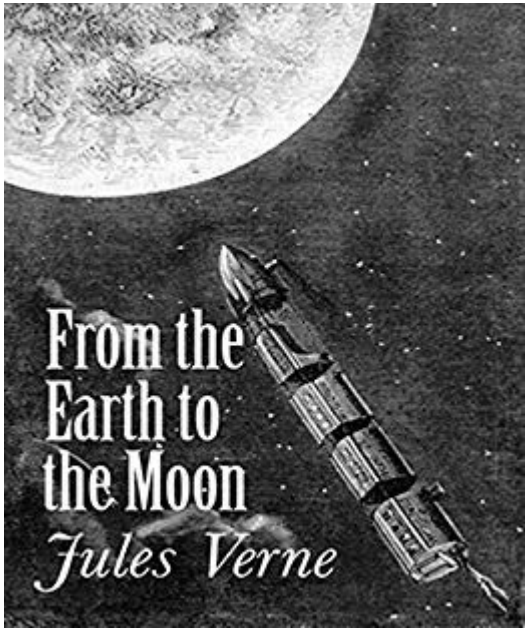
# Enerjide Dijitalleşme

Barış Sanlı
barissanli.com

ODTÜ Enformatik, 28 Şubat 2020

# Hayaller ve Gerçekleşmeler

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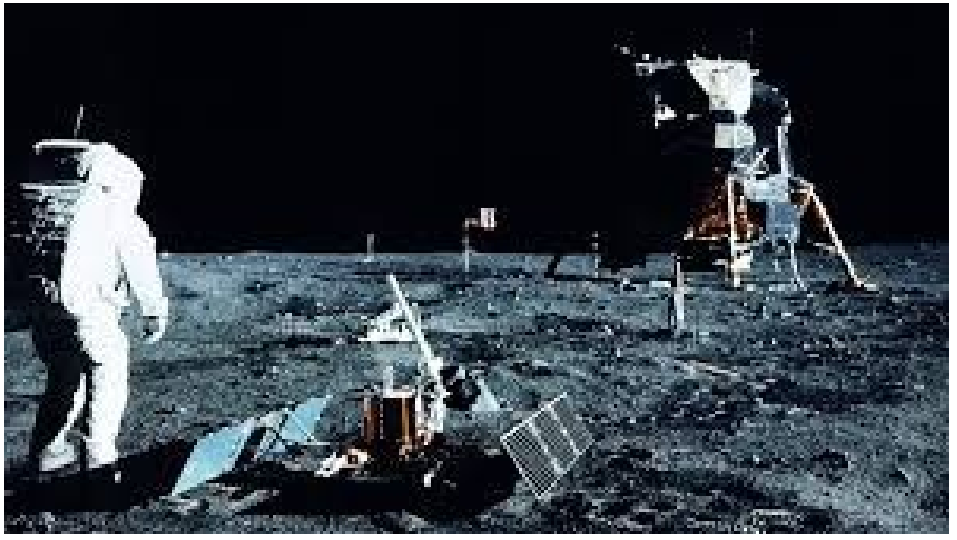


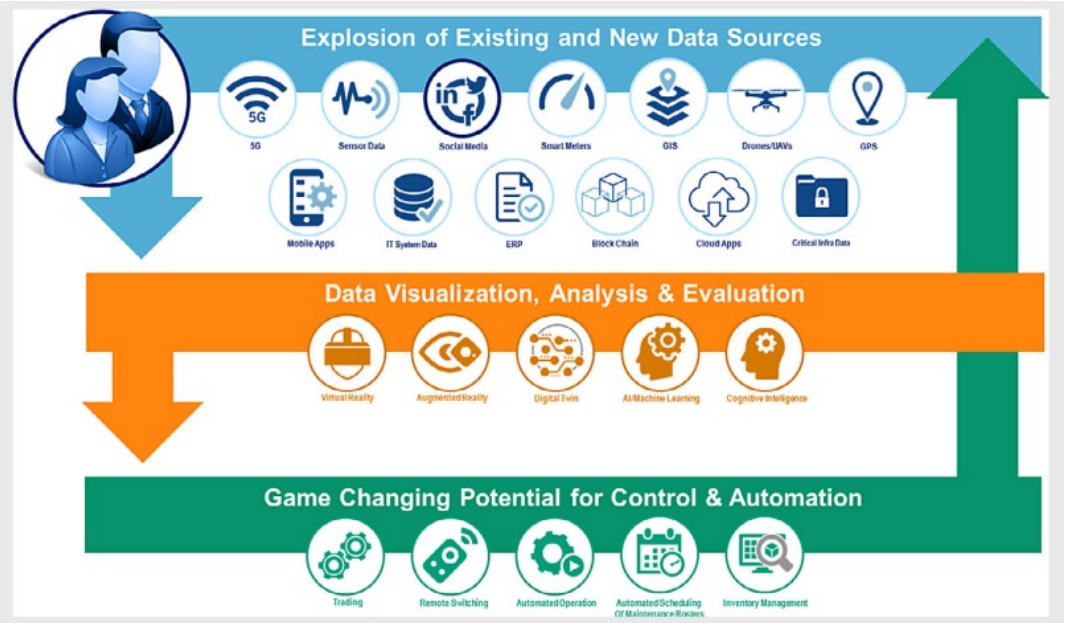
1969

# 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



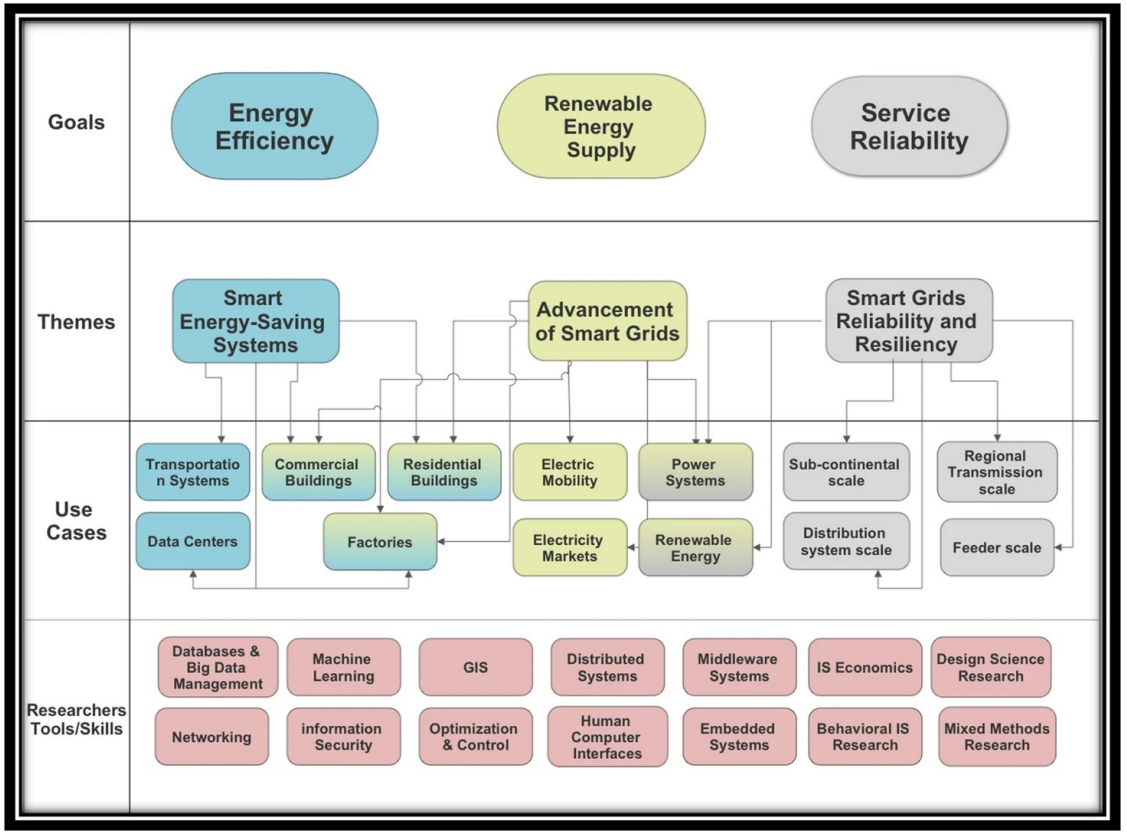

Digital technologies in the energy industry. *(Source: Pöyry Management Consulting.)*

# Elektrik : Emtia mı hizmet mi?

- Emtia ise (fiziksel varlıklar):
  - Dijitalleşme: emtia süreçleri
    - Üretim+izleme+lojistik

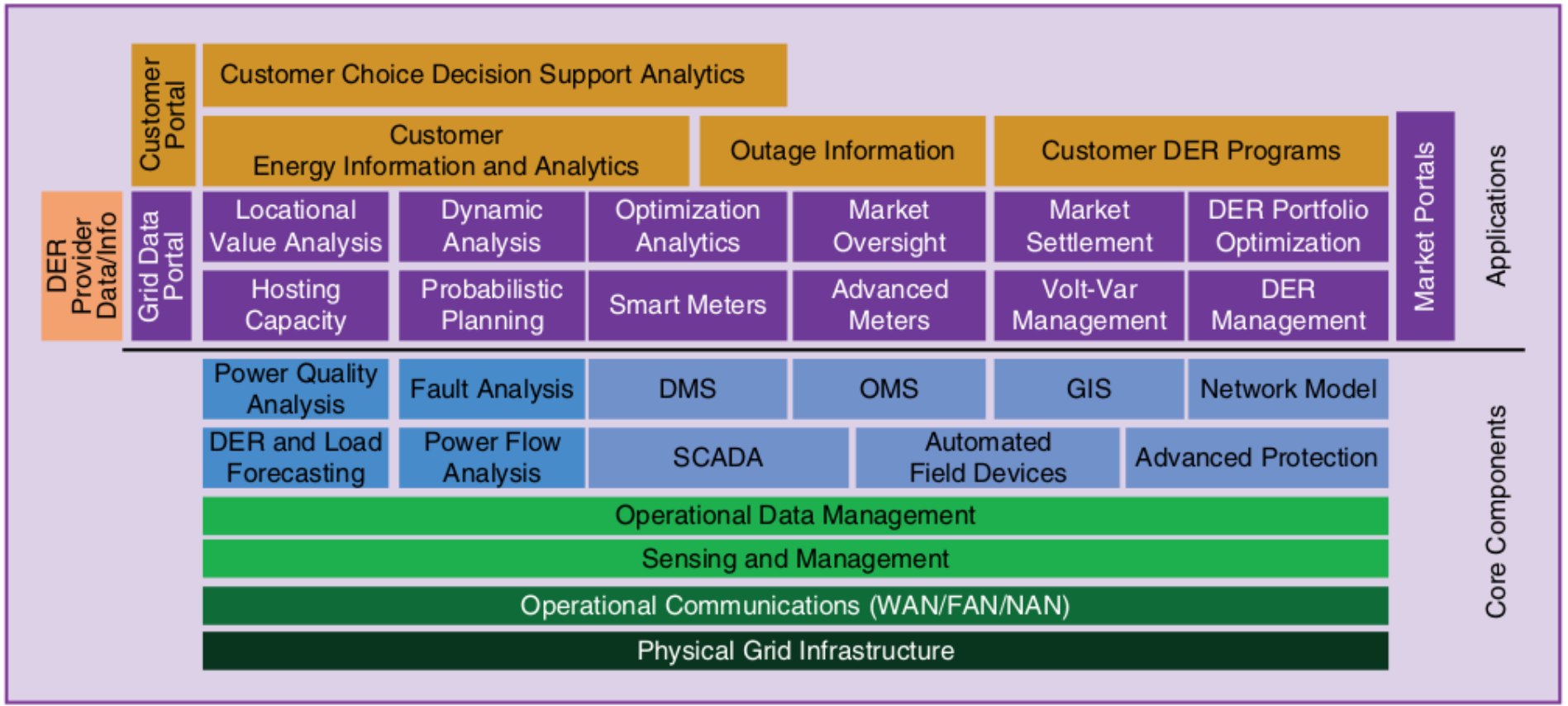
- Hizmet ise: (Dijital)
  - Üretici vs İletim hizmetleri vs Tüketici
  - Finans, çevre, tüketici hizmetleri
  - Dijital kooperatifler, menşei, tüketici pazarı

# Energy informatics enhanced research framework



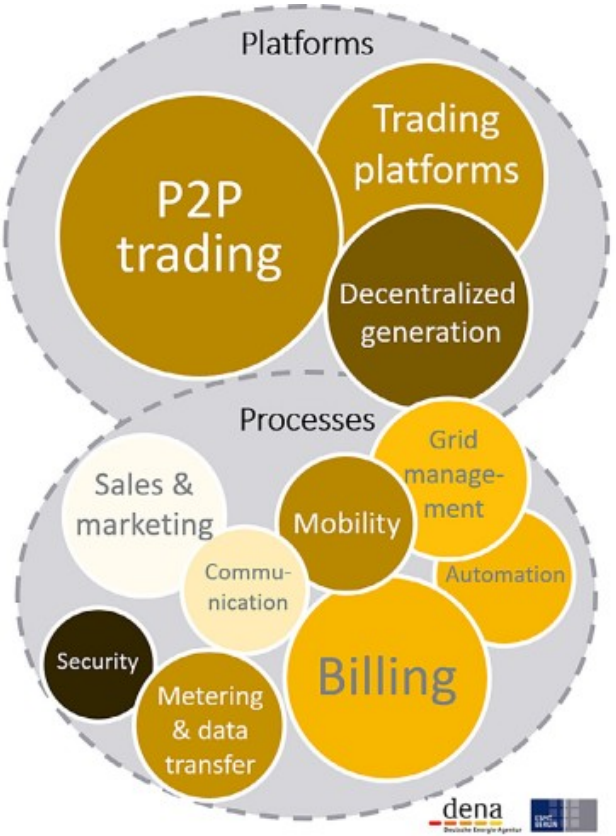

Electric grid reliability research, https://energyinformatics.springeropen.com/articles/10.1186/s42162-019-0069-z

# Ör: Dağıtım Sistem Platformu




ABD Enerji Bakanlığı – gelecek jenerasyon Dağıtım Sistem Platformu

# Ör: Kayıtzinciri (Blockchain)



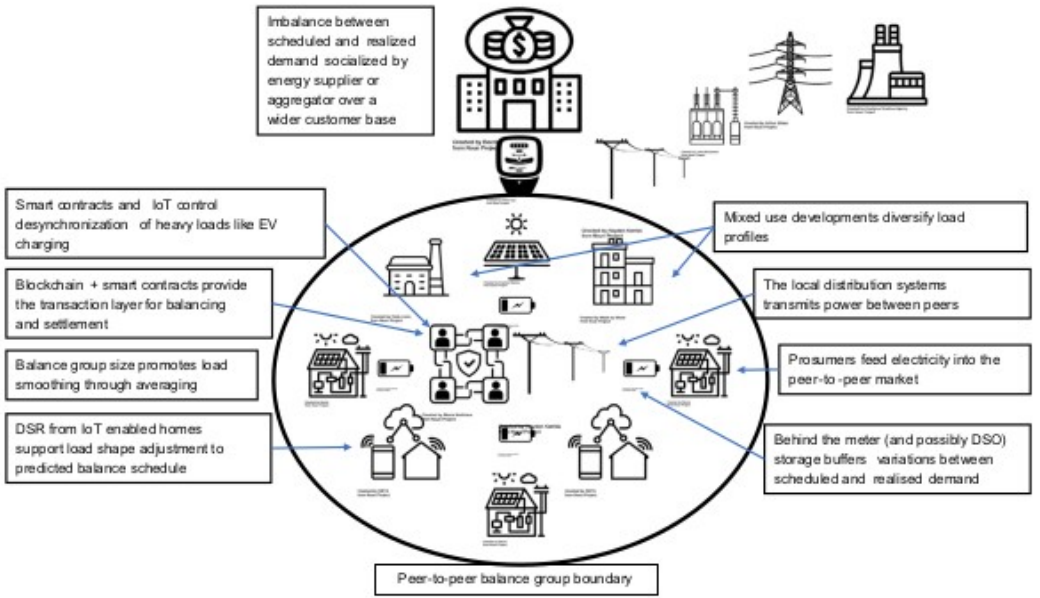
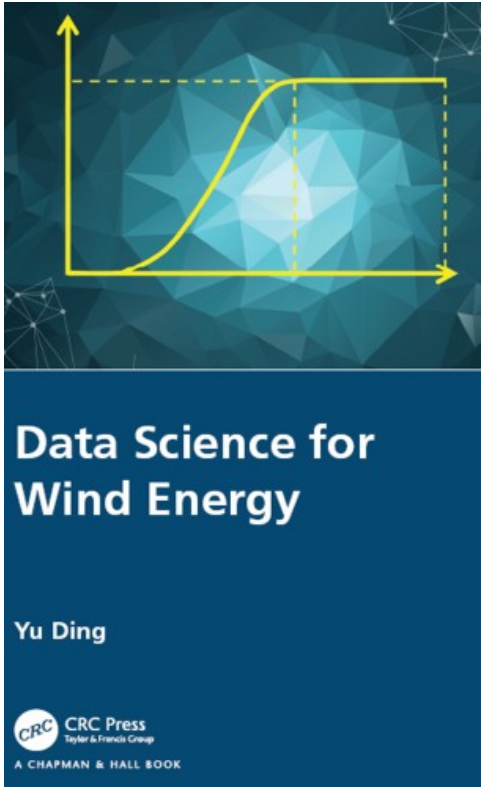
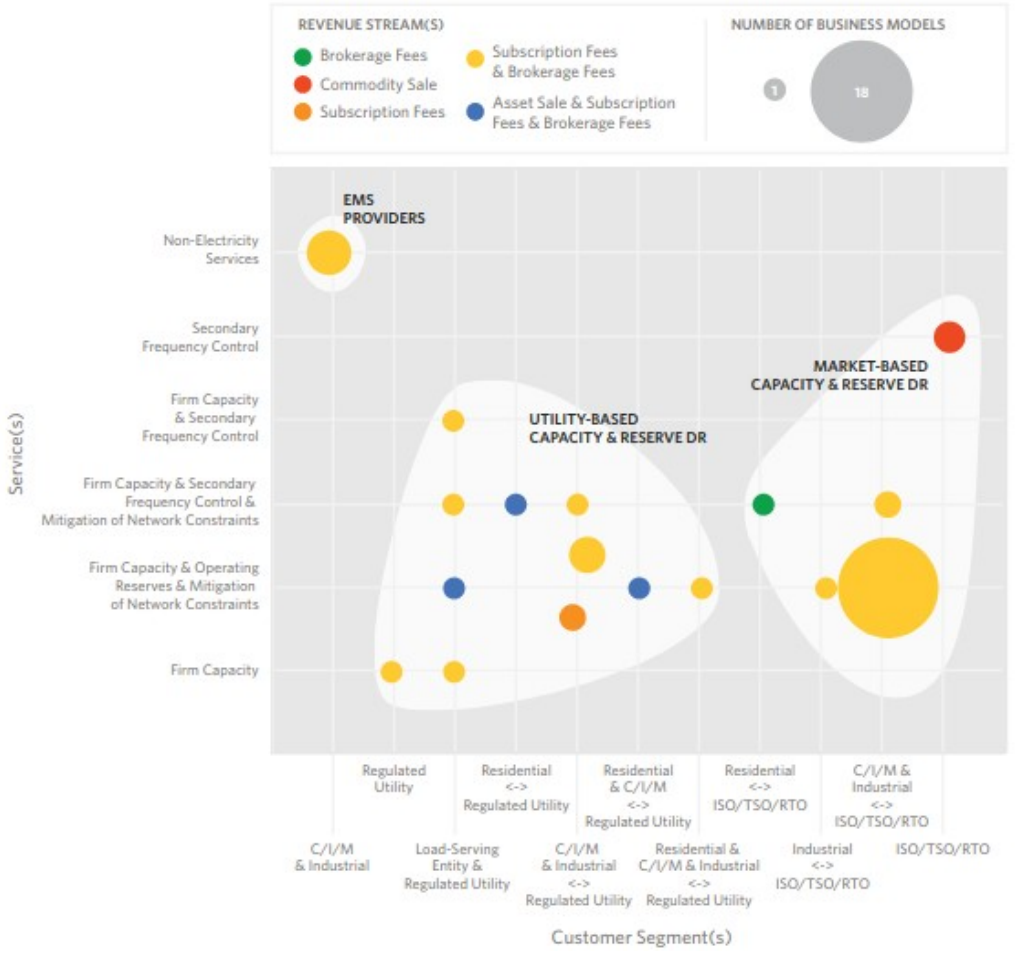



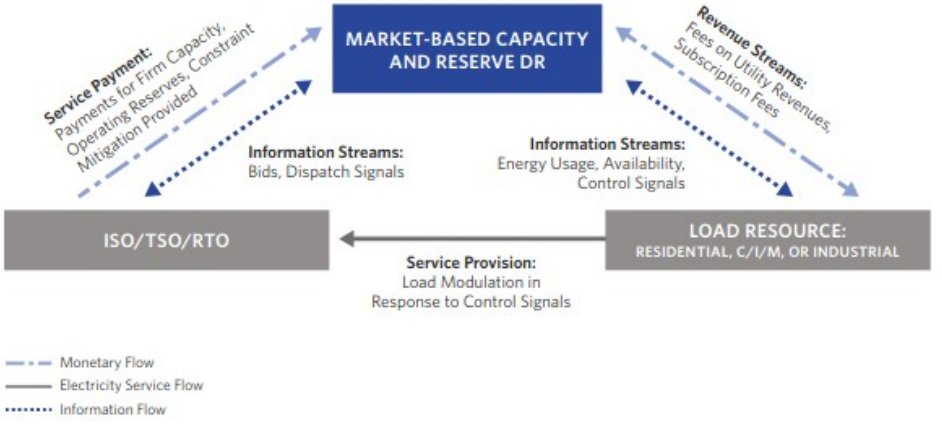

**FIGURE 2.3** Peer-to-peer balance group and balancing mechanisms. *(Source: Shipworth.)*

# Ör: Yenilenebilir/sistem işletimi



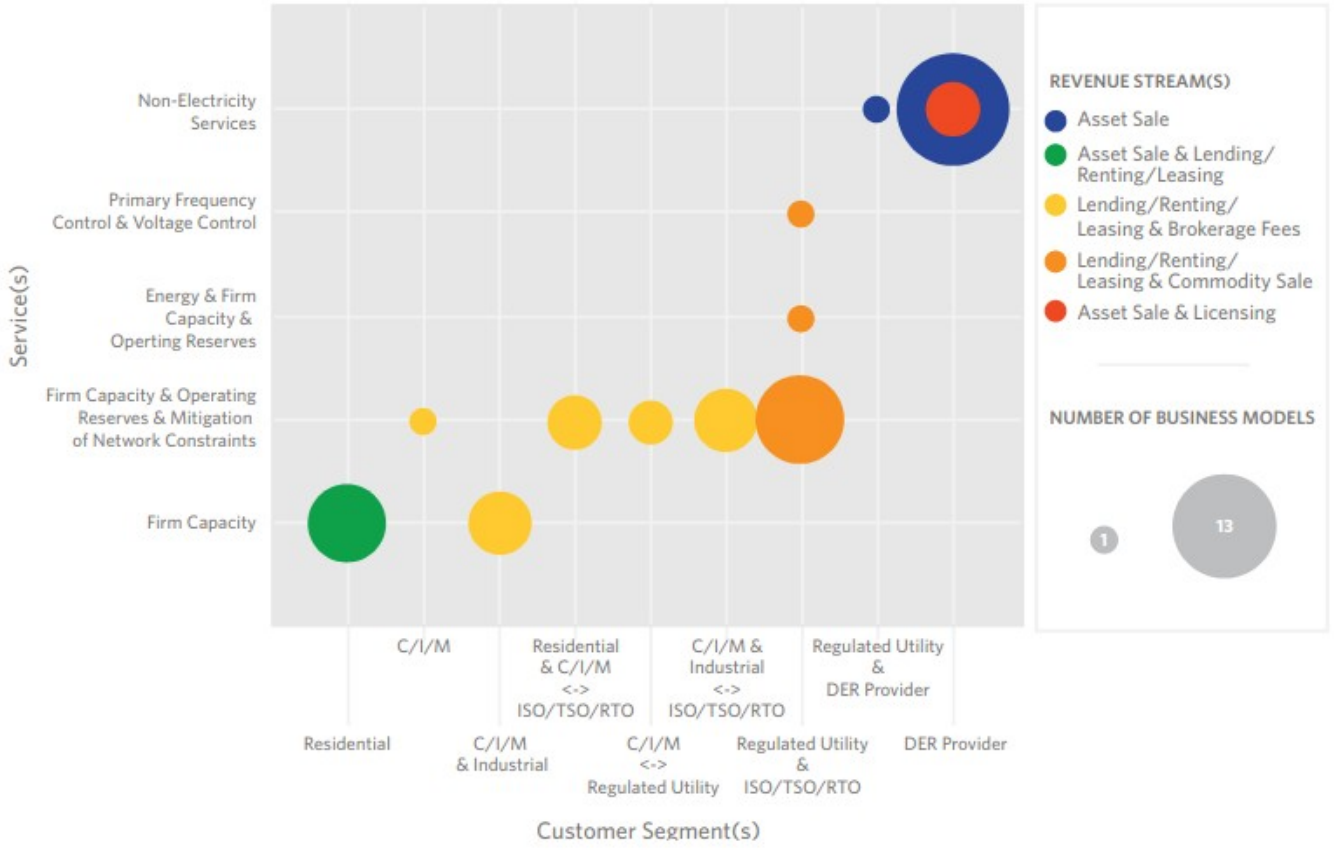

# Ör: Dağıtık sistemler – Talep ve Enerji yönetim sistemleri

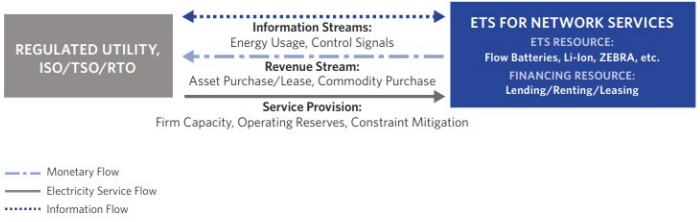



Utility of the Future, MIT

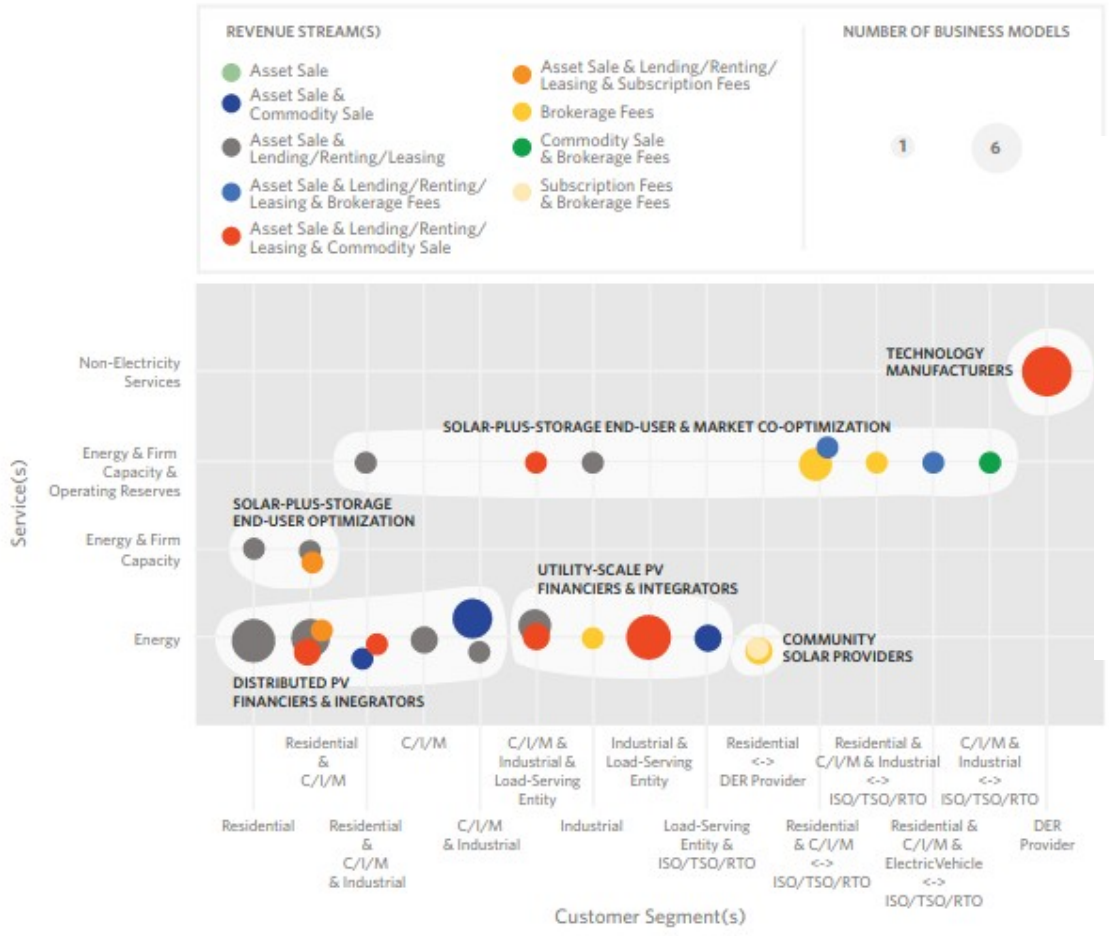
# Ör: Elektrik ve Termal depolama

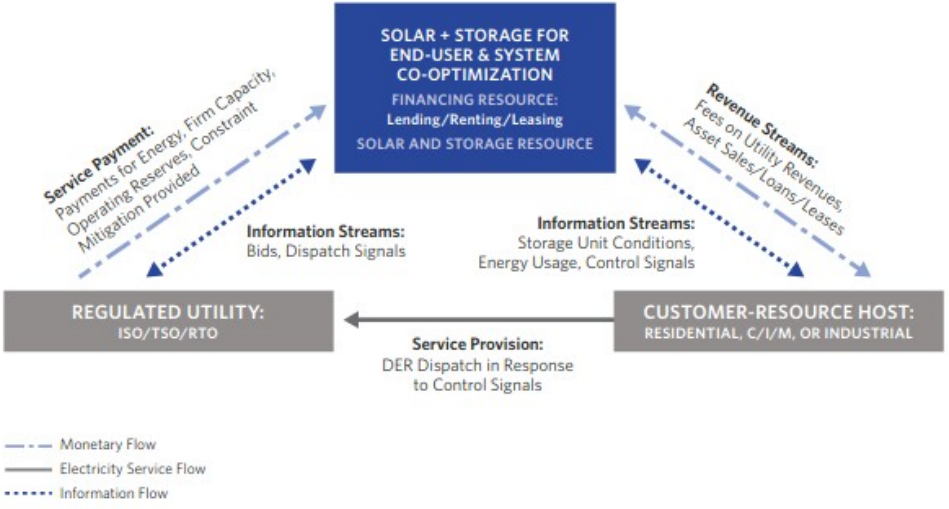



Utility of the Future, MIT

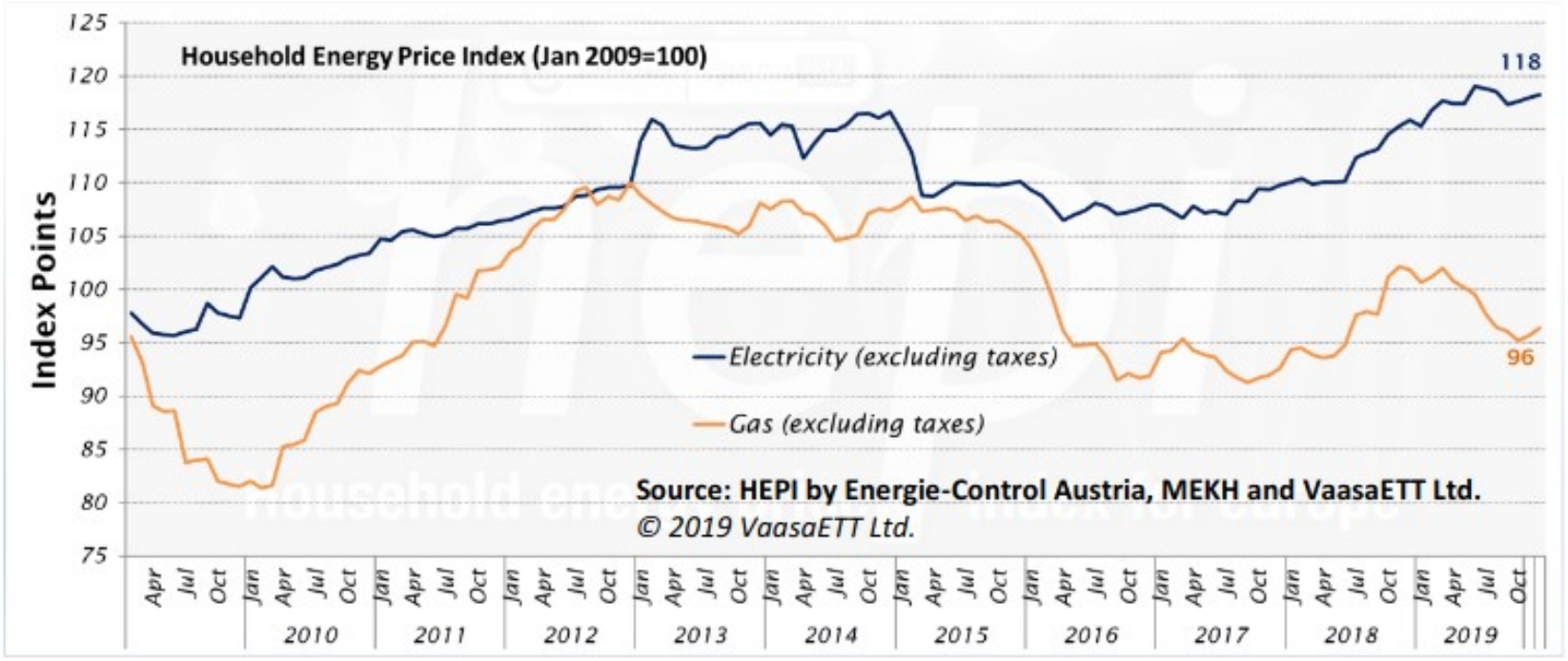
# Ör: Güneş iş modelleri




Utility of the Future, MIT

# AB’de elektrik ve gaz fiyatları




www.energypriceindex.com

# 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

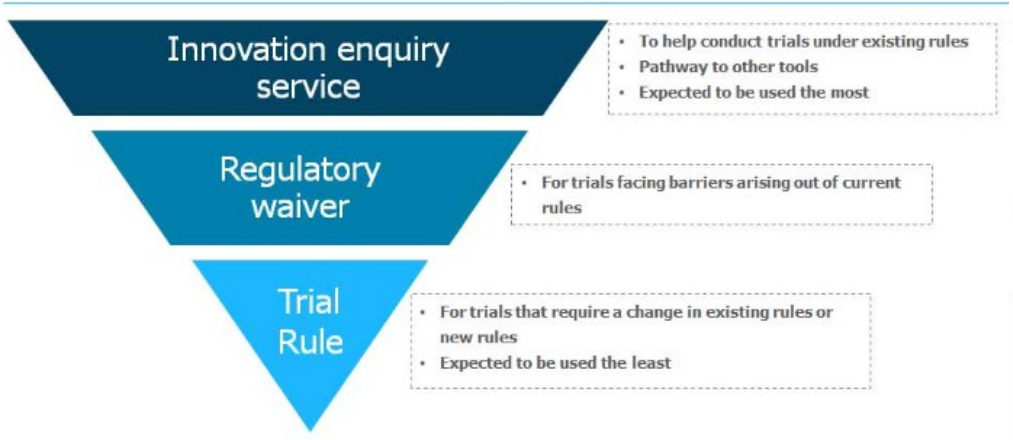
# Soru 2.1 Güvenilirlik

- 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


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.

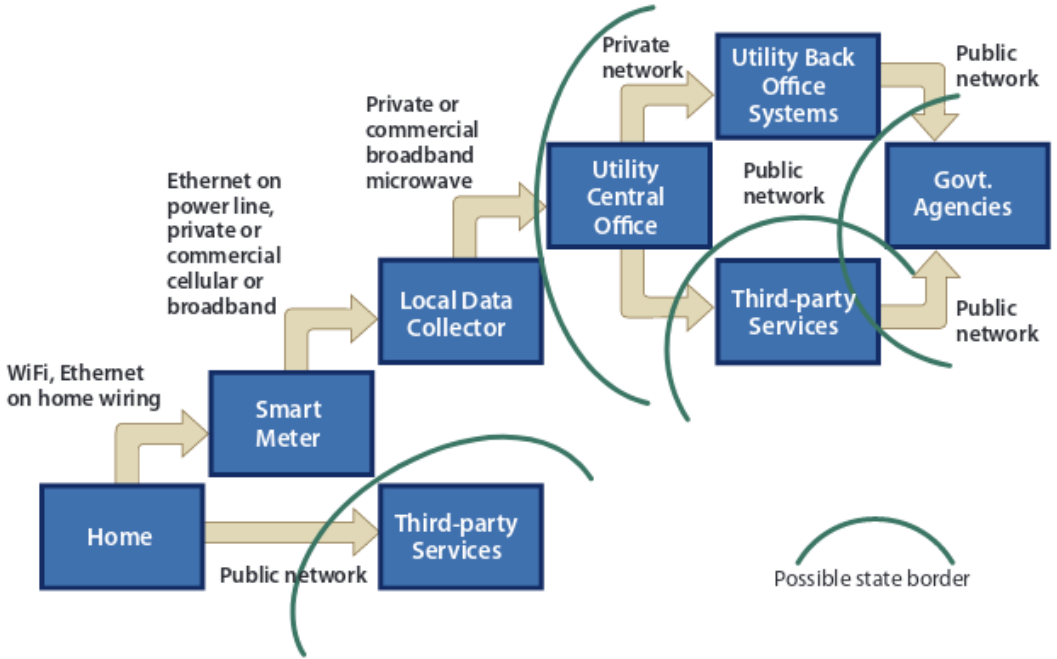
https://www.aemc.gov.au/market-reviews-advice/electricity-network-economic-regulatory-framework-review-2019

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

Sources:

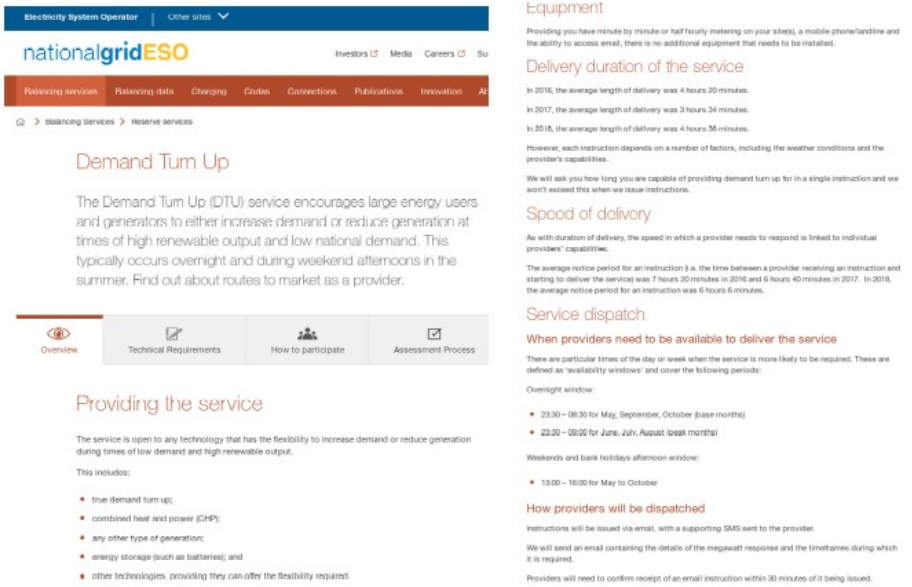
[a]S. McLaughlin, D. Podkuiko, and P. McDaniel, "Energy Theft in the Advanced Metering Infrastructure," in *Proceedings of the 4th International Workshop on Critical Information Infrastructure Security* (New York, NY: IEEE Press, 2009).

[b]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).

[c]InGuardians, *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?



Electricity System Operator | Other sites

nationalgridESO

Investors Media Careers Su

Balancing services Balancing data Charging Codes Connections Publications Innovation A

Balancing Services > Reserve services

## Demand Turn Up

The Demand Turn Up (DTU) service encourages large energy users and generators to either increase demand or reduce generation at times of high renewable output and low national demand. This typically occurs overnight and during weekend afternoons in the summer. Find out about routes to market as a provider.

Overview | Technical Requirements | How to participate | Assessment Process

## Providing the service

The service is open to any technology that has the flexibility to increase demand or reduce generation during times of low demand and high renewable output.

This includes:

- true demand turn up;
- combined heat and power (CHP);
- any other type of generation;
- energy storage (such as batteries); and
- other technologies, providing they can offer the flexibility required.

## 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 56 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.

## Spood of dolivory

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 – 08:30 for May, September, October (base months)
- 23:30 – 09:00 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

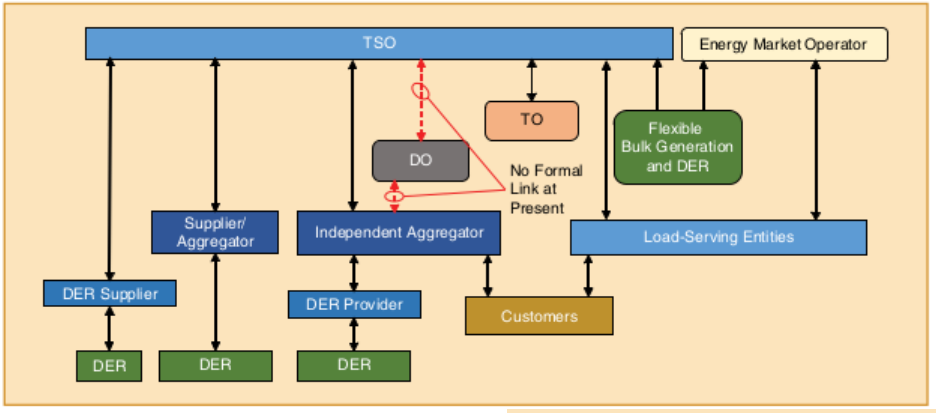
Instructions will be issued via email, with a supporting SMS sent to the provider.

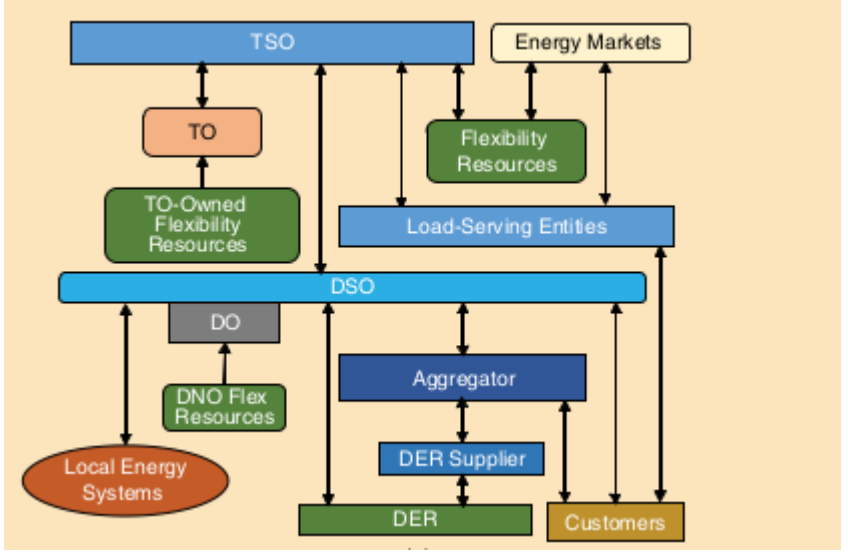
We will send an email containing the details of the megawatt response and the timeframes during which it is required.

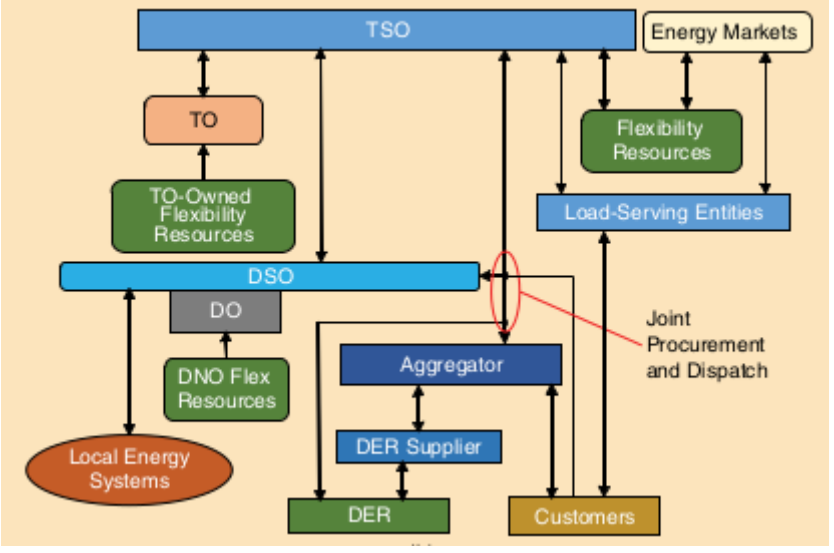
Providers will need to confirm receipt of an email instruction within 30 minutes of it being issued.

https://www.nationalgrideso.com/balancing-services/reserve-services/demand-turn

# Soru 7: Yeni bir şebeke mimarisi?

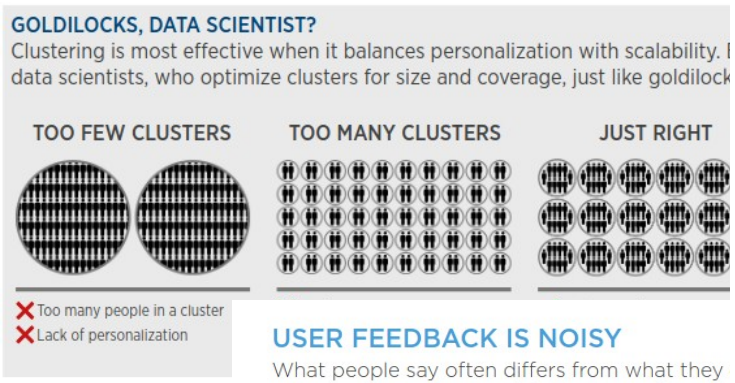


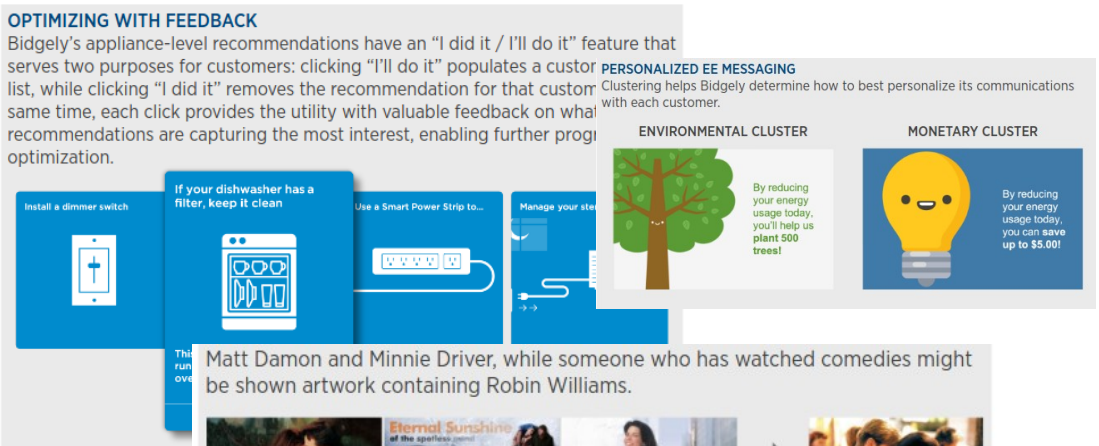



# Soru 8 : Elektrik tüketicisi – Hiper Kişiselleştirme?

## Elektrik tüketicisi Netflix seyircisine benzer mi?

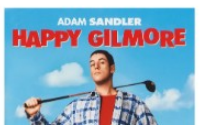



### USER FEEDBACK IS NOISY

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,



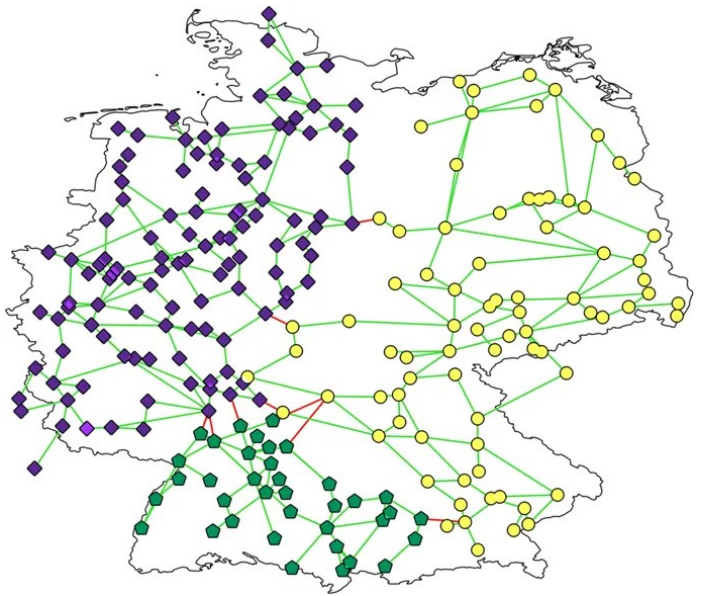


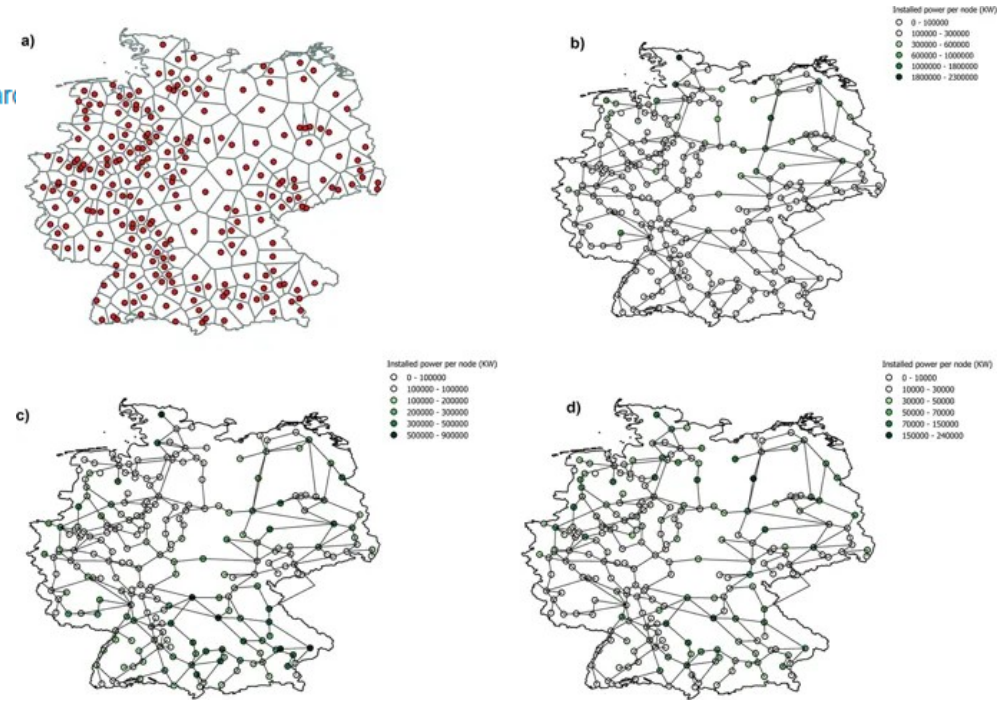
http://barissanli.com/eak/2020/01/elektrik-tuketicisi-netflix-seyircisine-benzer-mi/

# Enterkonneksiyon yönetimi – Akıllı adalama

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

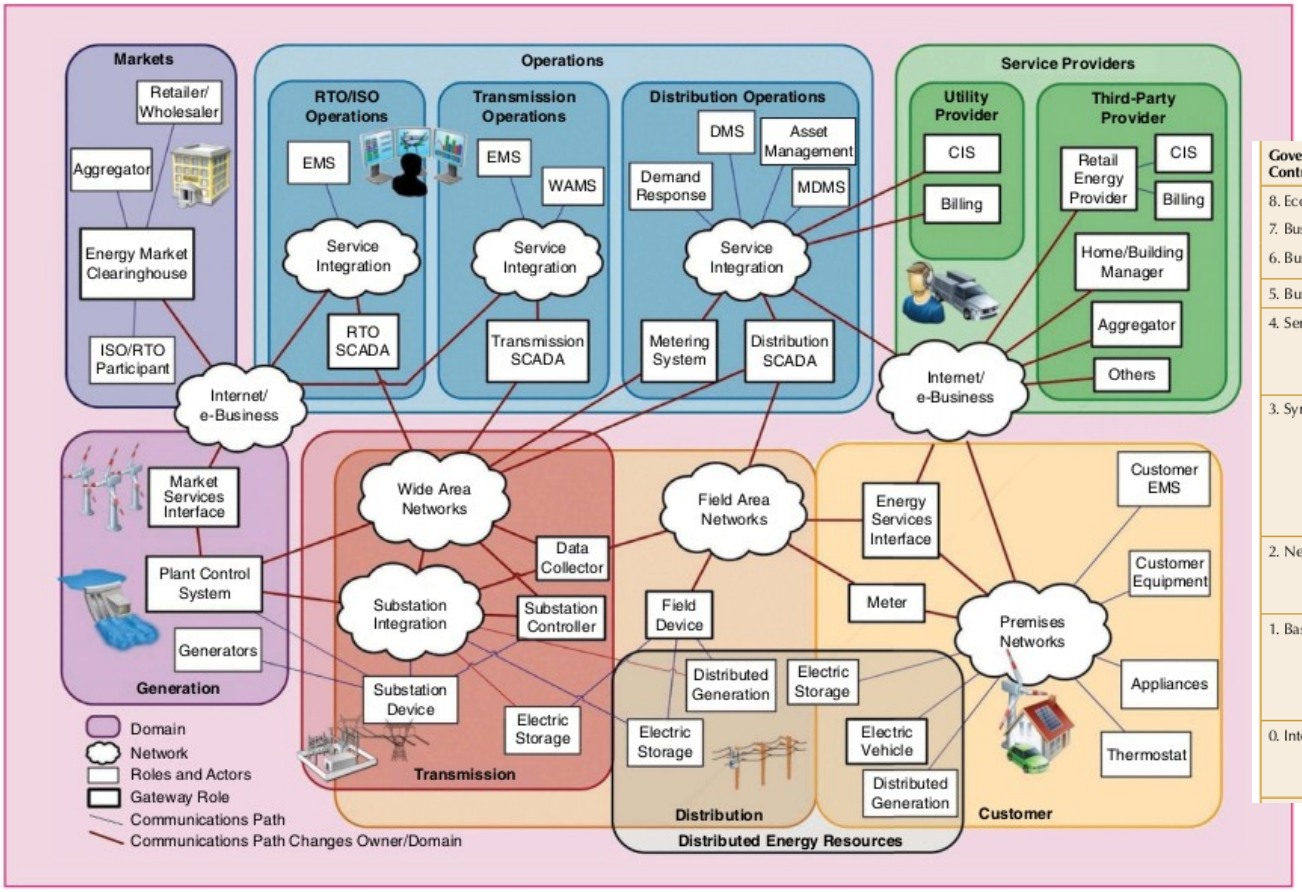
Mario Mureddu, Guido Caldarelli, Alfonso Damiano, Antonio Scala & Hildegar






https://www.nature.com/articles/srep34797

# Akıllı şebeke




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

IEEE PES – Power & Energy Sept-Oct 2019

# Tak-çalıştır şebeke

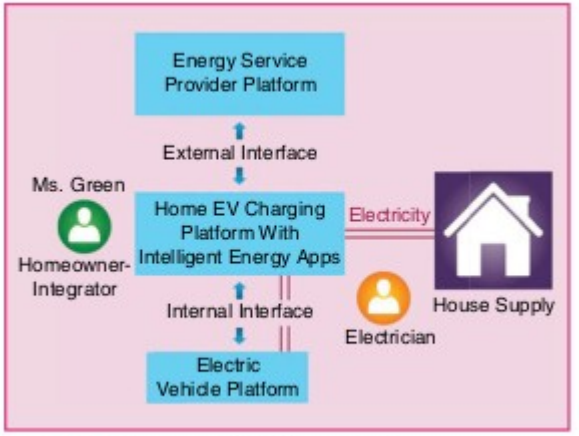
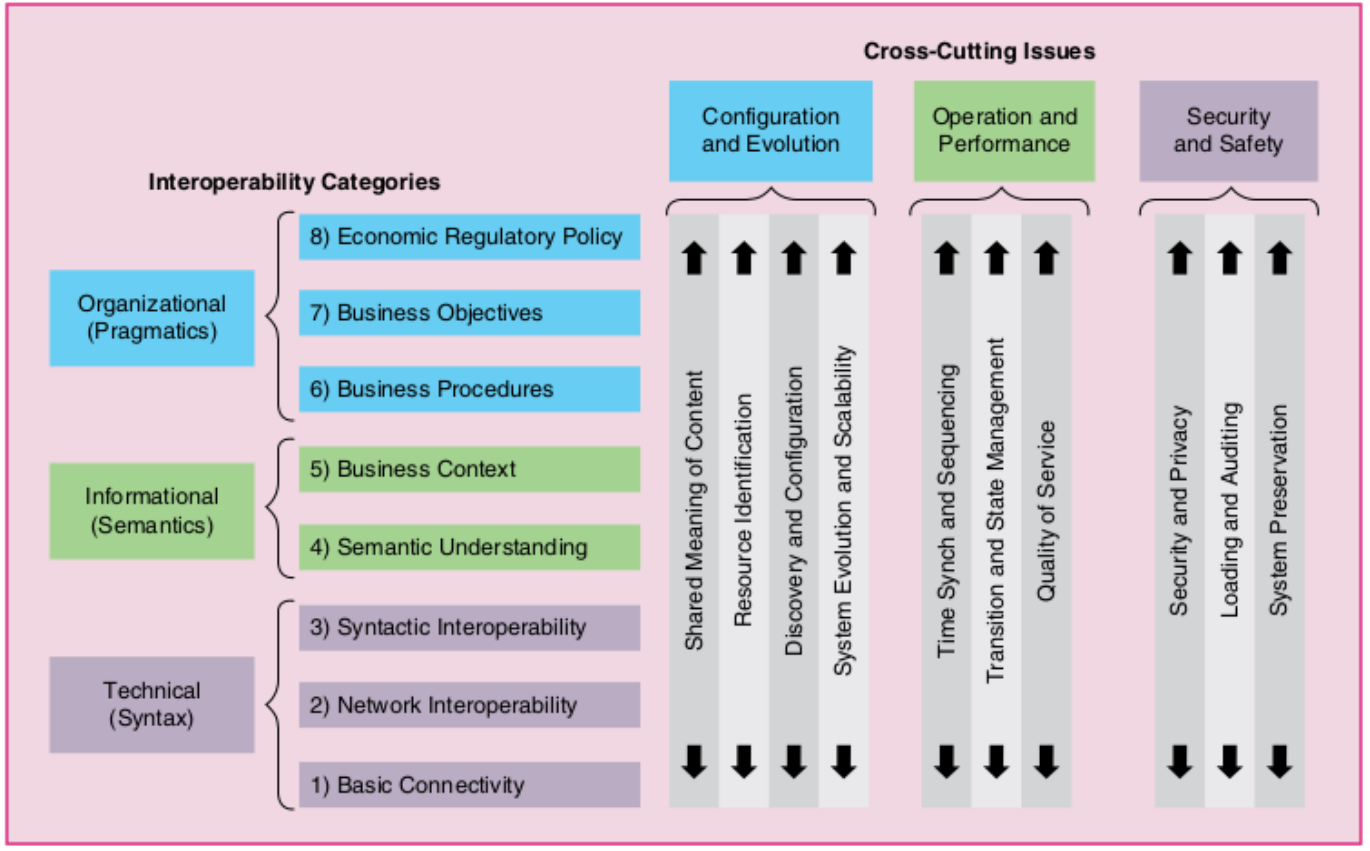




**figure 1.** Integrating a smart EV charger.

IEEE PES – Power & Energy Sept-Oct 2019

# Birlikte işlerlik (Interoperability)

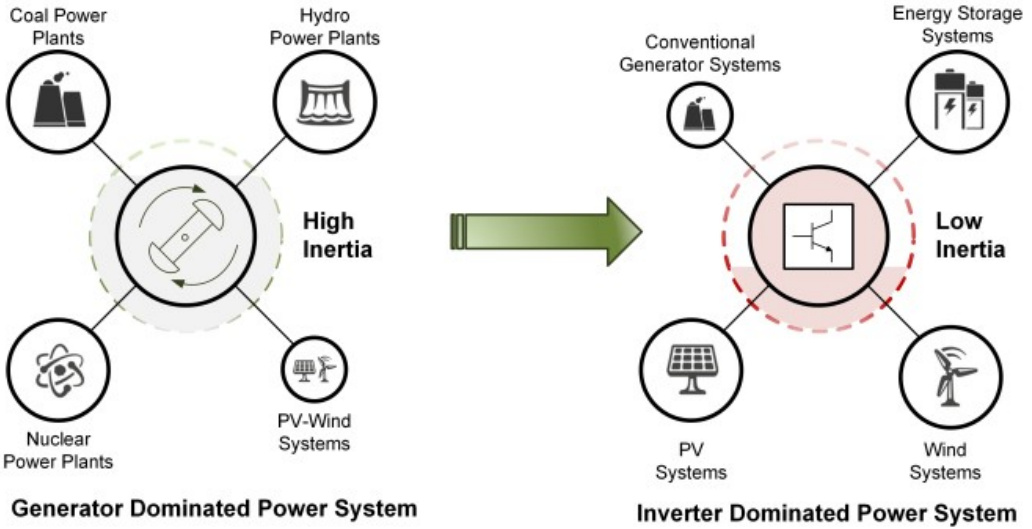


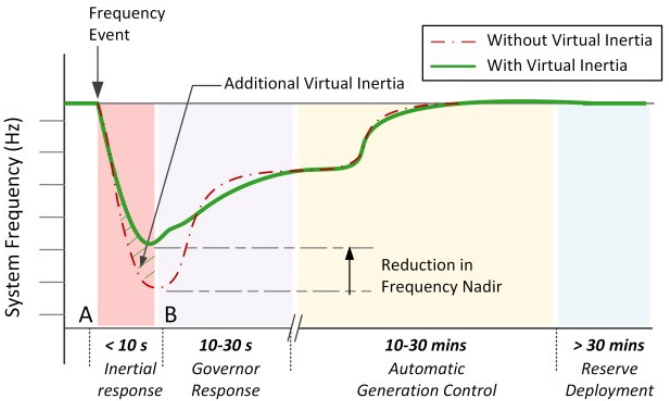

## Interoperability

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

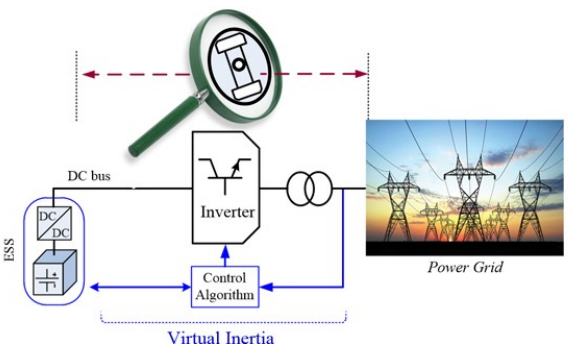
- reduces the cost and effort for system integration
- improves grid performance and efficiency
- facilitates more comprehensive grid security and cybersecurity practices
- increases customer choice and participation
- establishes industry-wide best practices
- functions as a catalyst for innovation.

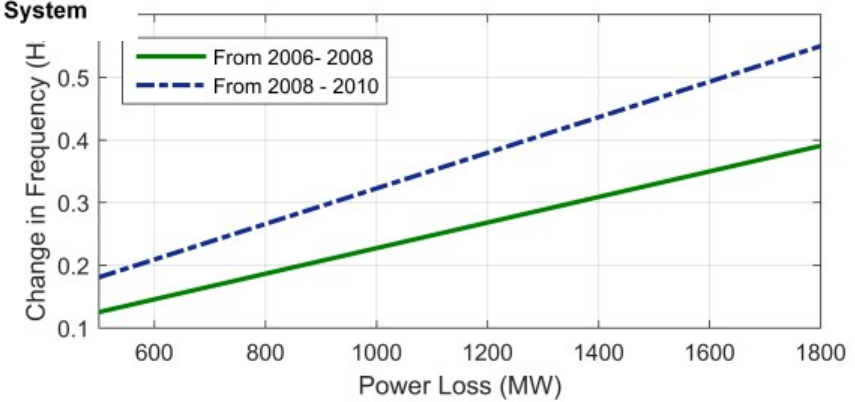
# Sanal Atalet – Yazılım ile fiziksel etki



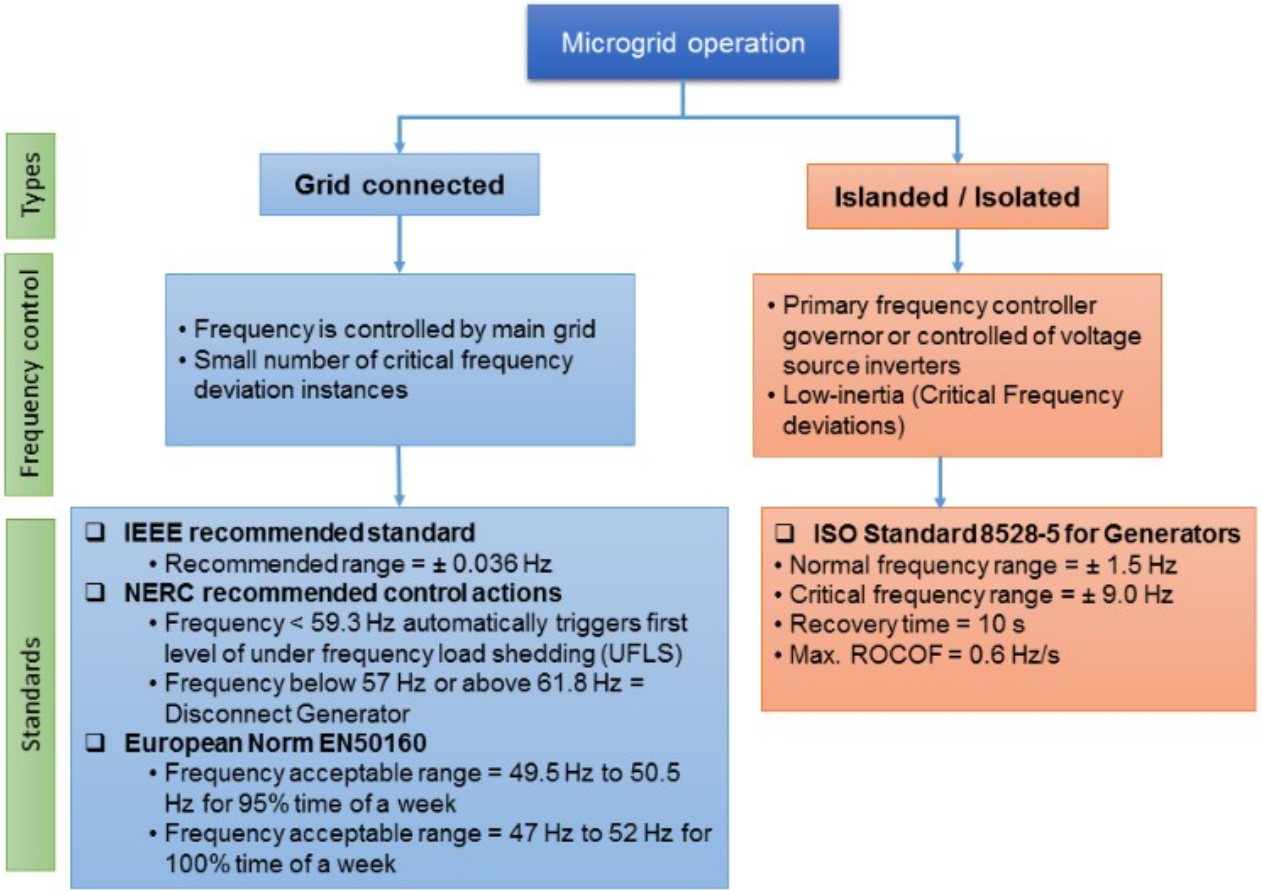

Multiple time-frame frequency response in a power system following a frequency event.



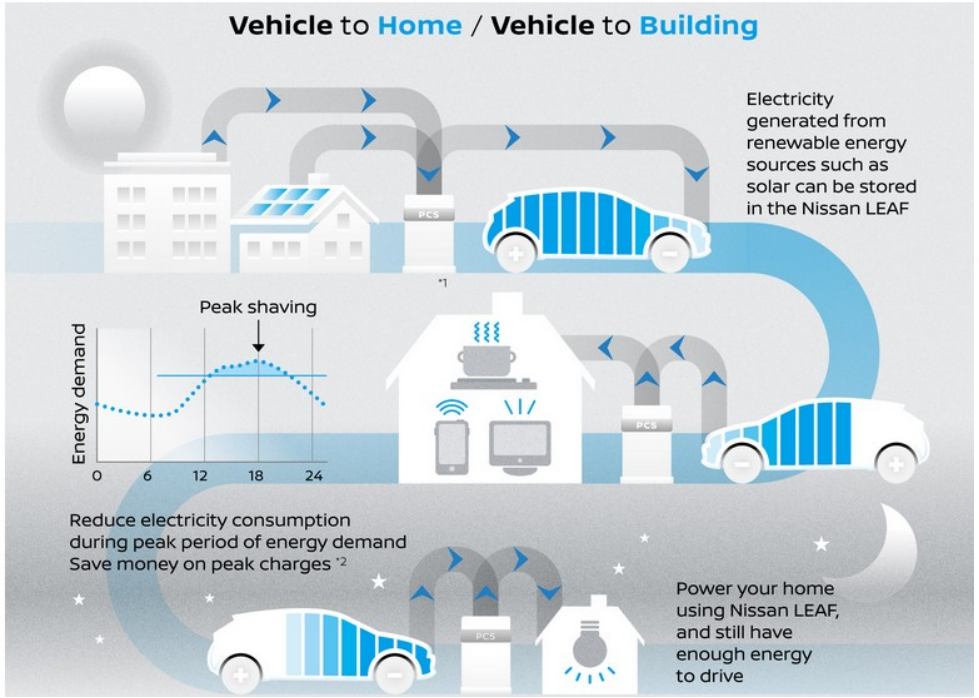

Increase in frequency changes in Electricity Reliability Council of Texas (ERCOT) connection

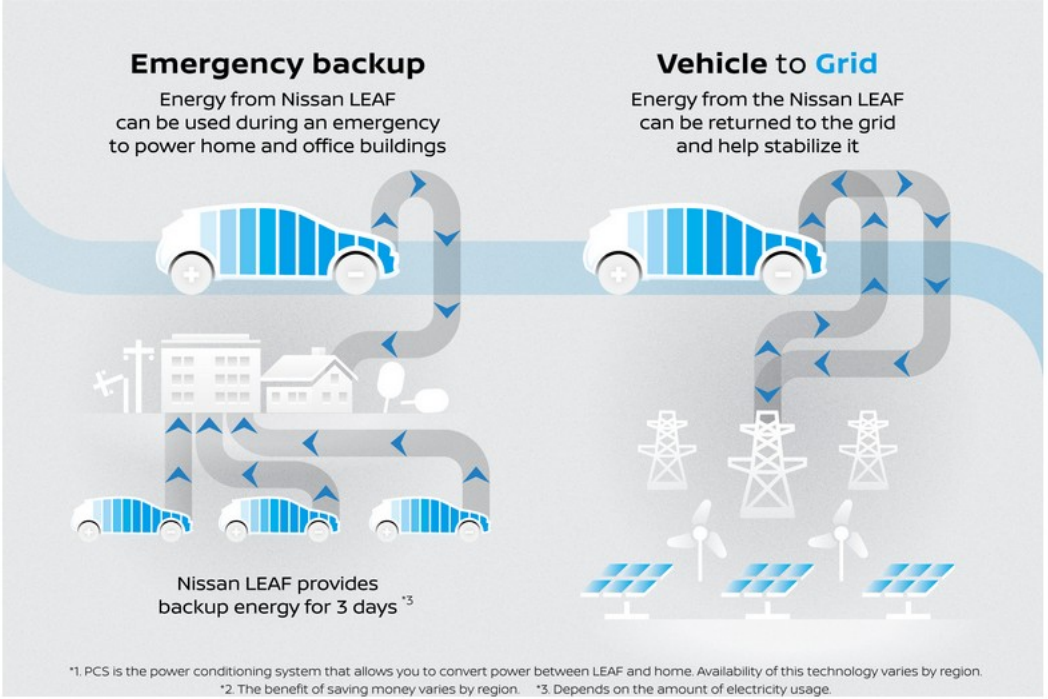
# Mikroşebekeler için frekans standardı




https://www.researchgate.net/publication/317937853_Virtual_Inertia_Current_Trends_and_Future_Directions

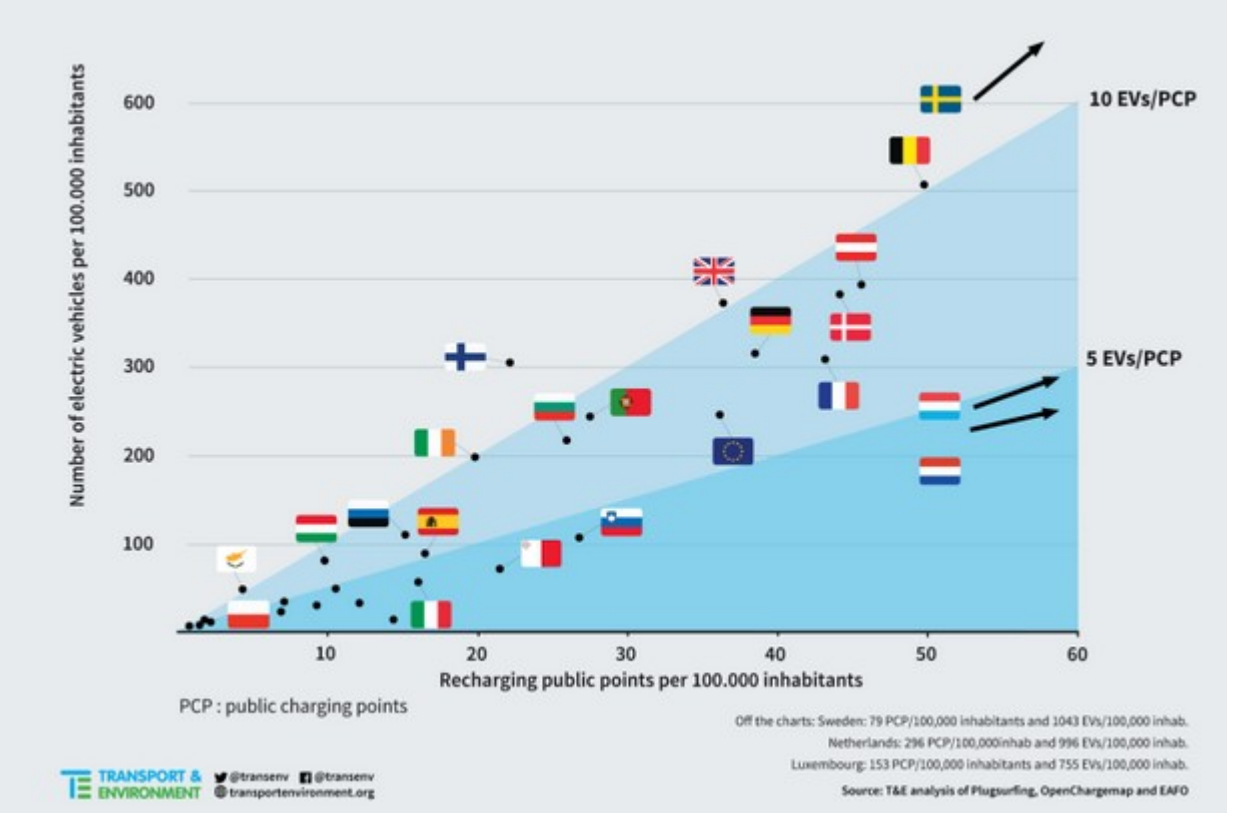
# Elektrikli Arabalar - V2X




**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?

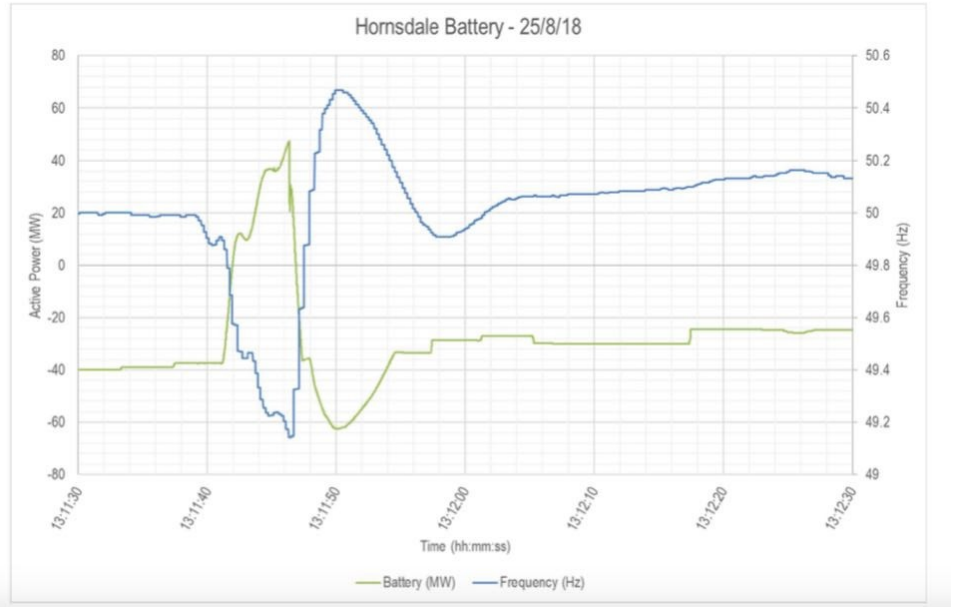



https://energypost.eu/eu-pathway-to-3m-ev-charge-points-by-2030/

# Hornsdale Güç Rezervi

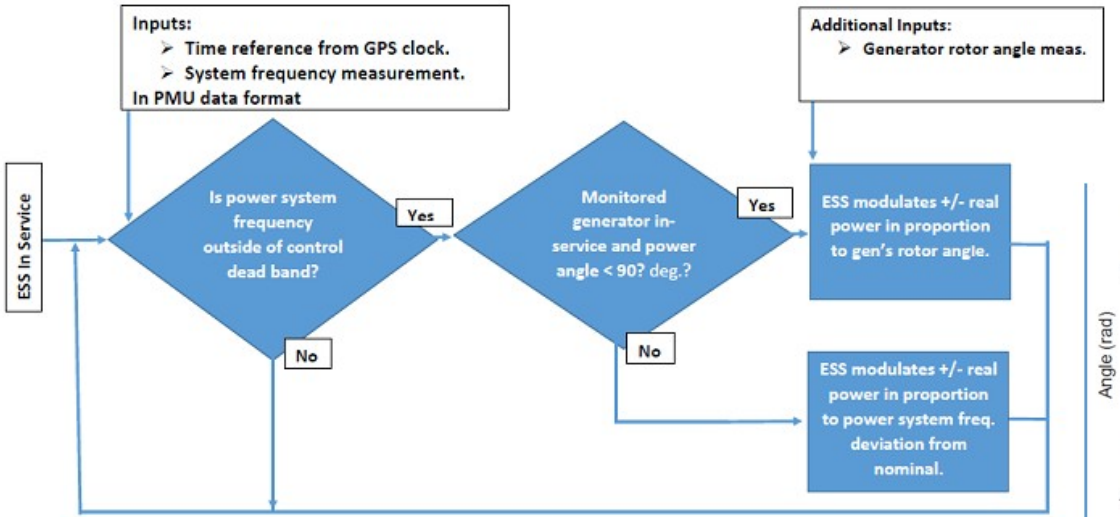
- 100MW/129MWh
- 100 MW in 140 ms

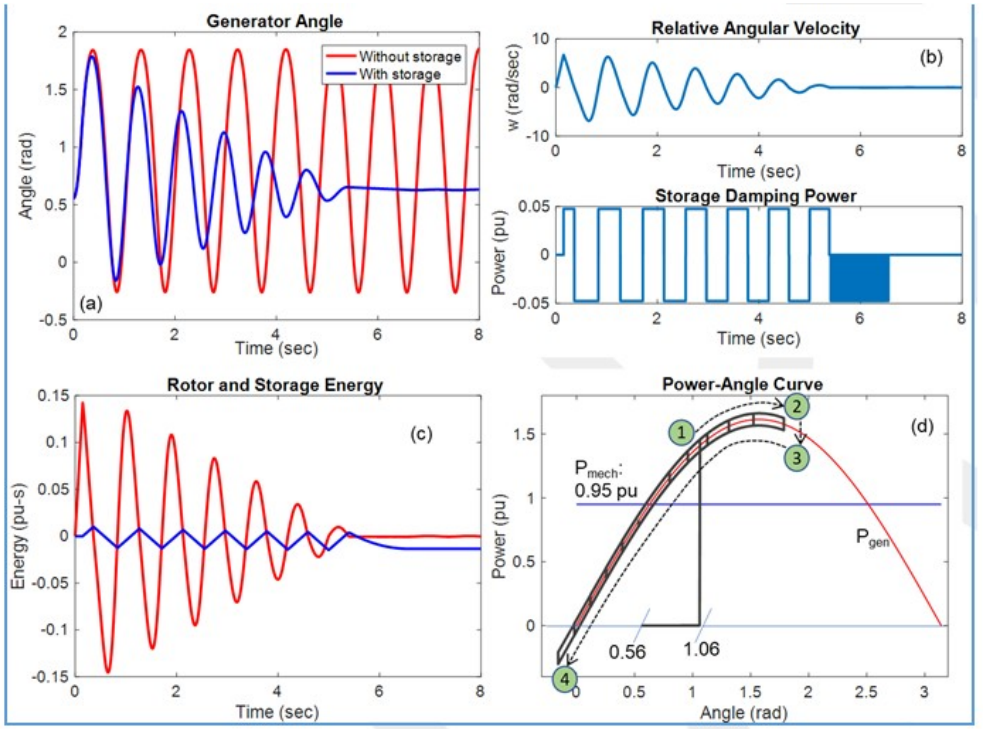
Figure 41 SA transmission-connected battery response – short-term




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

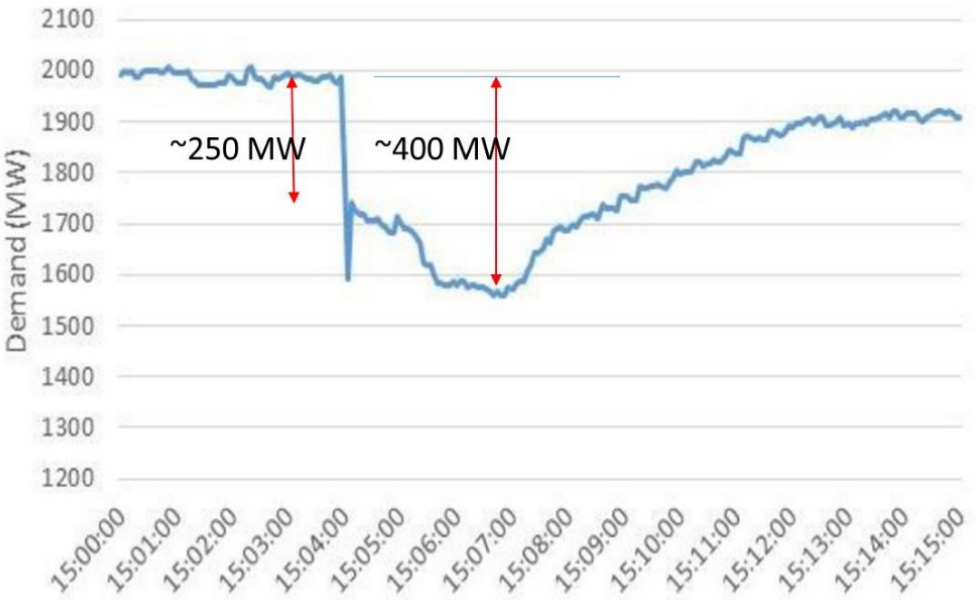
# Depolama ile Aktif Sönüm ile Frekans Kontrolü

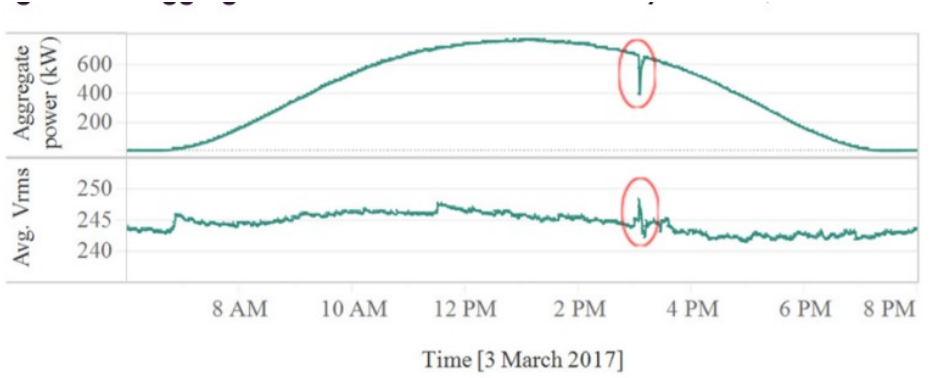


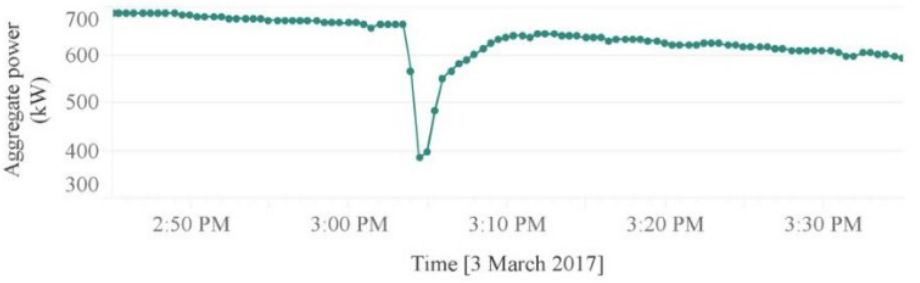




https://smartgrid.ieee.org/newsletters/january-2020/active-damping-with-energy-storage-to-improve-power-system-frequency-stability

# Güney Avustralya 3.3.2017




https://www.aemo.com.au/-/media/Files/Electricity/NEM/DER/2019/Technical-Integration/Technical-Integration-of-DER-Report.pdf

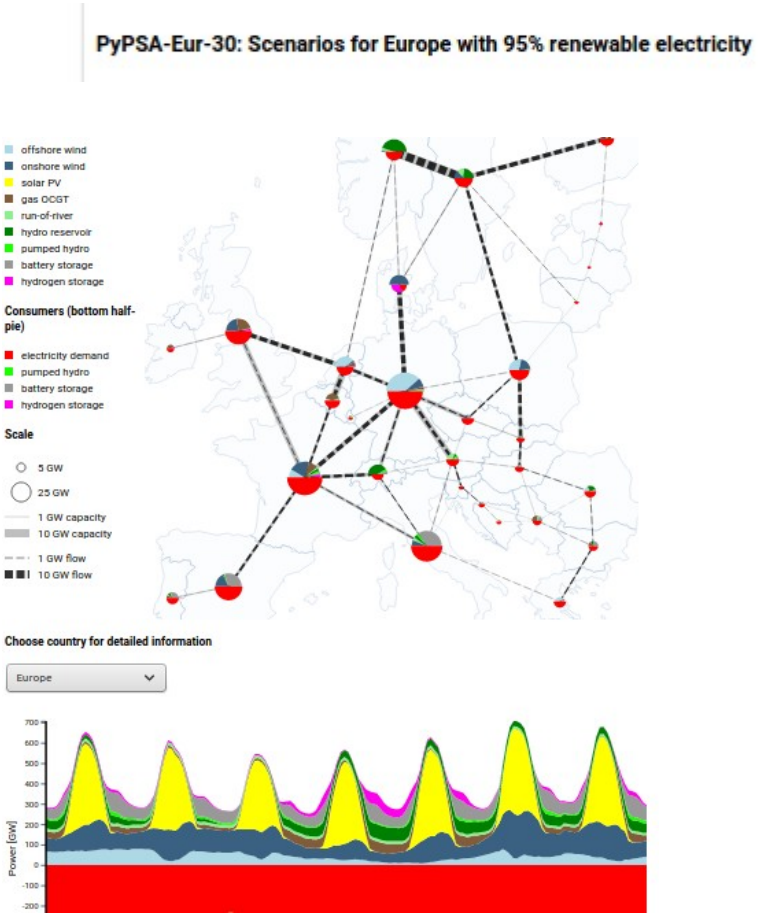
# Python

**home** download examples documentation publications animations forum

## PyPSA: Python for Power System Analysis

### Table of Contents





# Makine Öğrenmesi ile Fiyat tahmini

```
import pandas as pd
from sklearn.neural_network import MLPRegressor
```

```
pr=pd.read_excel("http://barissanli.com/python/2018-elektrik.xlsx" , sheet_name="2018-saatlik")
```

```
# pr.columns     # verimizdeki sütunlar
```

```
est = MLPRegressor(hidden_layer_sizes=(10,10), random_state=9)
est.fit(pr[['genel_toplam','l_gunes']],pr['ptf']);     #MLPRegressor ile modelimizi eğitelim
```

```
est.predict([[30000,5000]])[0]    # 30000 toplam talep ve 5000MW güneş ile fiyatı bul
```

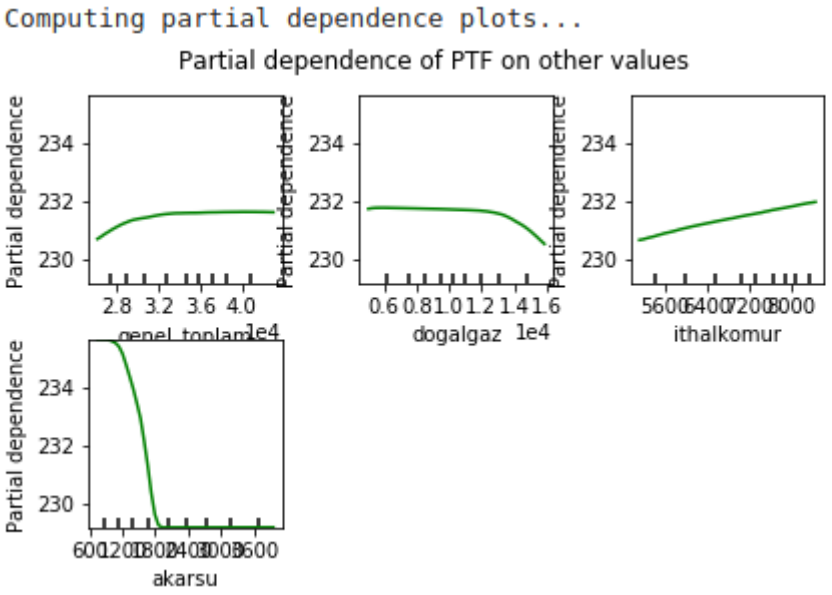
```
208.65588053172866
```

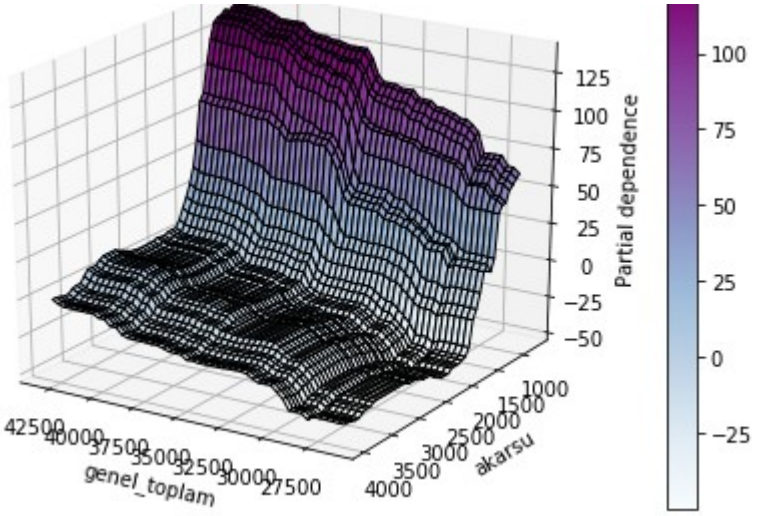
6 satır da elektrik fiyat tahmini!!!!

https://github.com/barissanli

# Makine Öğrenmesi Etkenleri

- Partial dependence




https://github.com/barissanli

# Yapay zeka

## New machine learning method could supercharge battery development for electric vehicles

by Matthew Vollrath, Stanford University

## 10 Applications of Machine Learning in Oil & Gas

By KC Cheung

Last Modified Date: January 10, 2020

1. Accurate Modelling
2. Pinpointing Exactly Where to Dig with Machine Learning
3. Applying Machine Learning in oil & gas to Improve Subsurface Characterisation
4. Optimizing Drilling Operations
5. Solving Problems Quickly with Machine Learning Applications
6. Predictive Maintenance
7. Internet of Things
8. Predictive Software For Energy Purchases Customer Market
9. Replacing Manual Workers
10. Machine Learning to Predict Operational Outcomes

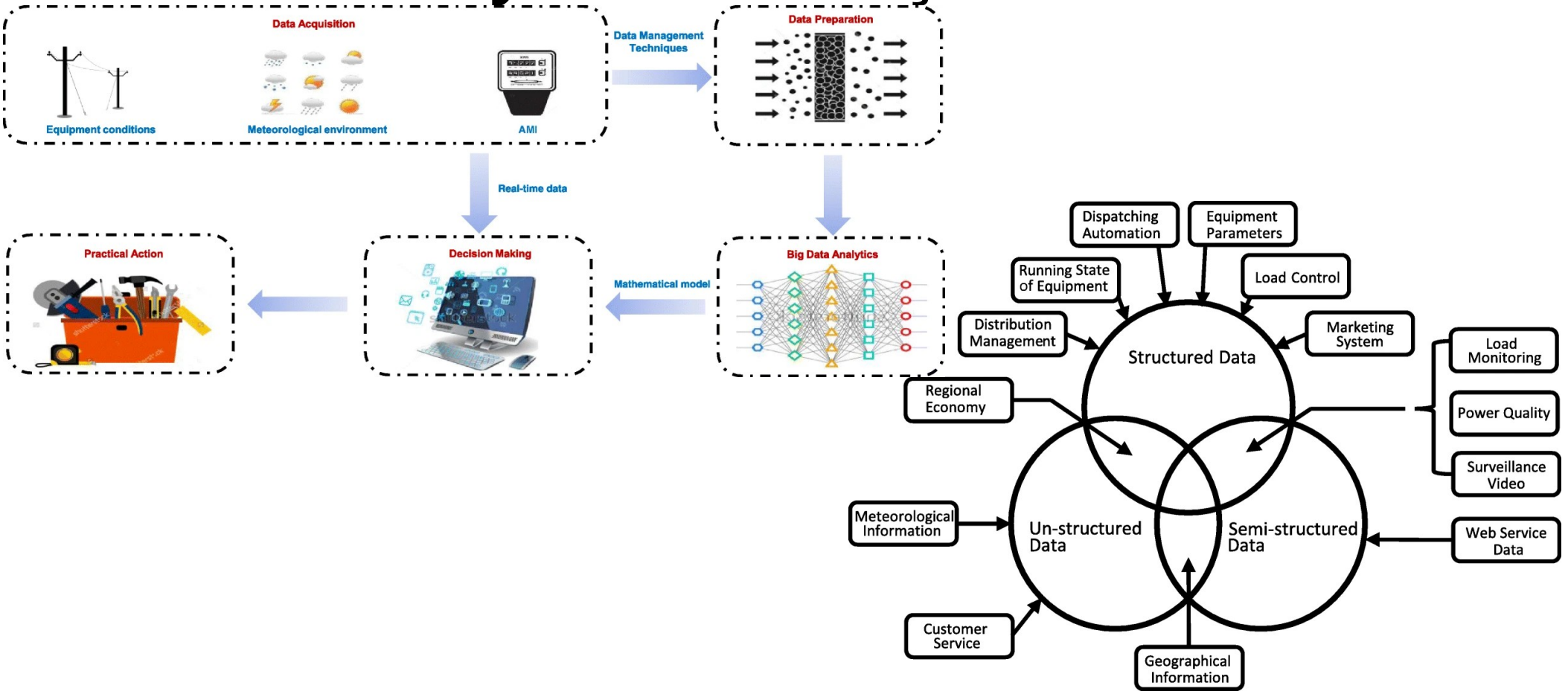
https://algorithmxlab.com/blog/10-applications-machine-learning-oil-gas-industry/
https://techxplore.com/news/2020-02-machine-method-supercharge-battery-electric.html

# Energy Informatics – Hot topics

- P6V2G: a privacy-preserving V2G scheme for two-way payments and reputation
- Clustering time series applied to energy markets
- State-based load profile generation for modeling energetic flexibility
- Protecting the grid topology and user consumption patterns during state estimation in smart grids based on data obfuscation
- Towards modular composition of agent-based voltage control concepts
- Distributed multi-objective scheduling of power consumption for smart buildings
- Deriving policies from connection codes to ensure ongoing voltage stability
- Towards domain-specific surrogate models for smart grid co-simulation
- Architectural and functional classification of smart grid solutions
- Enabling architecture based Co-Simulation of complex Smart Grid applications
- Impact of advanced electricity tariff structures on the optimal design, operation and profitability of a grid-connected PV system with en
- Virtualising redundancy of power equipment controllers using software-defined networking
- A cooperative demand-response framework for day-ahead optimization in battery pools
- Designing an integrated socio-technical behaviour change system for energy saving
- An optimisation-based energy disaggregation algorithm for low frequency smart meter data
- Trust-less electricity consumption optimization in local energy communities
- Comparison of solar power measurements in alpine areas using a mobile dual-axis tracking system
- Trading solar energy within the neighborhood: field implementation of a blockchain-based electricity market
- Visualizing and gamifying consumption data for resource saving: challenges, lessons learnt and a research agenda for the future
- Forecasting cross-border power transmission capacities in Central Western Europe using artificial neural networks
- A study on the impact of data sampling rates on load signature event detection
- Pool detection from smart metering data with convolutional neural networks

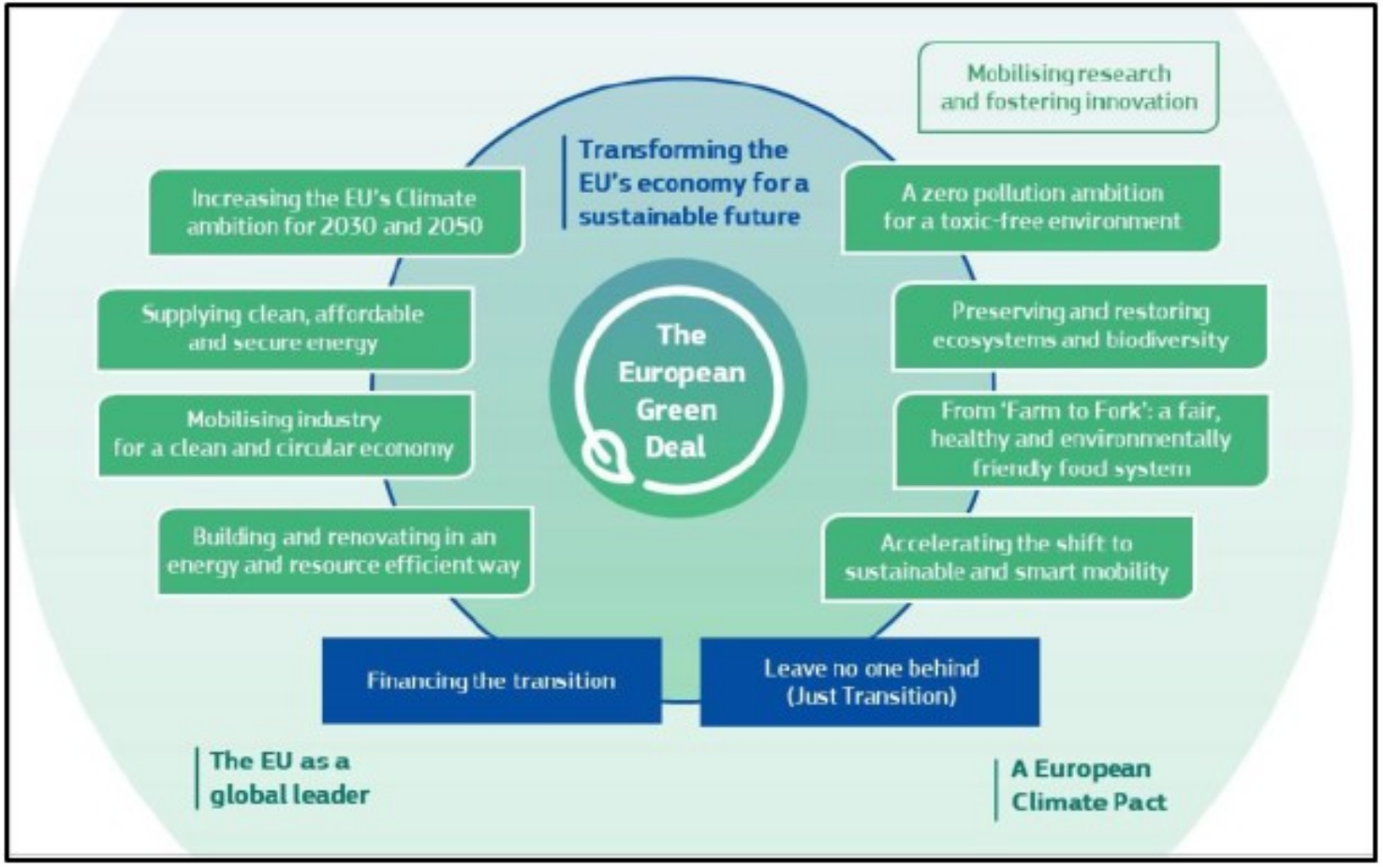
https://energyinformatics.springeropen.com/

# Büyük veri + Şebeke




https://energyinformatics.springeropen.com/articles/10.1186/s42162-018-0007-5

# AB Yeşil Paket



# ArGe yolculuğu

- Kurumsallaşma/Kültür/Katılımcılık
- Standart Girişimcilik Modeli
  - Kurum içi destek/mentör ekibi
  - Kurum dışı erişim  (“yeni fikir” yarışmaları)
  - Kurum içi girişimcilik destekleri
  - Ortak hareket (EPDK projelerine başvuru)

# Teşekkürler

barissanli.com