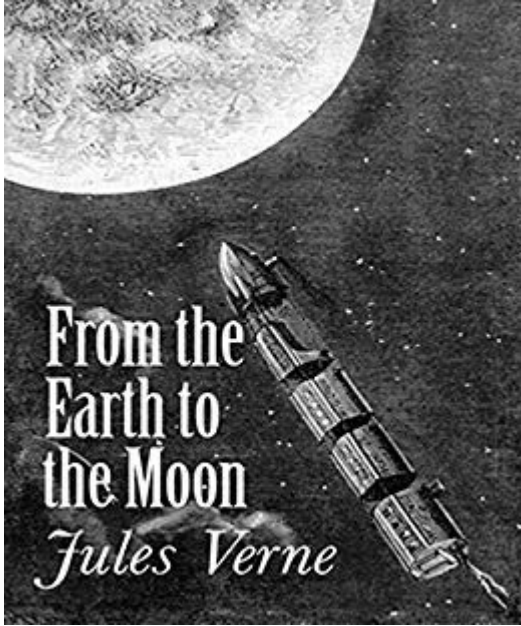


# Enerjide Dijitalleşme, Depolama, İnovasyon

Barış Sanlı  
barissanli.com

ODTÜ MD, 4 Şubat 2020

# Hayaller ve Gerçekleşmeler



1862



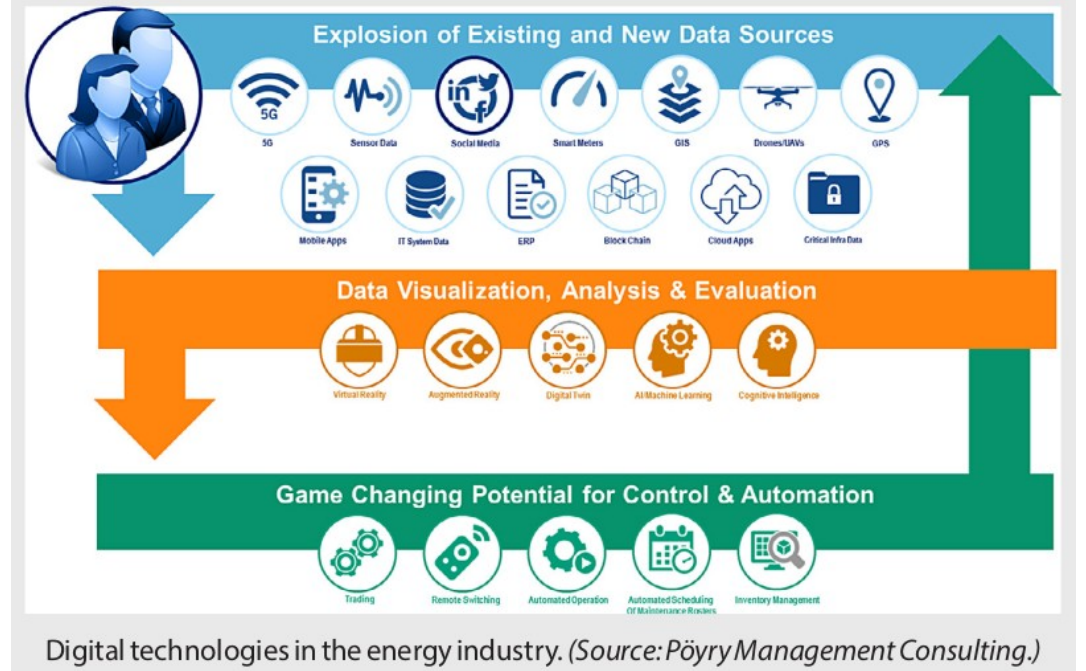
1969

# Genel olarak

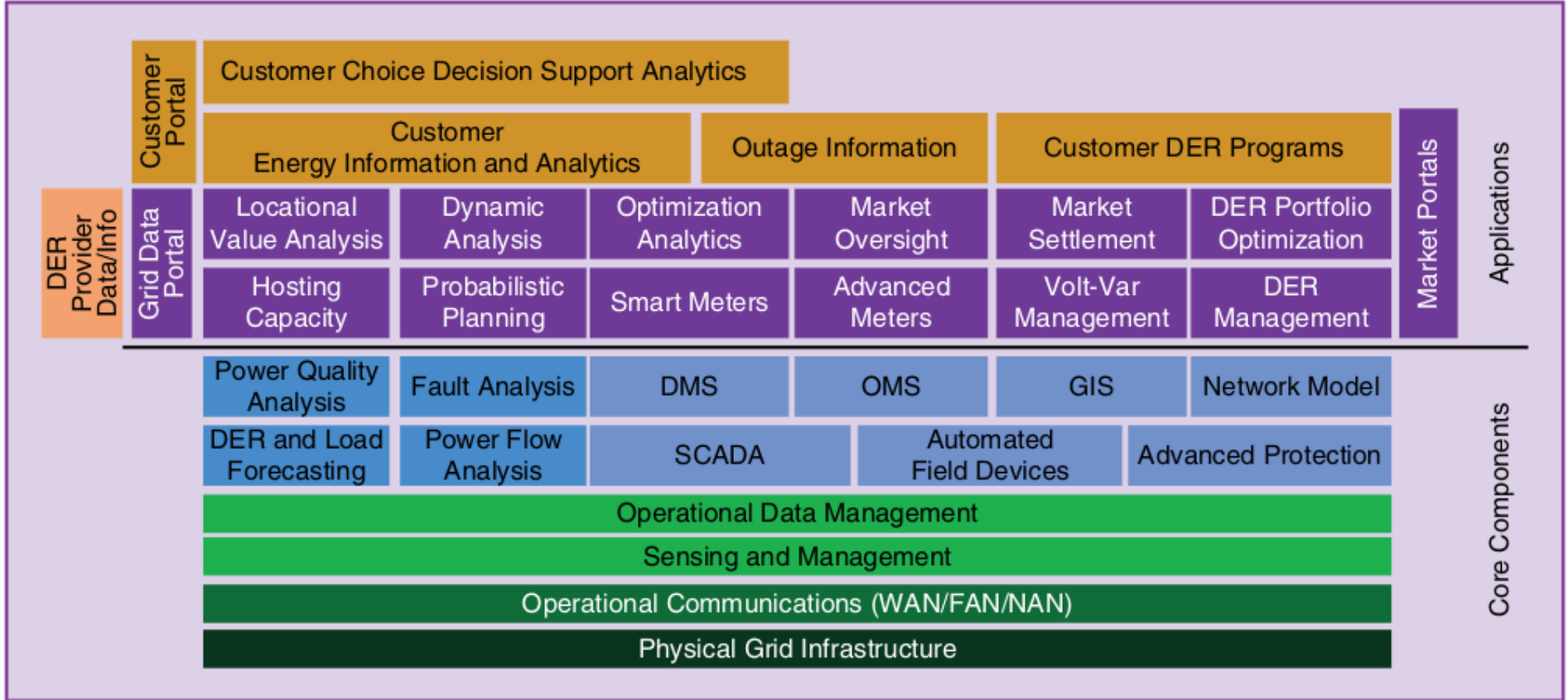
- Atomlar → Bitler(10101) → 𐄀𐄀𐄀
- Dijitalleşme ile 3'ünü de yönetmeye çalışıyoruz
- Doğal olmayan bir sistemi doğal kaynaklara geri döndürme
- Elektrik sistemi → dijital kontrol/izleme → yeni kontratlar
- Genel resim “herkese açık piyasa/işlemler”
- \*MS (Herşeyin Yönetim Sistemi)
- Nasıl?

# Dijitalleşme ne?

- Maliyetleri ve riskleri düşürerek verimliliği arttırmak veya iş yapış şekillerini değiştirerek müşteriler ile etkileşimi ve gelirleri arttırmak için dijital teknolojilerin kullanımı



# Ör: Dağıtım Sistem Platformu



ABD Enerji Bakanlığı – gelecek jenerasyon Dağıtım Sistem Platformu

# Ör: Kayıtzinciri (Blockchain)

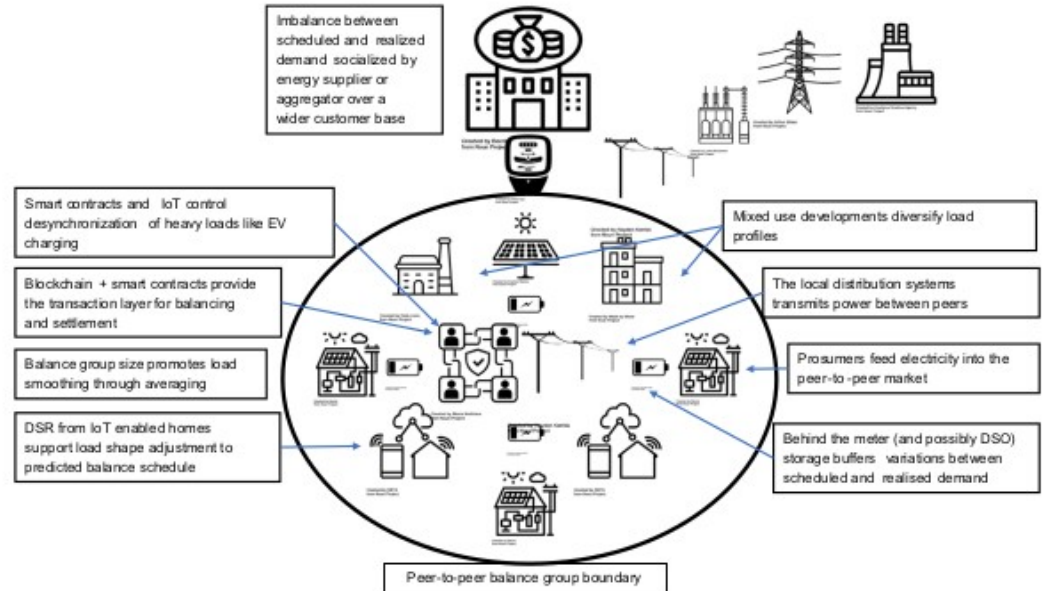
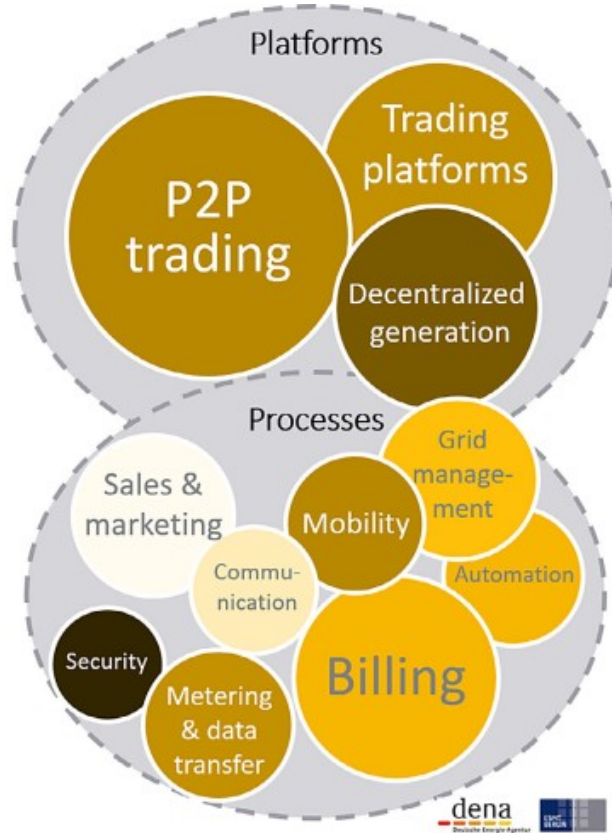
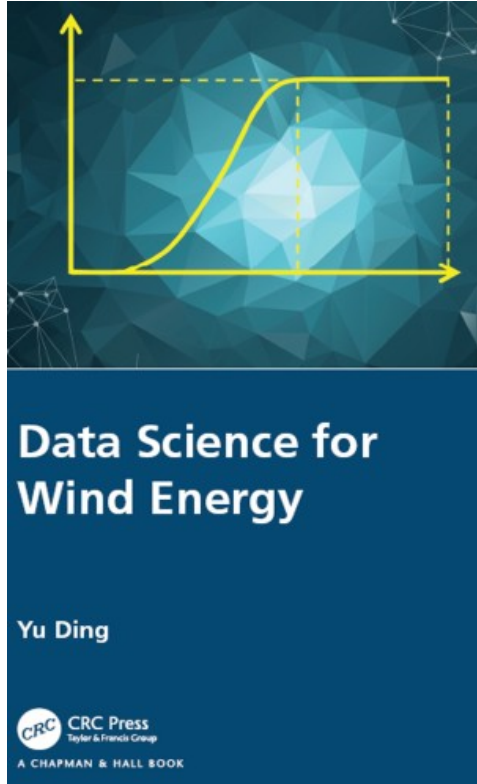


FIGURE 2.3 Peer-to-peer balance group and balancing mechanisms. (Source: Shipworth.)

# Ör: Yenilenebilir/sistem işletimi



## Big Data Application in Power Systems

Edited by

**Reza Arghandeh**

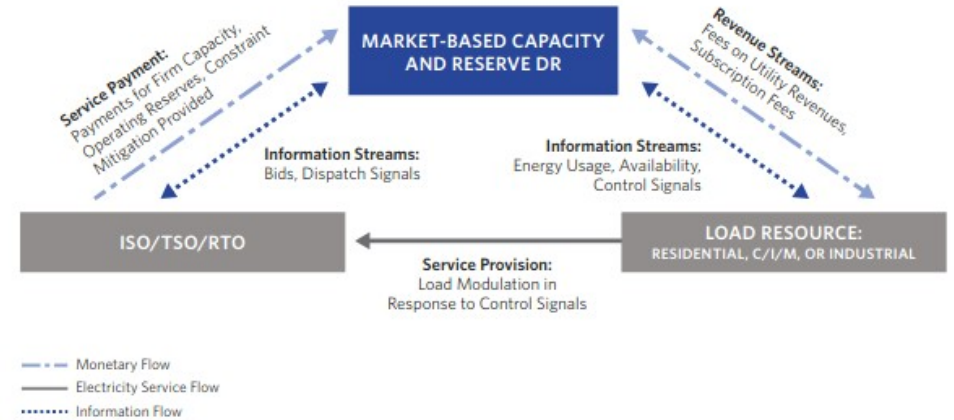
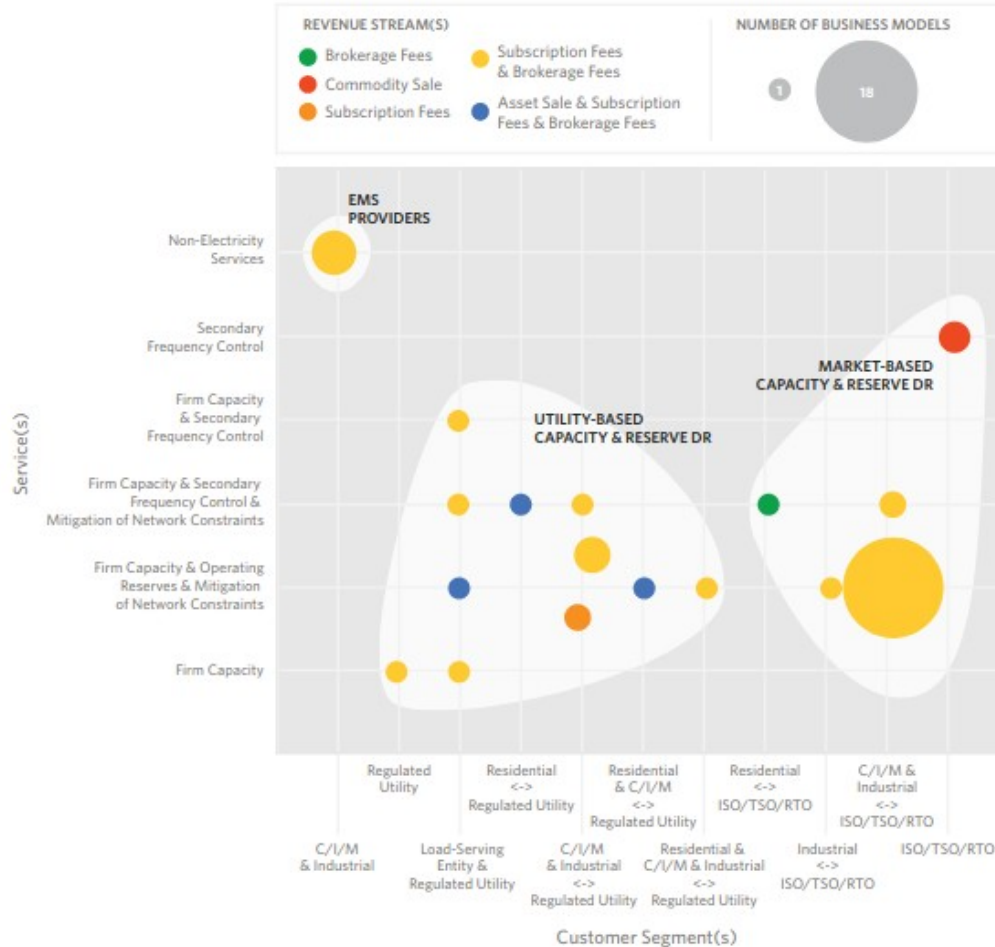
Assistant Prof. in Electrical Engineering,  
Department of Electrical & Computer Engineering,  
Florida State University

**Yuxun Zhou**

PhD candidate, Department of Electrical Engineering  
and Computer Sciences, UC Berkeley

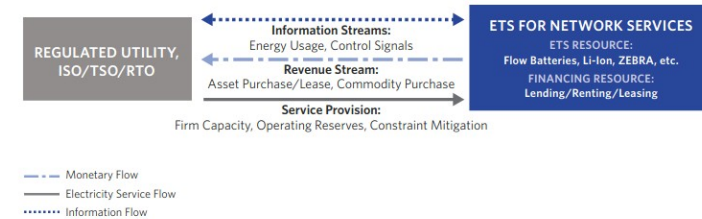


# Ör: Dağıtık sistemler – Talep ve Enerji yönetim sistemleri

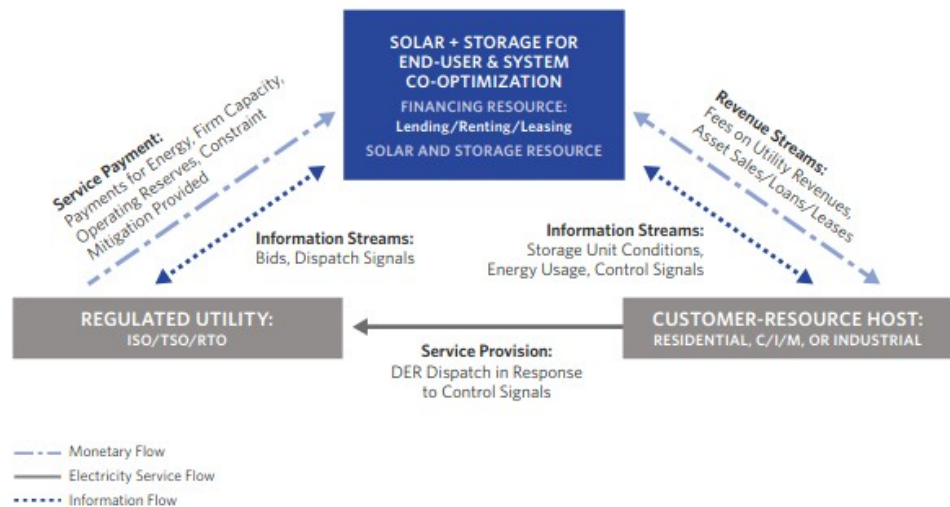
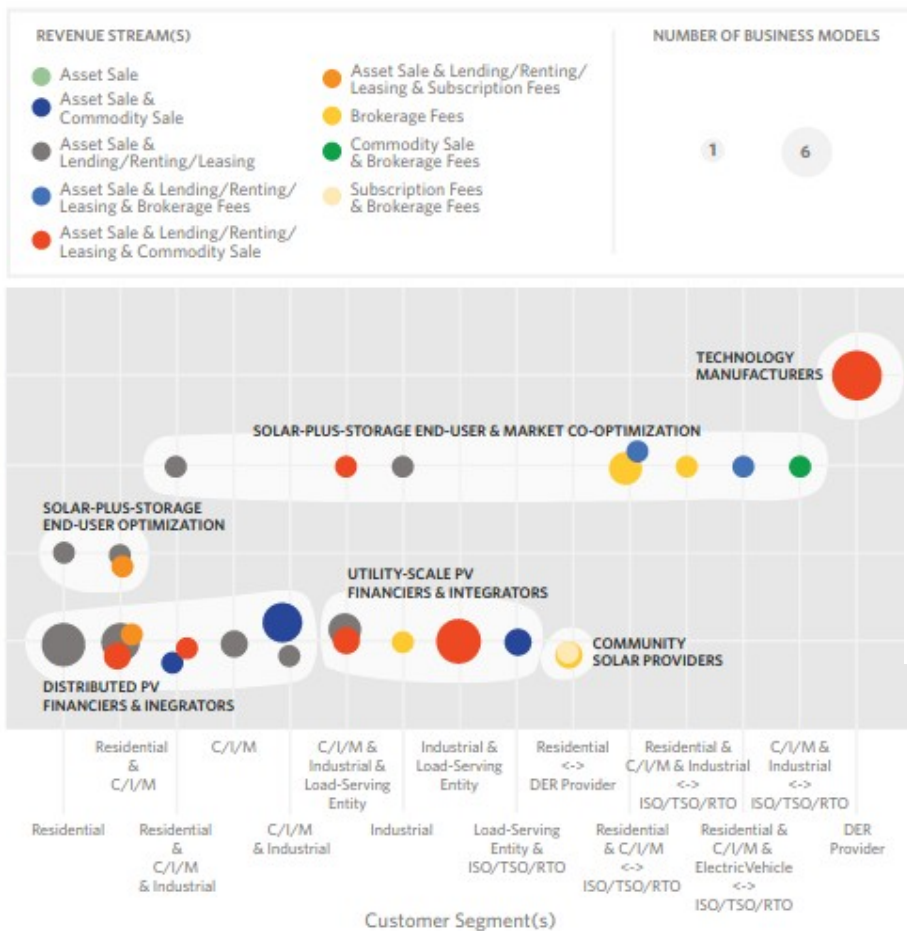




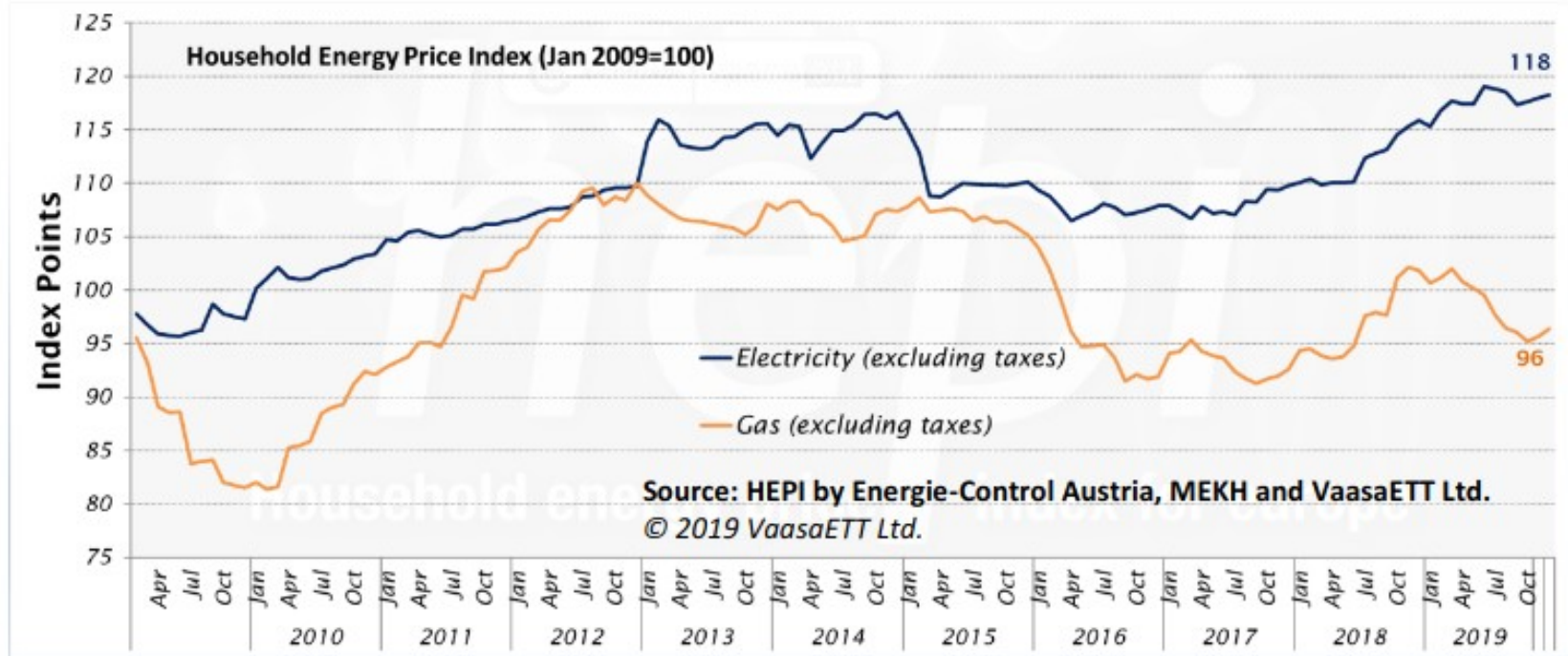
# Ör: Elektrik ve Termal depolama



# Ör: Güneş iş modelleri



# AB'de elektrik ve gaz fiyatları



# Başlangıç: Fiyat

- Kıtlık fiyatı (scarcity pricing)
  - Olmayan elektrik bedeli
    - güneş/talep yönetimi/depolama
- Maliyet/Fiyat/Değer
  - Güneş : sıfır marjinal maliyet
  - Güneş : 13.3 alım garantisi
- Boyut ? (Kapasite/Yer/)
- Piyasa
  - Spot yenilenebilir ve spot esneklik piyasaları

# Soru 2: Fiyat nasıl yansıtılacak?

- Sabit bedel
- Sabit bedel+değişken bedel
- Elektrik güvenilirliği seviyesine göre fiyat?
  - Yılda 12 saat max kesinti hizmeti
  - Yılda 1 saat max kesinti hizmeti

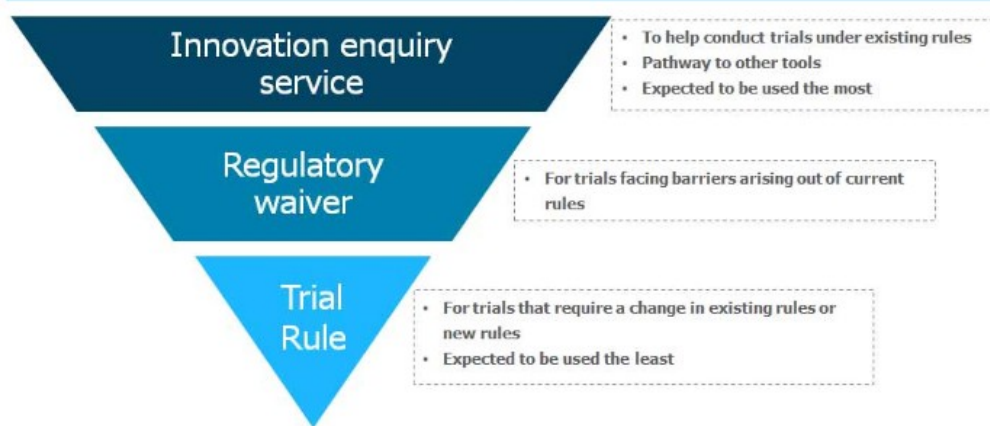
# Soru 2.1 Güvenilirlik

- İki ayrı senaryo
  - Tüketici grupları arası
  - IoT destekli ev aletleri
    - Farklı ev aletleri farklı tüketiciler gibi mi?
      - Tüketici no: 342343.0
      - Buzdolabı: 342343.1
      - Vs
- Güvenilirlik bir kamu faydası mı, fiyatlanmalı mı?

# Soru 3: Yeni fikirler nasıl test edilecek?

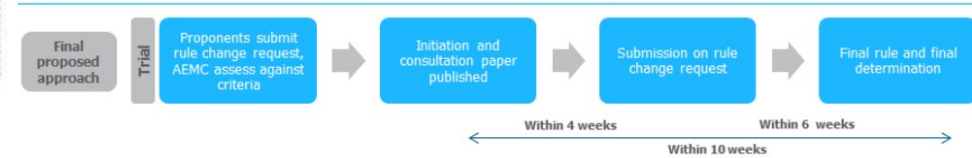
“Kanun değişikliği lazım” → her yeni iş modeline?

- Düzenleyici kum havuzu (Regulatory sandbox)



Source: AEMC

Figure 5.1: Trial rule change process overview



Source: AEMC

## RECOMMENDATION 20: PROCESS AND TIMELINE

The new trial rule change process should be less than 10 weeks long and involve one round of stakeholder consultation.

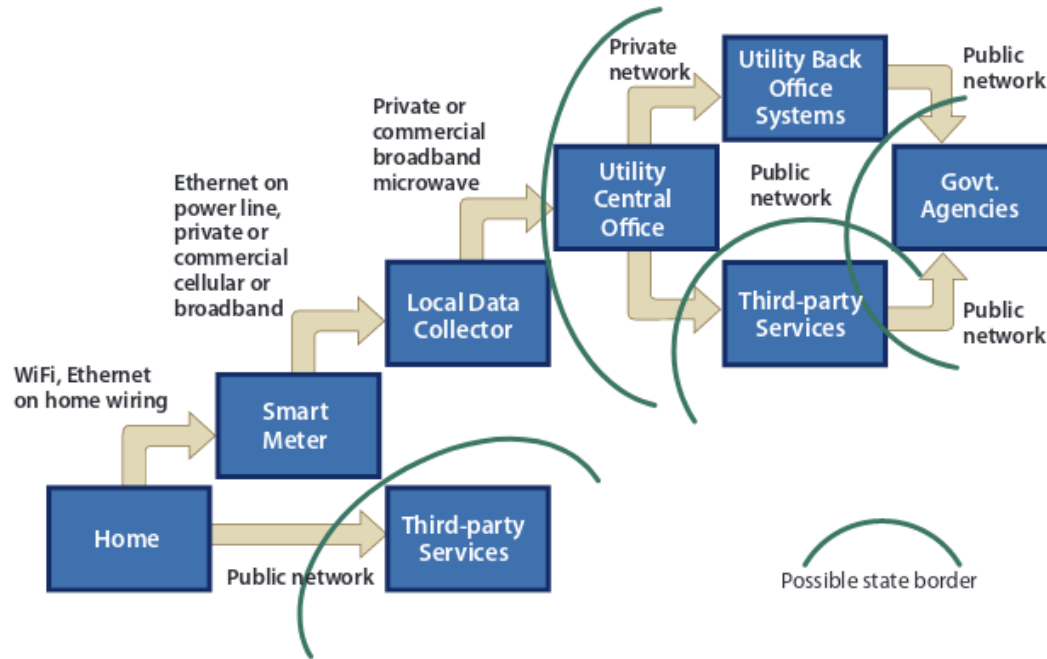
# Soru 4: Yapay zekanın konumu?

- Yapay zeka: Kara kutu mu, cam kutu mu?
- Önemli değil ise?
  - Tüketici hizmetleri, fiyat tahminleri, onarım/bakım
- Önemli ise
  - Sistem işletimi, anlık dengeleme (!!! Riskli alanlar)



# Soru 5: Sibergüvenlik?

- Kültür/Standart/Geri kurtarım



Attack Vector	Impact	Possible Solutions	Solution Requirements
Physical Attack on Meter	Energy theft Incorrect energy usage data sent Theft of energy-usage data Theft of personal/billing information Disruption of electricity supply	Tamper-proof sealing or physical locks <sup>a</sup> Tamper-detection mechanisms <sup>b</sup> Automated system protection <sup>c</sup> (e.g., data erasure) Regular updates of meter firmware, security certificates <sup>d</sup> Asymmetric encryption <sup>d</sup> Frequent but irregular change of cryptographic keys, pre-installation of keys <sup>e</sup> Design architecture to store data for minimum time necessary <sup>b</sup>	Sufficient network bandwidth for updates <sup>d</sup> Formal industry agreement on a "sufficient" bandwidth Minimum security standards (regularly updated) regarding software security, tamper-proof and tamper-detection mechanisms Policy requirement for regular software updates to meet security standards Policy requirement for automated system protection
Denial-of-Service Attack on Meter Data Collection Point	Denial of service to connected local area meters, disruption of local-area network Possible upstream cascading effects on utility data network due to missing data	Tamper-detection mechanisms at collection points Automated system protection <sup>c</sup> (e.g., data erasure)	Standards for tamper-detection mechanisms
Software Attack on Utility Meter Data Management System	Widespread theft of energy-usage data Widespread theft of personal/billing information Disruption of electricity supply Disconnection of meters	Utility security policies to prevent unauthorized access Detection methods for unauthorized access/tampering Separation of electricity delivery system from energy data management system	Corporate security policies User access policies Back-end system design policies Implementation of utility-side tamper-detection mechanisms

Sources:

<sup>a</sup>S. McLaughlin, D. Podkuiko, and P. McDaniel, "Energy Theft in the Advanced Metering Infrastructure," in *Proceedings of the 4th International Workshop on Critical Information Infrastructure Security* (New York, NY: IEEE Press, 2009).

<sup>b</sup>R. Shein, "Security Measures for Advanced Metering Infrastructure Components," in *2010 Asia-Pacific Power and Energy Engineering Conference* (New York, NY: APPEEC and IEEE, 2010).

<sup>c</sup>In Guardians, *Advanced Metering Infrastructure Attack Methodology, Vol 1.0*. (Washington, DC, 2009).

# Soru 6: Esneklik nasıl gelecek?

- Esneklik veya daha plastik bir elektrik sistemi
- Nasıl fiyatlanacak?

The screenshot shows the National Grid ESO website. The main navigation bar includes 'Electricity System Operator' and 'Other sites'. The secondary navigation bar lists 'Investors', 'Media', and 'Careers'. The primary navigation bar includes 'Balancing services', 'Balancing data', 'Charging', 'Codes', 'Connections', 'Publications', and 'Innovation'. The breadcrumb trail is 'Balancing Services > Reserve services'. The main content area is titled 'Demand Turn Up' and describes the service as encouraging large energy users and generators to increase demand or reduce generation at times of high renewable output and low national demand. Below this is a navigation bar with icons for 'Overview', 'Technical Requirements', 'How to participate', and 'Assessment Process'. The 'Providing the service' section lists various technologies that can participate, including true demand turn up, combined heat and power (CHP), any other type of generation, energy storage (such as batteries), and other technologies, provided they can offer the flexibility required. To the right, there are sections for 'Equipment', 'Delivery duration of the service', 'Speed of delivery', and 'Service dispatch', each providing specific details about the service's requirements and timelines.

## Equipment

Providing you have minute by minute or half hourly metering on your site(s), a mobile phone/landline and the ability to access email, there is no additional equipment that needs to be installed.

## Delivery duration of the service

In 2016, the average length of delivery was 4 hours 20 minutes.  
In 2017, the average length of delivery was 3 hours 34 minutes.  
In 2018, the average length of delivery was 4 hours 36 minutes.

However, each instruction depends on a number of factors, including the weather conditions and the provider's capabilities.

We will ask you how long you are capable of providing demand turn up for in a single instruction and we won't exceed this when we issue instructions.

## Speed of delivery

As with duration of delivery, the speed in which a provider needs to respond is linked to individual providers' capabilities.

The average notice period for an instruction (i.e. the time between a provider receiving an instruction and starting to deliver the service) was 7 hours 20 minutes in 2016 and 6 hours 40 minutes in 2017. In 2018, the average notice period for an instruction was 6 hours 6 minutes.

## Service dispatch

### When providers need to be available to deliver the service

There are particular times of the day or week when the service is more likely to be required. These are defined as 'availability windows' and cover the following periods:

Overnight window:

- 23:30 – 06:30 for May, September, October (base months)
- 23:30 – 02:00 for June, July, August (peak months)

Weekends and bank holidays afternoon window:

- 13:00 – 16:00 for May to October

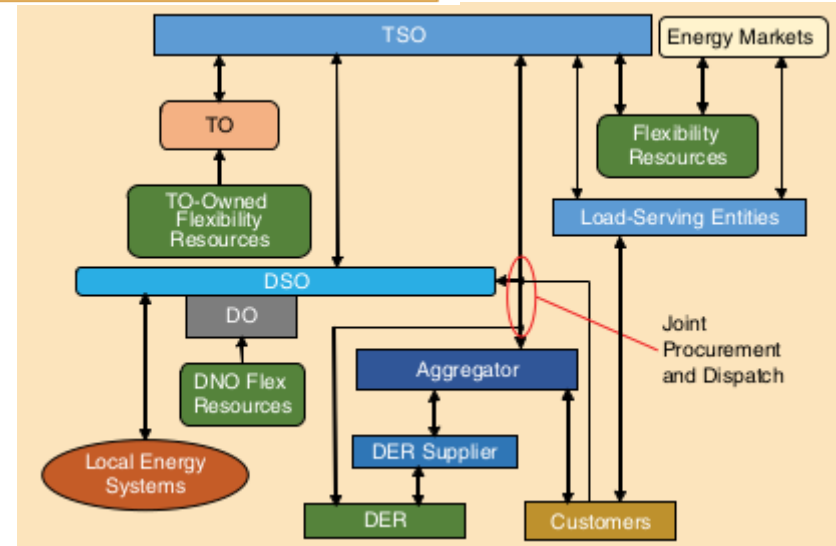
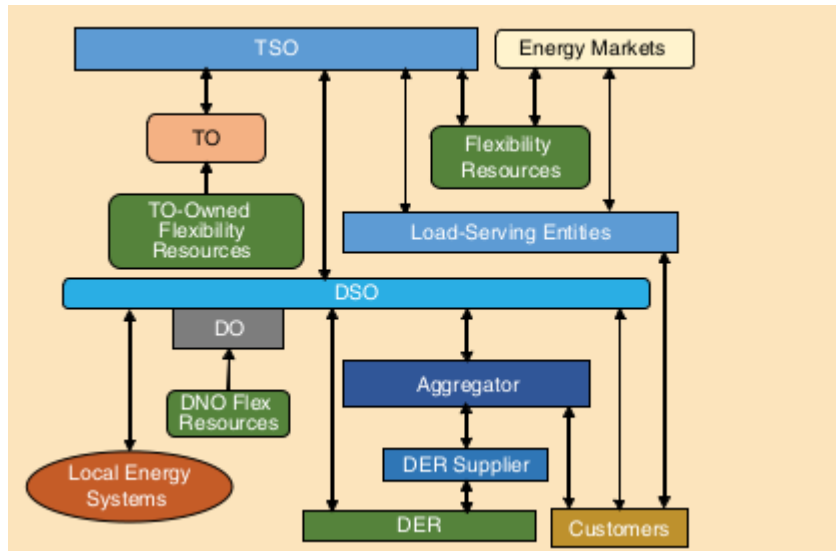
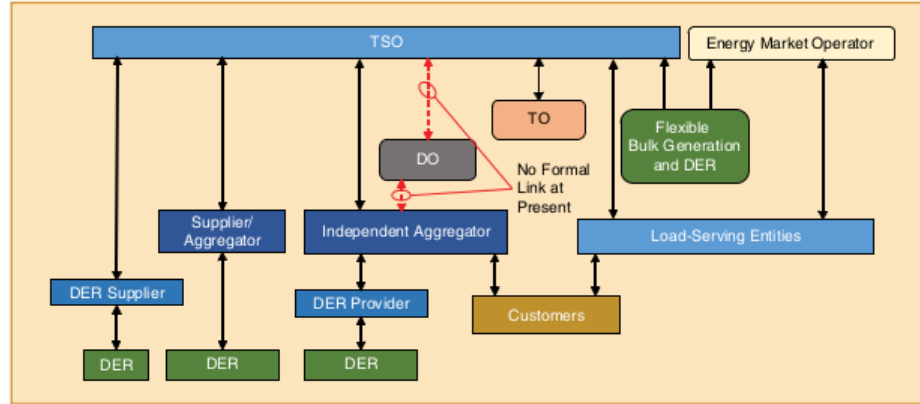
### How providers will be dispatched

Instructions will be issued via email, with a supporting SMS sent to the provider.

We will send an email containing the details of the megawatt response and the timeframes during which it is required.

Providers will need to confirm receipt of an email instruction within 30 minutes of it being issued.

# Soru 7: Yeni bir şebeke mimarisi?



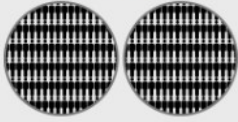
# Soru 8 : Elektrik tüketicisi – Hiper Kişiselleştirme?

## Elektrik tüketicisi Netflix seyircisine benzer mi?

### GOLDILOCKS, DATA SCIENTIST?

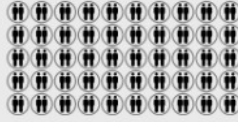
Clustering is most effective when it balances personalization with scalability. Like goldilocks, data scientists, who optimize clusters for size and coverage, just like goldilocks.

#### TOO FEW CLUSTERS

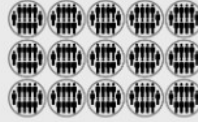


- ✗ Too many people in a cluster
- ✗ Lack of personalization

#### TOO MANY CLUSTERS



#### JUST RIGHT



### USER FEEDBACK IS NOISY

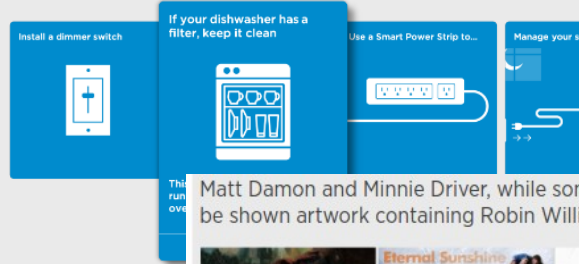
What people say often differs from what they consumers say they want better gas mileage y trucks at a record clip). This well-documented phenomenon, known as [declared vs. revealed preferences](#), makes it critically important to capture a number of different signals to ensure the clearest possible picture of user preferences.

In 2017, Netflix eliminated its long-standing 5-star rating system in order to more accurately capture user feedback. What they had found was that a user might watch a single highly-acclaimed documentary and rate it 5 stars,



### OPTIMIZING WITH FEEDBACK

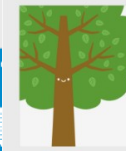
Bidgely's appliance-level recommendations have an "I did it / I'll do it" feature that serves two purposes for customers: clicking "I'll do it" populates a customer list, while clicking "I did it" removes the recommendation for that customer. At the same time, each click provides the utility with valuable feedback on what recommendations are capturing the most interest, enabling further program optimization.



### PERSONALIZED EE MESSAGING

Clustering helps Bidgely determine how to best personalize its communications with each customer.

#### ENVIRONMENTAL CLUSTER



By reducing your energy usage today, you'll help us plant 500 trees!

#### MONETARY CLUSTER



By reducing your energy usage today, you can save up to \$5.00!

Matt Damon and Minnie Driver, while someone who has watched comedies might be shown artwork containing Robin Williams.

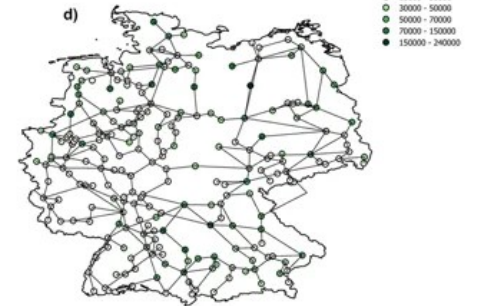
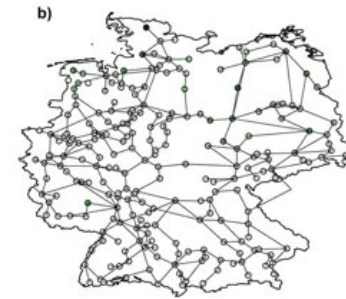
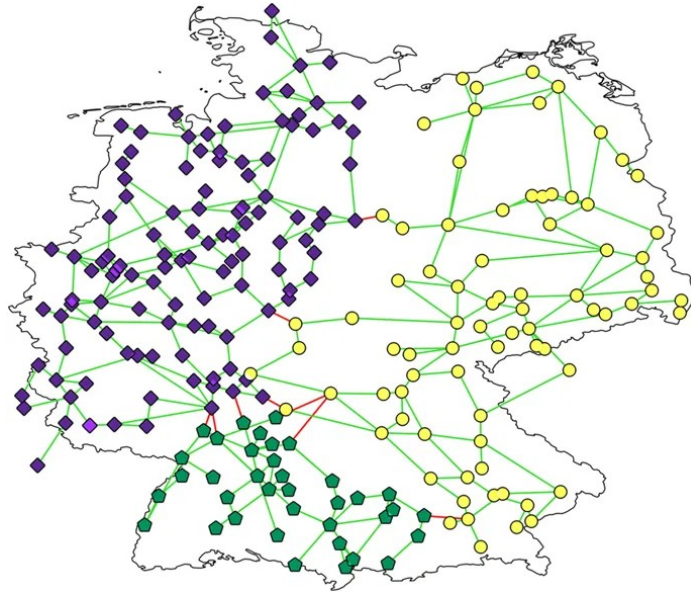


Bidgely also leverages data to personalize content delivery to

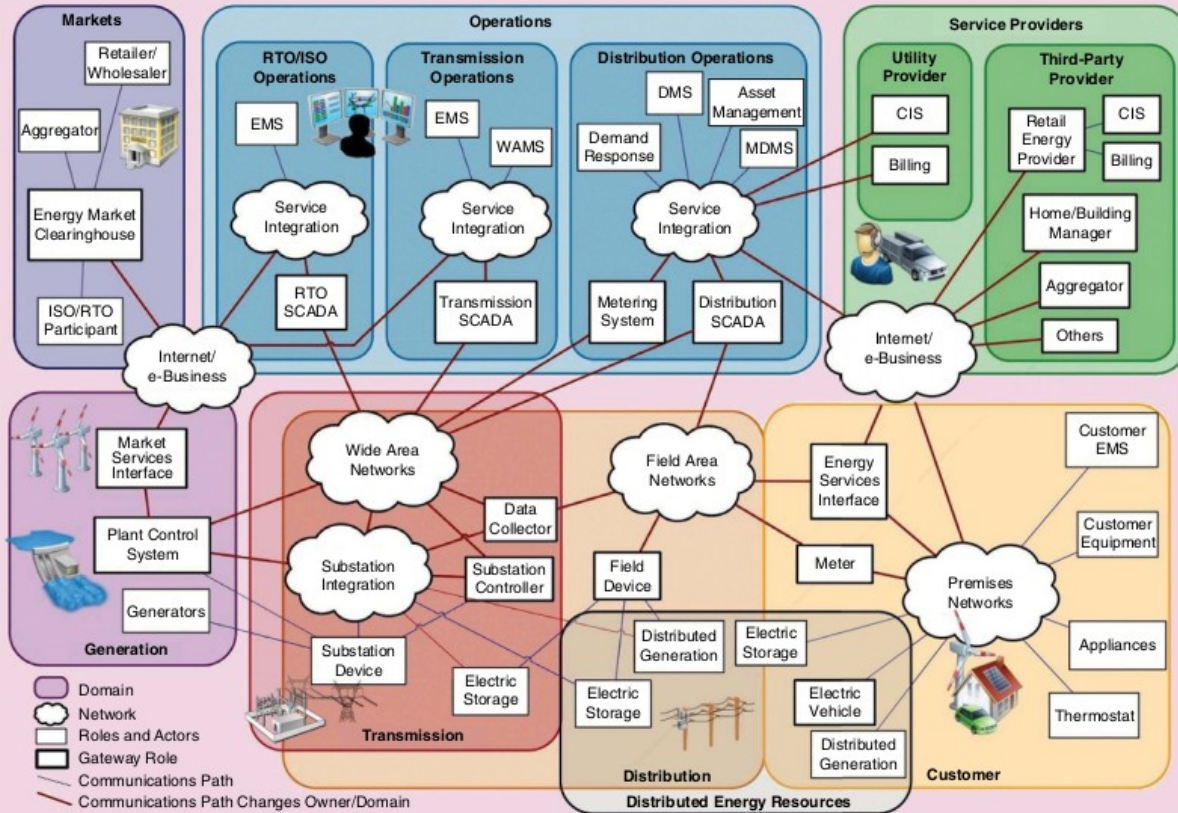
# Enterkonneksiyon yönetimi – Akıllı adalama

Islanding the power grid on the transmission level:  
less connections for more security

Mario Mureddu, Guido Caldarelli, Alfonso Damiano, Antonio Scala & Hildegard



# Akıllı Şebeke



Governmentwide Acquisition Contract Stack Layer	Inverter-Based Generation and Storage	EVs	Controllable Loads	Grid-Connected Microgrids
8. Economic/regulatory policy	Grid service defined by policy or economic market			
7. Business objectives	Grid service enabled as a business objective			
6. Business procedures	Entity provides signal requesting grid service			
	Inverter-based systems/vehicles/controllable loads/microgrid respond to request for grid service			
	Device controls defined for provision of grid service			
5. Business context	Data modeling relevant for providing a specific grid service			
4. Semantic understanding	SunSpec PV Models SunSpec/MESA Device Models OpenFMB	Vehicle data models	OpenADR 2.0	IEEE P2030.7 IEEE P2030.8
3. Syntactic interoperability	IEEE 2030.5 IEC 61850-7-420 IEEE 1815 IEEE 2030.2 IEEE 1547.3 Modbus	SAE J2847/3 <sup>a</sup> SAE J2847/2	OpenADR 2.0 ASHRAE 201 (FSGIM) ASHRAE 135 (BACnet-WS) IEC 14908 (LonMark) IEEE 2030.5 OBIX OASIS EMIX Modbus	Modbus IEEE 1815
2. Network interoperability	TCP/IP ZigBee IEEE 1815 CAN bus	TCP/IP UDP FTP HTTP	TCP/IP DALI ZigBee	TCP/IP IEEE 1815 CAN bus
1. Basic connectivity	Twisted Pair CTA-2045 IEEE 802.11 (Wi-Fi) IEEE 802.15.4 (Thread)	Twisted Pair CTA-2045 IEEE 802.11 SAE J1772 (PLC) SAE J2931/4 (PLC)	IEEE 802.11 IEEE 802.15.4	Twisted Pair RJ-45 CTA-2045 IEEE 802.11 IEEE 802.15.4
0. Interconnection	IEEE 1547 IEEE 1547.1 UL1741 IEEE 2030.2	SAE J3072 <sup>b</sup> SAE J2894-1 (PQ)	N/A	IEEE 1547.1 IEEE 2030.7 IEEE 2030.8 IEEE 1547.4

# Tak-çalıştır şebeke

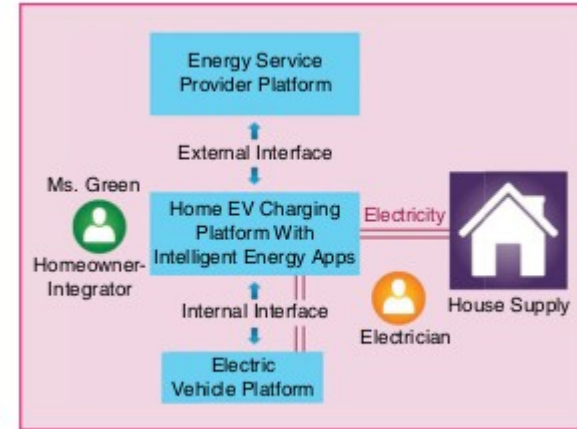
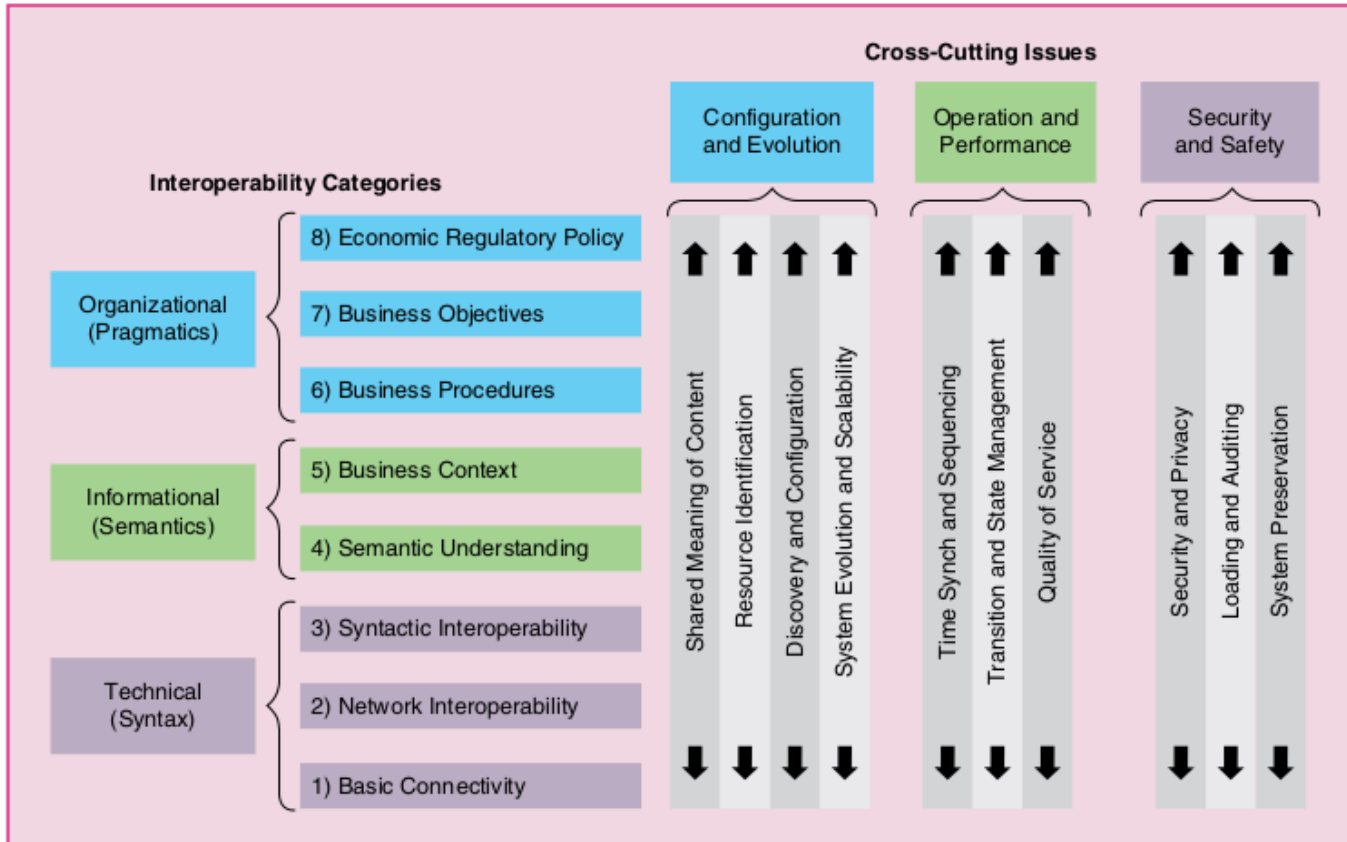


figure 1. Integrating a smart EV charger.

# Birlikte işlerlik (Interoperability)



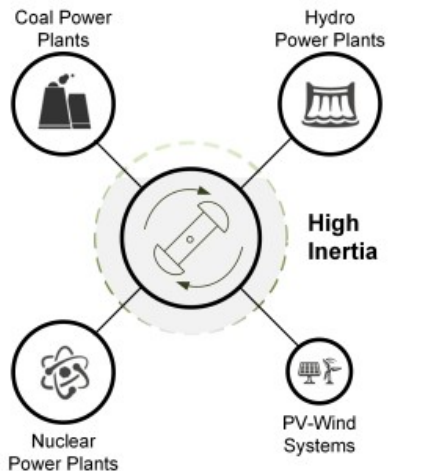
## Interoperability

ISO/IEC/IEEE standard 24765 defines interoperability as “the ability of two or more systems or components to exchange information and to use the information that has been exchanged.” Interoperability is valuable because it

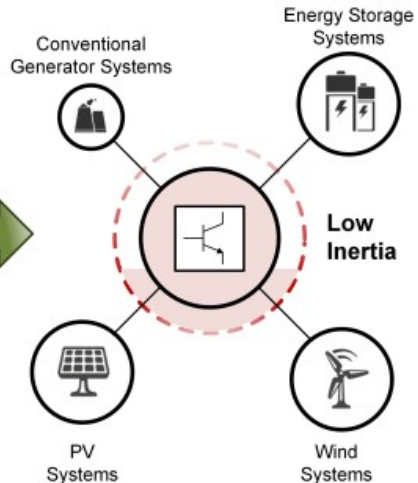
- reduces the cost and effort for system integration
- improves grid performance and efficiency
- facilitates more comprehensive grid security and cybersecurity practices
- increases customer choice and participation
- establishes industry-wide best practices
- functions as a catalyst for innovation.



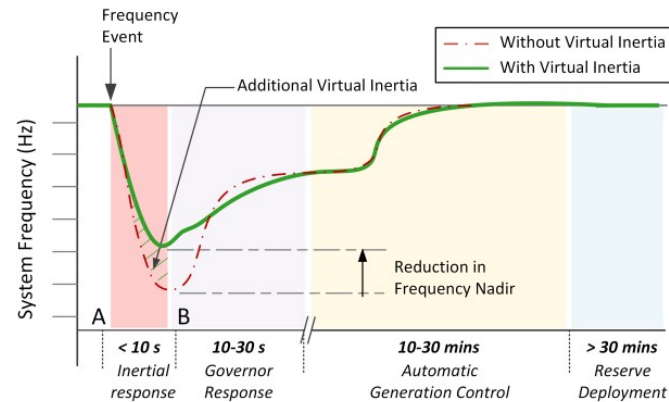
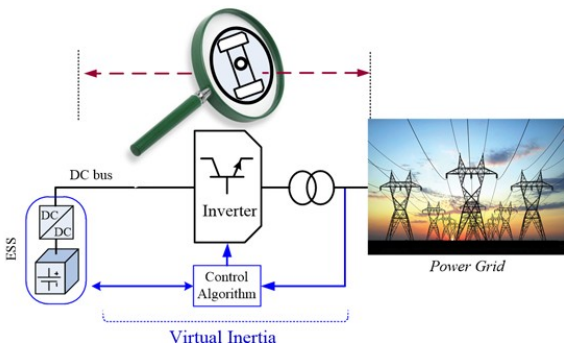
# Sanal Atalet



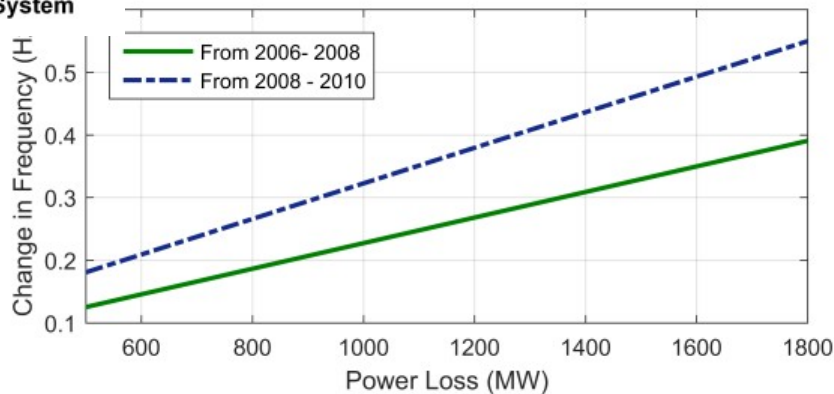
**Generator Dominated Power System**



**Inverter Dominated Power System**

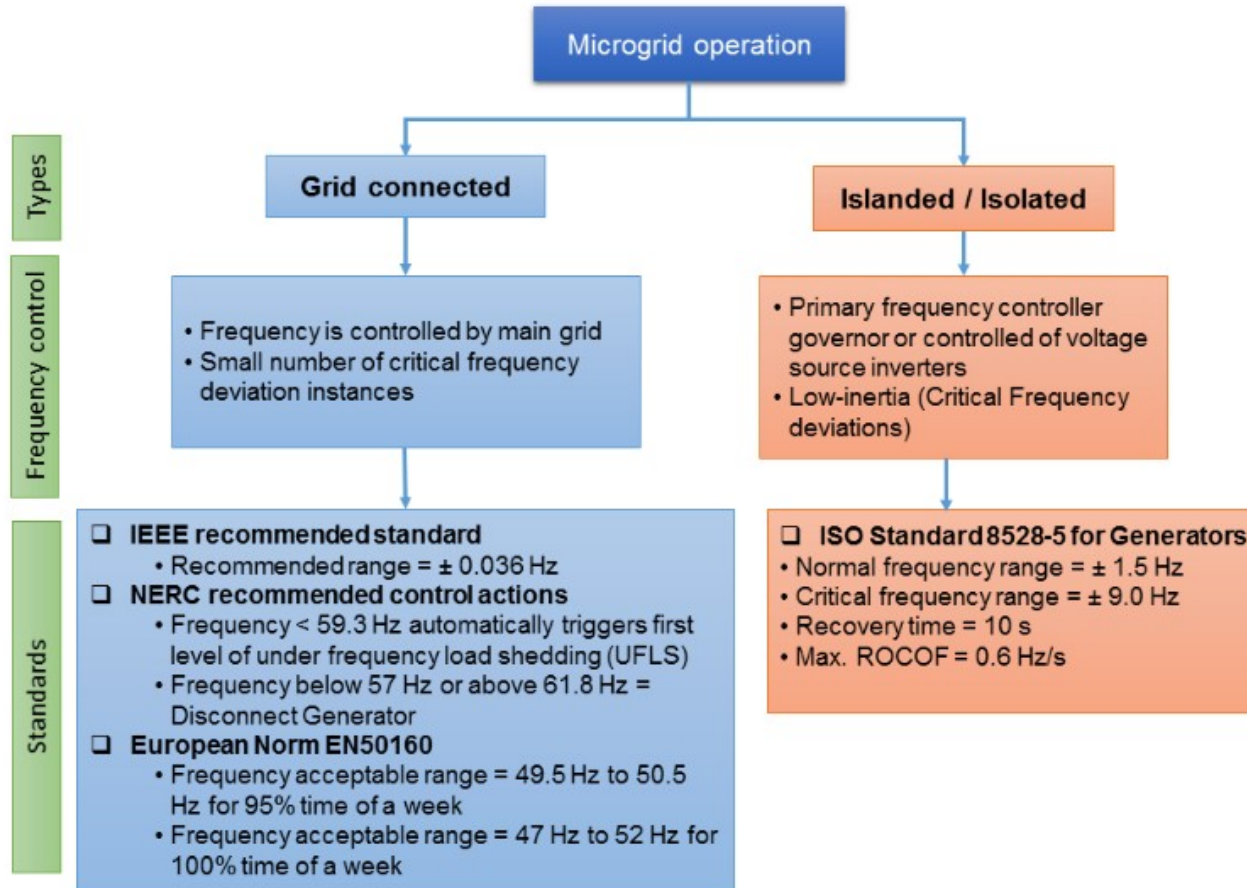


multiple time-frame frequency response in a power system following a frequency event.

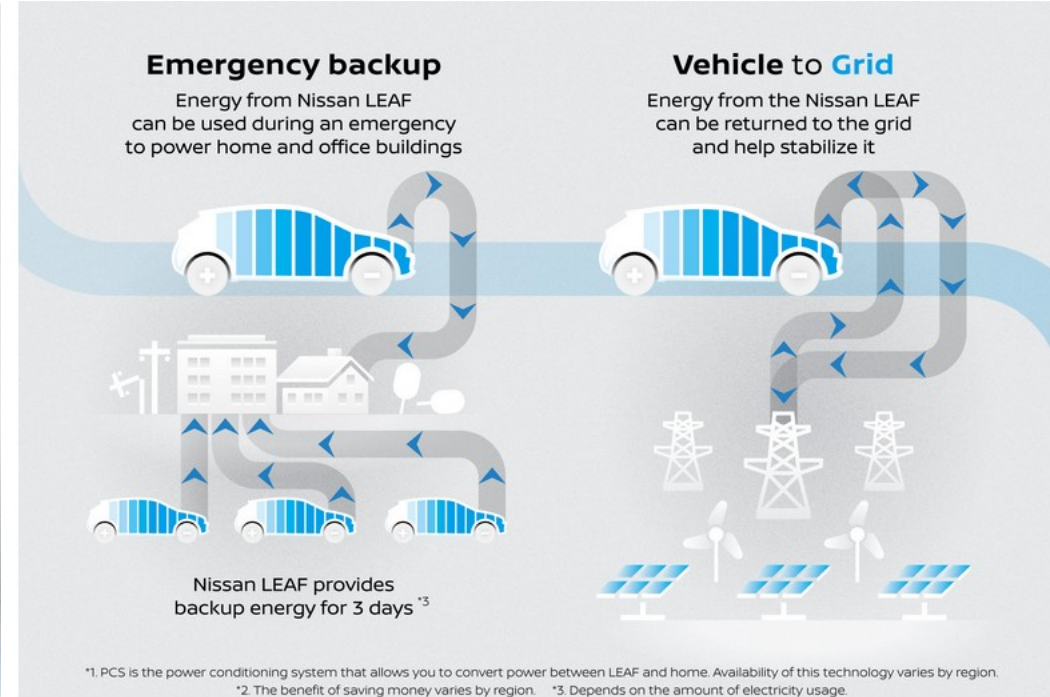
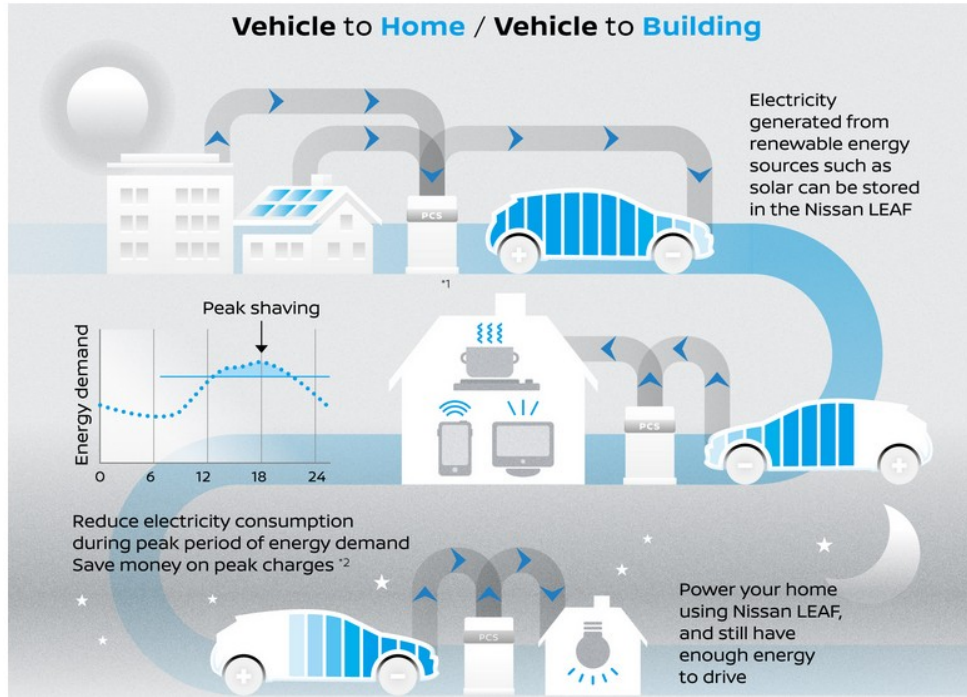


Increase in frequency changes in Electricity Reliability Council of Texas (ERCOT) connection

# Mikroşebekeler için frekans standardı

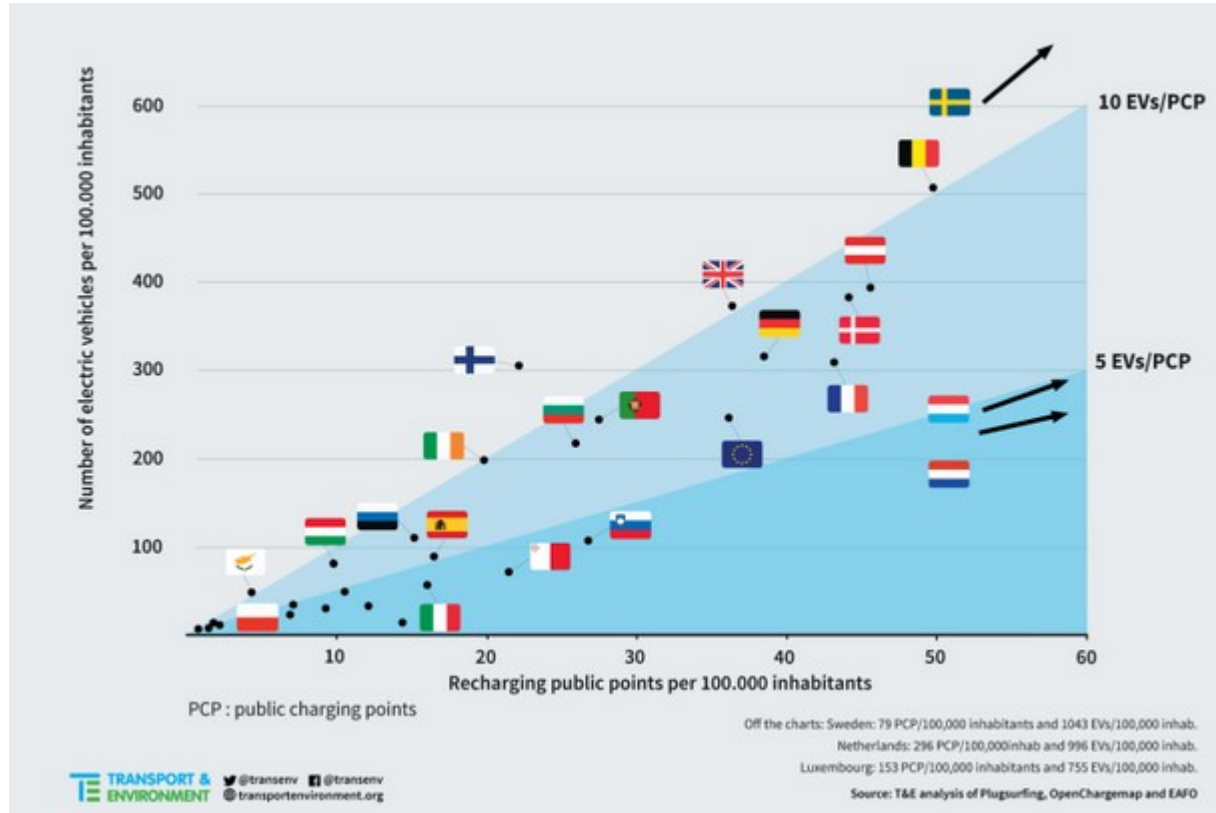


# Elektrikli Arabalar - V2X



Nissan to create electric vehicle 'ecosystem' <https://global.nissannews.com/en/releases/release-860852d7040eed420ffbaebb2241c3ea-nissan-to-create-electric-vehicle-ecosystem?>

# Ne kadar şarj noktasına ihtiyaç var?



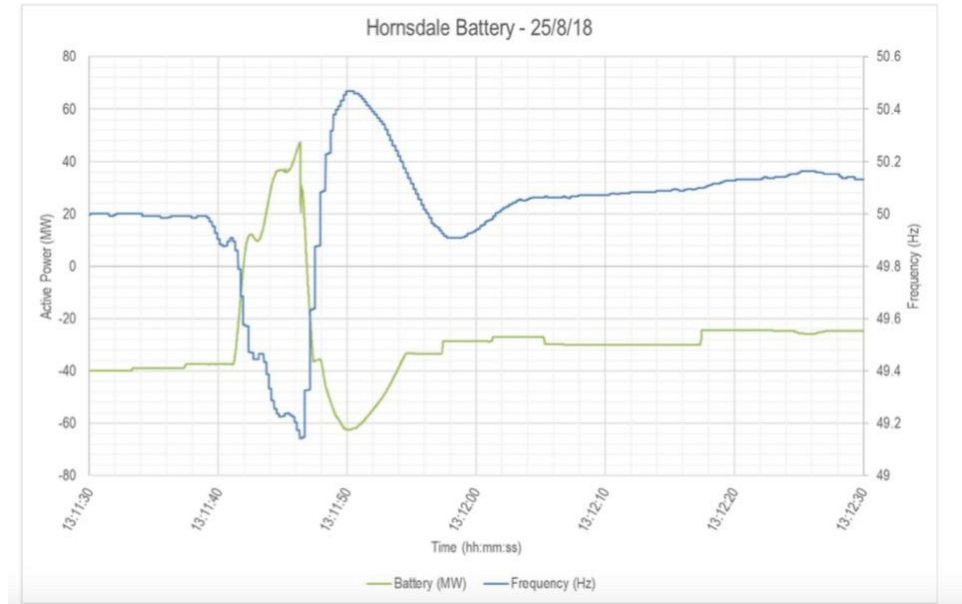
<https://energypost.eu/eu-pathway-to-3m-ev-charge-points-by-2030/>

# Hornsedale Güç Rezervi

- 100MW/129MWh
- 100 MW in 140 ms

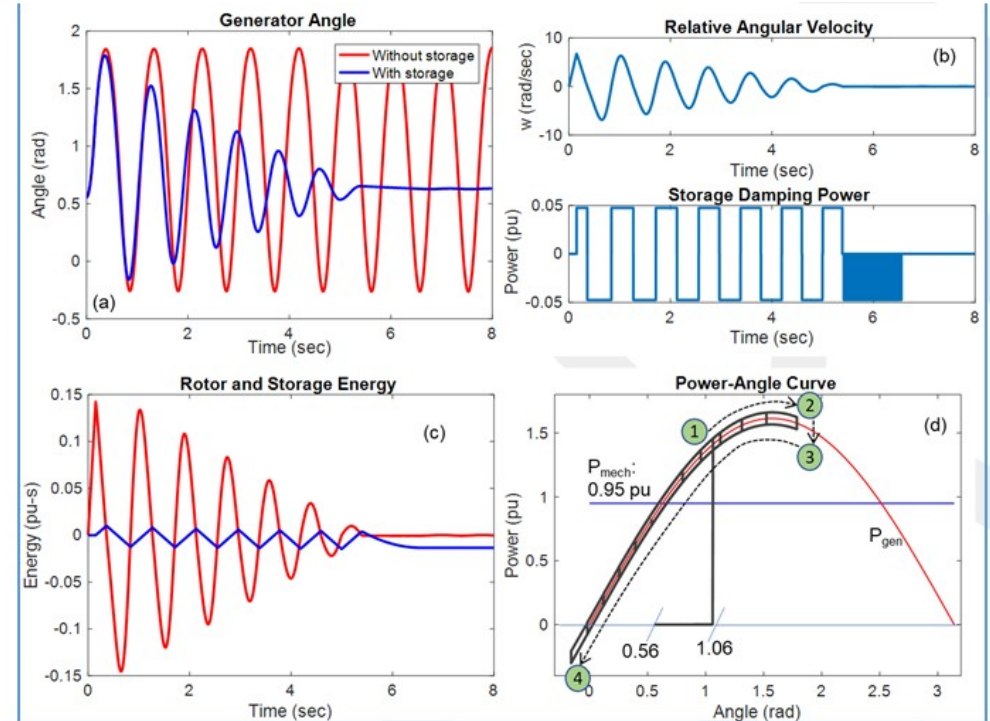
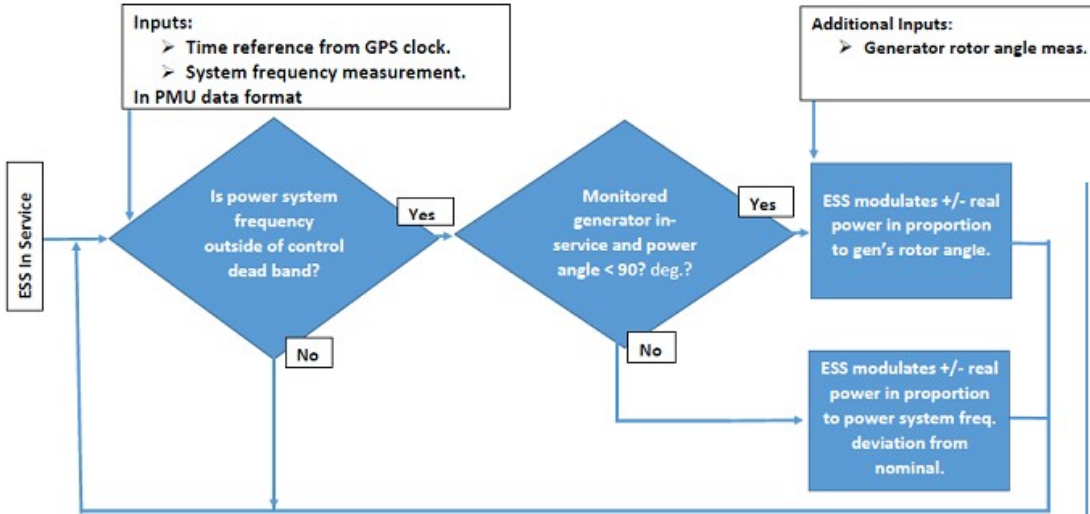


Figure 41 SA transmission-connected battery response – short-term

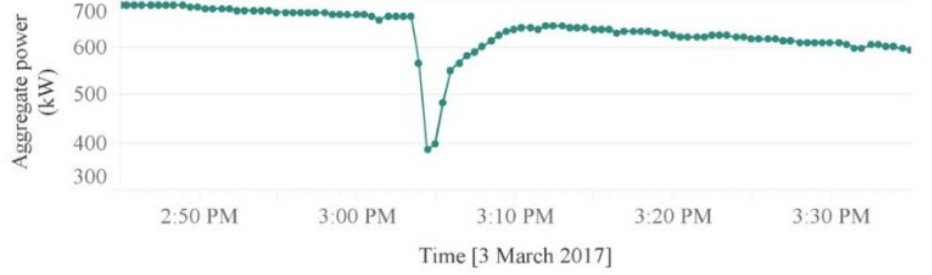
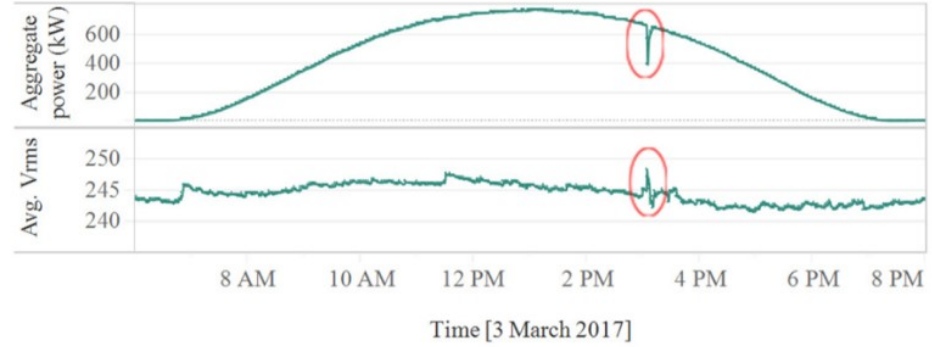
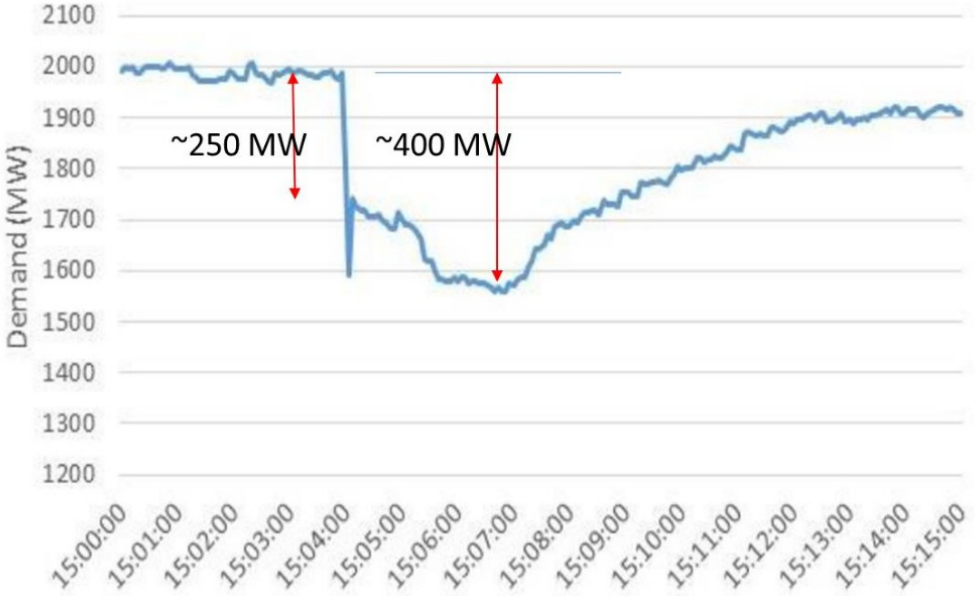


<https://reneweconomy.com.au/how-the-tesla-big-battery-kept-the-lights-on-in-south-australia-20393/>

# Depolama ile Aktif Sönüm ile Frekans Kontrolü



# Güney Avustralya 3.3.2017



# Python

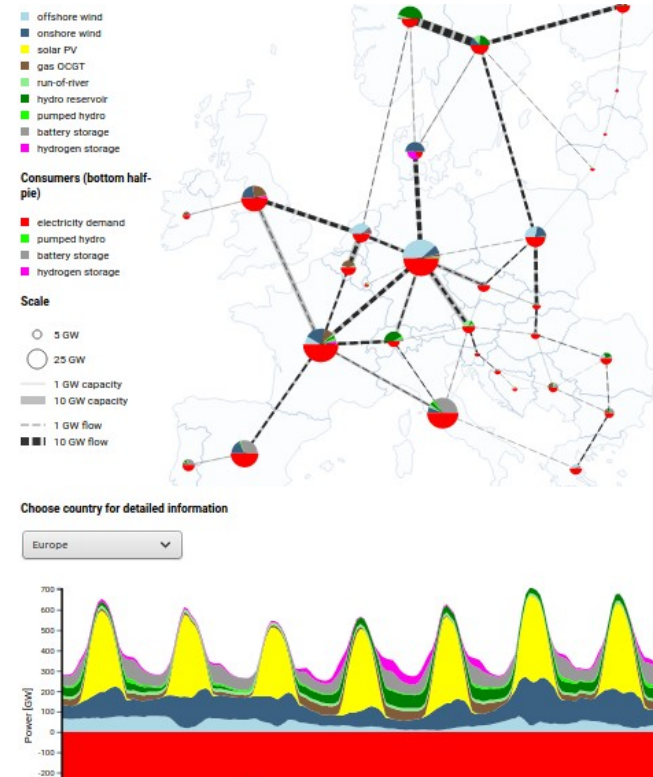
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[animations](#) [forum](#)

## PyPSA: Python for Power System Analysis

### Table of Contents

- [1. About](#)
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- [3. Documentation](#)
- [4. What PyPSA does and does not do \(yet\)](#)
- [5. Example scripts as Jupyter notebooks](#)
- [6. Screenshots](#)
- [7. What PyPSA uses under the hood](#)
- [8. Mailing list](#)
- [9. Citing PyPSA](#)
- [10. Licence](#)

PyPSA-Eur-30: Scenarios for Europe with 95% renewable electricity





# AB Yeşil Paket



# ArGe yolculuđu

- Kurumsallařma/Kültür/Katılımcılık
- Standart Giriřimcilik Modeli
  - Kurum ii destek/mentör ekibi
  - Kurum dıřı eriřim (“yeni fikir” yarışmaları)
  - Kurum ii girişimcilik destekleri
  - Ortak hareket (EPDK projelerine başvuru)

# Teşekkürler

[barissanli.com](http://barissanli.com)