Enerji Depolama Sistemleri

Mevcut Durum, Uluslararası Örnekler ve Türkiye

Barış Sanlı
barissanli.com

16 Ekim 2019 – İzmir

Yasal Uyarı

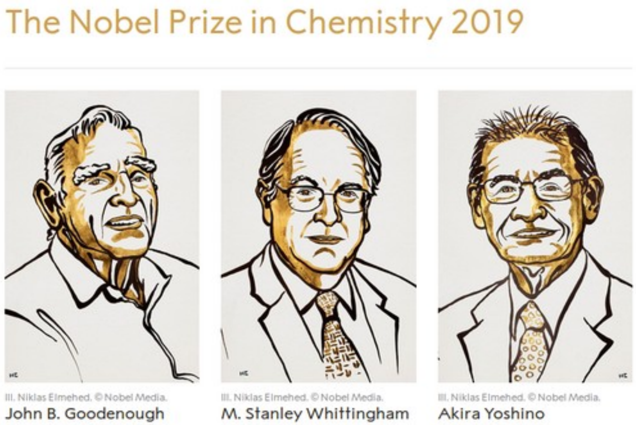
- Bu sunumdaki görüş/öneri/çalışma ve düşünceler hiçbir kurum, kuruluş veya derneğe atfedilemezler.

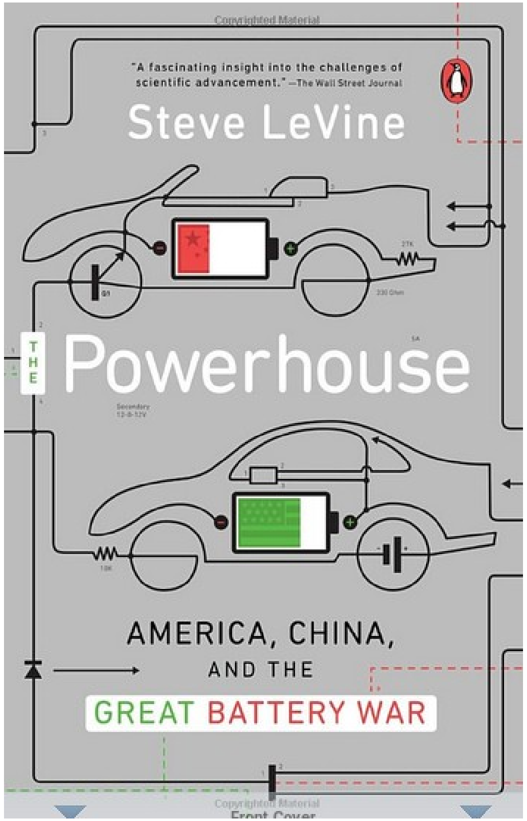
İçerik

- Türkiye
- Yenilenebilir ve elektrikli araba geleceği
- Dünya örnekleri (ABD, Avustralya)
  - Güvenlik/kurulum standartları
  - Piyasa mevzuatları

Nobel Kimya Ödülü ve Öyküsü

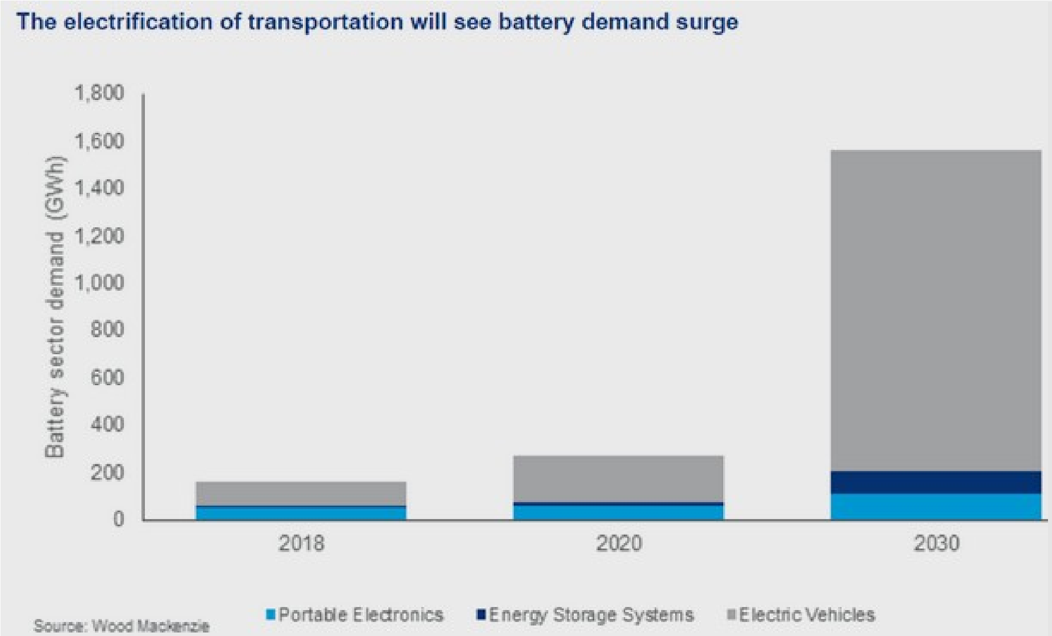
- Lithium Ion pillerin gelişimi için
- The Powerhouse: America, China, and the Great Battery War – Steve Levine

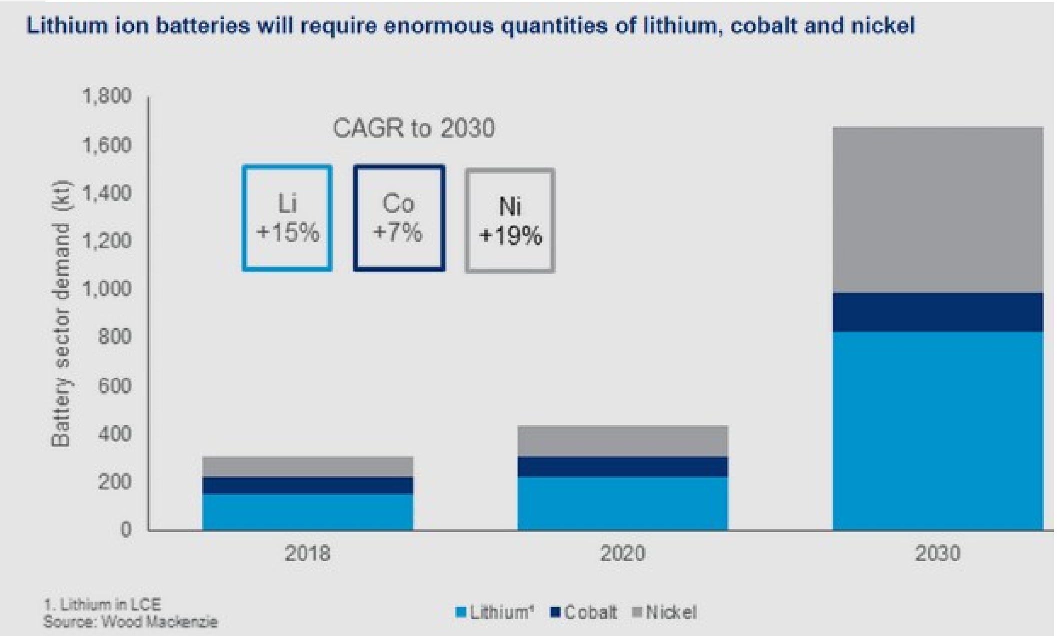




https://www.nobelprize.org/prizes/chemistry/2019/summary/

Dünyada Pil ve Li,Co,Ni talebi





https://www.woodmac.com/news/feature/electric-vehicle-battery-supply-chain-faq

Türkiye'nin pil kapasitesi-Arabalar

Kurşun - Asit

TÜİK taşıt sayısı	adet	V	A	Watt	Toplam	
Otomobil	12,505,020	12	60	720	9003.6	MW
Minibüs	490,653	12	150	1800	883.2	MW
Otobüs	215,214	12	200	2400	516.5	MW
Kamyonet	3,791,152	12	100	1200	4549.4	MW
Kamyon	845,306	12	150	1800	1521.6	MW
Motosiklet	3,302,391	12	5	60	198.1	MW
				Toplam	16672.4	MW
				Ortalama yıllık	1282.5	MW

barissanli.com
Değerler: TÜİK Ağustos 2019 taşıt rakamları
"Türkiye'deki taşıtların yaş ortalaması 13", Posta Gazetesi, 2 Şubat 2018

Türkiye'de pil kapasitesi - Bilişim

Lityum Ion

	adet	V	A	Watt	Toplam	
Cep telefonu	47,000,000	3.7	2.5	9.25	434.75	MW
Tablet	1,000,000	3.7	4	14.8	14.8	MW
Laptop	4,000,000	11.1	4	44.4	177.6	MW
					627.15	**MW**

barissanli.com

Kaynaklar/Kabuller: Türkiye'de akıllı cep telefonu sayısı esas alınmıştır. Yıllık ortalama 800.000 Laptop satışı üzerinden 5 yıllık bir kullanım kabul edilmiştir.

Pil değerleri ortalama alınmıştır, yeni modellerde bu rakamlar %50 daha yukarıda olabilir

Türkiye'de pil kapasitesi - EV

- Elektrikli arabalar ve hibritler

	2019	2018	2017	2016	2015	Toplam	Ortalama pil	Toplam(MWh)	
Elektrikli	138	155	77	44	119	533	30	16.0	Li-Ion
Hibrit	7424	3876	4451	950	106	16807	1.31	22.0	NiMH

barissanli.com
Kaynak/Kabuller: Türkiye Elektrikli ve Hibrit Araçlar Derneği
http://tehad.org/2019/10/14/elektrikli-ve-hibrid-otomobil-satis-rakamlari-aciklandi-2/
Pil kapasiteleri yazarın kabulüdür.

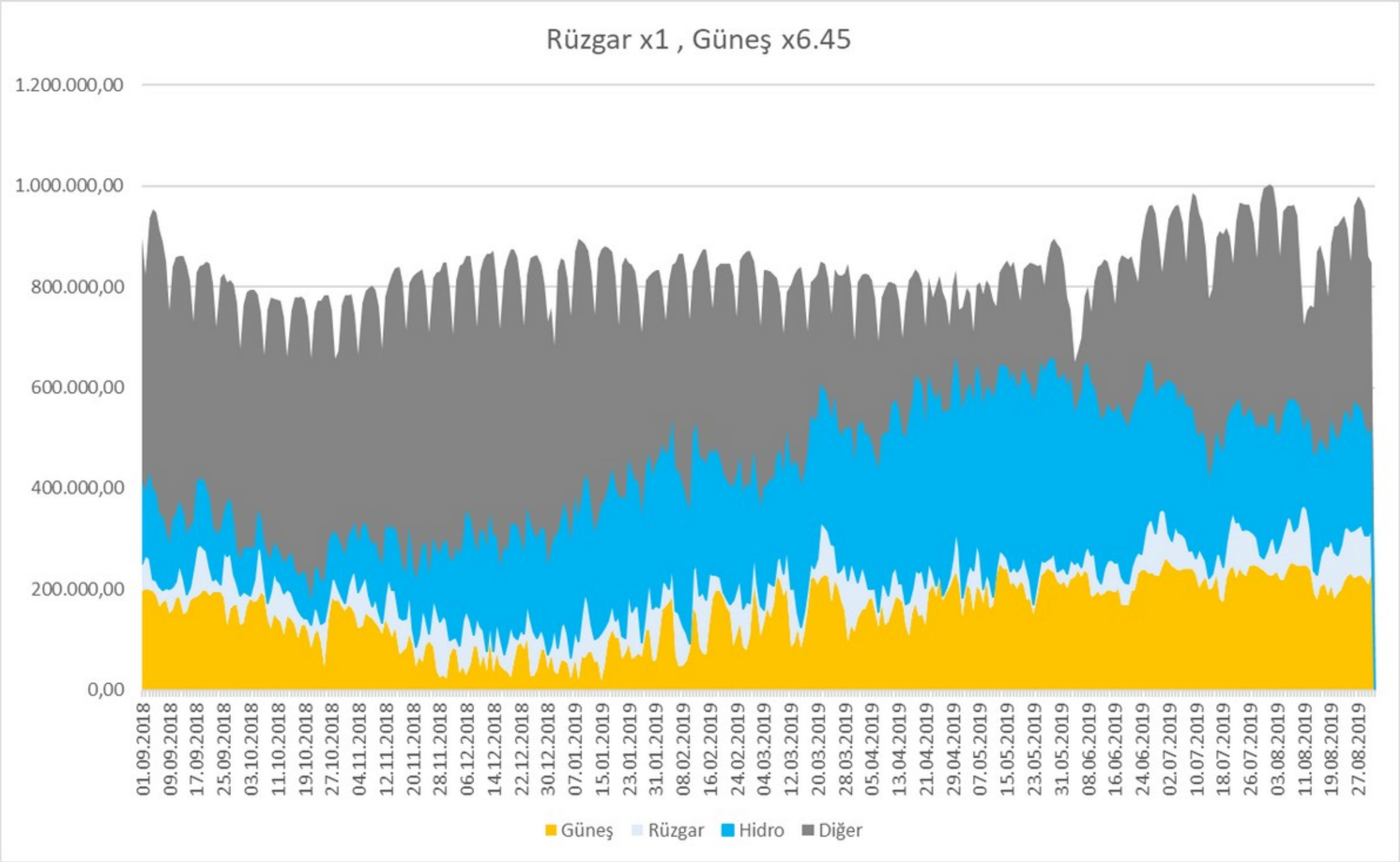
Toplam pil kapasitesi

- 16672.4 MWh – Taşıtlarda Kurşun/Asit
- 627.5 MWh – Cep telefon/Tablet/Laptop Li-Ion
- 16 MWh – Elektrikli araba Li-Ion
- 22 MWh – Hibrit araçlar NiMh
- Toplam: 17337 MWh

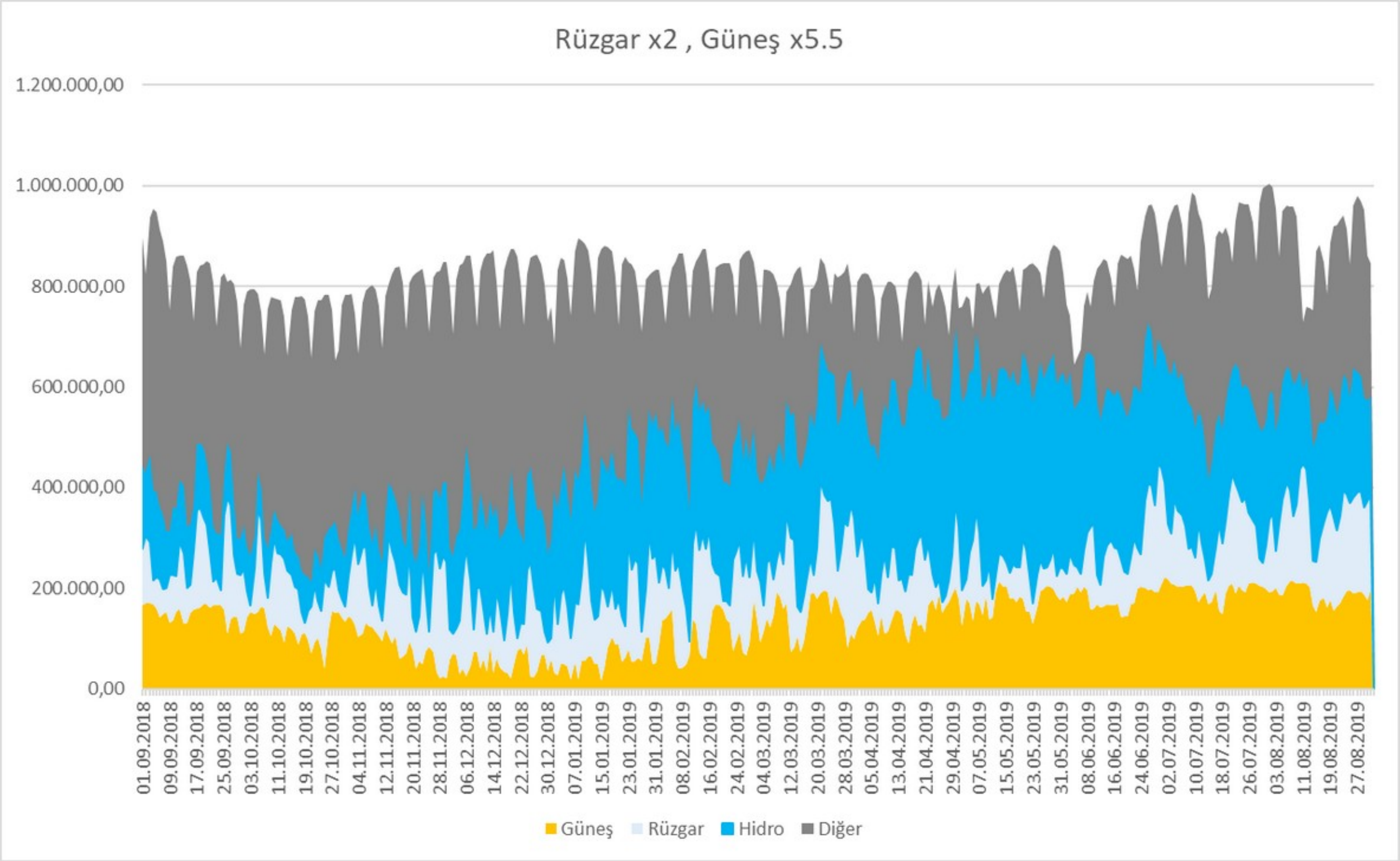
Yenilenebilir ve Elektrikli Arabalar

Türkiye

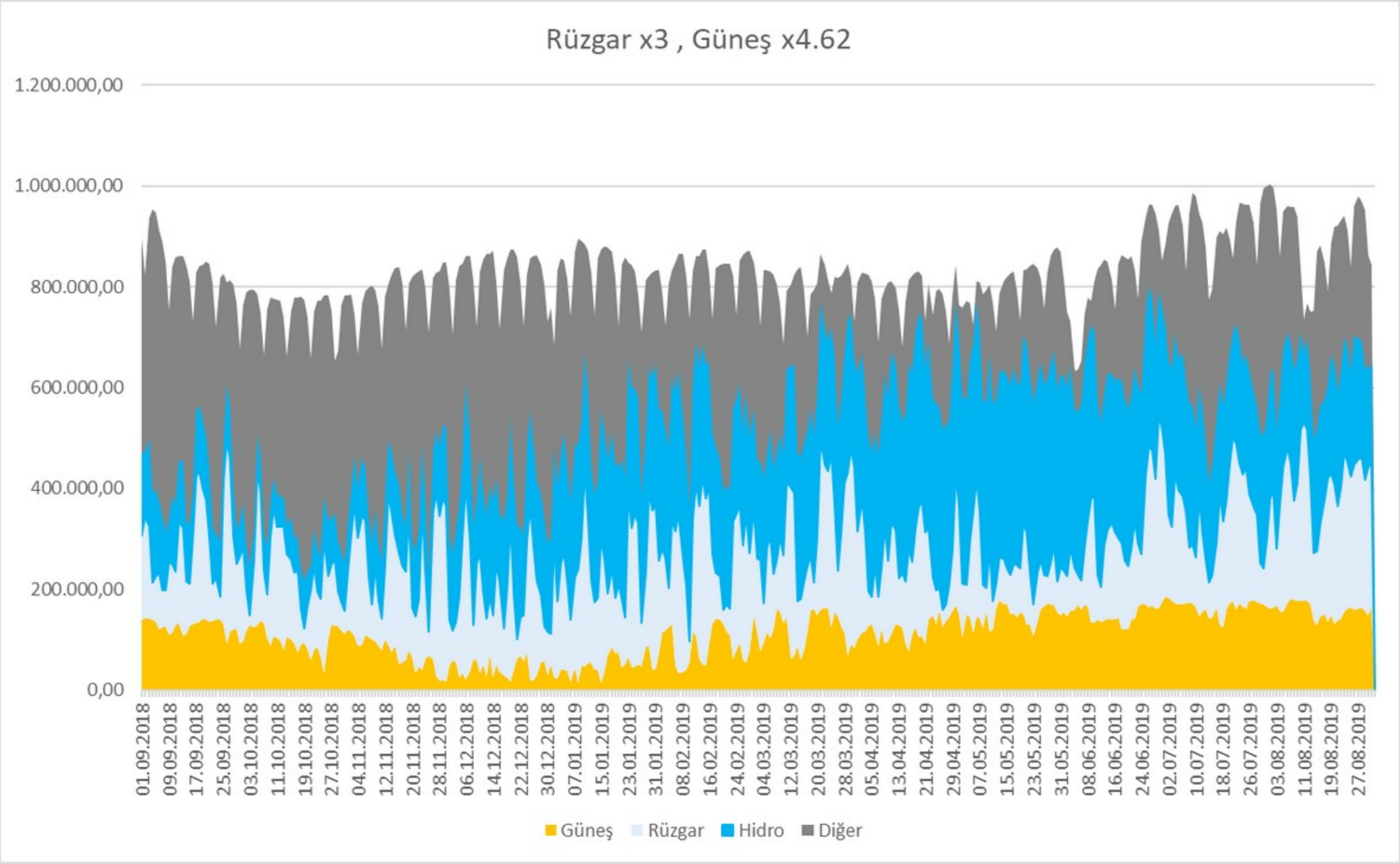
Rüzgar 7200 MW – Güneş 34830 MW



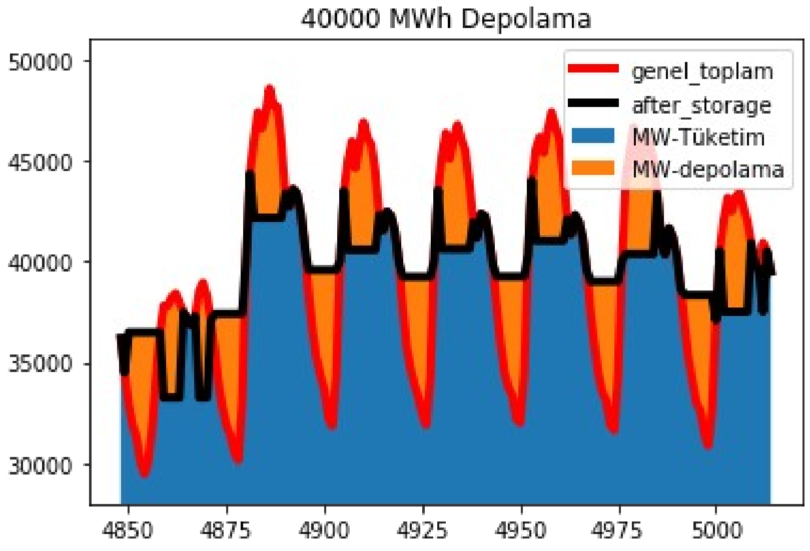
Rüzgar 14400 MW – Güneş 29700 MW

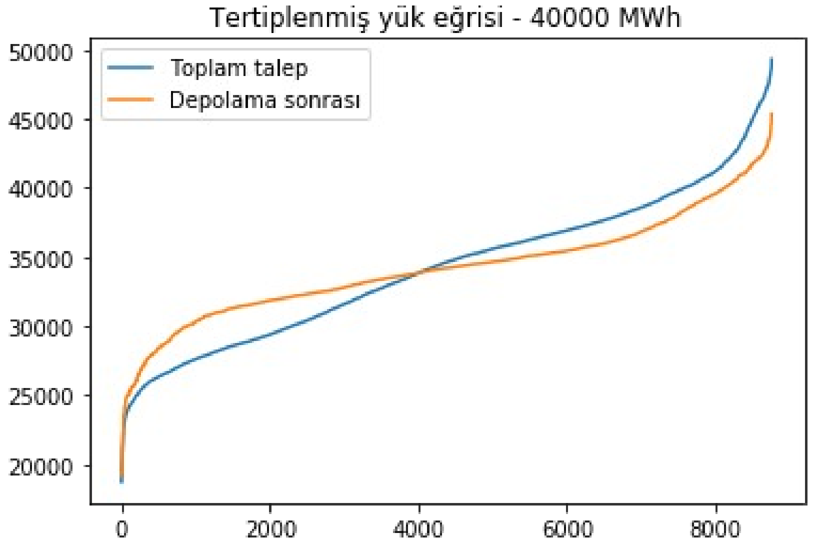


Rüzgar 21600 MW – Güneş 24968 MW



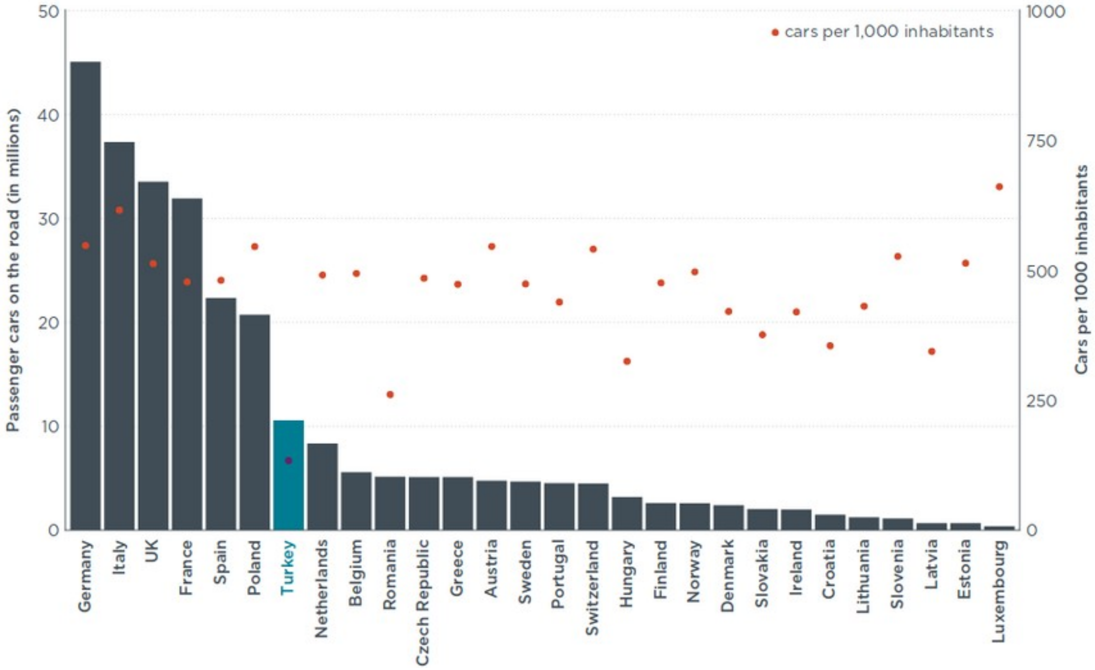
Enerji depolama simulasyonu ve Türkiye elektrik sistemine etkisi

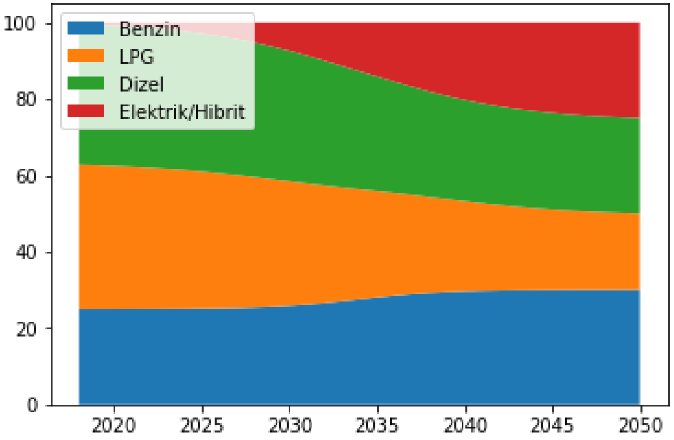


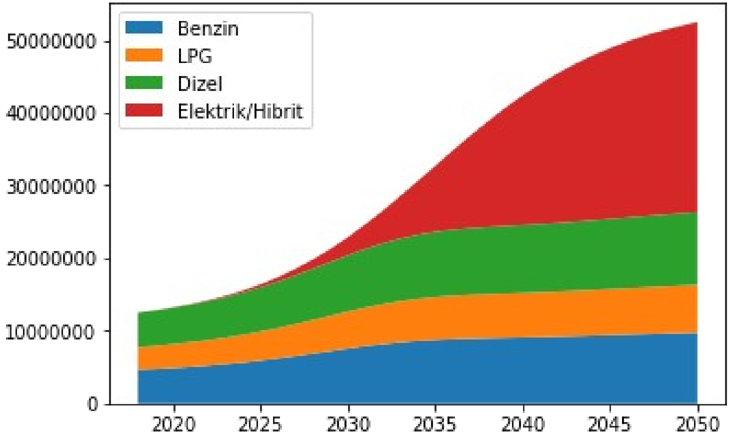


http://barissanli.com/python/depolama.php
Kodlar: https://github.com/barissanli/python-energy/

Türkiye Araba Projeksiyonu
Elektrikli ve Hibrit Araba Senaryoları



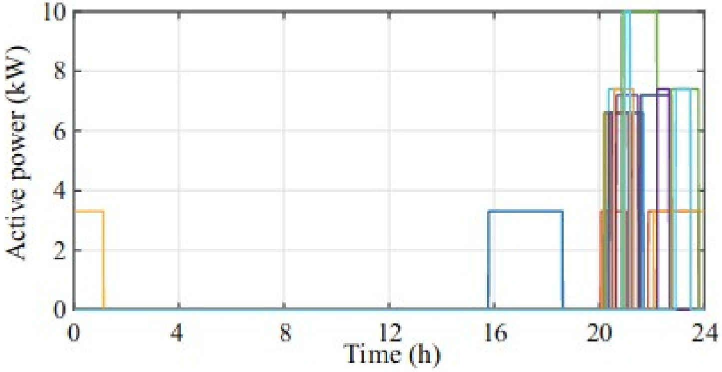




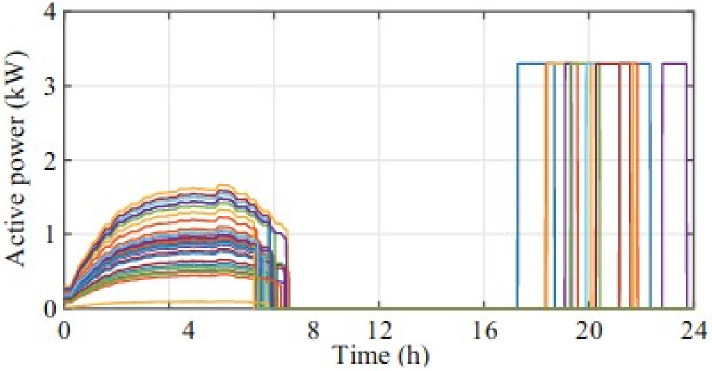
http://barissanli.com/python/araba.php

Kodlar: https://github.com/barissanli/python-energy/

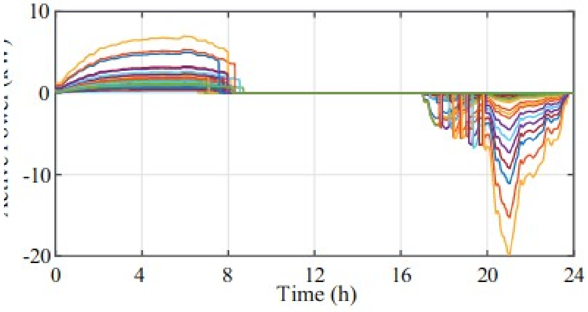
Dağıtım noktasından – Ankara



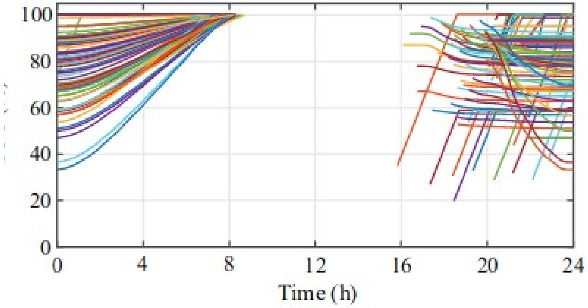
(a)



(b)



(c)



(d)

. 8. Results for individual PEVs for 10% penetration case: (a) uncontrolled arging powers of 20 PEVs, (b) smart charging powers of 40 PEVs, (c) V2G wers of 40 PEVs, and (d) SOC for all PEVs (Each different color stands for arging/V2G power/SOC for a specific vehicle with a total of 100 PEVs).

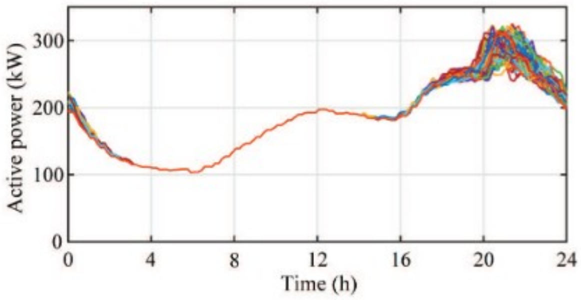


Fig. 6. Aggregated load profile with uncontrolled charging for 10% PEV penetration for 100 simulation runs.

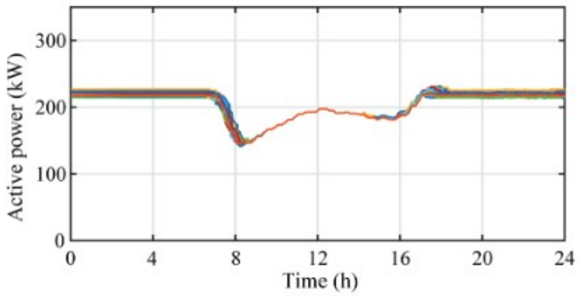


Fig. 7. Aggregated load profile with proposed algorithm for 10% PEV penetration for 100 simulation runs.

Adaptive V2G Peak Shaving and Smart ChargingControl for Grid Integration of PEVsFatih Erden, Mithat C. Kisacikoglu, and Nuh Erdogan

Bayram Trafiği - 2040

İstanbul dışına çıkan minimum
1.5milyon araç
Her biri 90KWh
Saatte ortalama 62500 araç

1000 araca 4 açık(kamu) şarj noktası
6000 şarj noktası sadece yer değiştirecek

Şarj noktası(kW)	Araç	Süre(saat)	MWh	MW
100	62500	0.9	5625	6250
150	62500	0.6	5625	9375
300	62500	0.3	5625	18750

Kaynak/tahminler: Hızlı şarj noktaları, saatlik araç rakamları tahminidir.
Şarj noktası sayısı için : "Deloitte : 28000 new charge points needed in the next 10 years"

Dünya Örnekleri

Dünya Örnekleri

- Standart daha yerleşmemiş ise
  - Pilot proje-öğrenme ve raporlama
- Hedef
- Lisanslı oyunculara hedefler
- Örnek projeler
- Standart belirleme

Düzenlemeler

- Teknik standartlar
  - Bina/yangın
  - Tesisat
  - Performans
- Piyasa işlemleri
  - Gün öncesi/dengesizlik
  - Yan hizmetler

ABD

NATIONAL FIRE PROTECTION ASSOCIATION

The leading information and knowledge resource on fire, electrical and related hazards

- Ulusal Yangın Koruma Birliği
- National Electrical Code (NEC)

Electrical codes and standards

The NFPA® family of codes and standards that deal with electrical issues are as dynamic as the subjects they address—including NFPA 70®, *National Electrical Code®* (NEC®), NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*, and NFPA 70E®, *Standard for Electrical Safety in the Workplace®*. These extensive documents reflect changing industry needs and evolving technologies, and are supported by research and development, as well as the practical experience and input of your peers in the field. This commitment to keeping you current also manifests in brand new products like NFPA 78, *Guide on Electrical Inspections*, which covers the minimum criteria to aid in organizing and conducting electrical inspections, as well as NFPA 1078, *Standard for Electrical Inspector Professional Qualifications*, which identifies minimum job performance requirements for electrical inspectors.

NFPA 70, National Electrical Code® »

NFPA 70B, Recommended Practice for Electrical Equipment Maintenance »

NFPA 70E, Standard for Electrical Safety in the Workplace »

NFPA 78, Guide on Electrical Inspections »

NFPA 110, Standard for Emergency and Standby Power Systems »

NFPA 111, Standard on Stored Electrical Energy Emergency and Standby Power Systems »

NFPA 1078, Standard for Electrical Inspector Professional Qualifications »

https://www.nfpa.org/NEC

NEC

- 705 – Enterkonnekte Enerji Güç Sistemleri
- 706 – Enerji Depolama Sistemleri
- NEC Correlating Committee altında
  - 79 üyeli DC (Doğru akım) Task Group
  - 12 standart referanslanmış
- Diğer maddeler 480, 690, 692 ve 694

https://iaeimagazine.org/magazine/2019/04/17/energy-storage-systems-nec-article-706/

NEC 2017 – Bölüm 7 – Özel Koşullar

- Madde 706 – Enerji Depolama Sistemleri (ESS)
- DC komitesi ~ Yakıt hücrelerine benzer

(1) NFPA 111-2013, Standard on Stored Electrical Energy Emergency and Standby Systems

(2) IEEE 484-2008, Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications

(3) IEEE 485-1997, Recommended Practice for Sizing Vented Lead- Acid Storage Batteries for Stationary Applications

(4) IEEE 1145-2007, Recommended Practice for Installation and Maintenance of Nickel Cadmium Batteries for Photovoltaic (PV) Systems

(5) IEEE 1187-2002, Recommended Practice for Installation Design, and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications

(6) IEEE 1578-2007, Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management

(7) IEEE 1635/ASHRAE 21-2012, Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications

(8) UL 810A, Electrochemical Capacitors

(9) UL 1973, Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications

(10) UL 1989, Standard for Standby Batteries

(11) UL Subject 2436, Spill Containment For Stationary Lead Acid Battery Systems

(12) UL Subject 9540, Safety of Energy Storage Systems and Equipment

NEC -M706

- ESS : Enerjiyi daha ileriki zamanda kullanmak için depolayabilen bir veya daha fazla parçanın biraraya getirilmesinden oluşan sistem
- ESS – Tüm Sistem (Self contained): hücreler, piller, modüller, ütm kontrol sistemleri, aydınlatma, yangın önlemleri, alarm sistemleri, bir tek depolama konteynır veya birimde bir araya getirilmiş
- ESS – Eşleşen parçaların mühendisliği (Pre-Engineered of Matched Components) Önceden mühendisliği yapılan ve sahada biraraya getirilen

https://allstarce.com/wp-content/uploads/2016/12/2017-NEC-Code-Ch-7-Article-706-.pdf

NEC 706

- Devre isterleri (Circuit Requirements)
- Elektrokimyasal enerji depolama
- Akış pil depolama (elektrolit sızıntısı)

100V sınırları, gaz boruları ile aynı odada izin verilmiyor, havalandırma, ayırıcılar

International Fire Code 2018

- 12.bölüm enerji sistemleri
  Bölüm 1206 – Elektrik Enerji Depolama Sistemleri

TABLE 1206.2
BATTERY STORAGE SYSTEM THRESHOLD QUANTITIES.

BATTERY TECHNOLOGY	CAPACITY[a]
Flow batteries[b]	20 kWh
Lead acid, all types	70 kWh
Lithium, all types	20 kWh
Nickel cadmium (Ni-Cd)	70 kWh
Sodium, all types	20 kWh[c]
Other battery technologies	10 kWh

For SI:1 kilowatt hour = 3.6 megajoules.

a. For batteries rated in amp-hours, kWh shall equal rated voltage times amp-hour rating divided by 1000.
b. Shall include vanadium, zinc-bromine, polysulfide-bromide, and other flowing electrolyte-type technologies.
c. 70 kWh for sodium-ion technologies.

https://codes.iccsafe.org/content/IFC2018/chapter-12-energy-systems#IFC2018_Pt03_Ch12_Sec1206

IFC 2018 -1206

- Üst limitler
- Yangın sistemleri
- Gaz algılama sistemi
- Dökülme

TABLE 1206.2.9
MAXIMUM ALLOWABLE BATTERY QUANTITIES

BATTERY TECHNOLOGY	MAXIMUM ALLOWABLE QUANTITIES[a]	GROUP H OCCUPANCY
Flow batteries[b]	600 kWh	Group H-2
Lead acid, all types	Unlimited	Not Applicable
Lithium, all types	600 kWh	Group H-2
Nickel cadmium (Ni-Cd)	Unlimited	Not Applicable
Sodium, all types	600 kWh	Group H-2
Other battery technologies	200 kWh	Group H-2[c]

For SI:1 kilowatt hour = 3.6 megajoules.

a. For batteries rated in amp-hours, Kilowatt-hours (kWh) shall equal rated battery voltage times the amp-hour rating divided by 1,000.

b. Shall include vanadium, zinc-bromine, polysulfide-bromide, and other flowing electrolyte-type technologies.

c. Shall be a Group H-4 occupancy if the fire code official determines that a fire or thermal runaway involving the battery technology does not represent a significant fire hazard.

ABD'de EDS Güvenliği

- ABD'de EDS
  - NFPA 70
  - NFPA 1, ICC IFC
  - NFPA 855
- ANSI
  - UL9540
  - UL1973
  - UL9540A
  - UL1974

NFPA 70, National Electrical Code (NEC)

ICC International Fire Code (IFC)

NFPA 1, Fire Code

NFPA 855, ESS Installation Standard

Requirements	Flooded LA & Ni-Cad	VRLA	Li-ion & Li Metal Polymer
1. Safety caps	1. Vent caps	1. Self- resealing flame arresting caps	1. NA
2. Thermal runaway mgmt.	2. NA	2. Required	2. Required
3. Spill control	3. Required	3. NA	3. NA
4. Neutralization	4. Required	4. NA	4. NA
5. Ventilation	5. Required	5. Required	5. NA
6. Signage	6. Required	6. Required	6. Required
7. Seismic Control	7. Required	7. Required	7. Required
8. Fire detection	8. Required		8. Required

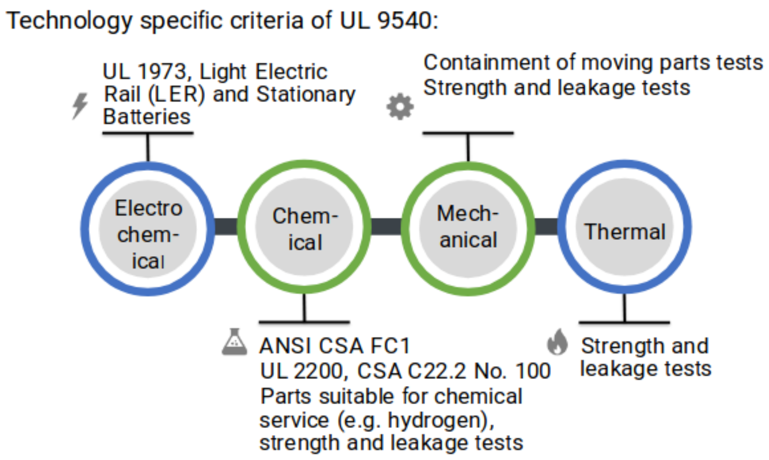
NFPA 70 National Electrical Code (NEC)

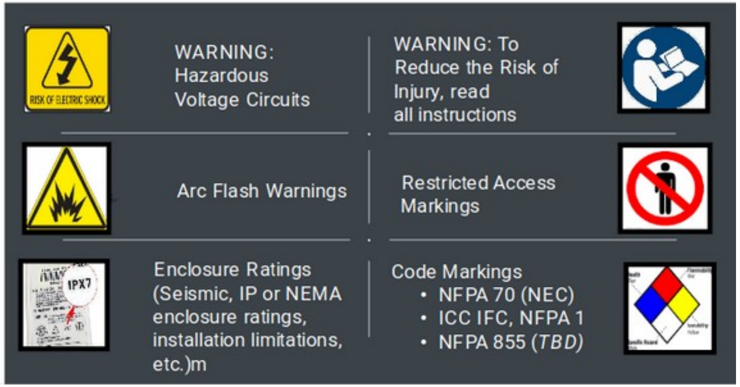
- Article 706 – Energy Storage Systems
  - New in 2017 edition
- Article 480 – Storage Batteries
- Article 712 – DC Micro grids
  - New in 2017 edition

https://share.ansi.org/Shared%20Documents/Standards%20Activities/International%20Standardization/Regional/Staff/LMM/US-Africa-CESP/CESP%20Kenya%202018/Presentations/UL%20Presentation.pdf

UL9540-Standard for Energy Storage Systems and Equipment

Kapsam
Genel elektrik güvenliği
Güvenlik analizi ve kontrol sistemleri
Yangın algılama ve bastırma(suppression)
Şebeke etkileşimi
Teknolojiler
İşaretler ve uyarılar
Elektrik testleri
Mekanik testler
Çevre testleri

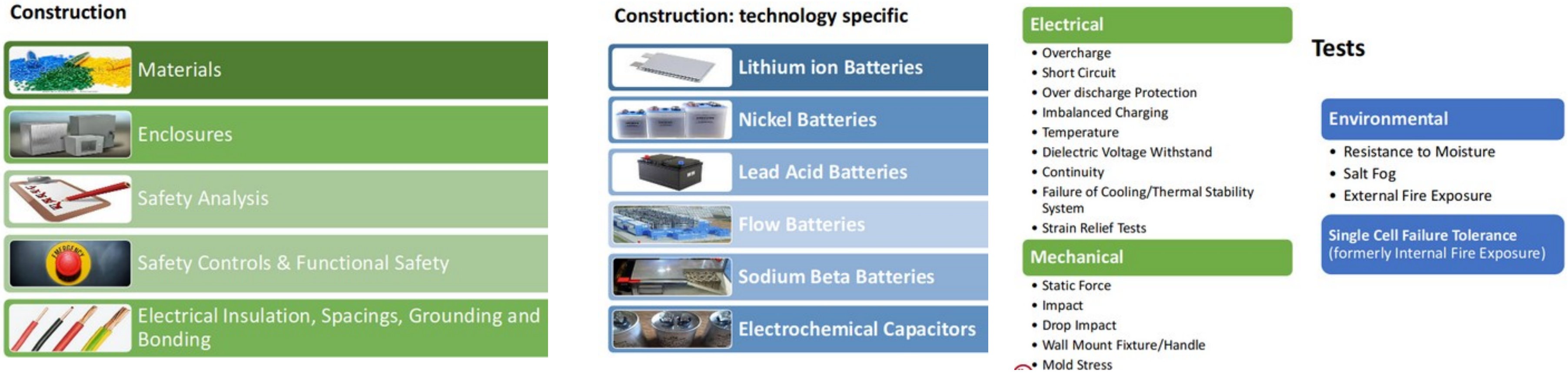




https://share.ansi.org/Shared%20Documents/Standards%20Activities/International%20Standardization/Regional/Staff/LMM/US-Africa-CESP/CESP%20Kenya%202018/Presentations/UL%20Presentation.pdf

UL1973

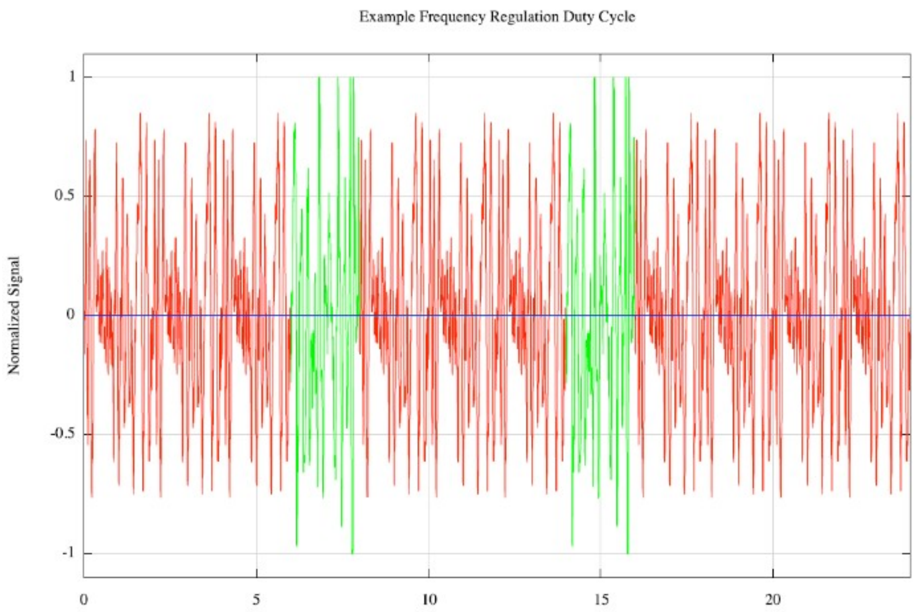
- UL 1973 - Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications



https://share.ansi.org/Shared%20Documents/Standards%20Activities/International%20Standardization/Regional/Staff/LMM/US-Africa-CESP/CESP%20Kenya%202018/Presentations/UL%20Presentation.pdf

PNNL

- PNNL-22010 Rev 2, Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems
  - Depolanan enerji
  - Doldur-boşalt verimlilik
  - Tepki zamanı
  - Yük alma oranı (ramp rate)
  - Reaktif güç tepki zamanı
  - Reaktif güç yük alma oranı
  - İç direnç
  - Boşta enerji kayıp oranı
  - Öz deşarj oranı



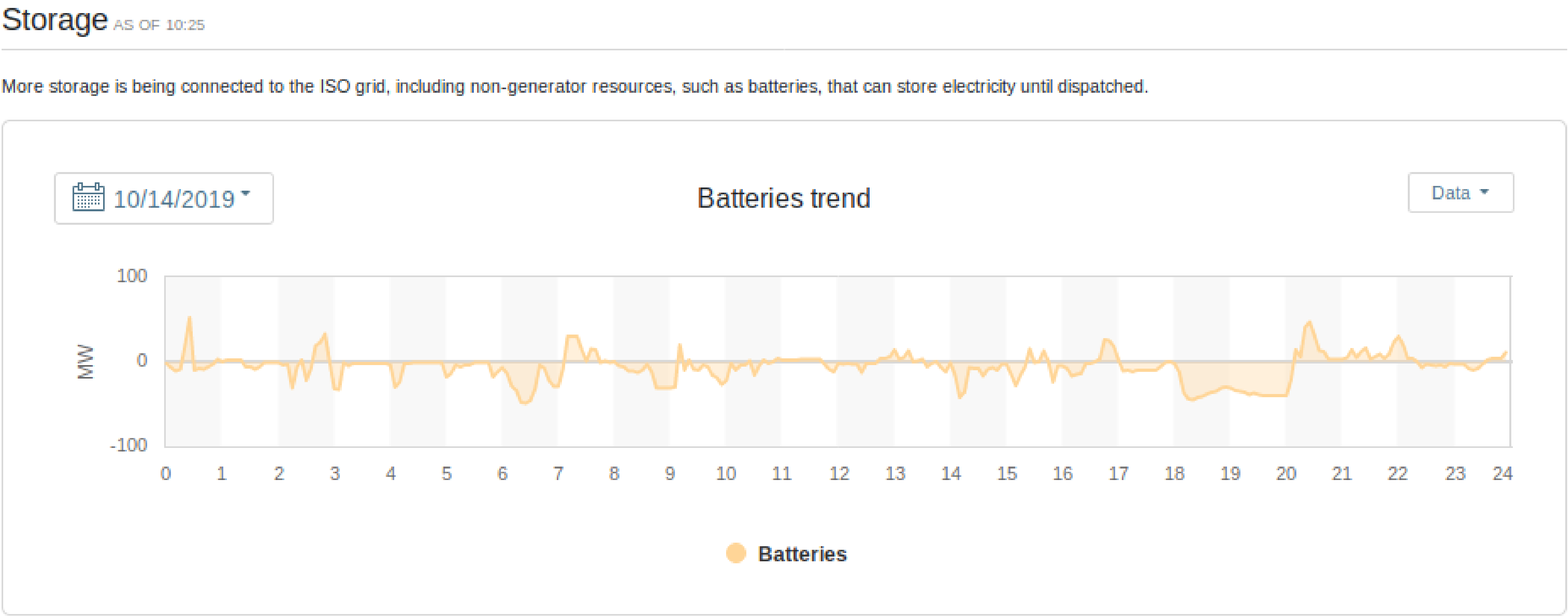
https://energystorage.pnnl.gov/

ABD California

- FERC – 2016 NOPR'da Enerji Depolama:
- Elektrik sisteminde nerede meskun olduğuna bakmaksızın şebekeden elektrik alıp bunu daha sonra şebekeye geri verin kaynak *"a resource capable of receiving electric energy from the grid and storing it for later injection of electricity back to the grid regardless of where the resource is located on the electrical system."*
- CAISO – (Sistem operatörü ~ TEİAŞ)
  - Çift taraflı teklif
    - Pozitif elektrik satımı
    - Negatif şebekeye alımı
  - Yan hizmet teklifi
  - SOC (State of Charge), şarj durumu da traderlar tarafından sisteme giriliyor

https://blog.powercosts.com/2018/01/21/bidding-energy-storage-resources-esr-caiso/

CAISO'da depolama kısmı



https://www.caiso.com/TodaysOutlook/Pages/supply.aspx

California

- AB 2514 (Assembly Bill) – Ch 469
  - Bölüm 7.7 yi ekliyor (Public Utilities Code)
- CPUC – 1 Mart 2012 – Hedef belirleme toplantısı
- 1 Ekim 2013 – Enerji depolama alım hedefi
  - 31 Aralık 2015
  - 31 Aralık 2020
- Şirketler - 1 Ekim 2014 – Kendi hedefleri
- Enerji depolama sistemi: Enerjiyi alabilen(absorb) , bir süre depolayabilen ve enerjiyi geri veren(tevzi) ticari olarak erişilebilir teknoloji
  –

https://www.cpuc.ca.gov/general.aspx?id=3462

California - AB2514

Alım ve uygulama şartları:

a) YEK'i güvenli işletme

b) Kesikli kaynakları tam güçte kullanma

c) Pik talep için fosil kaynağı azaltma

d) Yüksek emisyonlu kaynaktan elektrik

Alımını azaltma

e) İletim ve dağıtım kayıplarını azaltma,

şebeke kısıtları dahil

f) Pik zamanlarda elektrik talebini azaltma

g) İletim, dağıtım güncelleme yatırımlarını

azaltma-ertelemek için

f) Fosil kaynaklı üretimden alınan yanhizmet

yerine

adopted pursuant to Section 2836. The plan shall address the acquisition and use of energy storage systems in order to achieve the following purposes:

(a) Integrate intermittent generation from eligible renewable energy resources into the reliable operation of the transmission and distribution grid.

(b) Allow intermittent generation from eligible renewable energy resources to operate at or near full capacity.

(c) Reduce the need for new fossil-fuel powered peaking generation facilities by using stored electricity to meet peak demand.

(d) Reduce purchases of electricity generation sources with higher emissions of greenhouse gases.

(e) Eliminate or reduce transmission and distribution losses, including increased losses during periods of congestion on the grid.

(f) Reduce the demand for electricity during peak periods and achieve permanent load-shifting by using thermal storage to meet air-conditioning needs.

(g) Avoid or delay investments in transmission and distribution system upgrades.

(h) Use energy storage systems to provide the ancillary services otherwise provided by fossil-fueled generating facilities.

http://www.leginfo.ca.gov/pub/09-10/bill/asm/ab_2501-2550/ab_2514_bill_20100929_chaptered.pdf

Avustralya – Yol haritası

Figure 1 – Structure of Energy Storage Engagement

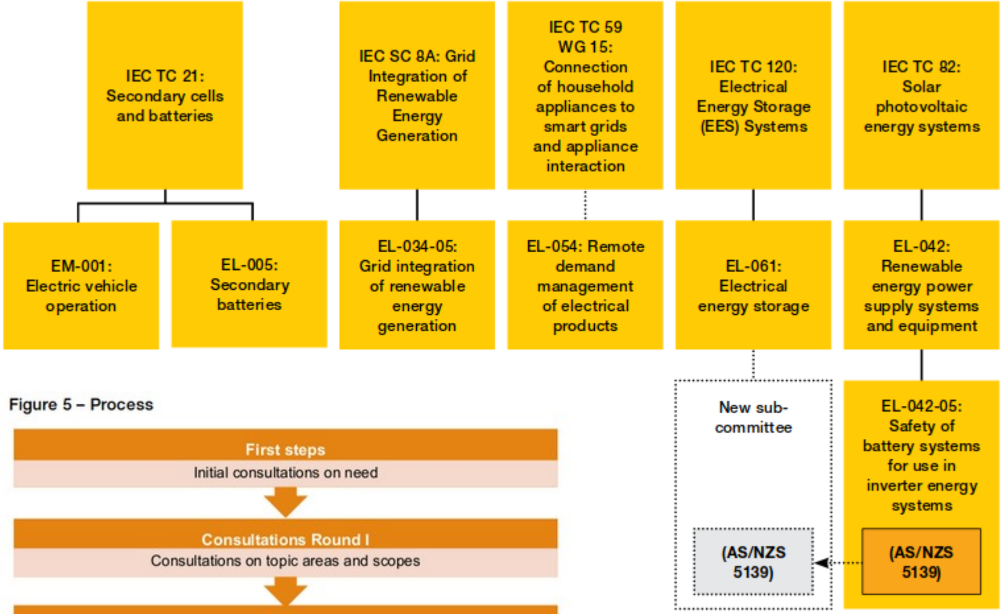
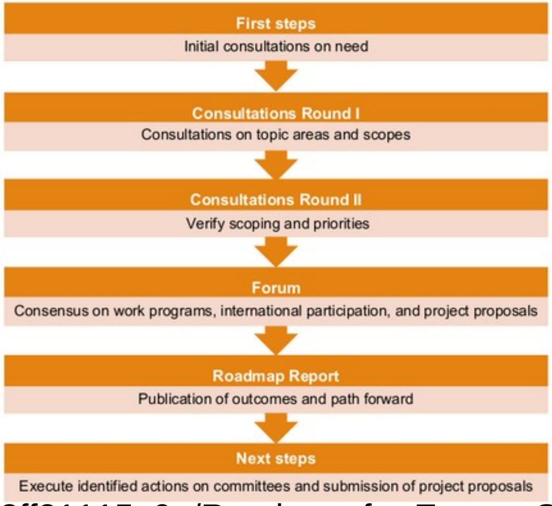


Figure 5 – Process



https://www.standards.org.au/getmedia/64b6ec70-48d8-4c01-ab33-93ff21115a9e/Roadmap-for-Energy-Storage-Standards.pdf.aspx

Komiteler, süreçler

Figure 4 – Relevant committees

EL-042: Renewable Energy Power Supply Systems

- Very active with a broad scope
- Current projects and publications include AS/NZS 4777 series and AS/NZS 5139
- AS/NZS 5139 will remain in scope until publication and may move to EL-061 for future maintenance
- Possible future scope (as related to energy storage systems): Inverters and related concerns

EL-061: Electrical Energy Storage

- Active, but in need of reconstitution
- Mirror to IEC TC 120
- Possible scope: Coordination of work, product standards

EL-005: Secondary Batteries

- Currently inactive, will likely be reactivated
- Previous published standards had a broad scope across battery types, including some relevant to this process.
- Possible future scope: Secondary batteries not included in household/building storage systems. This could include automotive batteries and others.
- Management of standards relevant to household/building electrical energy storage systems could be moved to EL-061.

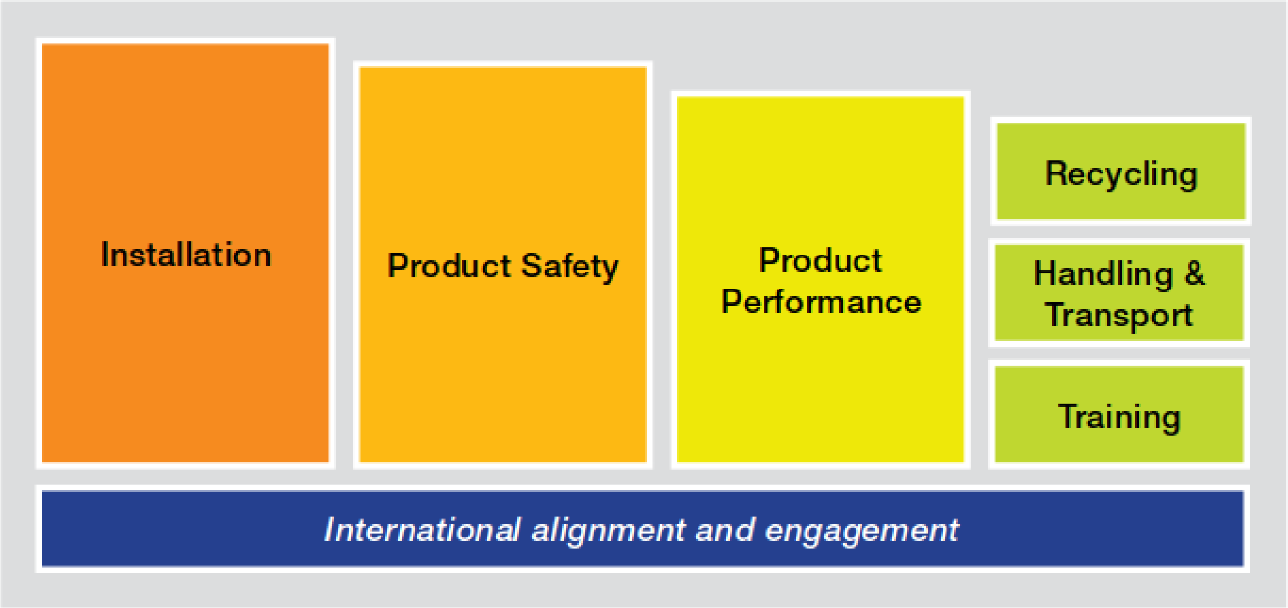
EL-054: Remote Demand Management of Electrical Products

- Active
- Currently working on the AS/NZS 4755 series
- Possible future scope (as related to energy storage systems): Update of remote demand management technologies in batteries.

EL-034-05: Grid Integration of Renewable Energy Generation

- Active, and in initial stages of engagement
- Mirroring IEC SC 8A
- Look to adopting standards at a future date

Figure 2 – Recurring themes



Öncelikler ve yol haritası

Figure 3 – Priorities

Safety of Installation

- Highest priority, with document in process: AS/NZS 5139, Installation and safety requirements of battery storage systems.

Product Standards

- Product safety (including marking) standards remain the highest priority and are currently lacking.
- Performance measurement is mid-to-high priority for certain stakeholders (consumer advocacy groups and government).
- Operational control standards gained moderate support from stakeholders.

Grid Connection

- Participation on IEC SC 8A was identified as important to ensure effective management of renewable energy sources and their connection to the grid.
- Demand response management (AS/NZS 4755 series) was identified as mid-to-high priority for certain stakeholders (networks, retailers, and battery manufacturers), with a specific need for education around this series.

Recycling

- Mid-to-high priority for some stakeholders, with industry bodies such as ABRI and CEC to lead initiatives.

Handling and Transport

- General consensus is that this is most appropriately handled by existing committee structures and documents.

Training

- Standards development of the above topics will support training, but no identified need for Standards Australia activity in this area.

International Participation

- Greater international participation was a common theme, especially as it relates to active participation on IEC TC 120 (Electrical Energy Storage Systems) and IEC SC 8A (Grid Integration of Renewable Energy Generation).

Priority	Action	By Whom	Implementation period
INSTALLATION			
Underway	Engagement in development of AS/NZS 5139 via sharing of committee drafts pilot	Stakeholders to express interest via relevant industry associations/nominating organisations[b]	2015 – publication (maintenance then to be transferred to EL-061)
Underway	Undertake standards development process for proposed AS/NZS 5139	Standards Australia technical committee EL-042 and subcommittee (Safety of battery systems for use in inverter energy systems)	2015 – publication (pending consensus[a]; publication expected Q1 FY 2016–2017, maintenance then to be transferred to EL-061)
INTERNATIONAL PARTICIPATION			
Underway	Reinvigorate EL-061 to mirror[d] IEC TC 120	Standards Australia/stakeholders	Feb 2017 – Jun 2017
COMMITTEE			
1	Undertake reconstitution[c] of EL-061	Standards Australia/stakeholders	Feb 2017 – Feb 2017
1	Delineate scopes between committees (EL-061, EL-005, EL-034-05, EL-042 and EL-054)	Standards Australia	Feb 2017 – May 2017
PRODUCTS[g]			
1	Development of product safety standards including marking	Stakeholders to submit proposal[e]	Round 14 (Feb – Mar 2017)
2	Development of performance standards	Stakeholders to submit proposal	Round 14 (Feb – Mar 2017)
3	Development of operational control standards	Stakeholders to submit proposal	Round 15 (Aug – Sep 2017)
GRID-CONNECTION			
Underway	Participate in EL-034-05 which mirrors IEC SC 8A (Grid integration of renewable energy generation)	Stakeholders to express interest	Feb 2017 – ongoing
2	Education program for AS/NZS 4755, in particular Part 3.5	Standards Australia may be in a position to co-resource this initiative with industry/government	February 2017
RECYCLING			
4	No direct action at present. ABRI and CEC and industry guidelines	NA	NA
HANDLING ANDTRANSPORT			
4	Liaison[f] with CH-009 to be created with EL-061	EL-061/CH-009	February 2017
TRAINING			
4	AS/NZS 5139 may assist. EL-061 to monitor.	EL-061	February 2017

AS/NZS 5139:2019, Electrical installations — Safety of battery systems for use with power conversion equipment

Son kısım

- Pil yeni değil
- Ama kitlesel kullanımı (konut/konteynır) gelişecek
- Yangın, performans ve tesisat
- Piyasa
- Eğitim ve insan kaynağı

Teşekkürler

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