



Mühendislik Fakültesi

Kimya Mühendisliği Bölümü

KMB 245-Enerji Teknolojileri

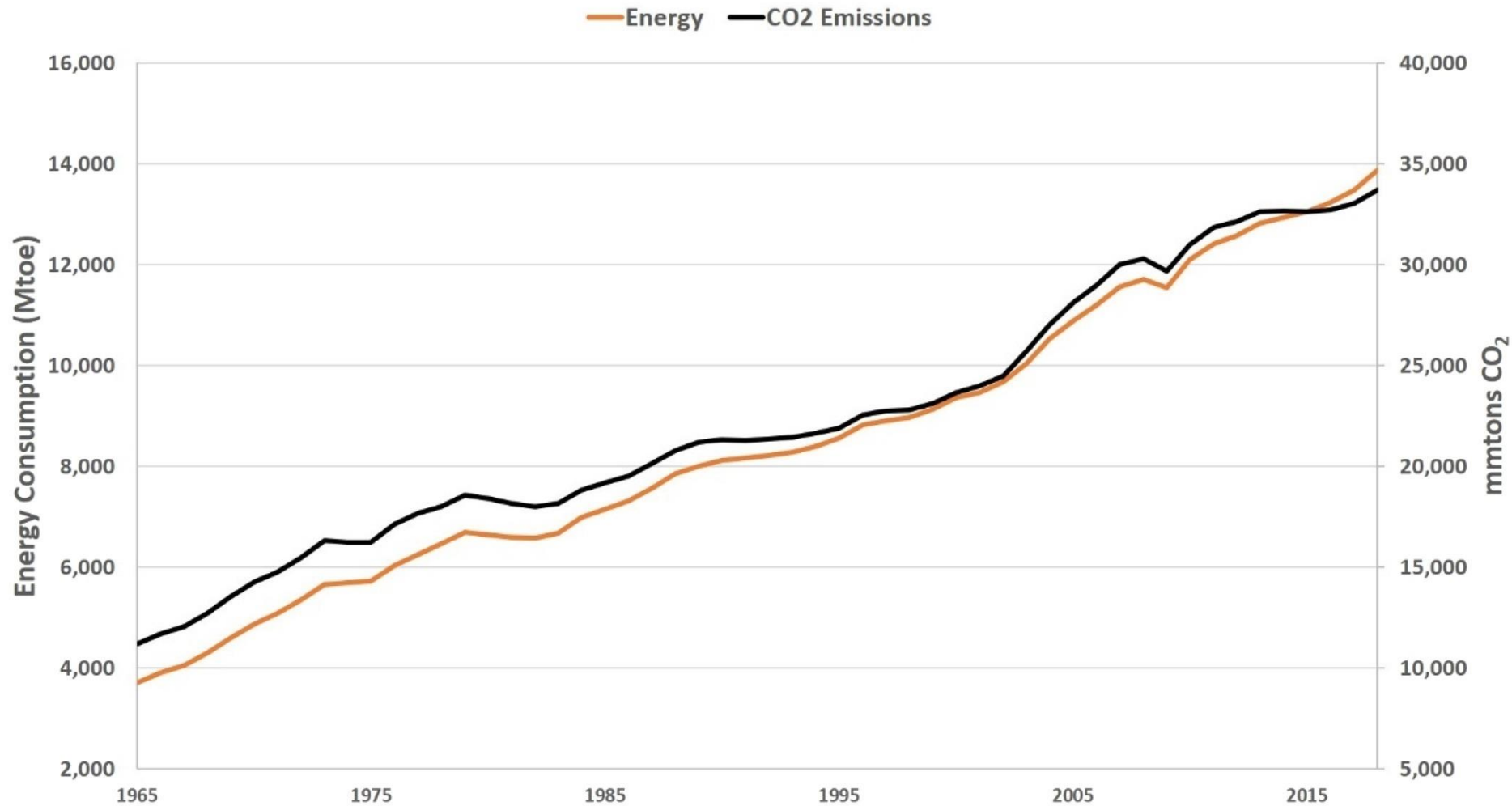
Dr. Öğr. Üyesi, İsa DEĞİRMENCI



Güneş Enerjisi

I. Ders

World Total Primary Energy Consumption and CO₂ Emissions



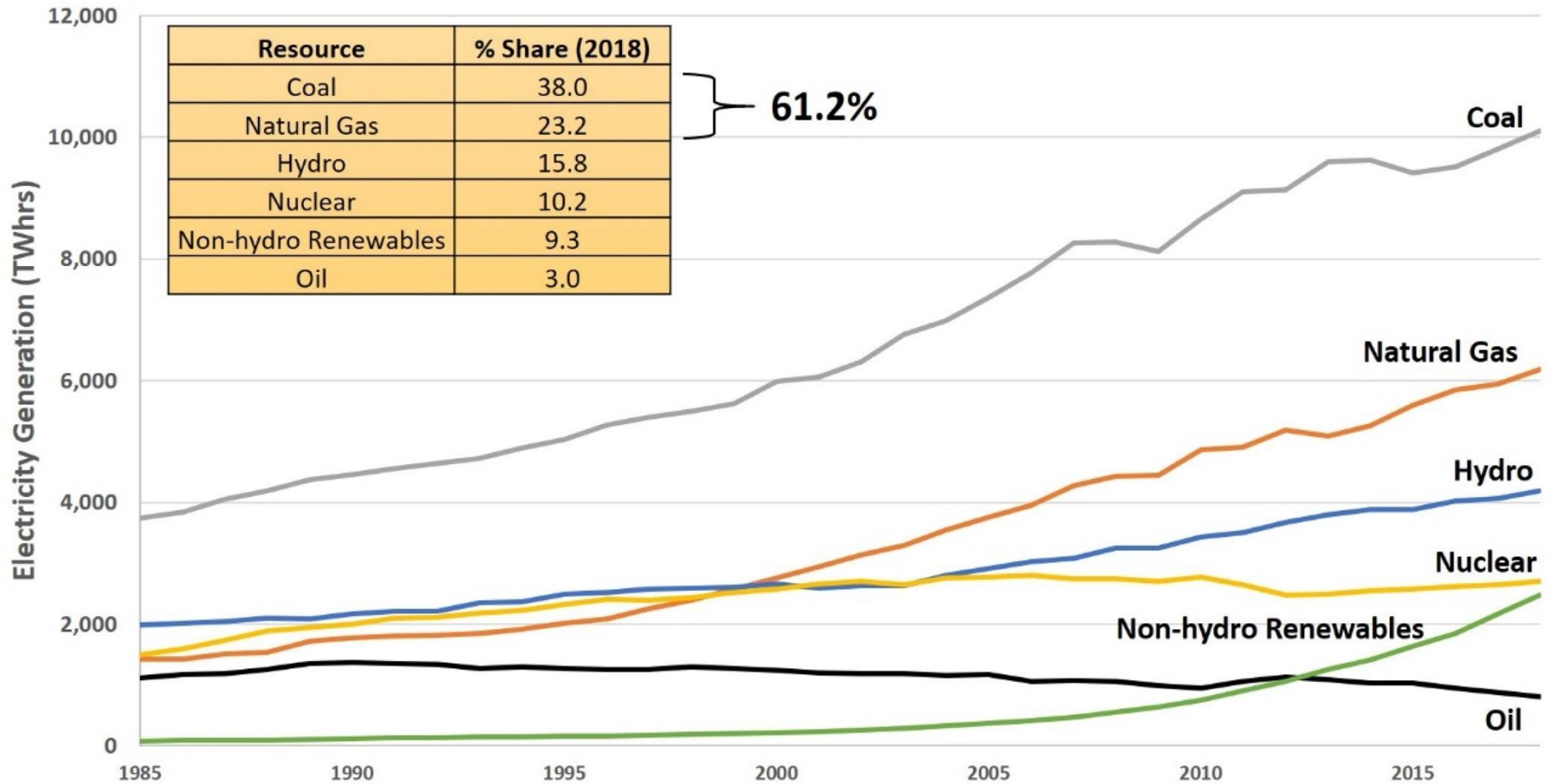
BP Statistical Review of World Energy 2019 ([BP, 2019](#)).

World Electricity Generation by Resource

Oil Natural Gas Coal Hydro Nuclear Non-hydro Renewables

Resource	% Share (2018)
Coal	38.0
Natural Gas	23.2
Hydro	15.8
Nuclear	10.2
Non-hydro Renewables	9.3
Oil	3.0

} 61.2%

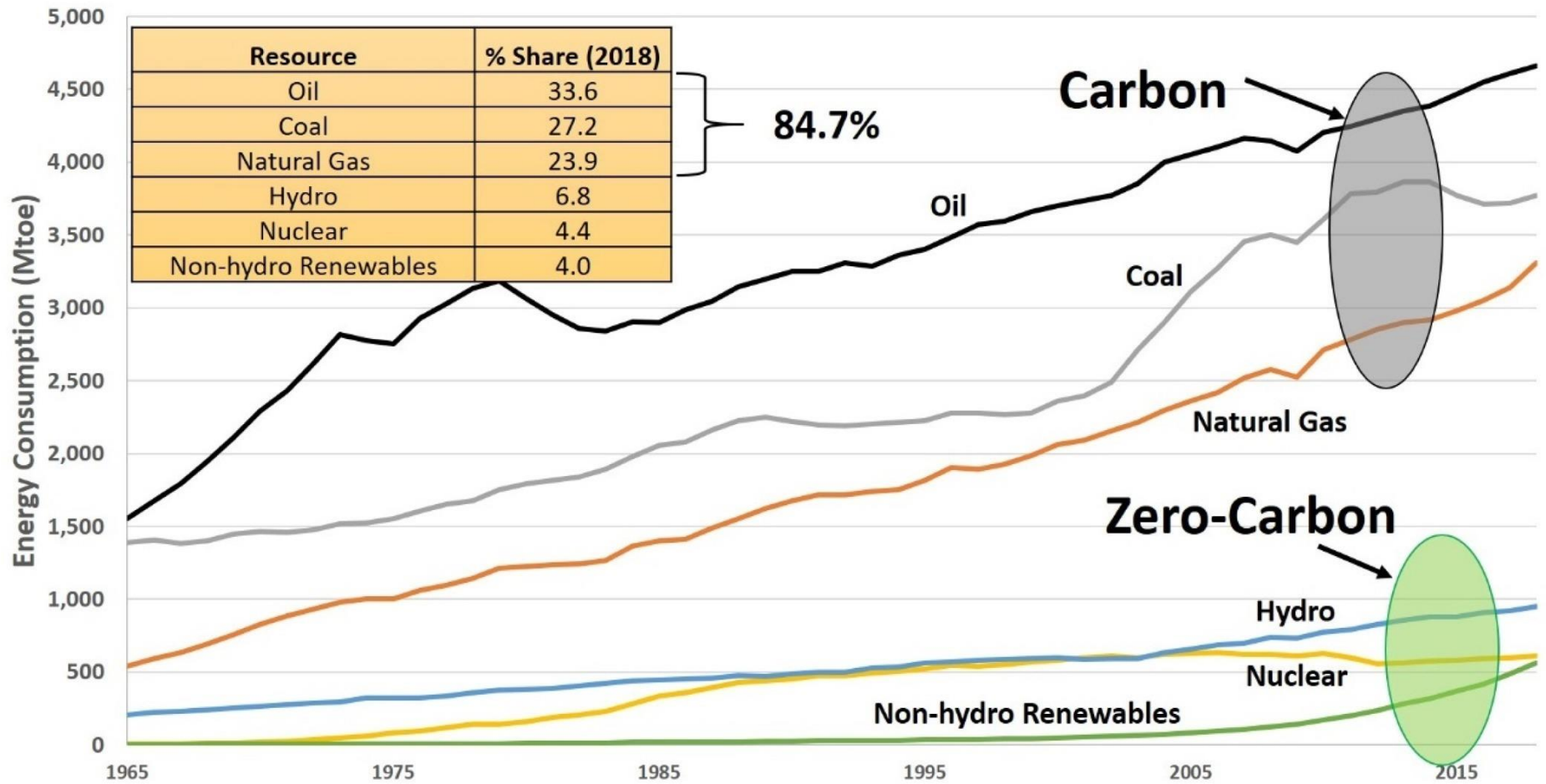


BP Statistical Review of World Energy 2019 ([BP, 2019](#)).

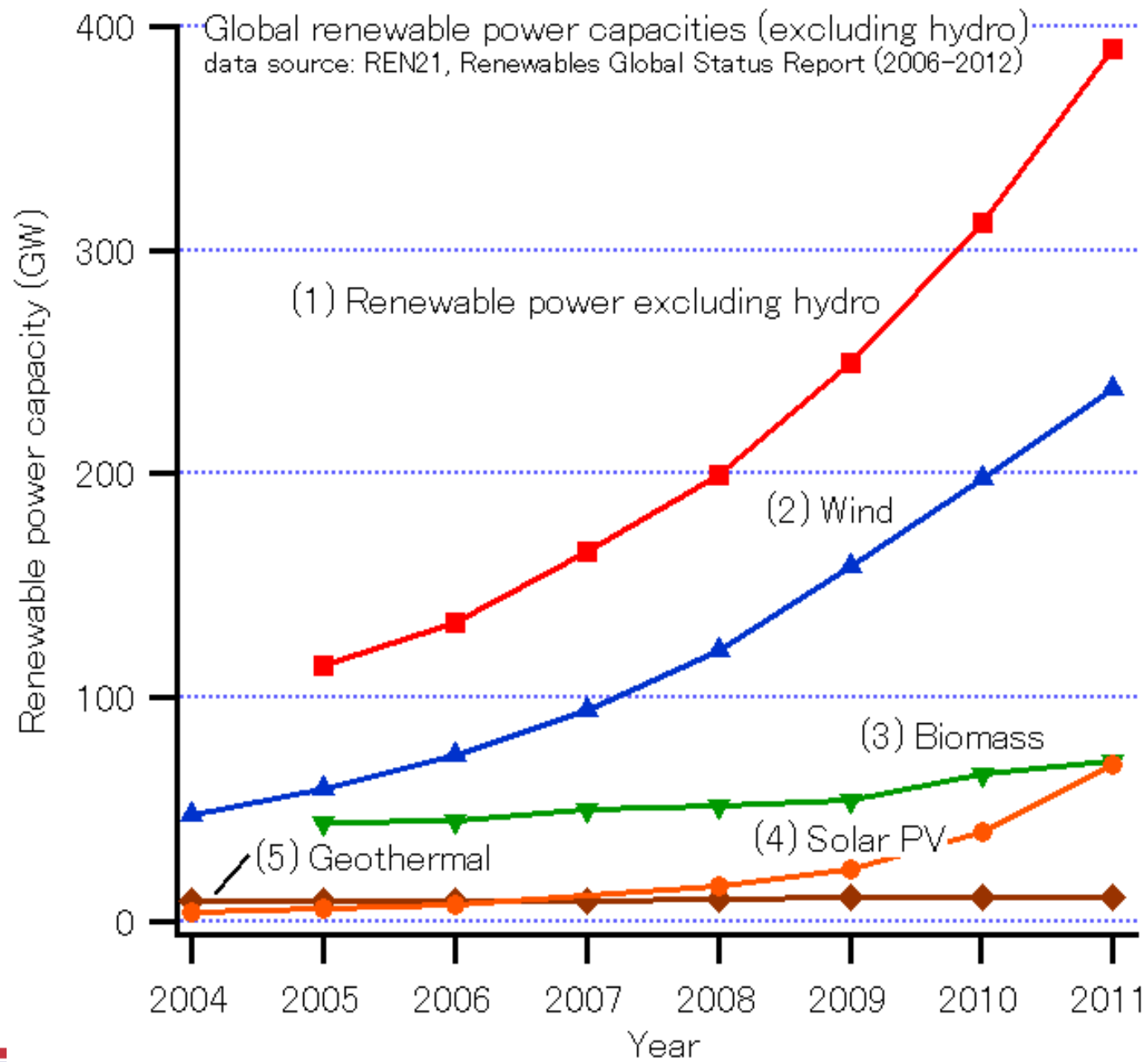
The Electricity Journal, 2020, 33, 1, 106690.

World Total Primary Energy Consumption by Resource

— Oil — Natural Gas — Coal — Nuclear — Hydro — Non-hydro Renewables

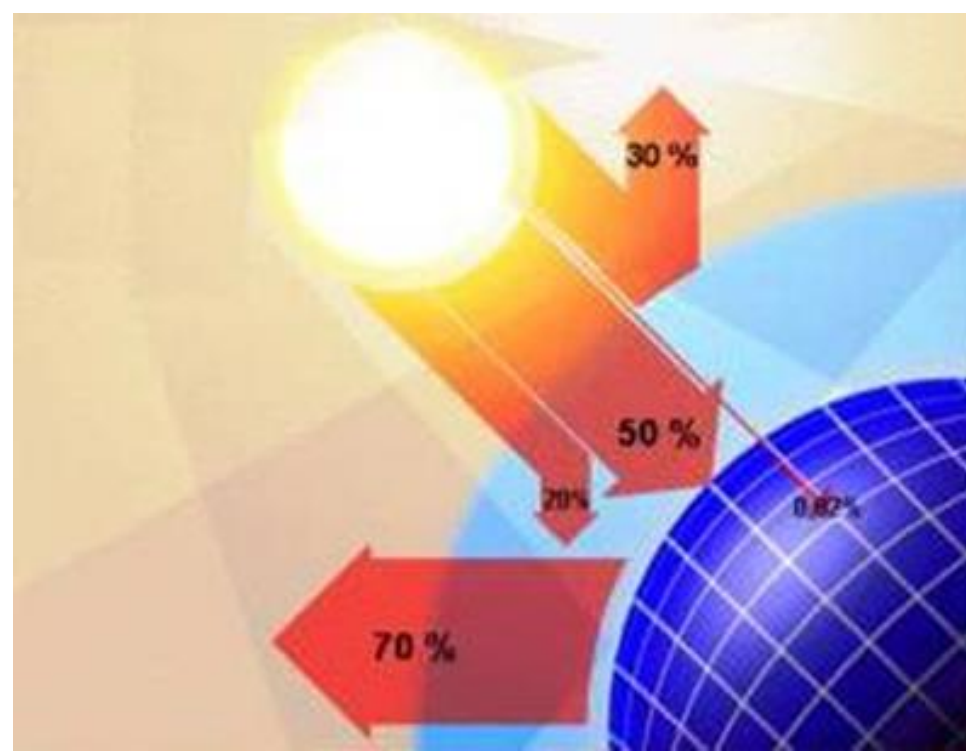


BP Statistical Review of World Energy 2019 ([BP, 2019](#)).



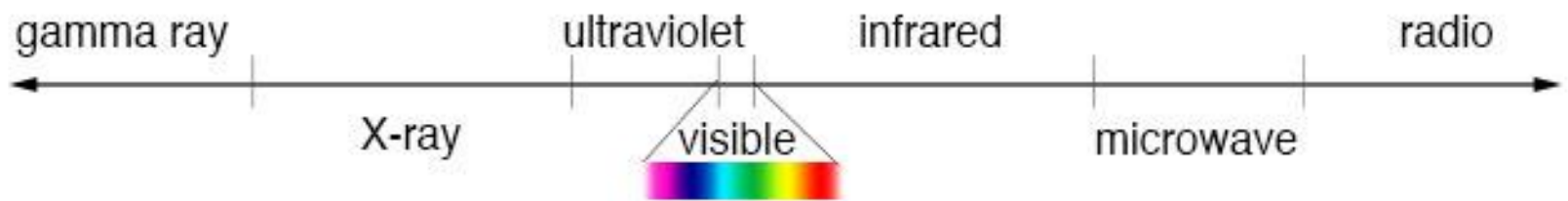
Güneş Kolektörleri (Isıl Güneş Teknolojileri)

- Güneş ışınımının %30 kadarı atmosfer tarafından geriye yansıtılır.
- Güneşten gelen ışınımın %20'si atmosfer ve bulutlarda tutulur.
- Güneş ışınımının %50'si atmosferi geçerek dünya yüzeyine ulaşır.
- Güneş ışınımının %2-3 kadarlık kısmı **Rüzgar enerjisine** dönüşüyor.



Dünya'ya güneşten gelen enerji, Dünya'da bir yılda kullanılan enerjinin 20 bin katıdır.

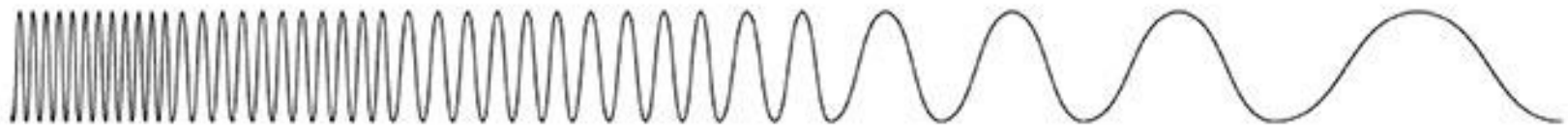




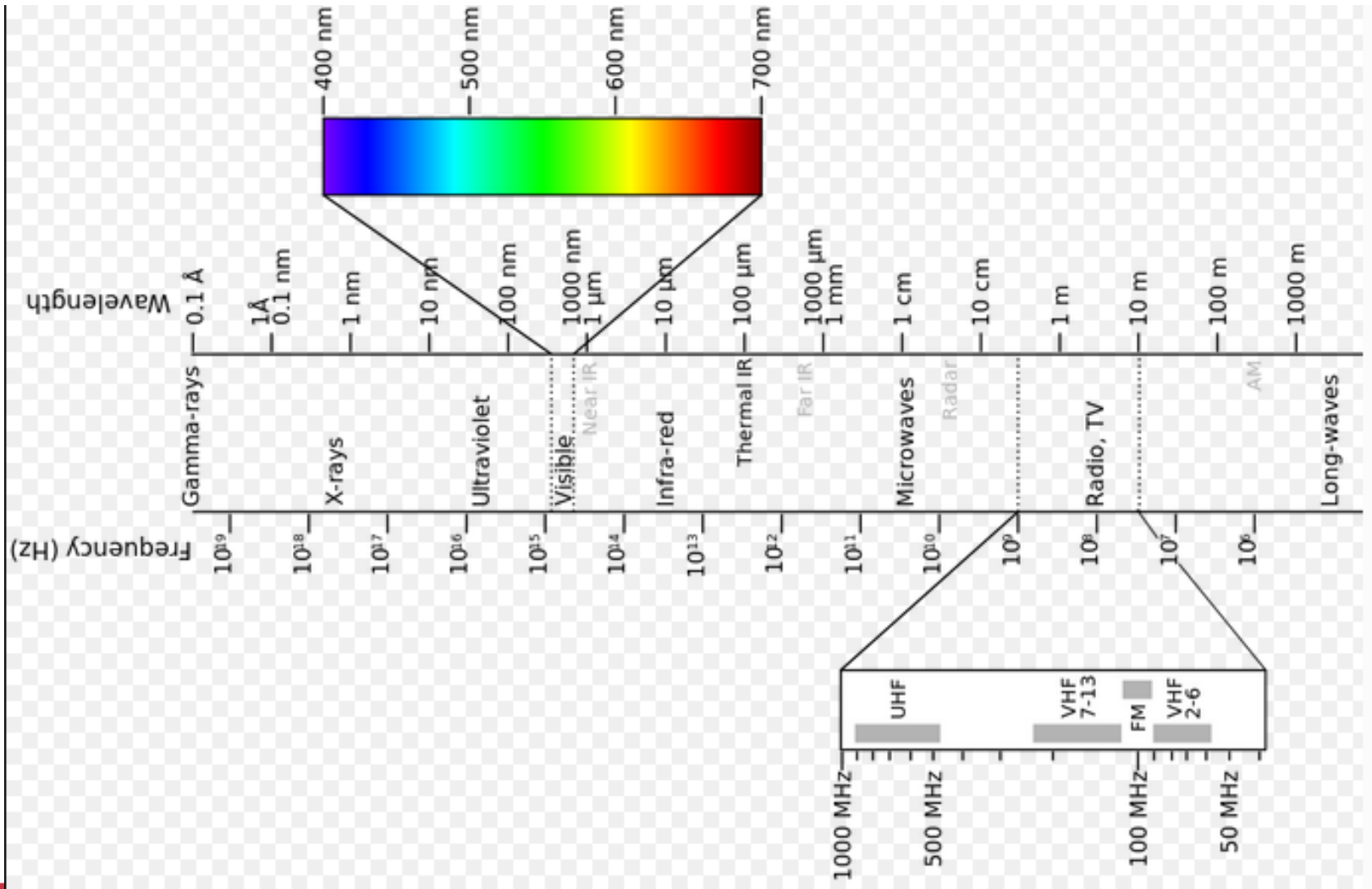
shorter wavelength
higher frequency
higher energy



longer wavelength
lower frequency
lower energy



Elektromanyetik Spektrum



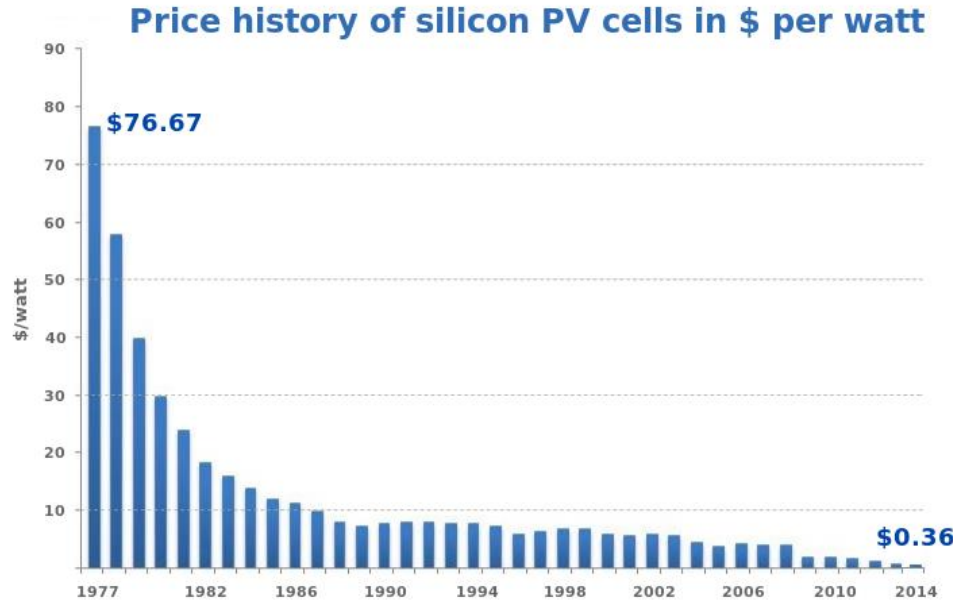
Dünyaya Ulaşan Güneş Enerjisi

- Dünya atmosferinin dışında güneş enerjisinin şiddeti, yaklaşık olarak 1370 W/m^2 değerindedir.
- Yeryüzüne ulaşan miktarı atmosferden dolayı $0-1100 \text{ W/m}^2$ değerleri arasında değişim gösterir. ($0-3950 \text{ kWh/m}^2$)
- Dünya'ya güneşten gelen enerji, Dünya'da bir yılda kullanılan enerjinin 20 bin katıdır

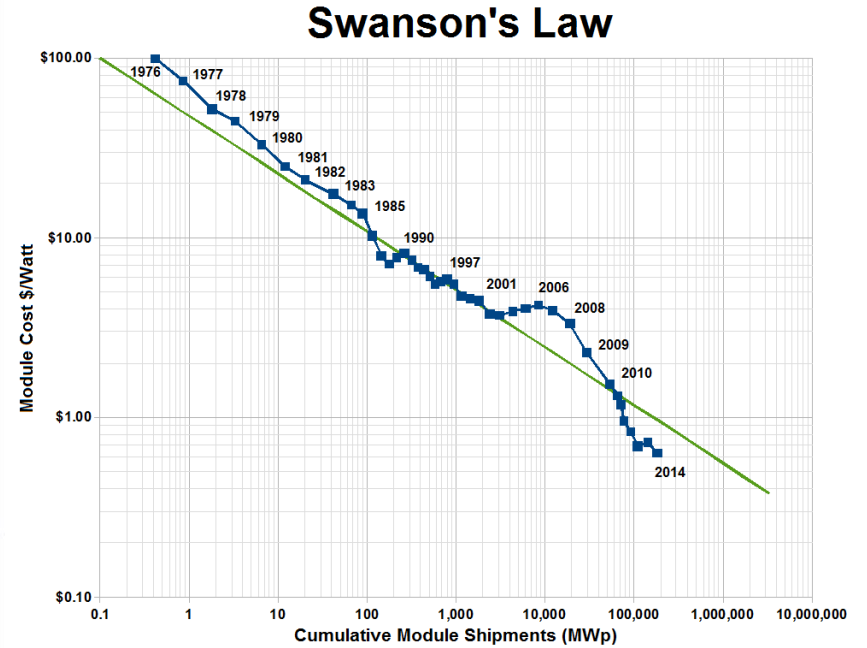




«Öğrenme-Tecrübe» Eğrileri



Source: Bloomberg, New Energy Finance & pv.energytrend.com

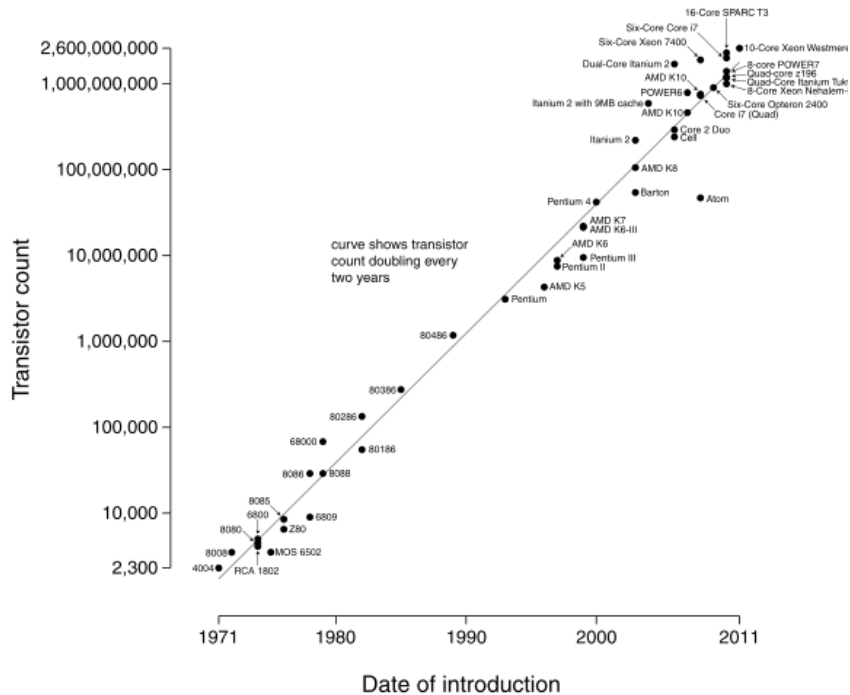


PV güç üretimi maliyeti, üretim 2 katına çıktığında maliyet (yıllara göre teknolojik ilerlemelerde göz önünde bulundurularak) %20 azalıyor.



«Öğrenme-Tecrübe» Eğrileri

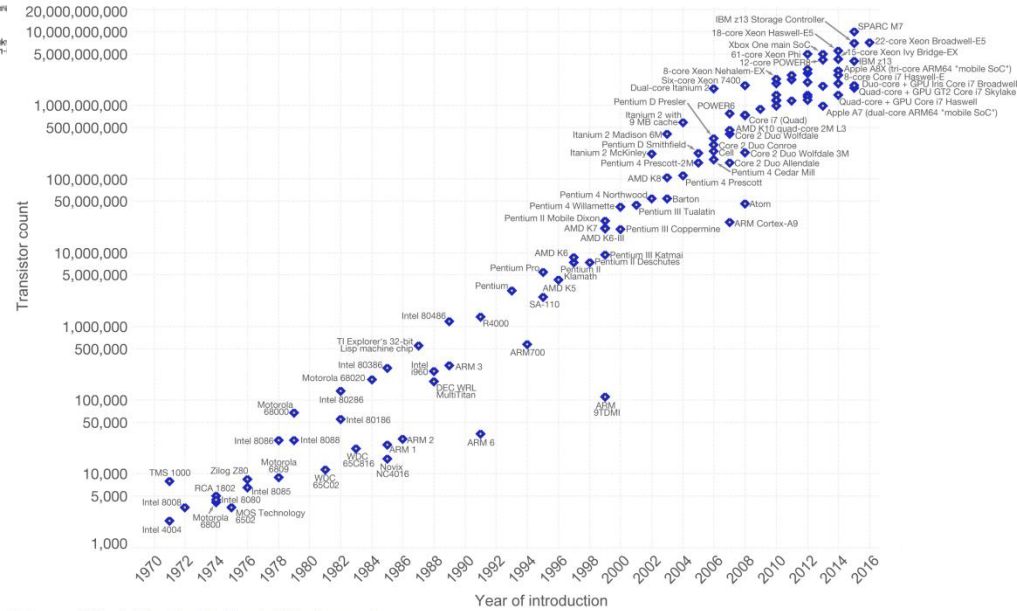
Microprocessor Transistor Counts 1971-2011 & Moore's Law



Moore's Law – The number of transistors on integrated circuit chips (1971-2016)

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important as other aspects of technological progress – such as processing speed or the price of electronic products – are strongly linked to Moore's law.

Our World
in Data



Data source: Wikipedia (https://en.wikipedia.org/wiki/Transistor_count)

The data visualization is available at [OurWorldinData.org](https://ourworldindata.org). There you find more visualizations and research on this topic.

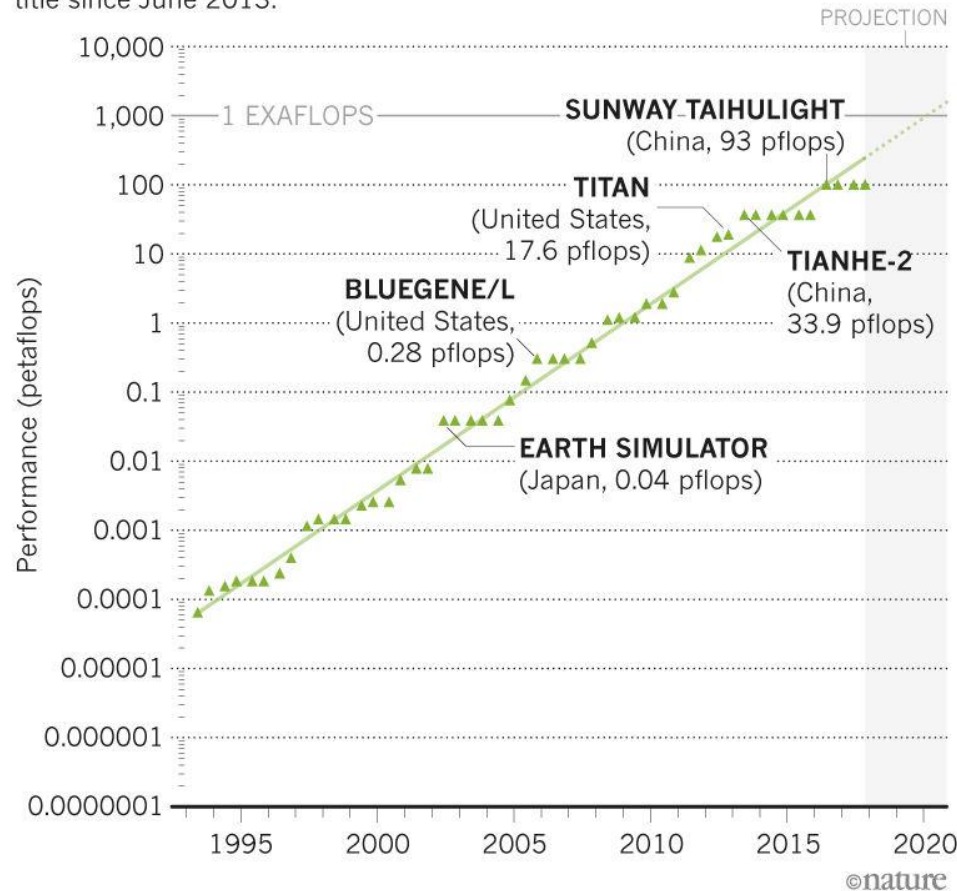
Licensed under CC-BY-SA by the author Max Roser.

Gordon Moore 1965, her 2 yılda, transistör sayısının 2 katına çıkacağını ön görür.



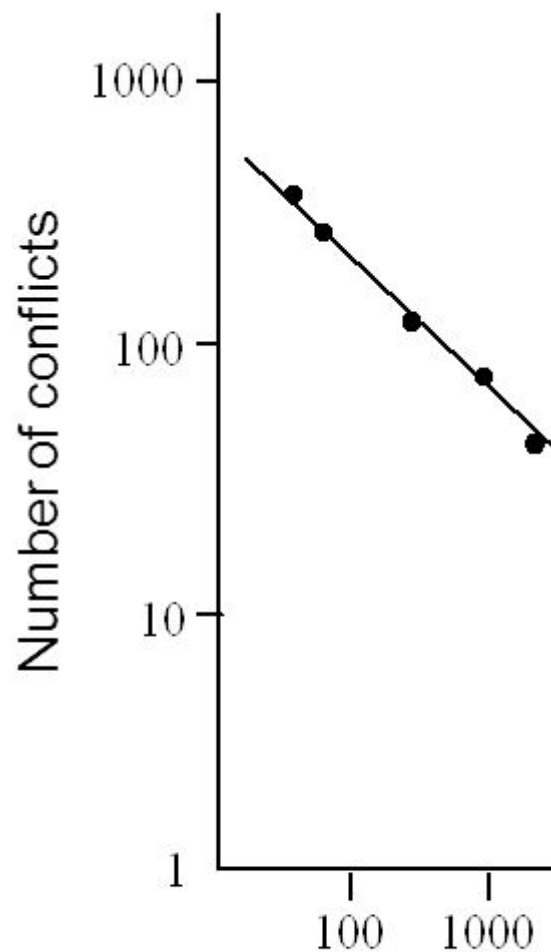
STEADY LEAPS

The performance of the most powerful supercomputer — rated by the Top500 list's speed test and measured in petaflops — has been improving since the list was launched in 1993. China has held the title since June 2013.

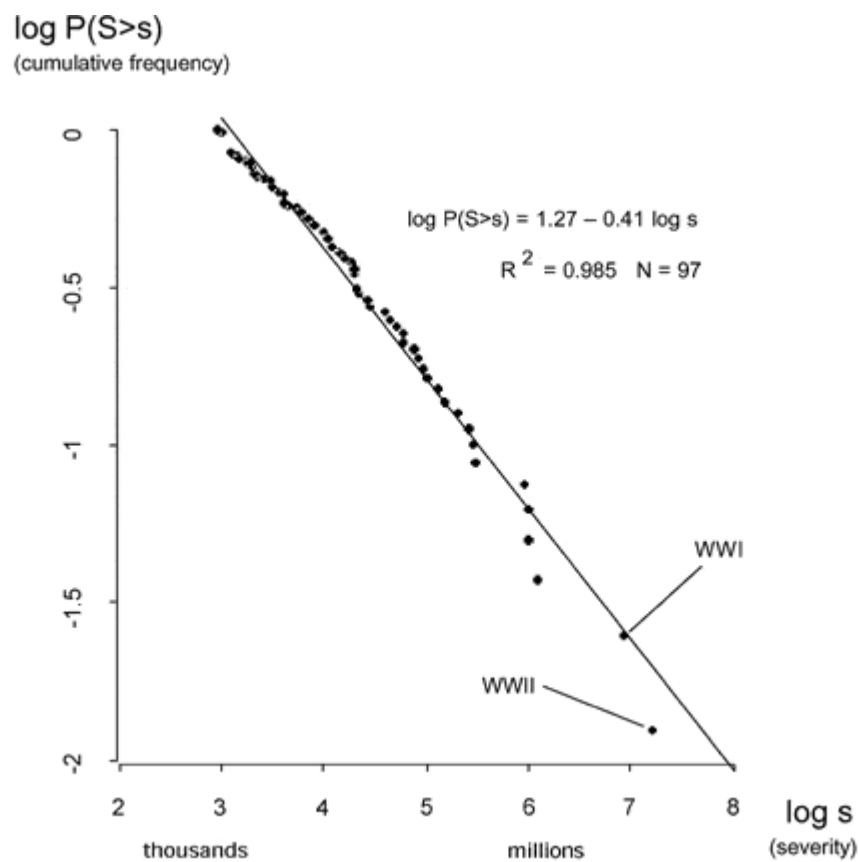


- https://www.nature.com/articles/d41586-017-07523-y?WT.ec_id=NATURE-20171201&spMailingID=55471256&spUserID=NTg1NDI4NTcyMgS2&spJobID=1285361346&spReportId=MTI4NTM2MTM0NgS2

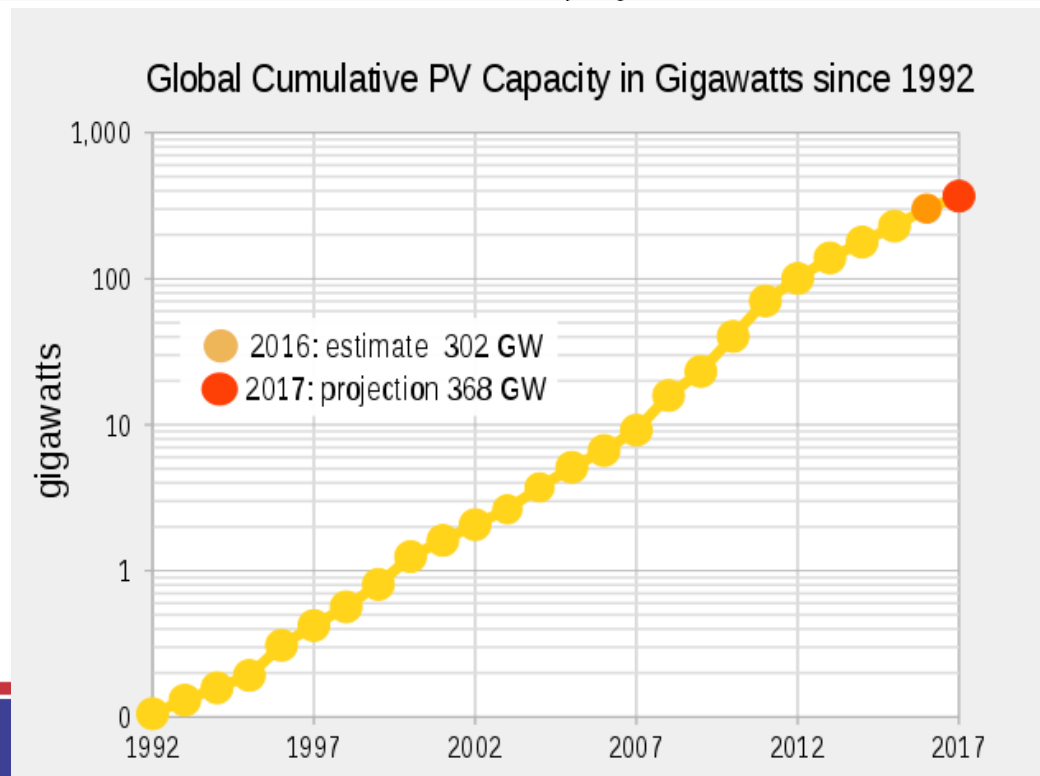
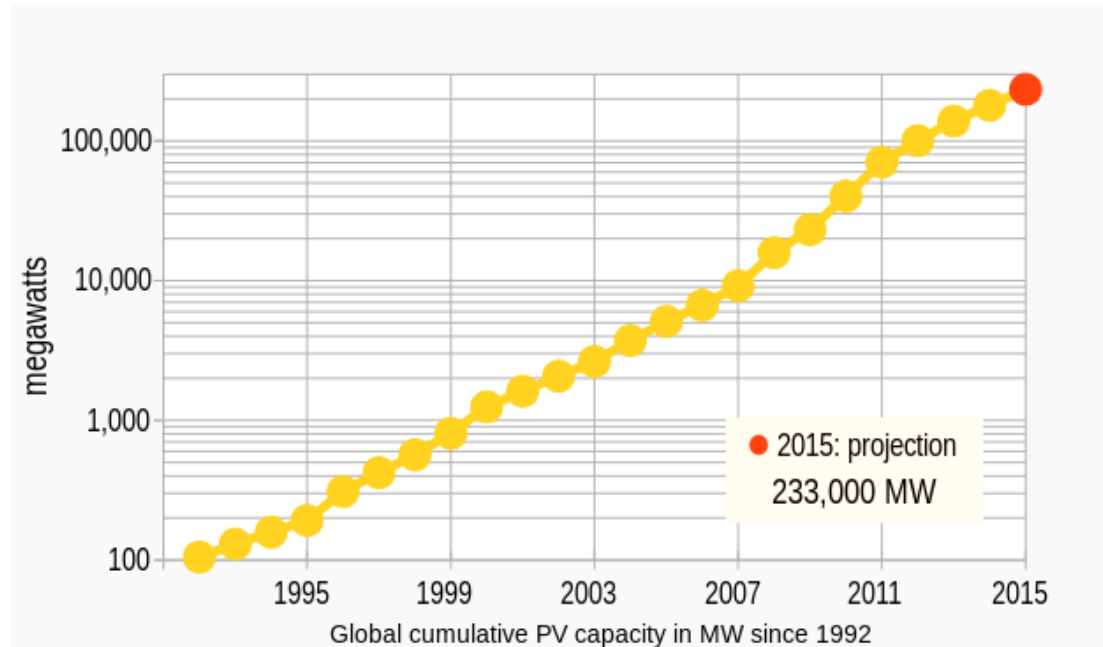




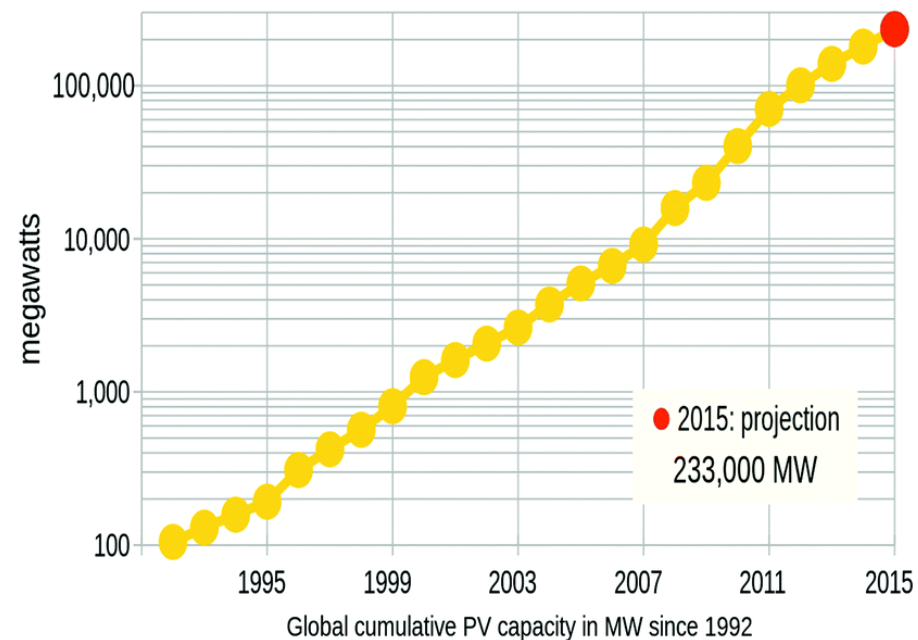
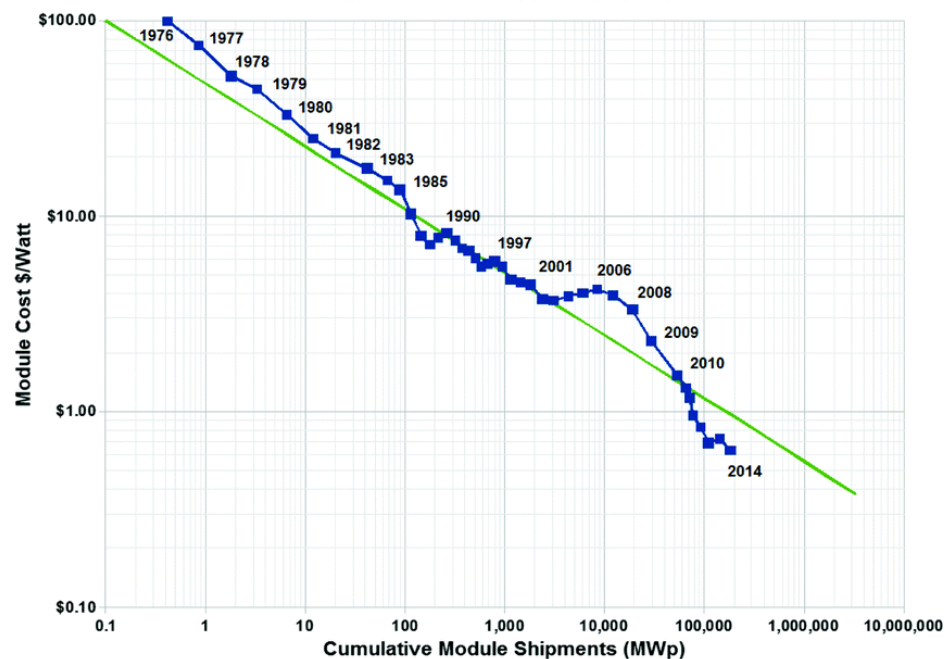
L. F. Richardson, *Statistics of Deadly Quarrels*, eds Q. Wright & C. C. Lienau (Boxwood Press, Pittsburgh, 1960)



Güneşten Elektrik Üretimi		
Year	Energy (TWh)	% of Total
2004	2.6	0.01%
2005	3.7	0.02%
2006	5.0	0.03%
2007	6.8	0.03%
2008	11.4	0.06%
2009	19.3	0.10%
2010	31.4	0.15%
2011	60.6	0.27%
2012	96.7	0.43%
2013	134.5	0.58%
2014	185.9	0.79%
2015	253.0	1.05%



Swanson's Law



2030'larda Dünya elektrik tüketiminin %20'si fotovoltaik kökenli olacak!

2050'lerde Dünya elektrik tüketiminin %16'si fotovoltaik kökenli olacak!

Fotovoltaik Enerji (PV)

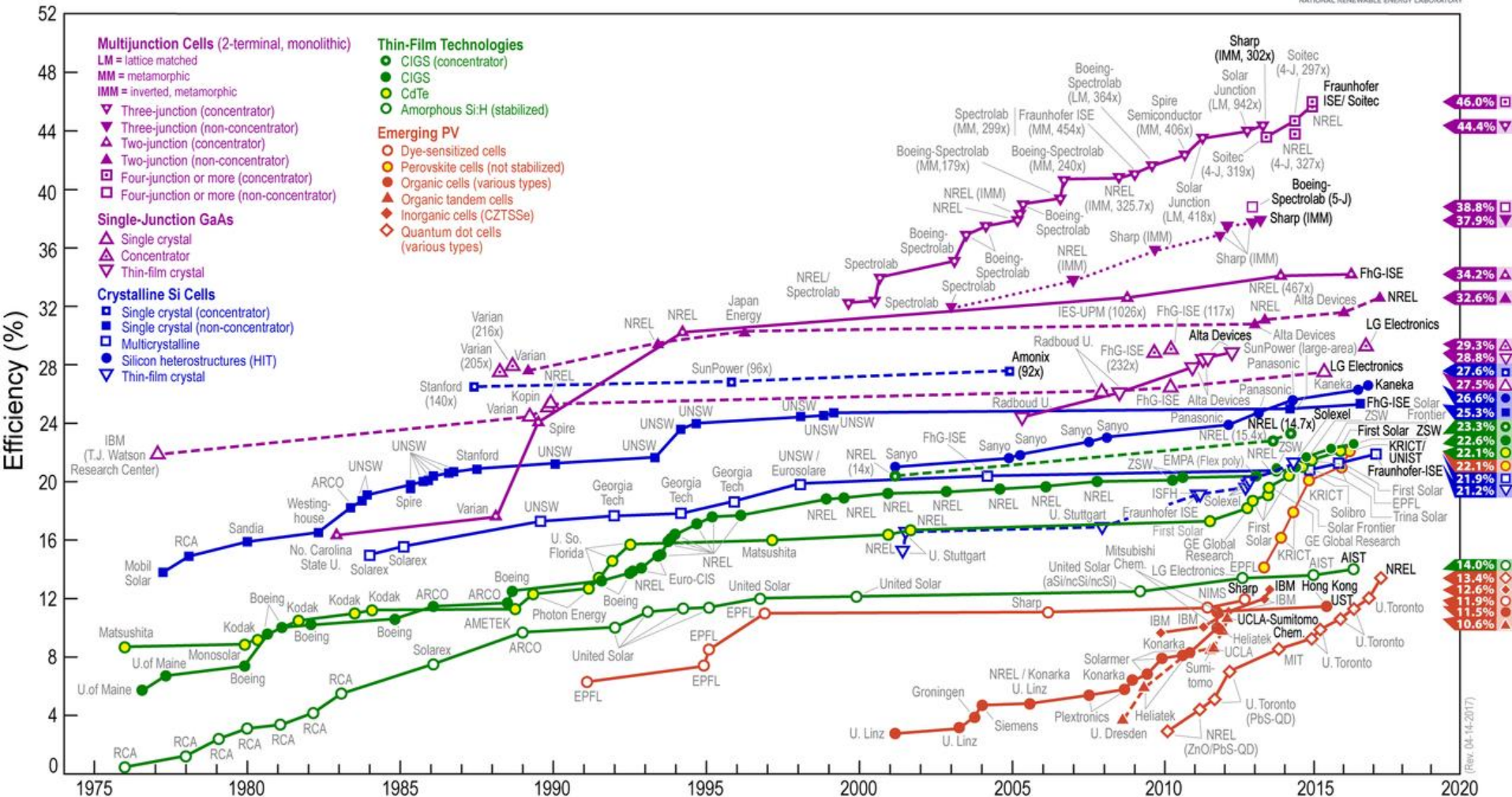
Tablo 2.3. – Fotovoltaik teknolojilerinin verim, alan gereksinimi ve elektrik enerjisi üretimi açılarından karşılaştırılması

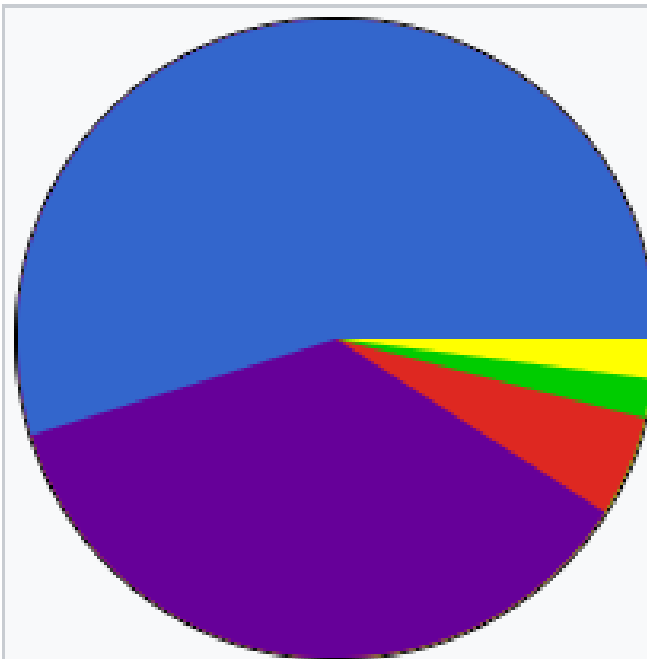
	İnce Film	Polikristal	Monokristal	Hibrit
Hücre Verimliliği	% 8 – 12	% 14 – 15	% 16 – 17	% 18 – 19
Modül Verimliliği	% 5 – 7	% 12 – 14	% 13 – 15	% 16 – 17
1 kWp modül için alan gereksinimi	Kaneka 15,5 m ² Unisolar 16 m ²	Sharp 8 m ²	Sharp 7 m ²	Sanyo 6 – 6,5 m ²
1 kWp modül için m ² başına yıllık enerji üretimi (güney tarafa 30° ile bakan)	50 – 52 kWh/m ²	100 kWh/m ²	107 kWh/m ²	139 – 150 kWh/m ²



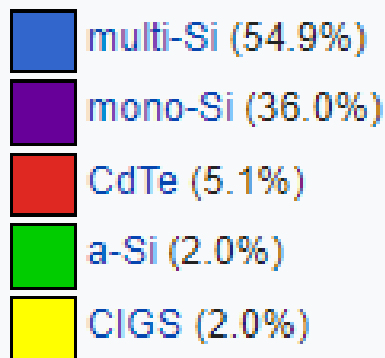
Fotovoltaik Enerji (PV)

Best Research-Cell Efficiencies

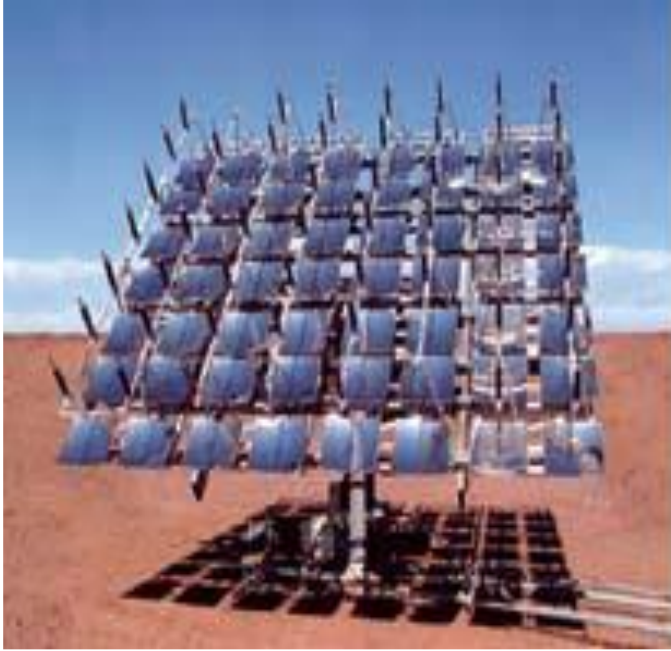


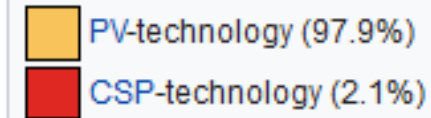
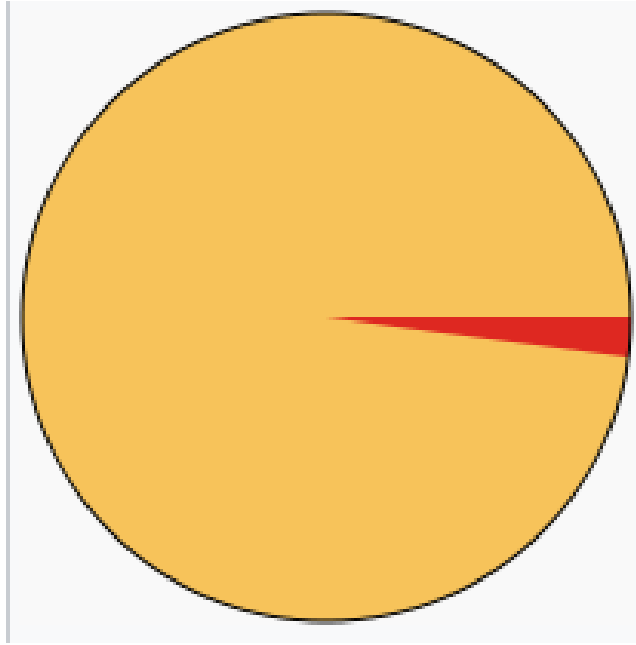


Global PV market by technology in 2013. [45]:18,19

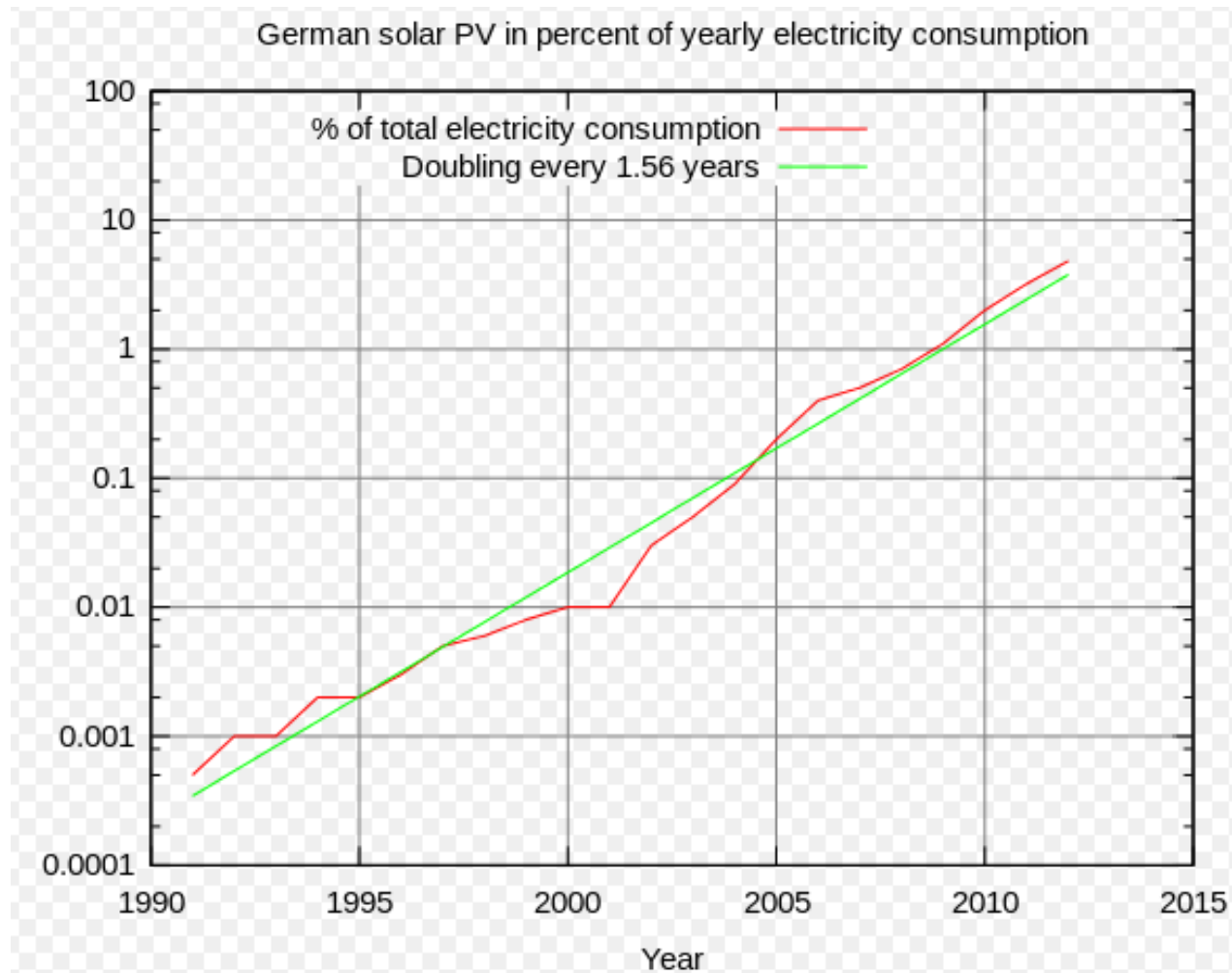


Yoğunlaştırılmış Fotovoltaik Enerji (CPV)





Elektrik üretim teknolojisine göre dünya güneş enerjisi elektrik üretimi kapasite dağılımı (2015 toplamda 232GW)



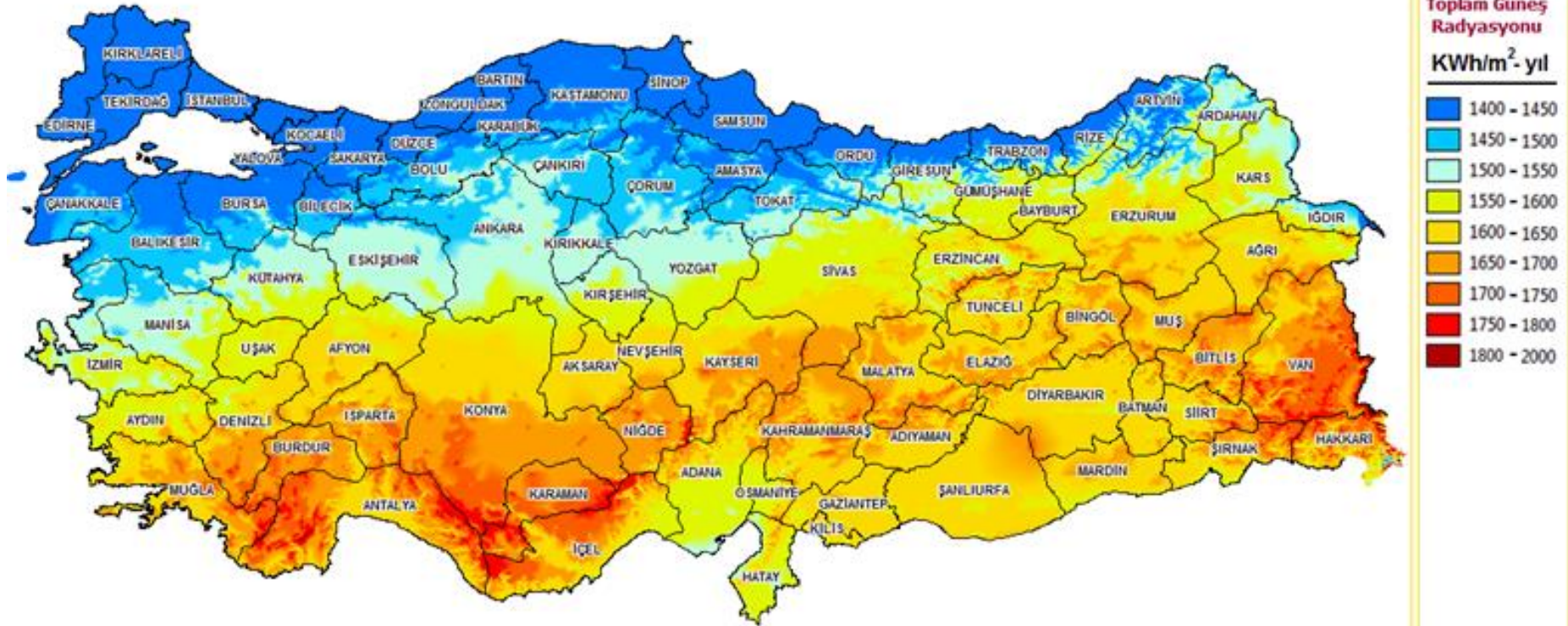
2013 yılı elektrik tüketiminin %5'i PV den.

Hedef: 2050 yılına gelindiğinde elektrik enerjisi üretiminin %80'ini yenilenebilir enerji kaynaklarından sağlamak



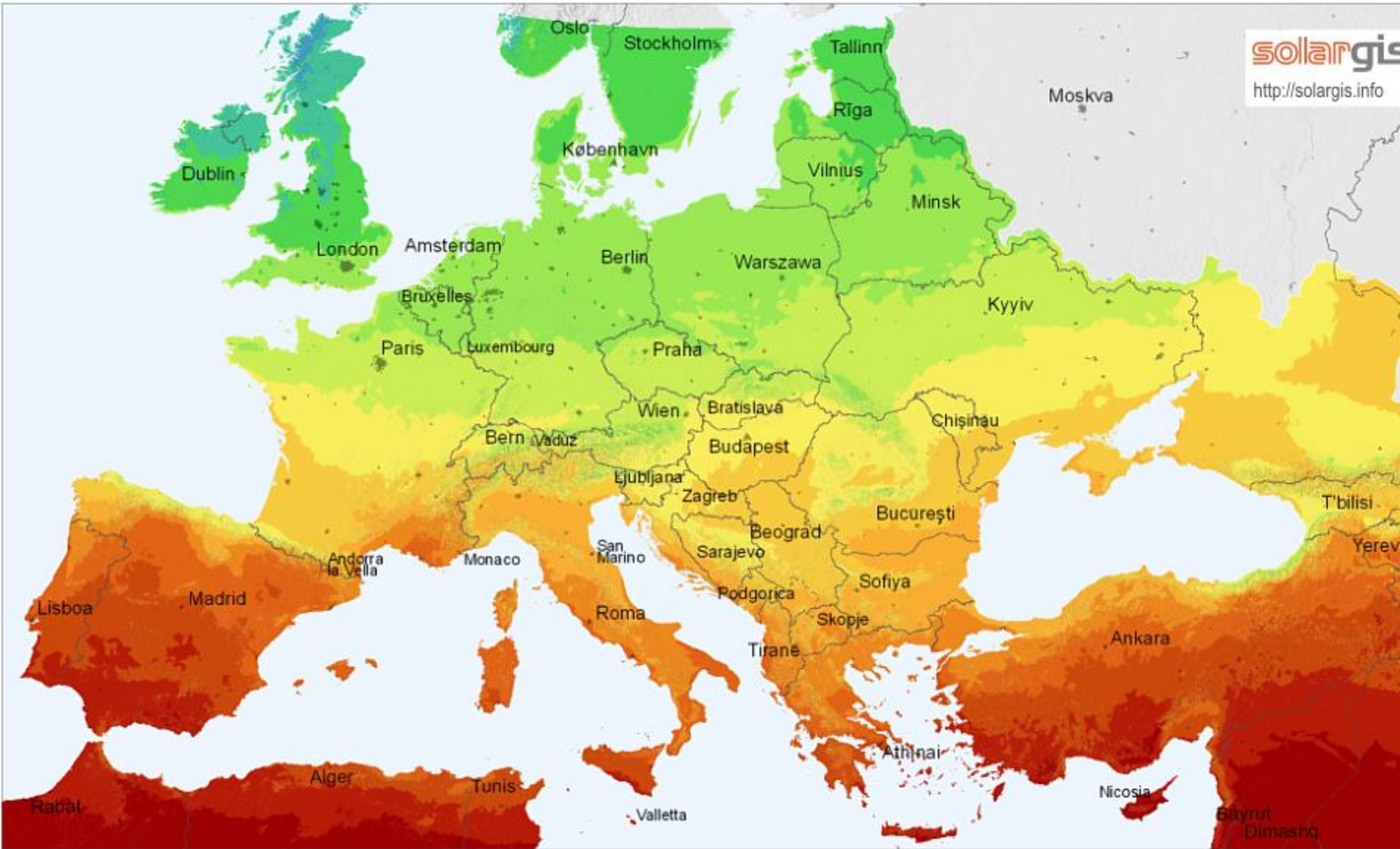
GÜNEŞ ENERJİSİ POTANSİYEL ATLASI (GEPA)

Açıklamalar



Global horizontal irradiation

Euro



solarGIS
<http://solargis.info>

Average annual sum (4/2004 - 3/2010)






















0 250 500

Türkiye’de üretilen PV elektrik enerji ne kadar?

- 2013 yılında Türkiye’de toplam PV elektrik enerji üretimi 18MW!
- Almanya’da 36000 MW (Rüzgar 34,3GW (%8))
- Yunanistan’da 2500 MW
- Bulgaristan’da 1000 MW
- Türkiye’de 18 MW (Rüzgar 3 GW (%5))



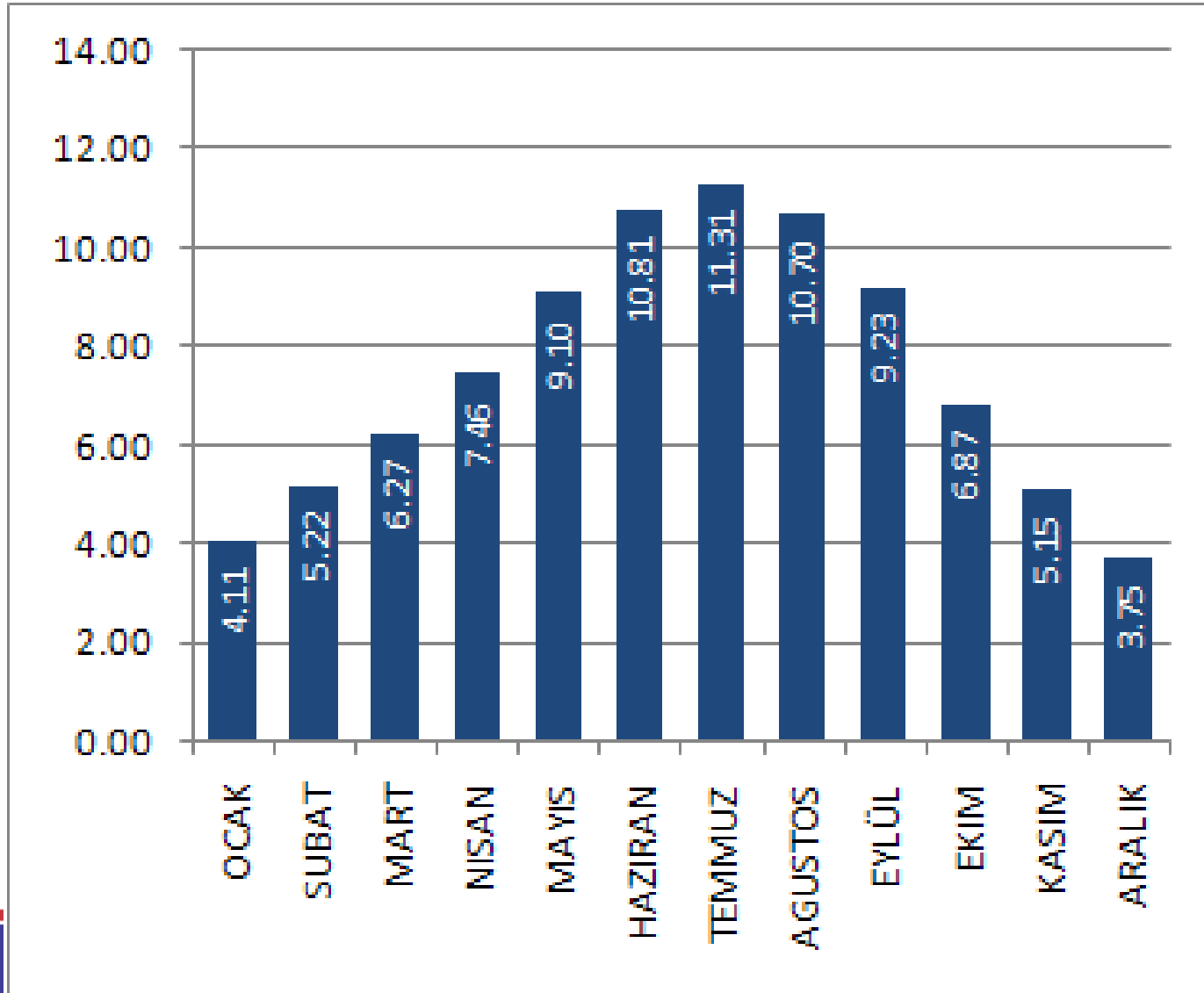
Solar PV capacity by country (MW) and share of total electricity consumption [[view/edit](#)]

	2015 ^[10]		2016 ^[3]		2017 ^[11]		2018 ^{[12][13]}		Share of total consumption ¹ ↕
Country ↕	Added ↕	Total ↕	Added ↕	Total ↕	Added ↕	Total ↕	Added ↕	Total ↕	
 China	15,150	43,530	34,540	78,070	53,000	131,000	45,000	175,018	3.3% (2018) ^[13]
 European Union	7,230	94,570		101,433		107,150	8,300	115,234	4.3% (2018) ^[13]
 United States	7,300	25,620	14,730	40,300	10,600	51,000	10,600	62,200	2.3% (2018) ^[13]
 Japan	11,000	34,410	8,600	42,750	7,000	49,000	6,500	55,500	6.8% (2018) ^[13]
 Germany	1,450	39,700	1,520	41,220	1,800	42,000	3,000	45,930	7.9% (2018) ^[13]
 India	2,000	5,050	3,970	9,010	9,100	18,300	10,800	26,869	5.4% (2018) ^[13]
 Italy	300	18,920	373	19,279	409	19,700		20,120	7.3% (2018) ^[13]
 United Kingdom	3,510	8,780	1,970	11,630	900	12,700		13,108	3.9% (2018) ^[13]
 Australia	935	5,070	839	5,900	1,250	7,200	3,800	11,300	6.3% (2018) ^[13]
 France	879	6,580	559	7,130	875	8,000		9,483	2.2% (2018) ^[13]
 South Korea	1,010	3,430	850	4,350	1,200	5,600	2,000	7,862	2.2% (2018) ^[13]
 Turkey			584	832	2,600	3,400	1,600	5,063	3.2% (2018) ^[13]
 Spain	56	5,400	55	5,490	147	5,600		4,744	2.7% (2018) ^[13]
 Netherlands	450	1,570	525	2,100	853	2,900	1,300	4,150	3.6% (2018) ^[13]
 Belgium	95	3,250	170	3,422	284	3,800		4,026	4.7% (2018) ^[13]
 Mexico			150	320	150	539	2,700	3,200	2.6% (2018) ^[13]
 Canada	600	2,500	200	2,715	212	2,900		3,113	0.6% (2018) ^[13]
 Thailand	121	1,420	726	2,150	251	2,700		2,720	2.3% (2018) ^[13]
 Greece	10	2,613						2,652	7.5% (2018) ^[13]

2019 Yılı Elektrik Üretiminin Kaynaklara Dağılımı

Kaynak			Üretim (MWh)	Oran (%)
Yerli	Yenilenebilir	Hidroelektrik	88.884.607	29,22
İthal	Fosil	İthal Kömür	60.381.270	19,86
İthal	Fosil	Doğalgaz	56.522.710	18,59
Yerli	Fosil	Taş Kömürü, Linyit ve Asfaltit	52.736.550	17,34
Yerli	Yenilenebilir	Rüzgar	21.749.838	7,15
Yerli	Yenilenebilir	Güneş	9.620.335	3,16
Yerli	Yenilenebilir	Jeotermal	8.929.730	2,94
Yerli	Yenilenebilir	Biyogaz	4.521.807	1,49
İthal	Fosil	Fuel-Oil ve Motorin	733.920	0,24
Yerli	-	Toplam	186.442.867	61,3
İthal	-	Toplam	117.637.900	38,7
-	Yenilenebilir	Toplam	133.706.318	44,0
-	Fosil	Toplam	170.374.450	56,0

Türkiye ortalama güneşlenme süreleri (saat)



TÜRKİYE PV Tipi Üretilebilecek Enerji (KWh-Yıl)

