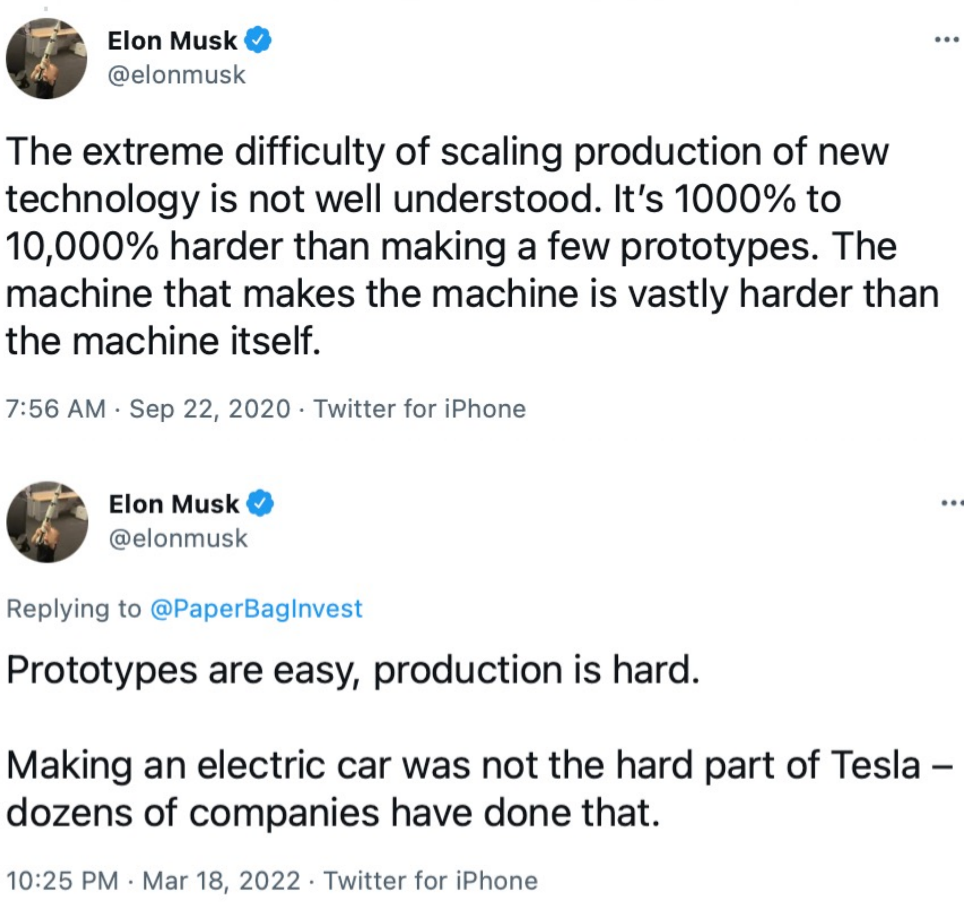
Enerjide Teknoloji Gelişimindeki Dinamikler

Barış Sanlı

Bazı sözler : Akademinin rolünü doğru anlamak

- Yeni teknolojinin ölçeklendirilmesinin ne kadar zor olduğu doğru anlaşılamıyor. Gerçekte prototip yapmaktan %1,000-10,000 daha zor. Makineleri yapan makineyi yapmak, makinenin kendisini yapmaktan kat kat daha zor
- Prototipler kolay, üretim zor. Elektrikli araba yapmak Tesla için zor olan kısım değildi, bunu onlarca şirket de yaptı.



Önemli araştırmacılar ve adresleri

Gökşin Kavlak

Massachusetts Institute of Technology
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Energy Systems · Technological Change · Industrial Ecology · Innovation

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TITLE	CITED BY	YEAR
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Life cycle carbon benefits of aerospace alloy recycling MJ Eckelman, L Ciacci, G Kavlak, P Nuss, BK Reck, TE Graedel Journal of Cleaner Production 80, 38-45	97	2014
Tracking the metal of the goblins: cobalt's cycle of use EM Harper, G Kavlak, TE Graedel Environmental science & technology 46 (2), 1079-1086	97	2012
Criticality of the geological zinc, tin, and lead family EM Harper, G Kavlak, L Burmeister, MJ Eckelman, S Erbis, ... Journal of Industrial Ecology 19 (4), 628-644	80	2015
Metals production requirements for rapid photovoltaics deployment G Kavlak, J McNerney, RL Jaffe, JE Trancik Energy & Environmental Science	73	2015

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Jessika E Trancik

Associate Professor, IDSS, MIT
Verified email at mit.edu
Energy Systems · Energy Conversion and Sto...

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TITLE	CITED BY	YEAR
Net-zero emissions energy systems SJ Davis, NS Lewis, M Shaner, S Aggarwal, D Arent, IL Azevedo, ... Science 360 (6396), eaas9793	824	2018
Transparent and catalytic carbon nanotube films JE Trancik, SC Barton, J Hone Nano letters 8 (4), 982-987	425	2008
Statistical basis for predicting technological progress B Nagy, JD Farmer, QM Bui, JE Trancik PloS one 8 (2), e52669	285	2013
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Potential for widespread electrification of personal vehicle travel in the United States ZA Needell, J McNerney, MT Chang, JE Trancik Nature Energy 1, 16112	227	2016
Role of design complexity in technology improvement J McNerney, JD Farmer, S Redner, JE Trancik Proceedings of the National Academy of Sciences 108 (22), 9008-9013	187	2011

https://scholar.google.com.tr/citations?hl=en&user=fdYetz8AAAAJ

Güneş panel fiyatları neden düştü?

Evaluating the causes of cost reduction in photovoltaic modules

Goksin Kavlak[a], James McNerney[a] and Jessika E. Trancik[a, b, *]

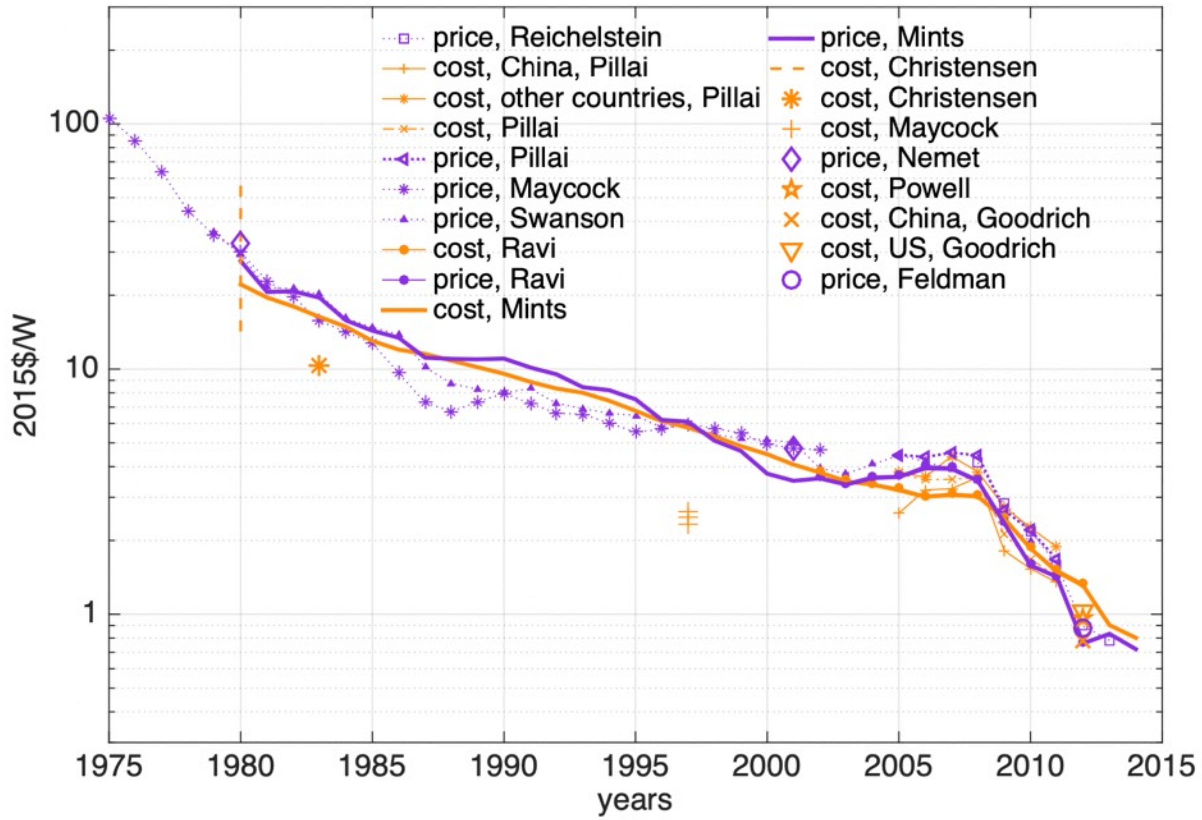
[a]Institute for Data, Systems and Society, Massachusetts Institute of Technology, Cambridge, MA, USA

[b]Santa Fe Institute, Santa Fe, NM, USA

*Corresponding author. Email: trancik@mit.edu

Abstract

Photovoltaics (PV) module costs have declined rapidly over forty years but the reasons remain elusive. We advance a conceptual framework and quantitative method for quantifying the causes of cost changes in a technology, and apply it to PV modules. Our method begins with a cost model that breaks down cost into variables that changed over time. Cost change equations are then derived to quantify each variable's contribution. We distinguish between



https://www.sciencedirect.com/science/article/pii/S0301421518305196

Fiyatlar, ölçek ve teknolojik değişim

Factor	Unit	1980	2001	2012	References and notes
Plant size (K)	MW/yr	1	13.3	1000	1980: (Swanson, 2006). 2001: (Fraunhofer Institute, 2017), (Swanson, 2006). 2012: (Applied Materials, 2011), (Fraunhofer Institute, 2017), (Swanson, 2006).
	modules/yr	1.72×10^4	8.09×10^4	3.35×10^6	Calculated by dividing the plant size in MW/yr by module power output in each year. We use the modules/year values to populate the plant size variable in our model.
Module efficiency (η)	unitless	8%	13%	15.2%	1980: (Mints, 2015),(Christensen, 1985). 2001: (Mints, 2015),(Rohatgi, 2003),(Symko-Davies et al., 2000). 2012:(Mints, 2015), (Powell et al., 2012).
Polysilicon price (p_s)	2015$/kg	126	36	26	1980: (Mints, 2015), (Williams, 1980), (Costello et al., 1980). 2001: (Mints, 2015),(Swanson, 2006). 2012: (Mints, 2015), (Powell et al., 2013).
Wafer area (A)	cm^2	90	156	243	1980: (Christensen, 1985), (Mints, 2015). 2001: (Mints, 2015), (Swanson, 2006). 2012: (Powell et al., 2012),(Mints, 2015).
Silicon thickness (t)	μm	500	300	180	1980: (Swanson, 2006). 2001: (Swanson, 2006), (Sarti and Einhaus, 2002). 2012: (Applied Materials, 2011), (Fraunhofer Institute, 2017), (Goodrich et al., 2013a).
Silicon utilization (U)	unitless	0.20	0.36	0.45	1980: (Hammond, 1977). 2001: (Sarti and Einhaus, 2002). 2012: (Centrotherm Photovoltaics, 2010).
Silicon usage (v) $\equiv t/U$	cm	0.25	0.086	0.04	See the references for t and U.
Yield (y)	unitless	75%	86%	95%	1980: (Mints, 2015). 2001: (Rohatgi, 2003), (Mints, 2015), (Sarti and Einhaus, 2002). 2012: (Applied Materials, 2011), (ITRPV, 2012), (Mints, 2015).
Share of materials costs (θ)	unitless	0.69	0.43	0.65	1980: (Williams, 1980). 2001: (Maycock, 1997). 2012: (Powell et al., 2013).
Scaling factor (b)	unitless	0.27	0.27	0.27	(Maycock, 1997).
Module cost	2015$/W	29.07	4.08	1.08	1980: (Mints, 2015), (Christensen, 1985). 2001: (Mints, 2015). 2012: (Mints, 2015), (Goodrich et al., 2013b), (Powell et al., 2013), (Ravi, 2013).

Table 1: Data used to calculate module cost components. Table S1 provides the individual data collected from the references above and the approach for obtaining the central estimate of each variable.

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Güneş fiyatları neden düştü? (Alt seviye)

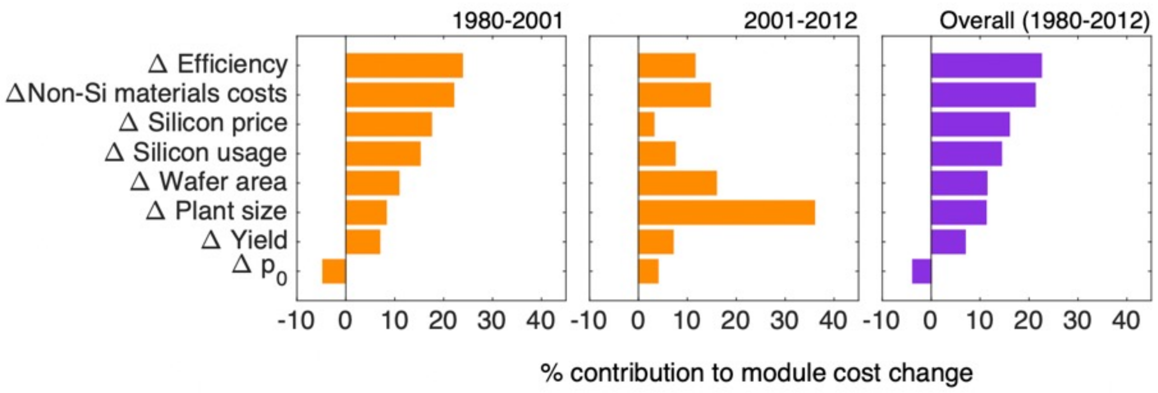

Figure 3: Contribution of the low-level mechanisms to module cost decline in 1980-2001 (left), 2001-2012 (middle), and 1980-2012 (right). Mechanisms are listed in the order of decreasing contribution for the 1980-2001 period.

Cost change due to:	1980-2001		2001-2012		1980-2012	
	Δ$/W	%	Δ$/W	%	Δ$/W	%
Δ Efficiency	-5.96	24%	-0.35	12%	-6.30	23%
Δ Non-Si materials costs	-5.51	22%	-0.44	14%	-5.95	21%
Δ Silicon price	-4.38	18%	-0.10	3%	-4.47	16%
Δ Silicon usage	-3.80	15%	-0.23	8%	-4.02	14%
Δ Wafer area	-2.71	11%	-0.48	16%	-3.19	11%
Δ Plant size	-2.07	8%	-1.08	36%	-3.15	11%
Δ Yield	-1.73	7%	-0.21	7%	-1.95	7%
Δ p_0	1.18	-5%	-0.12	4%	1.06	-4%
Change in module cost	-24.99	100%	-3.00	100%	-27.99	100%

Table 3: Contribution of the low-level mechanisms to module cost decline in 1980-2001 (left), 2 2012 (middle), and 1980-2012 (right). Mechanisms are listed in the order of decreasing contribu for the 1980-2001 period. Costs are in 2015 USD.

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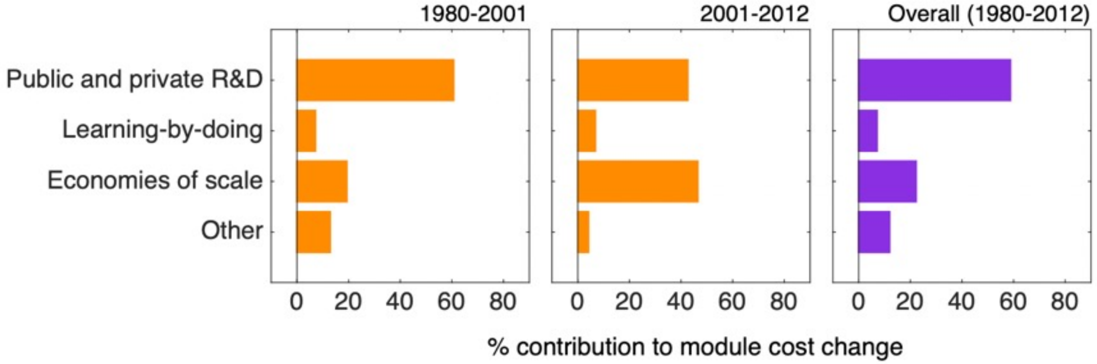
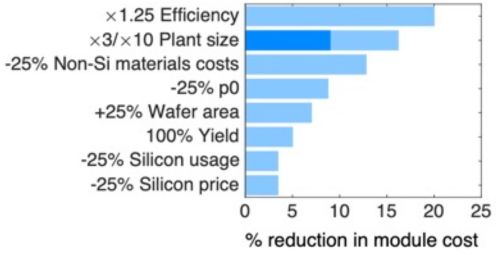
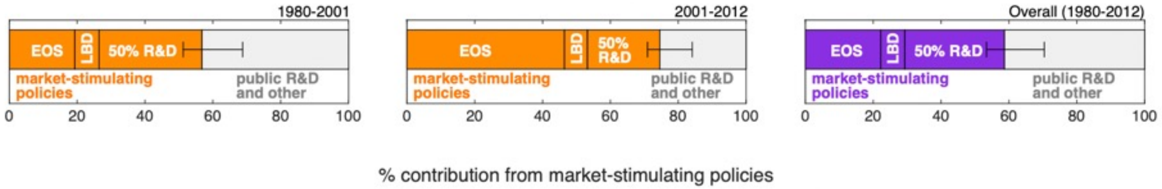
Güneş fiyatları neden düştü? (Üst seviye)

- Kamu özel ArGe
- Yaparak Öğrenmek
- Ölçek Ekonomisi
    - (kapsam ekonomisi)
- Alım Garantileri







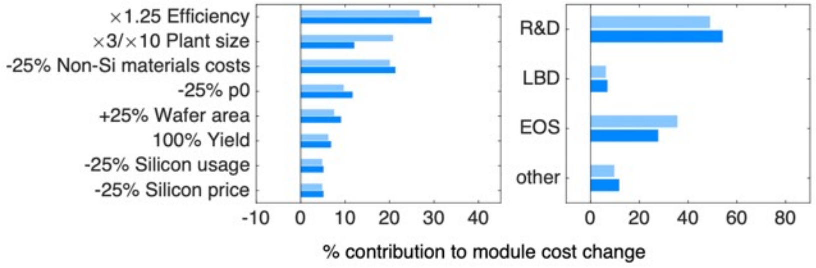


Figure 5: Percent contribution of market-stimulating policies (e.g. feed-in-tariffs, renewable portfolio standards) to module cost reduction in 1980-2001 (left), 2001-2012 (middle), and 1980-2012 (right). R&D = Research and development, LBD = Learning-by-doing, EOS = Economies of scale, Other = other mechanisms such as spillovers. Scale economies, learning-by-doing, and private R&D were all catalyzed by market-stimulating policies. Our data does not let us separate the effects of private and

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Lityum-İyon fiyatları neden düştü?

DOI: 10.1039/D1EE01313K (Analysis) *Energy Environ. Sci.*, 2021, **14**, 6074-6098

Determinants of lithium-ion battery technology cost decline†

Micah S. Ziegler [a], **Juhyun Song** [a] and **Jessika E. Trancik** *[ab]

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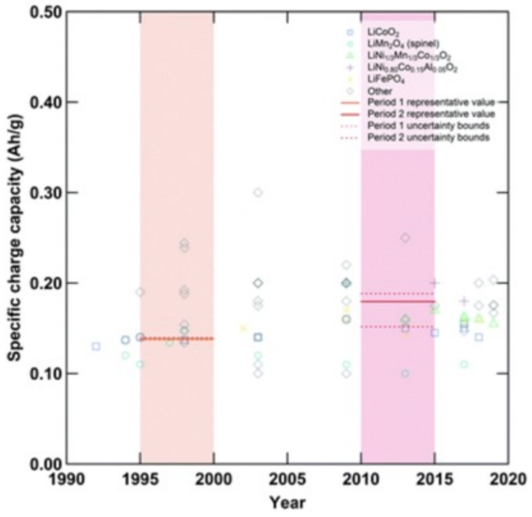
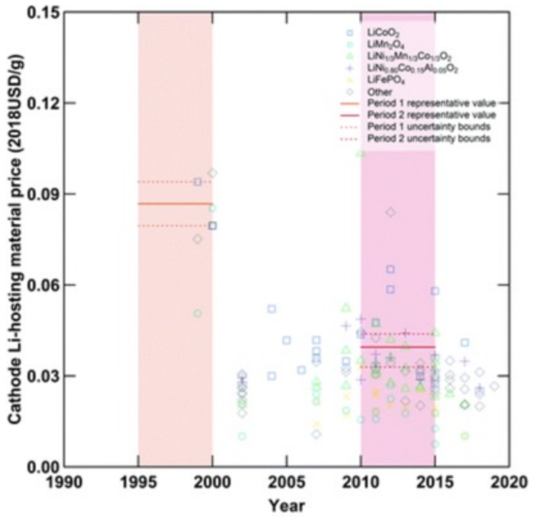
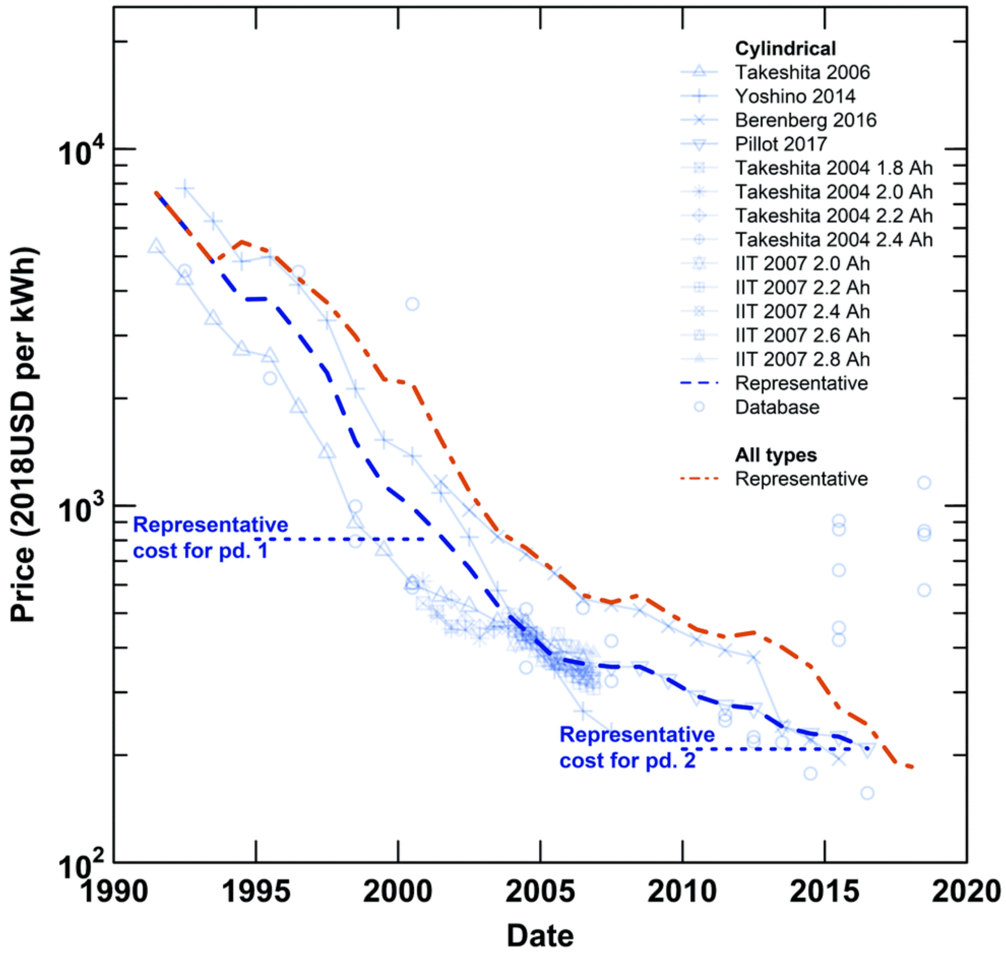
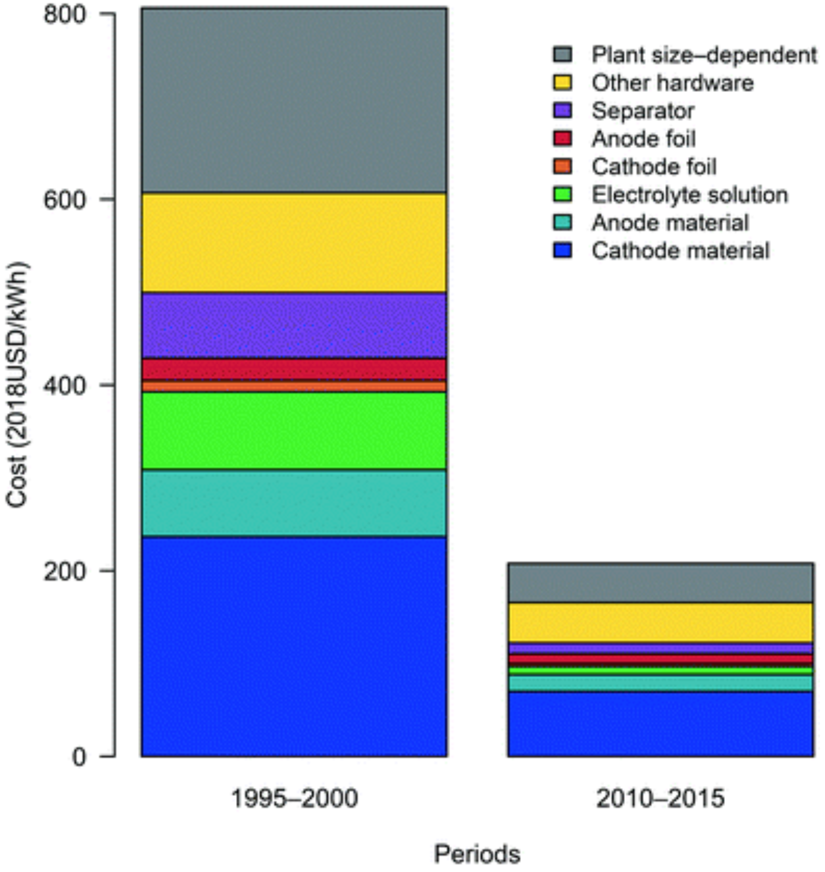


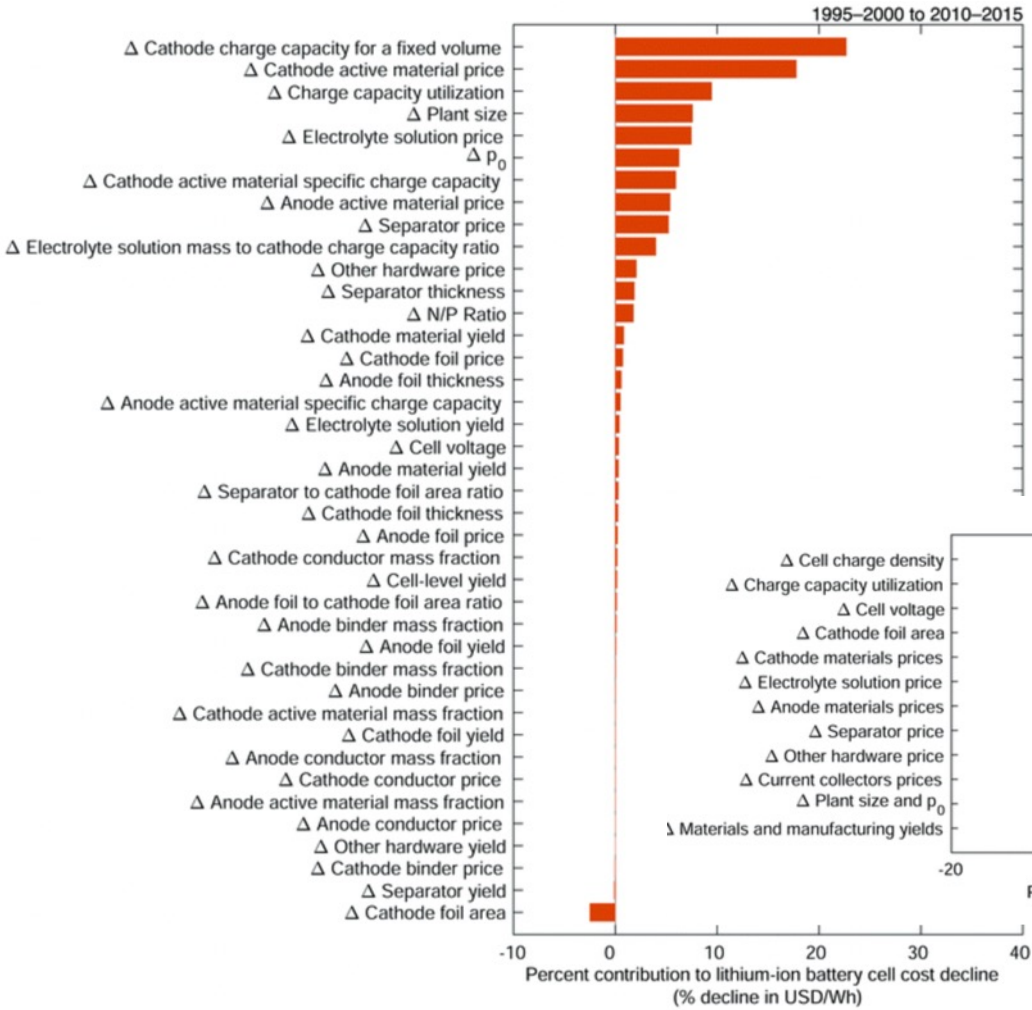


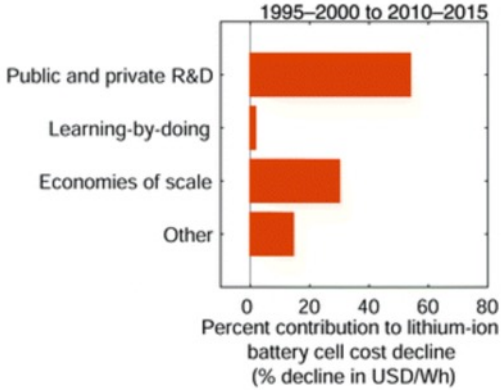


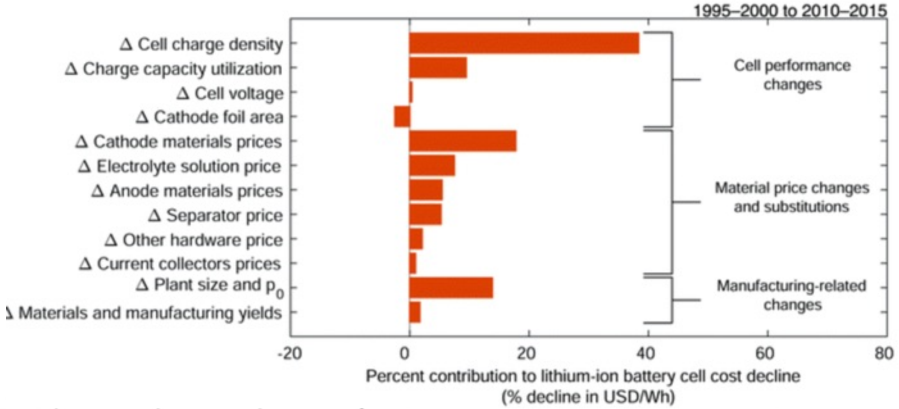
DOI: 10.1039/D1EE01313K

Li-Ion: Düşüşün Sebepleri









DOI: 10.1039/D0EE02681F

Diğer Makale – Li-Ion

DOI: 10.1039/D0EE02681F (Analysis) Energy Environ. Sci., 2021, 14, 1635-1651

Re-examining rates of lithium-ion battery technology improvement and cost decline†

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[b] Santa Fe Institute, Santa Fe, NM, USA

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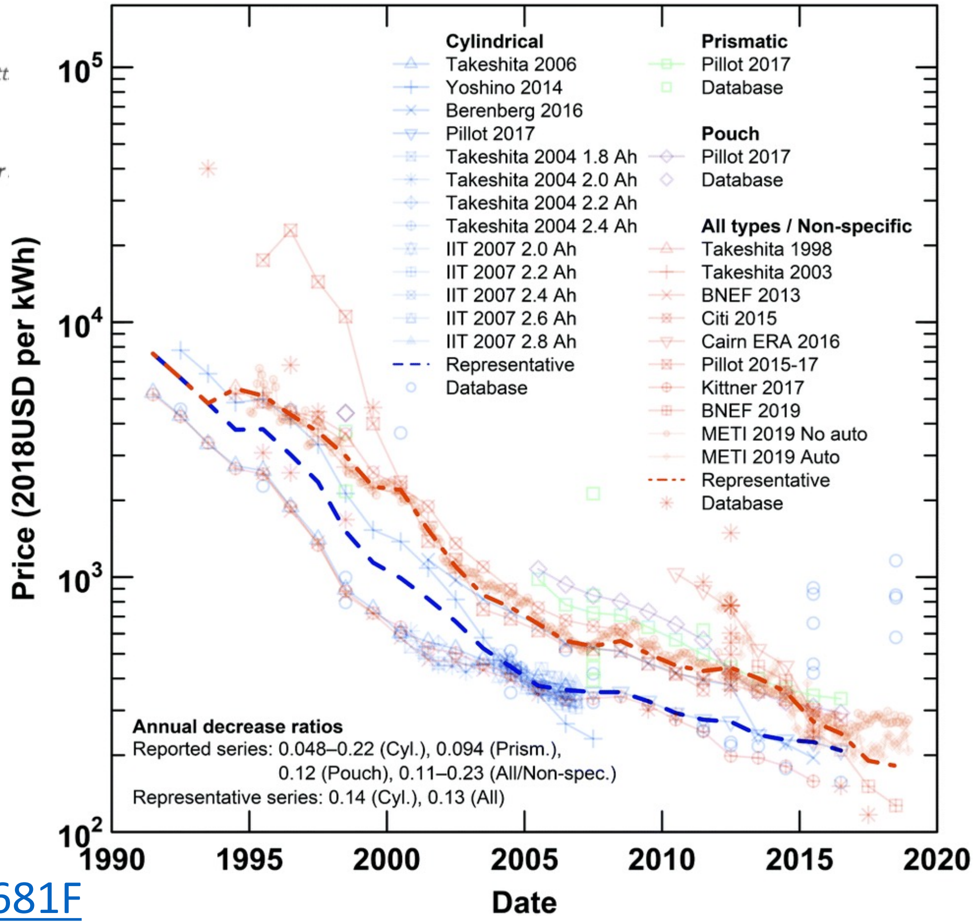
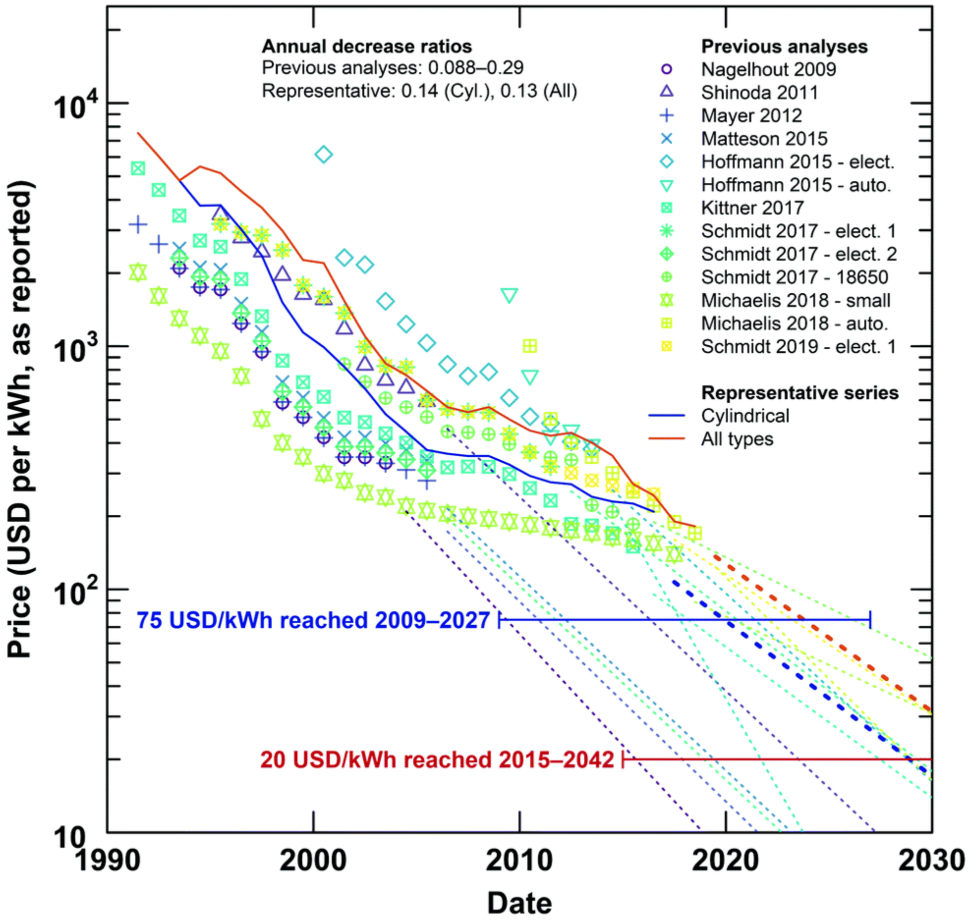
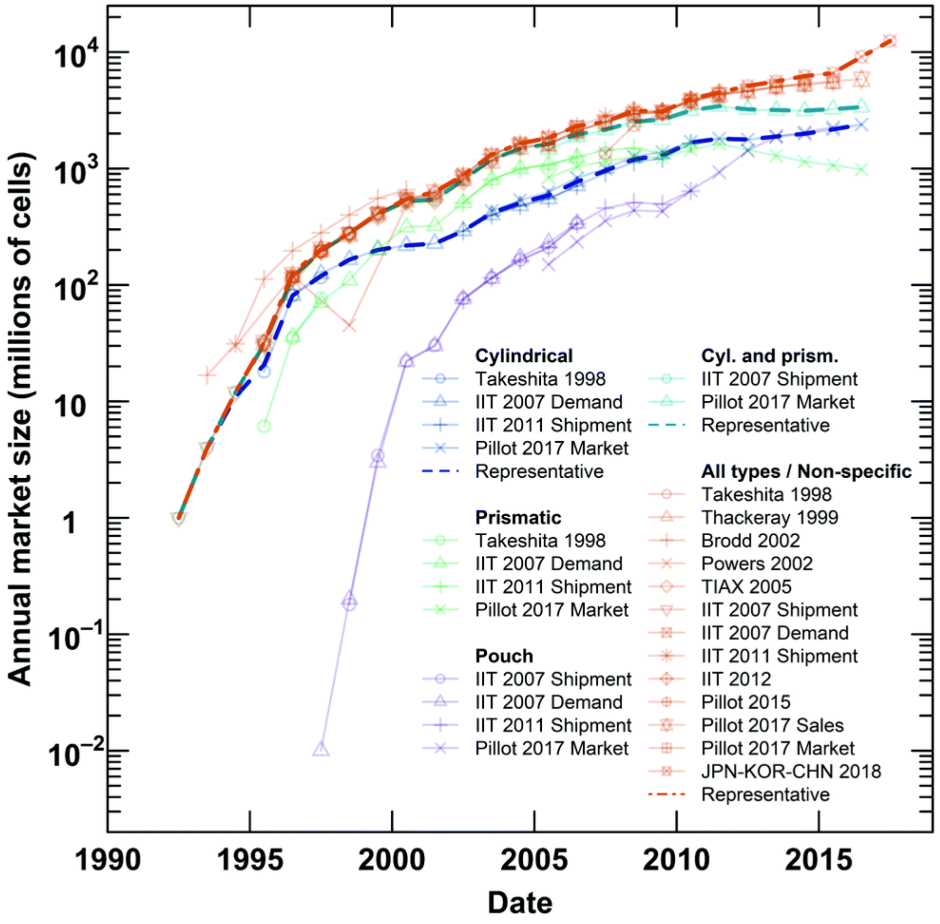
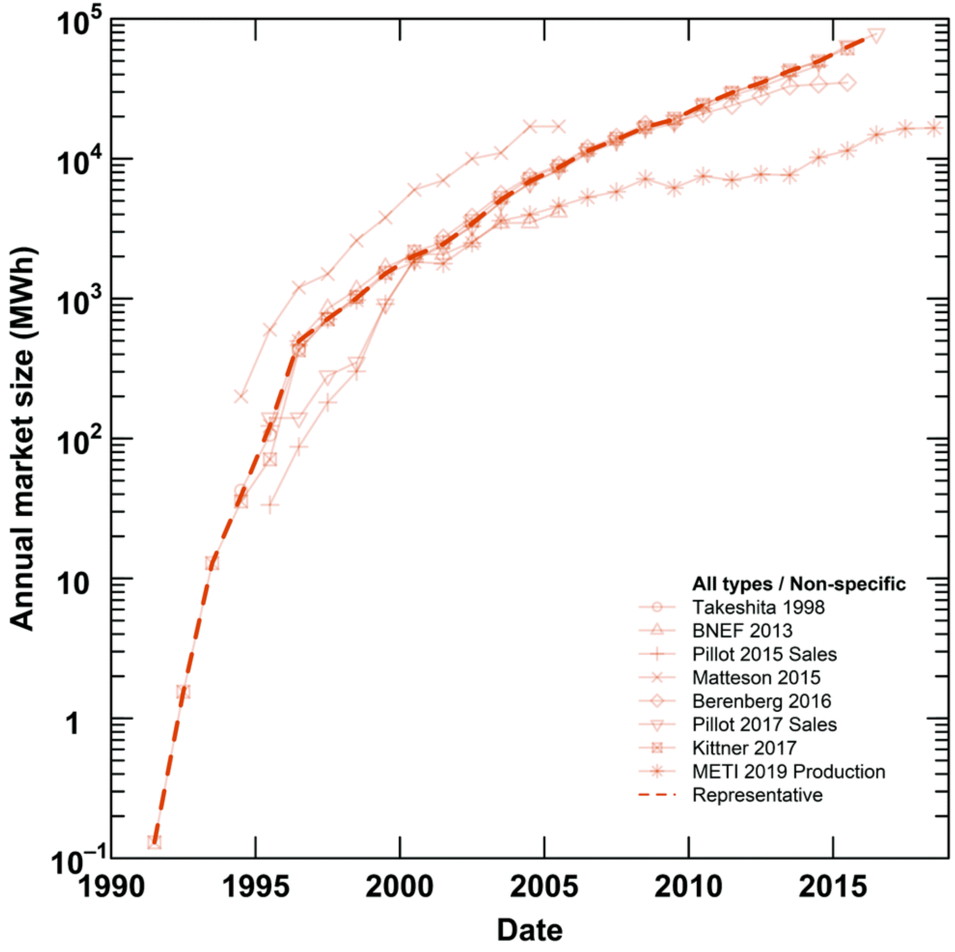




DOI: 10.1039/D0EE02681F

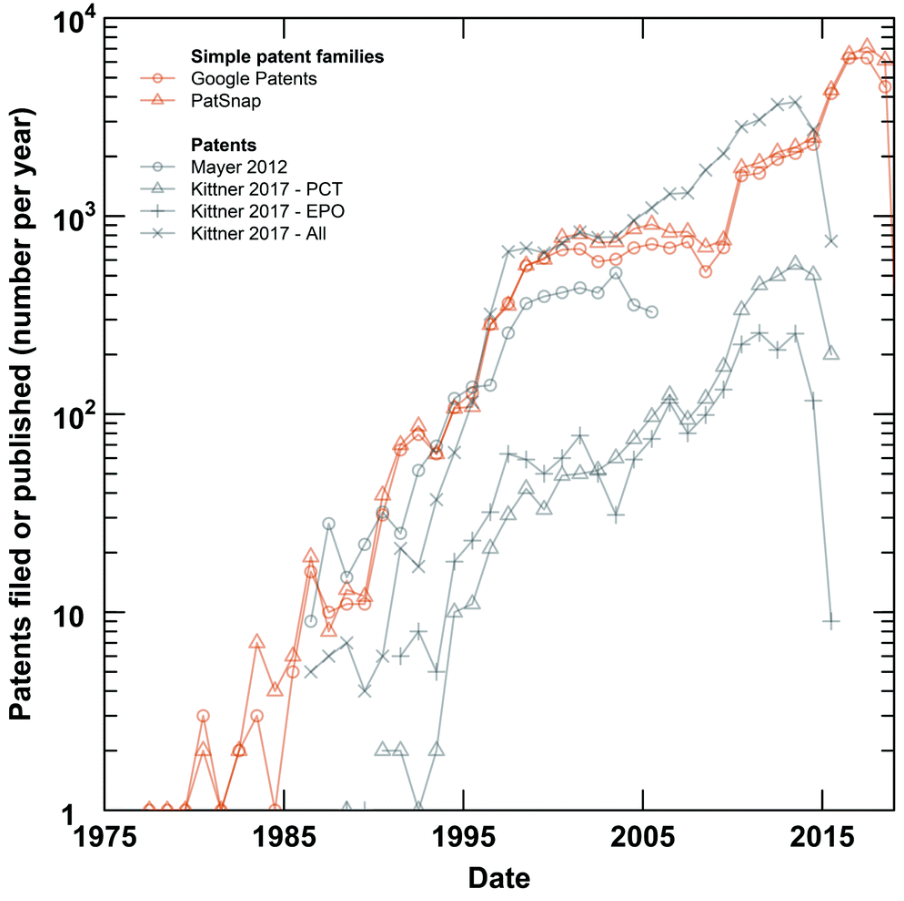
Pil Piyasası

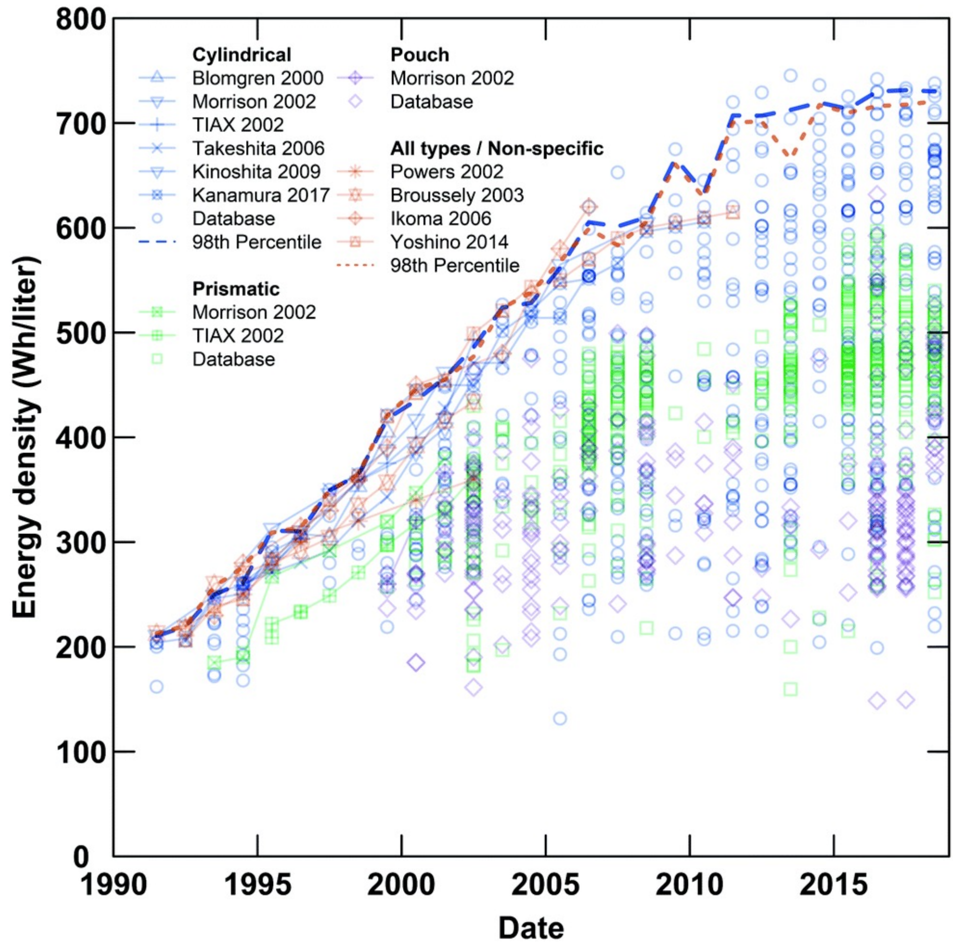




DOI: 10.1039/D0EE02681F

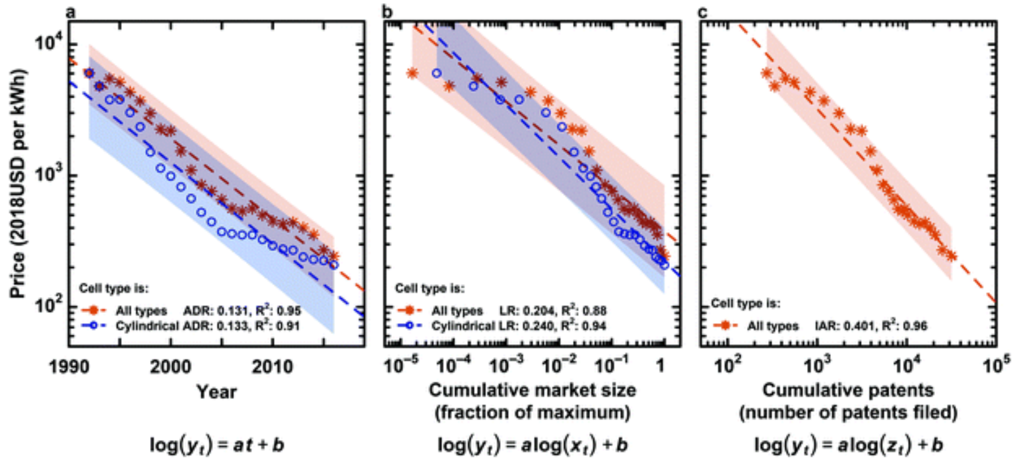
Pil patentleri – Enerji kapasitesi

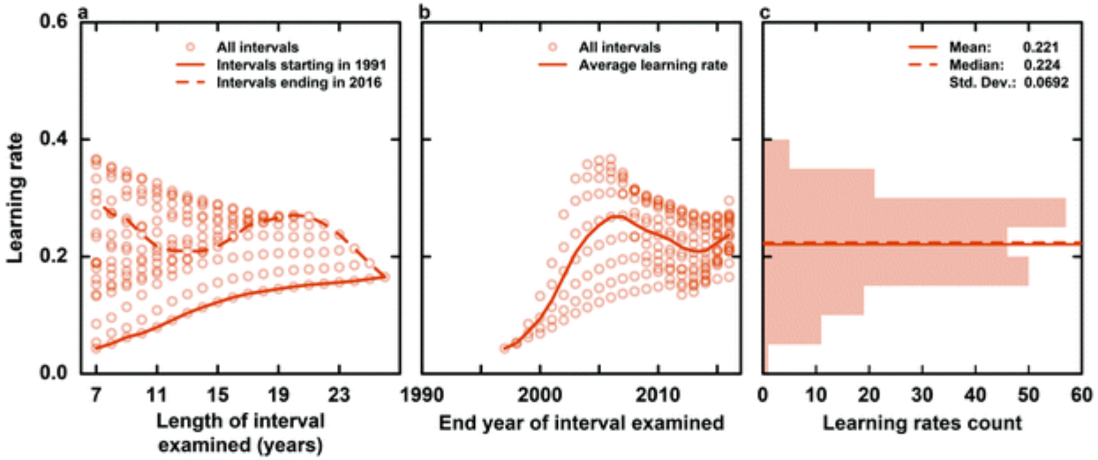


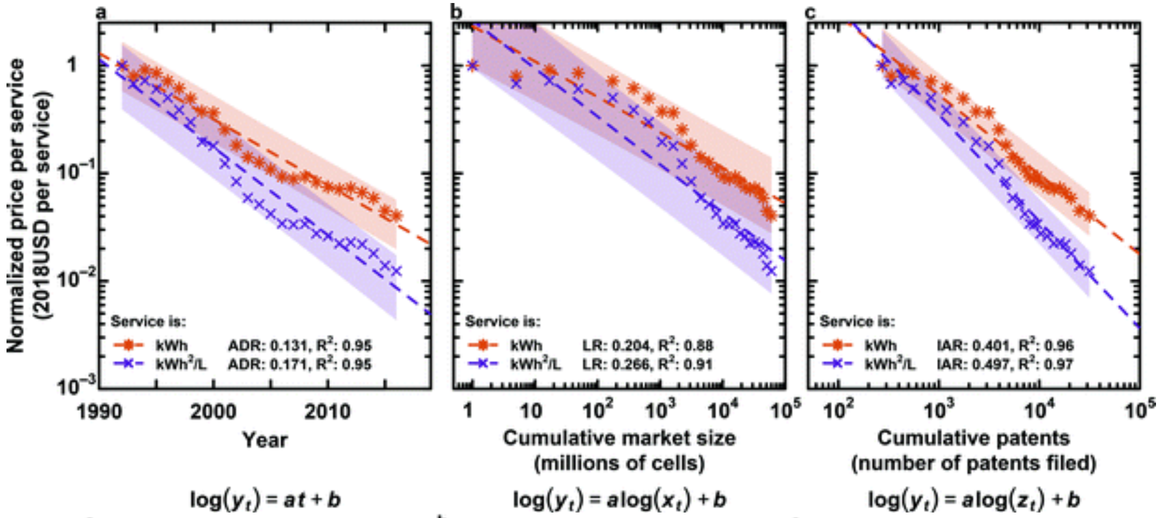


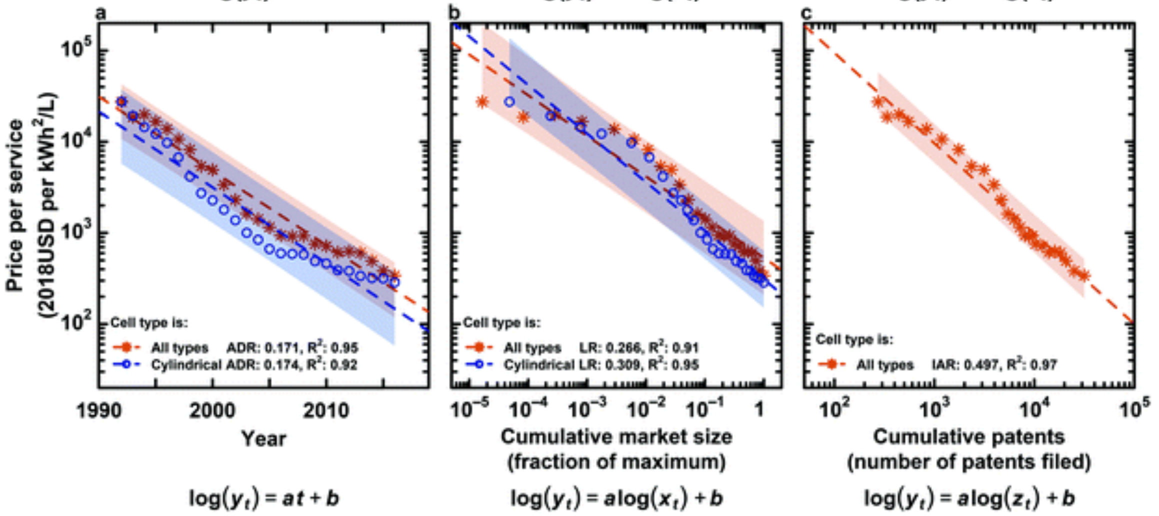
DOI: 10.1039/D0EE02681F

Öğrenme Oranları









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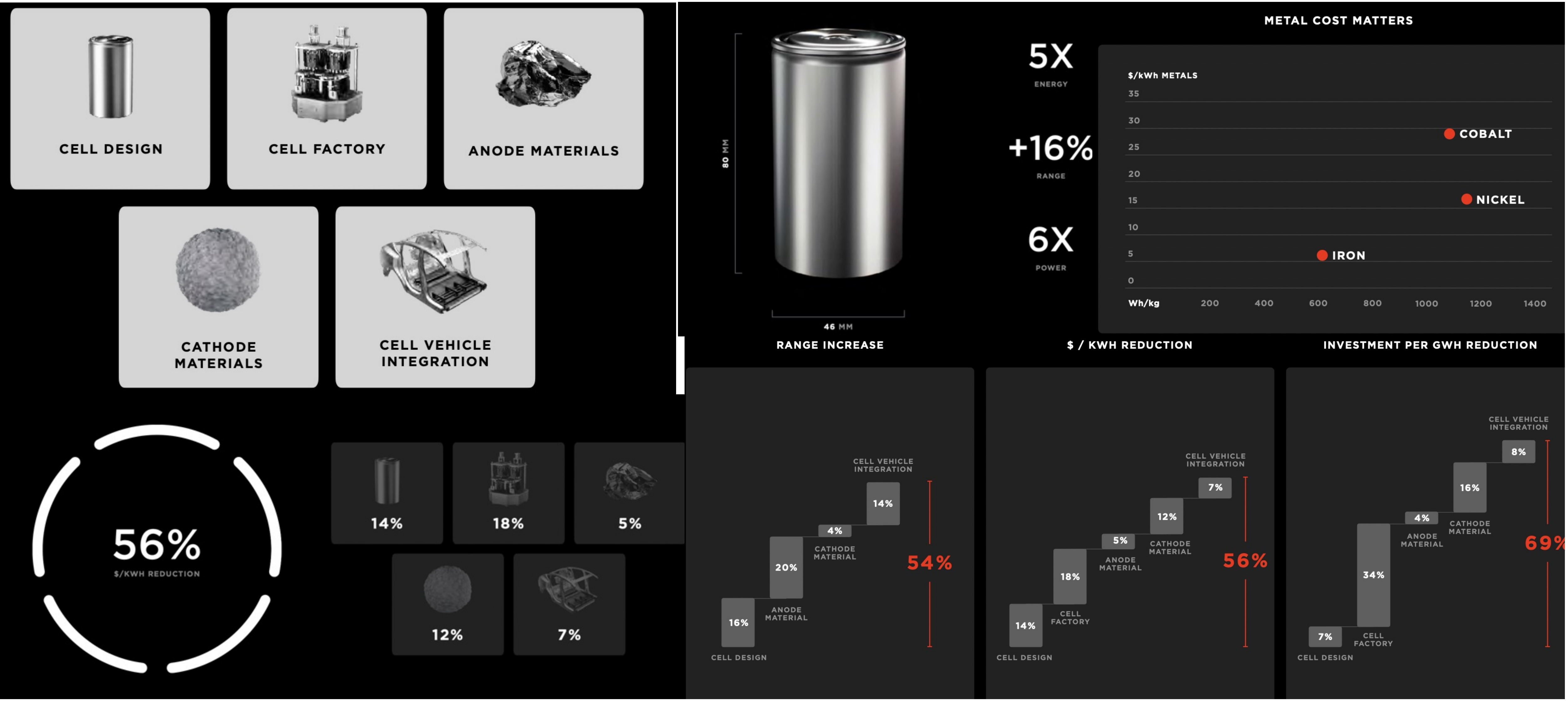
$$\text{price per service} = \left(\frac{\text{price}}{\text{energy capacity}}\right)^{f_1} \times \left(\frac{\text{volume}}{\text{energy capacity}}\right)^{f_2}.$$

Tesla Pil Günü



Ne sonuçlar?

- Akademi prototip için (ve insan yetiştirmek için)
- Ticari ürün ayrı bir ürün (tecrübe, test asıl bilgi)
- Teknolojik gelişimi çok katmanlı
  - Her katmanda para kaybetmek var
- Onlarca teknoloji, 100lerce prototip => Kazanan 1, getiri %100
- Piyasa büyüklüğü?
  - AB 300 milyar € = Türkiye eşdeğeri 52 milyar €
- Devlet bu işin ilk etapta kazananı değil, iticisi olacak mı?

Teşekkürler

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barissanli.com