Enerji Sektöründe kritik sorular

Barış Sanlı

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Bilkent Üniversitesi – 8 Mart 2017

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- Çalışmalar: www.barissanli.com
- Tarihsel dökümanlar: http://www.barissanli.com/calismalar/tarih/
- R ile enerji analizi: http://www.barissanli.com/calismalar/dersler/r/
- Murat Alanyalı ile enerji raporları/yayınları podcastleri

  https://soundcloud.com/user-323142157/

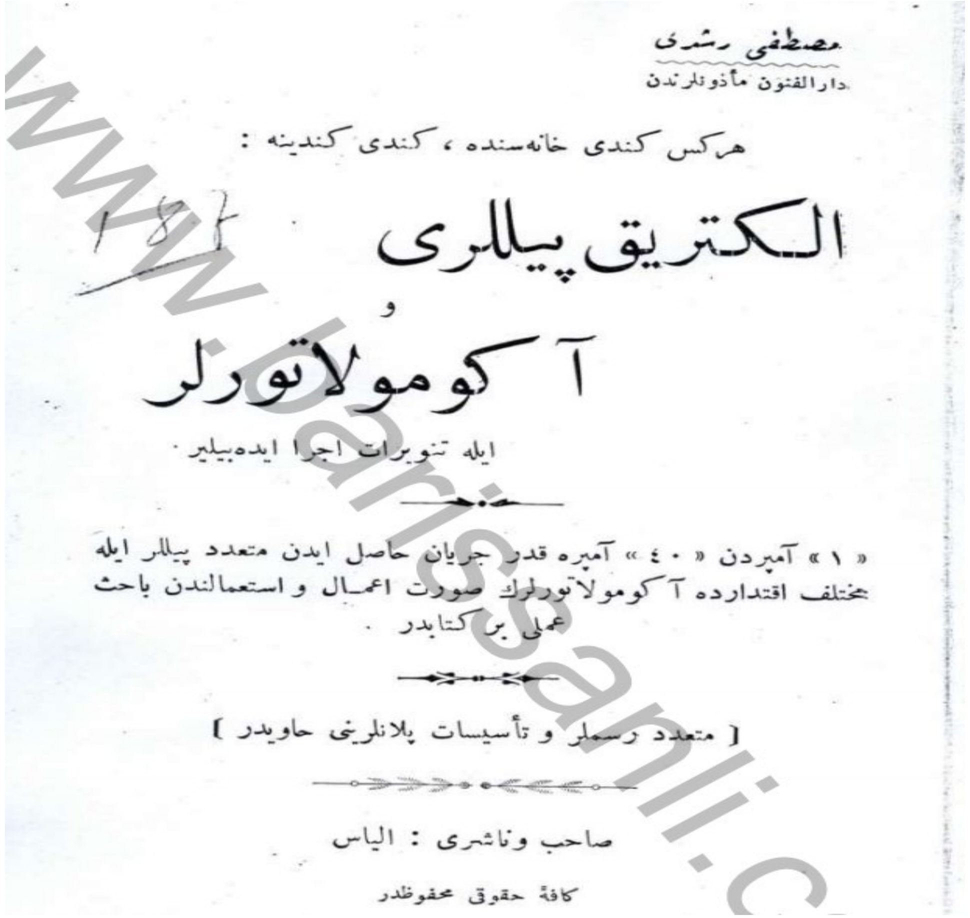
Anlatılmak istenen

- Bugün ki enerji sisteminin geleceğine dair fikir verebilecek, tarihsel olarak bir çok örnek var
- Enerji daha fazla elektriğe kayarken;
- Üretim modları daha fazla çevresel faktörlerden etkilenecek
- Enerji değil Enerji-teknoloji tarihi
- Belirsizlik bir araç olabilir

Özet

(Tarihsel bakış, Coğrafik durum, Sıcaklık, Bölgesel fark,
Bu sene neden soğuk?)

1915 – Osmanlıca Elektrik pilleri kitabı



مصطفى رشدى
دارالفنون مأذونلرندن

هرکس کندی خانه‌سنده ، کندی کندینه :

الکتریق پیللری
و
آکومولاتورلر

ایله تنویرات اجرا ایده‌بیلیر ·

« ۱ » آمپردن « ٤٠ » آمپره قدر جریان حاصل ایدن متعدد پیللر ایله مختلف اقتدارده آکومولاتورلرك صورت اعمال و استعمالندن باحث عملی بر کتابدر .

[متعدد رسملر و تأسیسات پلانلرینی حاویدر]

صاحب وناشری : الیاس

كافهٔ حقوق محفوظدر

۱۷ الکتریق پیللری

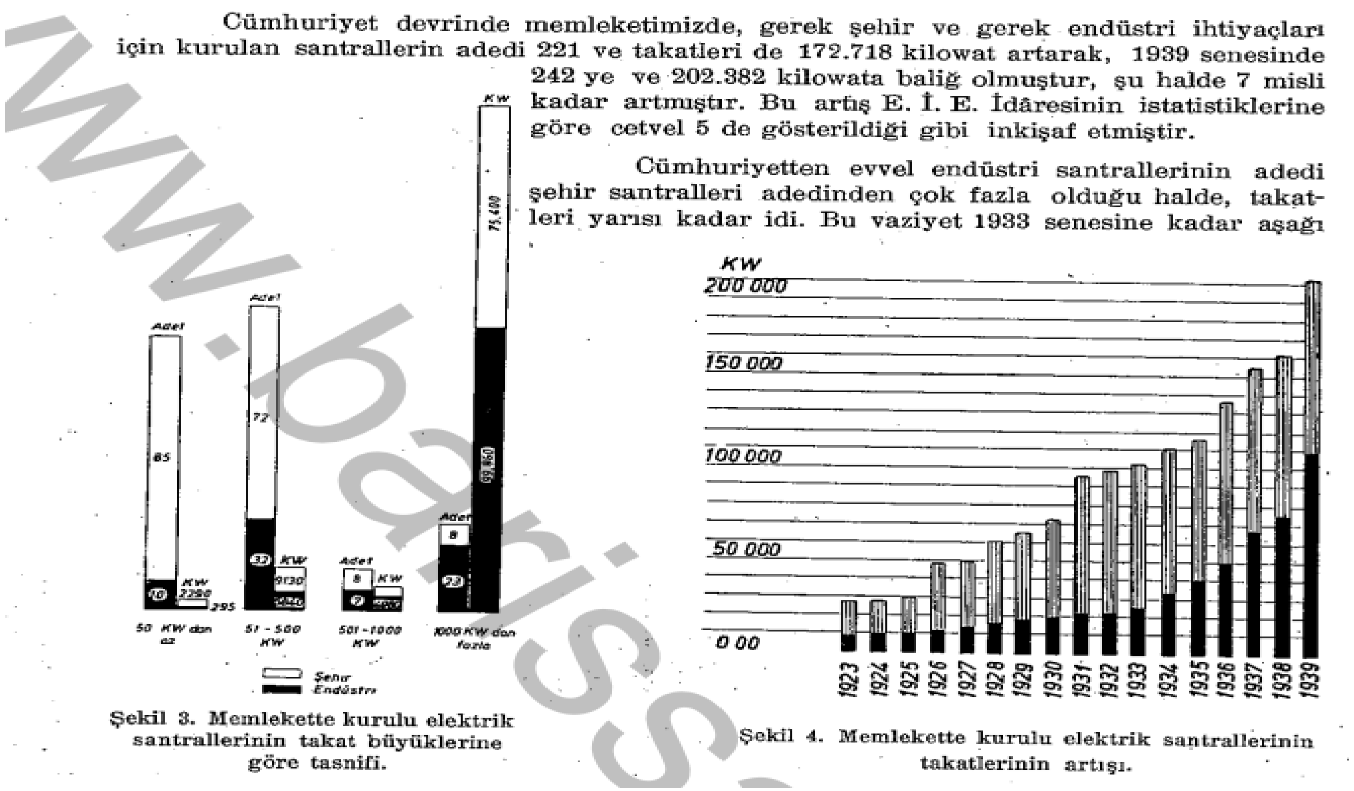
برتبدل یوقدر. آنجق برشی‌وارکه اوده مانع استقطاب ماده دها کثیر مقدارده بولنیورده. مدت دوام تزاید ایدییور . بو پیلك فیآتی‌ده فابریقه‌سنده ایکی فرانقدر . مدت دوامنك چوقلغی حسبیله متقطع صورتده ضیااستحصالنده فائده‌بخشدر. (۸—۱۰) دقیقه ظرفنده اینجه تللی لامبه‌لرله پك کوزل و پارلاق ضیا حاصل ایده‌بیلیر. مخترع (موسیوونسان) بوپیله (Simplex) نامنی ویرمشدر.

(شکل ۷)طوربه‌لی پیلك قطبلری

(شکل ۸)طوربه‌لی پیل

http://www.barissanli.com/calismalar/tarih/elektrikpilleri-1915-bs.pdf

1940 – Santraller kaça ayrılır

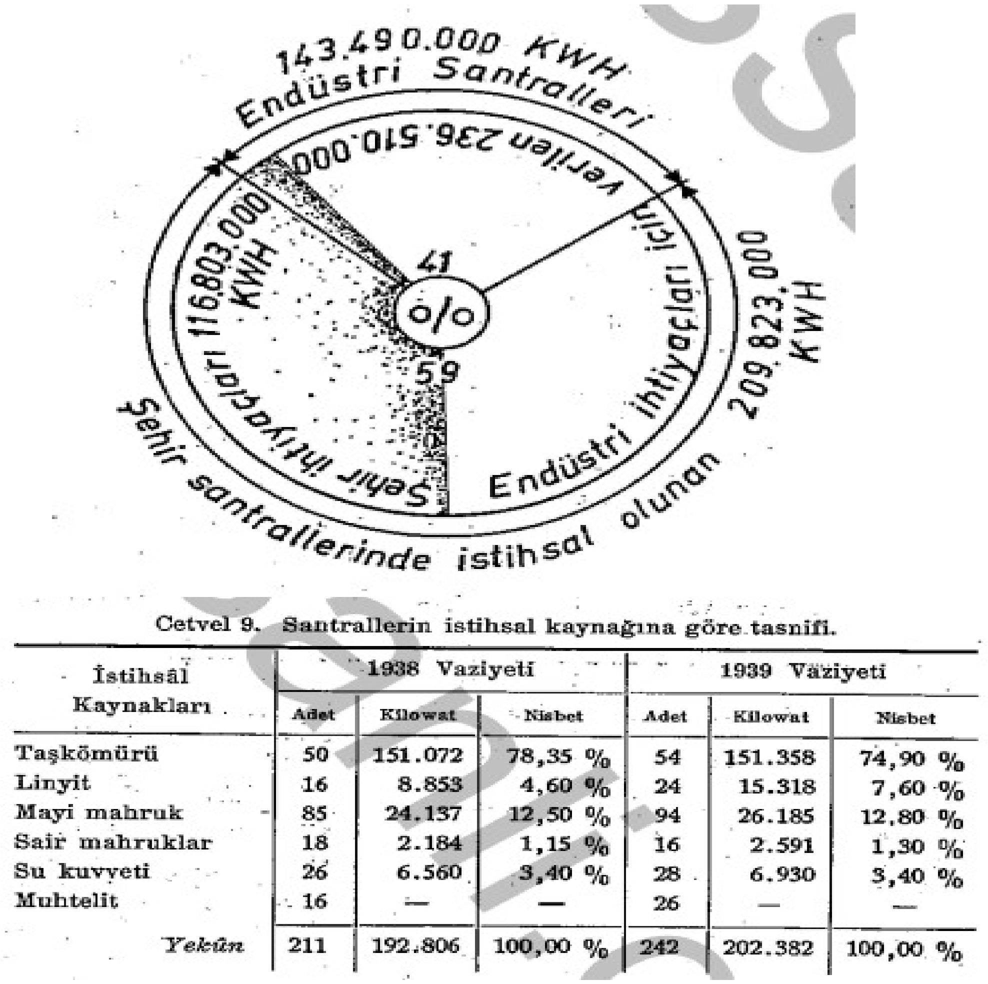


Cümhuriyet devrinde memleketimizde, gerek şehir ve gerek endüstri ihtiyaçları için kurulan santrallerin adedi 221 ve takatleri de 172.718 kilowat artarak, 1939 senesinde 242 ye ve 202.382 kilowata baliğ olmuştur, şu halde 7 misli kadar artmıştır. Bu artış E. İ. E. İdâresinin istatistiklerine göre cetvel 5 de gösterildiği gibi inkişaf etmiştir.

Cümhuriyetten evvel endüstri santrallerinin adedi şehir santralleri adedinden çok fazla olduğu halde, takatleri yarısı kadar idi. Bu vaziyet 1933 senesine kadar aşağı

Şekil 3. Memlekette kurulu elektrik santrallerinin takat büyüklerine göre tasnifi.

Şekil 4. Memlekette kurulu elektrik santrallerinin takatlerinin artışı.



Cetvel 9. Santrallerin istihsal kaynagına göre tasnifi.

İstihsâl Kaynakları	1938 Vaziyeti			1939 Vaziyeti		
	Adet	Kilowat	Nisbet	Adet	Kilowat	Nisbet
Taşkömürü	50	151.072	78,35 %	54	151.358	74,90 %
Linyit	16	8.853	4,60 %	24	15.318	7,60 %
Mayi mahruk	85	24.137	12,50 %	94	26.185	12,80 %
Sair mahruklar	18	2.184	1,15 %	16	2.591	1,30 %
Su kuvveti	26	6.560	3,40 %	28	6.930	3,40 %
Muhtelit	16	—	—	26	—	—
Yekûn	211	192.806	100,00 %	242	202.382	100,00 %

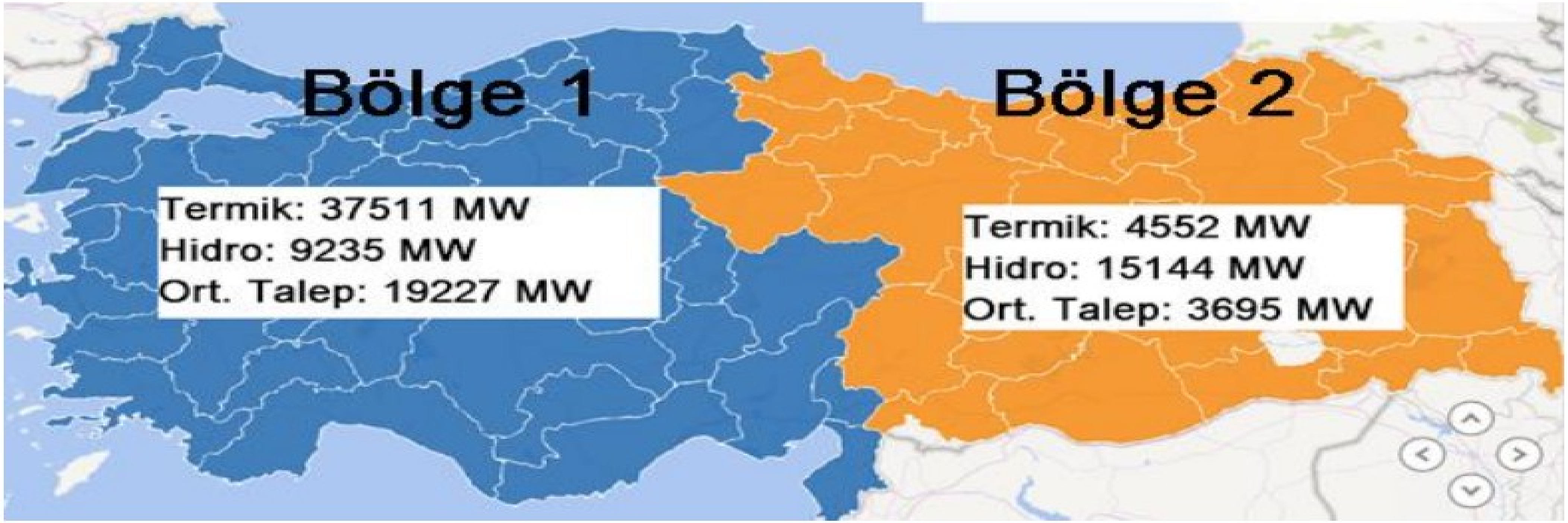
http://www.barissanli.com/calismalar/tarih/bsanli-EnergiEkonomisiveDurumu-1940.pdf

Enerjide bölgesel farklılıklar

Şekil 5. Doğu ve batı bölgelerinde temel farklılıklar

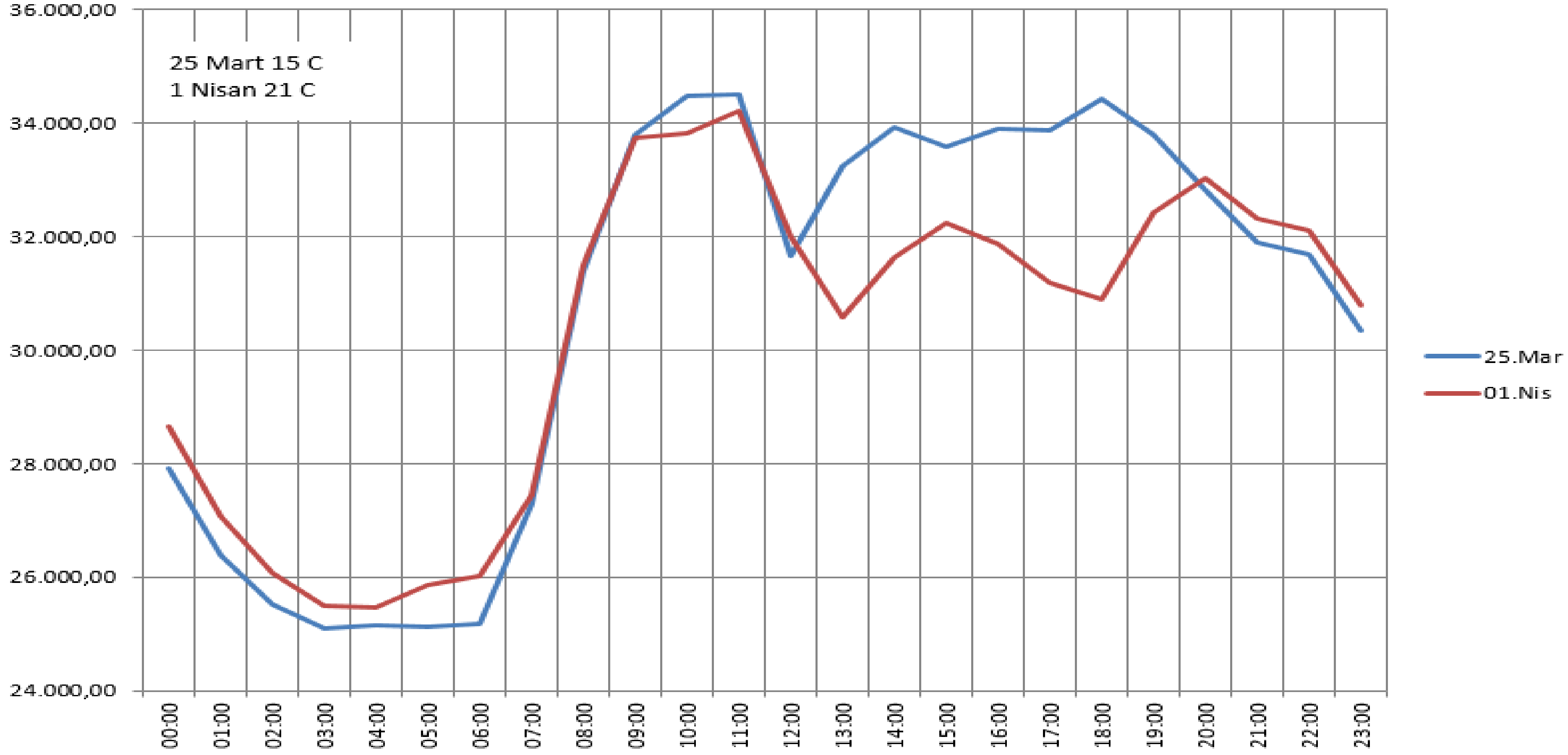
http://www.barissanli.com/calismalar/2015/bsanli-eilseven-makdeniz-trpiyasa.pdf

İki bölgenin hikayesi

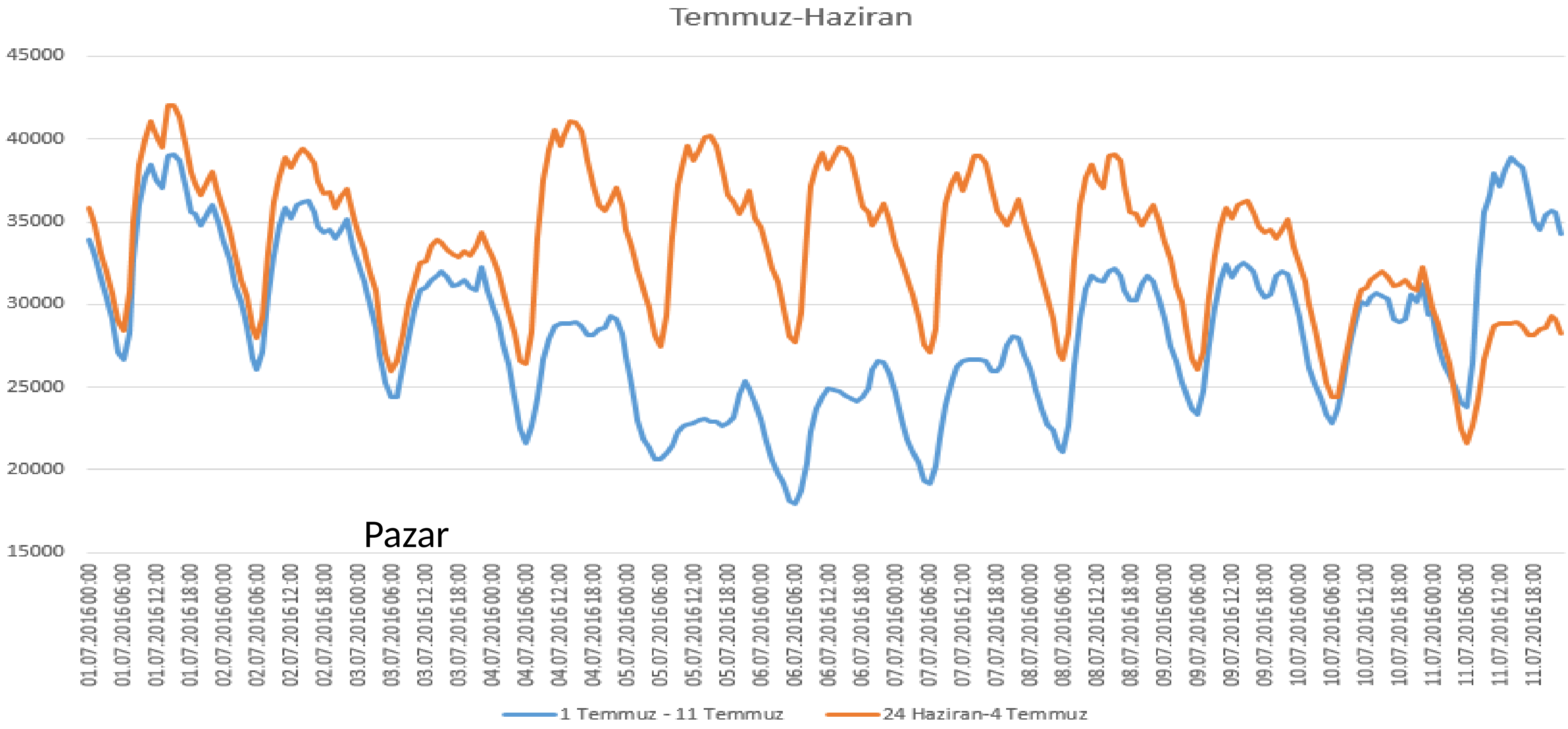


Şekil 7. Türkiye iki bölge olarak farklılıklar

Sıcaklığın etkisi – Cuma günü

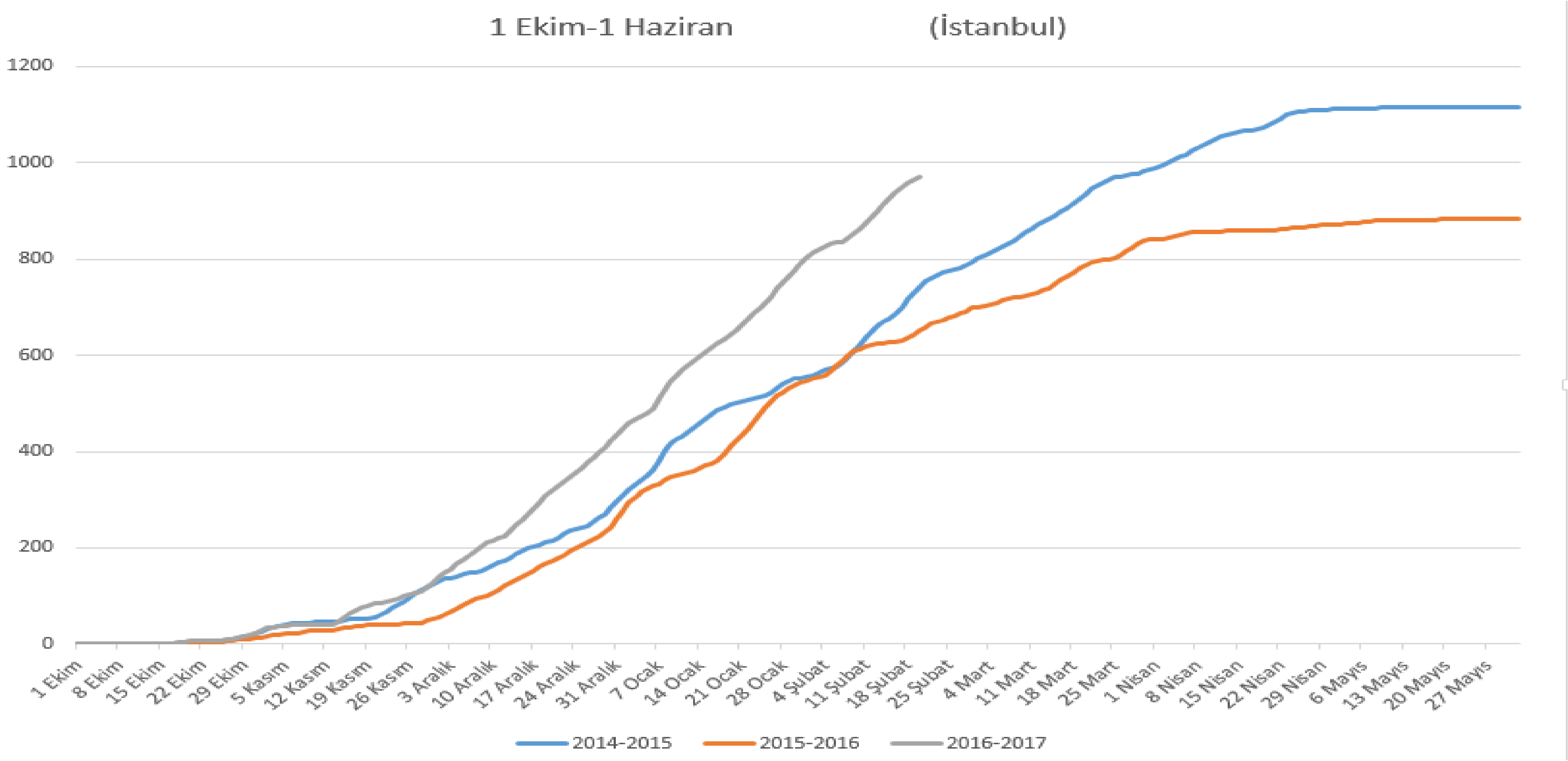


Hafta Kıyaslama

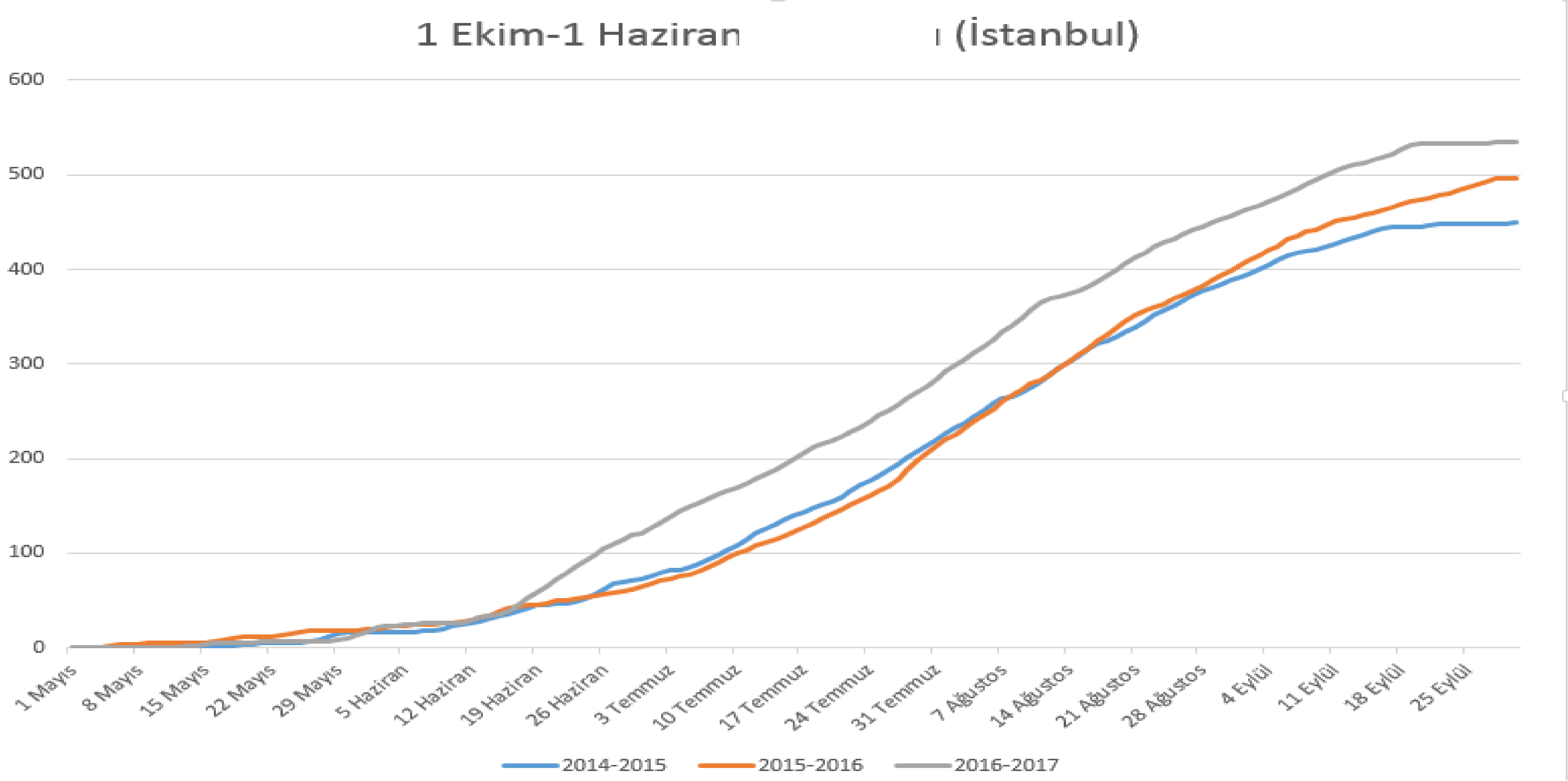


Pazar

Isıtma yılı

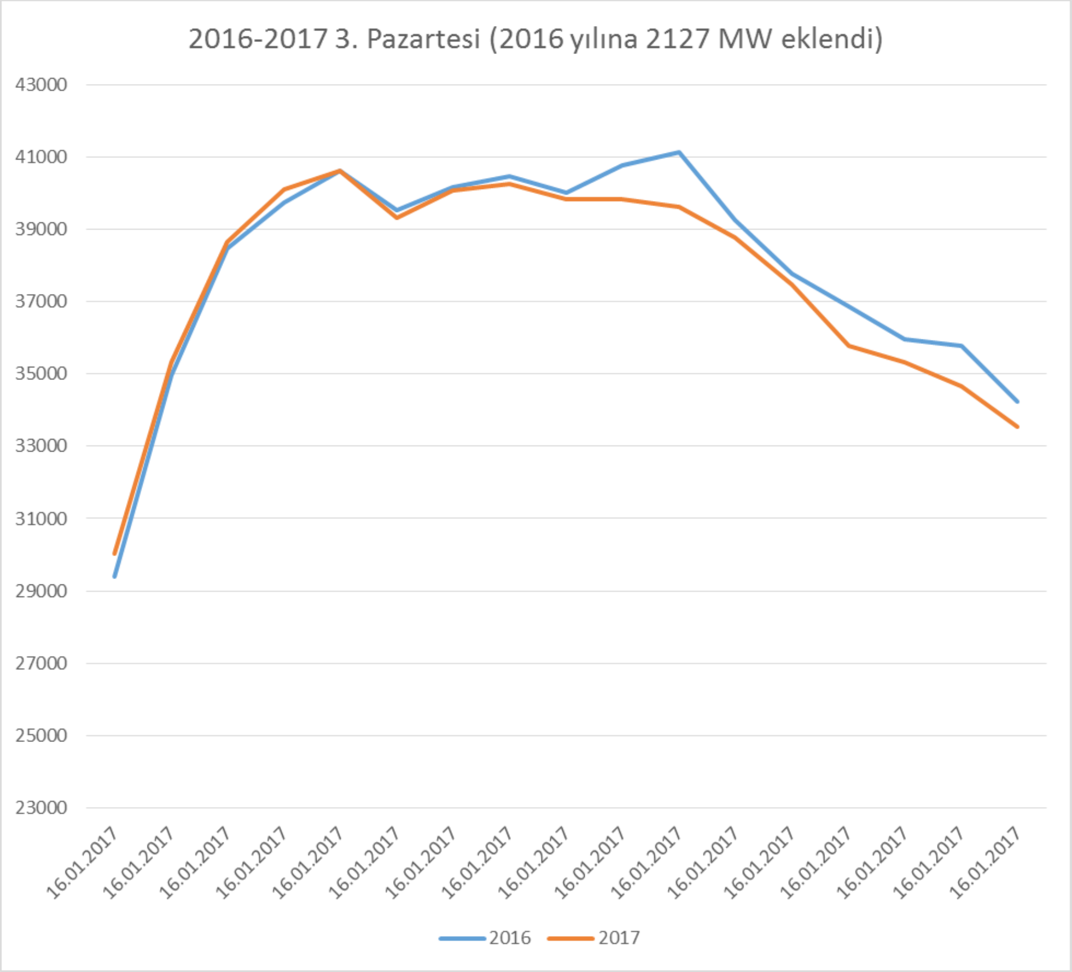

1 Ekim-1 Haziran (İstanbul)
1200
1000
800
600
400
200
0
1 Ekim
8 Ekim
15 Ekim
22 Ekim
29 Ekim
5 Kasım
12 Kasım
19 Kasım
26 Kasım
3 Aralık
10 Aralık
17 Aralık
24 Aralık
31 Aralık
7 Ocak
14 Ocak
21 Ocak
28 Ocak
4 Şubat
11 Şubat
18 Şubat
25 Şubat
4 Mart
11 Mart
18 Mart
25 Mart
1 Nisan
8 Nisan
15 Nisan
22 Nisan
29 Nisan
6 Mayıs
13 Mayıs
20 Mayıs
27 Mayıs
2014-2015
2015-2016
2016-2017

Soğutma Yılı

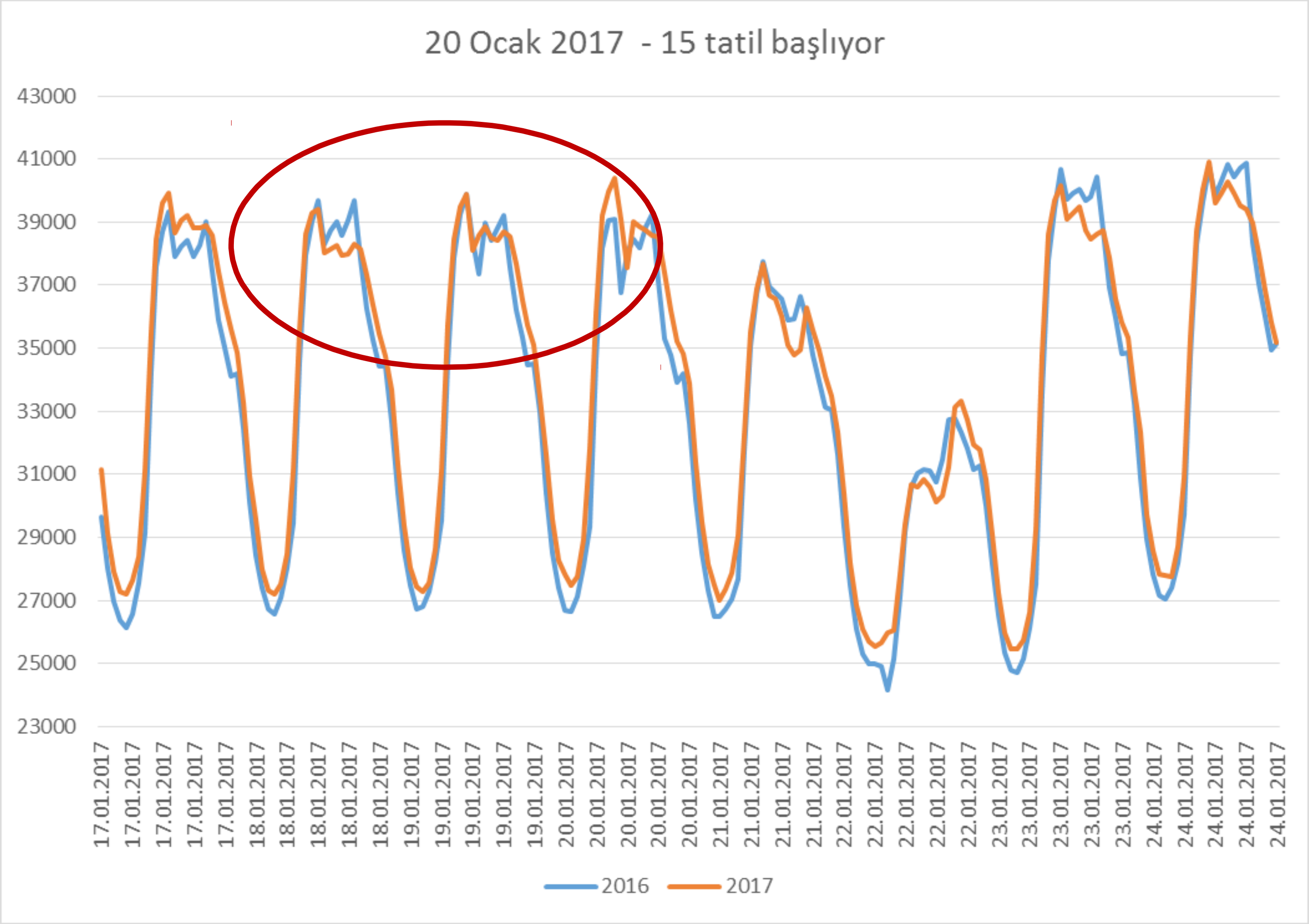


2016 ve 2017 kıyaslaması

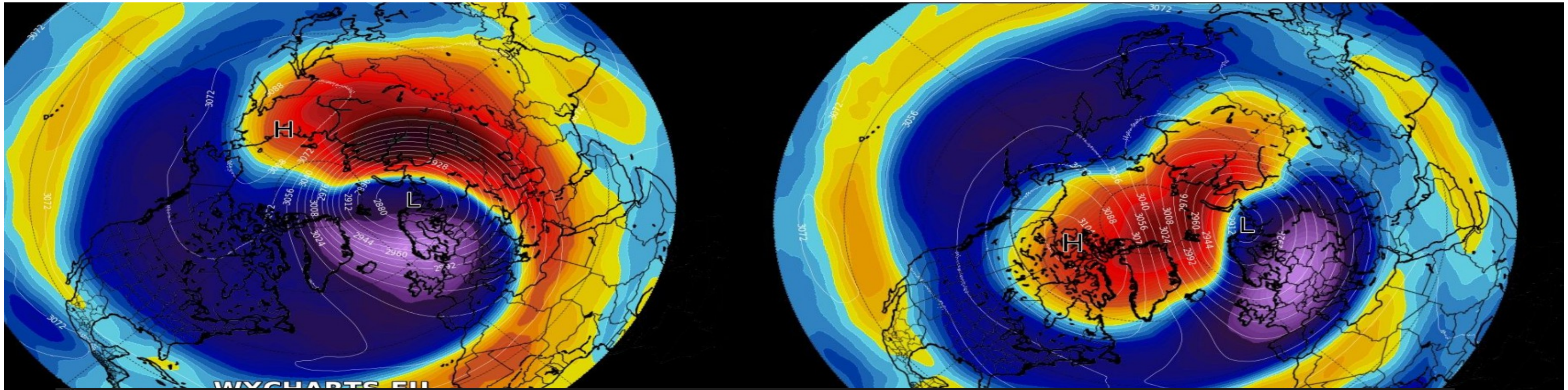
2017 3. pazartesi

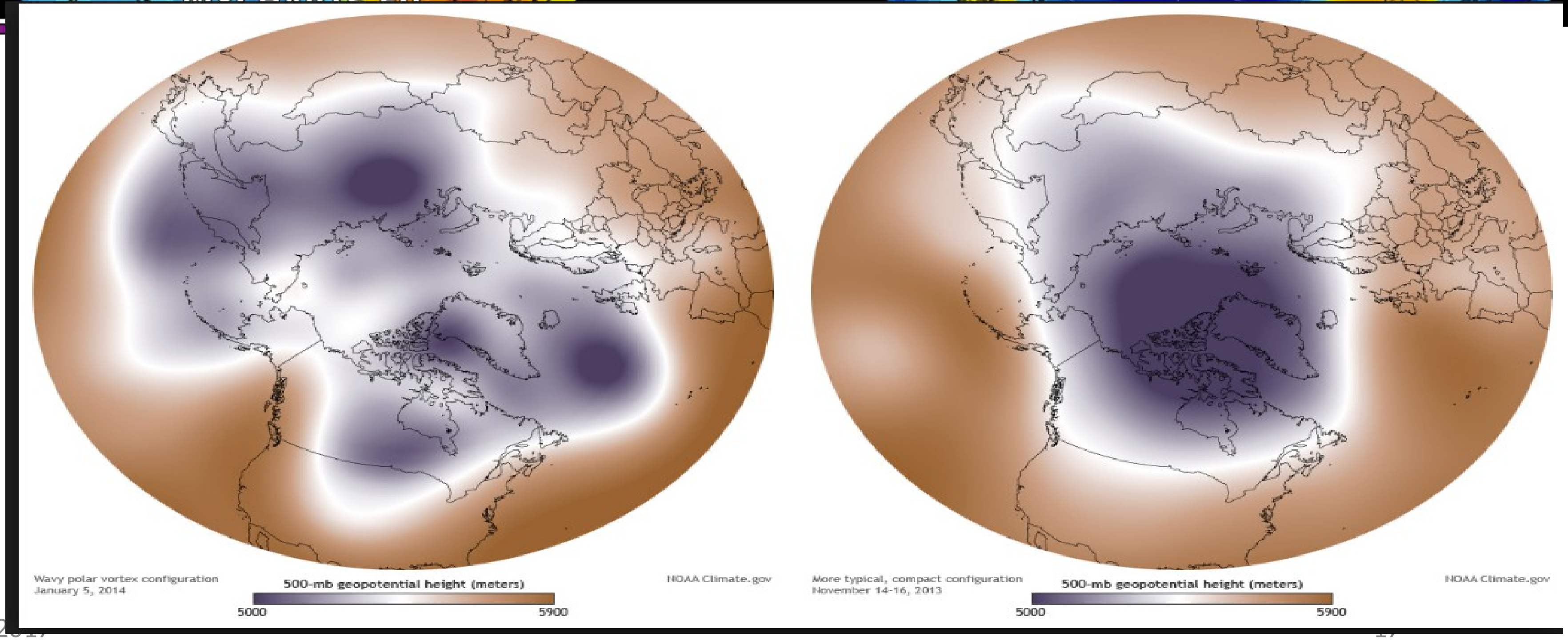


Yaşam şekli nasıl değişti



Polar Vortex- Türkiye’ye etkisi





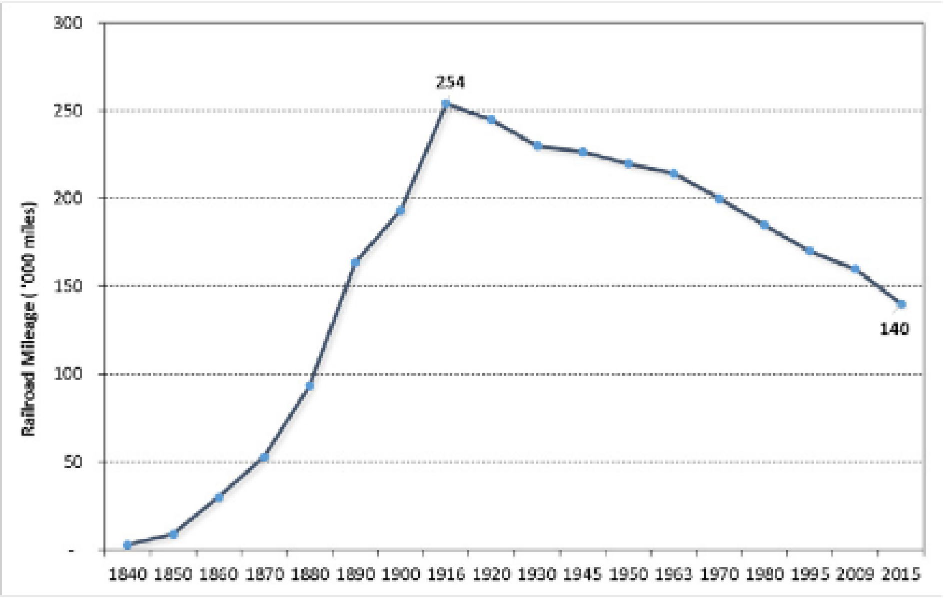
Enerji Sektörünün Geleceği için Geçmişten Örnekler

Readings in applied microeconomics: the power of the market / edited by Craig Newmark.

- Kereste yokluğu (The Timber Crisis – Charles Maurice and Charles W. Smithson)
- **1900-1908 (Kereste arzının sonu – 10 yılda tüm ağaçlar bitecek)**
- 1865-1880 : Hızlı bir ekonomik büyüme, demiryolları
  - ABD ve Avrupa arasındaki farklar
- 1880-1896 : Alternatif materyaller, dizayn iyileştirmeleri ile odun tasarrufu, kimyasallarla ömrü uzatmak (koruma/preservation deneseler de çok maliyetli)
- 1896 – kereste fiyatları artmaya başlıyor
- 1907'ye kadar %500-800 artıyor
- 1900-1914 arası demir, çelik, beton deneniyor
- 1915-1920 odun fiyatları tekrar hızla artıyor.

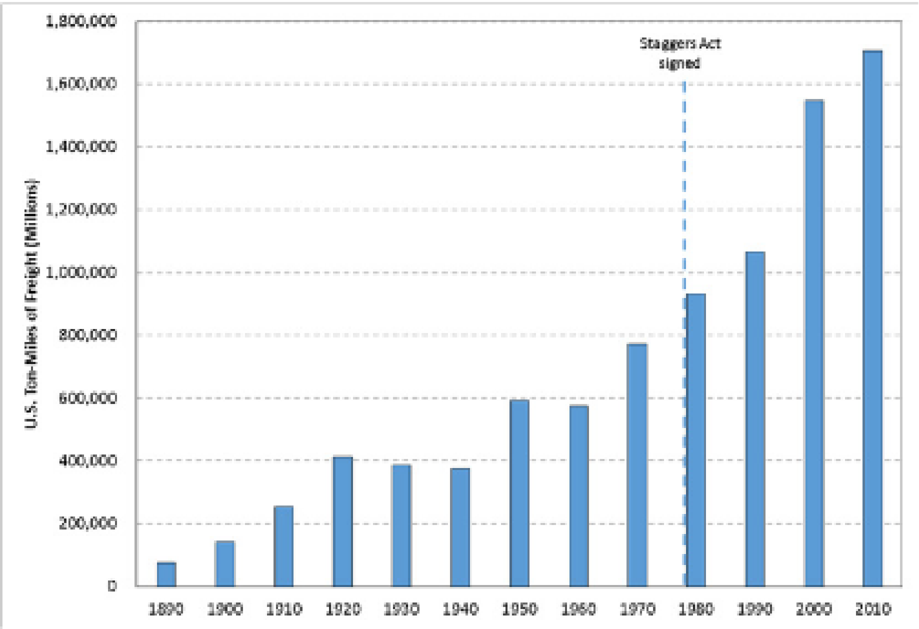
ABD‘de demiryollarına ne oldu?

Figure 1: Changes in railroad network mileage, 1840–2015



Source: Association of American Railroads (AAR), American-Rails.com.

Figure 2: Ton-miles of freight carried by rail, 1890–2010

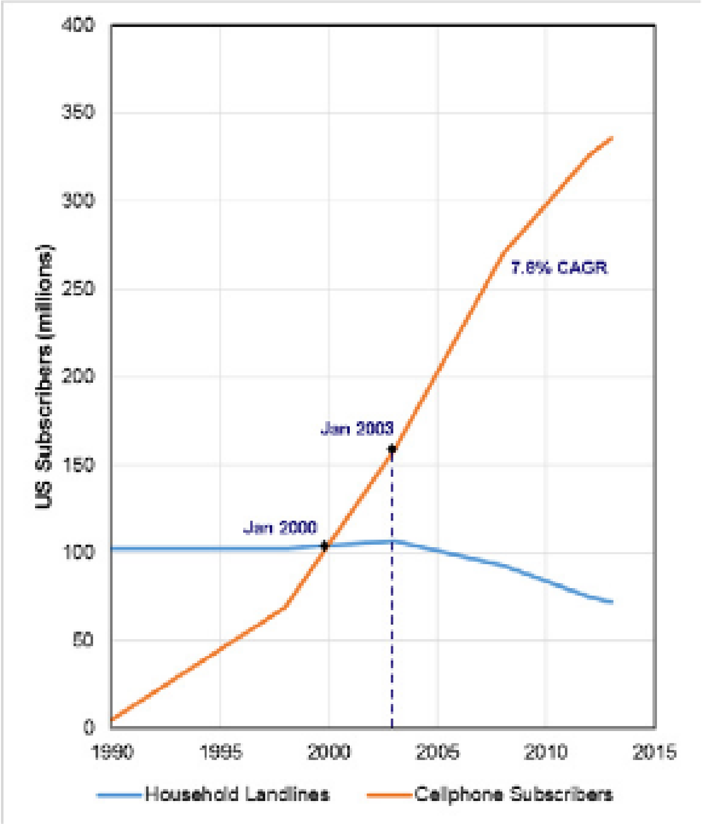


Note: The Staggers Act of 1980 was the culmination of nearly a decade of deliberation on deregulatic

http://energypolicy.columbia.edu/sites/default/files/energy/Railroads_Utilities_and_Free_Parking_What_Evolution_of_Transport_Monopolies_tells_us_about_Power_network_of_future.pdf

Cep telefonu vs Kara hatları (1990-2013)

Figure 4: Cell phone subscribers versus house landlines (1990–2013)



Source: London Economics International LLC using data from CTIA—The Wireless Association, US Census Bureau; note inflection point in 2003 when landline subscriptions began to fall.

- Türkiye‘de kara hatlarına ne oldu?
- Yer altındaki bakır teller ne oldu?

http://energypolicy.columbia.edu/sites/default/files/energy/Railroads_Utilities_and_Free_Parking_What_Evolution_of_Transport_Monopolies_tells_us_about_Power_network_of_future.pdf

Railroads, Utilities and Free Parking: What the Evolution of Transport Monopolies Tells Us About the Power Network of the Future, A.J. Goulding

- Elektrik şirketleri “doğal monopol“ statüsünü kaybedecek
- Yeni rekabetçi durum için tekrar yatırım ve iş modelleri
- Tüketiciler elektrik kullanımı ve hizmetlere verdikleri değerleri tekrar gözden geçirecek
- Kamusallar düzenli nakit gelirlerine daha az yaslanabilecek
- Kamusallar büyük hacimli elektriği uzun mesafelerde taşımaya odaklanmalı

http://energypolicy.columbia.edu/publications/report/railroads-utilities-and-free-parking-what-evolution-transport-monopolies-tells-us-about-power

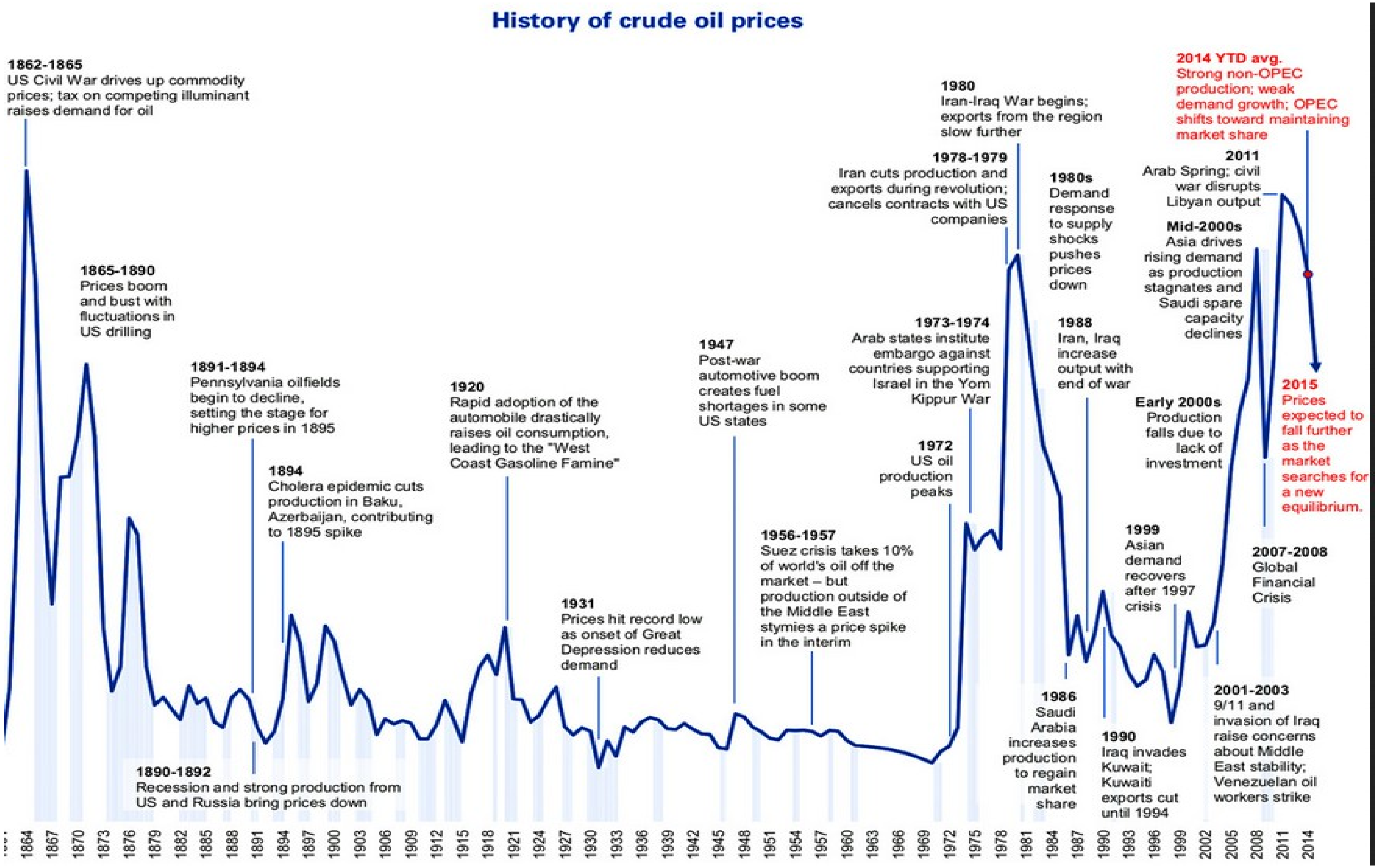
Anlatı Ekonomisi (Narrative Economics)

- Narrative Economics – Robert J. Shiller
- İnsan beyni anlatıları fazlasıyla dikkate alıyor, ve viral şekilde artıyor, ekonomik sonuçları oluyor
- 1919 ortasından 1920 sonuna kadar petrol fiyatları %50 artıyor. 1979'a kadar görülebilecek en yüksek seviyeye çıktı
- Bazı gazeteler, Meksika ve Rusya'daki petrol kesintileri
- Büyük depresyona rağmen "[1901e göre]benzin talebi 6 katına çıktı", 18 yıla petrol biter
- 1908'de Beyaz Saray'da Teddy Roosevelt, kaynakların bitişi
- 1920 Mayıs – David White – Baş jeolog, 5 veya 3 seneye üretim zirve yapar
- Yeni keşifler gerçekte 1920den sonra fiyatı hızla aşağı getirdi

Petrol fiyatlarının geleceği

- OPEC’in atası, şeyl 2-3 senede mi oldu

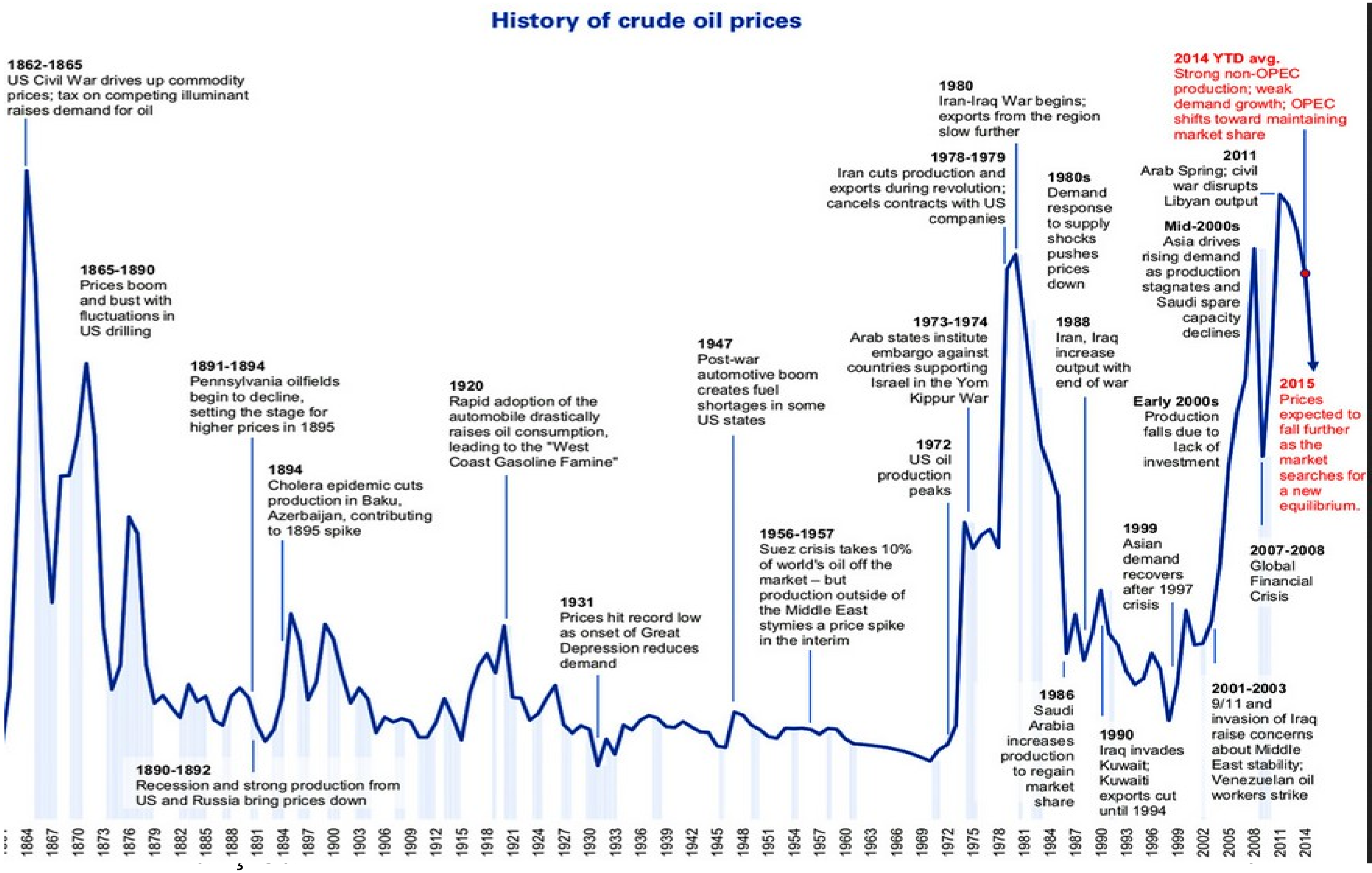
Fiyatlar 1972’lere kadar nasıl sabit gitti



http://www.businessinsider.com/annotated-history-crude-oil-prices-since-1861-2014-12

Arz fazlası nasıl yönetilir

- 1927 Oklahoma’da büyük bir keşif
- 1928-1929 California’da keşifler
- 1930 da büyük Doğu Texas sahası ile fiyatlar dip yaptı



History of crude oil prices

1862-1865
US Civil War drives up commodity prices; tax on competing illuminant raises demand for oil

1865-1890
Prices boom and bust with fluctuations in US drilling

1890-1892
Recession and strong production from US and Russia bring prices down

1891-1894
Pennsylvania oilfields begin to decline, setting the stage for higher prices in 1895

1894
Cholera epidemic cuts production in Baku, Azerbaijan, contributing to 1895 spike

1920
Rapid adoption of the automobile drastically raises oil consumption, leading to the "West Coast Gasoline Famine"

1931
Prices hit record low as onset of Great Depression reduces demand

1947
Post-war automotive boom creates fuel shortages in some US states

1956-1957
Suez crisis takes 10% of world's oil off the market – but production outside of the Middle East stymies a price spike in the interim

1972
US oil production peaks

1973-1974
Arab states institute embargo against countries supporting Israel in the Yom Kippur War

1978-1979
Iran cuts production and exports during revolution; cancels contracts with US companies

1980
Iran-Iraq War begins; exports from the region slow further

1980s
Demand response to supply shocks pushes prices down

1986
Saudi Arabia increases production to regain market share

1988
Iran, Iraq increase output with end of war

1990
Iraq invades Kuwait; Kuwaiti exports cut until 1994

1999
Asian demand recovers after 1997 crisis

Early 2000s
Production falls due to lack of investment

2001-2003
9/11 and invasion of Iraq raise concerns about Middle East stability; Venezuelan oil workers strike

Mid-2000s
Asia drives rising demand as production stagnates and Saudi spare capacity declines

2007-2008
Global Financial Crisis

2011
Arab Spring; civil war disrupts Libyan output

2014 YTD avg.
Strong non-OPEC production; weak demand growth; OPEC shifts toward maintaining market share

2015
Prices expected to fall further as the market searches for a new equilibrium.

Arz fazlası yönetimi - 2

- Hızlı üretim – 1924 Federal Oil Conservation Board
- 1926’da “ortak havzalardan üretim”
- 1929’da “Sherman Act”’a istisna ile petrol şirketleri anlaşıp üretim belirlesin
- Texas’ta Railroad Commission prorationing(sınırlama) ile görevlendirildi
- 1930-1932 5000 kuyu daha açılıyor. Fiyat 1.05’ten 0.25$’a düşüyor
- 1932’de olağanüstü hal (martial law) ile sahalar kapatılıyor
- 1933’te Texas, Oklahoma, Kansas Oil State Advisory Board kuruyor
- Anayasa Mahkemesi kararları anayasal bulmuyor
- “hot oil” problemi – sınırlama harici üretilen ürün
- 1935’de Kongre eyaletler arası petrol ticaretini sınırlandırıyor (karnelendirilmemiş petrol için)

Şeyl ne zaman başladı?

- DOE- Eastern Gas Shales Project(devasa gaz var) -1976
- Büyük ölçekte ilk hidrolik çatlatma DOE -1977
- DOE ilk çoklu çatlatma yatay sondaj Devonian şeyl – 1986
- DOE ve Gas Research Institute -> Mitchell enerji ilk kuyu, 1991
- DOE 3d mikrosismik haritalama yardımı – 1991
- 1980-2002 yoğun federal destek (Bölüm 29)

http://thebreakthrough.org/archive/new_investigation_finds_decade

https://www.foreignaffairs.com/articles/americas/2014-12-15/innovative-state

Şeyl

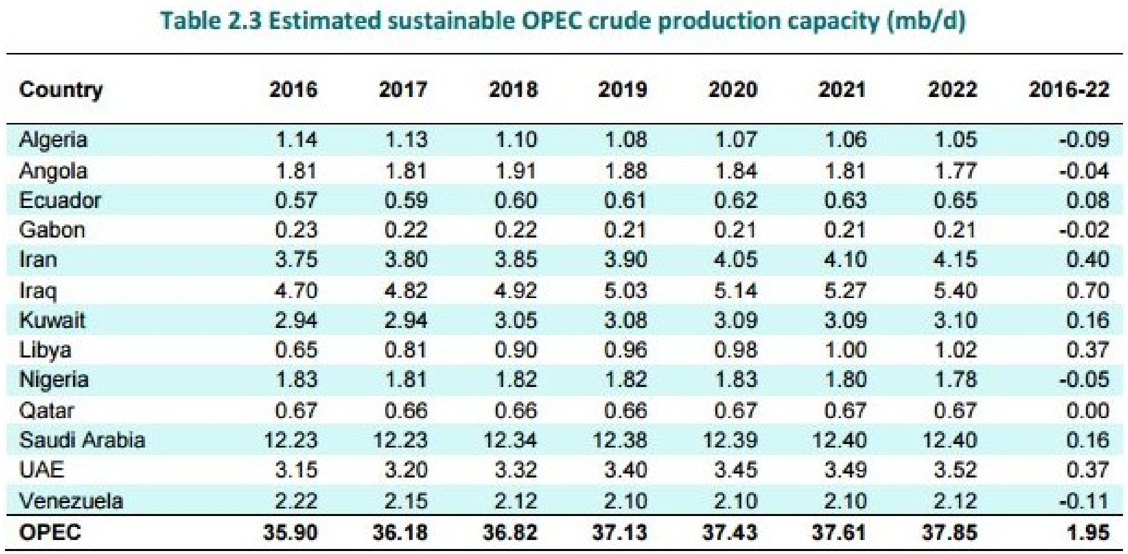
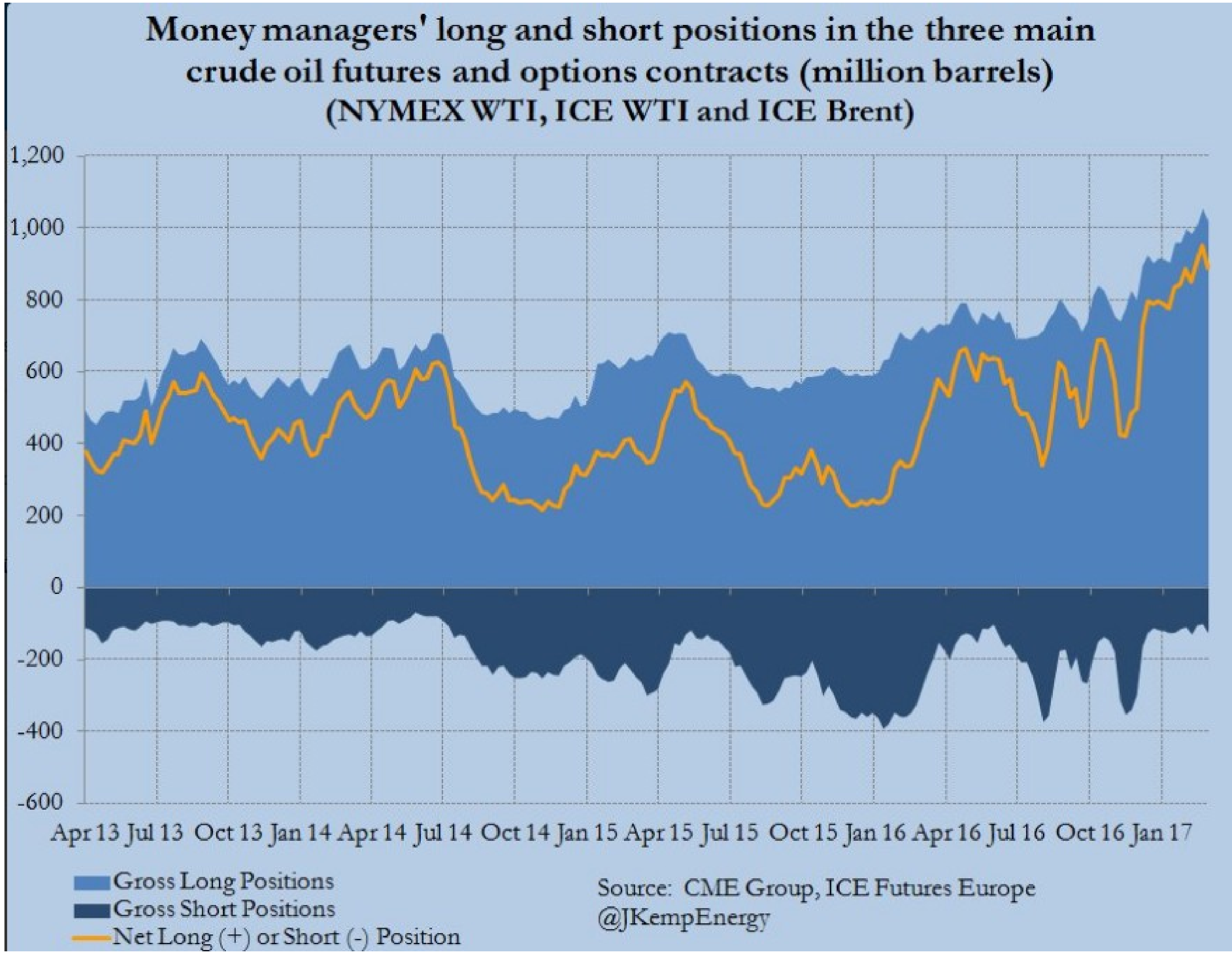


Table 2.3 Estimated sustainable OPEC crude production capacity (mb/d)

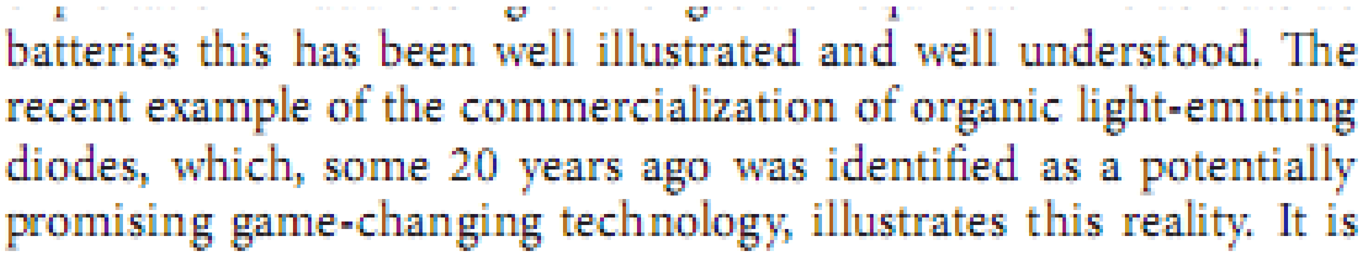
Country	2016	2017	2018	2019	2020	2021	2022	2016-22
Algeria	1.14	1.13	1.10	1.08	1.07	1.06	1.05	-0.09
Angola	1.81	1.81	1.91	1.88	1.84	1.81	1.77	-0.04
Ecuador	0.57	0.59	0.60	0.61	0.62	0.63	0.65	0.08
Gabon	0.23	0.22	0.22	0.21	0.21	0.21	0.21	-0.02
Iran	3.75	3.80	3.85	3.90	4.05	4.10	4.15	0.40
Iraq	4.70	4.82	4.92	5.03	5.14	5.27	5.40	0.70
Kuwait	2.94	2.94	3.05	3.08	3.09	3.09	3.10	0.16
Libya	0.65	0.81	0.90	0.96	0.98	1.00	1.02	0.37
Nigeria	1.83	1.81	1.82	1.82	1.83	1.80	1.78	-0.05
Qatar	0.67	0.66	0.66	0.66	0.67	0.67	0.67	0.00
Saudi Arabia	12.23	12.23	12.34	12.38	12.39	12.40	12.40	0.16
UAE	3.15	3.20	3.32	3.40	3.45	3.49	3.52	0.37
Venezuela	2.22	2.15	2.12	2.10	2.10	2.10	2.12	-0.11
OPEC	**35.90**	**36.18**	**36.82**	**37.13**	**37.43**	**37.61**	**37.85**	**1.95**



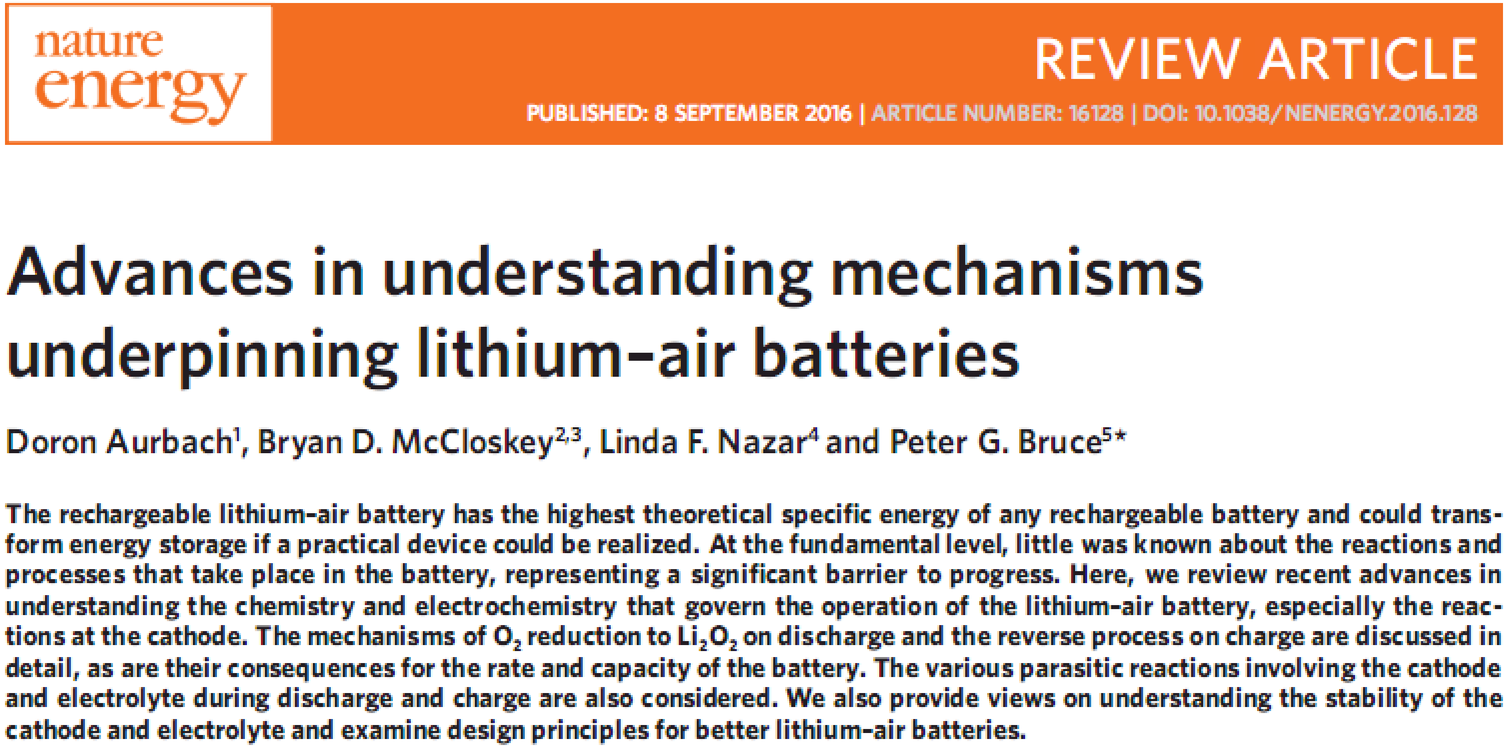
Money managers' long and short positions in the three main crude oil futures and options contracts (million barrels) (NYMEX WTI, ICE WTI and ICE Brent)

Source: CME Group, ICE Futures Europe
@JKempEnergy

Oyun değiştirici ne zaman hayata giriyor



batteries this has been well illustrated and well understood. The recent example of the commercialization of organic light-emitting diodes, which, some 20 years ago was identified as a potentially promising game-changing technology, illustrates this reality. It is



nature energy

REVIEW ARTICLE

PUBLISHED: 8 SEPTEMBER 2016 | ARTICLE NUMBER: 16128 | DOI: 10.1038/NENERGY.2016.128

Advances in understanding mechanisms underpinning lithium-air batteries

Doron Aurbach[1], Bryan D. McCloskey[2,3], Linda F. Nazar[4] and Peter G. Bruce[5]*

The rechargeable lithium-air battery has the highest theoretical specific energy of any rechargeable battery and could transform energy storage if a practical device could be realized. At the fundamental level, little was known about the reactions and processes that take place in the battery, representing a significant barrier to progress. Here, we review recent advances in understanding the chemistry and electrochemistry that govern the operation of the lithium-air battery, especially the reactions at the cathode. The mechanisms of O_2 reduction to Li_2O_2 on discharge and the reverse process on charge are discussed in detail, as are their consequences for the rate and capacity of the battery. The various parasitic reactions involving the cathode and electrolyte during discharge and charge are also considered. We also provide views on understanding the stability of the cathode and electrolyte and examine design principles for better lithium-air batteries.

http://www.nature.com/articles/nenergy2016128

Tahmin ve Öngörüde bazı kurallar

Prediction / Tahmin

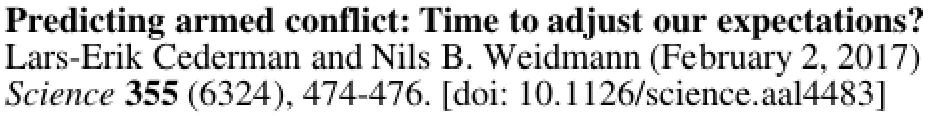
- ABD başkanlık seçimlerinde “data analitikçiler” neden yanıldı?
  - Sinyal ve gürültüyü birbirinden ayırmak gerekiyordu
  - Hernan Makse – İstatistiksel fizikçi
  - %80-%20 (hesaplanan), apart topar da makale yetiştiriyorlar

The pulse of the people
John Bohannon (February 2, 2017)
Science **355** (6324), 470-472. [doi: 10.1126/science.355.6324.470]

Kargaşaları tahmin etmek?

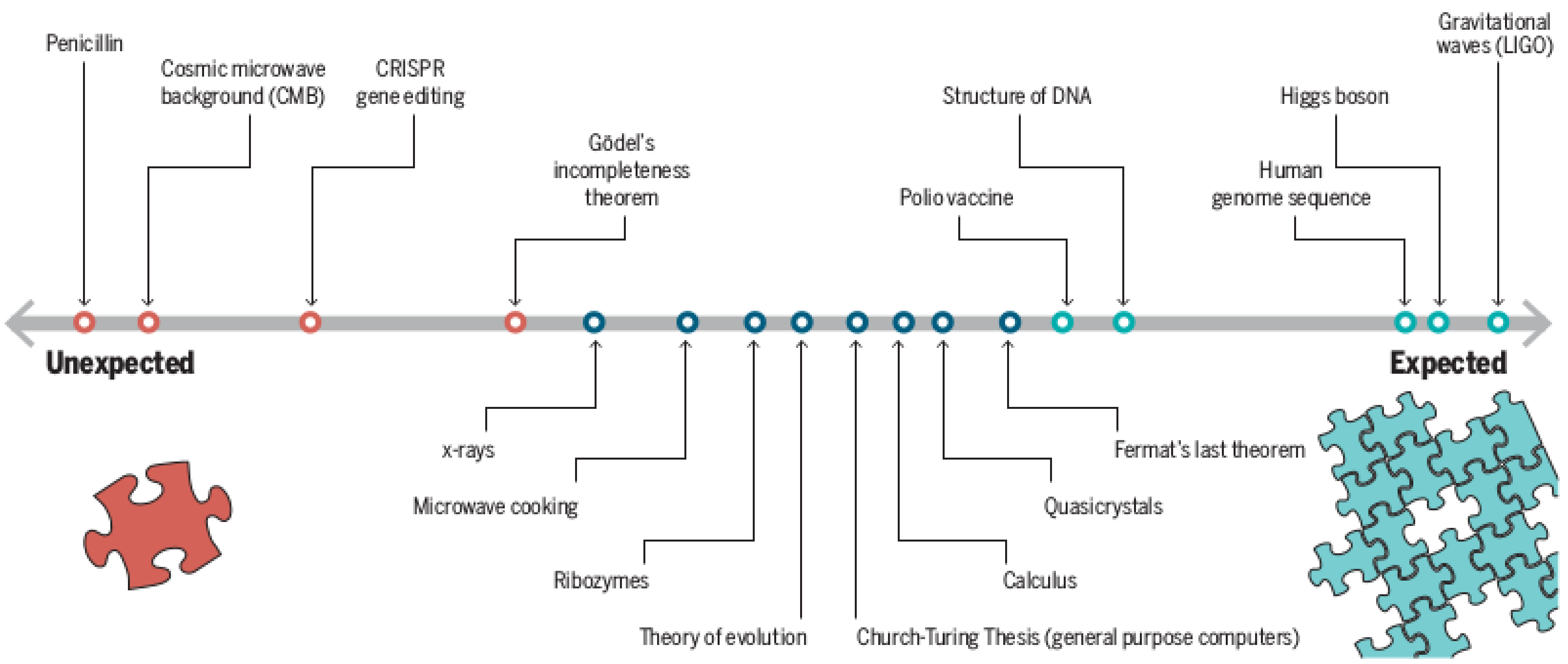
- Political Instability Task Force (Ward)
  - Tayland’daki darbeyi 1 ay önce tahmin ediyor
  - Sınırları aşan konular
  - Hangi data?
  - Sınırlar
  - “Low probability conflict events”

Science



Predicting armed conflict: Time to adjust our expectations?
Lars-Erik Cederman and Nils B. Weidmann (February 2, 2017)
Science **355** (6324), 474-476. [doi: 10.1126/science.aal4483]

Bilimsel Gelişmeleri Tahmin Etmek



GRAPHIC: ADAPTED BY K. SUTLIFF/SCIENCE

Fig. 1. How unexpected is a discovery? Scientific discoveries vary in how unexpected they were relative to existing knowledge. To illustrate this perspective, 17 examples of major scientific discoveries are arranged from the unanticipated (like antibiotics, programmable gene editing, and cosmic microwave background radiation) to expected discoveries (like the observation of gravitational waves, the structure of DNA, or the decoding of the human genome).

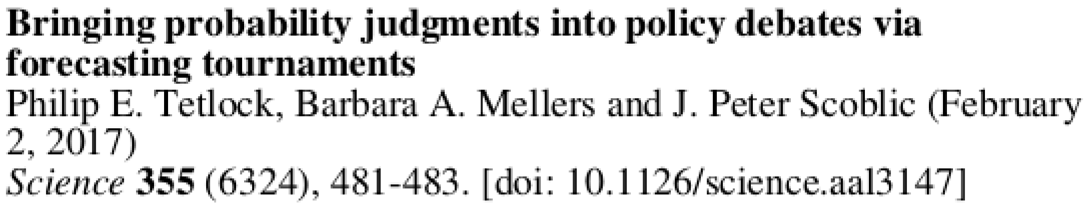
- Tahmin edilebilir kısım var, bir de tahmin edilemez kısım var
- Neden önemli?
- Enerji-teknoloji

Science

Data-driven predictions in the science of science
Aaron Clauset, Daniel B. Larremore and Roberta Sinatra (February 2, 2017)
Science **355** (6324), 477-480. [doi: 10.1126/science.aal4217]

Olasılıksal yargı ile politik tartışmalar – Tahmin Turnuvaları

- U.S. Intelligence Advanced Research Projects Activity’s (IARPA’s) Aggregative Contingent Estimation (ACE) programı
- Brier Score
- Tahmin piyasaları > Tahmin anketleri
  (ama ağırlıklı seçilmiş kalabalık>piyasalar)
- Kişilerin geçmiş tahmin tutarlılıkları önemli
- Başarılılar: Bir konudaki inanışı test etmeye/hipotez olarak görmeye istekli/tahmini de bir tür geliştirilmesi gereken beceri olarak görüyor



Bringing probability judgments into policy debates via forecasting tournaments
Philip E. Tetlock, Barbara A. Mellers and J. Peter Scoblic (February 2, 2017)
Science **355** (6324), 481-483. [doi: 10.1126/science.aal3147]

Tahmin mi Anlaşılabilirlik mi?

- Basit modeller genellemede daima en başarılı değil
- Tahmin başarısı ile modelin anlaşılabilirliği çatışmak zorunda değil
- Tahmin ederek anlaşılabilirlik arttırılabilir

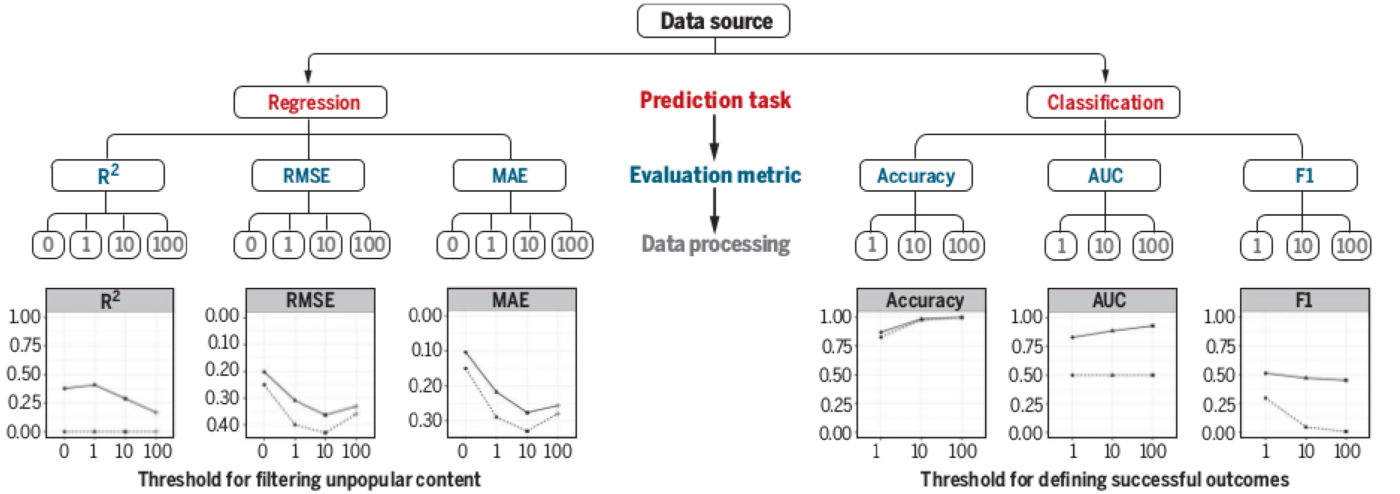


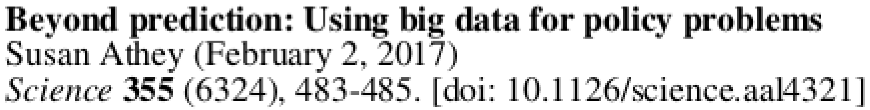
Fig. 1. A single question may correspond to many research designs, each yielding different answers. (**Top**) A depiction of the many choices involved in translating the problem of understanding diffusion cascades into a concrete prediction task, including the choice of data source, task, evaluation metric, and data preprocessing. The preprocessing choices shown at the terminal nodes refer to the threshold used to filter observations for regression or define successful outcomes for classification. Cascade sizes were log-transformed for all of the regression tasks. (**Bottom**) The results of each prediction task, for each metric, as a function of the threshold used in each task. The lower limit of each vertical axis gives the worst possible performance on each metric, and the top gives the best. Dashed lines represent the performance of a naive predictor (always forecasting the global mean for regression or the positive class for classification), and solid lines show the performance of the fitted model. R^2, coefficient of determination; AUC, area under the ROC curve; RMSE, root mean squared error; MAE, mean absolute error; F1 score, the harmonic mean of precision and recall.

Science

Prediction and explanation in social systems
Jake M. Hofman, Amit Sharma and Duncan J. Watts (February 2, 2017)
Science **355** (6324), 486-488. [doi: 10.1126/science.aal3856]

Modelleri yaparken

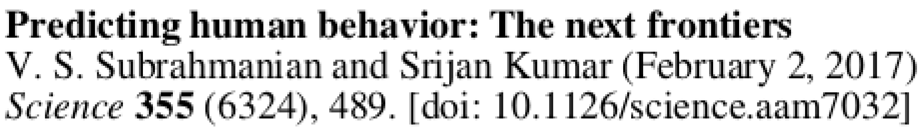
- Şeffaflık ve Yorumlanabilirlik önemli
- Adil ve ayırımcı olmaması önemli



Beyond prediction: Using big data for policy problems
Susan Athey (February 2, 2017)
Science **355** (6324), 483-485. [doi: 10.1126/science.aal4321]

İnsanları anlamak

- Daha fazla veri her zaman daha iyi tahmin modelleri demek değil. Gürültü verinin üzerine çıkabilir.
- Ender olay tahminleri..
- Çok adımlı modeller ile sürecin parçalarına bakmak
- İnsan davranışları dinamik olarak değişiyor



Predicting human behavior: The next frontiers
V. S. Subrahmanian and Srijan Kumar (February 2, 2017)
Science **355** (6324), 489. [doi: 10.1126/science.aam7032]

Elektrik talep tahminleri

(En çok referans verilen çalışmalar, bir bias var mı?)

Grey prediction with rolling mechanism for electricity demand forecasting of Turkey (Cites 297) - 2007

Industrial:140.37 TWh - 2015 (103 TWh)
Total: 265.7 TWh - 2015 (261 TWh)

ELSEVIER

Energy

Volume 32, Issue 9, September 2007, Pages 1670–1675

Grey prediction with rolling mechanism for electricity demand forecasting of Turkey

Diyar Akay , Mehmet Atak

Department of Industrial Engineering, Gazi University, 06570 Ankara, Turkey

Received 7 August 2006, Available online 16 January 2007

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http://dx.doi.org/10.1016/j.energy.2006.11.014

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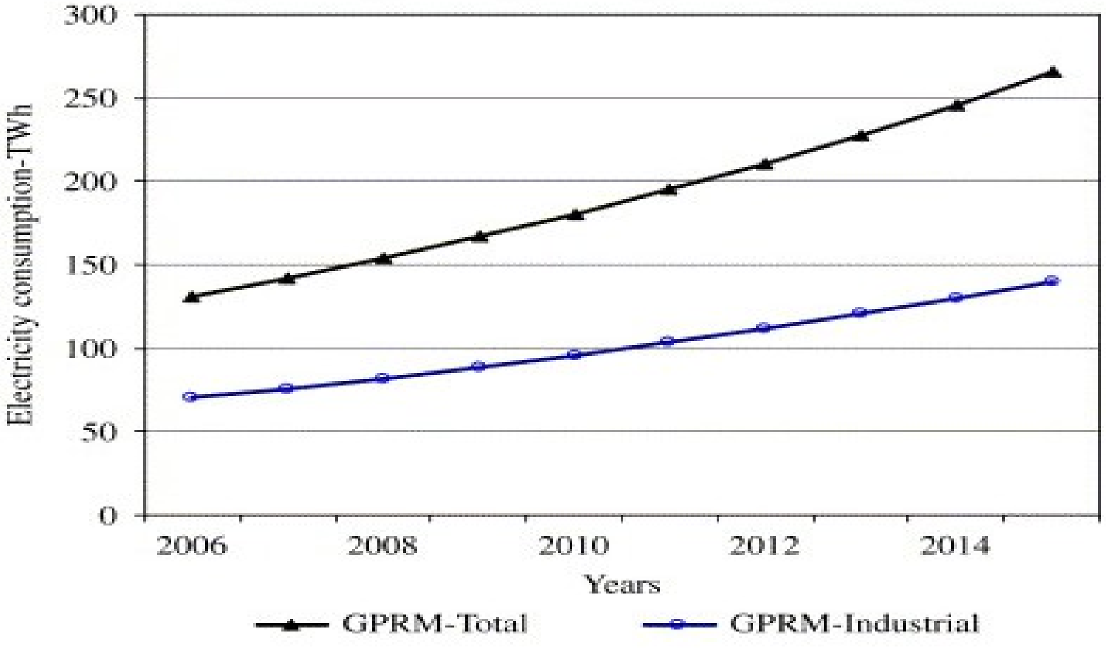

http://www.sciencedirect.com/science/article/pii/S0360544206003458

Electricity demand analysis using cointegration and ARIMA modelling: A case study of Turkey (Cites 214)

- 2014 : 257 TWh demand 251 prod / 207 TWh net


Energy Policy
Volume 35, Issue 2, February 2007, Pages 1129–1146

Electricity demand analysis using cointegration and ARIMA modelling: A case study of Turkey

Erkan Erdogdu
Show more

http://dx.doi.org/10.1016/j.enpol.2006.02.013

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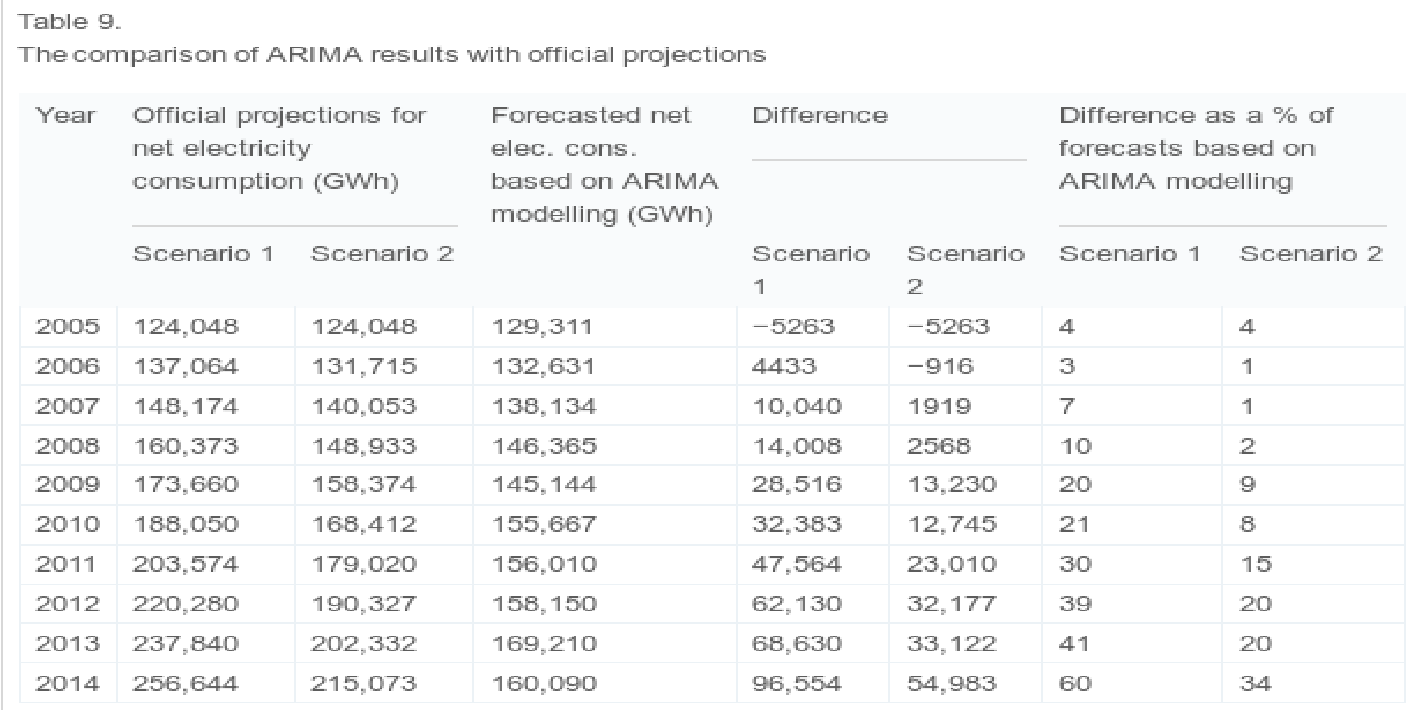


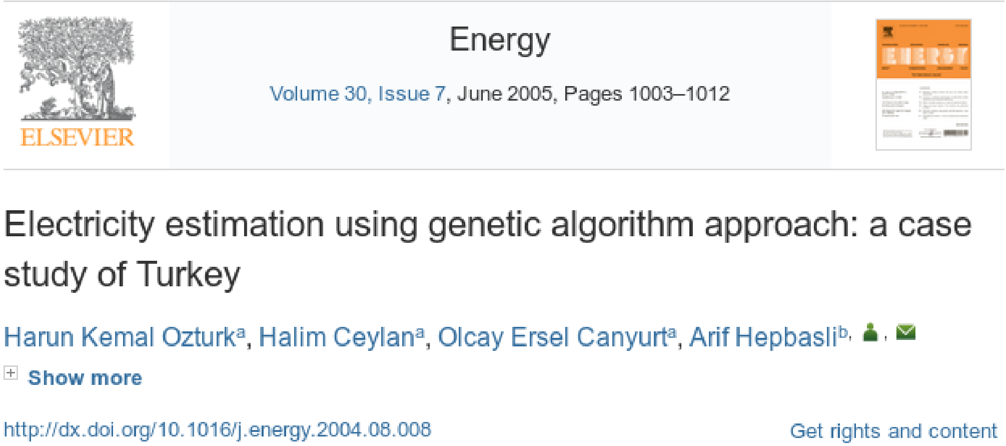
Table 9.
The comparison of ARIMA results with official projections

Year	Official projections for net electricity consumption (GWh)		Forecasted net elec. cons. based on ARIMA modelling (GWh)	Difference		Difference as a % of forecasts based on ARIMA modelling	
	Scenario 1	Scenario 2		Scenario 1	Scenario 2	Scenario 1	Scenario 2
2005	124,048	124,048	129,311	−5263	−5263	4	4
2006	137,064	131,715	132,631	4433	−916	3	1
2007	148,174	140,053	138,134	10,040	1919	7	1
2008	160,373	148,933	146,365	14,008	2568	10	2
2009	173,660	158,374	145,144	28,516	13,230	20	9
2010	188,050	168,412	155,667	32,383	12,745	21	8
2011	203,574	179,020	156,010	47,564	23,010	30	15
2012	220,280	190,327	158,150	62,130	32,177	39	20
2013	237,840	202,332	169,210	68,630	33,122	41	20
2014	256,644	215,073	160,090	96,554	54,983	60	34

http://www.sciencedirect.com/science/article/pii/S030142150600098X

Electricity estimation using genetic algorithm approach: a case study of Turkey (Cites 141)

- 2016 ~ 278 Twh



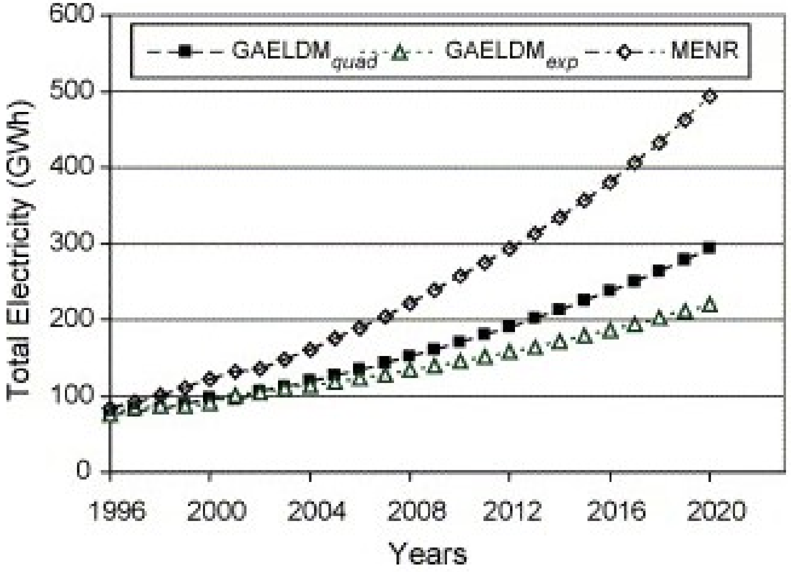
Energy

Volume 30, Issue 7, June 2005, Pages 1003–1012

Electricity estimation using genetic algorithm approach: a case study of Turkey

Harun Kemal Ozturk[a], Halim Ceylan[a], Olcay Ersel Canyurt[a], Arif Hepbasli[b],

http://dx.doi.org/10.1016/j.energy.2004.08.008



http://www.sciencedirect.com/science/article/pii/S036054420400339 1

Turkey's short-term gross annual electricity demand forecast by fuzzy logic approach
(Cites: 78)

- 2014 – 257 TWh

Energy Policy

Volume 38, Issue 5, May 2010, Pages 2438–2445

Turkey's short-term gross annual electricity demand forecast by fuzzy logic approach

Serhat Kucukali[a], [1], Kemal Baris[b]

Show more

http://dx.doi.org/10.1016/j.enpol.2009.12.037

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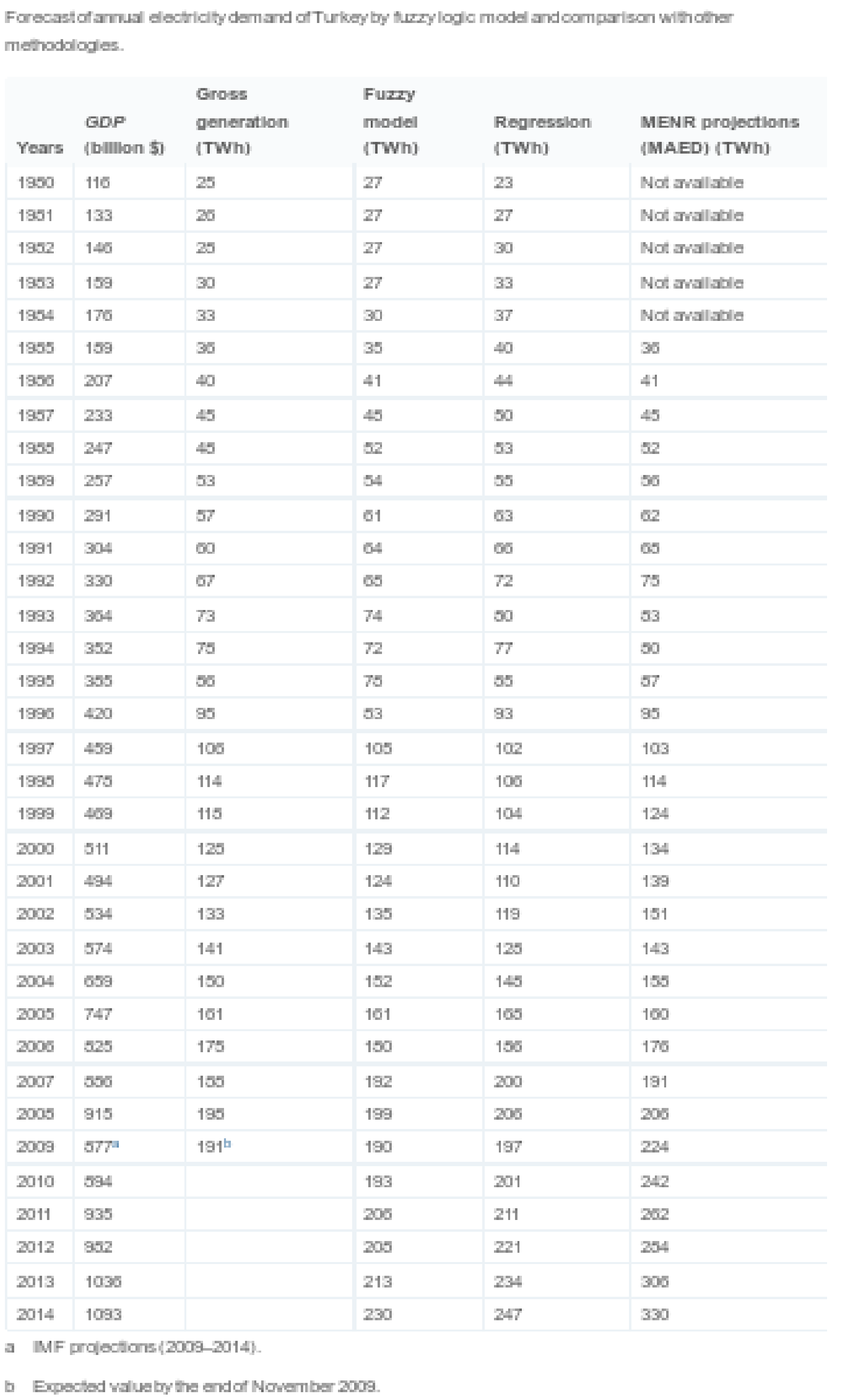


Forecast of annual electricity demand of Turkey by fuzzy logic model and comparison with other methodologies.

Years	GDP (billion $)	Gross generation (TWh)	Fuzzy model (TWh)	Regression (TWh)	MENR projections (MAED) (TWh)
1980	116	25	27	23	Not available
1981	133	26	27	27	Not available
1982	146	28	27	30	Not available
1983	159	30	27	33	Not available
1984	176	33	30	37	Not available
1985	189	36	35	40	36
1986	207	40	41	44	41
1987	233	45	45	50	45
1988	247	48	52	53	52
1989	257	53	54	55	56
1990	291	57	61	63	62
1991	304	60	64	66	65
1992	330	67	65	72	75
1993	364	73	74	80	83
1994	352	78	72	77	80
1995	385	86	78	85	87
1996	420	95	93	93	95
1997	459	106	105	102	103
1998	478	114	117	108	114
1999	469	116	112	104	124
2000	511	125	129	114	134
2001	494	127	124	110	139
2002	534	133	135	119	151
2003	574	141	143	128	143
2004	659	150	152	145	158
2005	747	161	161	168	160
2006	825	176	180	158	176
2007	886	188	192	200	191
2008	915	198	199	208	208
2009	877[a]	191[b]	190	197	224
2010	894		193	201	242
2011	935		208	211	262
2012	982		208	221	284
2013	1036		213	234	308
2014	1093		230	247	330

a IMF projections (2009–2014).

b Expected value by the end of November 2009.

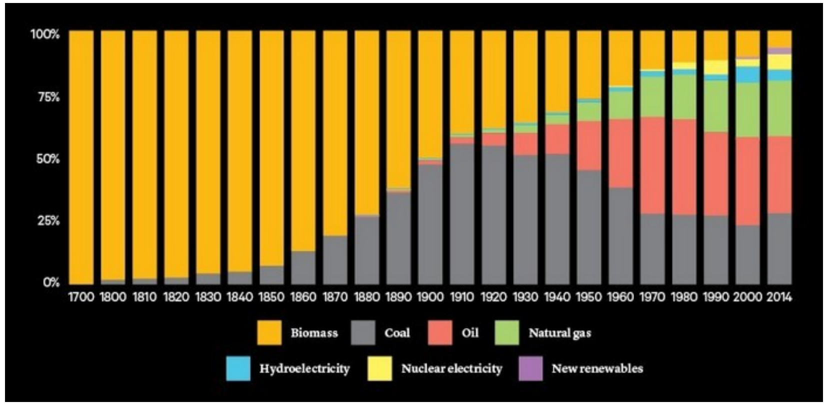
http://www.sciencedirect.com/science/article/pii/S0301421509009938

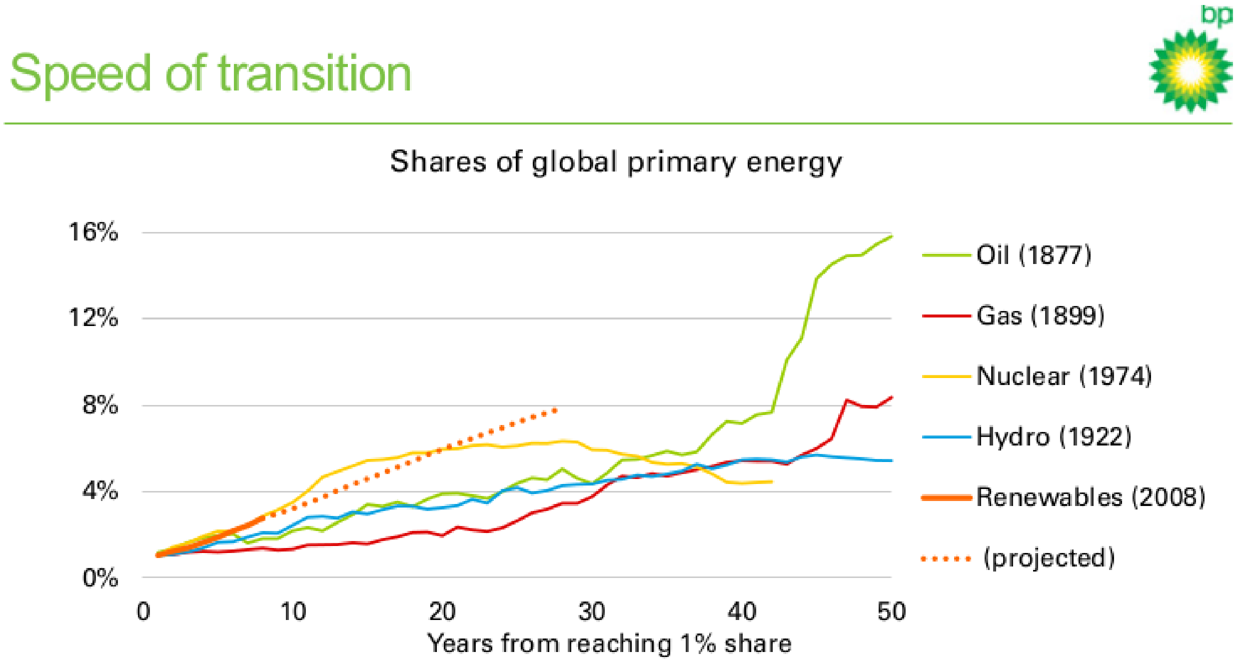
Yöntem ne?

- 2007’den itibaren pekçok model incelendi
- Modellerin hepsinin bir içyargısı – tarafı var. Algoritmalarla sabit
- Aynı ekonomik büyüme verisi ile 10 ayrı sonuç
- O zaman, çok model çalıştırarak “bias” i normalize et
- Gruplaştıkları demetleri al, alt-üst ve ortalama al

Enerji Dönüşümü ne kadar sürer

Dönüşüm hızları

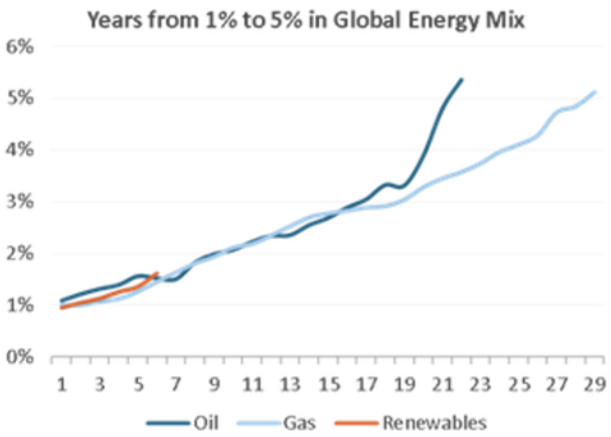


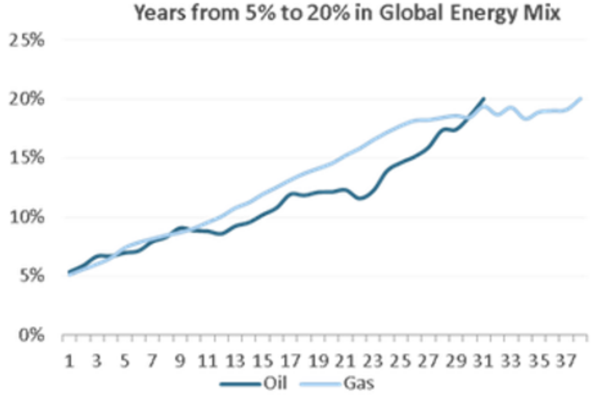


Speed of transition

see "Economic development and the demand for energy" by Ruehl et al, Energy Policy, 2012

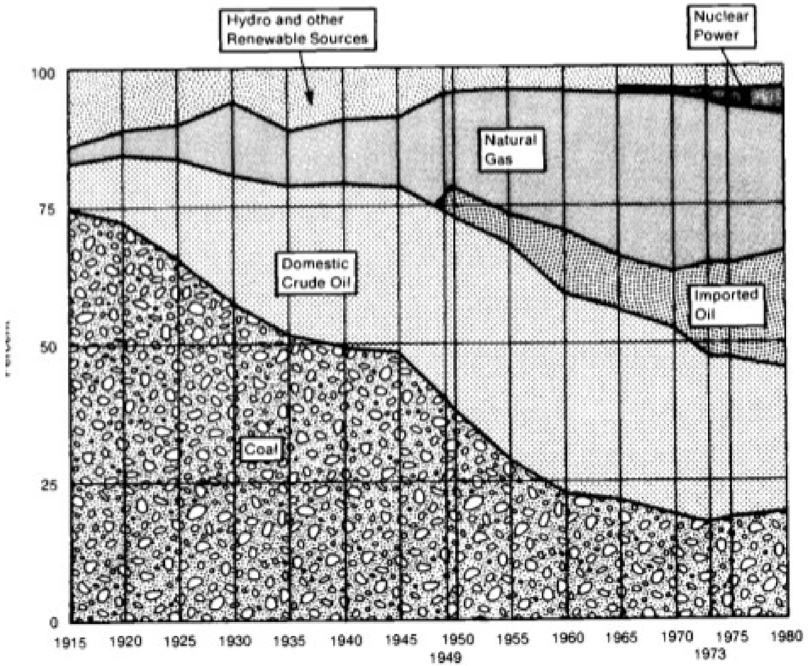
BP Statistical Review of World Energy





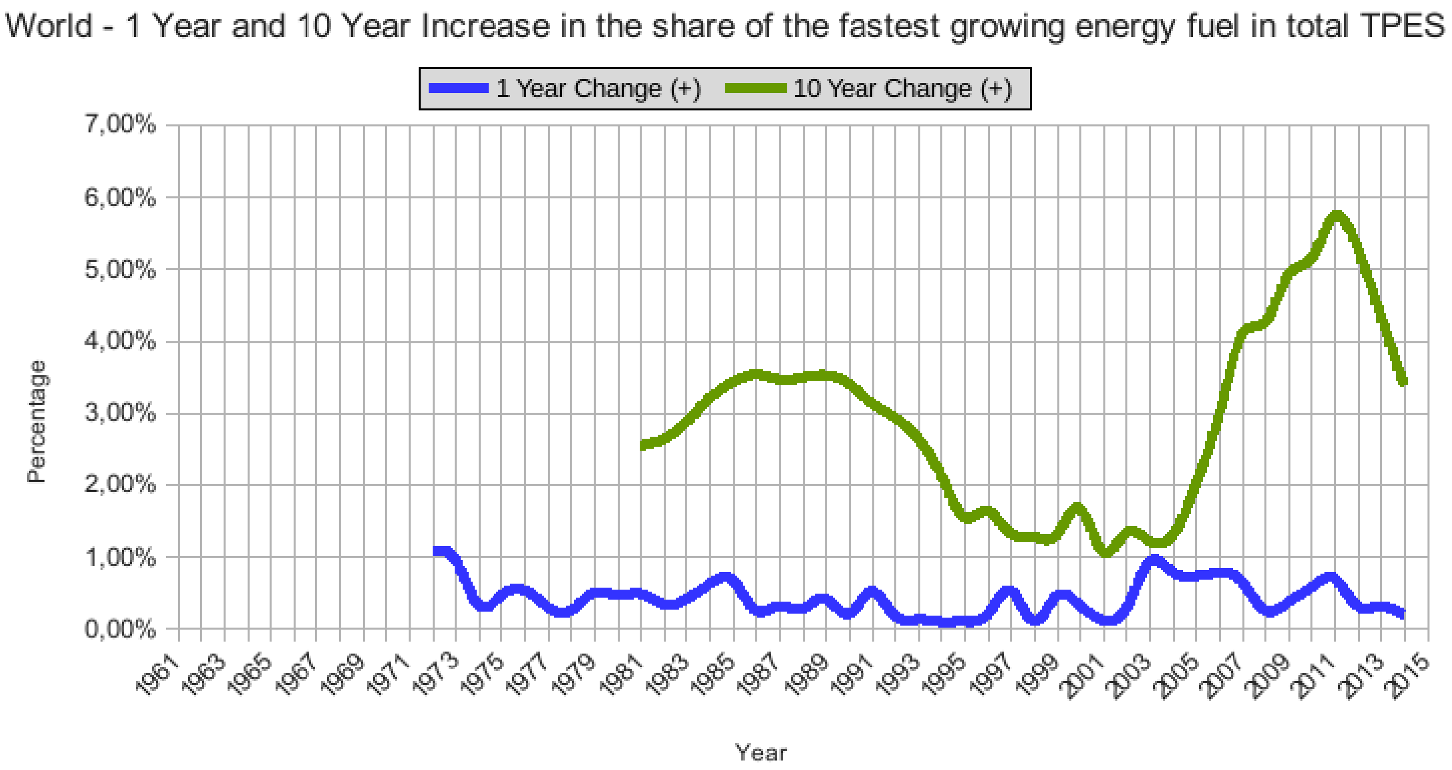
Kömür ilk kez mi düşüyor

U.S. Consumption of Energy Fuels
1915-1980
(Percent on a BTU-equivalent Basis)



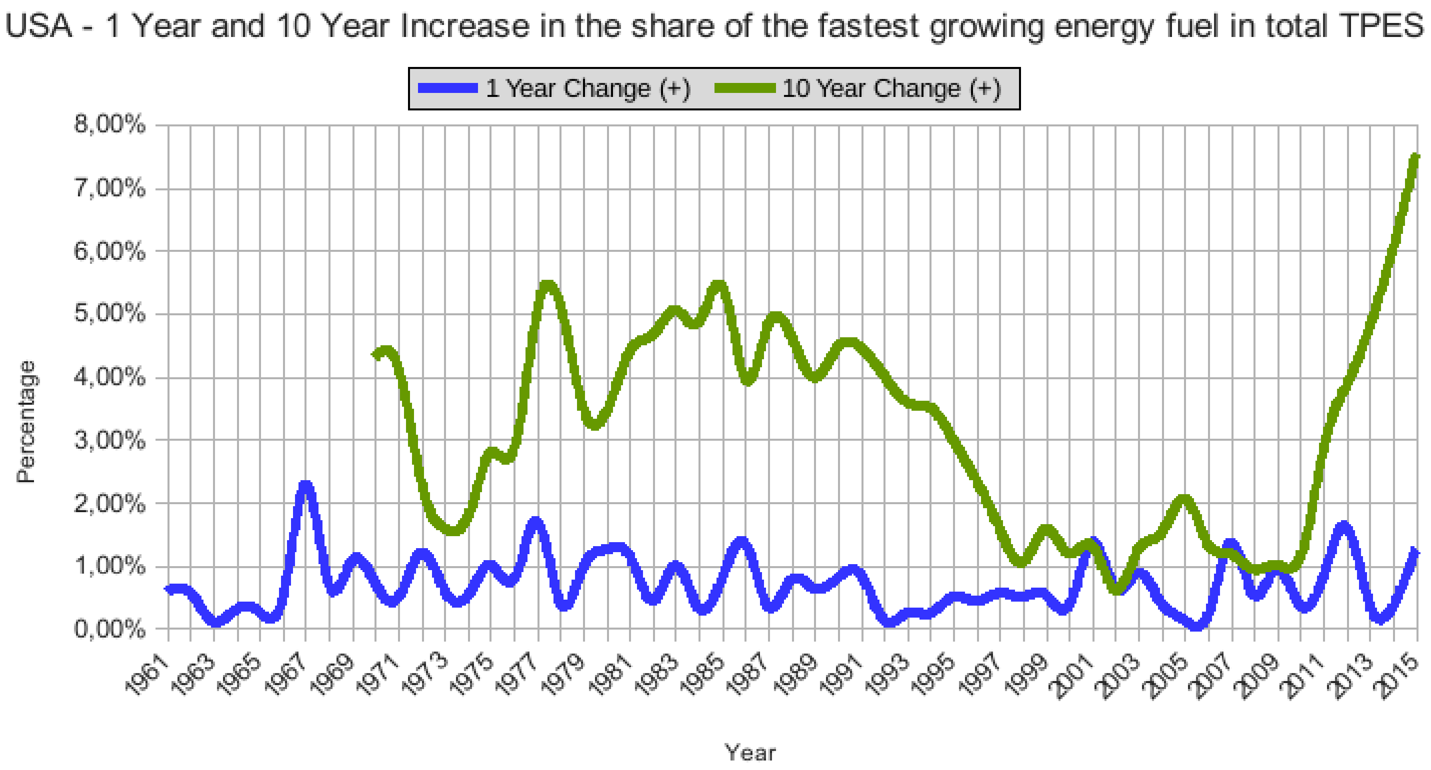
Sources: Sam Shurr et al., Energy in the American Economy, 1850–1975 (Baltimore: Johns Hopkins University Press, 1960); American Petroleum Institute, Basic Petroleum Data Book, November 1976; Exxon Background Series, World Energy Outlook (New York: Exxon Corporation, 1981).

Dünyadaki dönüşüm – Kömür/Petrol/Gaz



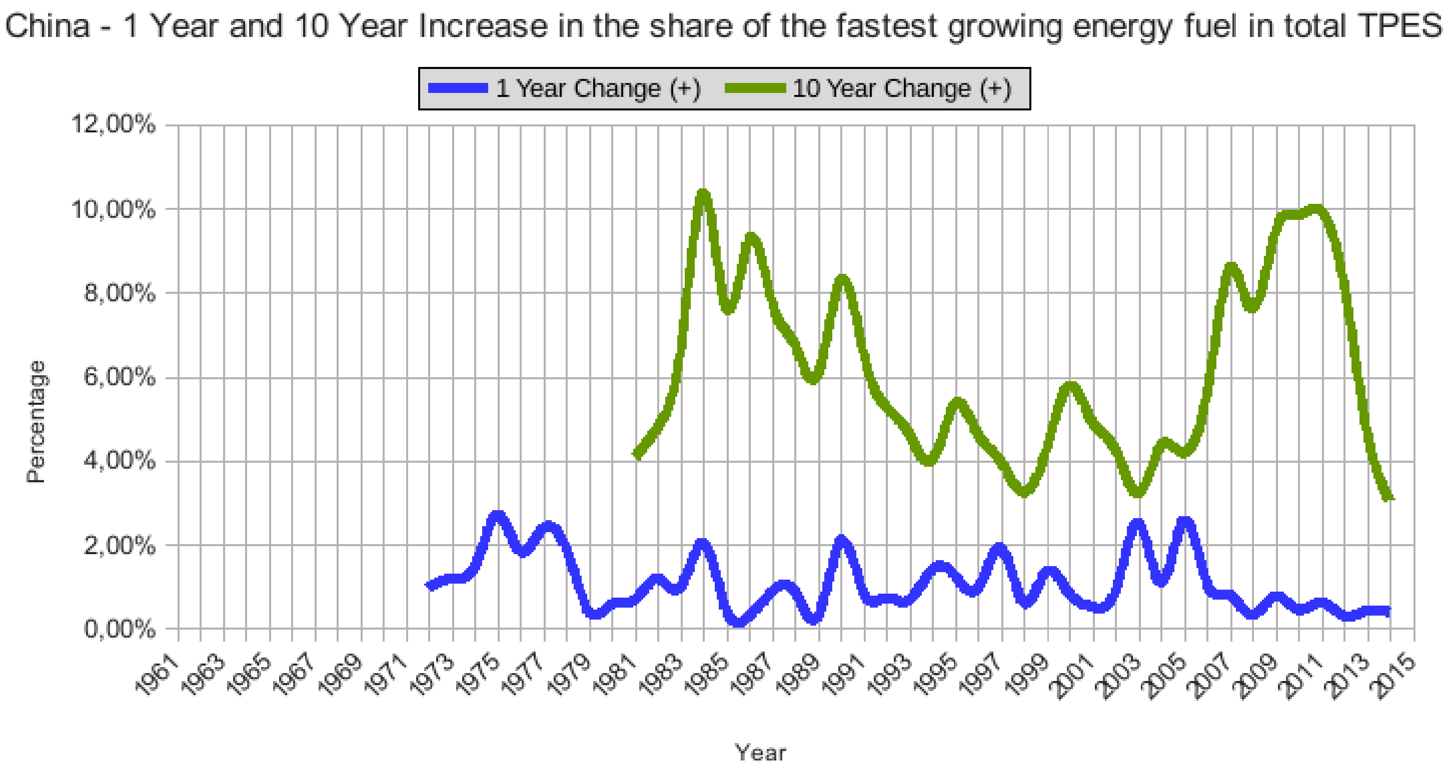
http://www.barissanli.com/calismalar/2017/bsanli-speedofenergytransition.pdf

ABD



http://www.barissanli.com/calismalar/2017/bsanli-speedofenergytransition.pdf

Çin


China - 1 Year and 10 Year Increase in the share of the fastest growing energy fuel in total TPES
1 Year Change (+)
10 Year Change (+)
12,00%
10,00%
8,00%
6,00%
4,00%
2,00%
0,00%
Percentage
1961
1963
1965
1967
1969
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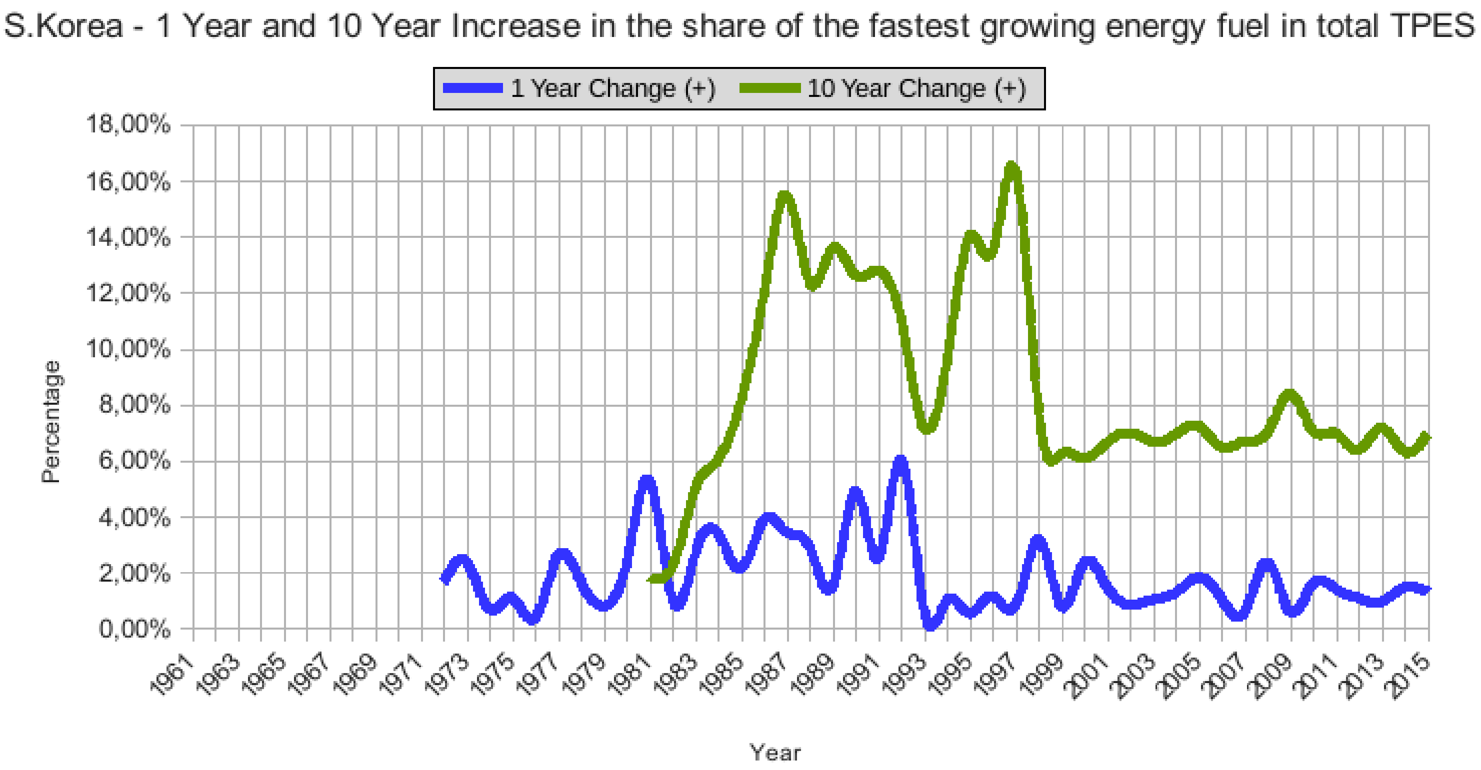
2015
Year

Kore


S.Korea - 1 Year and 10 Year Increase in the share of the fastest growing energy fuel in total TPES
1 Year Change (+)
10 Year Change (+)
18,00%
16,00%
14,00%
12,00%
10,00%
8,00%
6,00%
4,00%
2,00%
0,00%
Percentage
1961
1963
1965
1967
1969
1971
1973
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1977
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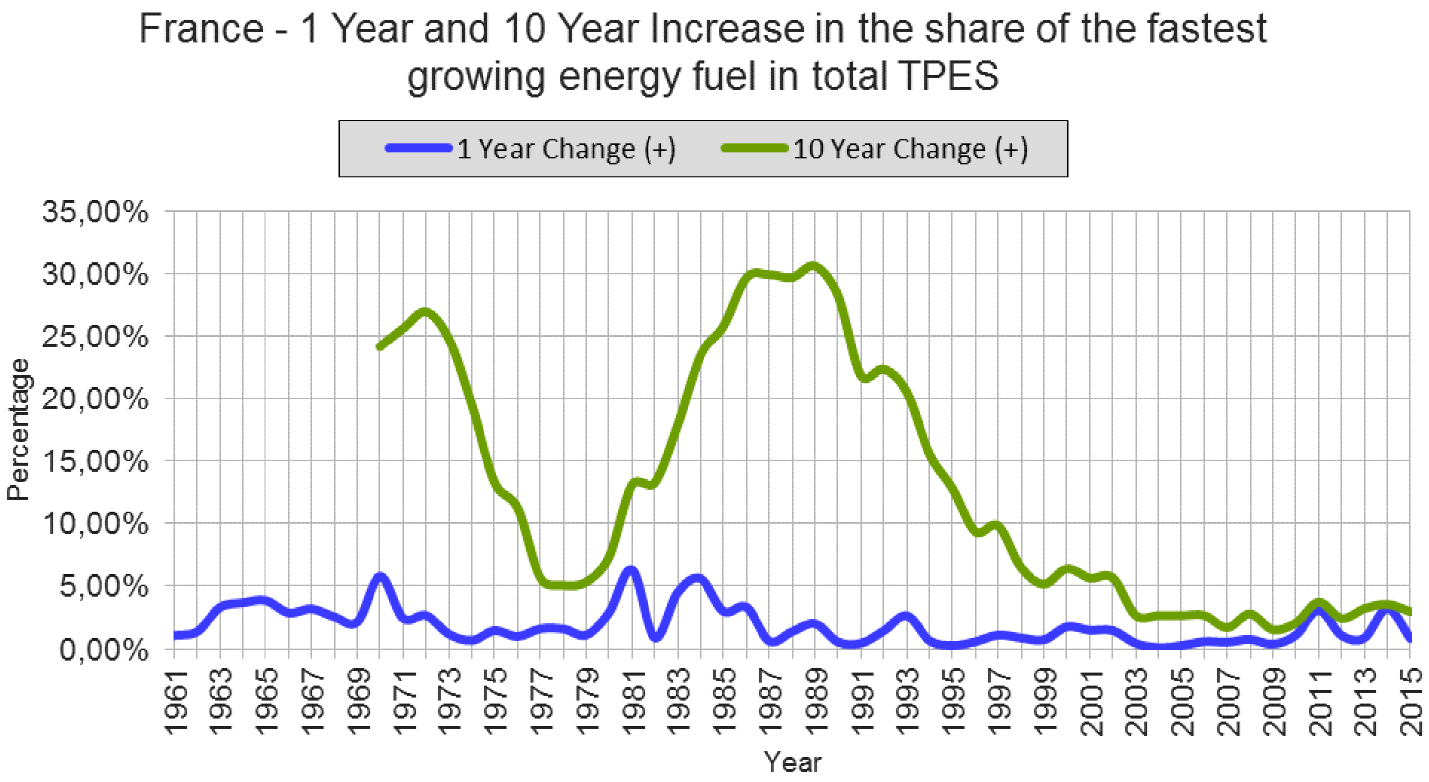
2015
Year

Fransa


France - 1 Year and 10 Year Increase in the share of the fastest growing energy fuel in total TPES
1 Year Change (+)
10 Year Change (+)
Percentage
35,00%
30,00%
25,00%
20,00%
15,00%
10,00%
5,00%
0,00%
1961
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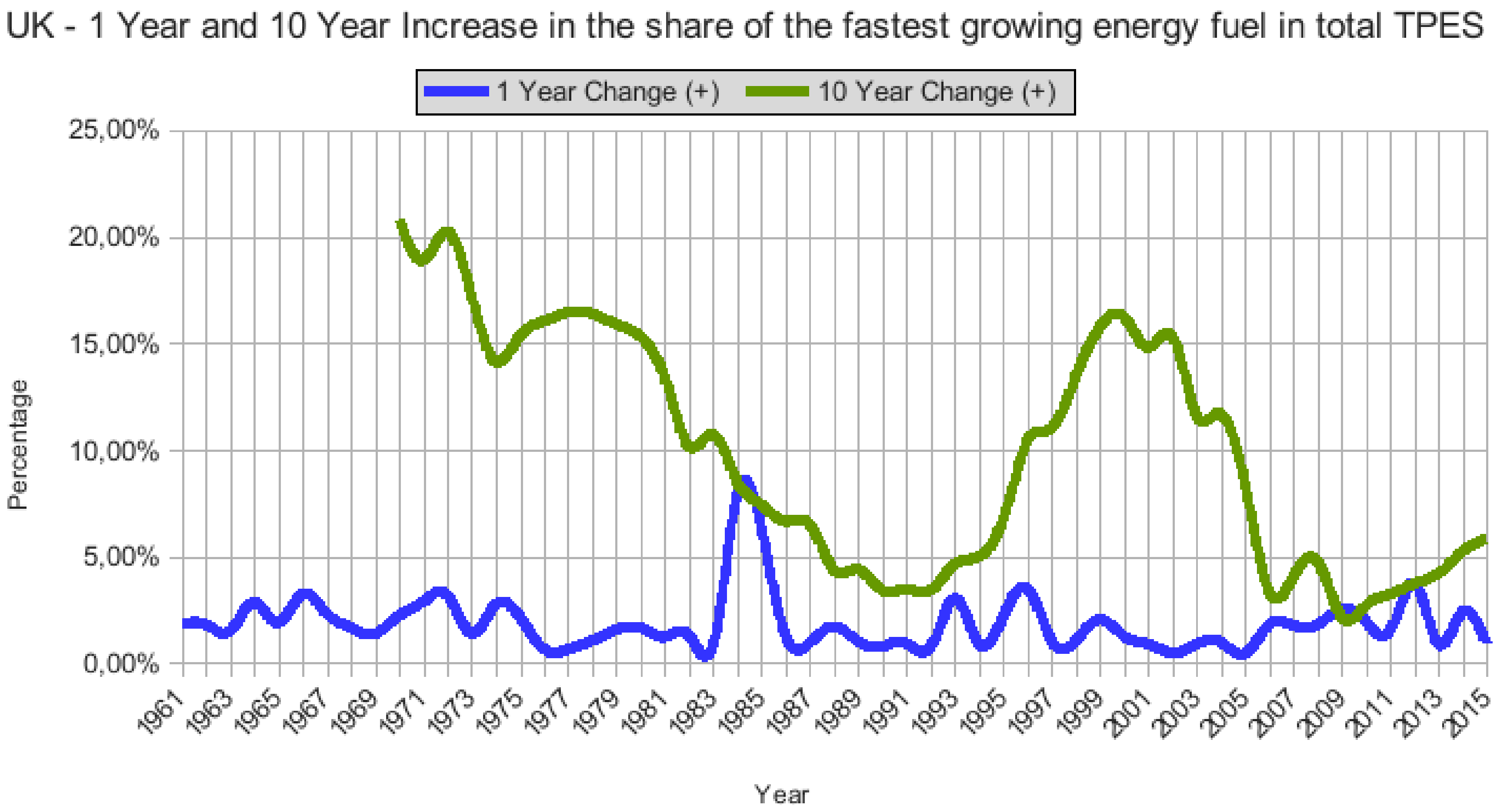
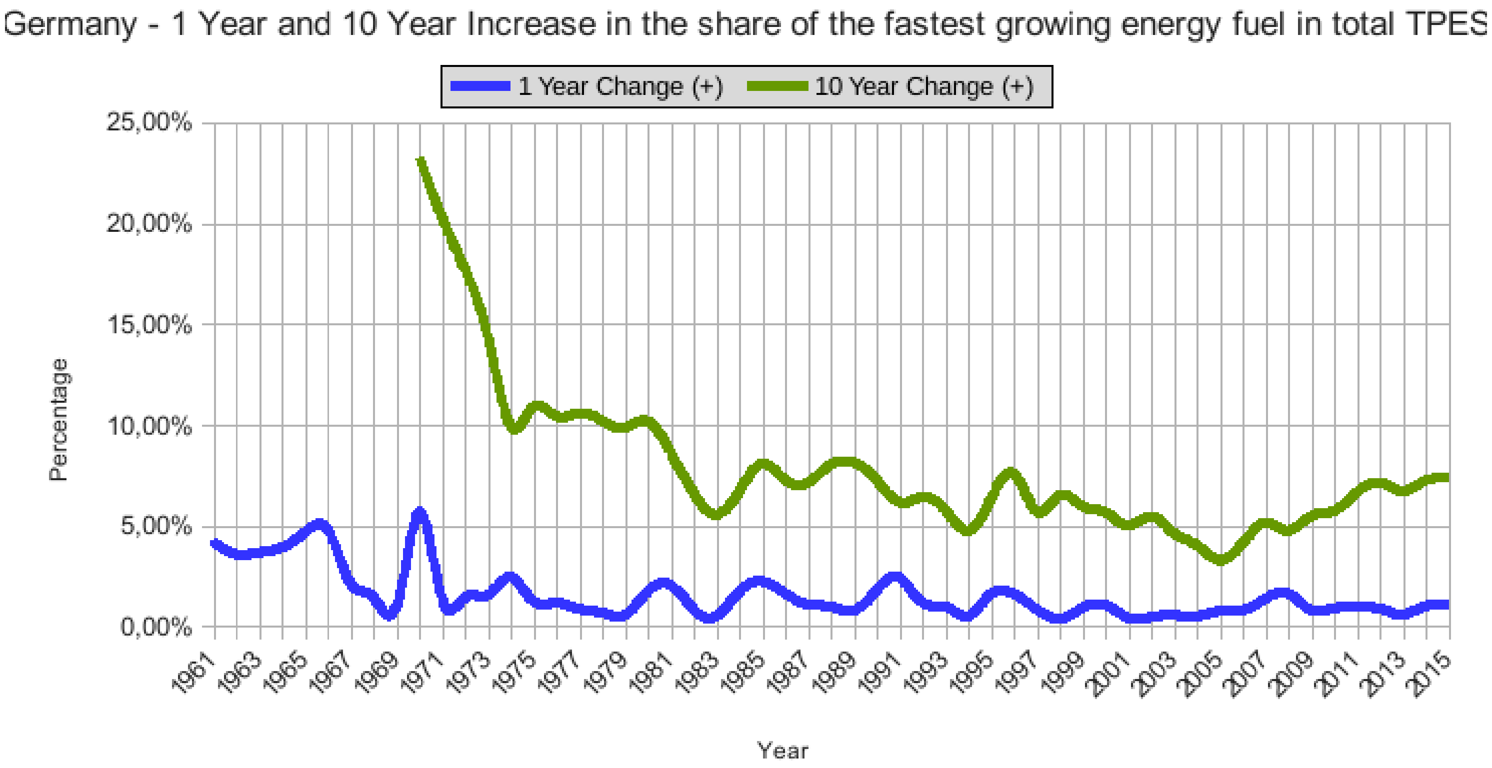
Year

İngiltere Enerji dönüşümü



Almanya


Germany - 1 Year and 10 Year Increase in the share of the fastest growing energy fuel in total TPES
1 Year Change (+)
10 Year Change (+)
25,00%
20,00%
15,00%
10,00%
5,00%
0,00%
Percentage
1961
1963
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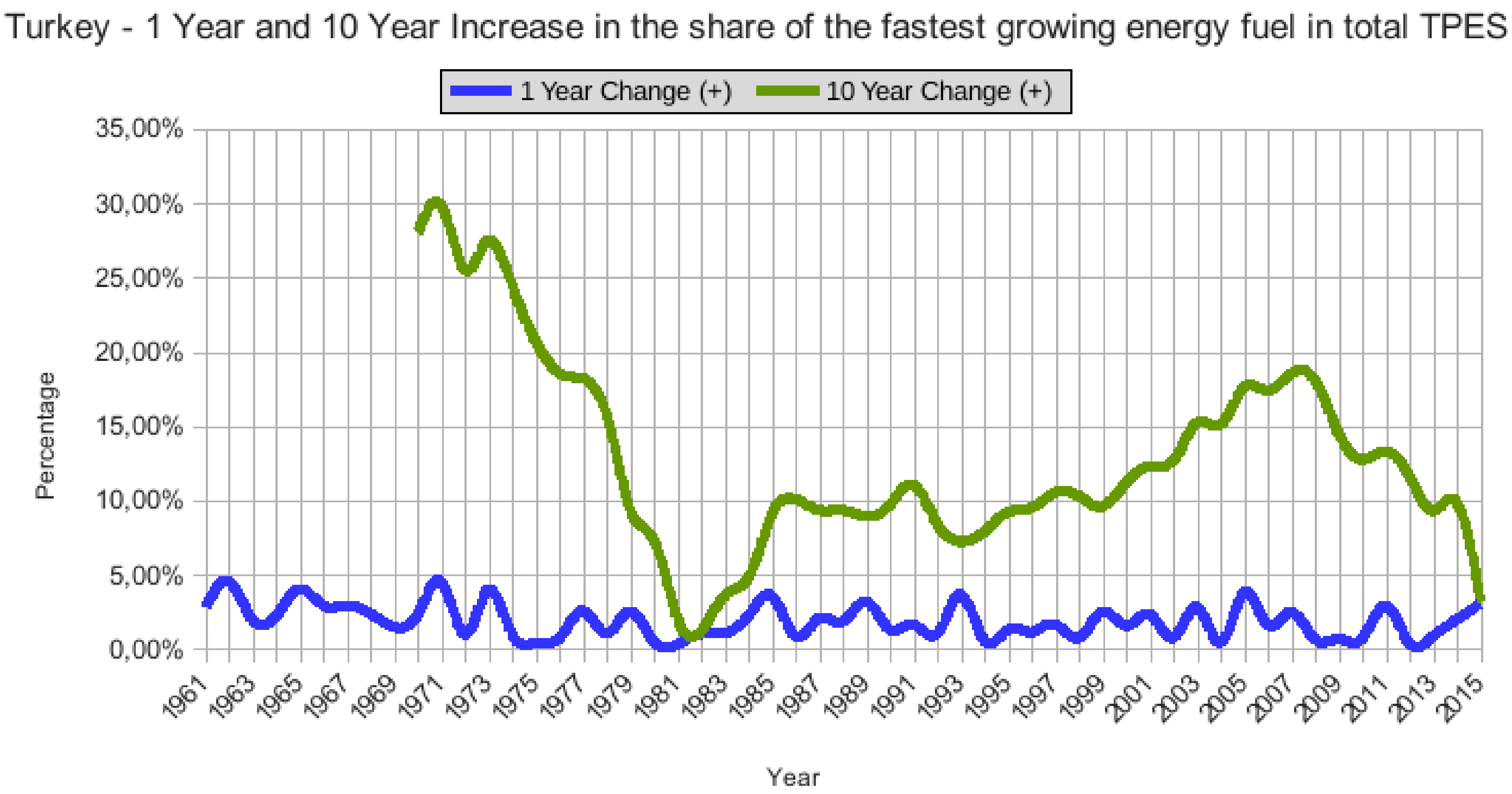
2015
Year

Türkiye


Turkey - 1 Year and 10 Year Increase in the share of the fastest growing energy fuel in total TPES
1 Year Change (+)
10 Year Change (+)
35,00%
30,00%
25,00%
20,00%
15,00%
10,00%
5,00%
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Percentage
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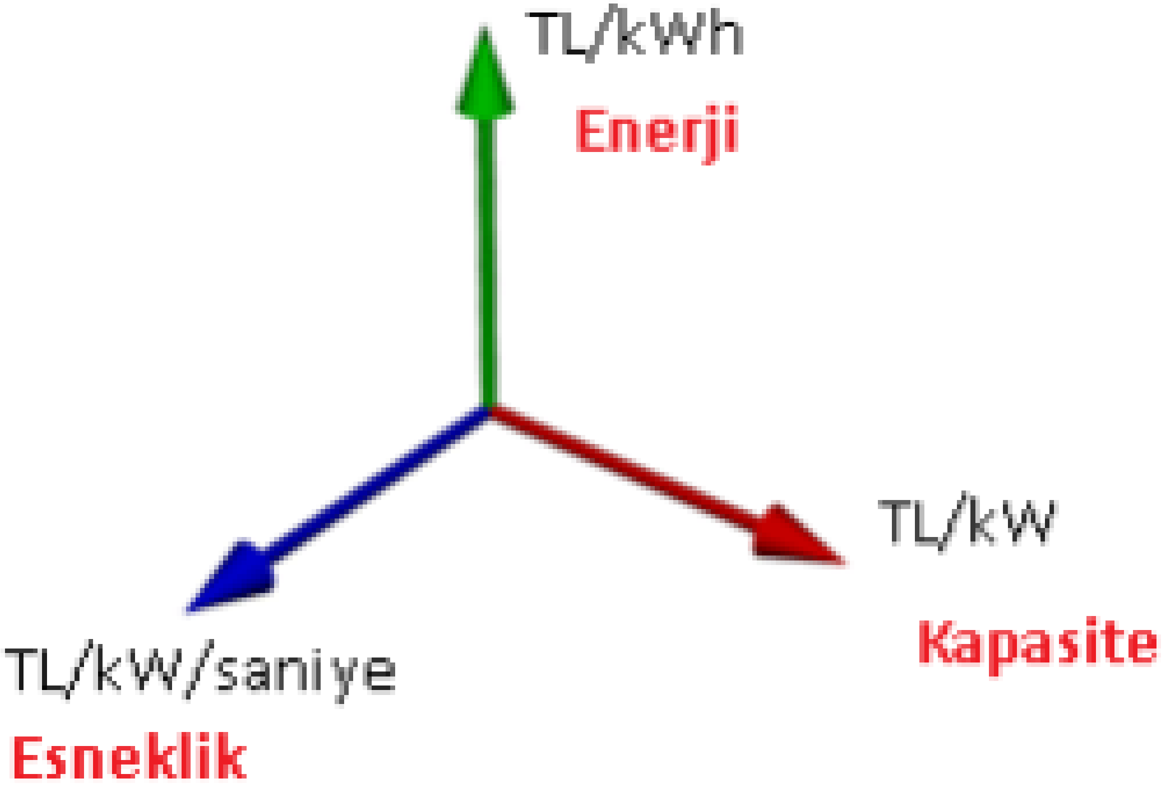
Year

Nasıl bir yöntem?
Belirsizliği araç haline getirmek

Arz güvenliği

- Enerji/kapasite(kapasite -> esnek ve sabit)
- Enerji güvenliği (Güvenilir kapasite* zaman)
- Kapasite güvenliği
  - Taşıma
  - Tedarik
    - Esnek (kısa dönem)
    - Sabit (uzun dönem)

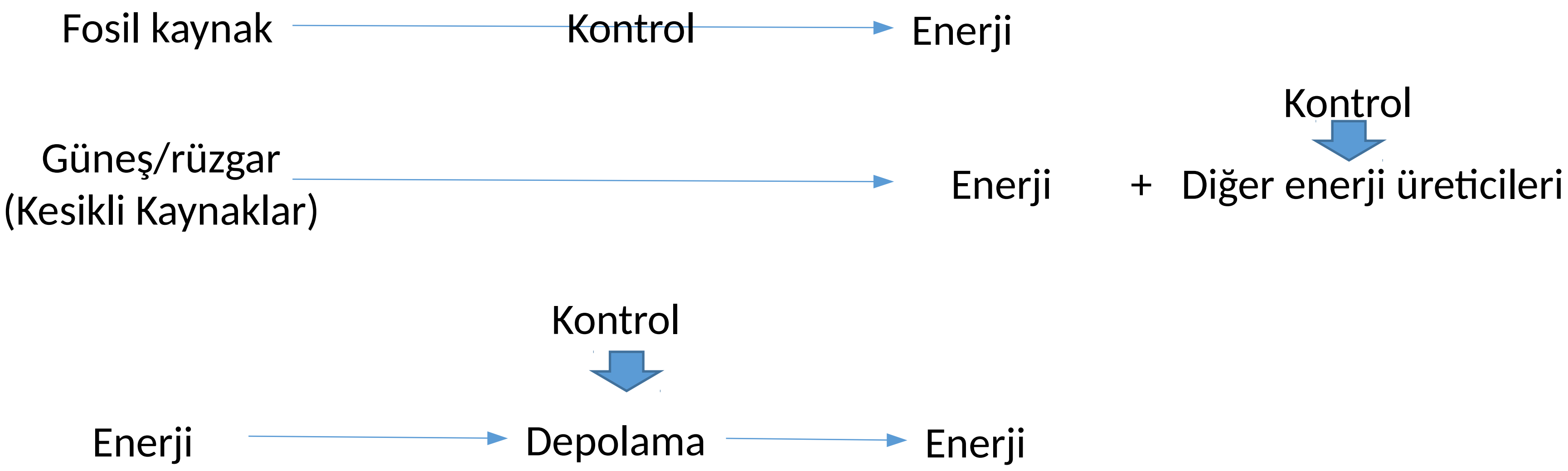
Elektrik fiyatları kaç boyutlu



http://www.barissanli.com/calismalar/2016/epd-20160504.pdf

İşin ekonomisine bakmak

- Bir kaynağın kontrol edilebilir olmasının maliyete bir etkisi yok mu?



Fosil kaynak → Kontrol → Enerji

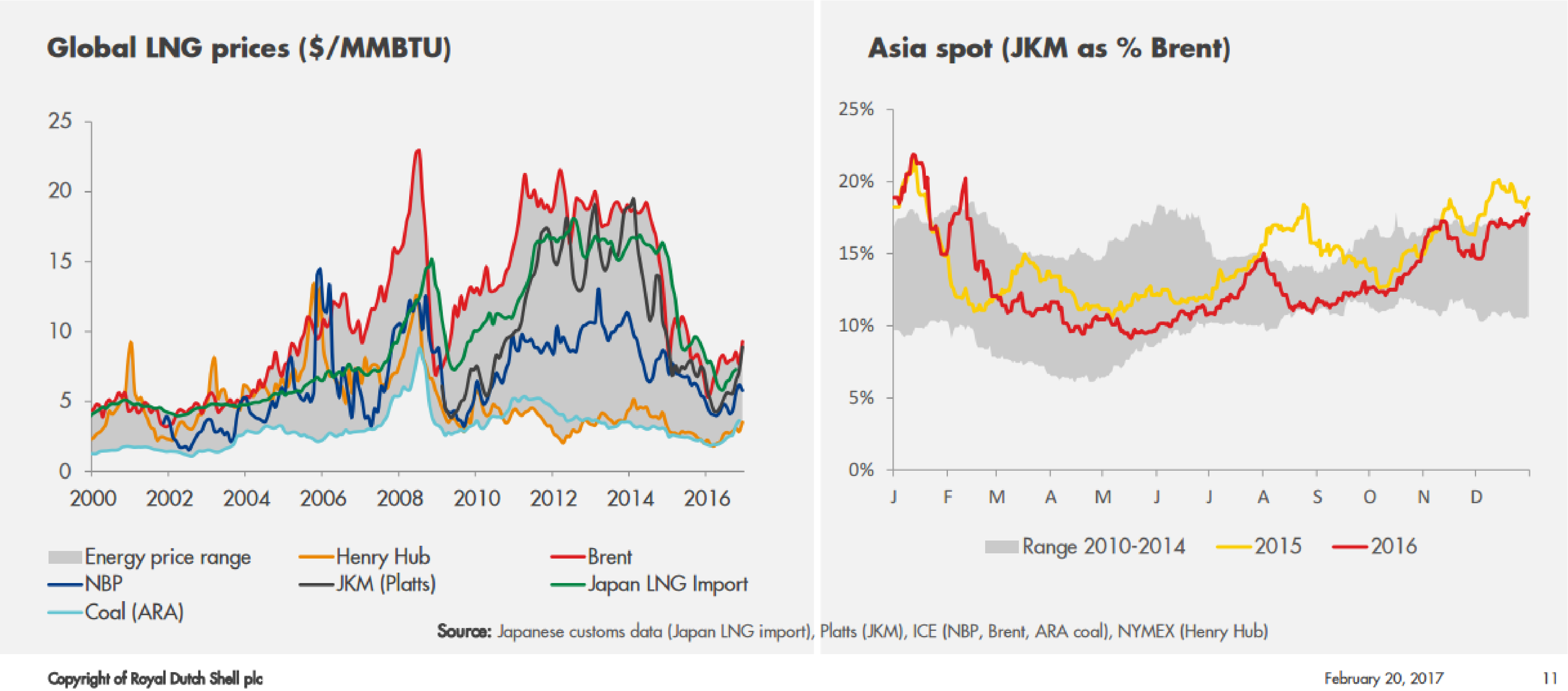
Kontrol

Güneş/rüzgar
(Kesikli Kaynaklar) → Enerji + Diğer enerji üreticileri

Kontrol

Enerji → Depolama → Enerji

Fiyat tahminleri nasıl yapılacak

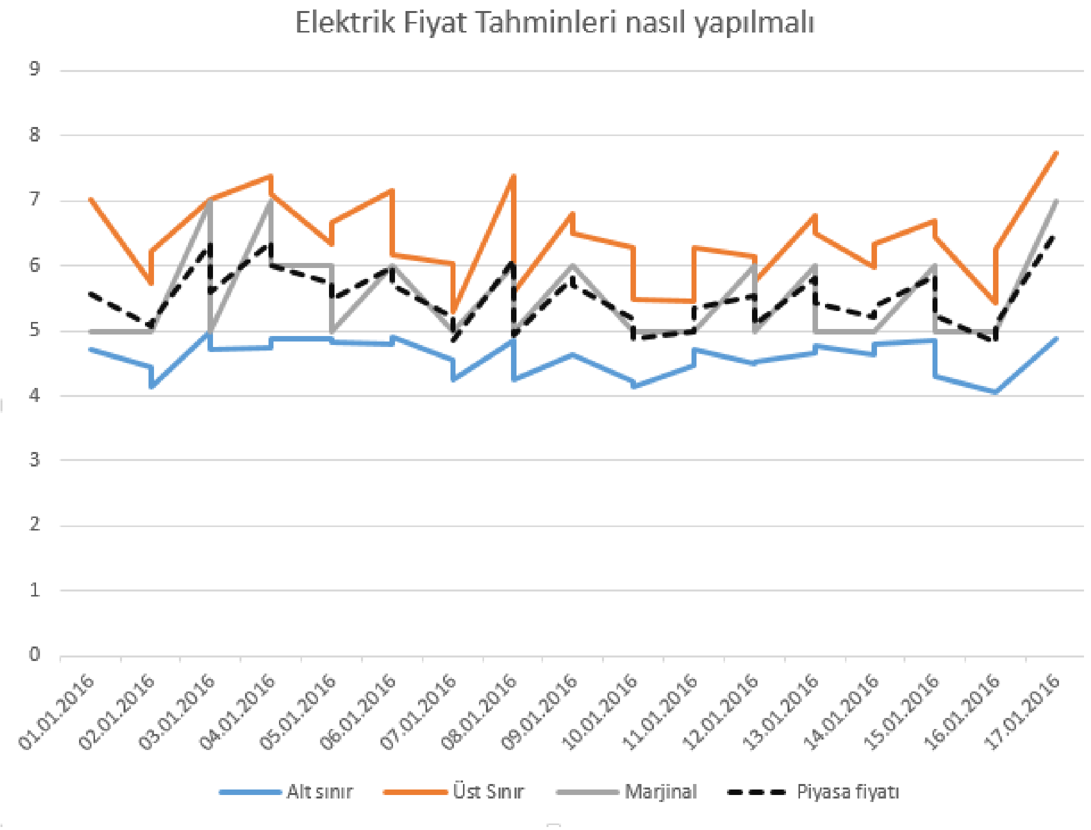


Source: Japanese customs data (Japan LNG import), Platts (JKM), ICE (NBP, Brent, ARA coal), NYMEX (Henry Hub)

February 20, 2017 11

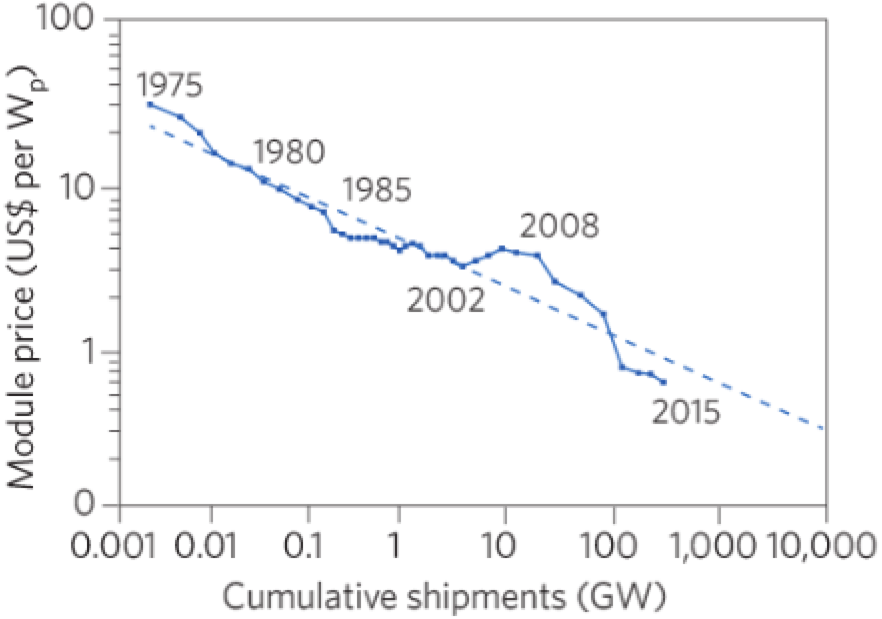
http://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook/_jcr_content/par/textimage_1374226056.stream/1488553857486/3c9c37f3c9be68923c5cce00799ec8ac1ef1cc264f4f557bf9694ce1cff2e2f2/shell-lng-outlook-2017-slides-presentation.pdf

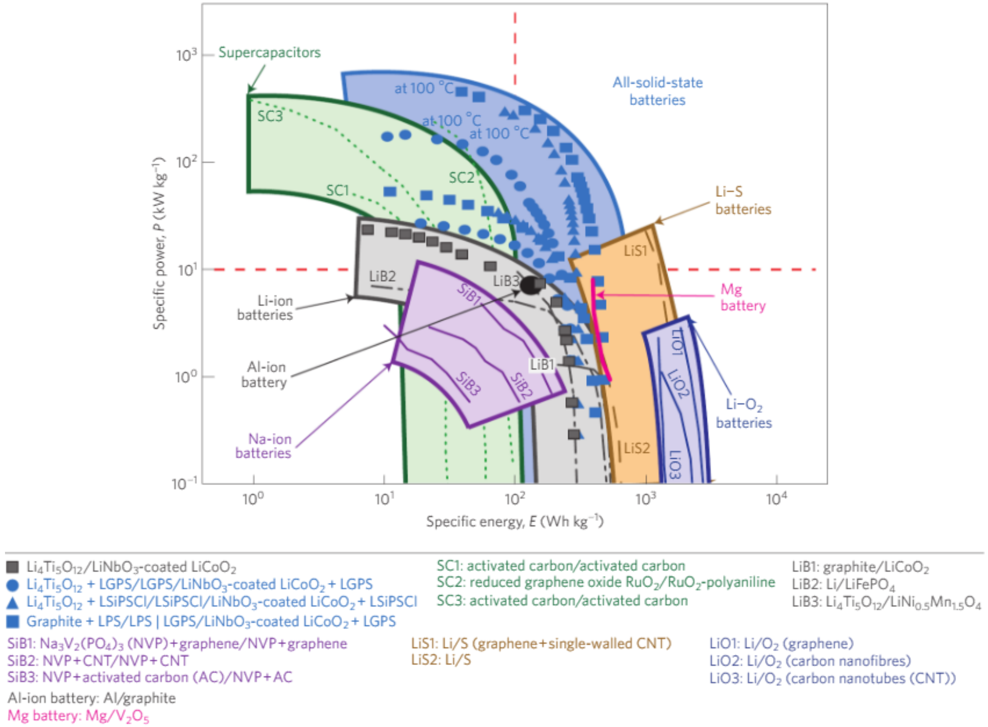
Fiyat tahminleri nasıl yapılmalı -simulasyon



Yeni teknoloji dalgası
Güneş, Piller, arabalar..

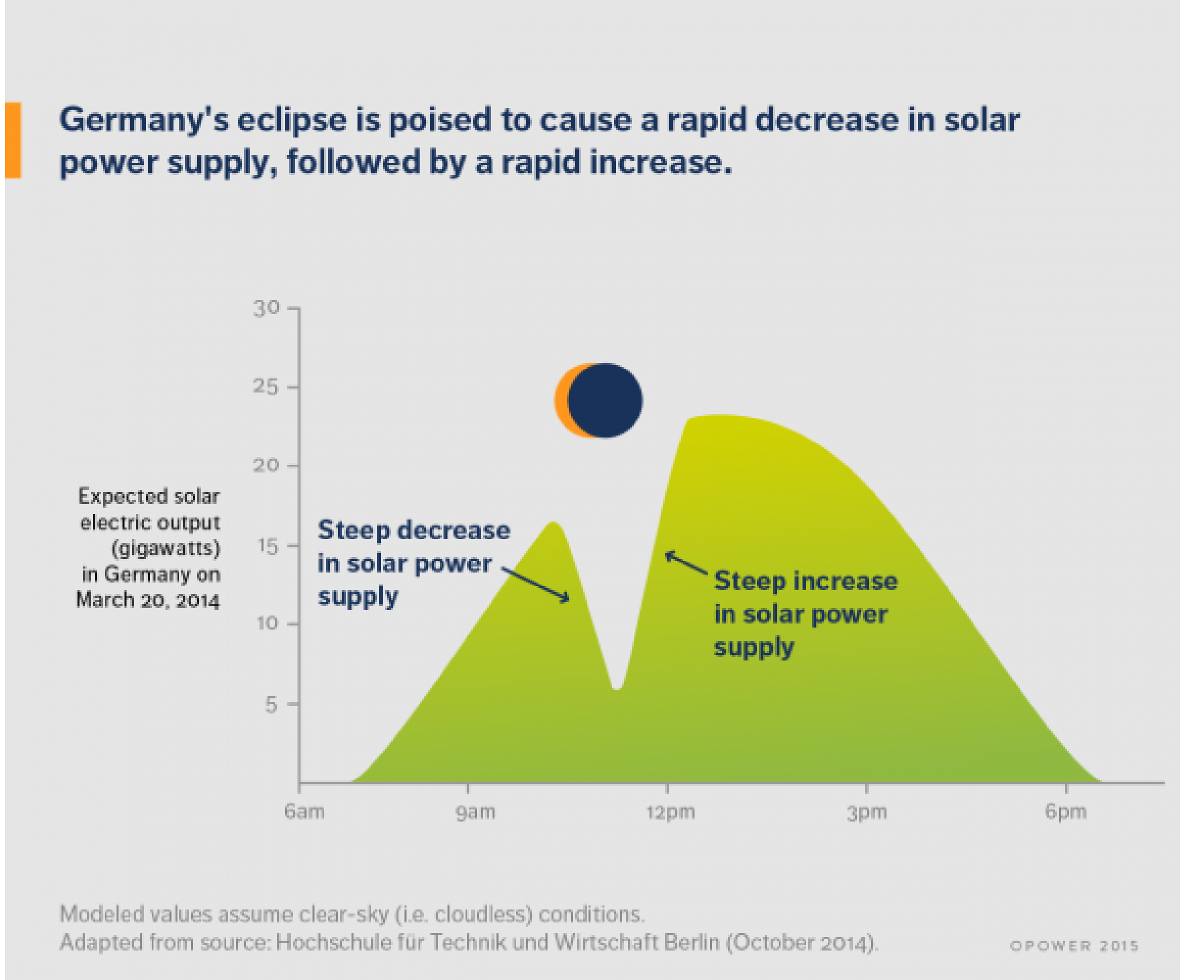
Güneş modüller ve piller





http://www.nature.com/articles/nenergy201630.epdf

Eclipse



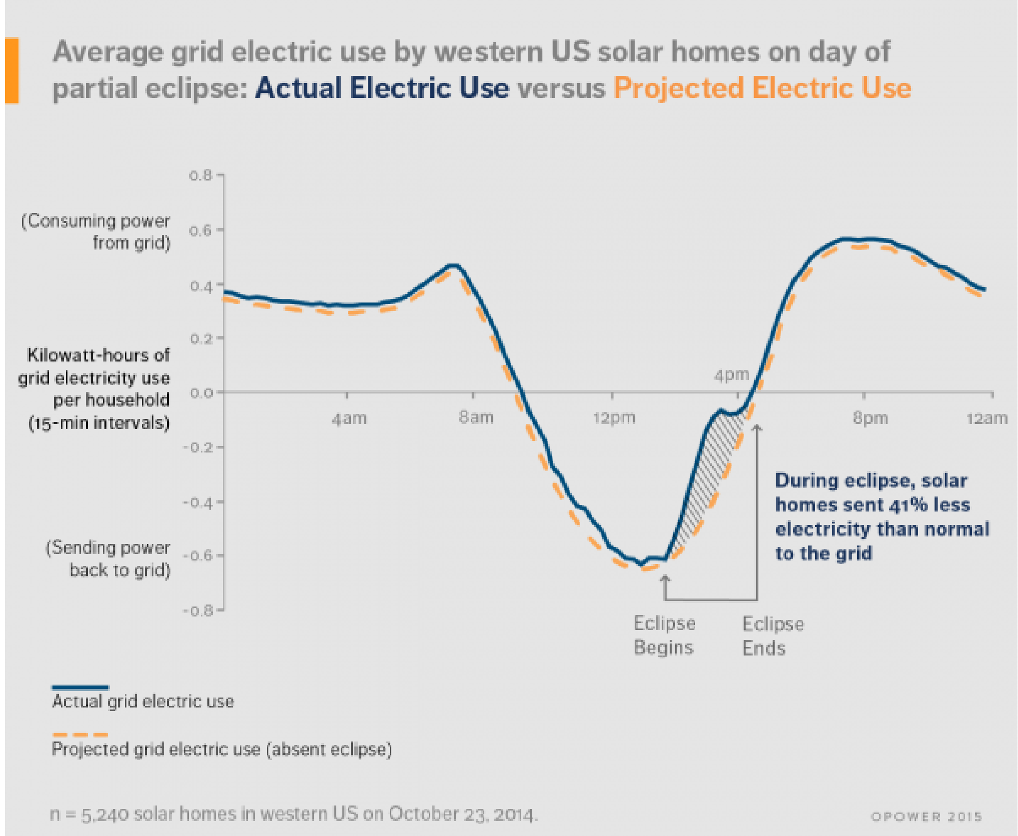
Germany's eclipse is poised to cause a rapid decrease in solar power supply, followed by a rapid increase.

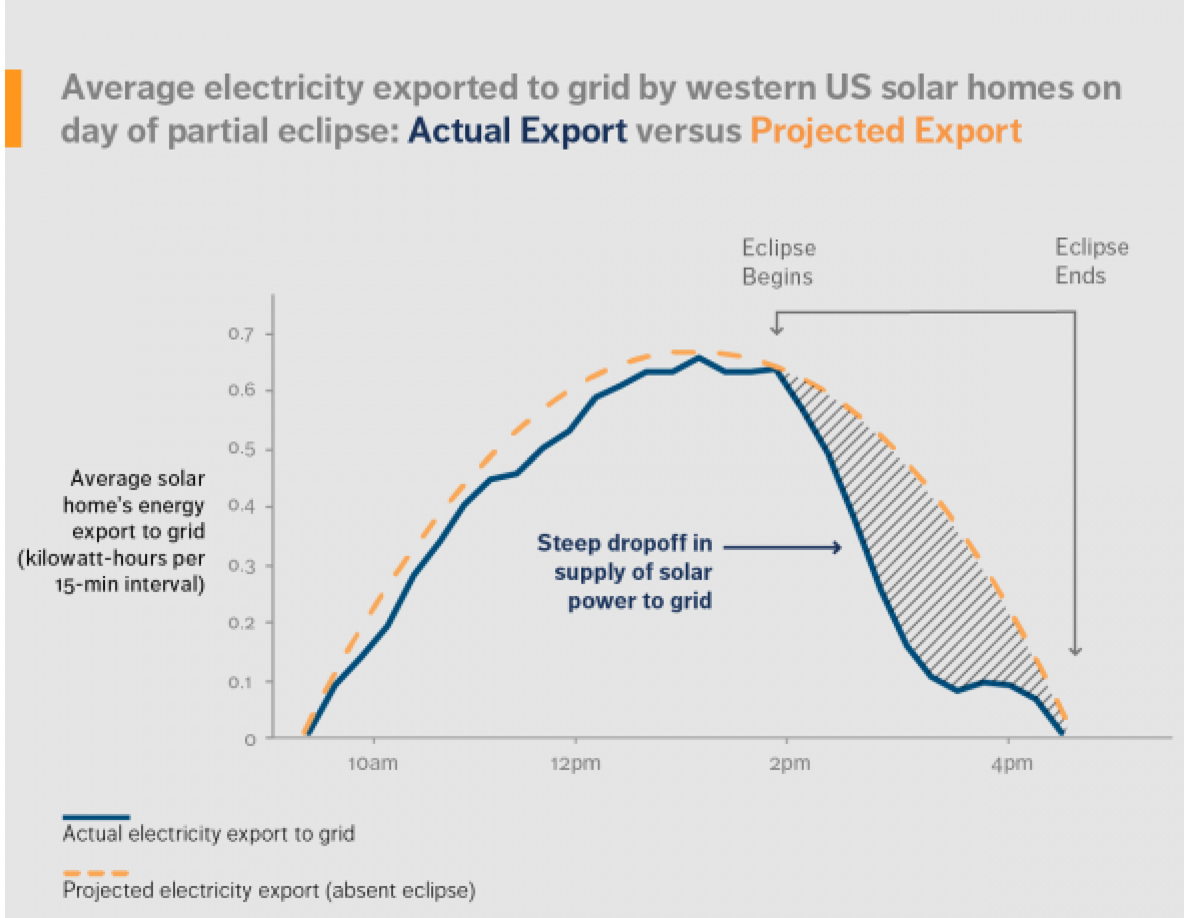
Modeled values assume clear-sky (i.e. cloudless) conditions.
Adapted from source: Hochschule für Technik und Wirtschaft Berlin (October 2014).

OPOWER 2015

https://www.greentechmedia.com/articles/read/What-Happens-to-a-PV-Powered-Country-During-a-Massive-Solar-Eclipse-We

Güneş tutulması

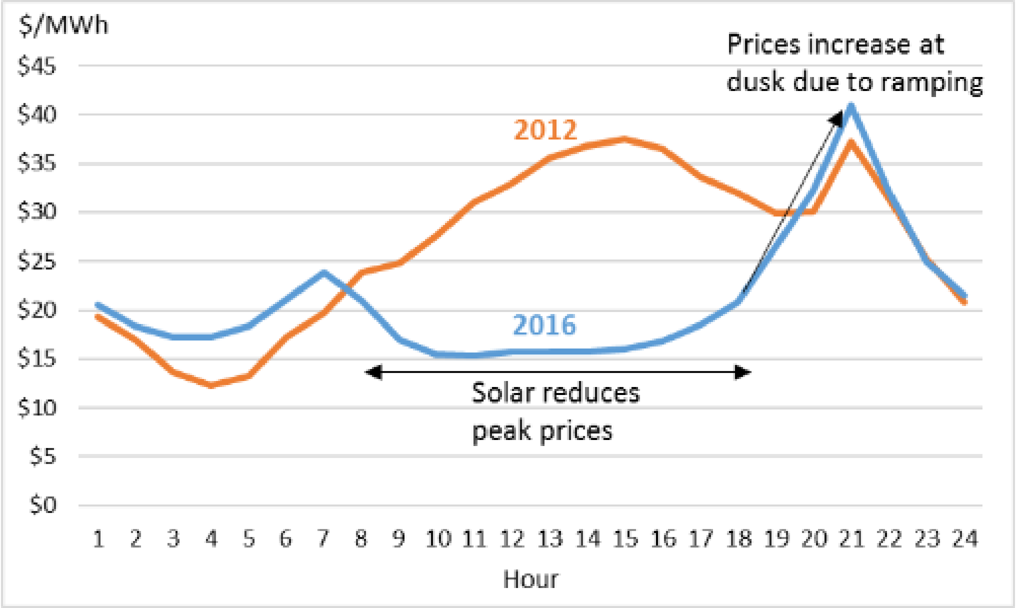




https://www.greentechmedia.com/articles/read/What-Happens-to-a-PV-Powered-Country-During-a-Massive-Solar-Eclipse-We

California'da elektrik fiyatları

Day-Ahead Average Hourly Electricity Prices at SP-15 (CAISO), May 2012 versus May 2016



Source: SparkLibrary, based on data from CAISO

http://energypost.eu/solar-growth-will-wreck-economics-existing-power-markets/

Görülmeyen maliyetler

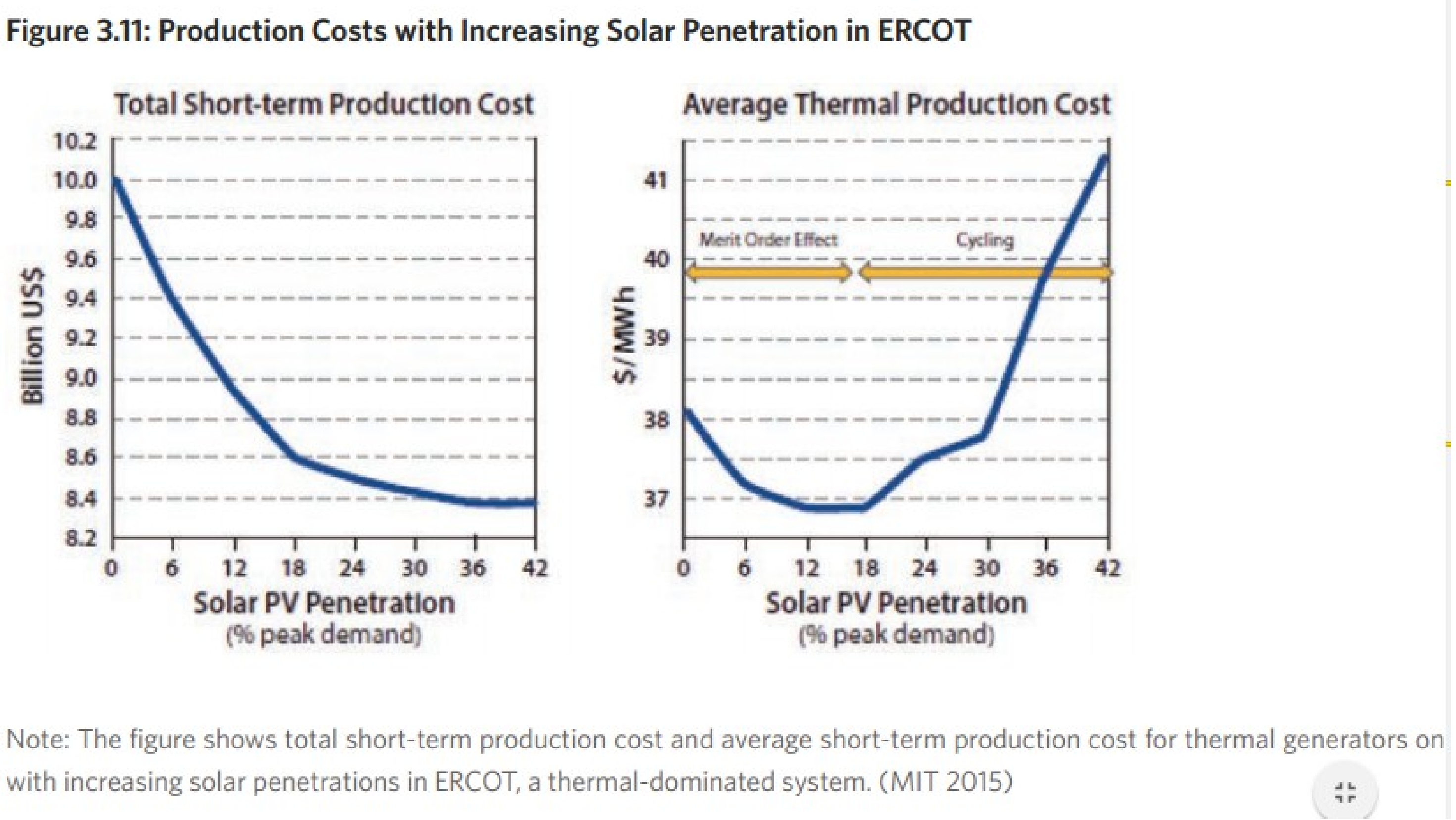
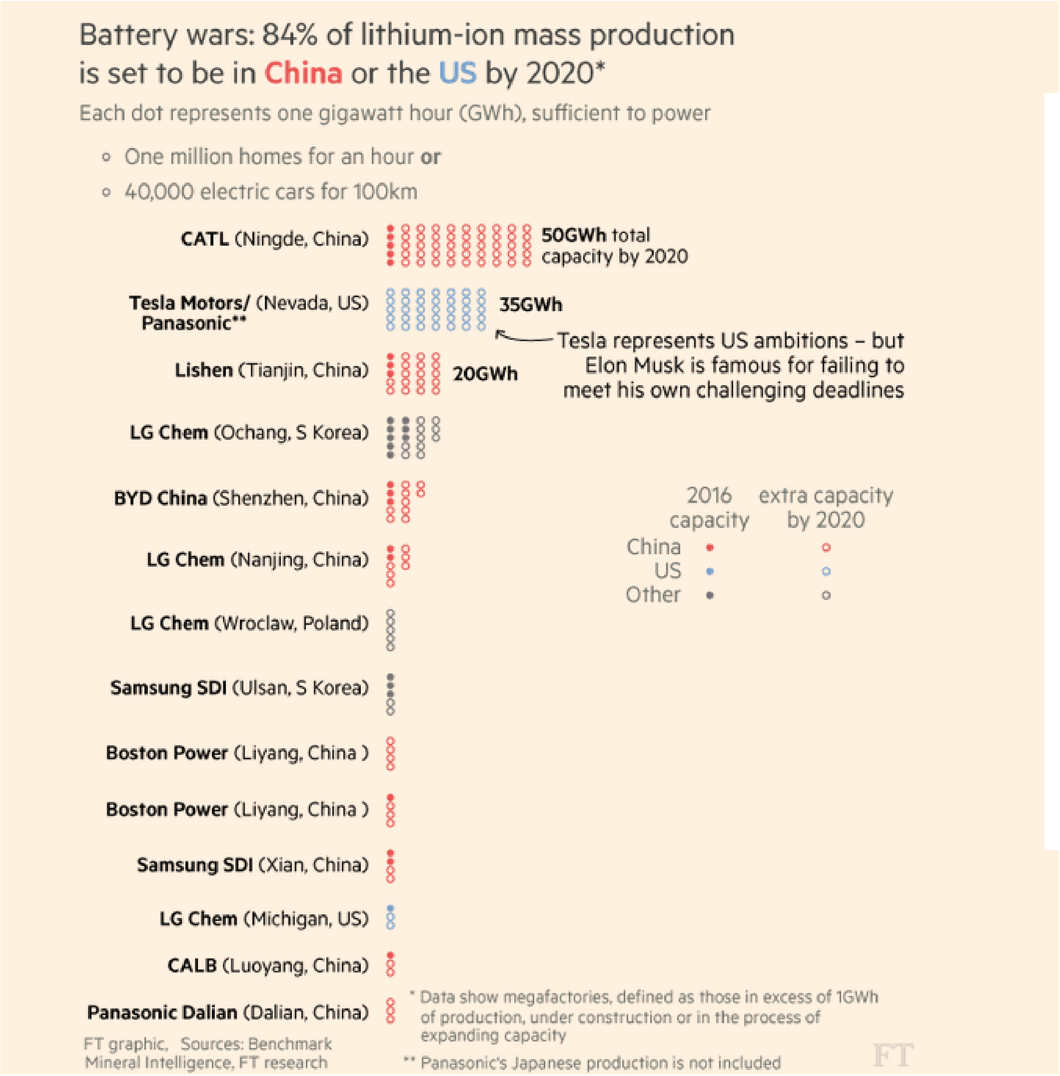


Figure 3.11: Production Costs with Increasing Solar Penetration in ERCOT

Note: The figure shows total short-term production cost and average short-term production cost for thermal generators on
with increasing solar penetrations in ERCOT, a thermal-dominated system. (MIT 2015)

https://energy.mit.edu/wp-content/uploads/2016/12/Utility-of-the-Future-Full-Report.pdf

Pil savaşları nereye?


Battery wars: 84% of lithium-ion mass production is set to be in China or the US by 2020*

Each dot represents one gigawatt hour (GWh), sufficient to power

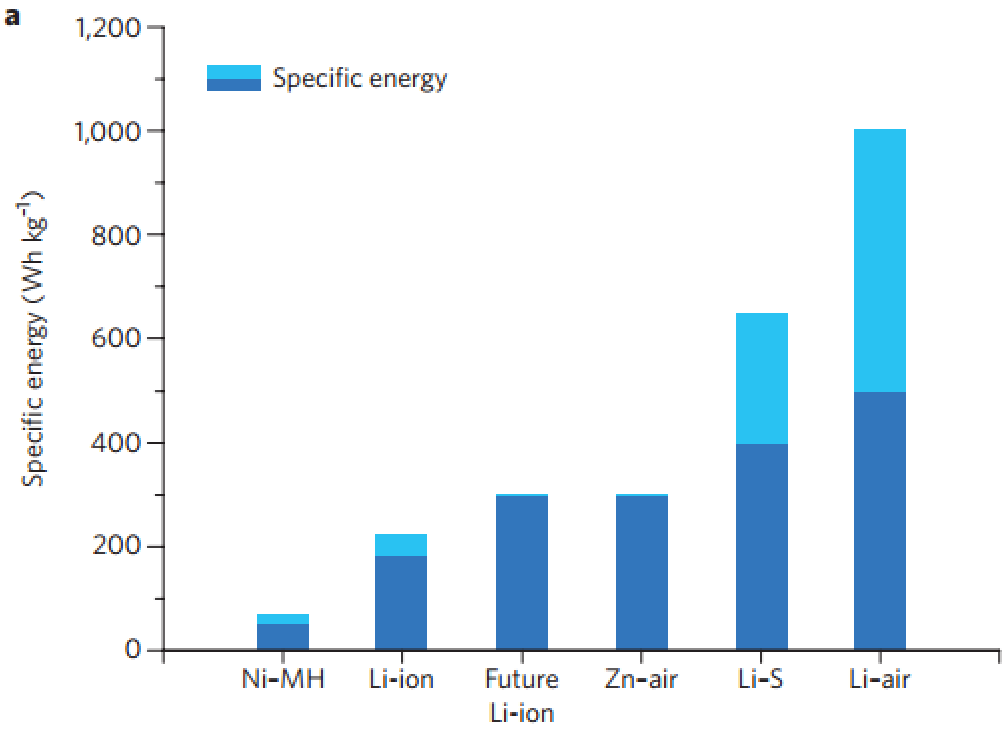
- One million homes for an hour **or**
- 40,000 electric cars for 100km

Tesla represents US ambitions – but Elon Musk is famous for failing to meet his own challenging deadlines

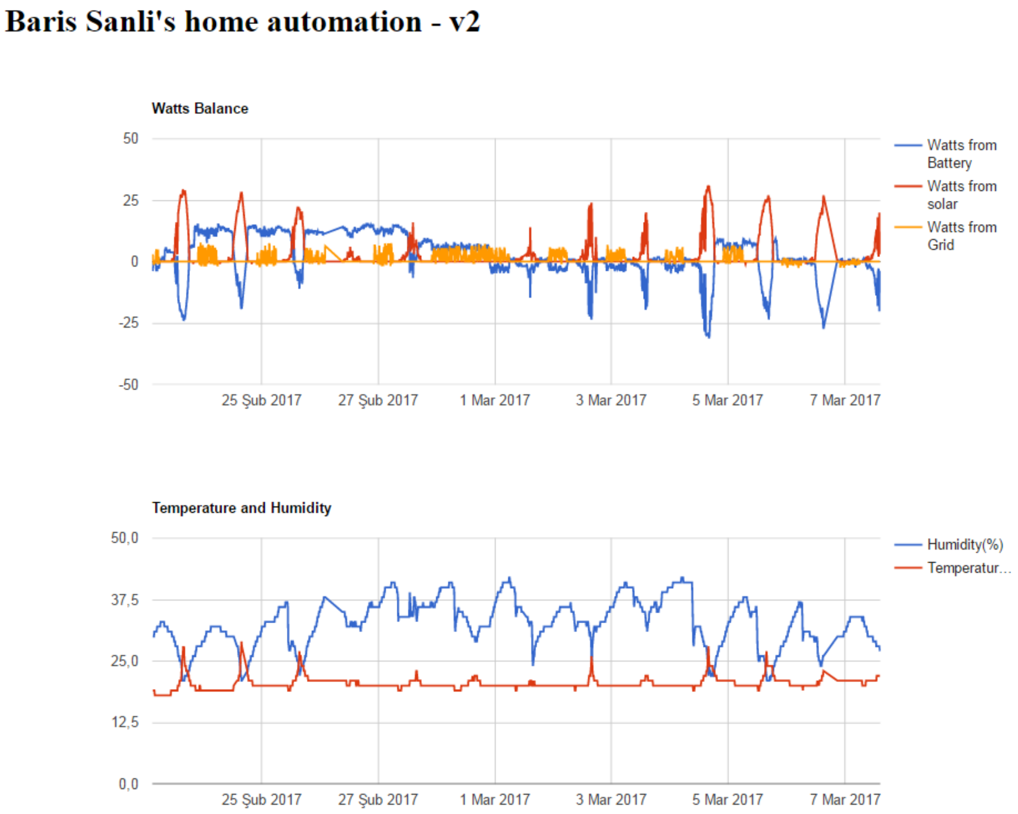
* Data show megafactories, defined as those in excess of 1GWh of production, under construction or in the process of expanding capacity

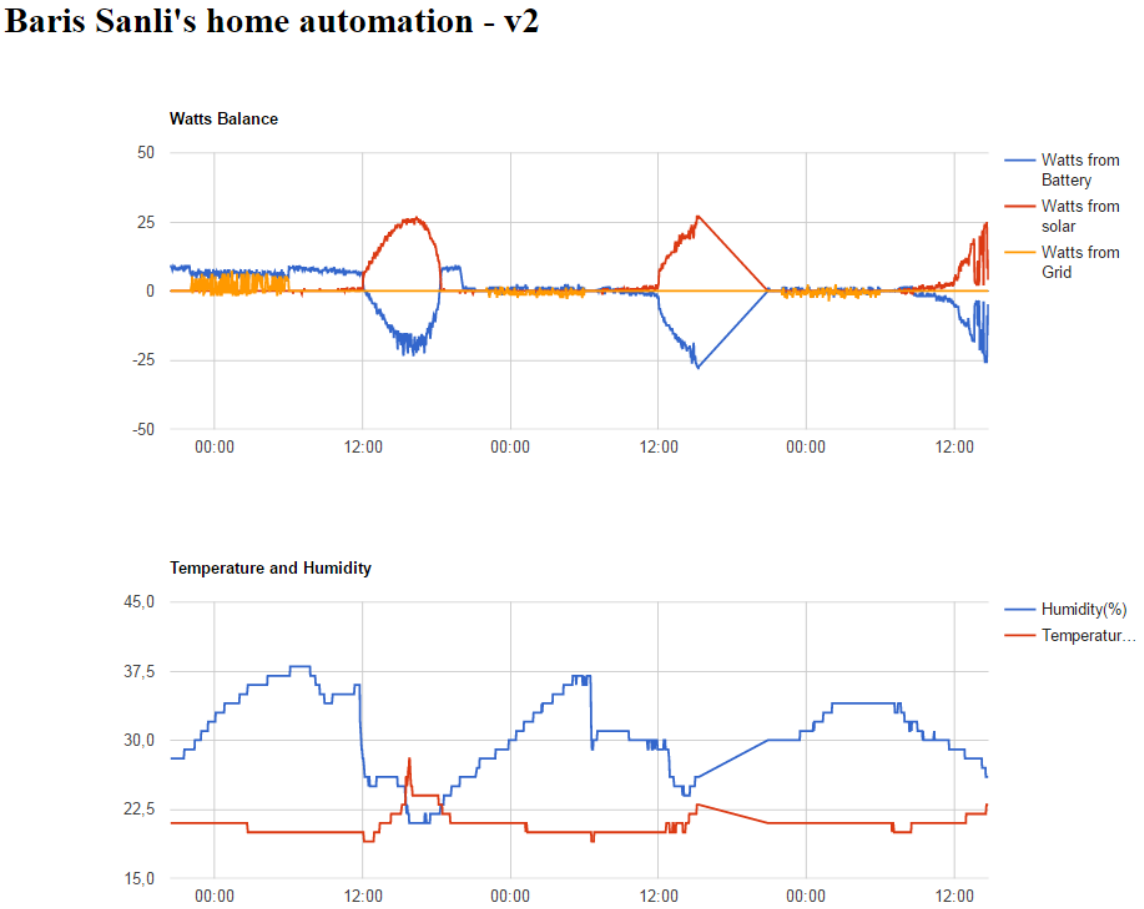
** Panasonic's Japanese production is not included

FT graphic, Sources: Benchmark Mineral Intelligence, FT research



Evdeki güneş-pil sistemi (Ankara – 40 W)

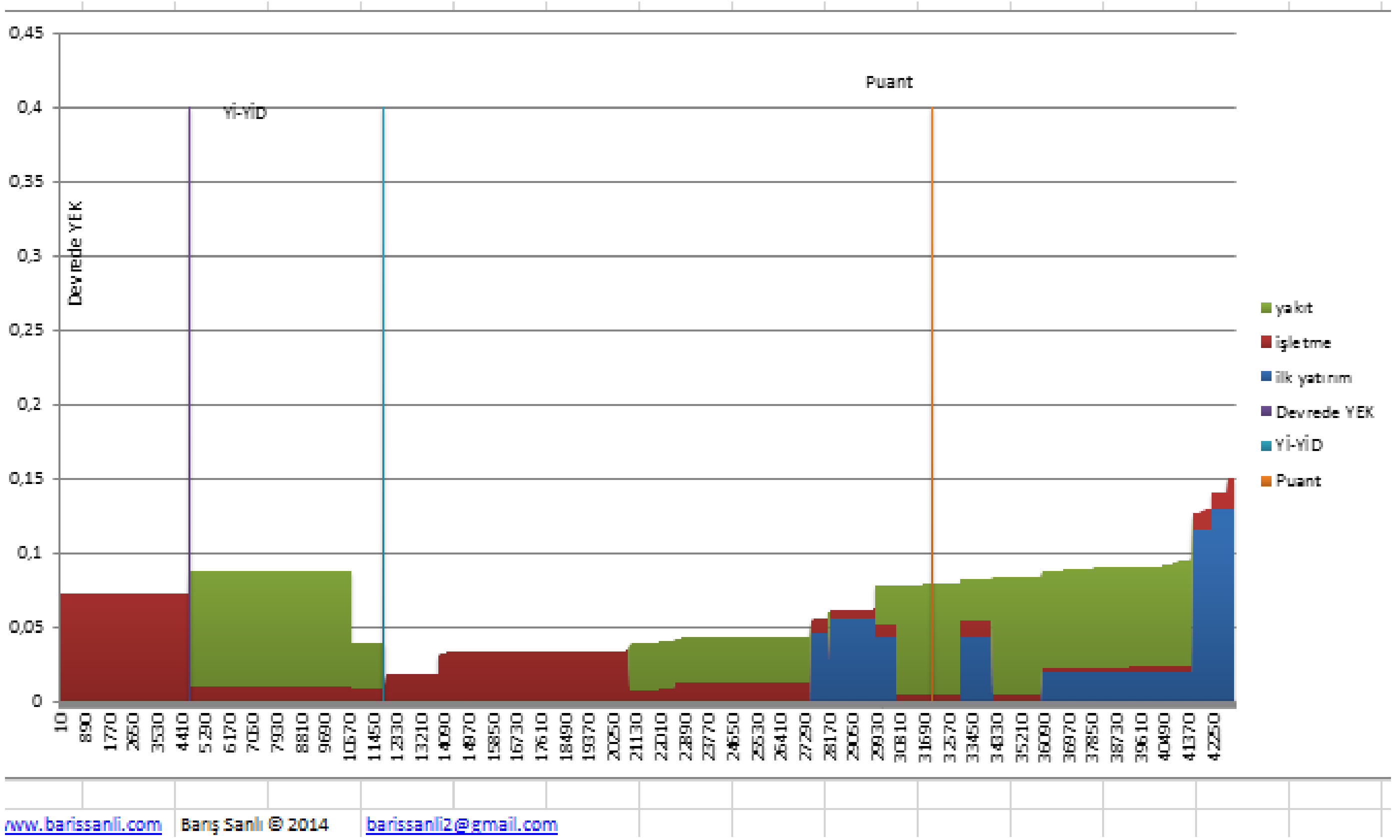

Baris Sanli's home automation - v2


Baris Sanli's home automation - v2

http://barissanli.com/ev/index2.html

http://barissanli.com/ev/

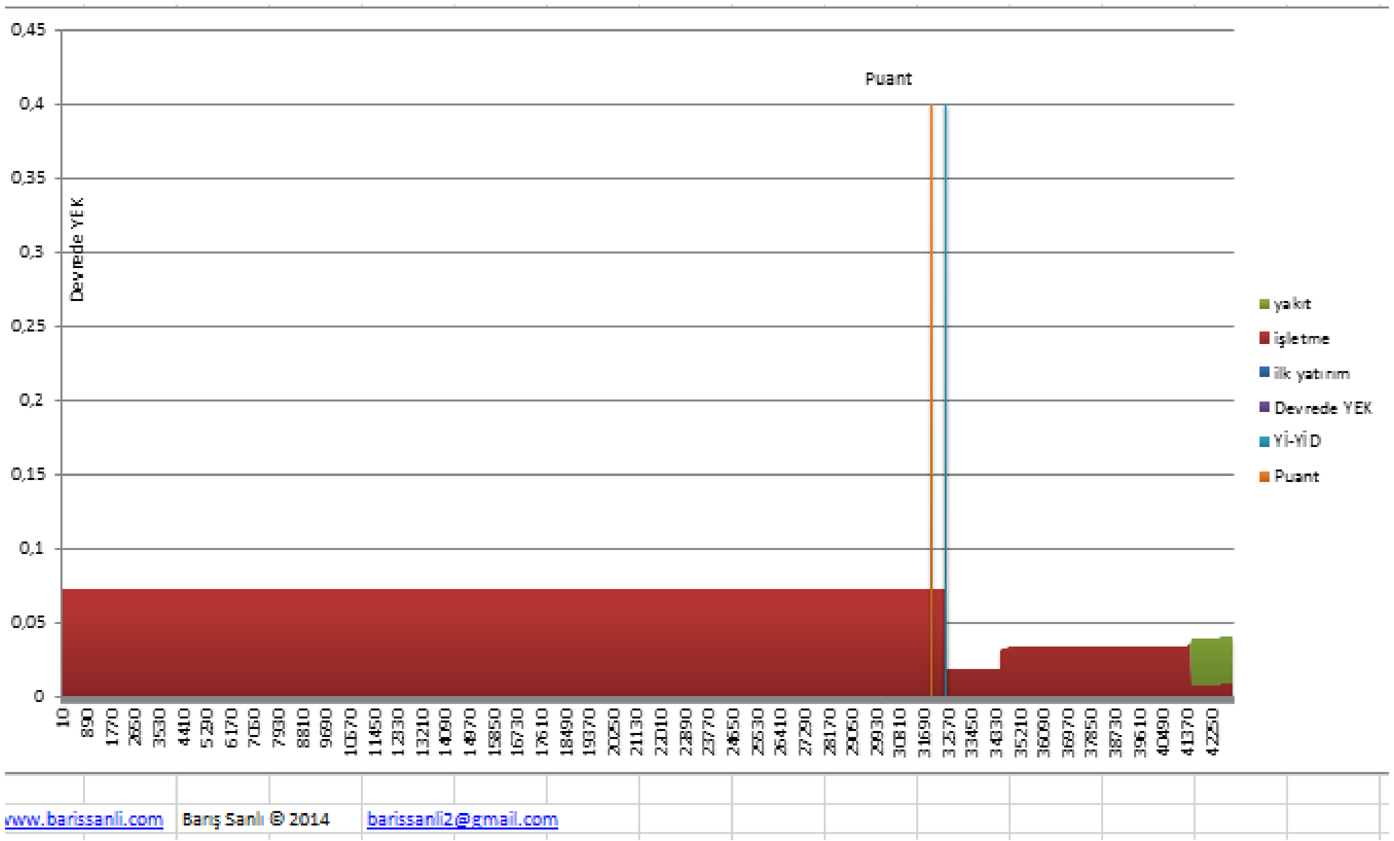
Sıradan bir gün



ww.barissanli.com | Barış Sanlı © 2014 | barissanli2@gmail.com

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

100% Güneş – Ama hangi güneş



Talep mi üretim mi önce zirve yapacak

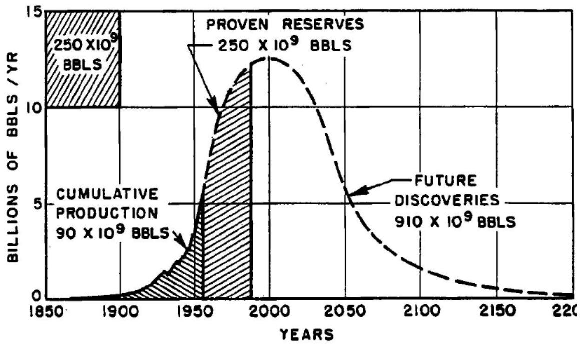
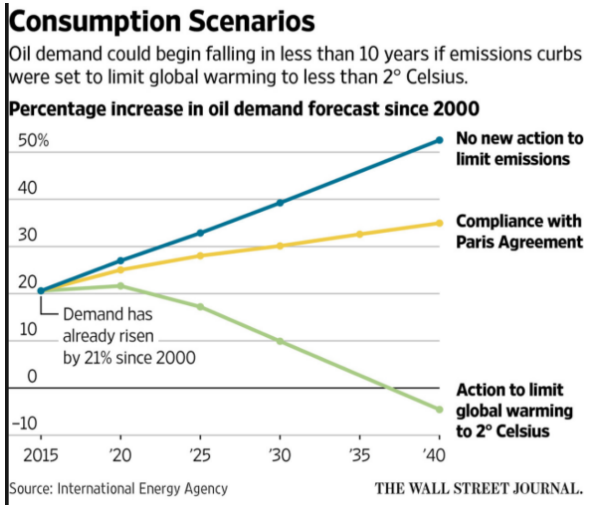


Figure 20 – Ultimate world crude-oil production based upon initial reserves of 1250 billion barrel



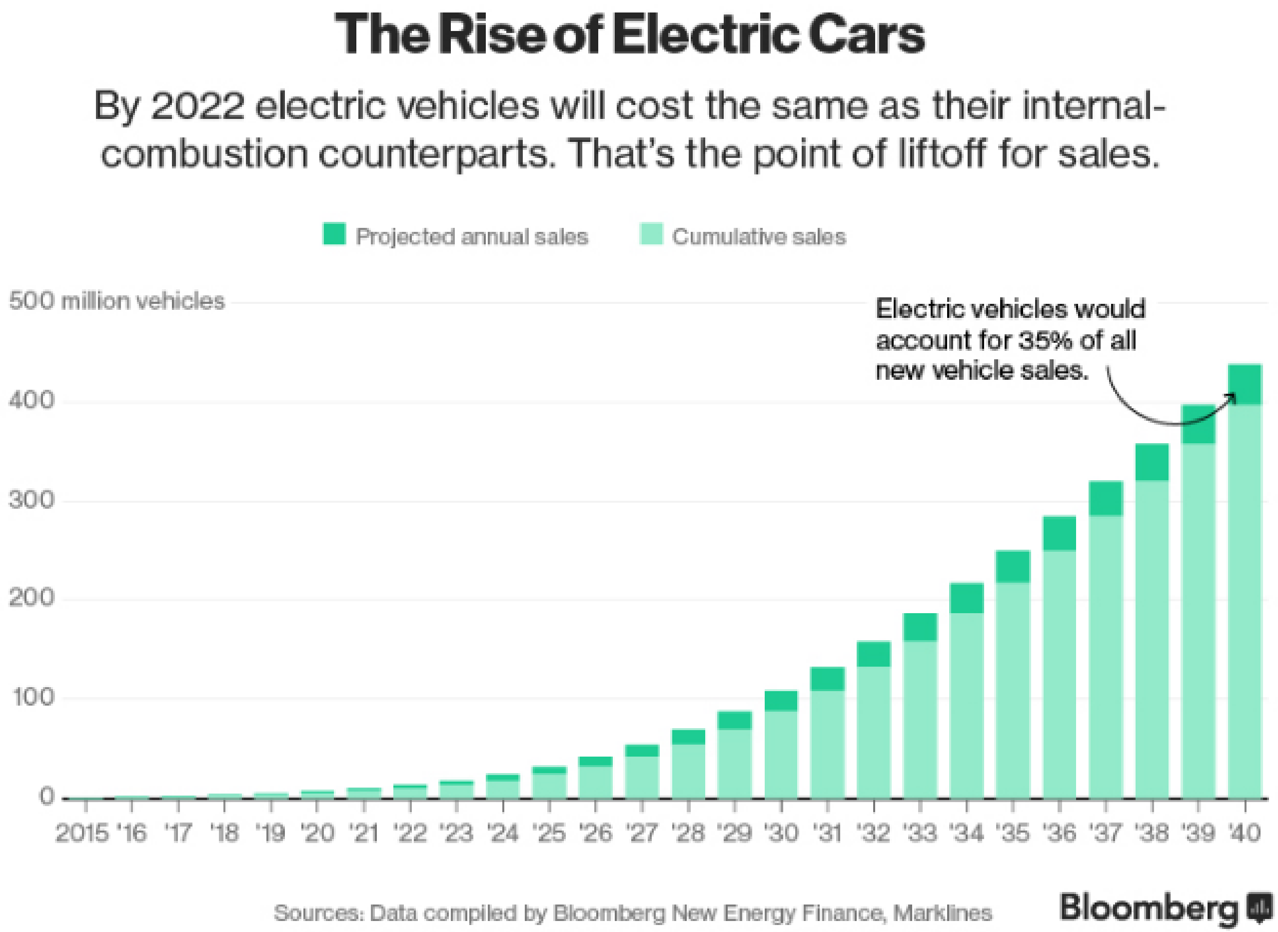
Consumption Scenarios

Oil demand could begin falling in less than 10 years if emissions curbs were set to limit global warming to less than 2° Celsius.

Percentage increase in oil demand forecast since 2000

Source: International Energy Agency

THE WALL STREET JOURNAL.



The Rise of Electric Cars

By 2022 electric vehicles will cost the same as their internal-combustion counterparts. That's the point of liftoff for sales.

Electric vehicles would account for 35% of all new vehicle sales.

Sources: Data compiled by Bloomberg New Energy Finance, Marklines

Bloomberg

Hubbert, M. K., 1956, Nuclear energy and the fossil fuels, in American Petroleum Institute Spring Meeting: San Antonio, Texas, p. 40.

Çinli taksicilerin tecrübesi

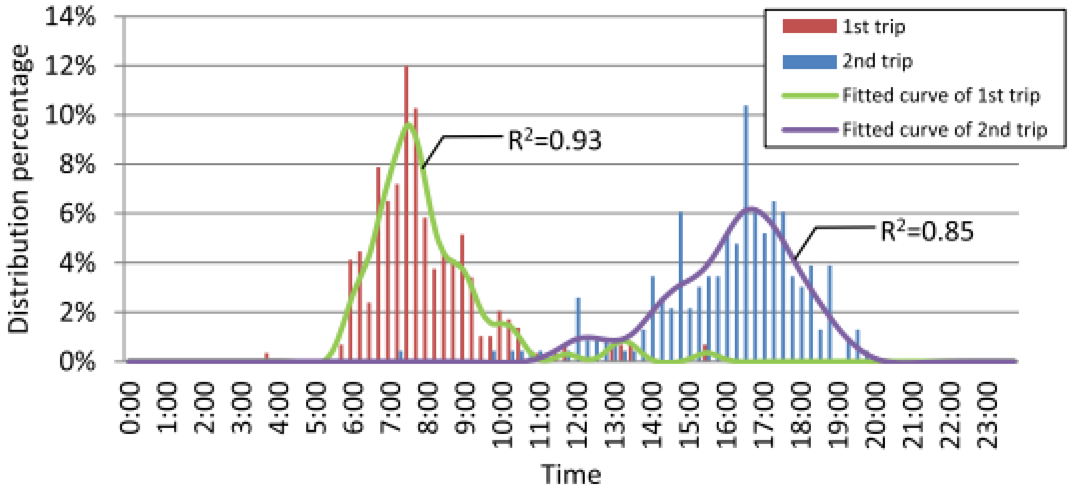


Fig. 6. Distribution of departure time from charging stations.

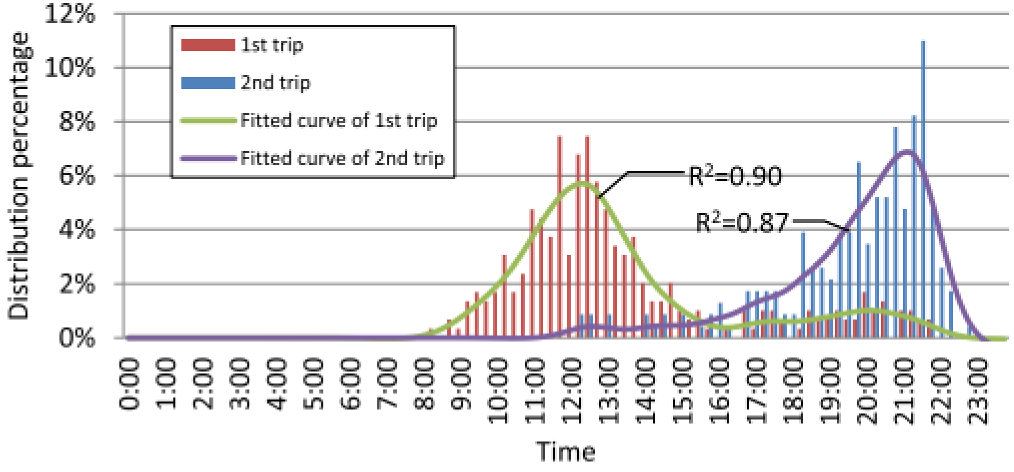


Fig. 7. Distribution of arrival time at charging stations.

Energy

journal homepage: www.elsevier.com/locate/energy

Large-scale deployment of electric taxis in Beijing: A real-world analysis

Yuan Zou [a, *], Shouyang Wei [a], Fengchun Sun [a], Xiaosong Hu [b], Yaojung Shiao [c]

[a] Beijing Collaborative Innovation Center for Electric Vehicle, National Engineering Laboratory for Electric Vehicles, School of Mechanical Engineering, Beijing Institute of Technology, Beijing 100081, China

[b] The State Key Laboratory of Mechanical Transmissions, Chongqing University, Chongqing 400044, China

[c] Department of Vehicle Engineering, National Taipei University of Technology, Taipei, China

Y. Zou et al. / Energy 100 (2016) 25–39

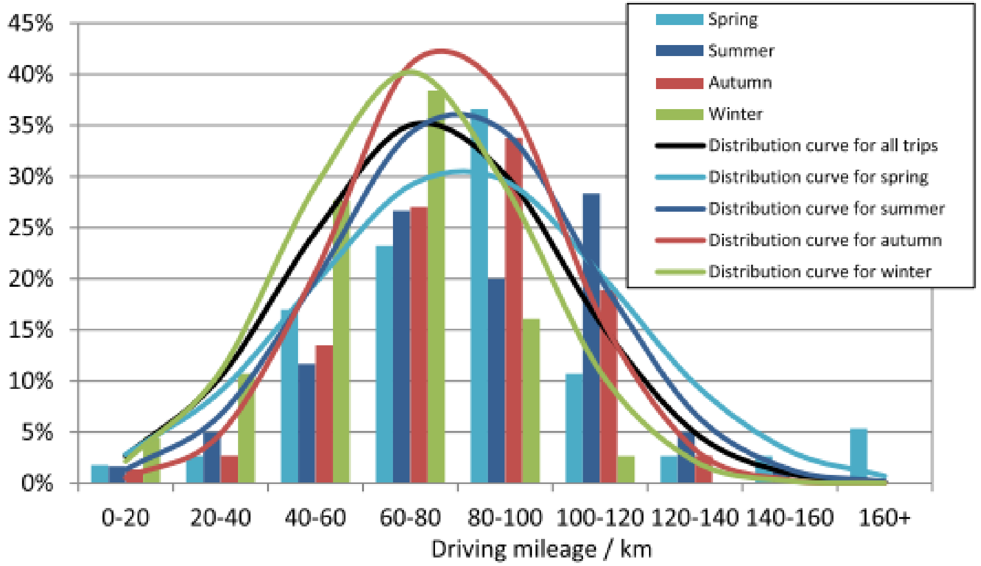


Fig. 5. Distribution of single-trip driving mileage.

https://www.researchgate.net/publication/294645827_Large-scale_deployment_of_electric_taxis_in_Beijing_A_real-world_analysis

Hayır mı şer mi?

- Ulaştırma da dijitize mi oluyor
- Değişimler
  - Araç bakım parça zinciri
  - Araba satış bayileri
  - Elektrik sistemi (2040’da %8)
  - Petrol şirketleri?
  - Yol ve şarj ağı
  - Şehirler
  - Elektrikli uçak?
  - Vergiler-Maliye Bakanlıkları

https://about.bnef.com/blog/liebreich-mccrone-electric-vehicles-not-just-car/

Basit bir elektrikli araba hesabı

- Ortalama 21-25 kWh/100 km
- Klima 3-5 kWh
- Türkiye’de 15000 km/yıl ortalama araç
- Piller 200 Wh/kg’dan 400 km menzil için
  - 500kg pil
- Yıllık elektrik talebi 3750 kWh (*0.41 krş = 1537 TL)
- 1 milyon araç -> 3.7 Twh (2016 brüt üretim 278 Twh)
- kWh’i 170$’dan 100kWh için 17000$

Elektrik piyasalarında «kayıp para problemi»

Kapasite piyasası sorunu

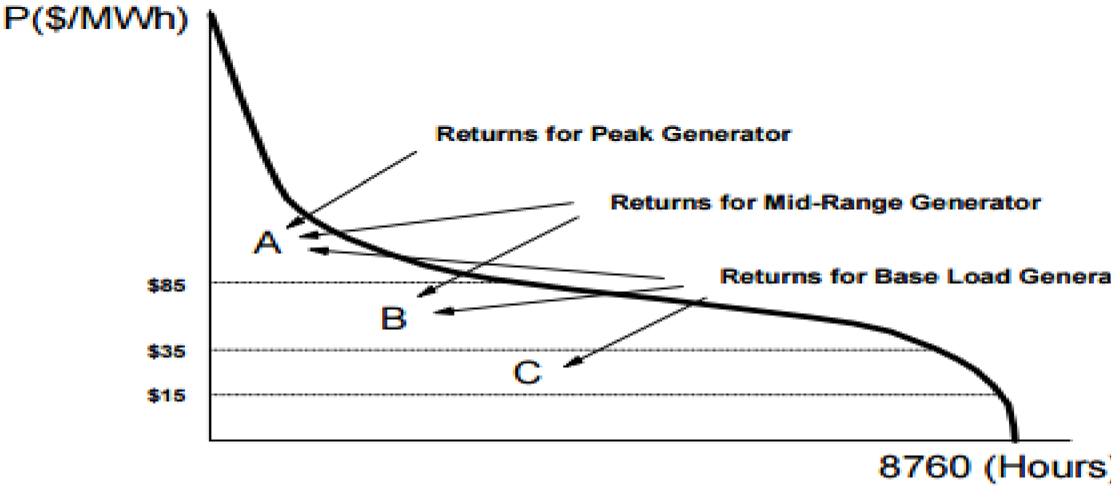
Sistem

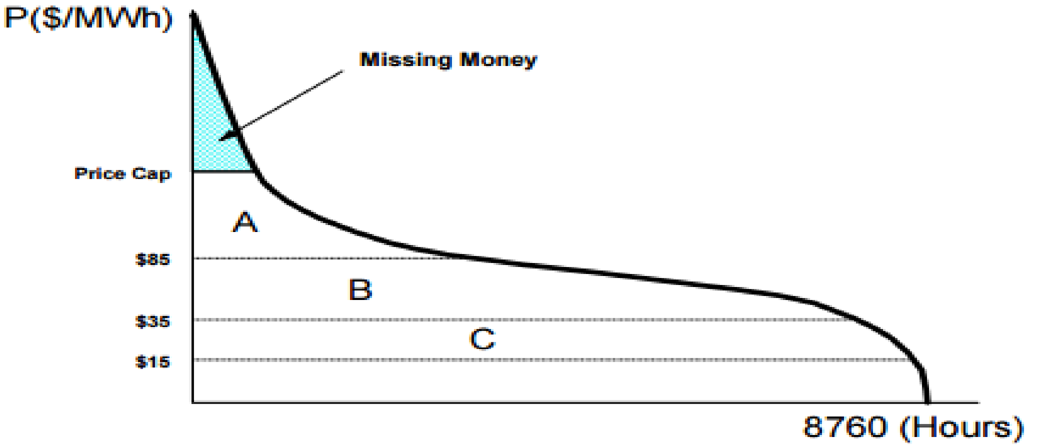
- Herkesin ne üreteceği, ne kadar üreteceği, tüketeciği kesin olarak bilinse
  - Planlama yapılır, üretim-yatırım belirlenirdi
  - Rezerv kapasite gerekmezdi
- Fakat elektrik sistemi belirsizliklerle dolu:
  - Santral devreden çıkabilir
  - Tüketicinin tüketimi değişebilir
  - Hat kopabilir

Sistem yöneticisi

- O zaman kısıtlar koyuyor
  - Maksimum transfer kapasitesi kışın şudur, yazın şudur
  - Talep değiştikçe, yeterli üretim anlık dengeleyecek
- Her kısıt bir kavram/hizmet doğurur
  - Yan hizmetler
    - Dengeleme
    - Rezerv kapasite
    - Emreamade güç
- Ama her hizmet bir kısıt sonucu oluşmaz
  - Emisyon vs

William Hogan’ın yaklaşımı

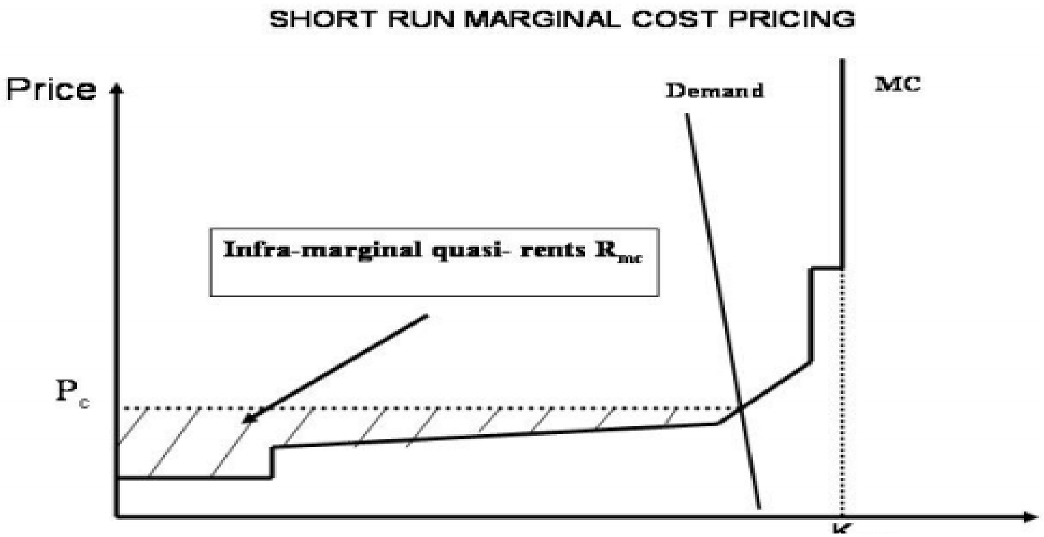

A Market Price Duration Curve

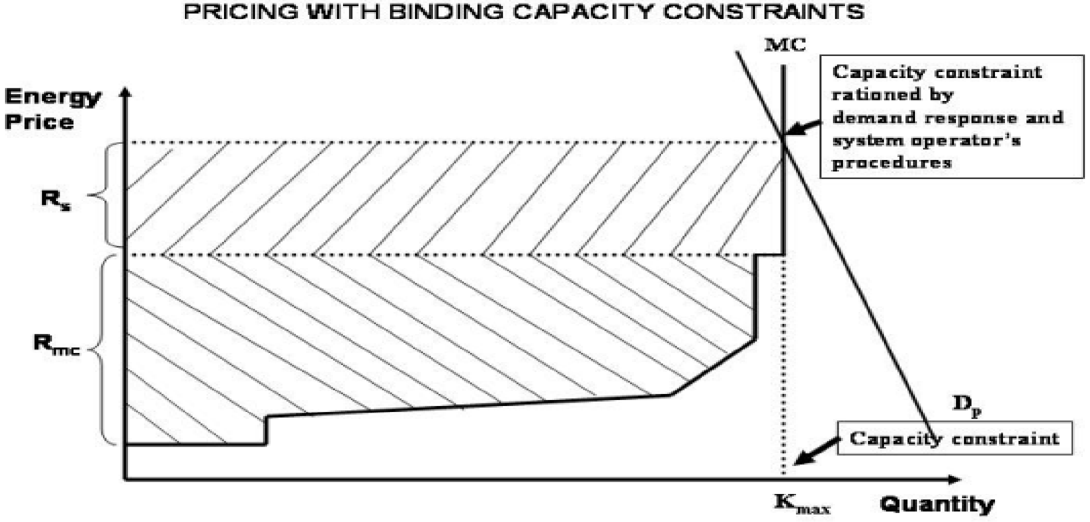

A Price Cap Results in "Missing Money"

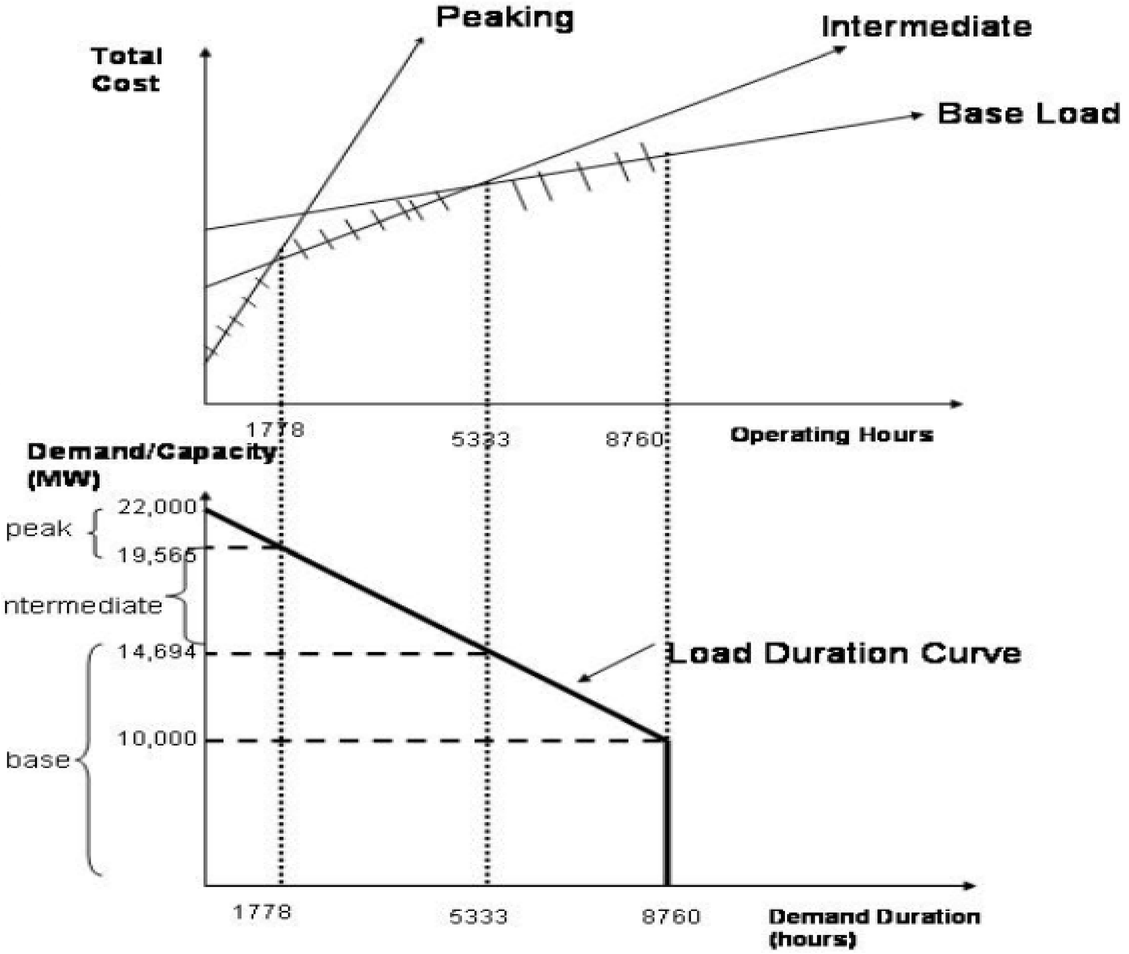
Missing money reduces the payments to all types of generation.

https://ferc.gov/eventcalendar/files/20060207132019-hogan_energy_only_092305.pdf

Paul Joskow

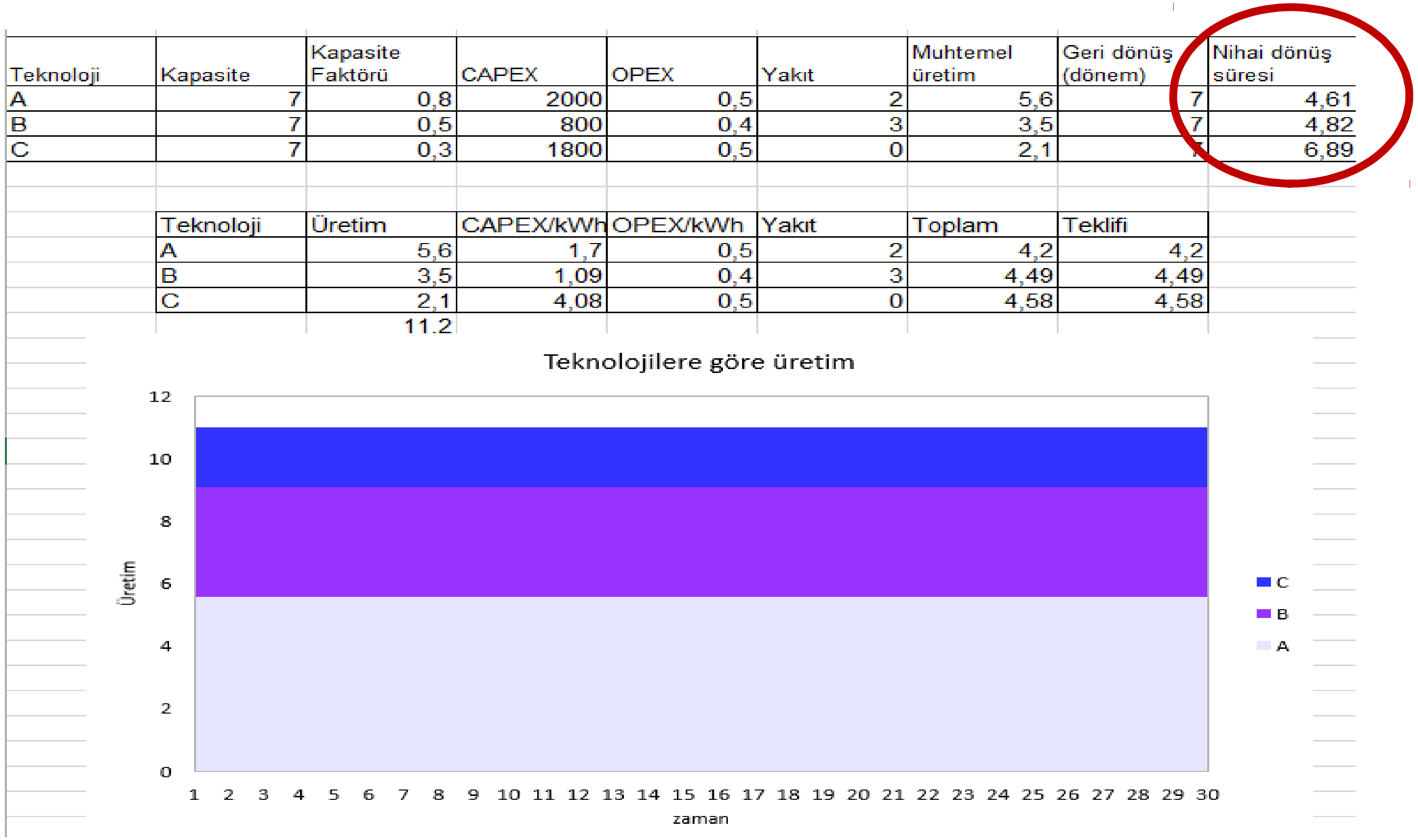






http://economics.mit.edu/files/1190

3 Elektrik santrali olan bir Piyasa



Teknoloji	Kapasite	Kapasite Faktörü	CAPEX	OPEX	Yakıt	Muhtemel üretim	Geri dönüş (dönem)	Nihai dönüş süresi
A	7	0,8	2000	0,5	2	5,6	7	4,61
B	7	0,5	800	0,4	3	3,5	7	4,82
C	7	0,3	1800	0,5	0	2,1	7	6,89

Teknoloji	Üretim	CAPEX/kWh	OPEX/kWh	Yakıt	Toplam	Teklifi
A	5,6	1,7	0,5	2	4,2	4,2
B	3,5	1,09	0,4	3	4,49	4,49
C	2,1	4,08	0,5	0	4,58	4,58
	11.2					

3 teknoloji var

A: Baz yük/belki kömür

B: Peaker/doğalgaz gibi

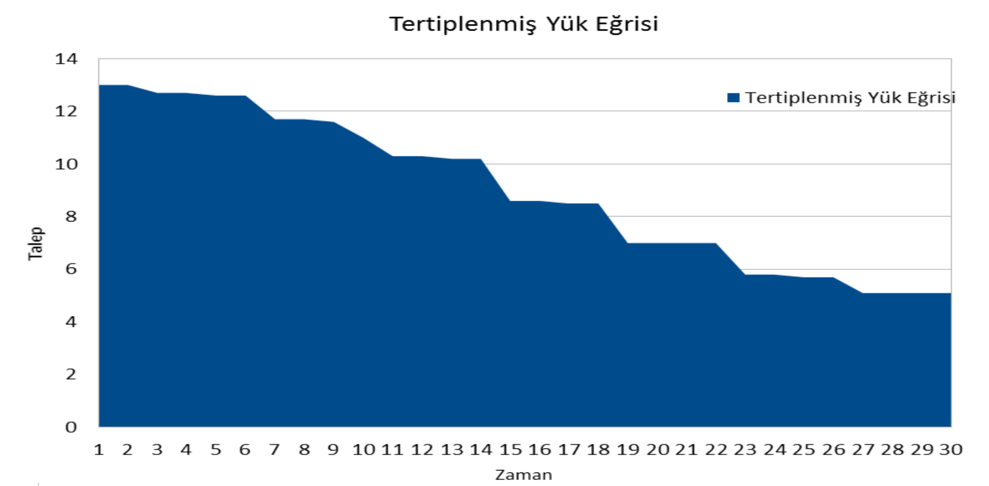
C: Yenilenebilir

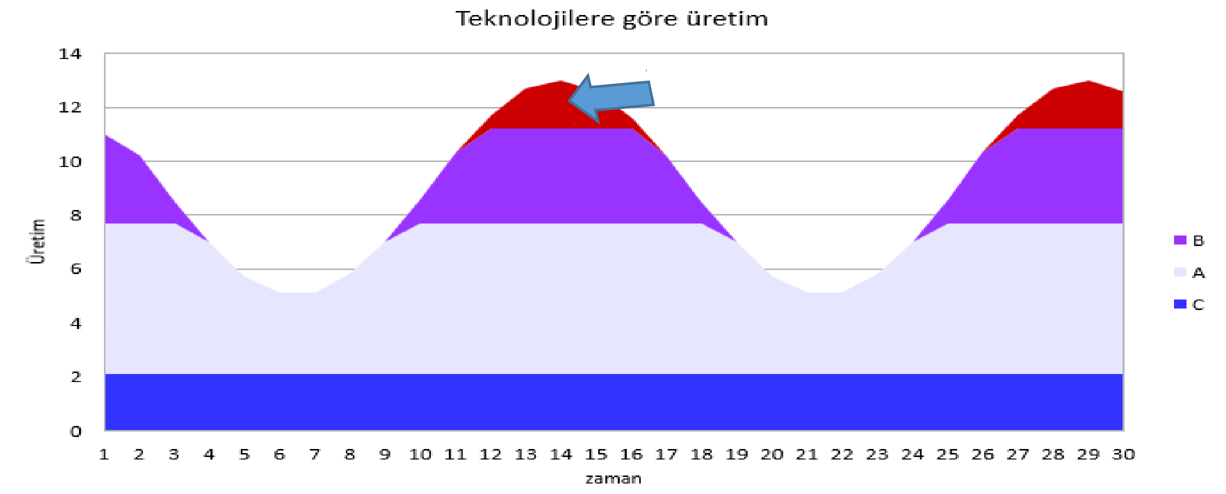
Farzedelim bunlar CAPEX'leri bid etse

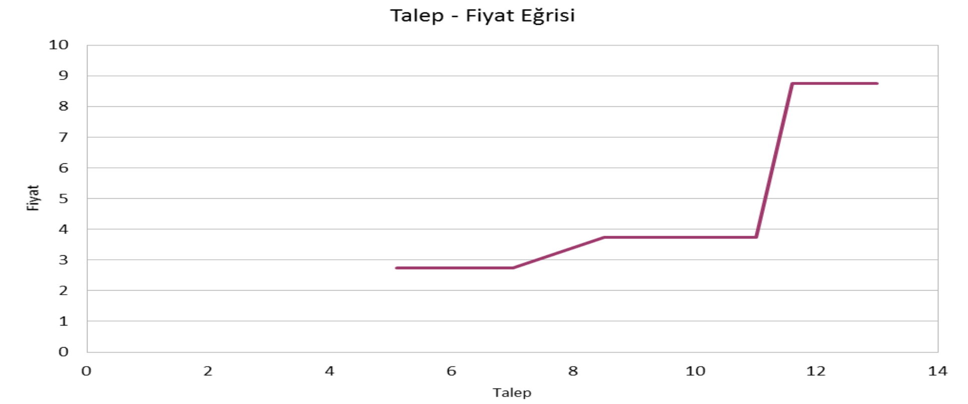
Talep 11 iken sorun yok

Model 4- Yokluk fiyatlaması

Teknoloji	Kapasite	Kapasite Faktörü	CAPEX	OPEX	Yakıt	Muhtemel üretim	Geri dönüş (dönem)	Nihai dönüş süresi
A	7	0,8	2000	0,5	2	5,6	7	4,33
B	7	0,5	800	0,4	3	3,5	7	4,14
C	7	0,3	1800	0,5	0	2,1	7	5,90
	21					11,2		
	Teknoloji	Üretim	CAPEX/kWh	OPEX/kWh	Yakıt	Toplam		
	A	5,6	1,7	0,5	2	2,5	2,75	
	B	3,5	1,09	0,4	3	3,4	3,74	
	C	2,1	4,08	0,5	0	0,5	0,55	
		11,2					3,74	
		Voll	10					
		Kar beklentis	%10,00					

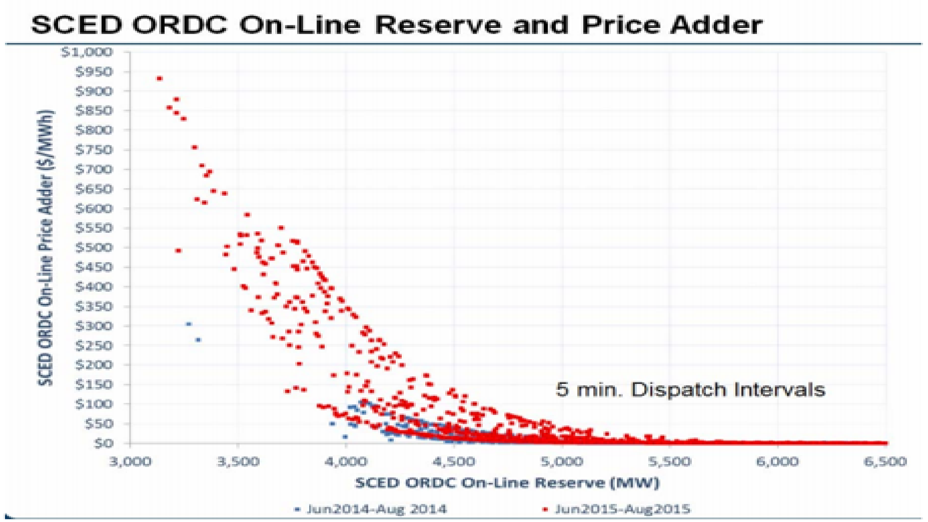




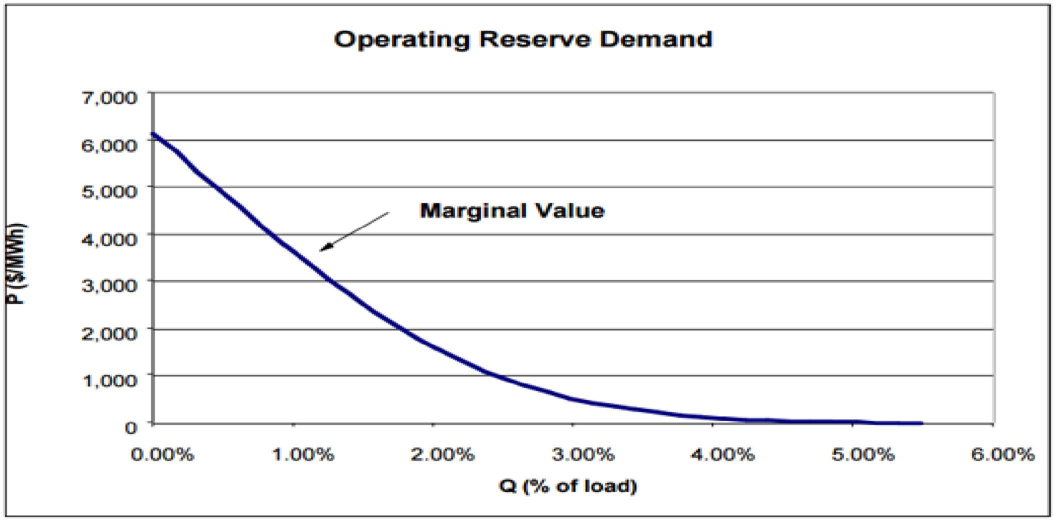


ORDC

Teksas Piyasası (2015-2014), (Prof W. Hogan, Harvard, https://www.hks.harvard.edu/fs/whogan/Hogan_IHS_110916.pdf)



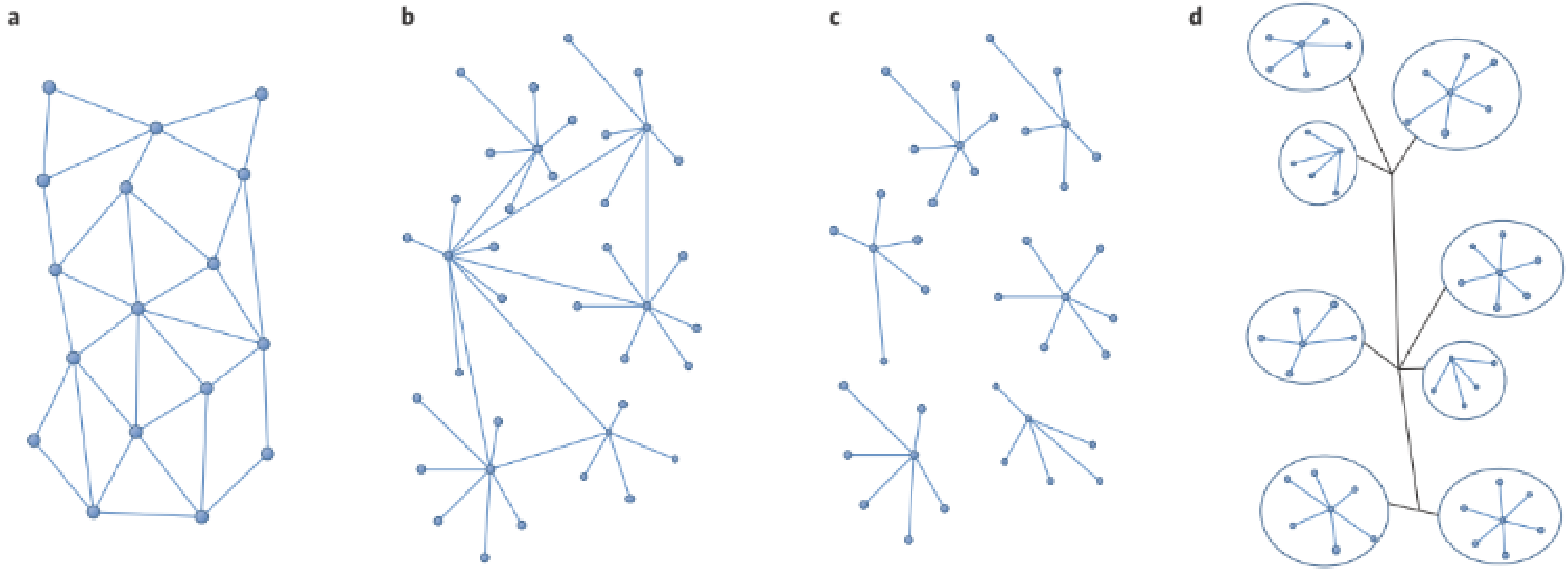
Surendran, *Analysis of Reserves and Prices, July 2, 2015-August 23: Hour Ending 17:00*, ERCOT TAC Presentation,



Kaç MW kaç Kwh?

Çok boyutlu hale gelen
bir tahmin sorunu

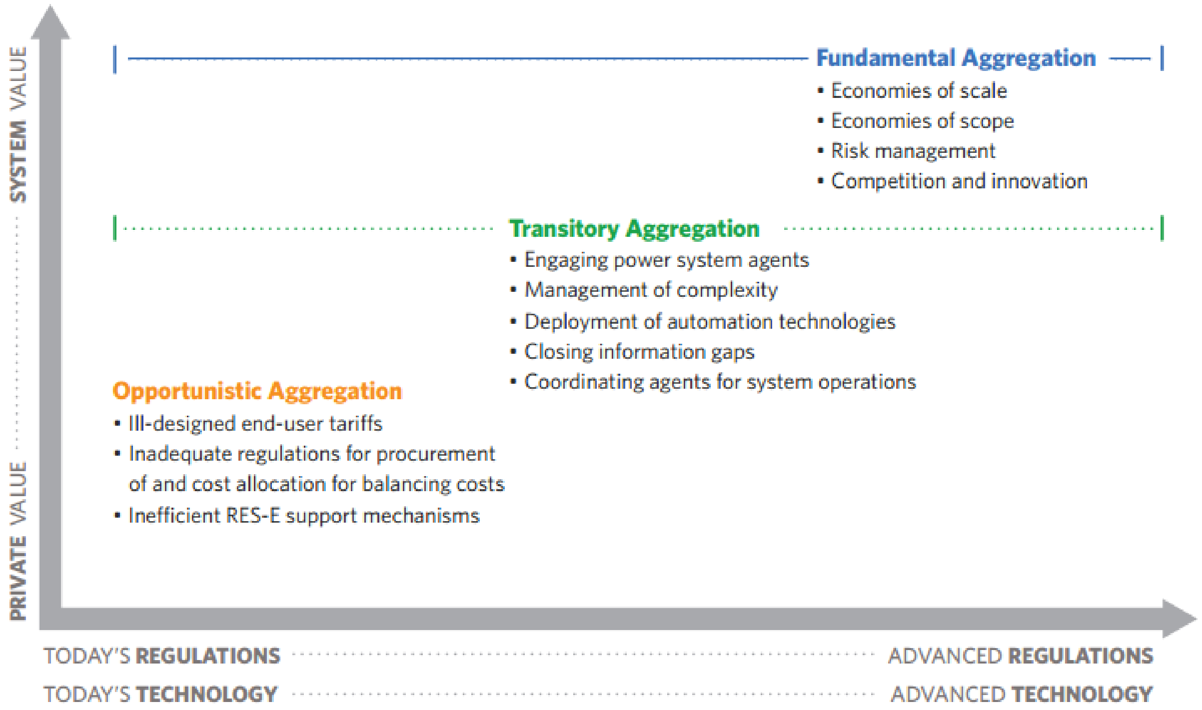
Değişik Piyasa Yapıları



Electricity market design in the prosumer era, Nature Energy 1, Article number: 16032 (2016)
, Nature Publishing Group. 2016. Nature energy. http://www.nature.com/nenergy

Birleştiriciler ama hangi birleştirici?

Figure 6.4: Value of Aggregators Based on Technology and Regulatory Contexts



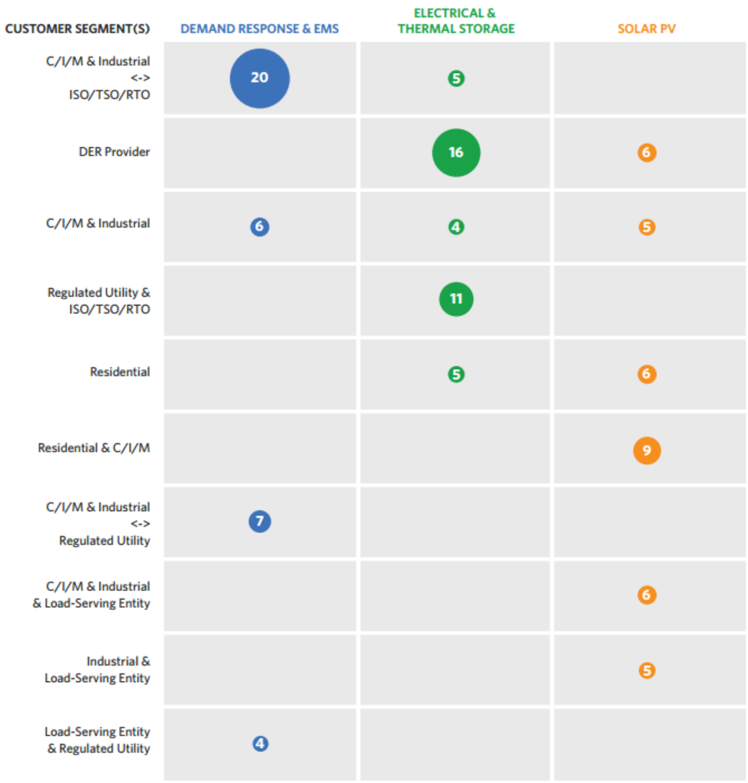
https://energy.mit.edu/wp-content/uploads/2016/12/Utility-of-the-Future-Full-Report.pdf

Hangi iş modelleri

Figure 6.5: Electricity Services Summary

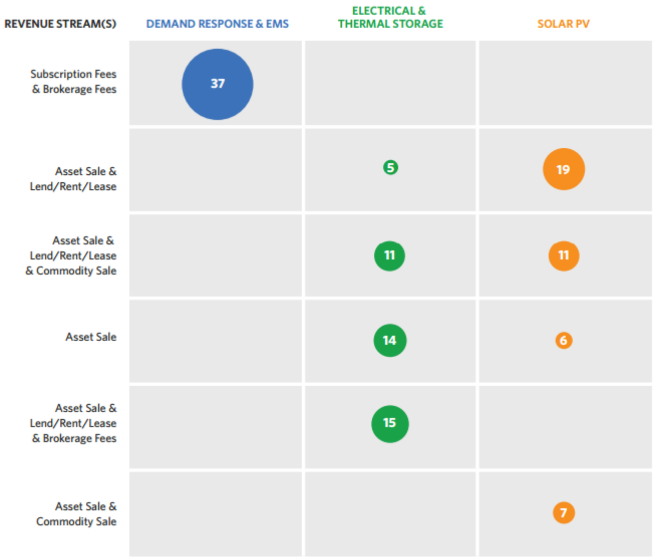
SERVICE(S)	DEMAND RESPONSE & EMS	ELECTRICAL & THERMAL STORAGE	SOLAR PV
Firm Capacity & Operating Reserves & Mitigation of Network Constraints	28	20	
Energy			37
Non-Electricity Services	6	17	6
Firm Capacity		9	
Firm Capacity & Secondary Frequency Control & Mitigation of Network Constraints	6		
Energy & Firm Capacity & Operating Reserves			4

Figure 6.6: Summary of Customer Segments



CUSTOMER SEGMENT(S)	DEMAND RESPONSE & EMS	ELECTRICAL & THERMAL STORAGE	SOLAR PV
C/I/M & Industrial <-> ISO/TSO/RTO	20	5	
DER Provider		16	6
C/I/M & Industrial	6	4	5
Regulated Utility & ISO/TSO/RTO		11	
Residential		5	6
Residential & C/I/M			9
C/I/M & Industrial <-> Regulated Utility	7		
C/I/M & Industrial & Load-Serving Entity			6
Industrial & Load-Serving Entity			5
Load-Serving Entity & Regulated Utility	4		

Figure 6.7: Summary of Revenue Streams

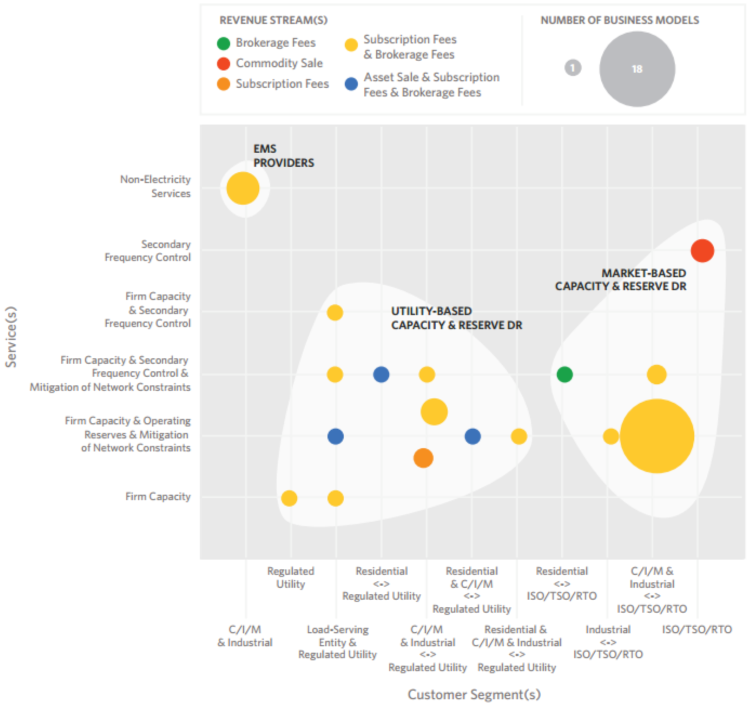


REVENUE STREAM(S)	DEMAND RESPONSE & EMS	ELECTRICAL & THERMAL STORAGE	SOLAR PV
Subscription Fees & Brokerage Fees	37		
Asset Sale & Lend/Rent/Lease		5	19
Asset Sale & Lend/Rent/Lease & Commodity Sale		11	11
Asset Sale		14	6
Asset Sale & Lend/Rent/Lease & Brokerage Fees		15	
Asset Sale & Commodity Sale			7

https://energy.mit.edu/wp-content/uploads/2016/12/Utility-of-the-Future-Full-Report.pdf

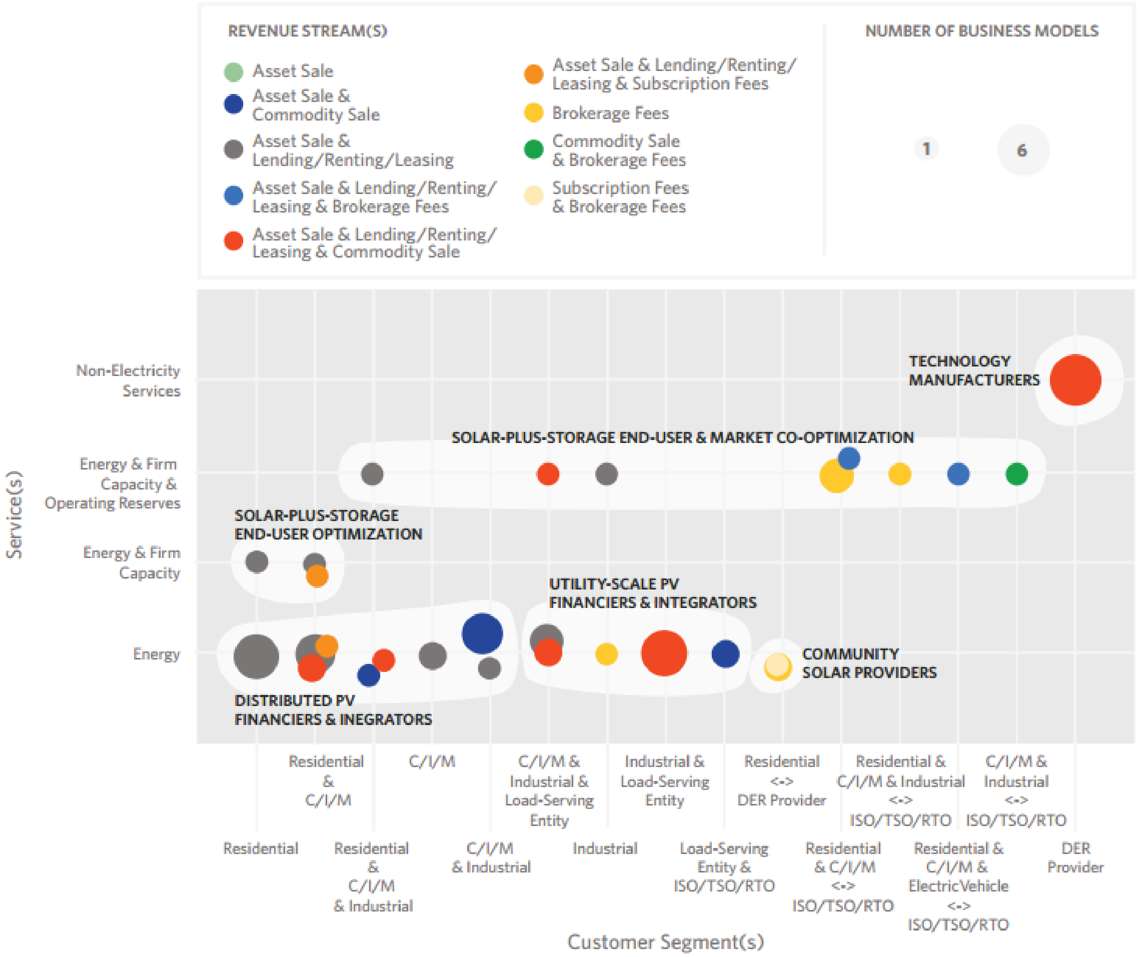
İş Modelleri

Figure 6.8: Taxonomy of Demand Response and Energy Management System Business Models



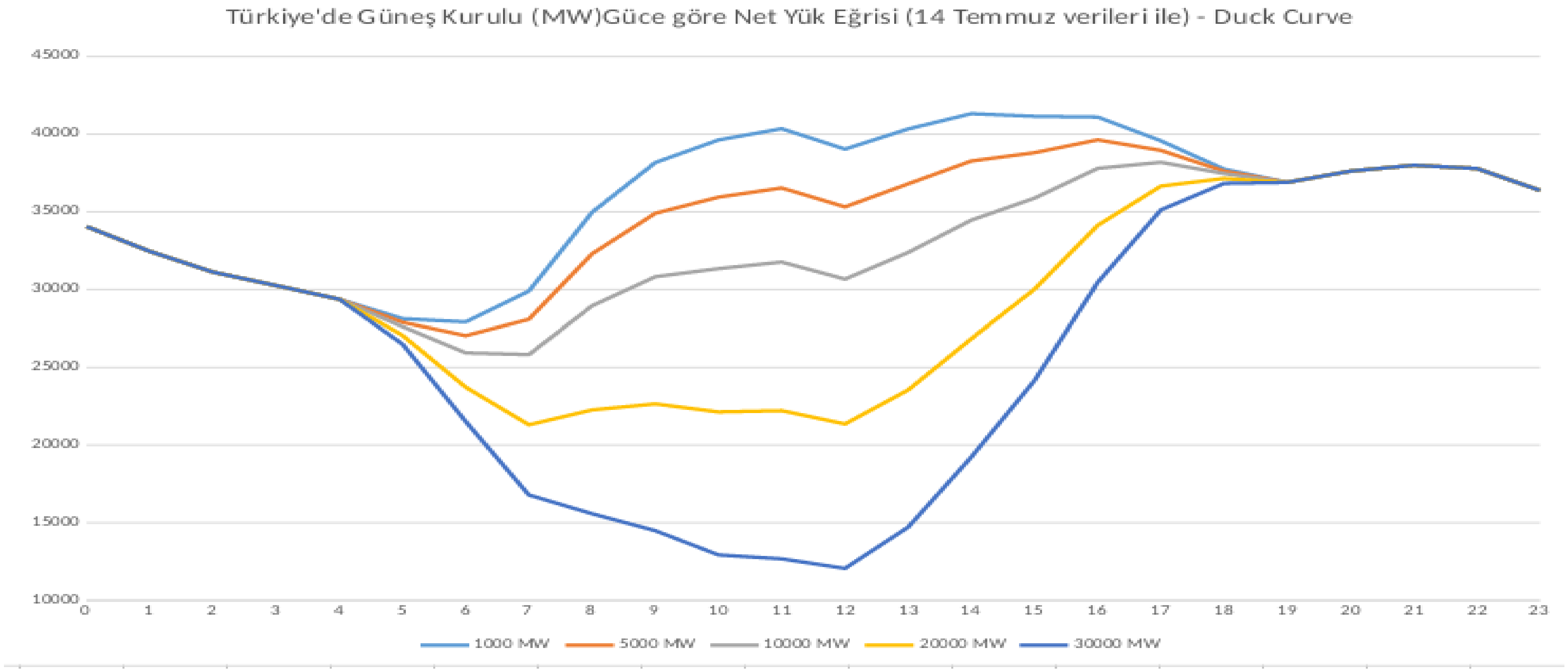
CHAPTER 6: Restructuring Revisited: Electricity Industry Structure in a More Distributed Future **219**

Figure 6.9: Taxonomy of Solar PV and Solar-plus-Storage Business Models

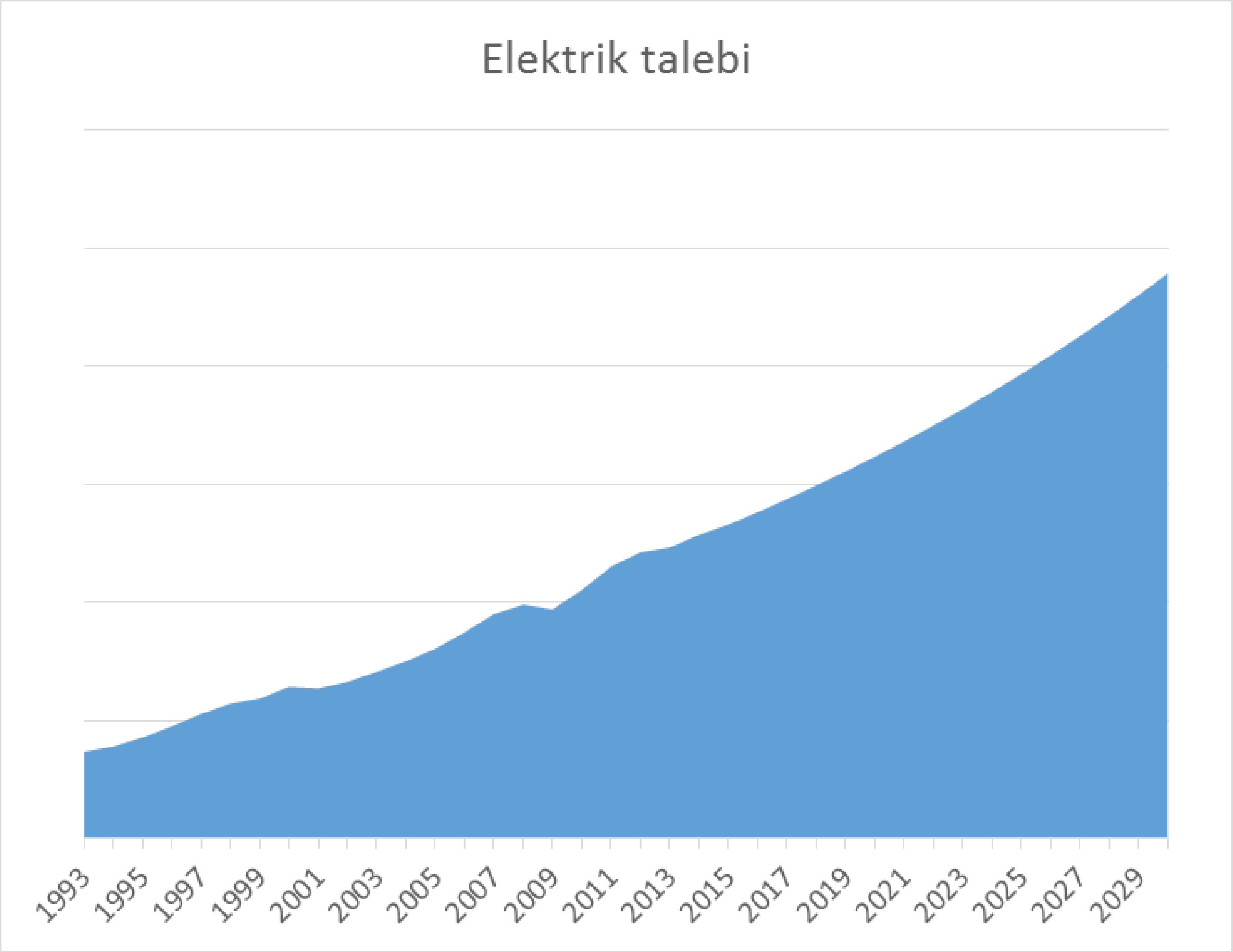


https://energy.mit.edu/wp-content/uploads/2016/12/Utility-of-the-Future-Full-Report.pdf

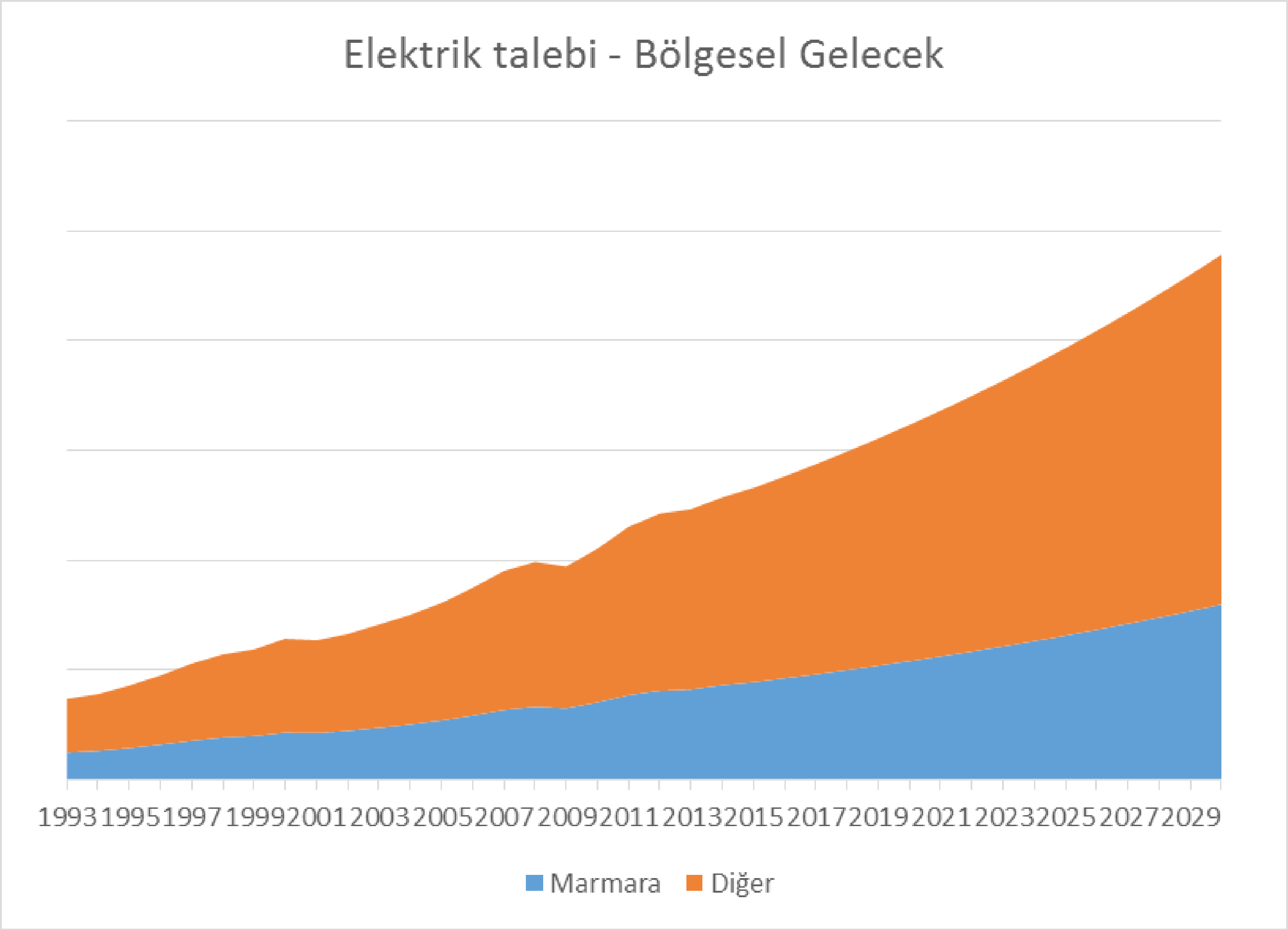
Türkiye Güneş Gelişimi – Ördek Eğrisi



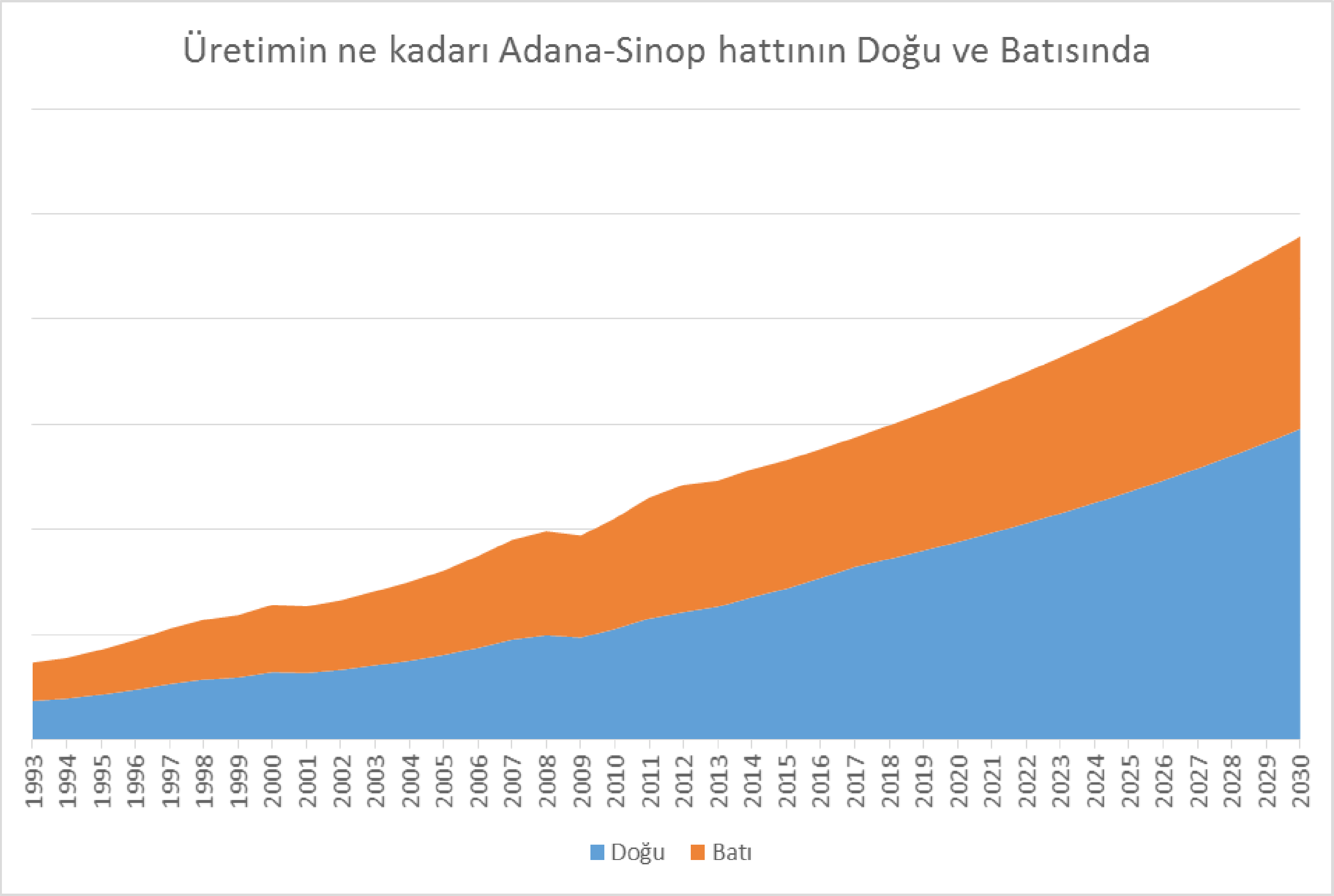
Elektrik geleceği



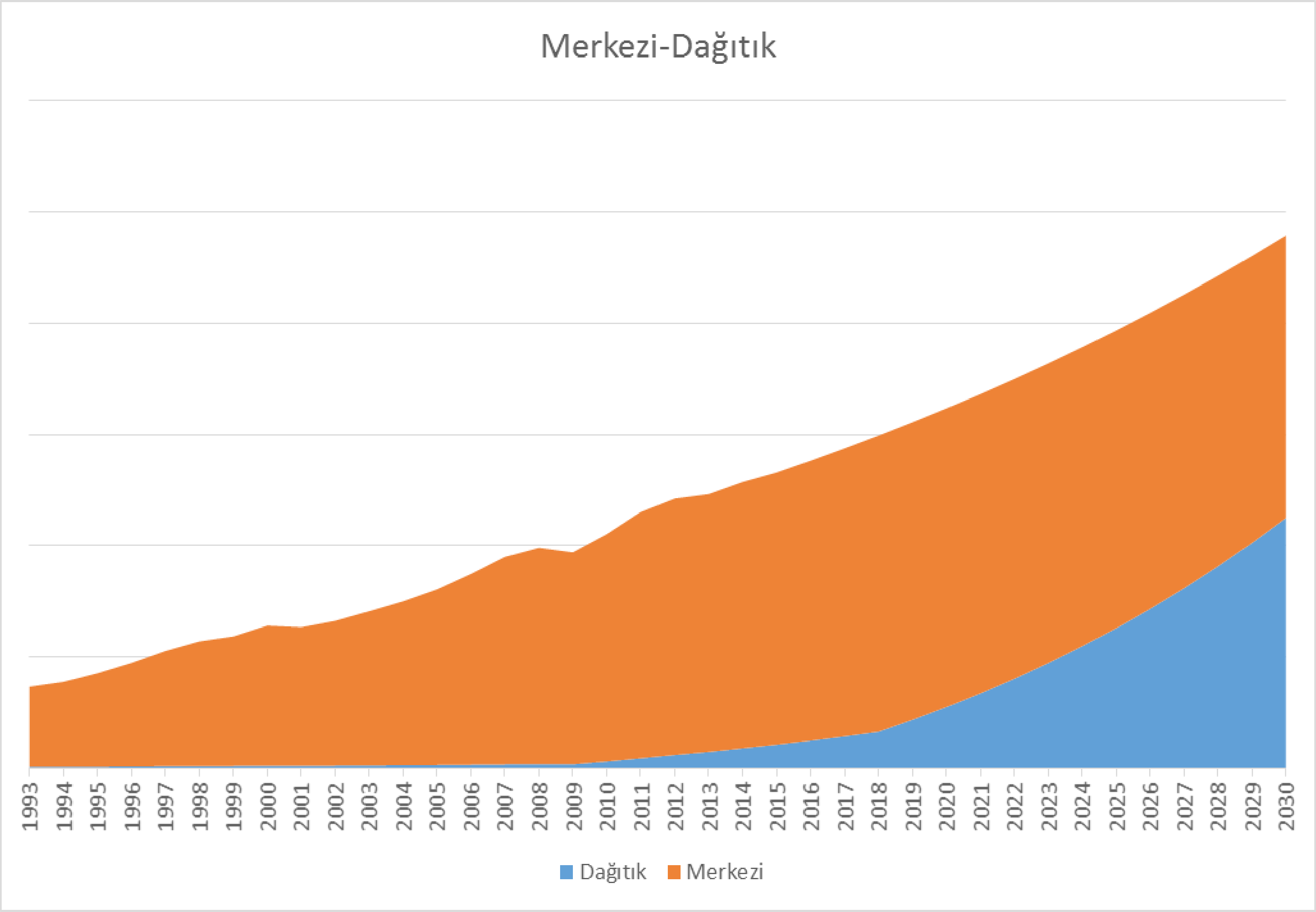
Talebin bölgesel dağılımı?



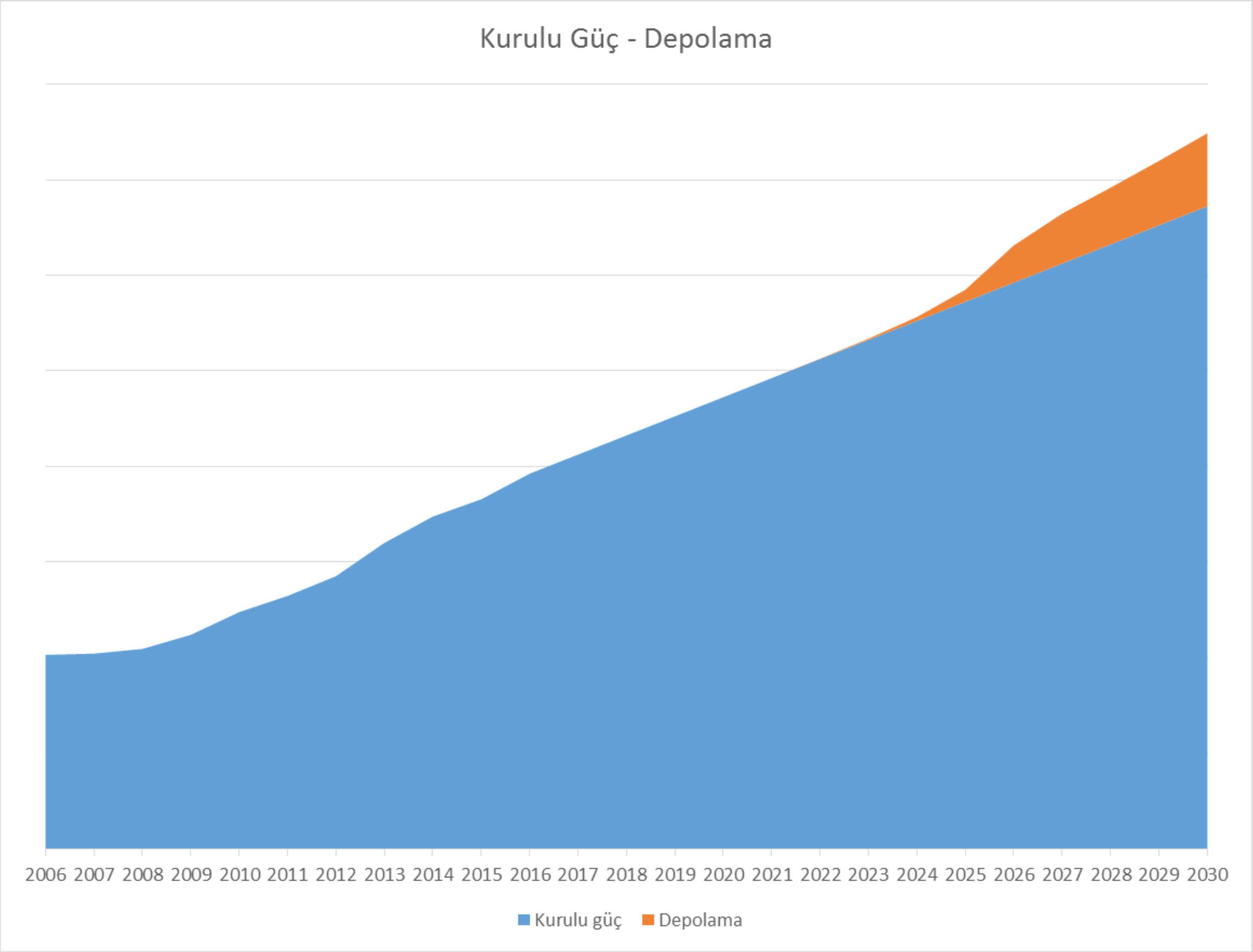
Üretimin bölgesel dağılımı



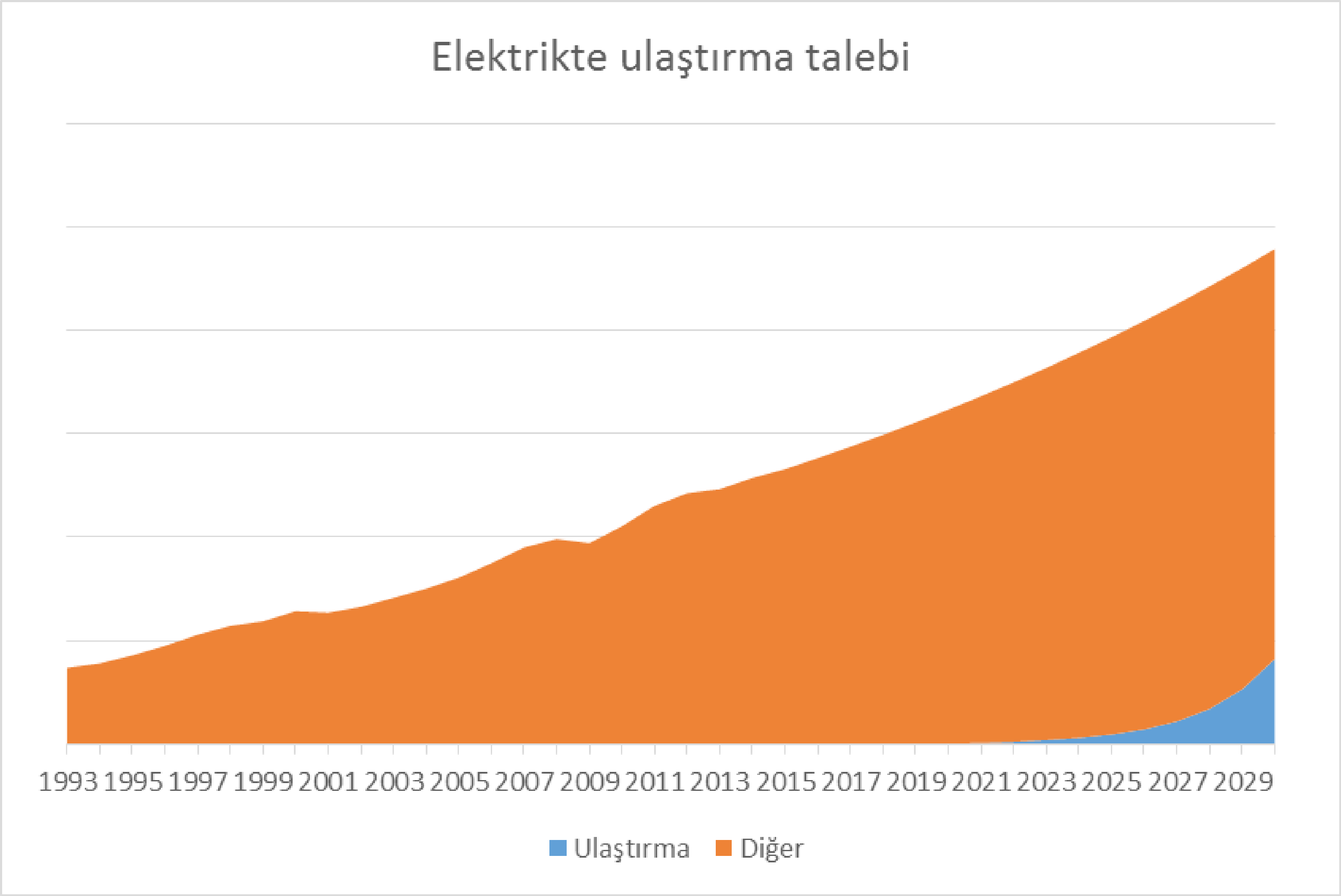
Ne kadarı merkezi, ne kadarı dağıtık



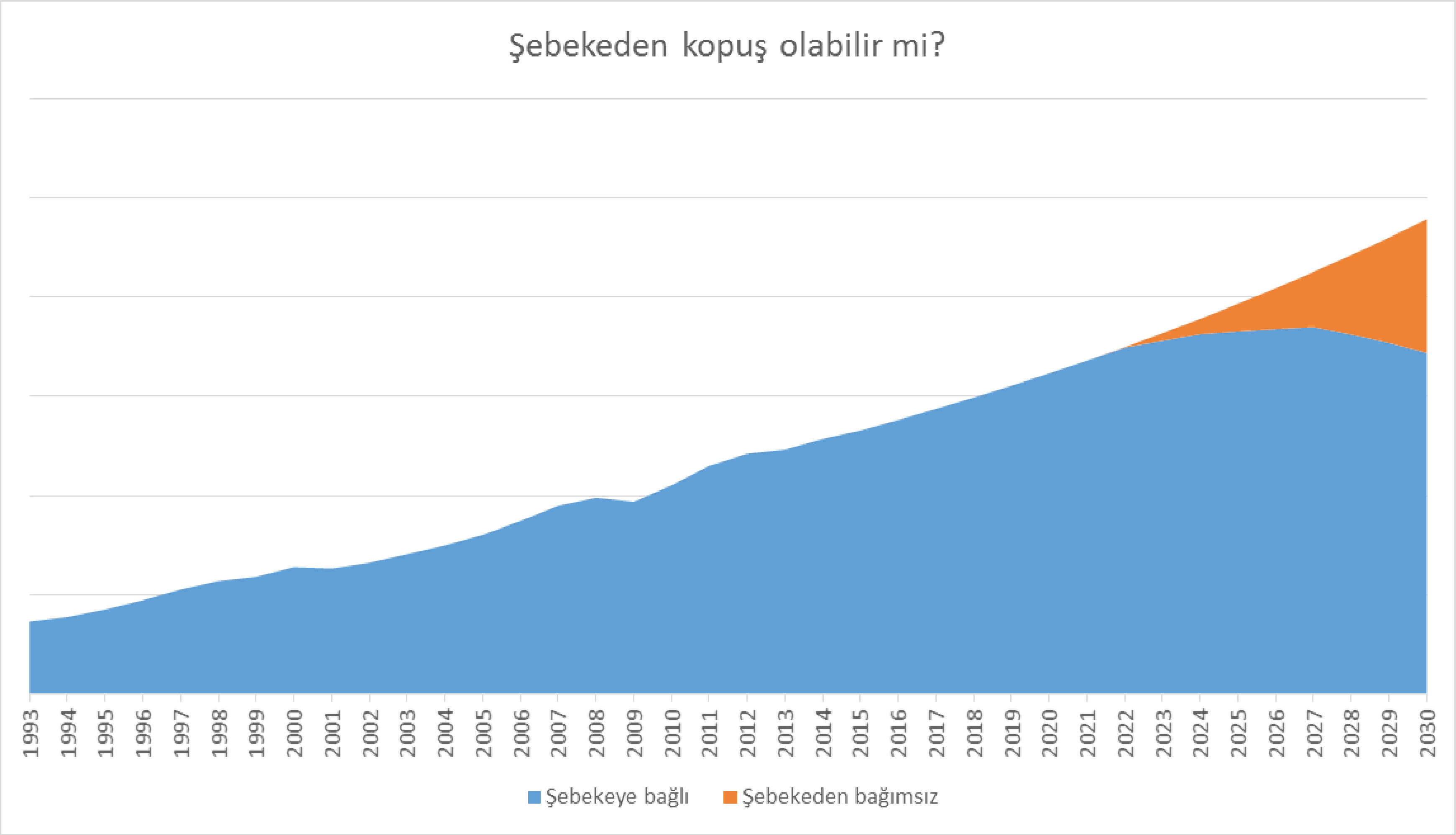
Kurulu güç - Depolama



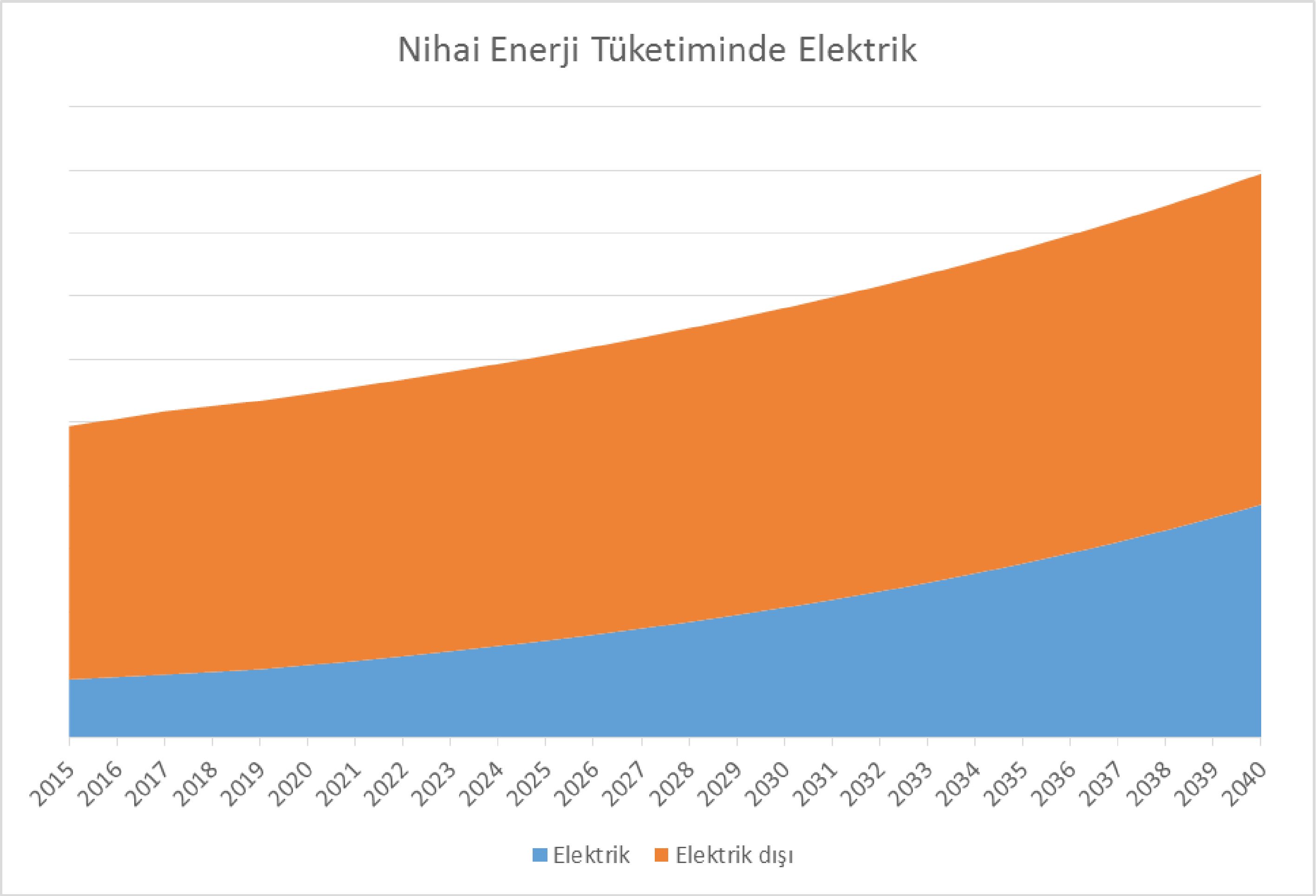
Elektrikte ulaştırma payı



Sabit telefon hatlarının kaderi?



Robotlar, arabalar, dijital dünya



Teşekkürler

- Barış Sanlı
- www.barissanli.com