929.7	10971.2	5649.0	5025.1	2198.9	5932.2	1594.9	0.0	189.8	792.0	294.2	201.5	244.7	0.0	1.8	150.0	39.7	0.0	30970.4	204.0	224.1
1	1	2018	20	32407.3	10949.9	5931.0	5059.4	2140.9	5999.9	1679.6	0.0	179.4	797.0	311.7	201.5	242.6	0.0	0.0	156.0	31.6	0.0	32466.3	195.4	214.2
1	1	2018	21	31775.3	10414.6	4490.1	4970.2	2101.0	6116.4	1903.5	0.0	176.0	799.0	294.2	201.5	247.2	0.0	1.8	219.0	39.7	0.0	31890.0	145.0	178.8
1	1	2018	22	31497.0	10118.1	4417.9	4899.0	1963.9	6217.3	1919.2	0.0	181.0	801.5	126.9	201.5	242.2	0.0	1.6	157.0	33.3	0.0	31530.3	143.0	169.0
1	1	2018	23	31015.5	9626.6	3390.3	4979.6	1969.5	6004.3	2110.6	0.0	177.8	799.6	183.3	204.5	227.2	0.0	0.0	68.4	33.8	0.0	31087.3	112.6	123.0
2	1	2018	0	28414.0	9494.4	2113.4	5003.3	1899.3	5779.5	2234.8	0.0	173.1	822.3	296.1	247.5	245.3	0.0	0.0	125.0	33.0	0.0	28447.0	197.0	118.0
2	1	2018	1	28785.2	9242.9	1903.8	4961.9	1594.3	5628.8	2378.8	0.0	173.4	822.0	282.6	203.5	248.1	0.0	0.0	238.0	34.3	0.0	28829.5	174.9	106.2
2	1	2018	2	29642.3	9734.5	703.2	4979.3	1443.9	5289.5	2492.6	0.0	173.9	824.0	273.8	209.5	246.1	0.0	0.0	180.0	34.7	0.0	29676.9	199.0	89.0

Örnek bir depolama işleyişi

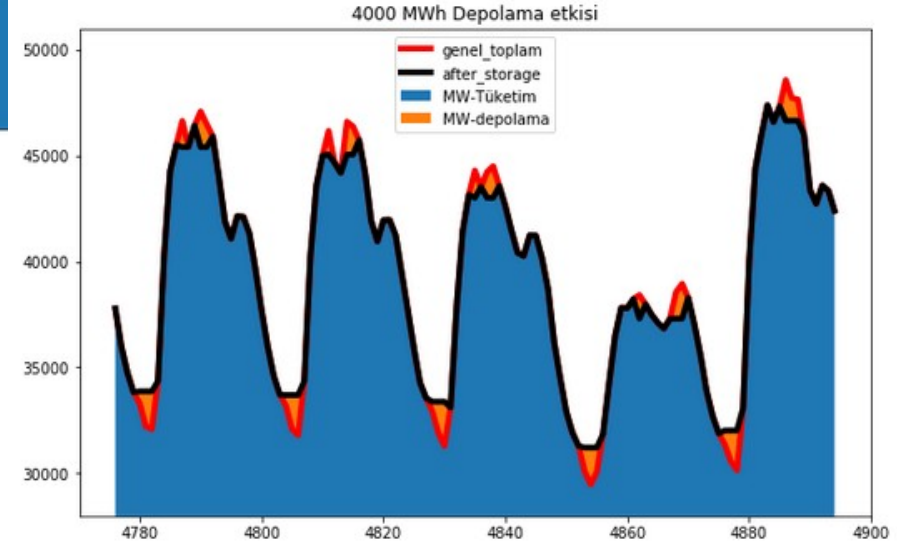
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1	26269.61	205.34	142.00	0.00	26269.61
2	24579.44	164.94	120.00	0.00	24579.44
3	23815.73	154.52	120.00	0.00	23815.73
4	23139.84	112.64	89.00	1318.65	24458.49
5	23013.76	105.02	65.00	1444.73	24458.49
6	23221.87	85.00	84.99	1236.62	24458.49
7	23858.80	119.89	80.00	0.00	23858.80
8	24518.96	152.90	115.01	0.00	24518.96
9	26388.15	193.27	193.27	0.00	26388.15
10	28401.24	204.00	204.00	0.00	28401.24
11	29846.83	169.99	180.00	0.00	29846.83
12	30350.94	145.00	174.17	0.00	30350.94
13	30555.04	169.99	178.10	0.00	30555.04
14	30448.82	169.99	178.10	0.00	30448.82
15	30023.62	169.99	179.99	0.00	30023.62
16	30153.90	184.94	185.00	0.00	30153.90
17	31672.77	160.00	170.00	0.00	31672.77
18	33174.67	200.00	215.00	-1603.56	31571.11
19	33070.37	203.99	234.11	-1499.26	31571.11
20	32468.29	185.36	214.17	-897.18	31571.11
21	31806.04	145.00	178.78	0.00	31806.04



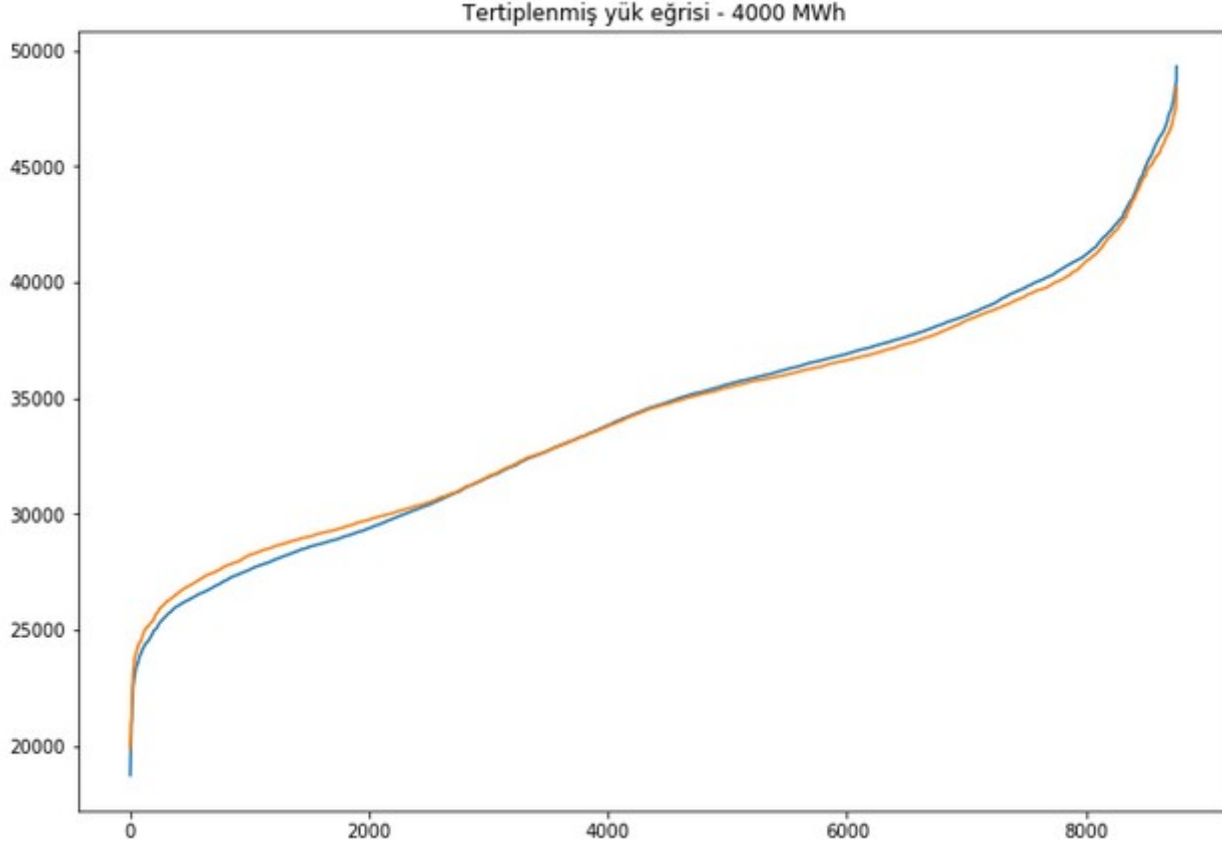
Kış

Yaz



Enerji Depolama

Tertiplenmiş yük eğrisi



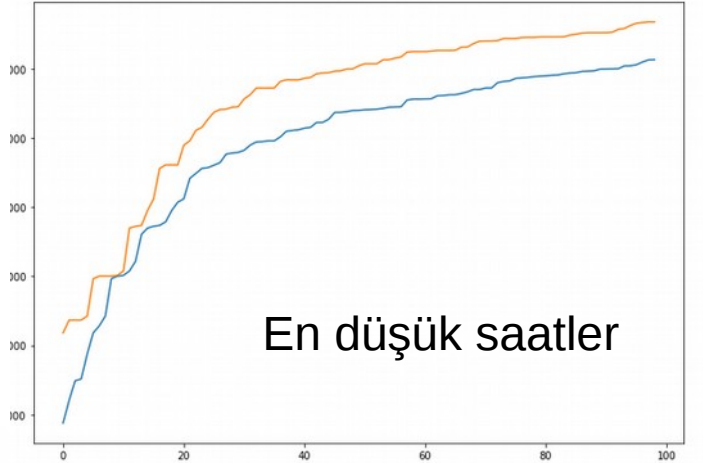
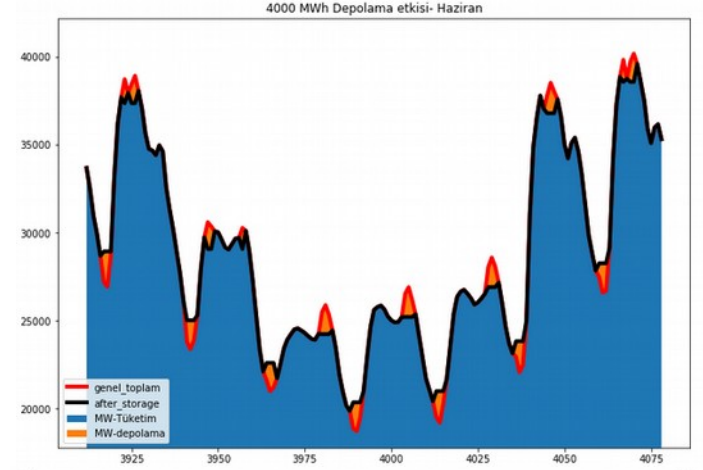
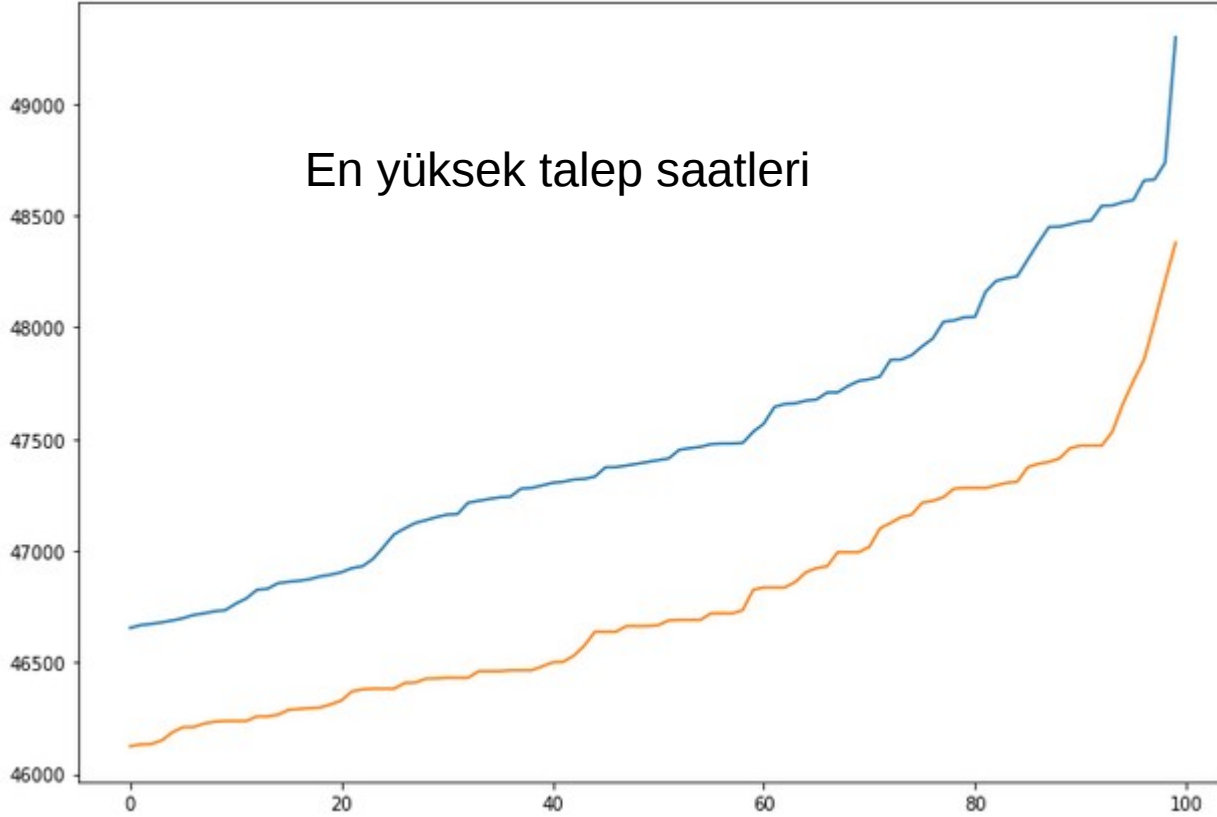
En yüksek talep günleri

	gun	ay	yil	saat	haftanin_gunu	lisansli_toplam	dogalgaz	barajli	linyit	akarsu	...	l_biyogaz	l_kanal tipi	l_biyokutle	l_gunes	l_diger	genel_toplam	ptf	smf	storage	after_storage
4622	12	7	2018	14	4	44829.83	17319.97	8423.37	4994.20	1758.10	...	13.65	4.47	13.46	3426.22	0.01	48304.40	229.99	229.99	-1873.063333	46431.336667
5123	2	8	2018	11	4	44674.34	15014.26	9031.52	5285.97	1577.74	...	13.13	3.40	10.55	3658.62	0.13	48378.90	300.44	309.44	0.000000	48378.900000
5147	3	8	2018	11	5	44609.16	15382.10	8224.42	4730.02	1732.46	...	11.36	4.55	12.59	3789.20	0.08	48449.12	298.97	308.97	-1167.976667	47281.143333
5125	2	8	2018	13	4	44790.02	14885.46	9083.17	5255.98	1647.02	...	13.00	3.21	10.43	3613.71	0.12	48450.56	301.10	310.10	-980.373333	47470.186667
5102	1	8	2018	14	3	44936.66	15287.37	10577.18	5309.38	1562.72	...	11.30	4.14	13.41	3481.25	0.04	48460.90	310.37	313.45	-1467.463333	46993.436667
5270	8	8	2018	14	3	44917.43	13953.92	10125.89	4933.81	1672.79	...	11.20	4.45	12.72	3504.65	0.04	48473.10	303.65	309.00	-1637.293333	46835.806667
5054	30	7	2018	14	1	45132.76	17008.18	10685.70	4689.35	1705.40	...	12.52	4.45	14.01	3303.36	0.07	48477.69	248.33	265.00	-1815.036667	46662.653333
5294	9	8	2018	14	4	44889.28	13517.49	10533.42	5180.15	1652.83	...	10.32	4.73	11.41	3600.59	0.10	48543.84	302.93	321.80	-1824.580000	46719.260000
5246	7	8	2018	14	2	44919.01	15357.40	10281.31	4341.36	1482.83	...	10.56	4.47	12.74	3575.30	0.10	48545.26	313.54	313.54	-1854.830000	46690.430000
4886	23	7	2018	14	1	45092.48	17228.44	10046.05	5043.14	1669.59	...	12.60	4.33	12.25	3434.88	0.08	48559.87	245.42	255.42	-1922.820000	46637.050000
5103	1	8	2018	15	3	45549.78	15110.71	10960.15	5336.82	1797.64	...	11.15	4.41	12.31	2978.02	0.04	48569.79	308.91	318.00	-1576.353333	46993.436667
5150	3	8	2018	14	5	45230.24	14954.23	9168.57	4493.39	1730.36	...	11.93	4.67	13.80	3371.08	0.11	48657.08	299.85	315.51	-1375.936667	47281.143333
5127	2	8	2018	15	4	45660.96	14967.80	9386.13	5317.07	1622.46	...	12.79	2.87	12.96	2947.96	0.00	48661.53	305.27	305.27	-1191.343333	47470.186667
5151	3	8	2018	15	5	45825.96	14763.72	9658.50	4695.53	1635.57	...	10.35	4.66	10.92	2857.85	0.07	48737.23	301.92	316.01	-1456.086667	47281.143333
5126	2	8	2018	14	4	45871.70	14711.42	10192.92	5309.51	1634.65	...	12.72	3.05	12.88	3376.29	0.14	49298.47	306.40	315.00	-1828.283333	47470.186667

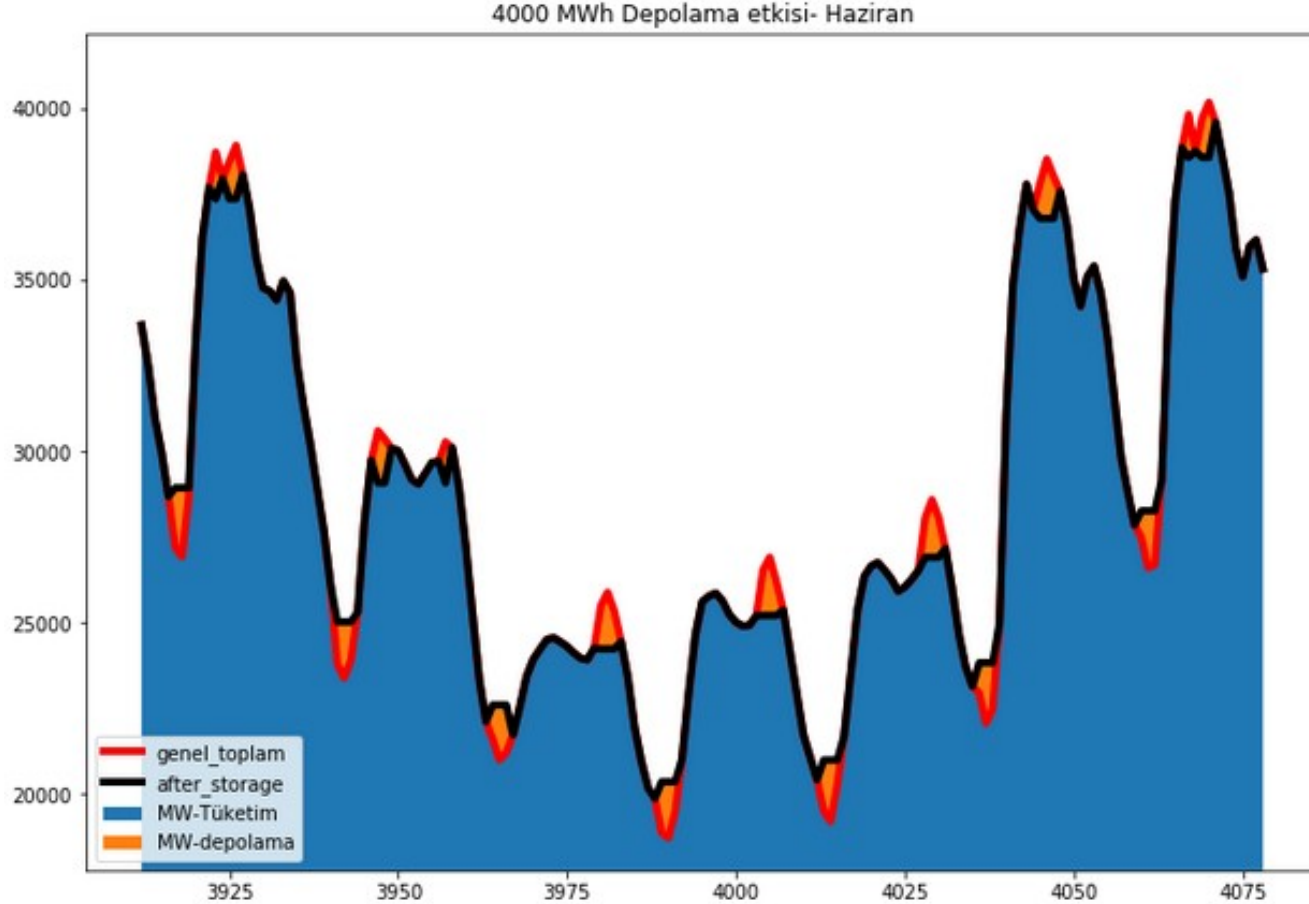
En düşük talep günleri

gun	ay	yil	saat	haftanin_gunu	lisansli_toplam	dogalgaz	barajli	linyit	akarsu	...	l_biyogaz	l_kanal tipi	l_biyokutle	l_gunes	l_diger	genel_toplam	ptf	smf	storage	after_storage	
3990	16	6	2018	6	6	18414.07	2115.91	2270.87	4726.28	2199.58	...	12.44	2.87	12.67	281.50	0.34	18727.99	98.69	30.00	1638.990000	20366.980000
3989	16	6	2018	5	6	18816.40	2128.57	2312.45	4693.89	2319.51	...	12.20	2.90	13.02	31.09	0.13	18881.63	124.99	34.99	1485.350000	20366.980000
4014	17	6	2018	6	7	18895.87	2108.38	2642.58	5233.54	2111.89	...	12.68	3.73	11.81	281.10	0.36	19207.51	99.99	90.41	1795.120000	21002.630000
3991	16	6	2018	7	6	18534.48	2170.48	2529.80	4707.13	2352.09	...	8.62	3.49	13.09	928.96	0.81	19491.32	124.99	90.00	875.660000	20366.980000
4013	17	6	2018	5	7	19458.07	2199.79	2798.49	5221.86	2257.68	...	8.84	3.91	12.98	28.65	0.13	19516.00	141.90	130.00	1486.630000	21002.630000
3988	16	6	2018	4	6	19840.75	2131.32	2630.02	4693.63	2330.64	...	12.77	2.83	11.79	0.91	0.11	19879.03	159.99	30.00	0.000000	19879.030000
3987	16	6	2018	3	6	20141.81	2116.59	2295.65	4709.97	2454.62	...	12.87	2.92	12.43	0.32	0.12	20182.89	145.53	25.53	0.000000	20182.890000
4015	17	6	2018	7	7	19323.18	1836.49	3272.87	5280.08	2182.76	...	11.88	3.45	12.30	931.31	0.62	20284.38	147.67	130.00	718.250000	21002.630000
4012	17	6	2018	4	7	20395.22	2437.30	3094.19	5274.17	2382.52	...	9.60	3.75	12.77	0.75	0.12	20425.63	160.00	140.00	0.000000	20425.630000
3986	16	6	2018	2	6	20922.60	2166.02	2575.15	4701.60	2528.95	...	13.35	2.94	12.89	0.27	0.11	20965.43	160.00	30.00	0.000000	20965.430000
3965	15	6	2018	5	5	20933.67	1846.10	3174.14	5028.78	2354.04	...	12.94	4.48	12.14	33.45	0.15	21002.12	180.98	171.00	1606.946667	22609.066667
3992	16	6	2018	8	6	19208.65	2265.95	2979.86	4696.37	2438.92	...	11.52	3.71	12.99	1775.12	1.15	21013.99	160.00	120.20	0.000000	21013.990000
4011	17	6	2018	3	7	21042.62	2745.44	2950.54	5267.92	2434.38	...	13.07	3.78	11.89	2.12	0.12	21076.41	144.87	130.00	0.000000	21076.410000
3966	15	6	2018	6	5	20896.61	2106.38	3127.09	4989.66	2288.36	...	12.14	4.72	12.27	284.49	0.34	21217.04	147.86	147.86	1392.026667	22609.066667
3964	15	6	2018	4	5	21573.83	2022.72	3265.34	5046.67	2453.13	...	13.13	4.57	12.15	1.01	0.13	21608.04	189.85	179.85	1001.026667	22609.066667

Tertiplenmiş yük eğrisinin en yüksek ve düşük kısmı

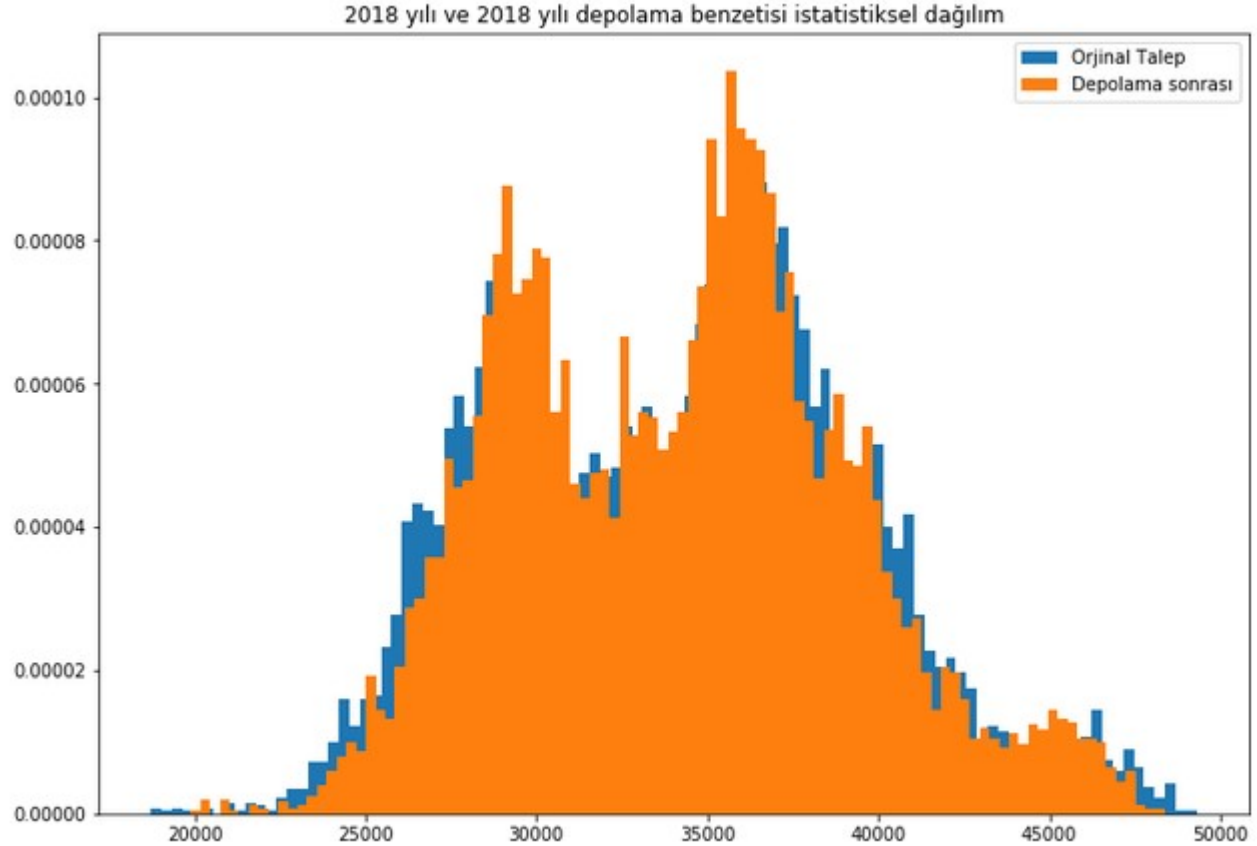


En düşük talep günleri-Depolama ne yapsın?



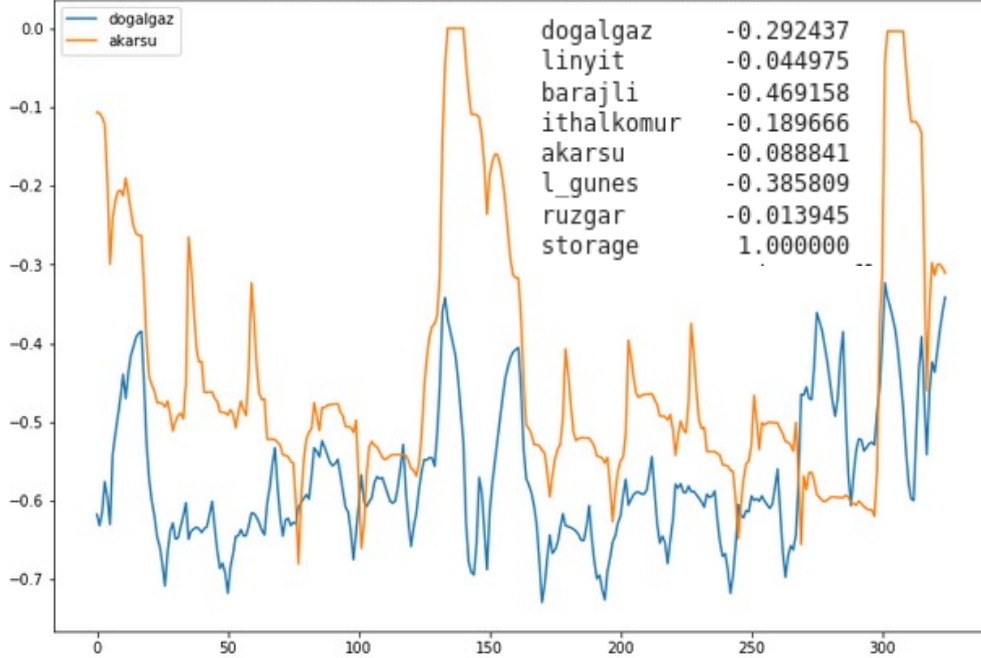
İstatistiksel ölçüler

- Standart sapma
 - 2018: 5384 MW
 - 2018+depolama: 4961 MW
- 4000 MWh depolama sapmayı 423 MW azalttı
- Ortalama günlük tüketim :
 - 816 GWh
 - 4GWh (doldur-boşalt etkisi)
 - % 0.5

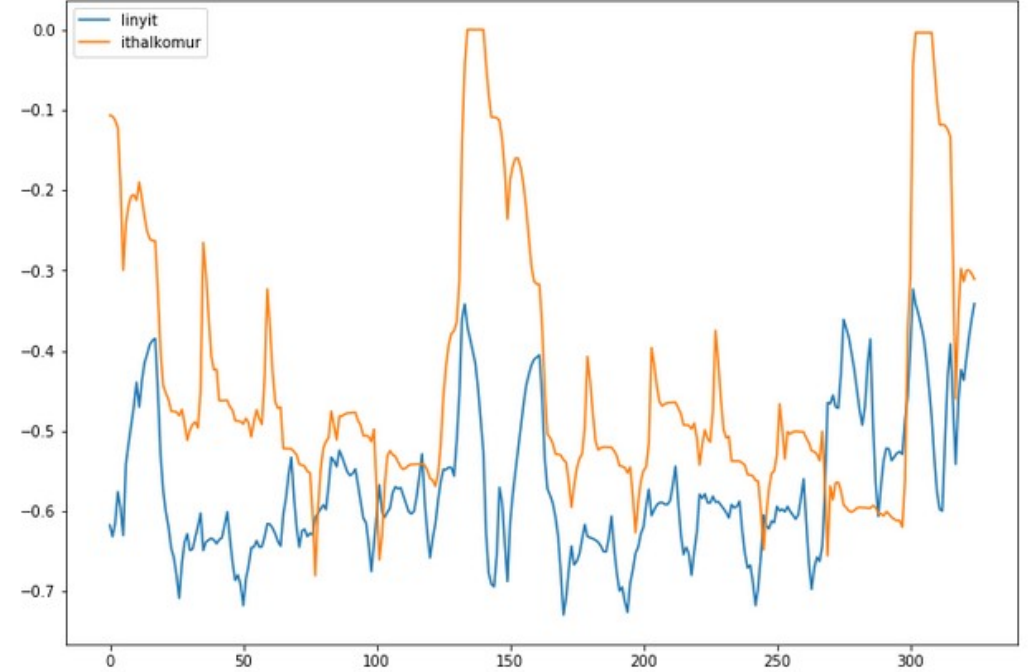


İltiler(Korelasyon)

30ar günlük hareketli pencerelerde iki kaynak arasındaki ilinti

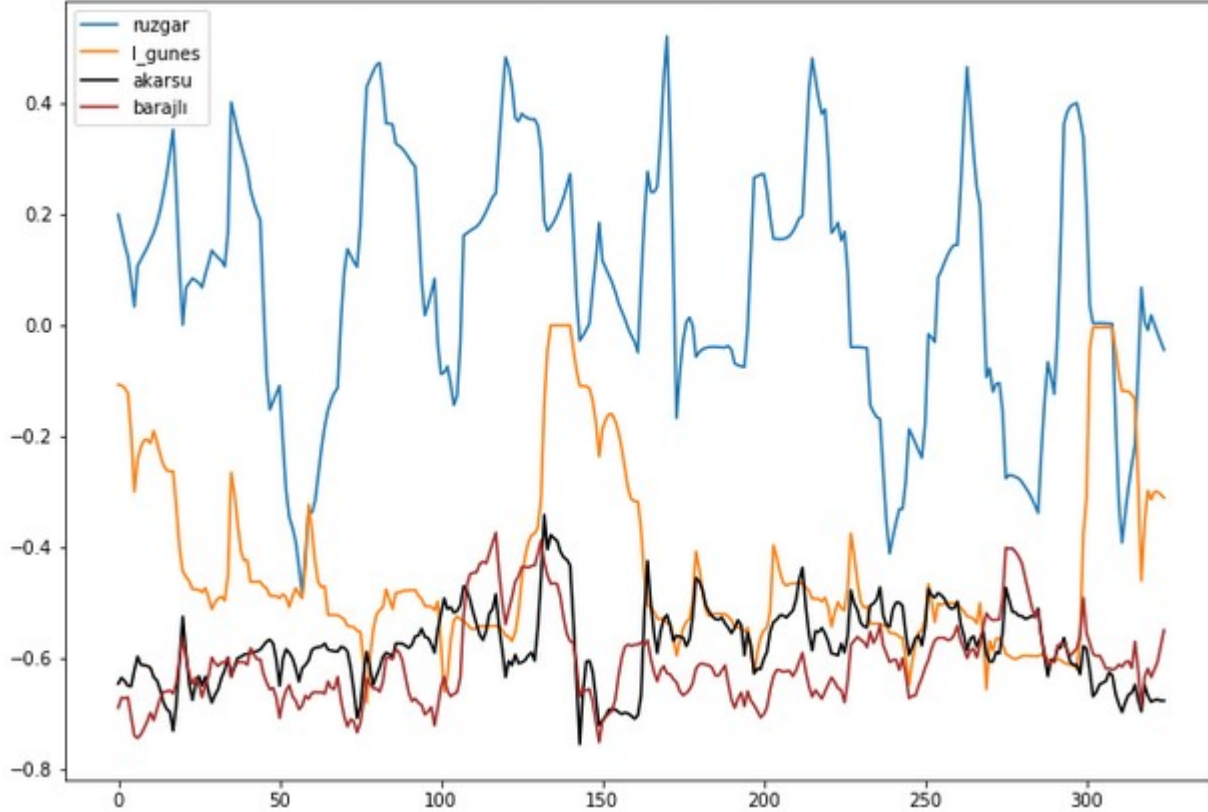


30ar günlük hareketli pencerelerde iki kaynak arasındaki ilinti



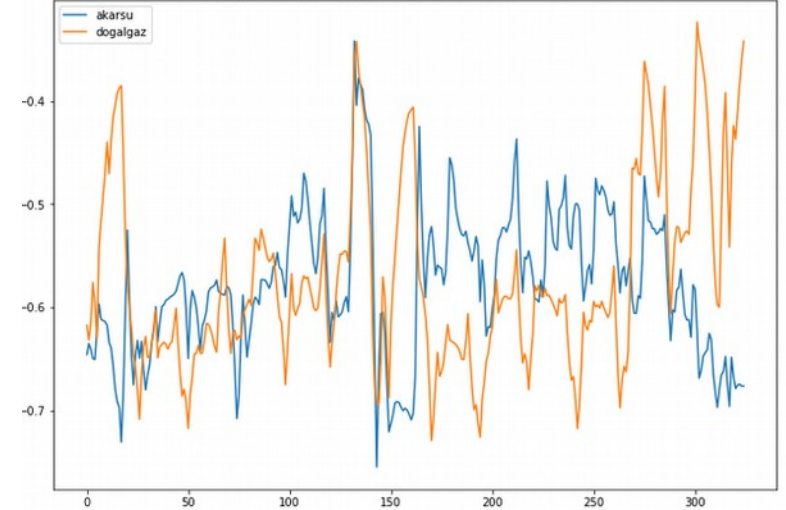
İlintiler (Yenilenebilir Kaynaklar)

30ar günlük hareketli pencerelerde kaynaklar arasındaki ilinti

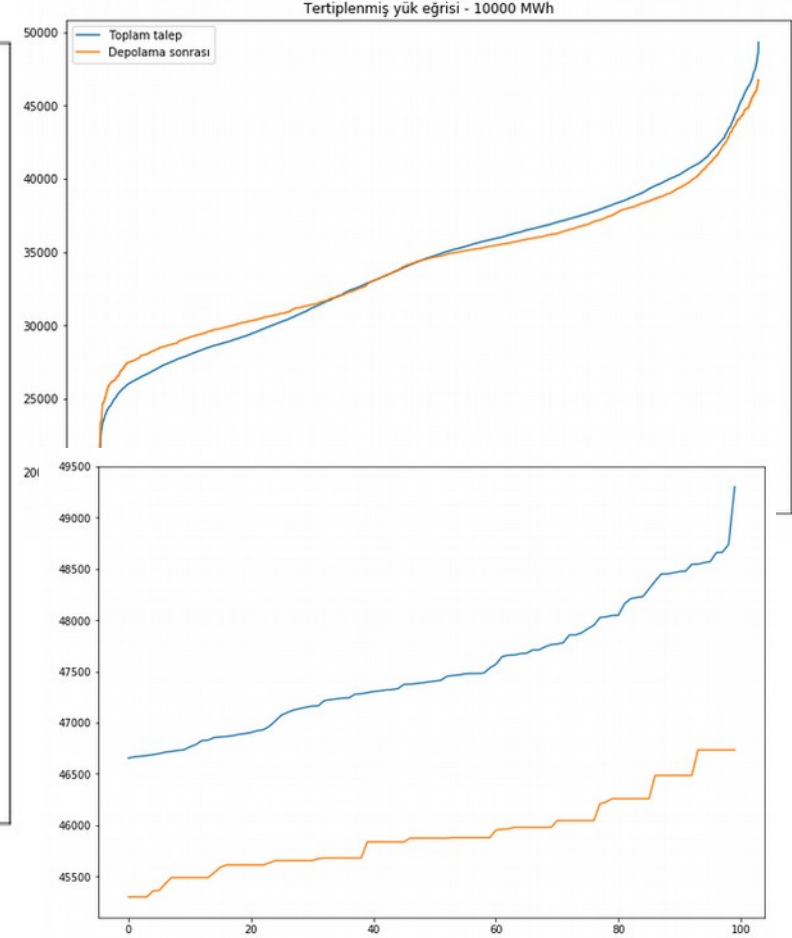
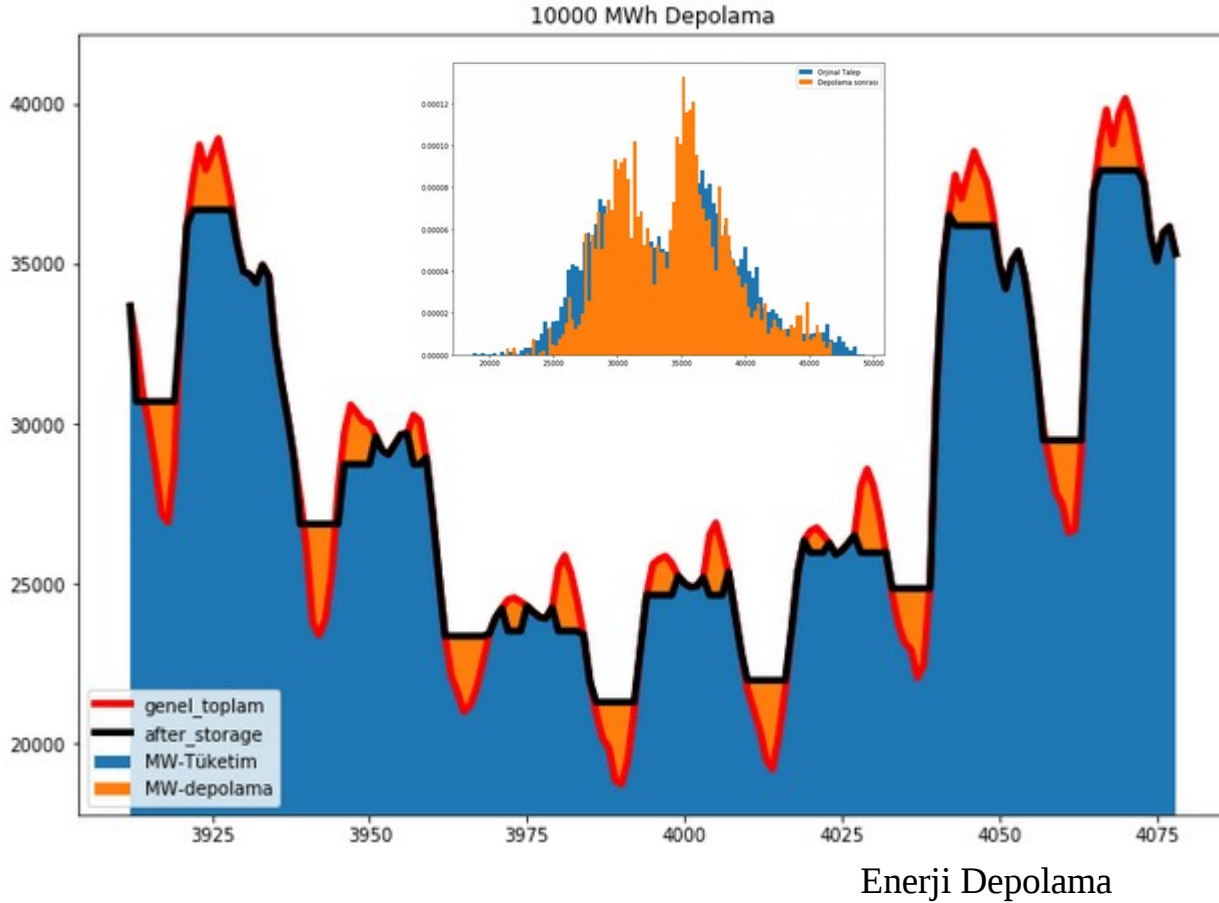


енерги Дероаша

30ar günlük hareketli pencerelerde kaynaklar arasındaki ilinti



10000 Mwh (7-8 saatlik döngüler)



Sonuç

- Depolama ne kadar deęişim getirir
 - Petrolde "ulusal stok"
 - Doğalgazda "depolama"
 - Elektrik "hidro?"
- Güneş-depolama ikilisi tartışmalı
 - nimet-külfet dengesi
- Deęer üretim de mi, tüketim de mi?
 - Altyapı ihtiyacını azaltıyorsa tüketimde
- Sibergüvenlik sonuçları

Teşekkürler

Barış Sanlı

Tüm veri ve paylaşımlar için:

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