



Enerji 101 – Ders 4

Elektrik Teknolojisi ve Ekonomisi Eğitimi

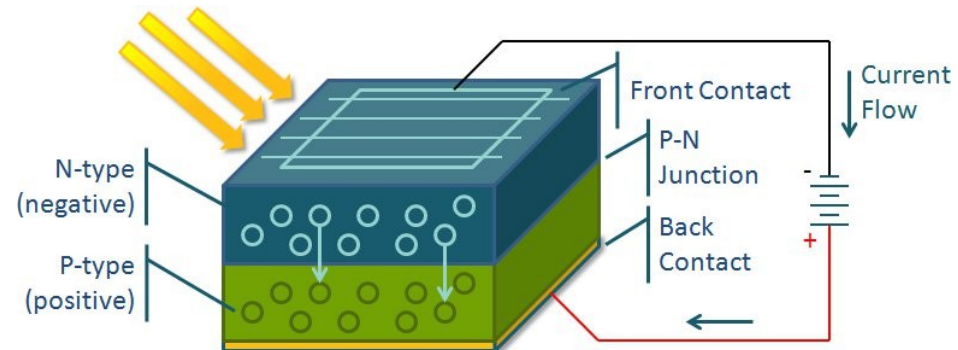
Barış Sanlı

Elektrik

- Bir enerji taşıyıcısı
 - Elektrik var ise diğer uçta bir “hareket” vardır
- Elektron hareketi
 - 80 cm/saat
- Daha çok ışık gibi
 - Işık depolanıyor mu?

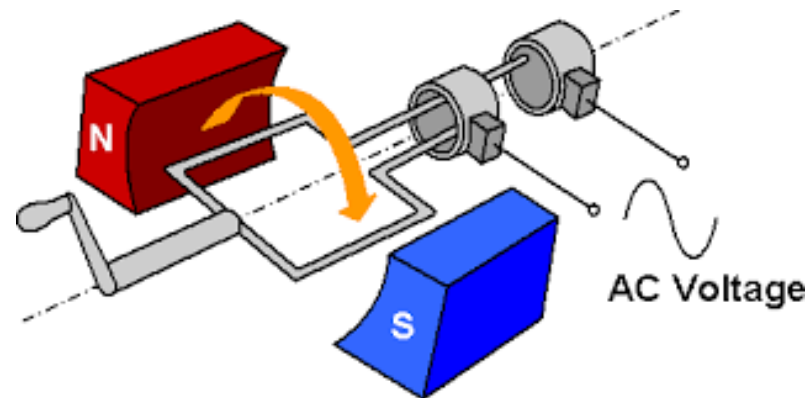
Elektrik elde etme yöntemi

- Elektron dengesizliği
 - Fazla-eksik
- Kimyasal (tarihsel)
- Mekanik (günümüz)
- Fizik – yarı iletken/kuantum (gelecek mi?)

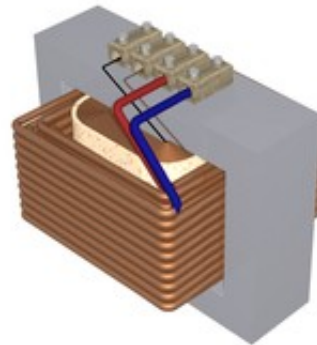
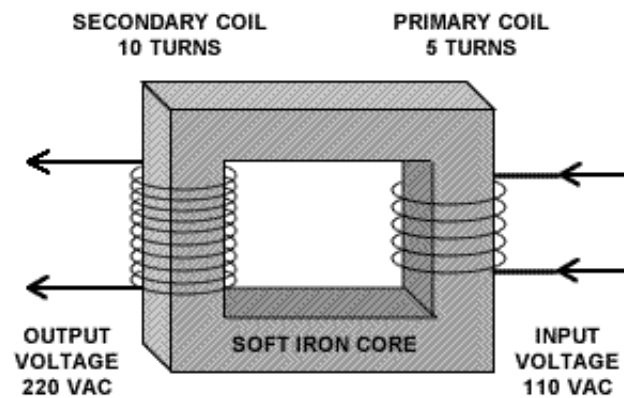


Manyetizma

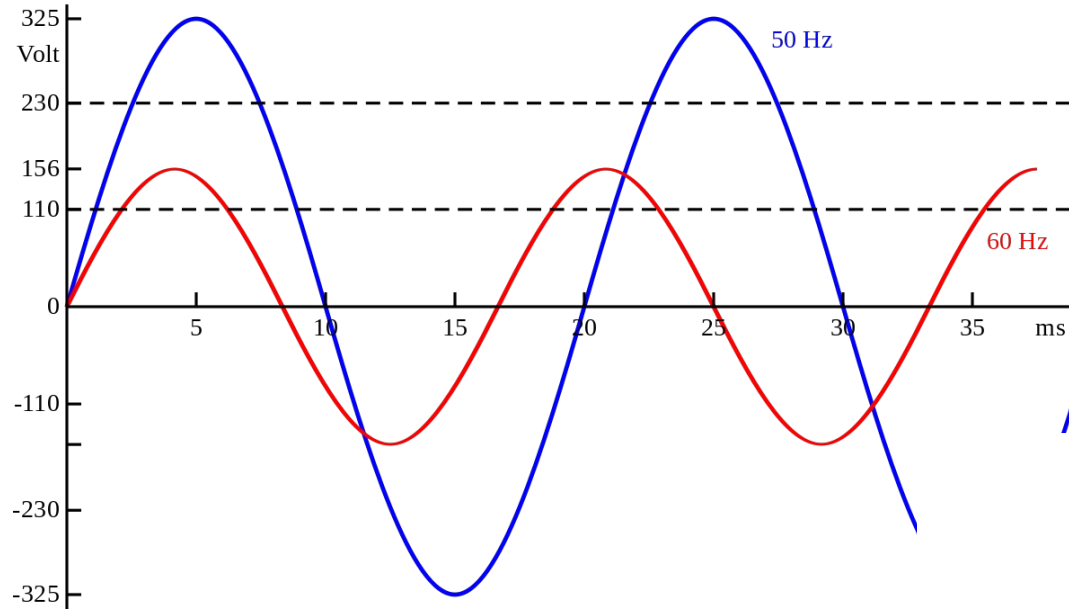
- Üretim



- Transformatör

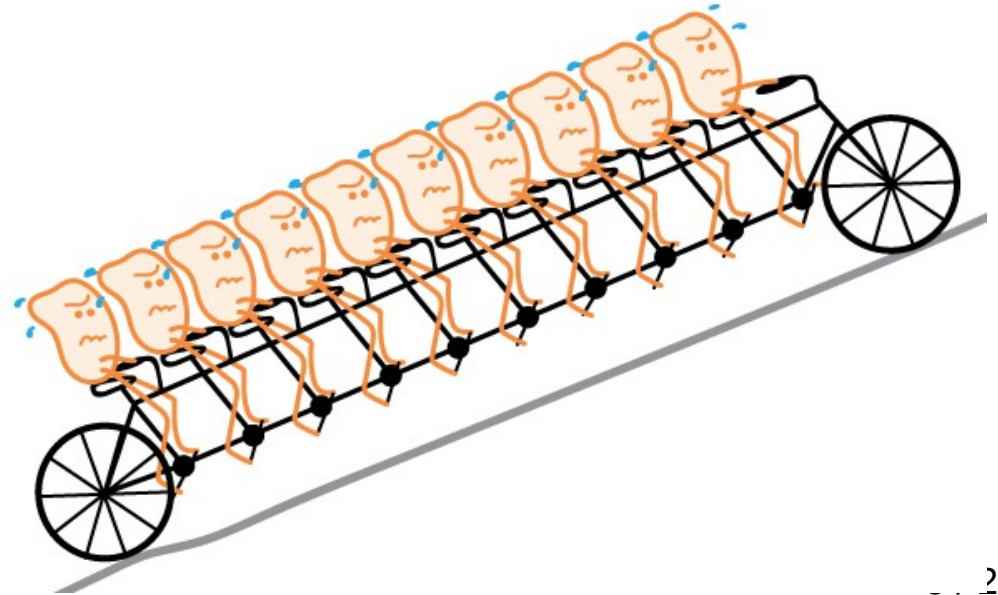


Voltaj -Frekans



Su analogisi : Yükseklik – Voltaj
Debi – Akım

Bisiklet örneği



Elektriğin Taşınması

- USB kabloları
 - 2.0 maksimum 5 metre
 - 3.0 maksimum 3 metre
- Hat boyu voltaj düşüşü var
 - Kabloya
 - Akıma bağlı
- En az kayıp yüksek voltaj, düşük akım
 - Yüksek voltaj !!!

Voltage Drop at 500mA						
AWG	15cm	50cm	1m	2m	3m	5m
20	0.064997	0.076655	0.09331	0.12662	0.15993	0.22655
22	0.067944	0.08648	0.11296	0.16592	0.21888	0.3248
24	0.072633	0.10211	0.14422	0.22844	0.31266	0.4811
26	0.080085	0.12695	0.1939	0.3278	0.4617	0.7295
28	0.091935	0.16645	0.2729	0.4858	0.6987	1.1245

Voltage Drop at 1000mA						
AWG	15cm	50cm	1m	2m	3m	5m
20	0.129993	0.15331	0.18662	0.25324	0.31986	0.4531
22	0.135888	0.17296	0.22592	0.33184	0.43776	0.6496
24	0.145266	0.20422	0.28844	0.45688	0.62532	0.9622
26	0.16017	0.2539	0.3878	0.6556	0.9234	1.459
28	0.18387	0.3329	0.5458	0.9716	1.3974	2.249

Voltage Drop at 2000mA						
AWG	15cm	50cm	1m	2m	3m	5m
20	0.259986	0.30662	0.37324	0.50648	0.63972	0.9062
22	0.271776	0.34592	0.45184	0.66368	0.87552	1.2992
24	0.290532	0.40844	0.57688	0.91376	1.25064	1.9244
26	0.32034	0.5078	0.7756	1.3112	1.8468	2.918
28	0.36774	0.6658	1.0916	1.9432	2.7948	4.498

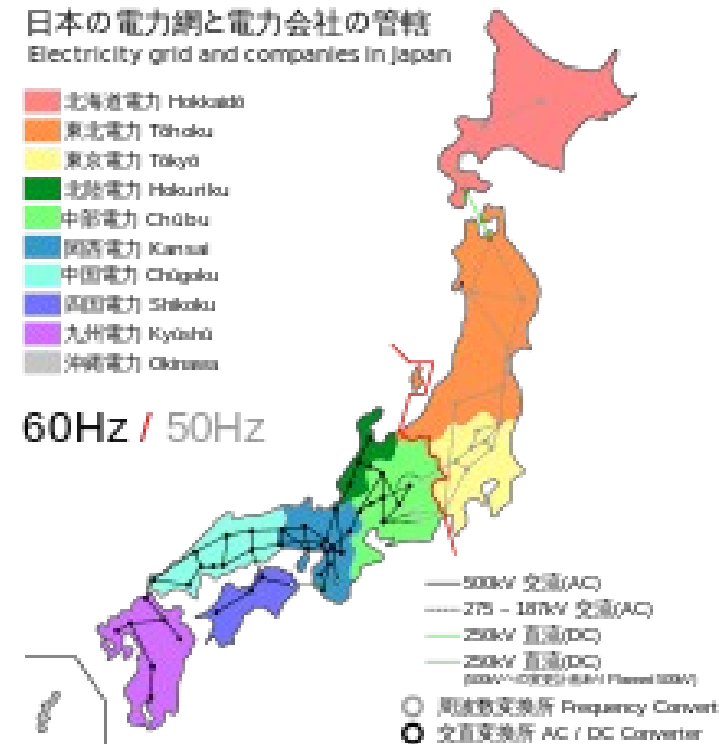
Voltage Drop at 2400mA						
AWG	15cm	50cm	1m	2m	3m	5m
20	0.311983	0.367944	0.447888	0.607776	0.767664	1.08744
22	0.326131	0.415104	0.542208	0.796416	1.050624	1.55904
24	0.348638	0.490128	0.692256	1.096512	1.500768	2.30928
26	0.384408	0.60936	0.93072	1.57344	2.21616	3.5016
28	0.441288	0.79896	1.30992	2.33184	3.35376	5.3976

<=0.25v >0.25v >0.5v

by goughlui.com

Modern elektrik sistemi

- Edison DC-110 Volt
- Tesla 240 V – 60 hertz
- Westinghouse ark lambalarından 60 hertz
- Almanya'da AEG, 50 Hertz, 120 V
- Avrupa 1950'lere kadar 120 V sonra 220 V 60Hz / 50Hz
- İngiltere hem 220 V hem de 50 Hz'e geçti



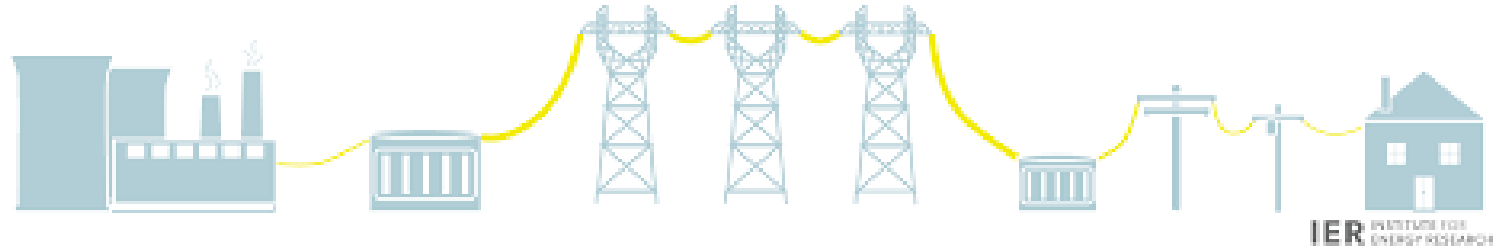
İki bakış

Teknik

Üretim

İletim

Dağıtım



İdari
Finansal

Politika



Düzenleyici

Piyasa İşletmecisi

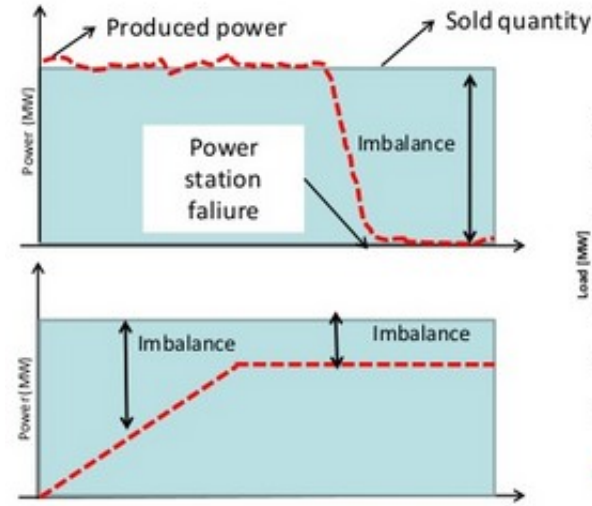
Toptan Satış

Perakende Satış

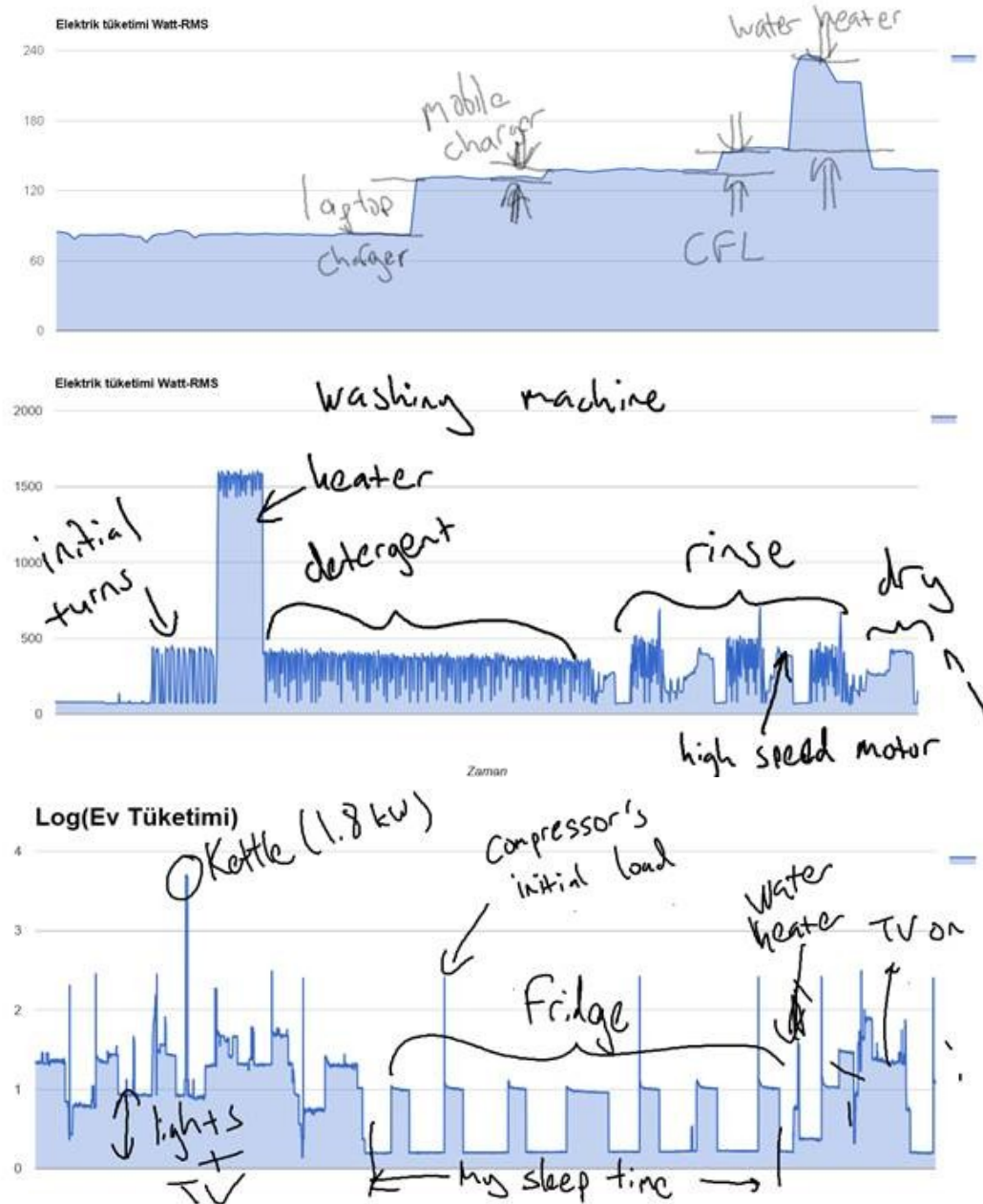
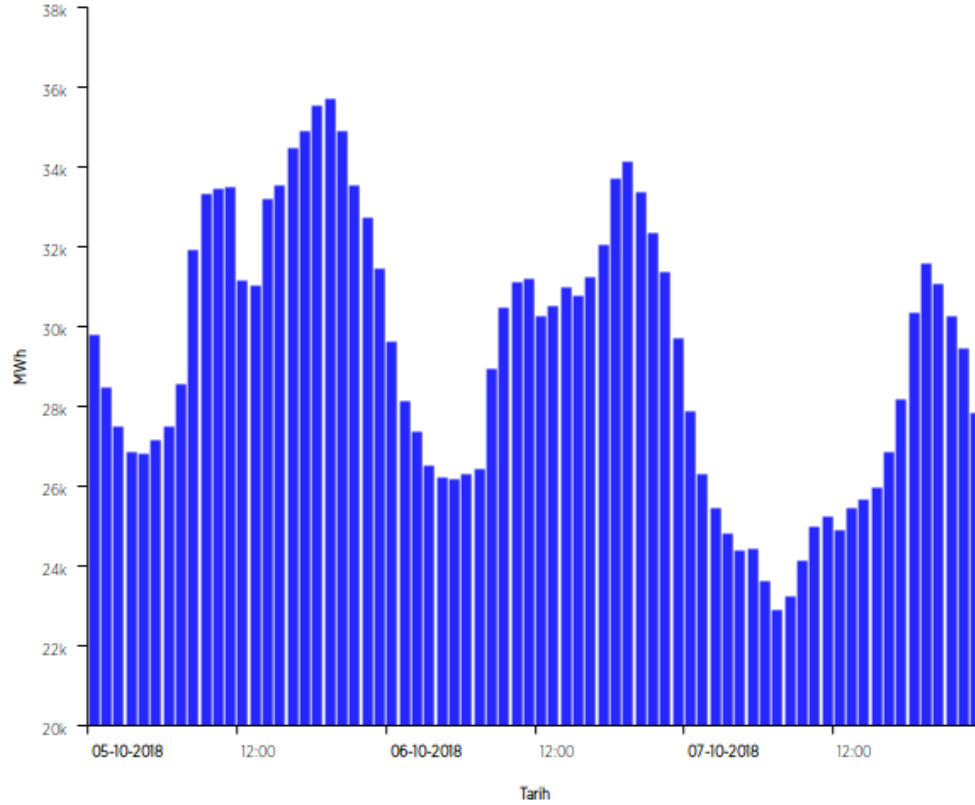
Serbest Tüketiciler

Elektrikte temel iki sorun

- Tüm sistem tüketiciye göre
 - Tüketici talebini yönetmiyor
 - Anlık dengeleme ihtiyacı
- Elektrik depolama (büyük ölçekli-ekonomik)
 - Üretici ve sistem bu belirsizliği yönetmek zorunda
- O zaman?
 - Planlama
 - Yedekleme
 - Esneklik (üretimde)

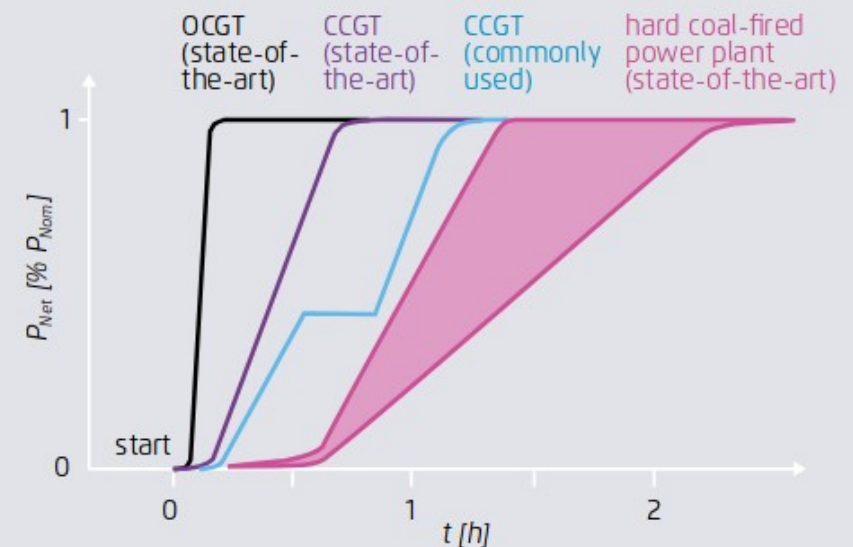
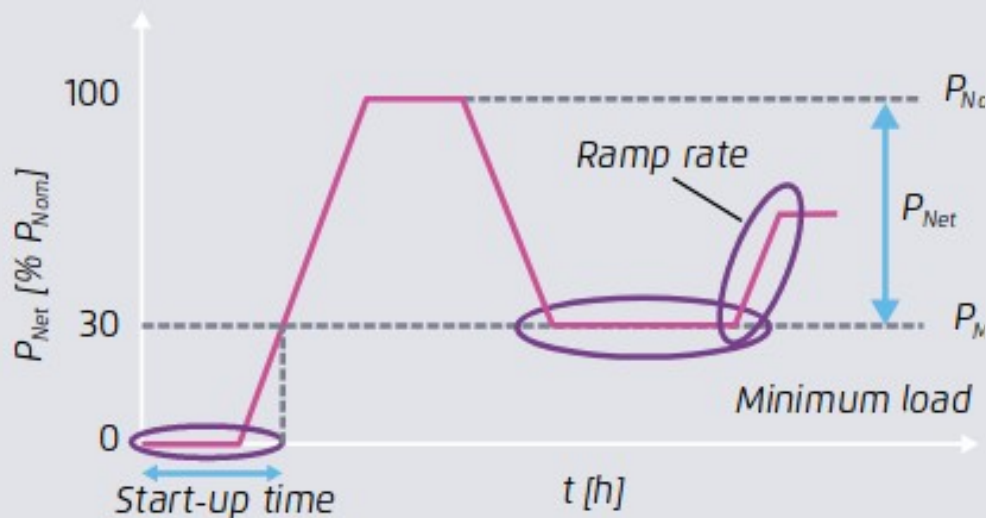


Tüketim



Üretim teknolojileri

Property	OCGT	CCGT	Hard coal-fired power plant	Lignite-fired power plant
Most commonly used power plants				
Minimum load [% P_{Nom}]	40–50 %	40–50 %	25–40 % ^a	50–60 %
Average ramp rate [% P_{Nom} per min]	8–12 %	2–4 %	1.5–4 %	1–2 %
Hot start-up time [min] or [h]	5–11 min ^b	60–90 min	2.5–3 h	4–6 h
Cold start-up time [min] or [h]	5–11 min ^c	3–4 h	5–10 h	8–10 h
State-of-the-art power plants				
Minimum load [% P_{Nom}]	20–50 %	30–40 % (20 % with SC ^d)	25 ^e –40 % ^f	35 ^g –50 %
Average ramp rate [% P_{Nom} per min]	10–15 %	4–8 %	3–6 %	2–6 ^h %
Hot start-up time [min] or [h]	5–10 min ⁱ	30–40 min	80 min–2.5 h	1.25 ^j –4 h
Cold start-up time [min] or [h]	5–10 min ⁱ	2–3 h	3–6 h	5 ^k –8 h

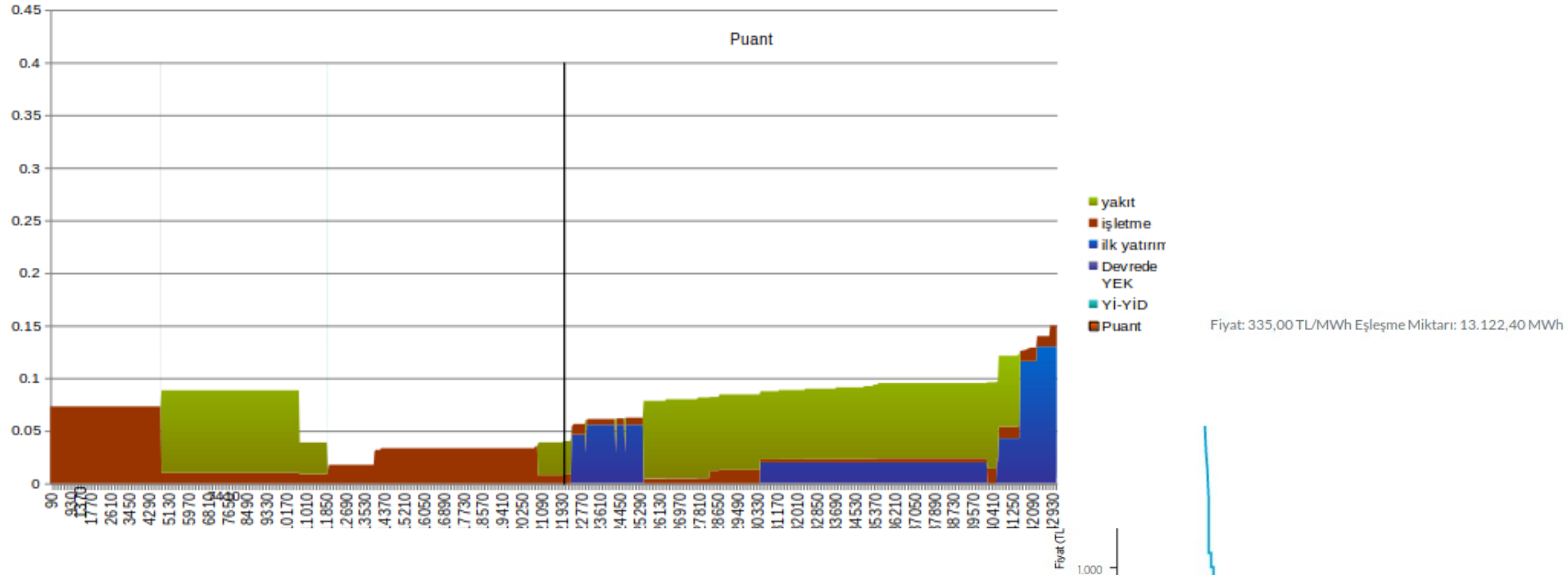


Sistem nasıl dengeleniyor?

- Voltaj ve frekans
 - Voltaj → reaktif
 - Frekans → üretim
- Gün öncesi planlama yapılıyor
 - Rüzgar/güneş tahminleri
- Anlık yedek bırakacak santraller/hatlar belirleniyor
 - Esneklikle önemli
- Gerçek zamanda da düzeltici talimat
- Gerçek zamandan sonra faturalama

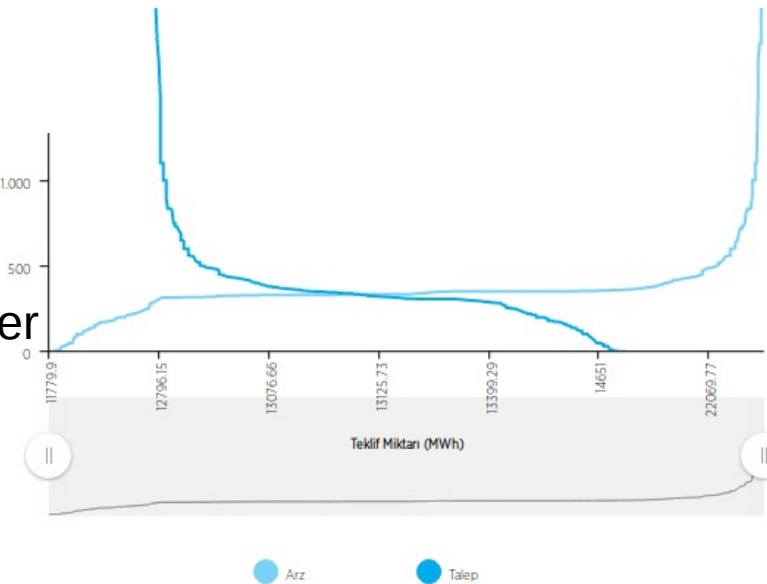


Piyasa İşletmecisi



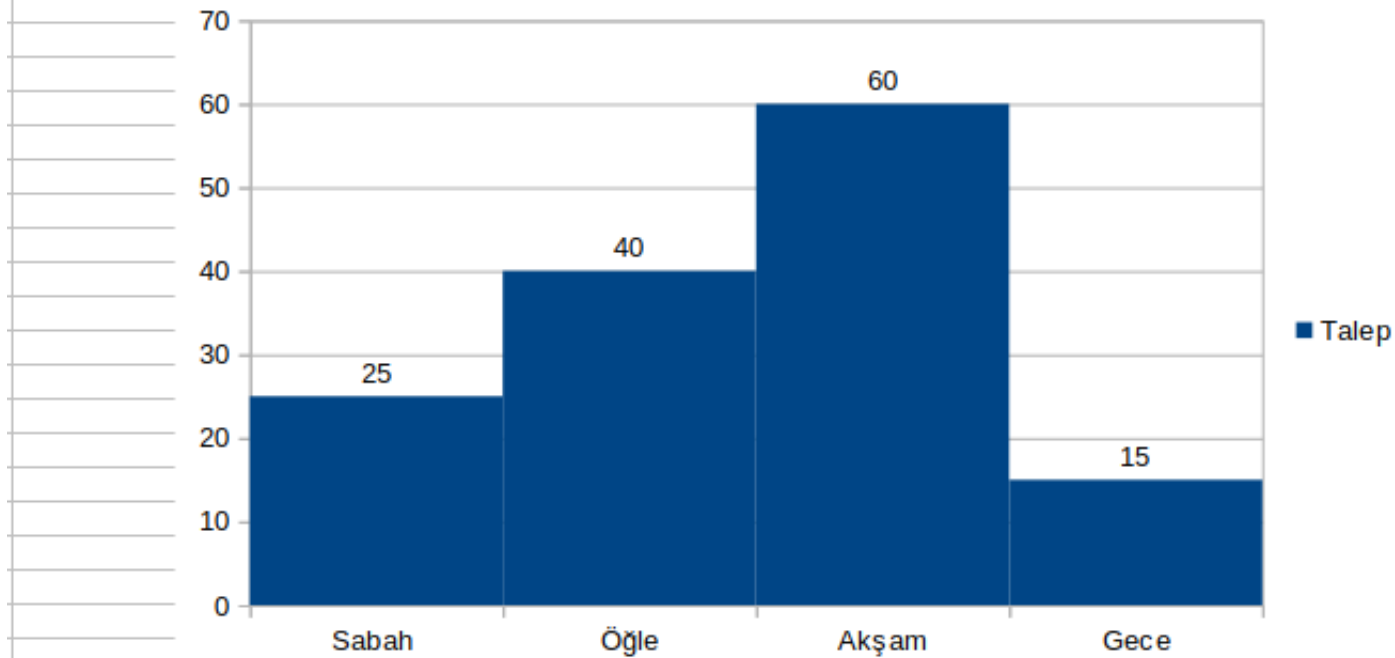
Marjinal fiyat: sistemde o anda çalışan ve gerekli olan en yüksek maliyetli santral fiyatı tüm piyasa fiyatını belirler

Petrol fiyatı gibi: Suudi petrol maliyeti 5\$, Rusya 10\$
Neden petrol 80 \$?

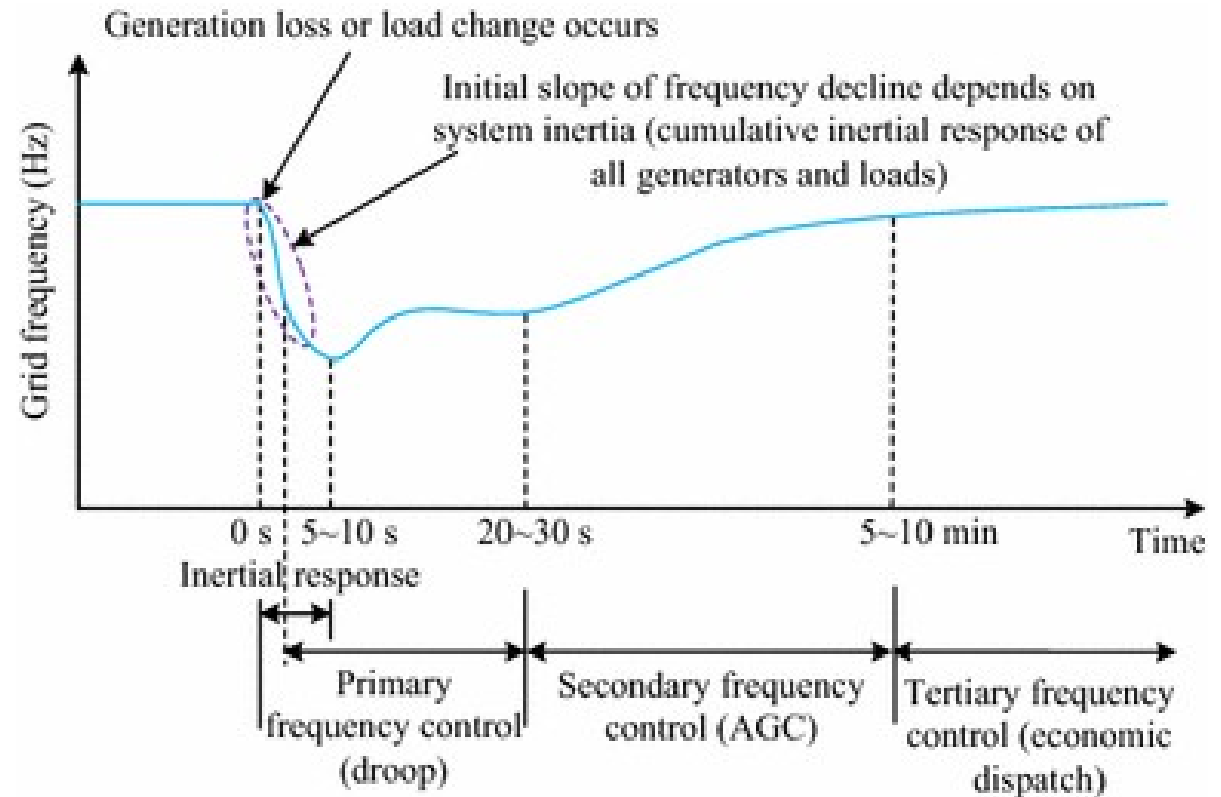
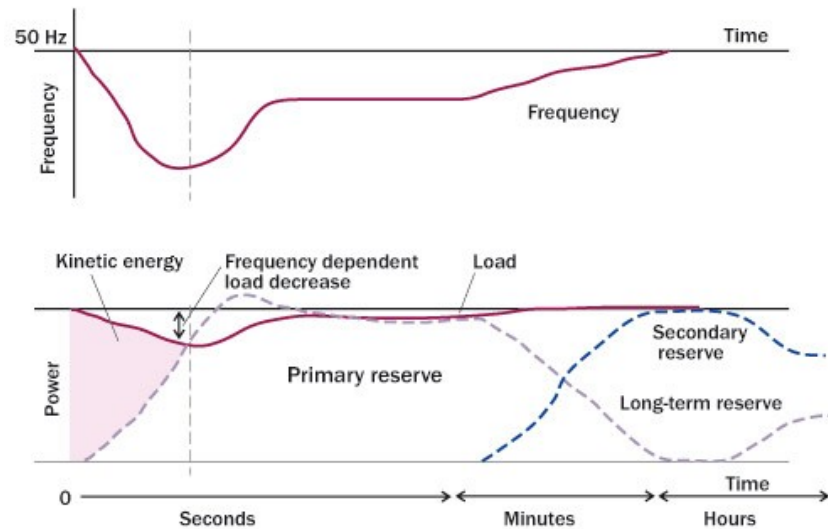


3 oyunculu piyasa

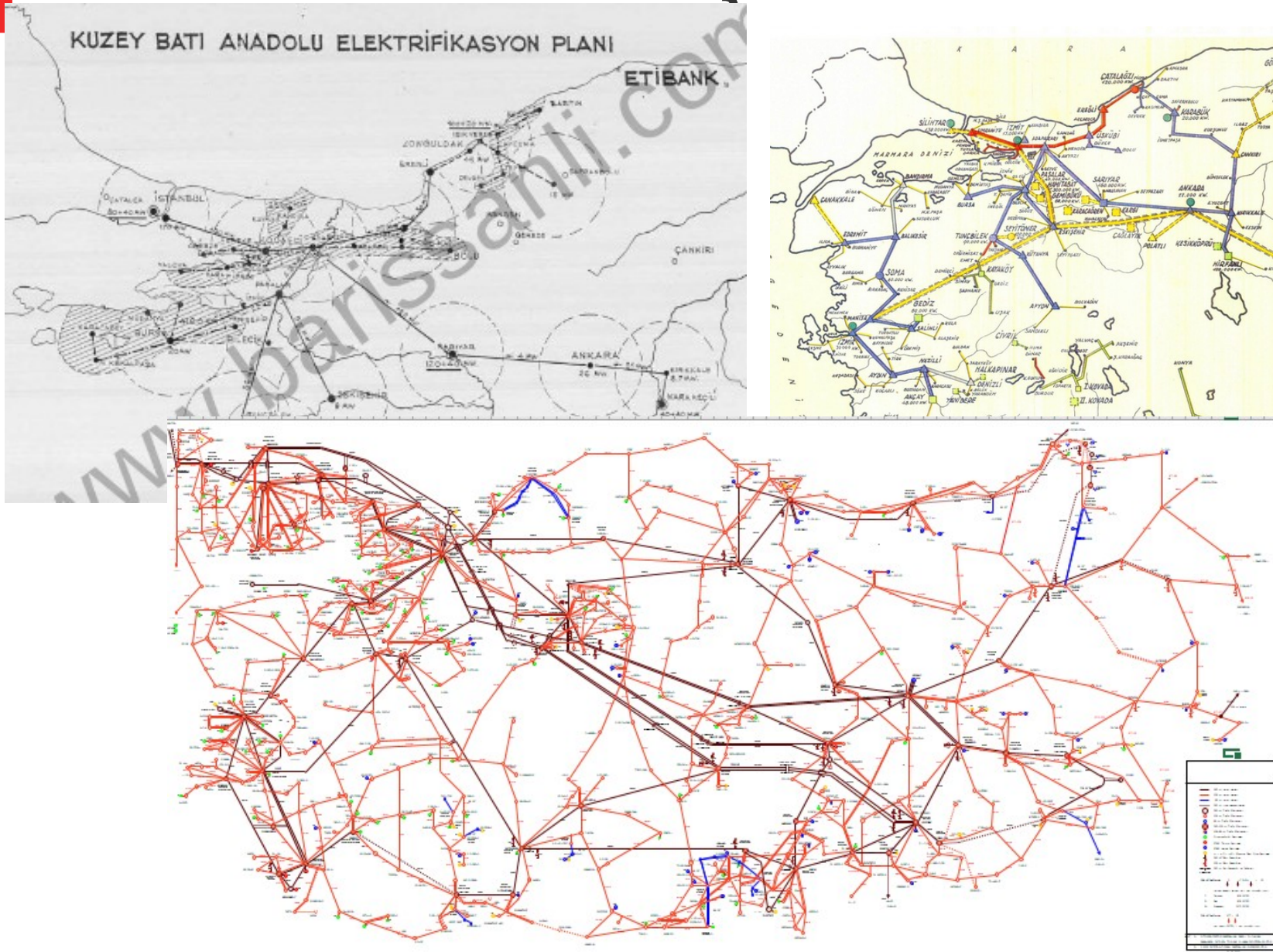
		Üretim kapasite	Fiyat			
	Santral A	30	100			
	Santral B	25	150			
	Santral C	17	350			
		Sabah	Öğle	Akşam	Gece	
	Talep	25	40	60	15	
Üretim	A	25	30	30	15	
	B	0	10	25	0	
	C	0	0	5	0	
	Fiyat	100	150	350	100	TL
		(A)	(B)	(C)	(A)	



Frekans



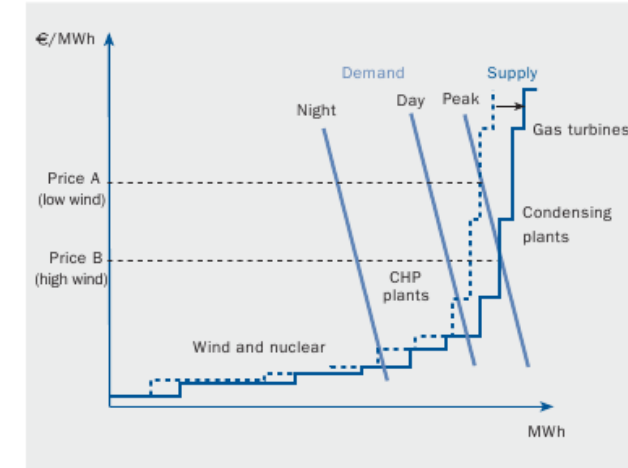
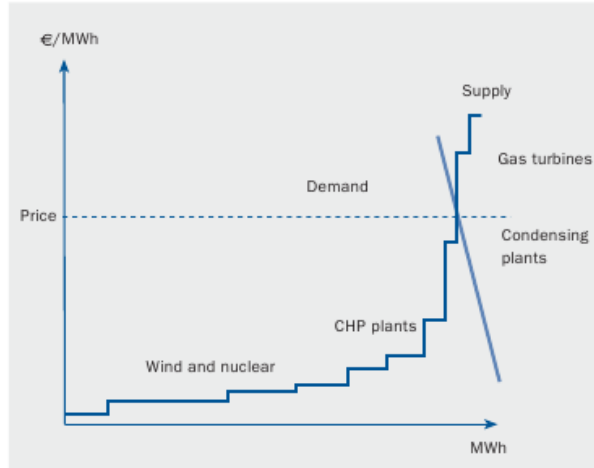
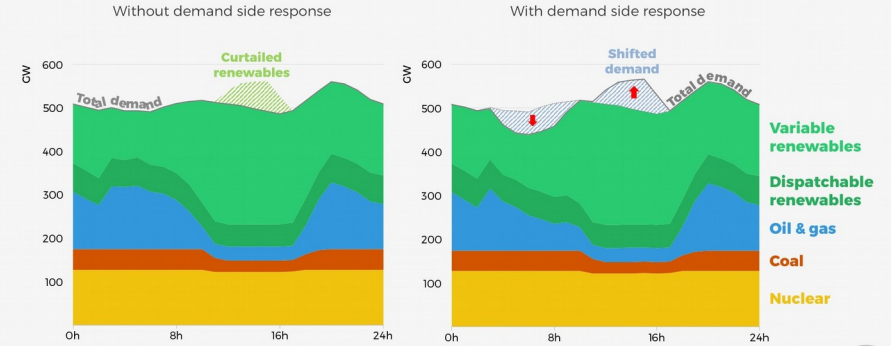
Enterkonnekte şebeke



Asimetrik bir ilişki

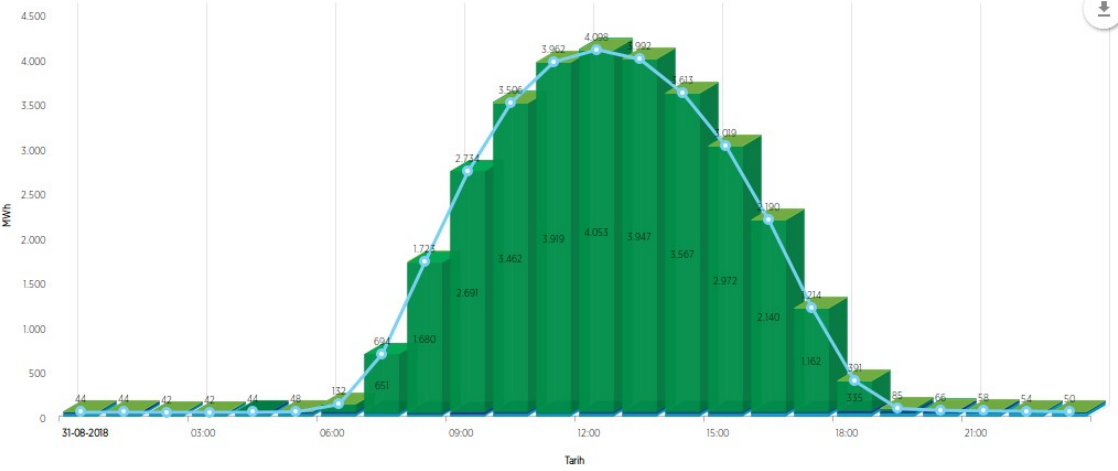
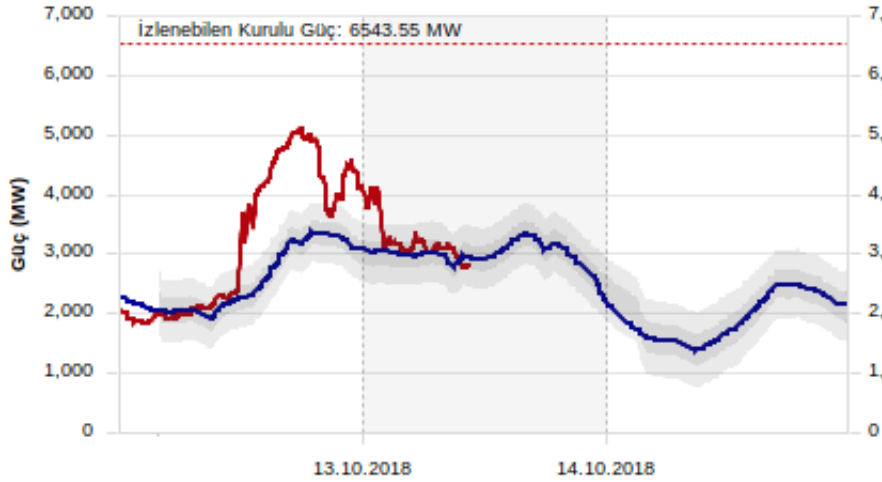
- Akşam 20:00-21:00 arası 1 TL'lik elektrik tüketiyorsanız....
- Elektriğe verdiğiniz değer nedir?
 - Akşam
 - Tatilde
 - Evde yok iken
- Talep tarafı sisteme girecek mi?

Impact of demand response on a daily load curve
World Energy Outlook 2017

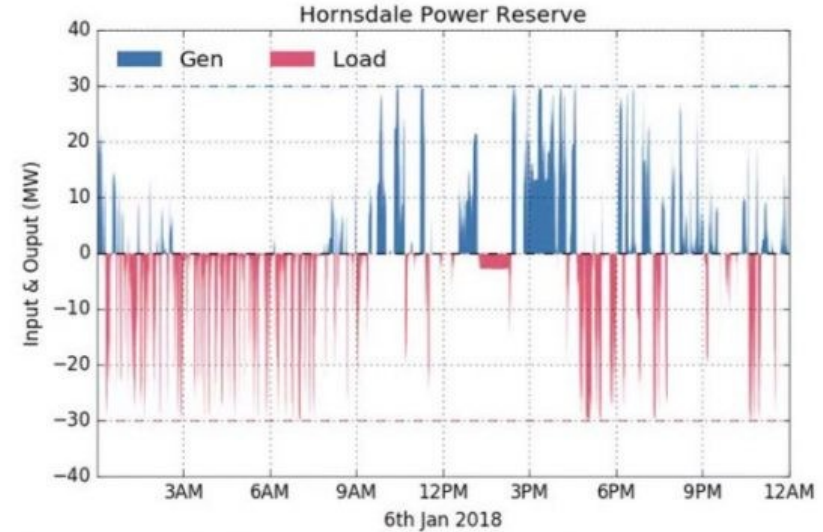
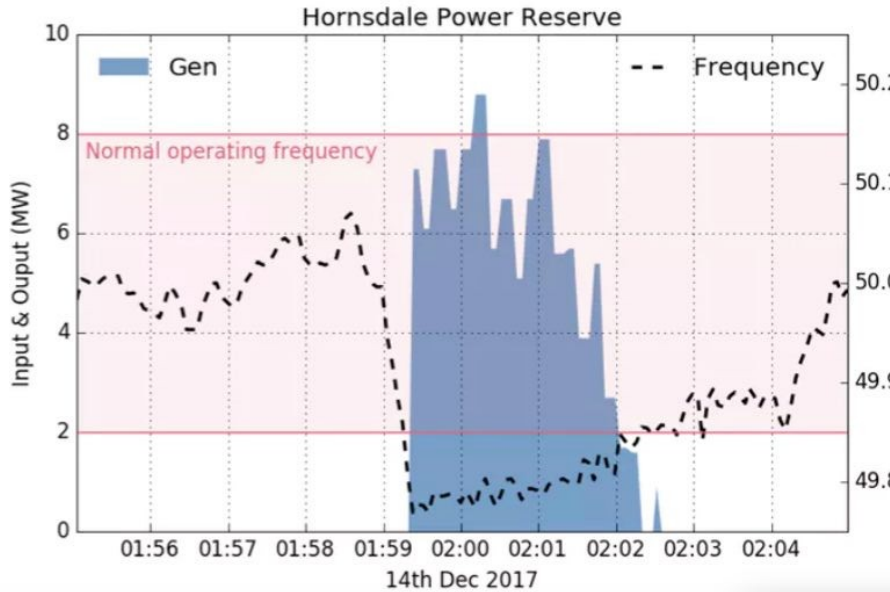


Yenilenebilir ve Piller

TÜRKİYE Geneli İzlenebilir RES'lerin Toplam Güç Üretimi ve Tahmini

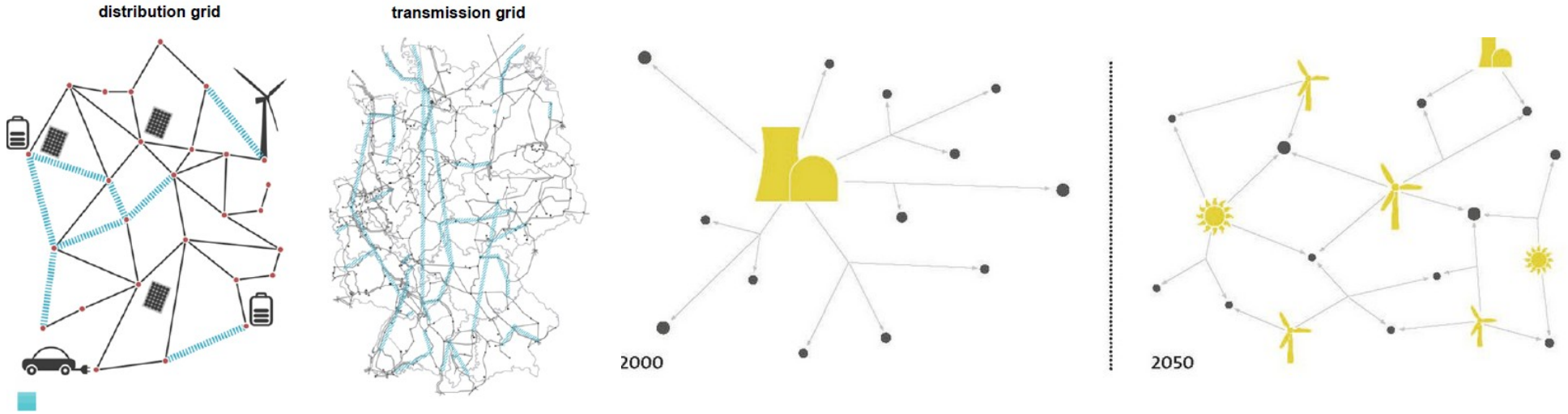


NGR –
Üretimi
olmayan
kaynaklar



Generation and consumption of the Hornsdale Power Reserve on the 6th of Jan 2018. Author provided [data from AEMO]

Gelecek



Evde hamur, un, su var.... Neden herkes ekmek satın alıyor?



Sorular

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