Enerji 101 – Ders 4

Elektrik Teknolojisi ve Ekonomisi Eğitimi

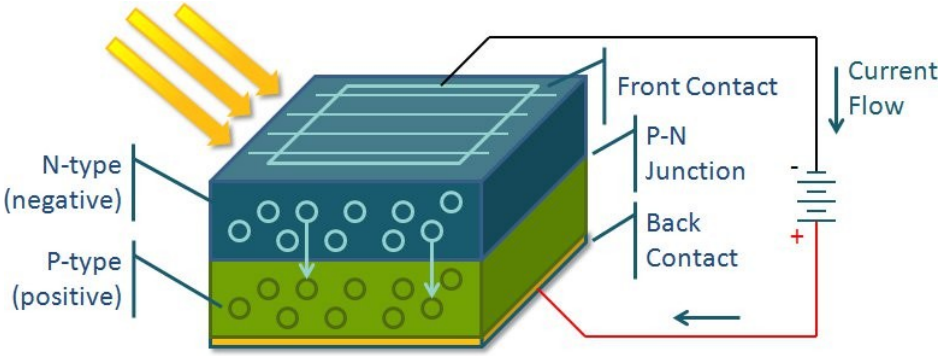
Barış Sanlı

Elektrik

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

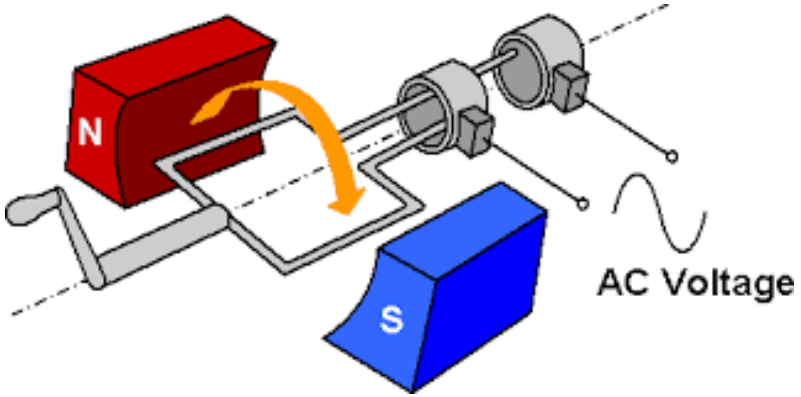
Elektrik elde etme yöntemi

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

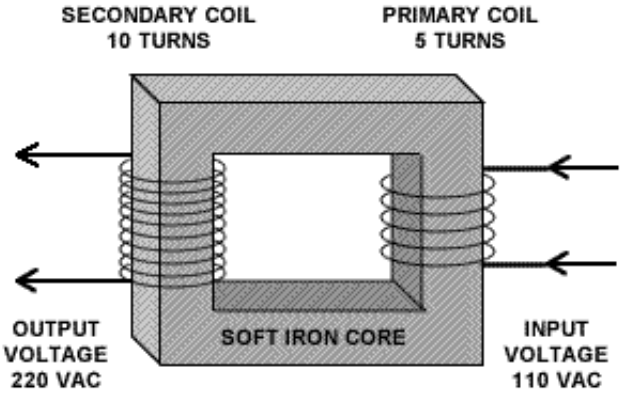


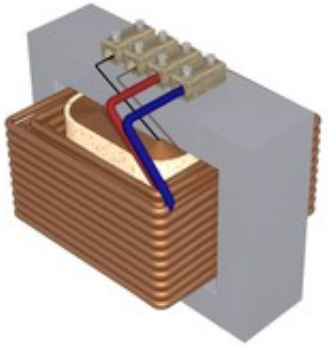
Manyetizma

- Üretim

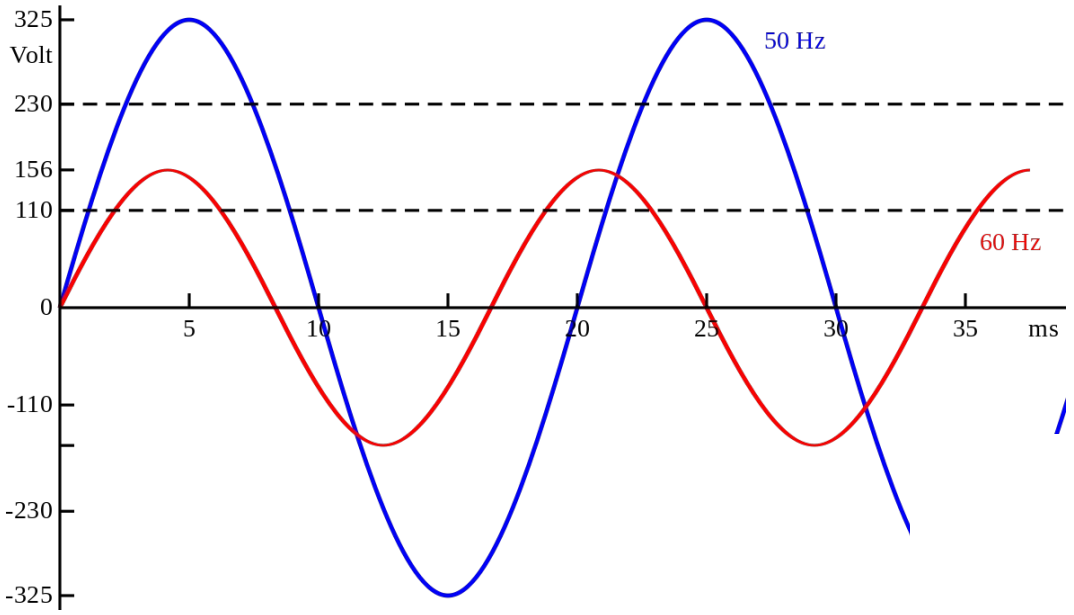


- Transformatör



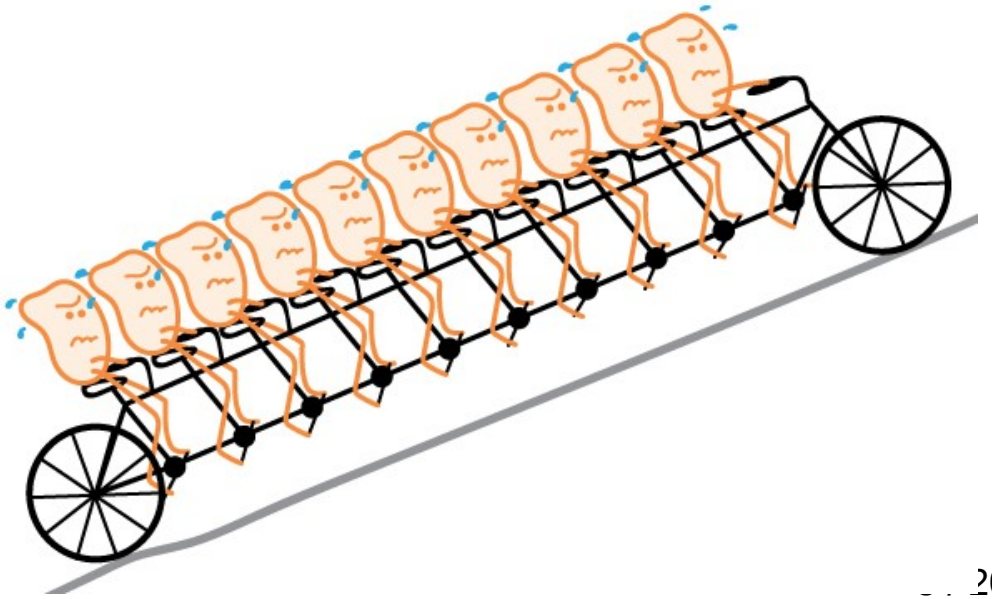


Voltaj -Frekans



Su analojisi : 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

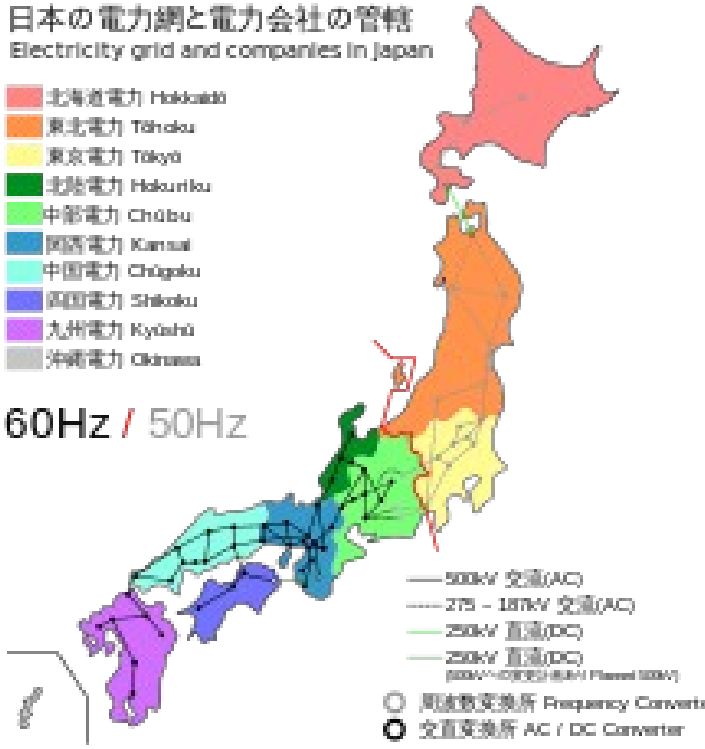
AWG	15cm	50cm	1m	2m	3m	5m
20	0.311983	0.367944	0.447888	0.607776	0.767664	1.08744
22	0.326131	0.415104	0.542208	0.796416	1.050624	1.55904
24	0.348638	0.490128	0.692256	1.096512	1.500768	2.30928
26	0.384408	0.60936	0.93072	1.57344	2.21616	3.5016
28	0.441288	0.79896	1.30992	2.33184	3.35376	5.3976

<=0.25v >0.25v >0.5v by goughlui.com

https://goughlui.com/2014/10/01/usb-cable-resistance-why-your-phonetablet-might-be-charging-slow/

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
- İngiltere hem 220 V hem de 50 Hz’e geçti

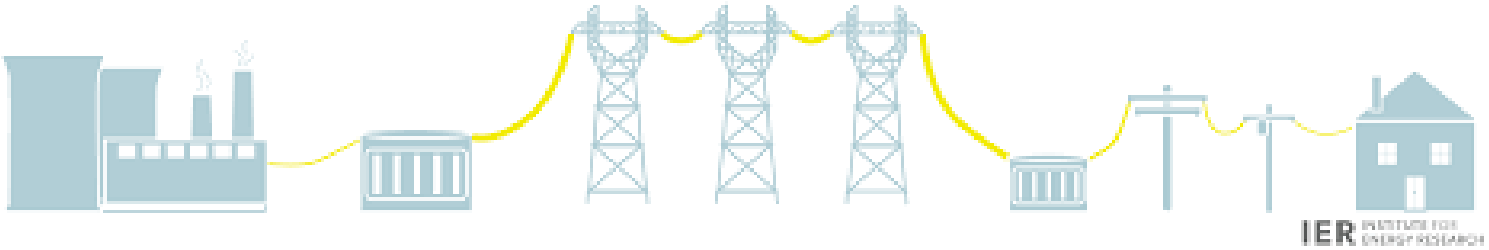


https://www.quora.com/Electrical-Engineering-Why-is-Indias-frequency-maintained-in-50-Hz-only

İki bakış

Teknik

Üretim İletim Dağıtım



İdari
Finansal

Politika

Düzenleyici

Piyasa İşletmecisi

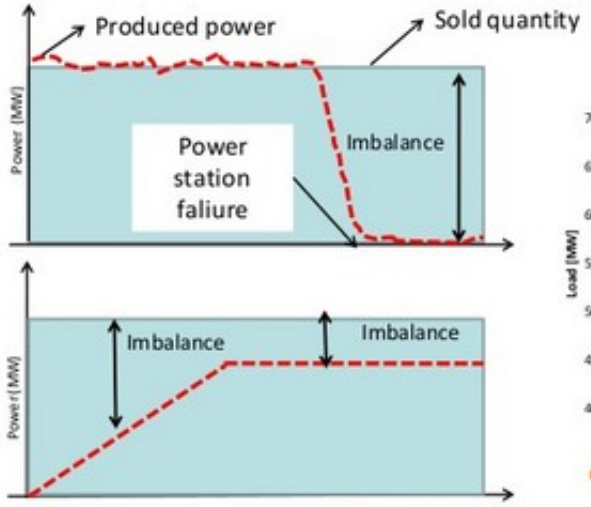
Toptan Satış

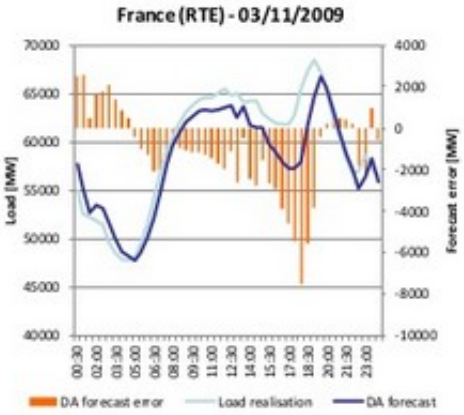
Perakende Satış

Serbest Tüketiciler

Elektrikte temel iki sorun

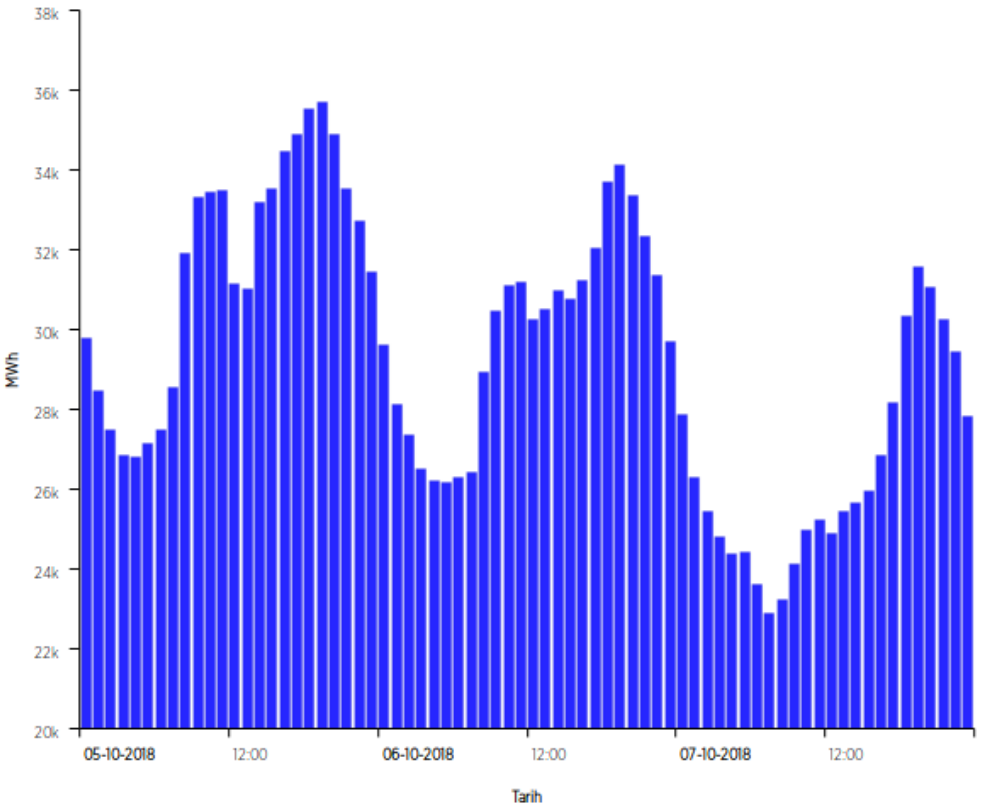
- Tüm sistem tüketiciye göre
  - Tüketici talebini yönetmiyor
  - Anlık dengeleme ihtiyacı
- Elektrik depolama (büyük ölçekli-ekonomik)
  - Üretici ve sistem bu belirsizliği yönetmek zorunda

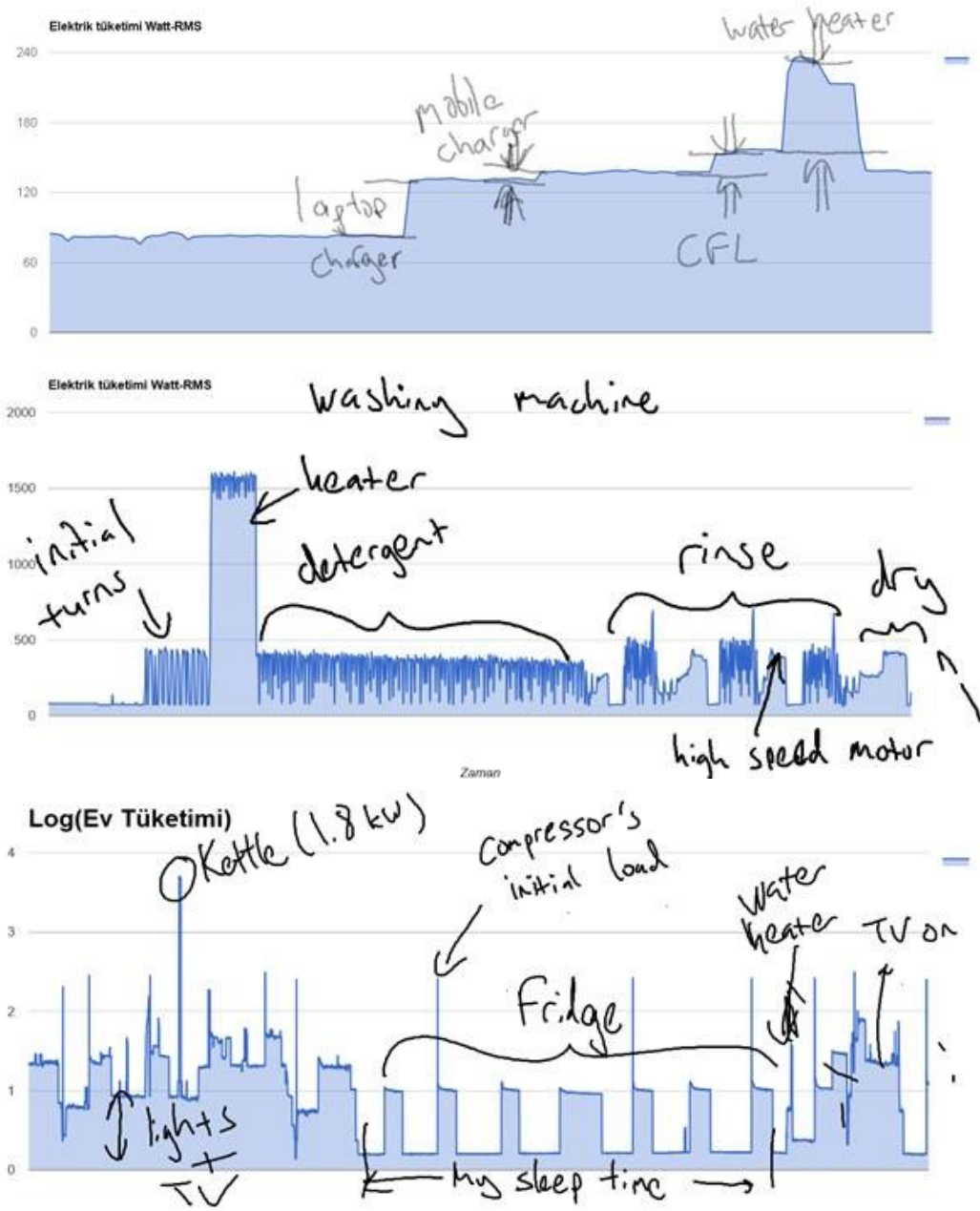




- O zaman?
  - Planlama
  - Yedekleme
  - Esneklik (üretimde)

Tüketim

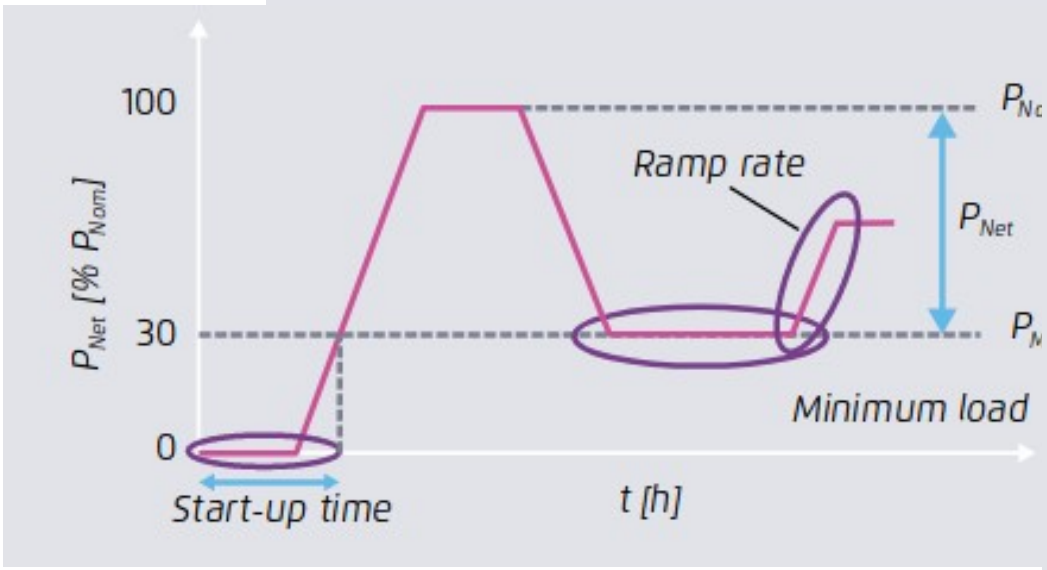


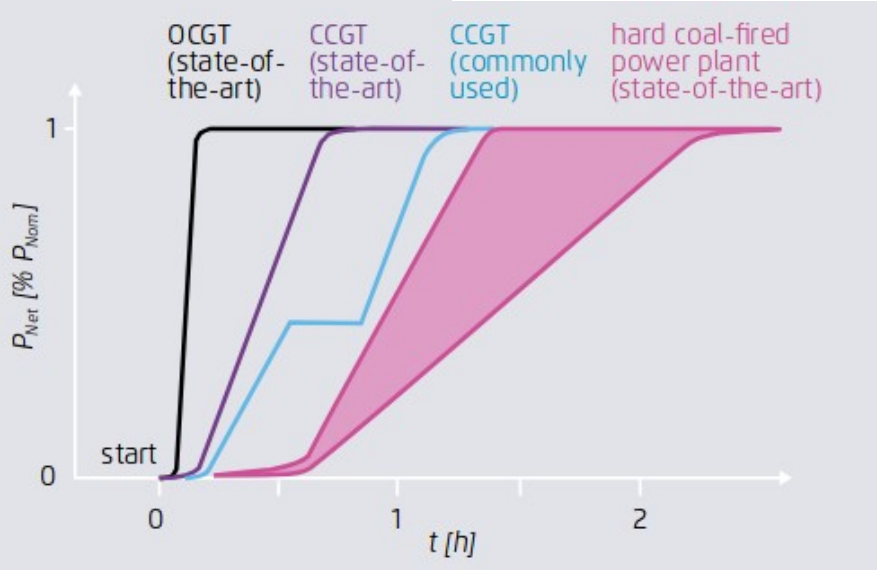


https://seffaflik.epias.com.tr/transparency/tuketim/gerceklesen-tuketim/gercek-zamanli-tuketim.xhtml

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



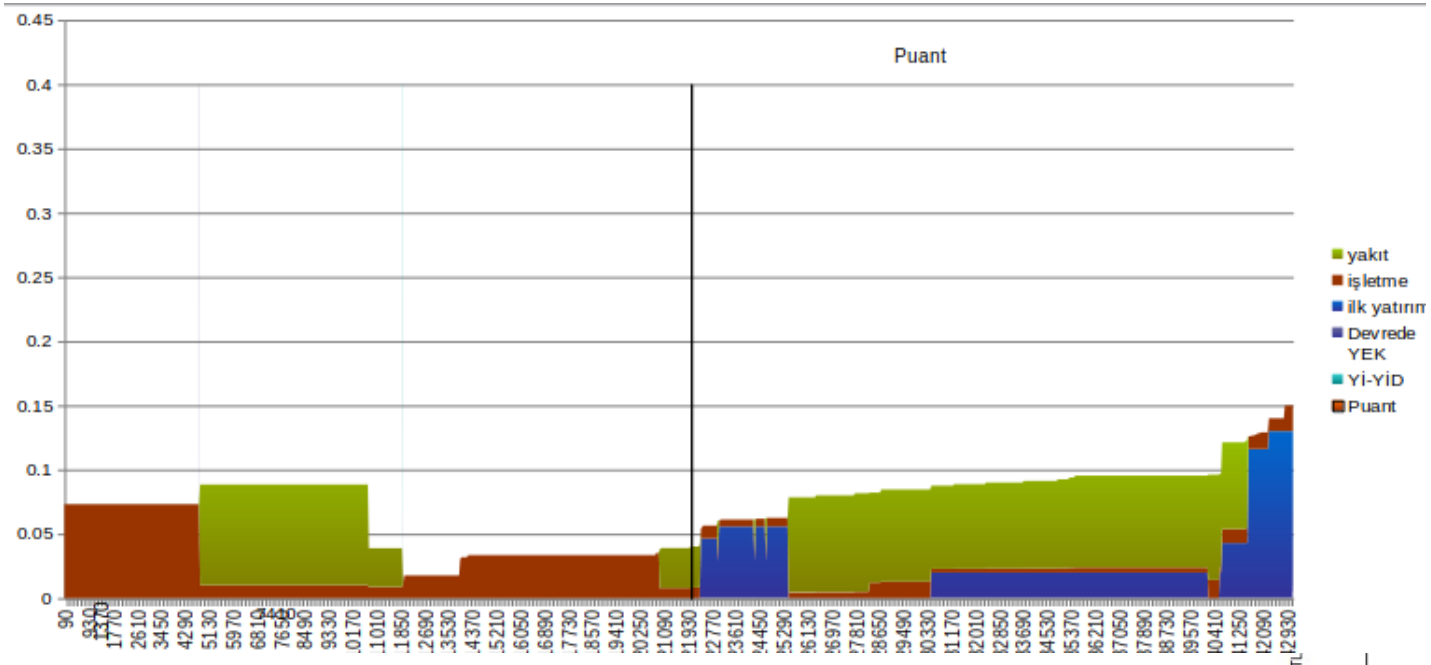


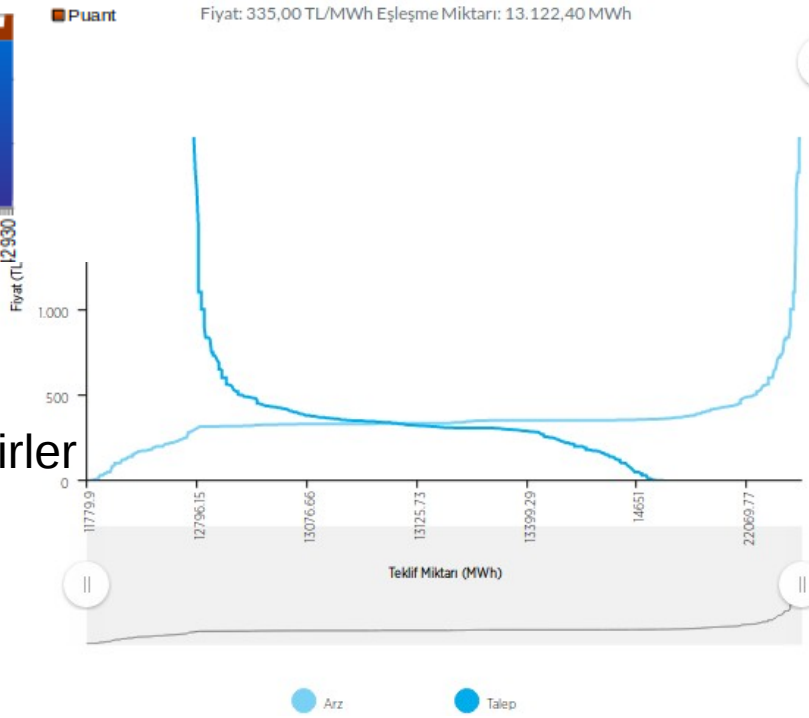
https://www.agora-energiewende.de/fileadmin2/Projekte/2017/Flexibility_in_thermal_plants/115_flexibility-report-WEB.pdf

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

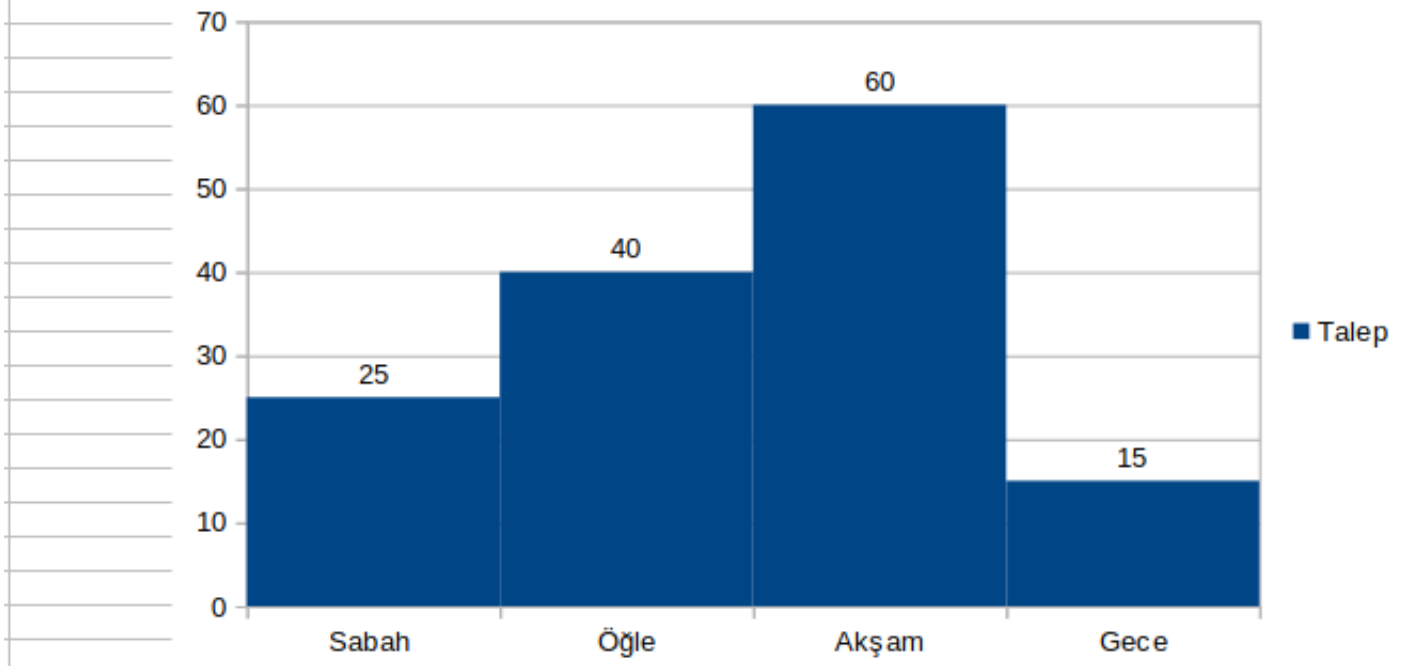
Petrol fiyatı gibi: Suudi petrol maliyeti 5$, Rusya 10$
Neden petrol 80 $?

https://seffaflik.epias.com.tr/transparency/piyasalar/gop/arz-talep.xhtml

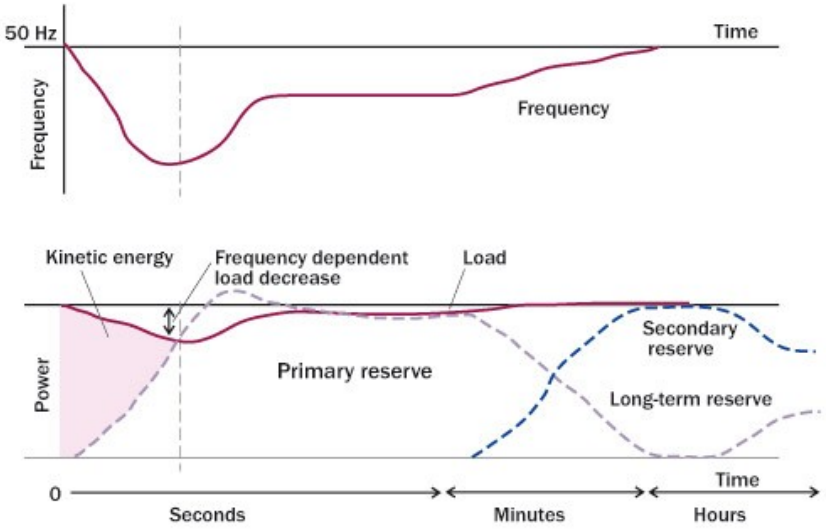
http://www.barissanli.com/calismalar/2014/TPM-v2.xls

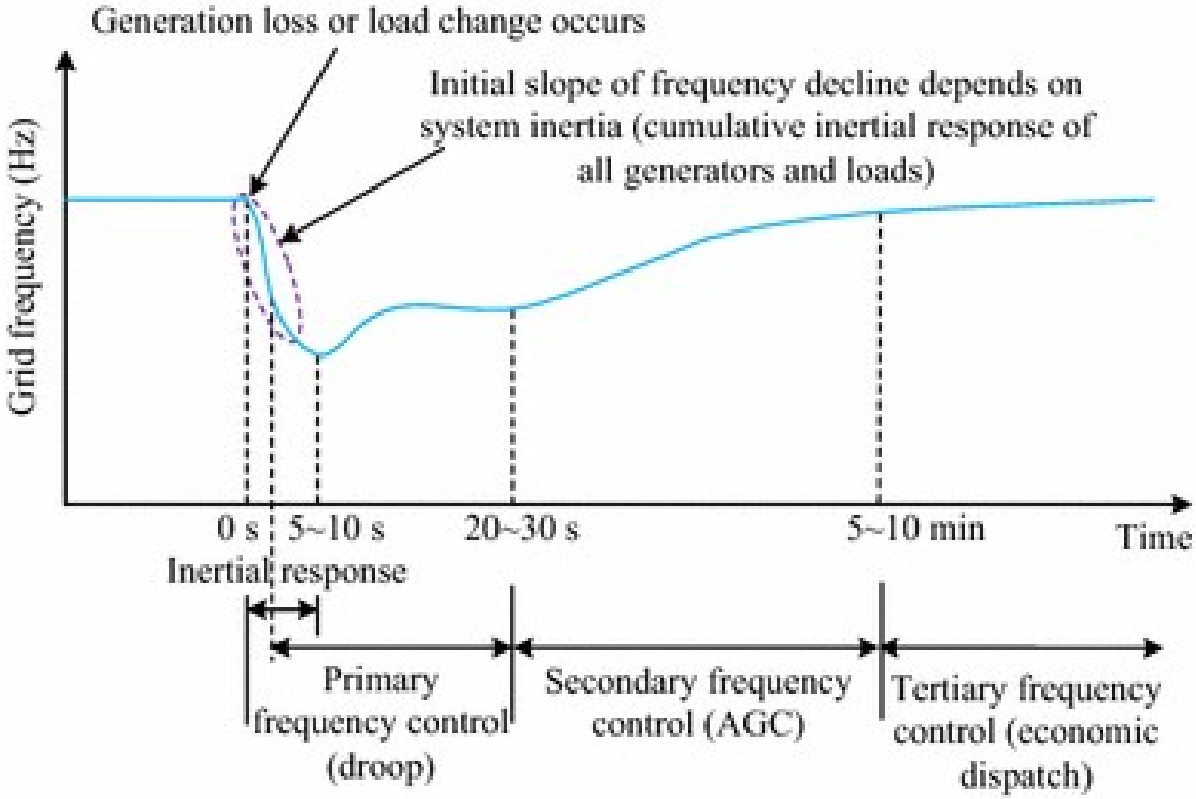
3 oyunculu piyasa

		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)		



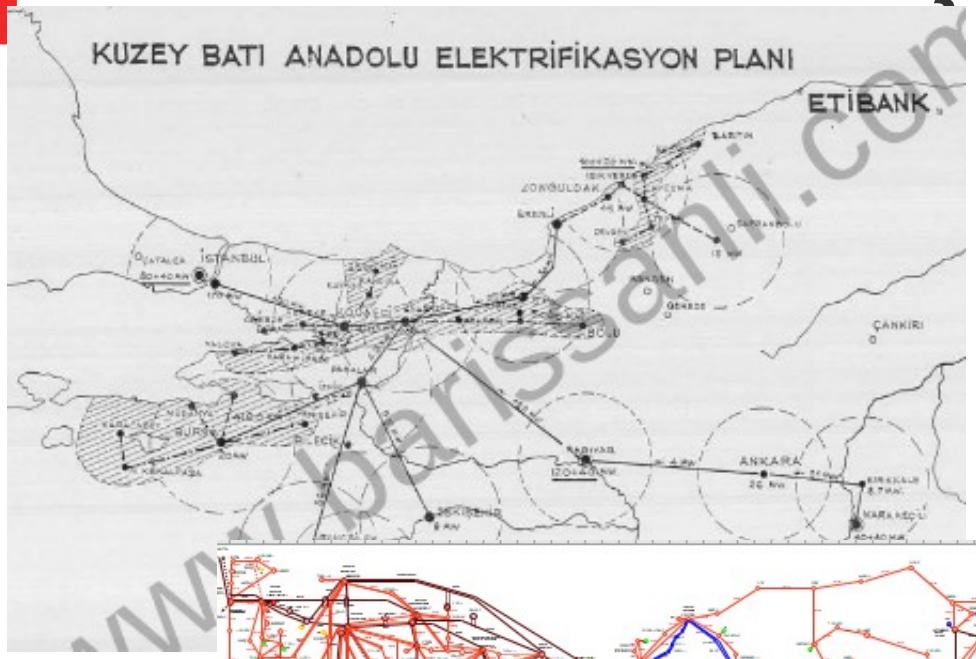
Frekans

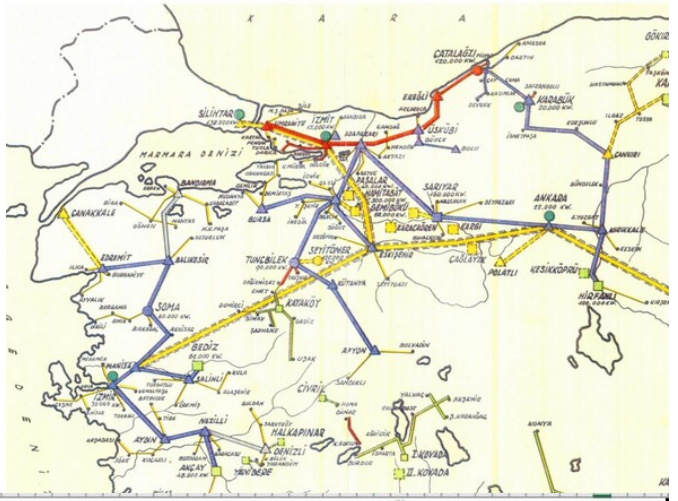


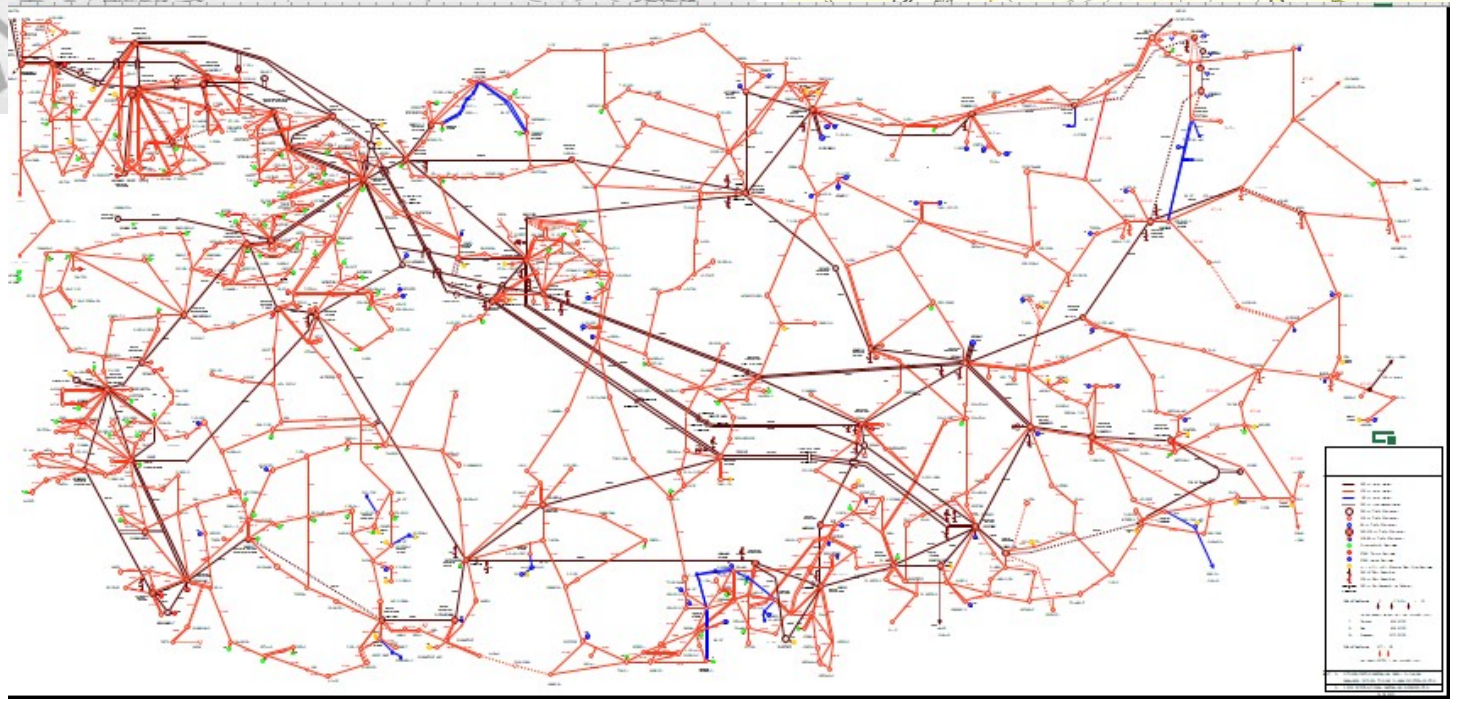


https://link.springer.com/article/10.1007/s40565-017-0315-y

Enterkonnekte şebeke



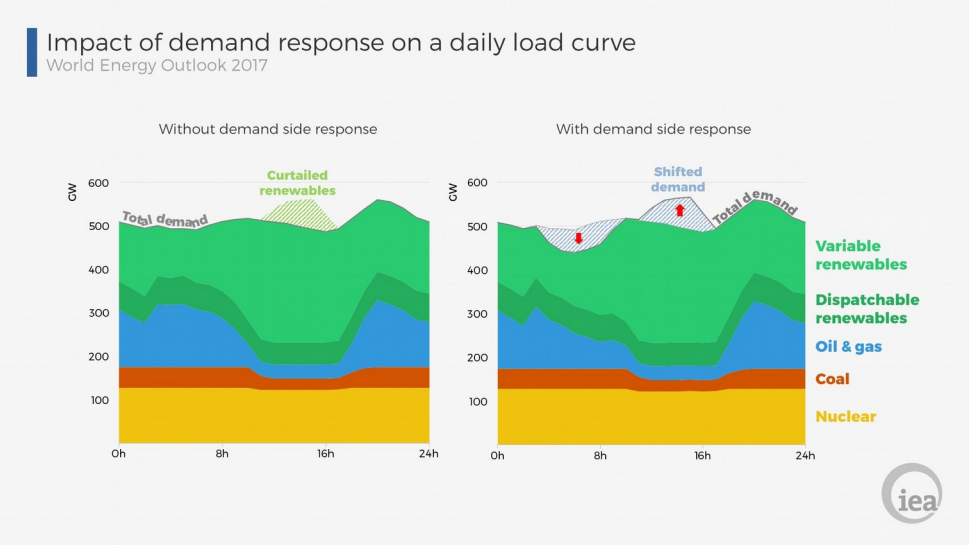


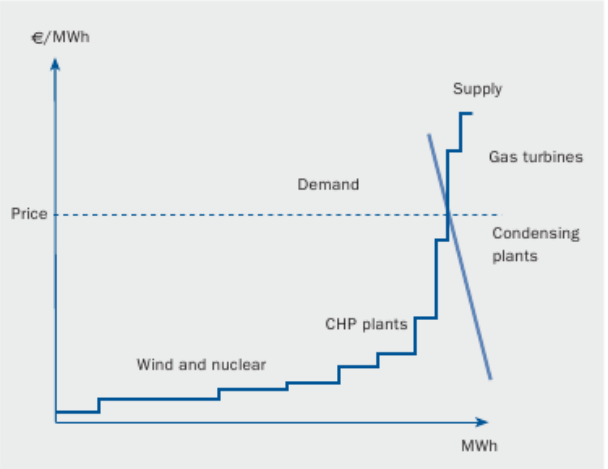


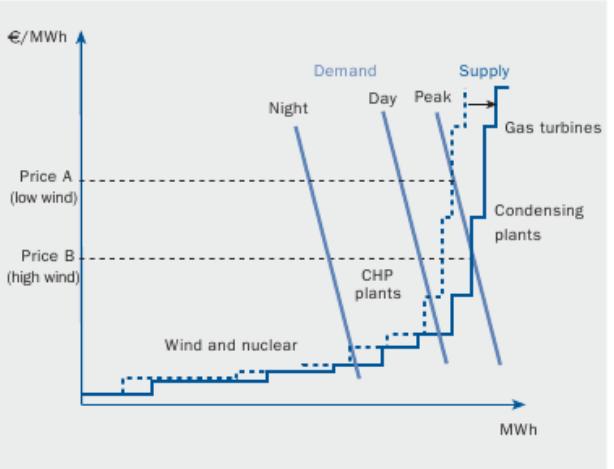
https://electronicsystematic.blogspot.com/2018/02/turkiye-enterkonnekte-sebeke-sistemi.html

Asimetrik bir ilişki

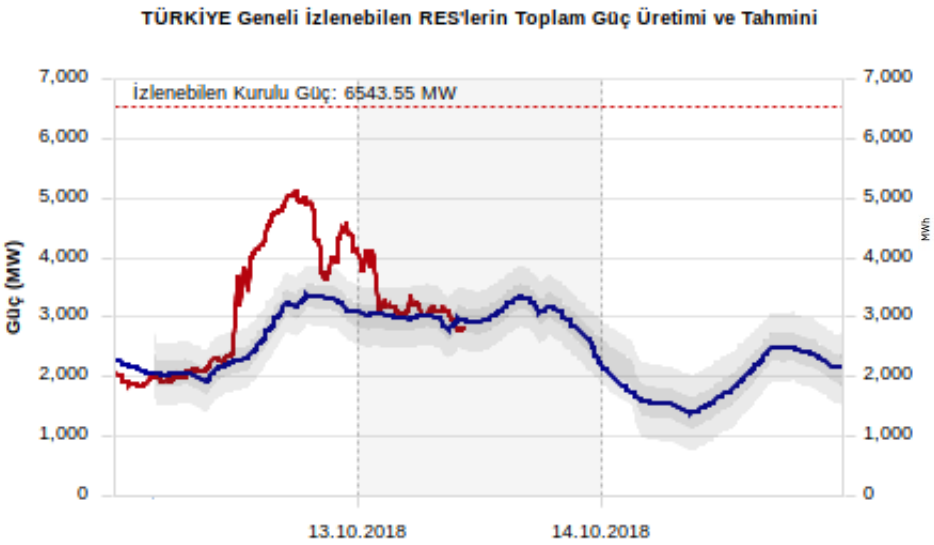
- Akşam 20:00-21:00 arası 1 TL'lik elektrik tüketiyorsanız….
- Elektriğe verdiğiniz değer nedir?
  - Akşam
  - Tatilde
  - Evde yok iken
- Talep tarafı sisteme girecek mi?

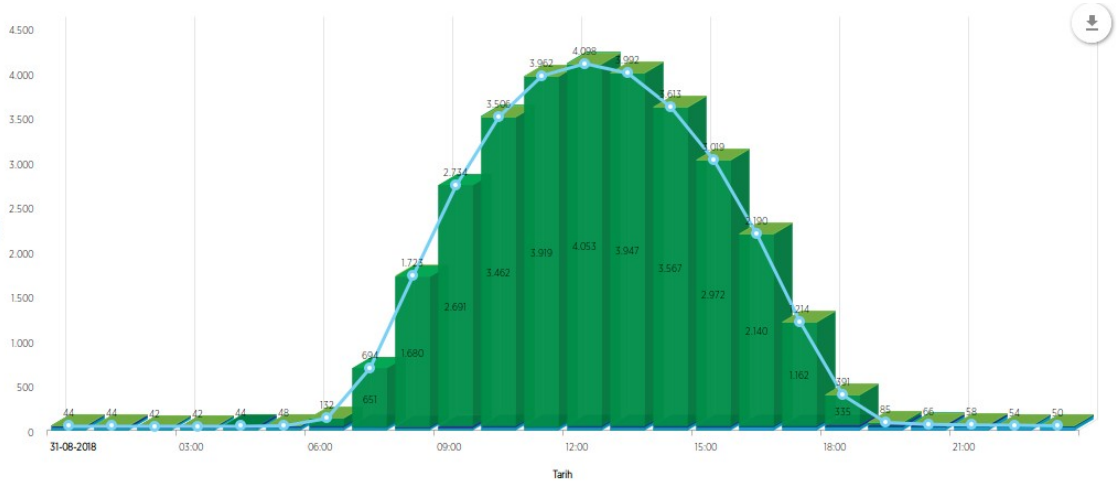




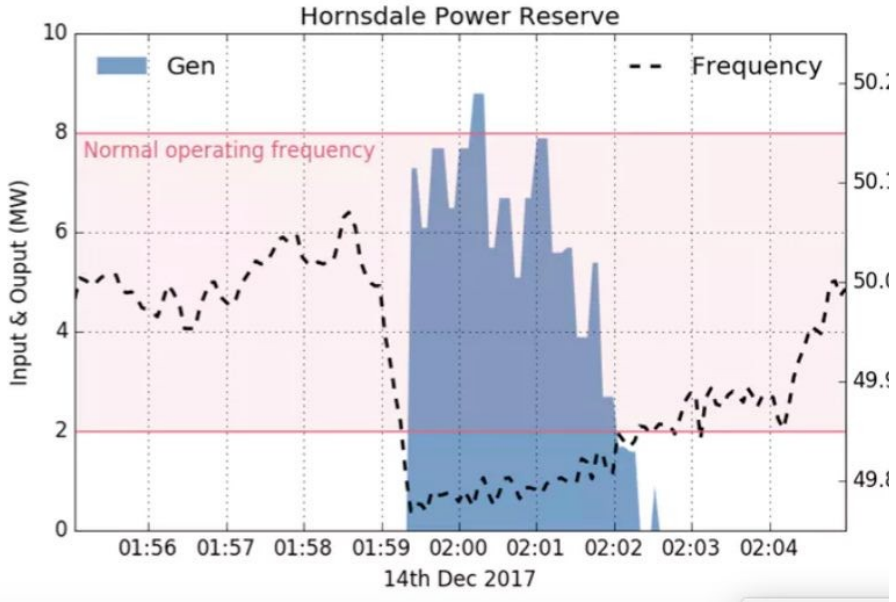


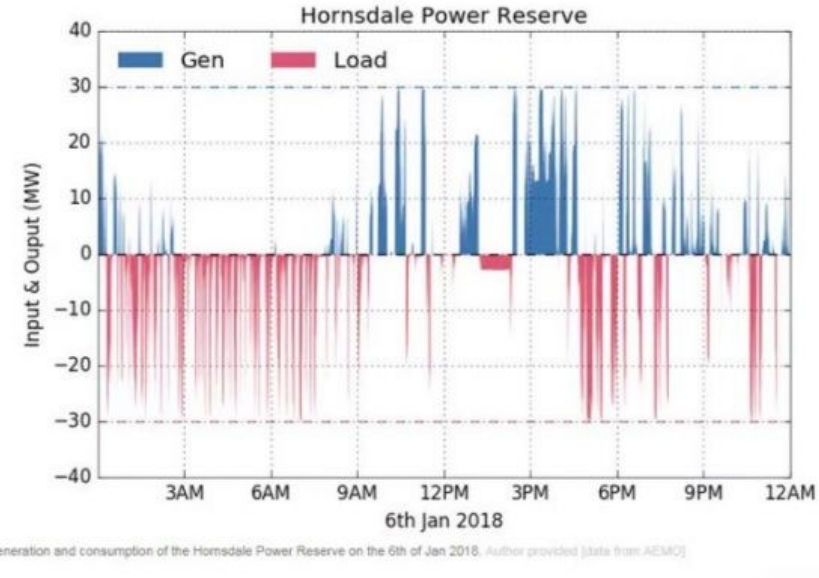
Yenilenebilir ve Piller





NGR – Üretimi olmayan kaynaklar

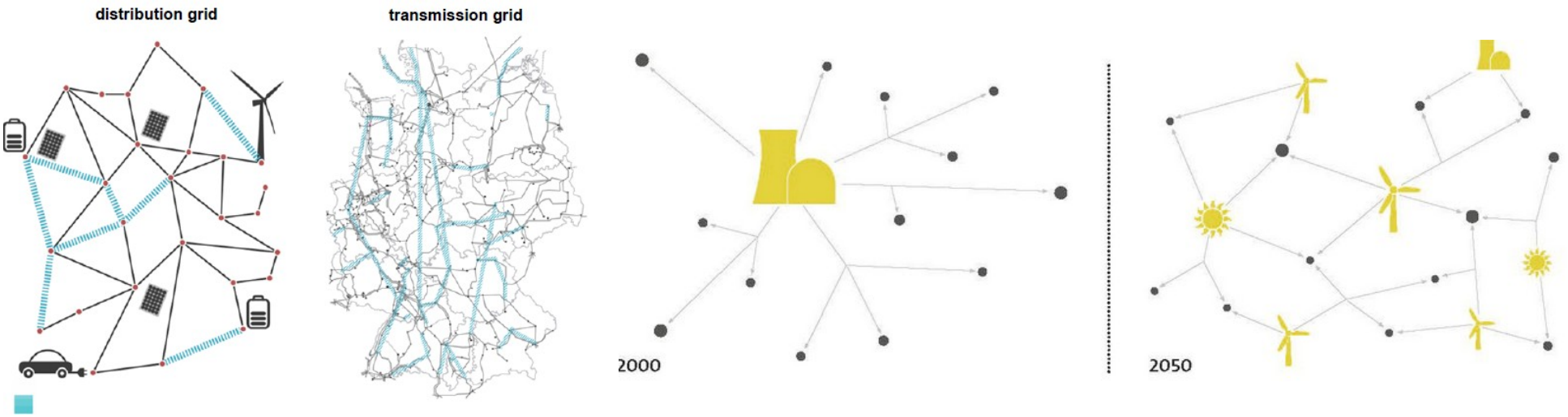




Generation and consumption of the Hornsdale Power Reserve on the 6th of Jan 2018. Author provided [data from AEMO]

https://seffaflik.epias.com.tr/transparency/uretim/yekdem/lisanssiz-uretim-miktari.xhtml

Gelecek



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

https://phys.org/news/2012-09-solar-energy-stabilise-power-grid.html

Sorular ?