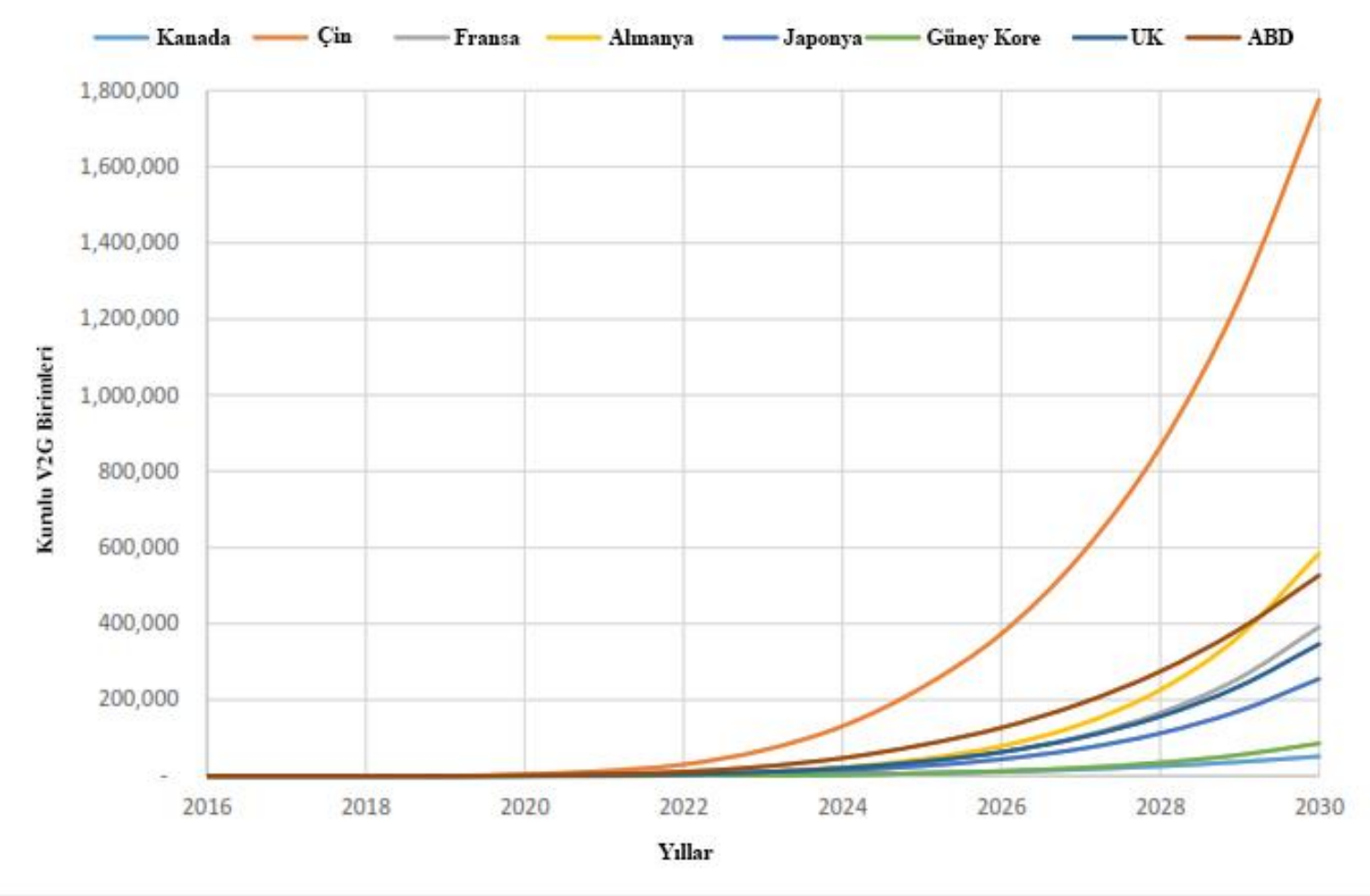
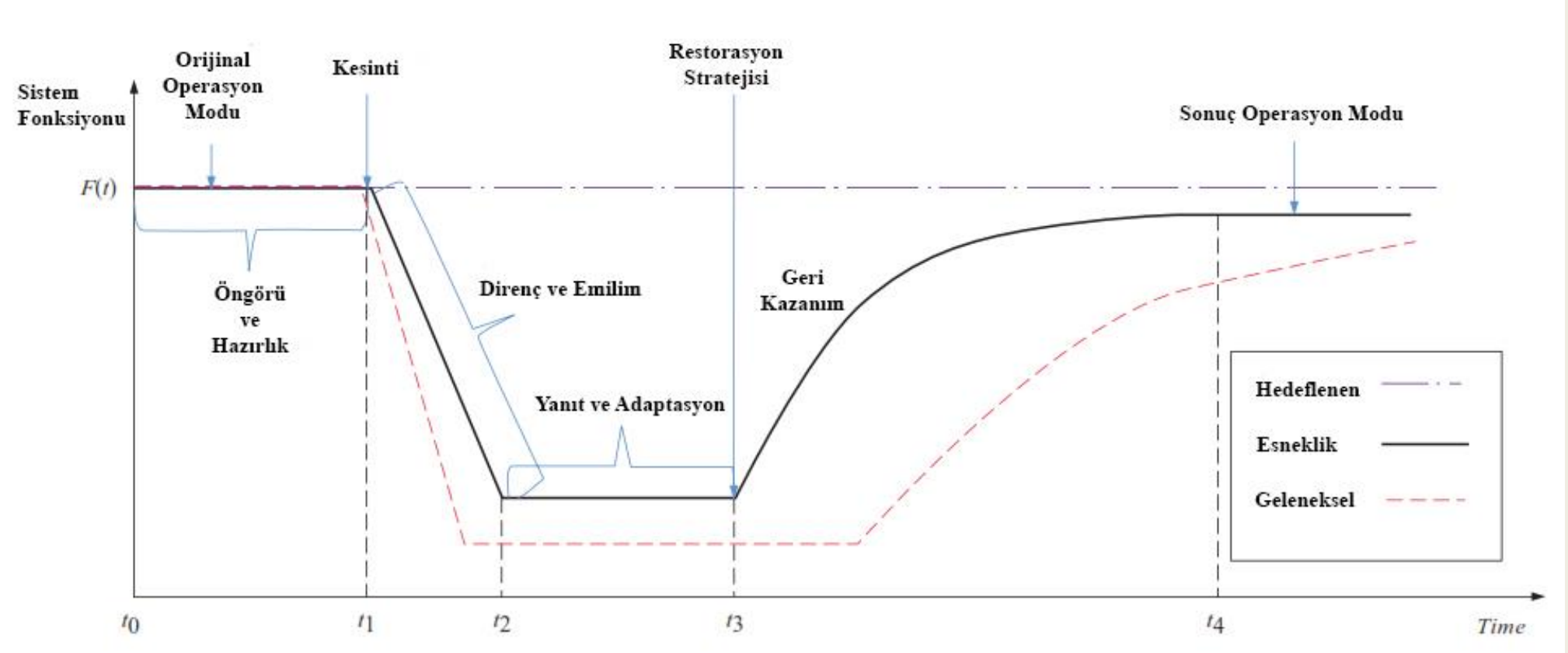
Elektrik Güç Sisteminin Dayanıklılığını Arttırmak İçin Elektrikli Araçların Acil Durum Kaynağı Olarak Kullanılması Ve Optimizasyon Tabanlı Yeni Bir Yaklaşımın Geliştirilmesi

V2G


Kanada
Çin
Fransa
Almanya
Japonya
Güney Kore
UK
ABD
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
Kurulu V2G Birimleri
2016
2018
2020
2022
2024
2026
2028
2030
Yıllar

Dayanıklılık -Resiliency-

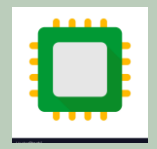


Bu çalışmada,

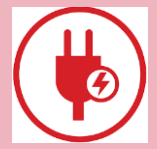
- Dağıtım sisteminin kayda değer bir süre boyunca kullanılamaması durumunda elektrik arz-talep güvenliğinin sağlanması için elektrikli araç filosunun deşarj gücü kapasitesi kullanılarak yeterli bir enerji kaynağı oluşturulması doğrultusunda bir optimizasyon modeli oluşturulmuştur.

Literatürden elde edilen verilere dayanarak tüketim için kritik ve kritik olmayan yük profilleri oluşturulup buna göre talebin karşılanması amaçlanmıştır.

Gerçekçi bir yaklaşım geliştirmek amacıyla, TLC'nin New York taksileri için kaydedilmiş yolculuk kayıtları ile regresyon yapılarak lokasyonlara göre olası taksi sayısı tahmin edilip, buna göre optimizasyon modeli geliştirilmiştir.

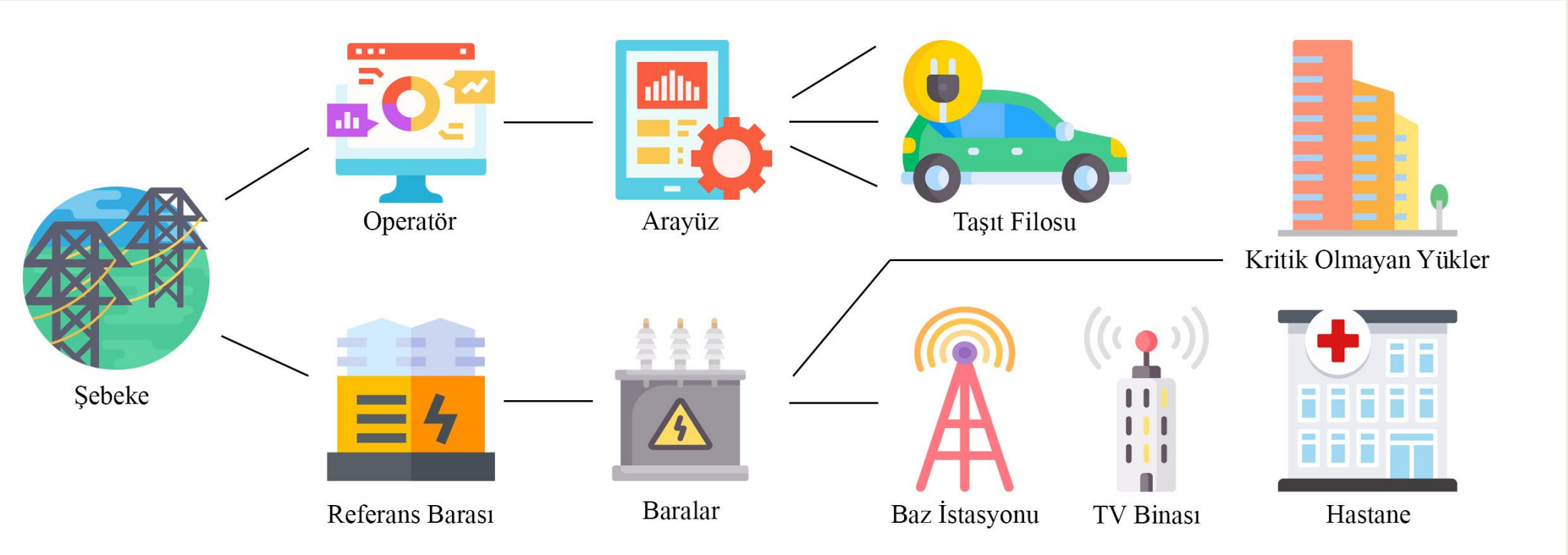


Bu opmizasyon modelinin programlanmasında karmaşık tam sayılı lineer programlama yöntemi (Mixed Integer Linear Programming – MILP) kullanılmış olup modelin benzetim çalışması Python 2.7 versiyonunun PuLP 1.6.8 açık kaynak kodlu kütüphanesi içinde CPLEX ticari optimizasyon çözücüsü ile yapılmıştır.



Her EV güç kaynağı olarak kabul ederek, bunların tedarik, deşarj süresi, kullanım limiti gibi parametreleri hesaplanmıştır

Sistemin Tanıtımı



Zaman Serisi Tahmin Yöntemleri

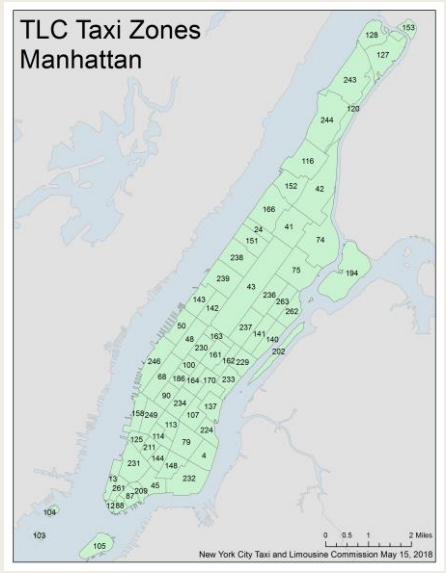
- SARIMA - ARIMA
- Holt-Winters
- Linear Regression
- PROPHET

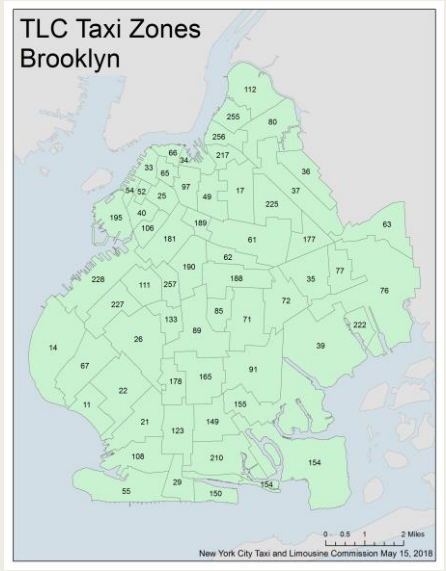
Regresyon analizi

- İki ya da daha çok değişken arasındaki ilişkiyi matematiksel bir denklem yardımıyla ifade eden bir analiz metodudur.

PROPHET

- Facebook tarafından 2017'de scikit-learn kütüphanesi üzerine inşa edilen ve mevsimsel etkiler üzerinden tahmin etmek için kullanılan bir prosedürdür.





TLC Trip Record Data

- Sarı taksi yolculuk kayıtları

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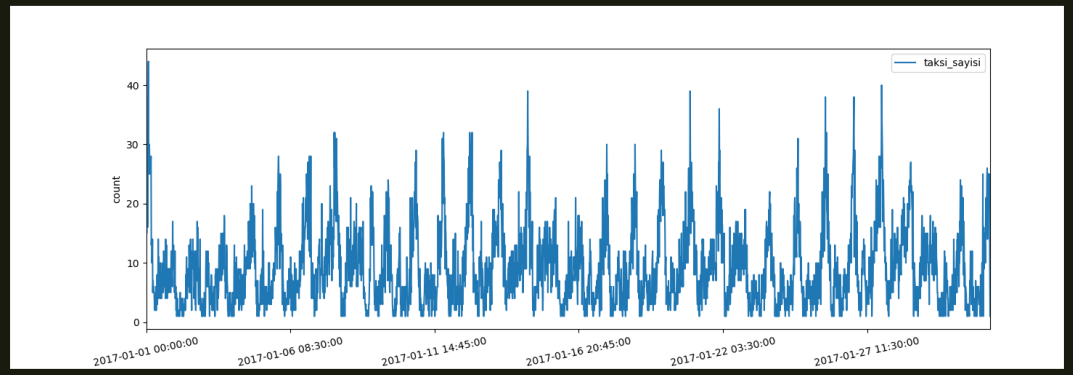
```

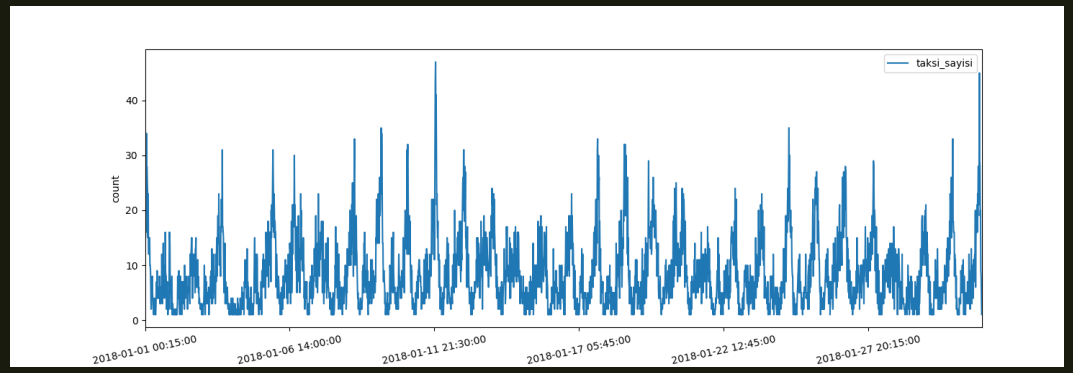
BROOKLYN MAP

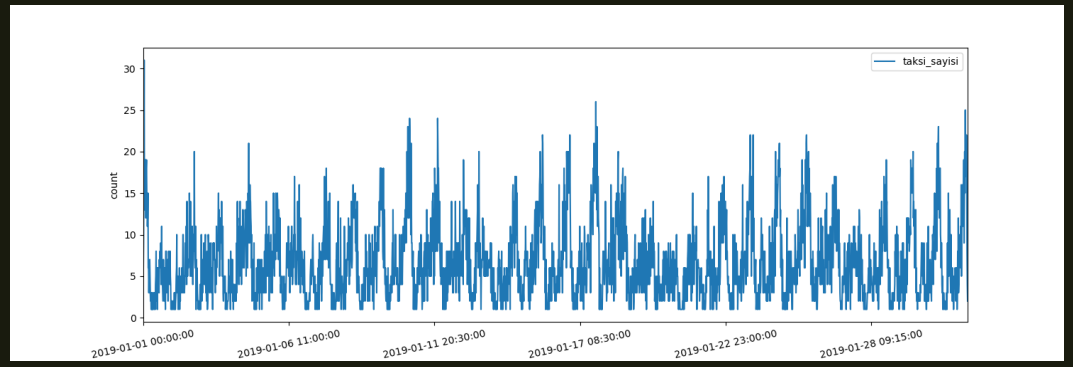
- Downtown Brooklyn

Neihborhoods:

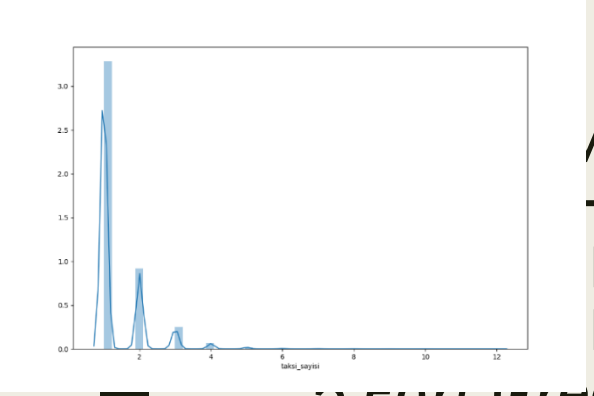
- Fort Greene
- Brooklyn Navy Yard
- Brooklyn Heights
- Boerum Hill





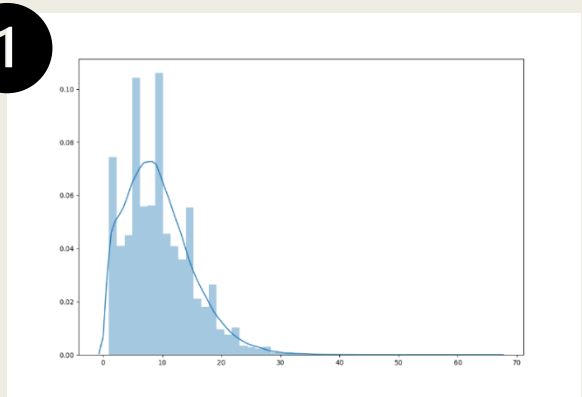


- Downtown Brooklyn 2017-2018-2019 Yıllarına Göre Taksi Sayısı



wn Brooklyn
Hill
Heights
Navy Yard
3.Fort Greene

1



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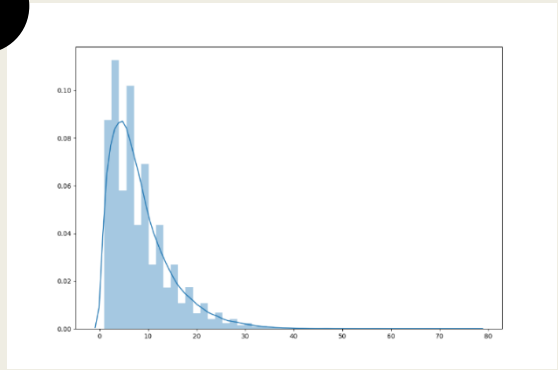

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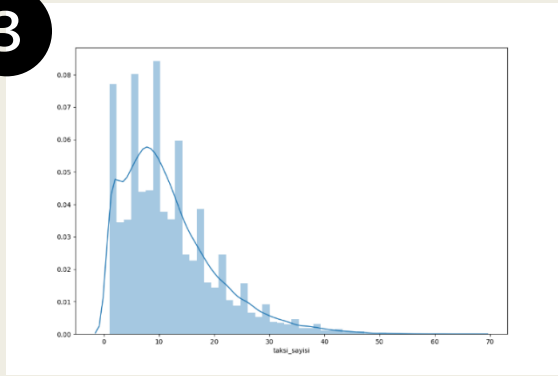

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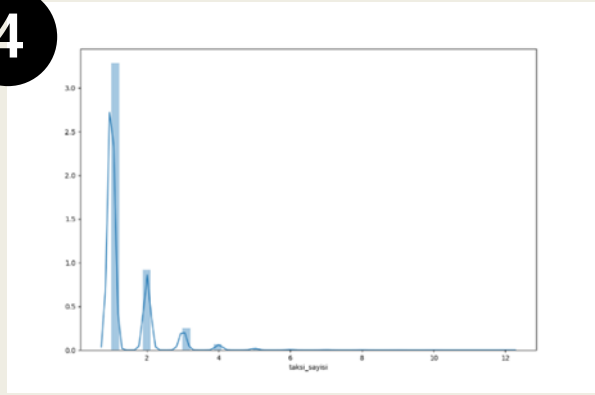

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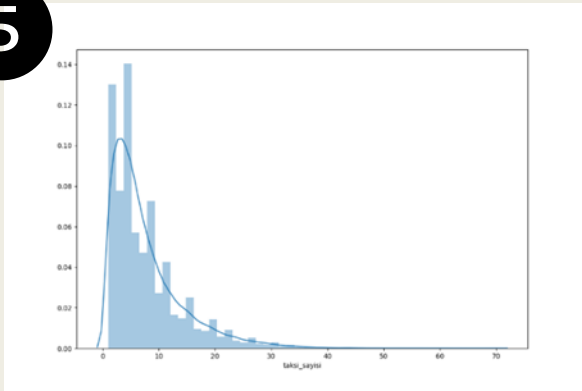

Polynomial Regression

(yıl, ay, gün, dilim, haftanın günü, saat)

2019-01-07 10:12:00	[12]
2019-01-08 10:12:00	[15]
2019-01-11 10:12:00	[9]
2019-01-15 10:12:00	[19]
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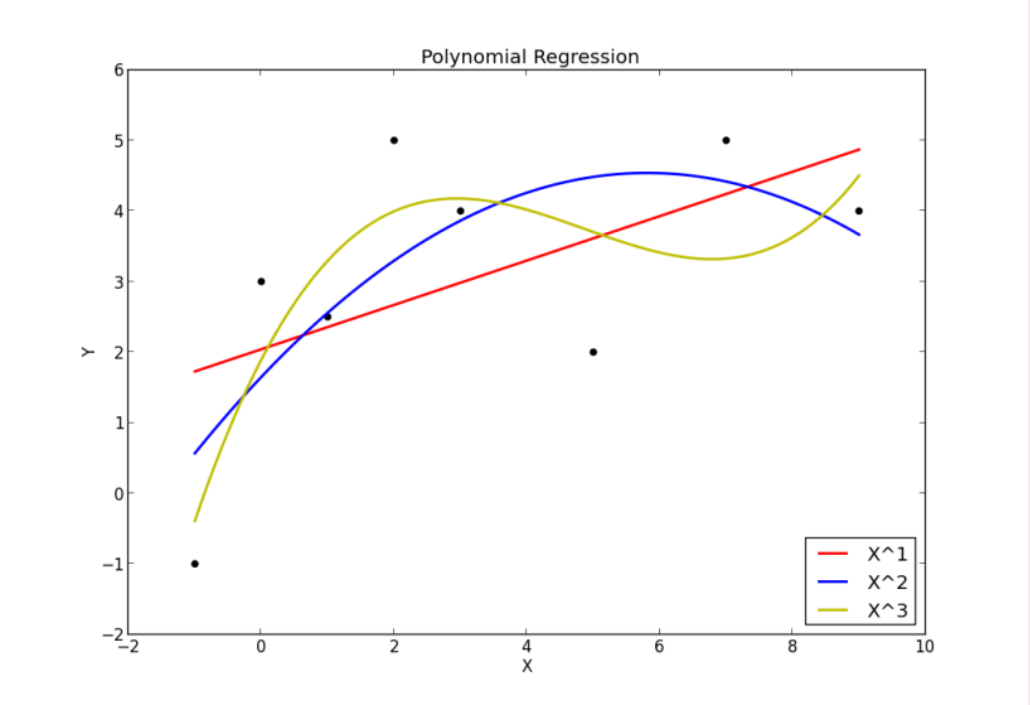
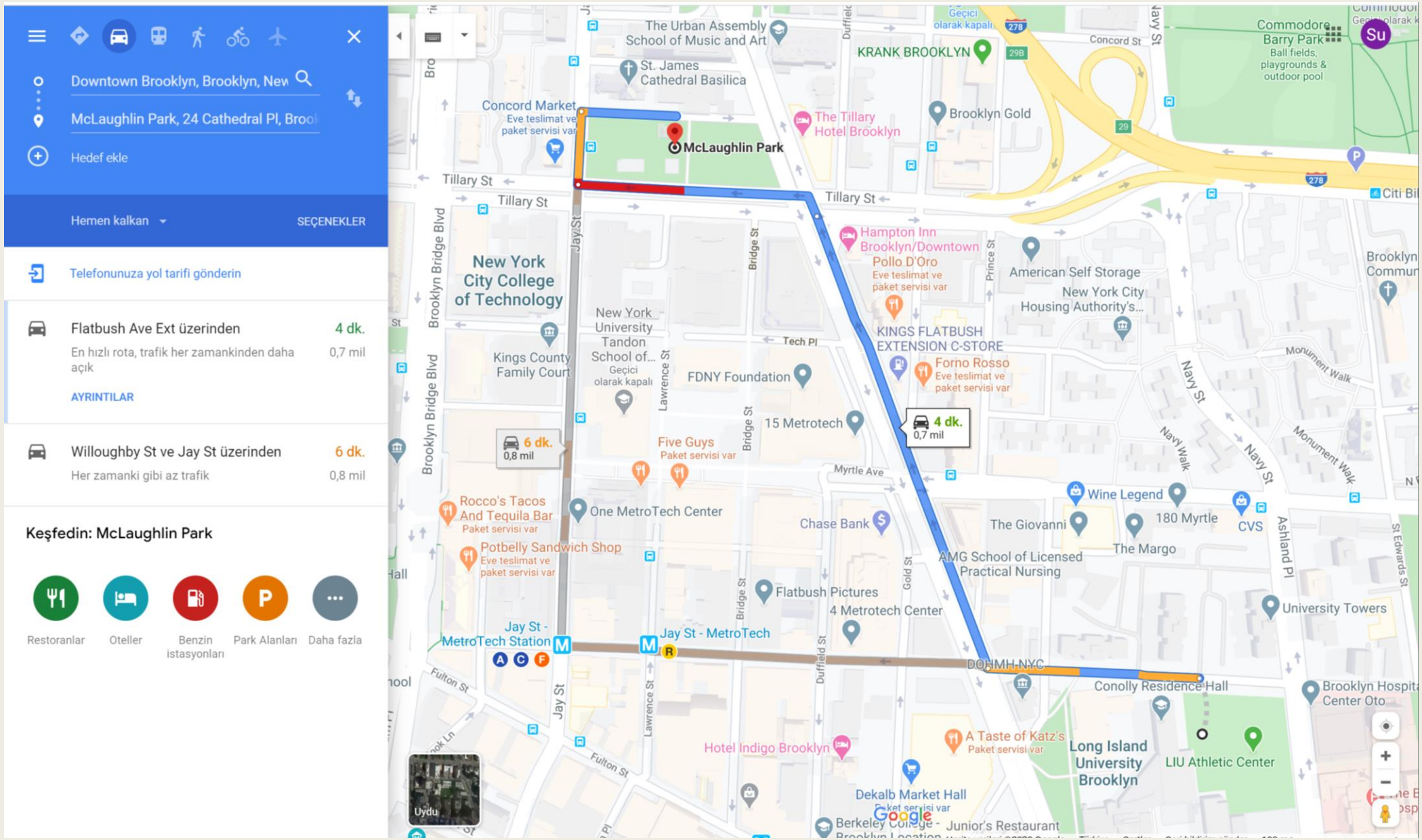
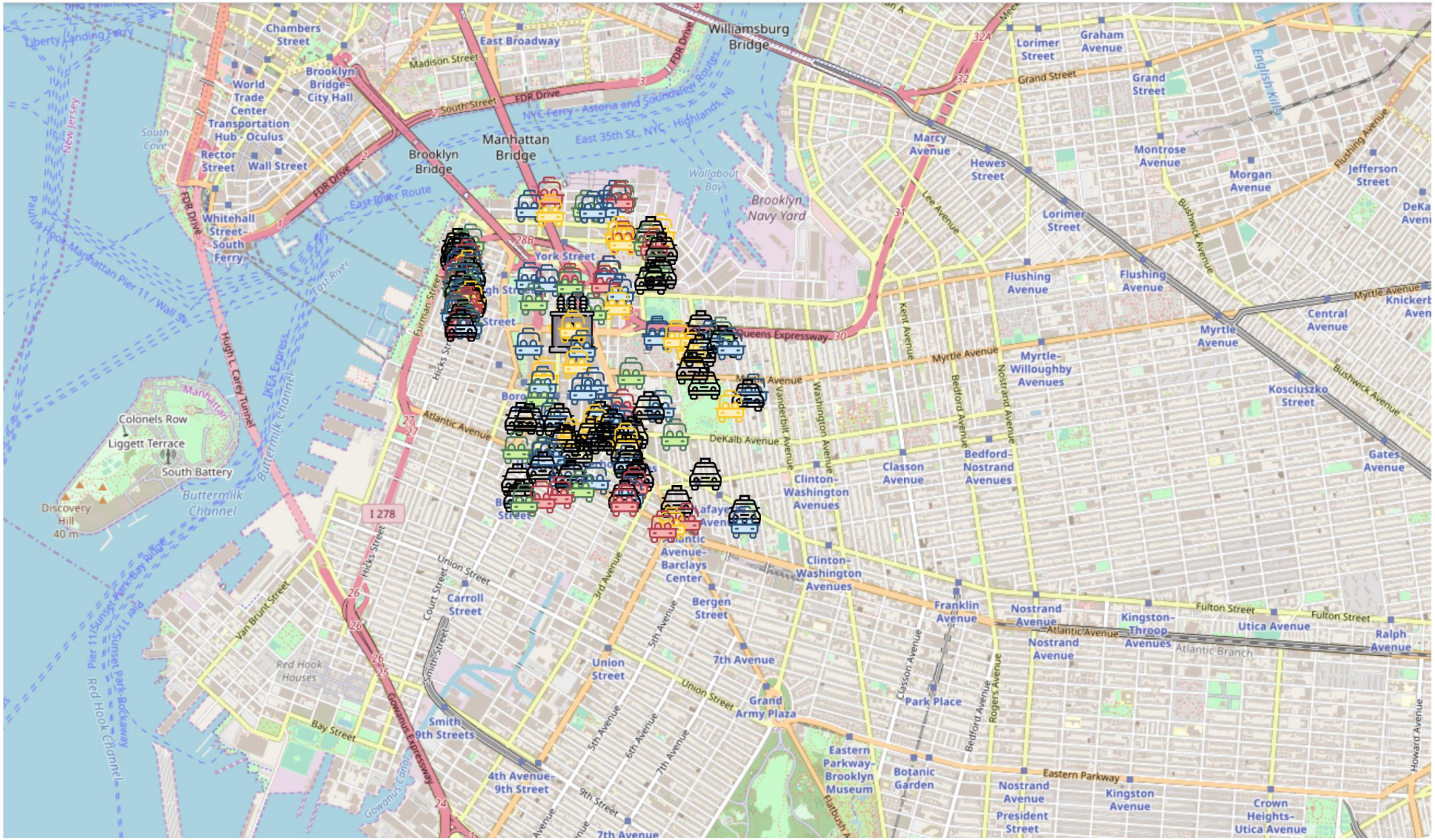
[[10.42104167]]



EV_ID	Distance
EV1	
EV2	0.8 mil
EV3	0.6 mil
EV4	0.3 mil
EV5	0.2 mil
EV6	
EV7	0.8 mil
EV8	
EV9	
EV10	0.3 mil

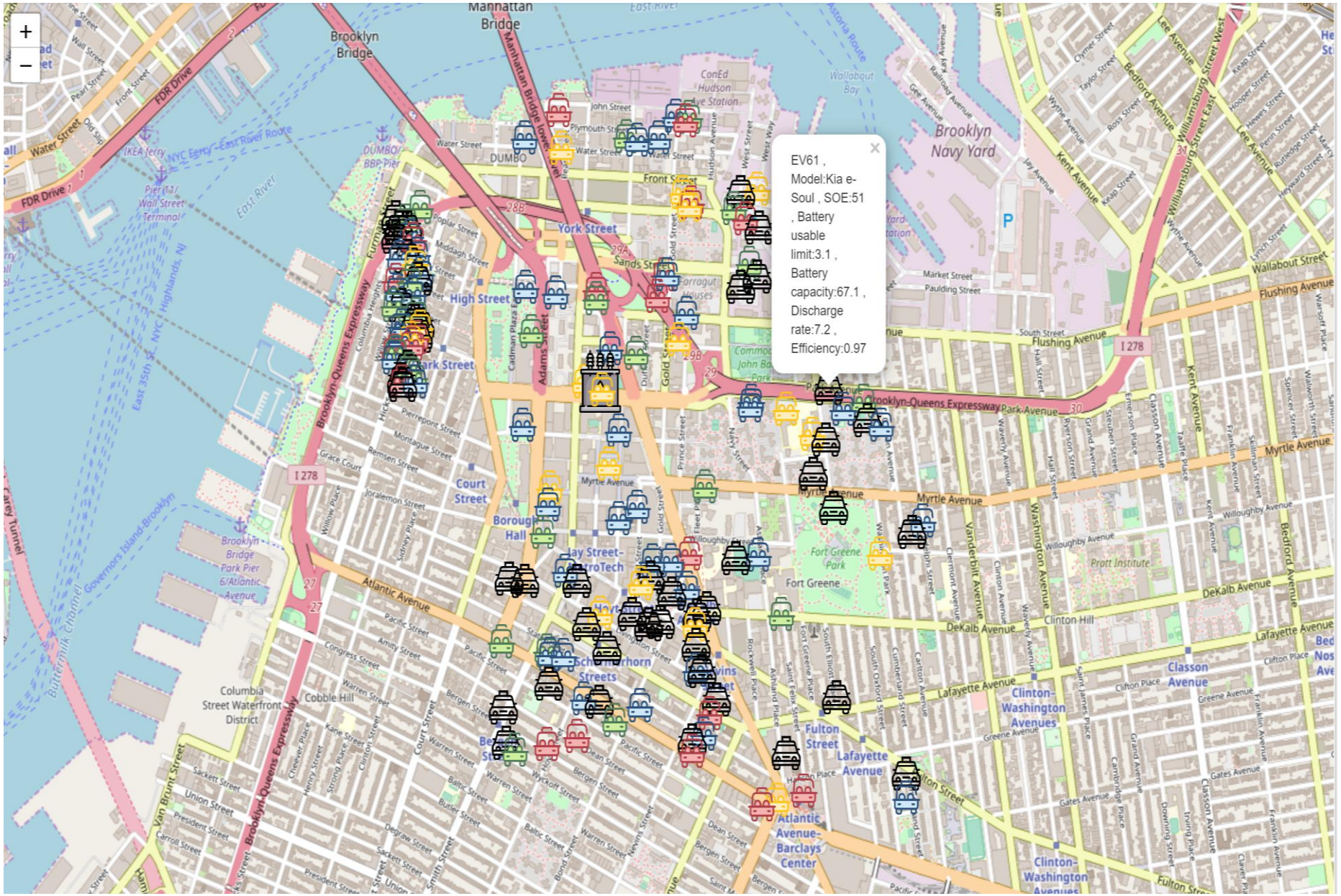
lat	long
40.69148	-73.98
40.69796	-73.9891
40.70426	-73.9879
40.69631	-73.986
40.69529	-73.9895
40.69642	-73.9948
40.70109	-73.9947
40.69082	-73.9871
40.69815	-73.994



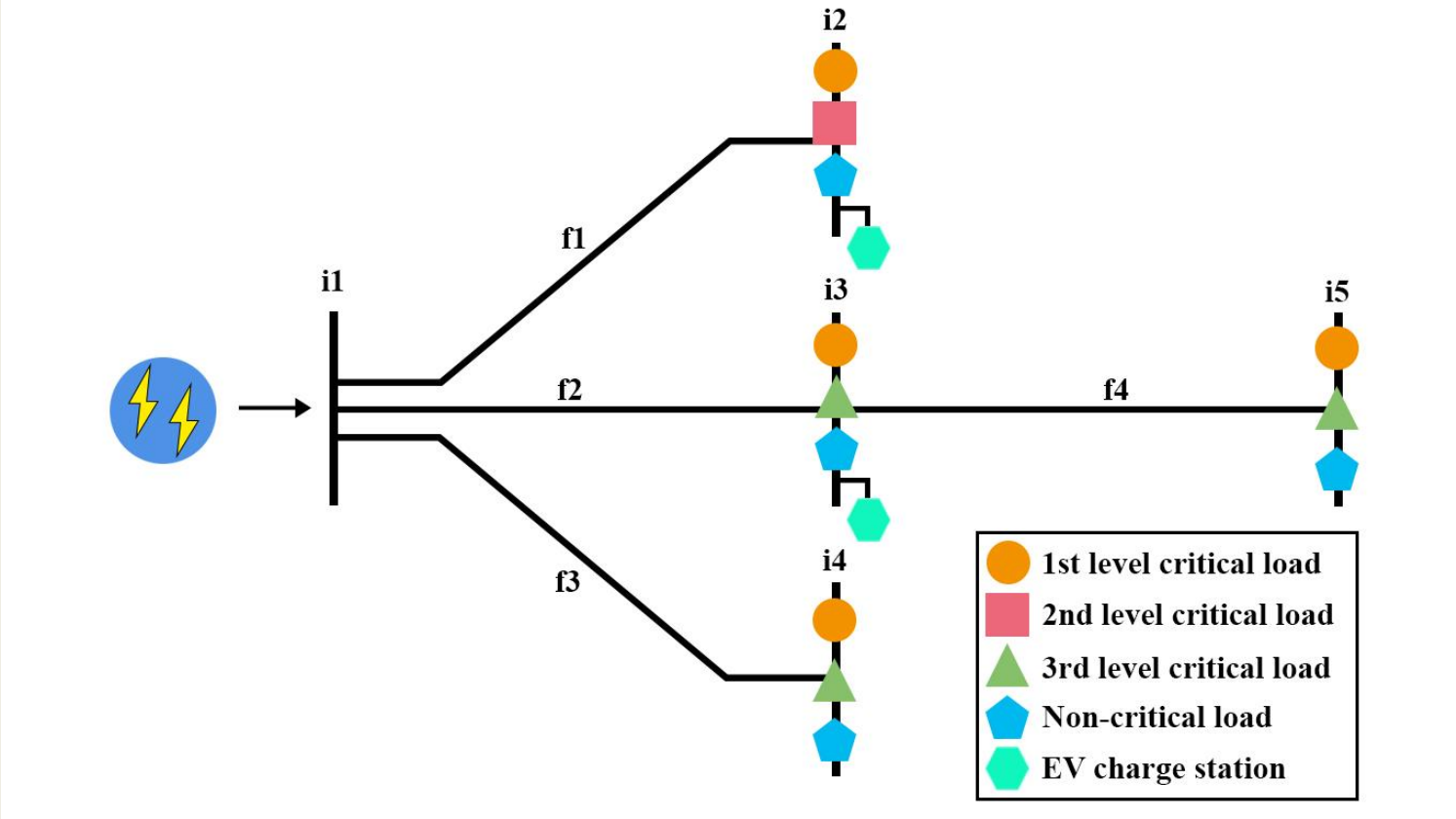

Williamsburg Bridge
Manhattan Bridge
Brooklyn Bridge
Chambers Street
East Broadway
Madison Street
South Street
FDR Drive
World Trade Center Transportation Hub - Oculus
Brooklyn Bridge–City Hall
Rector Street
Wall Street
Whitehall Street–South Ferry
East River Route
NYC Ferry - Astoria and Soundview Routes
NYC Ferry - East 35th St., NYC - Highlands, NJ
Wallabout Bay
Brooklyn Navy Yard
York Street
Queens Expressway
Myrtle Avenue
DeKalb Avenue
Atlantic Avenue
Hicks Street
Furman Street
Clinton–Washington Avenues
Classon Avenue
Bedford–Nostrand Avenues
Myrtle–Willoughby Avenues
Kosciuszko Street
Gates Avenue
Central Avenue
Myrtle Avenue
Flushing Avenue
Jefferson Street
Morgan Avenue
Montrose Avenue
Marcy Avenue
Hewes Street
Lorimer Street
Graham Avenue
Grand Street
Lee Avenue
Kent Avenue
Bushwick Avenue
Vanderbilt Avenue
Washington Avenue
Nostrand Avenue
Bedford Avenue
Franklin Avenue
Atlantic Avenue–Barclays Center
Carroll Street
Bergen Street
Union Street
7th Avenue
Grand Army Plaza
Park Place
Eastern Parkway–Brooklyn Museum
Botanic Garden
Eastern Parkway
Nostrand Avenue
President Street
Kingston Avenue
Crown Heights–Utica Avenue
Kingston–Throop Avenues
Utica Avenue
Ralph Avenue
Fulton Street
Atlantic Branch
Howard Avenue
Court Street
Smith Street
3rd Avenue
5th Avenue
6th Avenue
7th Avenue
9th Street
4th Avenue–9th Street
Smith 9th Streets
Gowanus Expressway
Gowanus Canal
Bay Street
Van Brunt Street
Red Hook Houses
Red Hook Channel
Pier 11/Sunset Park Bridge
Sunset Park-Bay Ridge
Hugh L. Carey Tunnel
IKEA Express
Buttermilk Channel
Manhattan
Colonels Row
Liggett Terrace
South Battery
Discovery Hill
40 m
Governors Island
Liberty Landing Ferry
New Jersey
South Cove
Paulus Hook
Manhattan Pier 11 / Wall St
East River
I 278
FDR Drive
Lorimer Street
Flushing Avenue
Myrtle Avenue
Bushwick Avenue
Knickerbocker Avenue
DeKalb Avenue
Gates Avenue
Fulton Street
Utica Avenue
Ralph Avenue
Howard Avenue
Eastern Parkway
Crown Heights–Utica Avenue
Kingston Avenue
Nostrand Avenue
President Street
Botanic Garden
Eastern Parkway–Brooklyn Museum
Grand Army Plaza
Park Place
Classon Avenue
Franklin Avenue
Clinton–Washington Avenues
Atlantic Avenue–Barclays Center
Carroll Street
Bergen Street
Union Street
7th Avenue
4th Avenue–9th Street
Smith 9th Streets
Gowanus Expressway
Gowanus Canal
Bay Street
Van Brunt Street
Red Hook Houses
Red Hook Channel
Pier 11/Sunset Park Bridge
Sunset Park-Bay Ridge
Hugh L. Carey Tunnel
IKEA Express
Buttermilk Channel
Manhattan
Colonels Row
Liggett Terrace
South Battery
Discovery Hill
40 m
Governors Island
Liberty Landing Ferry
New Jersey
South Cove
Paulus Hook
Manhattan Pier 11 / Wall St
East River
I 278
FDR Drive


EV91 , Model:Kia e-Soul , SOE:50 , Battery usable limit:3.1 , Battery capacity:67.1 , Discharge rate:7.2 , Efficiency:0.97
Orange Street
Clark Street
Pineapple Street
Hicks Street
Henry Street
Columbia Heights
Willow Street
Furman Street
Brooklyn-Queens Expressway
I 278
High Street
Cadman Plaza West
Cadman Plaza East
Cadman Plaza Park
Brooklyn War Memorial
Pineapple Walk
Henry Ward Beecher
Plymouth Church
Bevacco
Plaza Cleaners
Blink
Fortune House
Vineapple
Plymouth Cafe
All-in One Market
Park Plaza Diner
Gristedes
Cadman Towers
Tazza
Clark's Restaurant
Iron Chef House
Jubilee Gallery
Dansk Somandskirke
Eastern Athletics
First Presbyterian Church
German Evangelical Lutheran Zion Church
College Place

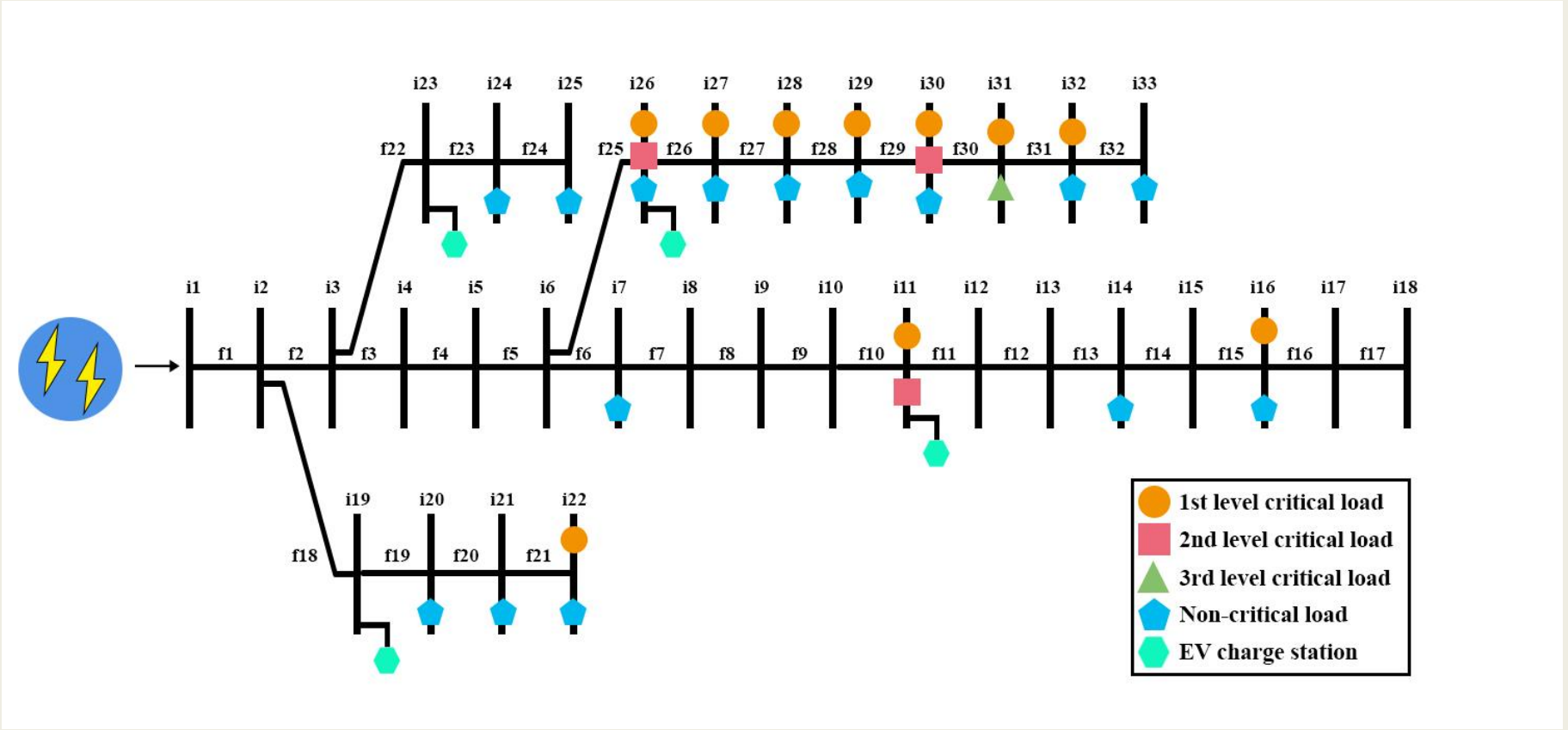

?
Durum:SoE
DR
Eff
McLaughlin Park
Cadman Plaza Park
Walt Whitman Park
Brooklyn War Memorial
Tillary Street
Nassau Street
Concord Street
Clark Street
Johnson Street
Tech Place
Myrtle Avenue
Montague Street
Pierrepont Street
Remsen Street
Jay Street
Bridge Street
Gold Street
Navy Street
Prince Street
Duffield Street
Adams Street
Cadman Plaza West
Cadman Plaza East
Monroe Place
Henry Street
Clinton Street
Court Street
Flatbush Avenue Extension
Brooklyn-Queens Expy
High Street
Pineapple Walk
Hunts Lane
Tillary Street & Adams Street
Jay Street & Concord Street
Flushing Avenue & Navy Street
Navy Street & Sands Street
Farragut Houses
Golconda Playground
Public School 287
Trinity Park
Weinburg Triangle
The Tillary Hotel
Hampton Inn
Eightyfourth Precinct Police Station
Ingersoll Community Center
Fleet Walk
Navy Walk
Hudson Walk
Wunsch Building
MetroTech Walk
MetroTech Commons
New York City College of Technology
12 MetroTech Supreme & Family Courts
1 MetroTech Center
2 MetroTech Center
NY State Supreme Court 2nd District
US District Court for Eastern District of New York
Emergency Management Headquarters
Brooklyn Heights Library
One Pierrepont Plaza
Downtown Station Brooklyn Post Office
Korean War Veterans Plaza
Saint Ann's School
Church of the Saviour
First Presbyterian Church
German Evangelical Lutheran Zion Church
Cadman Towers
Our Lady of Lebanon Roman Catholic Church
Saint Francis
Citibank
Chase
New York Marriott at the Brooklyn Bridge
Blink
The Eagle
The Giovanni
The Margo


EV61 , Model:Kia e-Soul , SOE:51 , Battery usable limit:3.1 , Battery capacity:67.1 , Discharge rate:7.2 , Efficiency:0.97
Brooklyn Bridge
Manhattan Bridge
Brooklyn Navy Yard
Brooklyn-Queens Expressway
Atlantic Avenue
Fulton Street
Lafayette Avenue
Myrtle Avenue
Flushing Avenue
DeKalb Avenue
Clinton Hill
Fort Greene
Court Street
Borough Hall
High Street
York Street
Atlantic Avenue-Barclays Center
Clinton-Washington Avenues
Classon Avenue
Columbia Street Waterfront District
Cobble Hill
DUMBO
Water Street
FDR Drive
I 278

5 Baralı Sistem



IEEE-33 Baralı Sistem



Optimizasyon Algoritması

Amaç Fonksiyonu

$$\max \sum_{i}\sum_{t}\sum_{d}\left(w_d . u_{i,t}^{d}\right) - \sum_{t}\lambda_t + \sum_{i}\sum_{e}\sum_{t}\beta_{i,e,t}$$

EV Bağlantı Denklemleri

$$\alpha_{i,e,t} = 0 \quad , \quad i \in i', \forall e, t < t_{event}, t \geq t_{dep}$$

$$\alpha_{i,e,t} = 0 \quad , \quad i \notin i', \forall e, \forall t$$

$$\sum_{\boldsymbol{e}} \alpha_{i,e,t} < \kappa_i \quad , \quad i \in i', t = t_{event}$$

$$\alpha_{i,e,t} \leq b_{i,e} \quad , \quad i \in i', \forall e, t = t_{event}$$

$$\beta_{i,e,t} = 1 - \alpha_{i,e,t} \quad , \quad \forall i, \forall e, \forall t$$

EV Deşarj Denklemleri

$$P_{i,e,t}^{dis} \geq 0 \quad , \qquad \forall i, \forall e, \forall t$$

$$P_{i,e,t}^{dis} \leq \alpha_{i,e,t}.DR_e \quad , \qquad i \in i', \forall e, \qquad t_{event} + 1 \leq t < t_{dep}$$

$$SOE_{i,e,t} = 0 \quad , \qquad \forall i, \forall e, t < t_{event}, t \geq t_{dep}$$

$$SOE_{i,e,t} = soe_{e,t} \,.\, \alpha_{i,e,t} \quad , \qquad \forall i, \forall e, t = t_{event}$$

$$SOE_{i,e,t} = \left(soe_{e,t-1} - soe_e^{loss}\right).\alpha_{i,e,t} \quad , \qquad \forall i, \forall e, \qquad t = t_{event} + 1$$

$$SOE_{i,e,t} = SOE_{i,e,t-1} - \left(\frac{P_{i,e,t-1}^{dis}}{\eta_e}\right).\Delta T \quad , \forall i, \forall e, t_{event} + 1 \leq t < t_{dep}$$

$$SOE_{i,e,t} \geq SOE_{min} \,.\, \alpha_{i,e,t} \quad , \qquad \forall i, \forall e, t_{event} + 1 \leq t < t_{dep}$$

Güç Dengesi Denklemleri

$$P_{i,t}^{f,load} + g_i . P_{i,t}^{fleet} + \sum_{\forall l \epsilon L : i \in \Omega_l^j} f_{l,t} - \sum_{\forall l \epsilon L : i \in \Omega_l^i} f_{l,t} = P_{i,t}^{load} \quad , \qquad \forall i, \forall t$$

$$P_{i,t}^{fleet} = \sum_{\boldsymbol{e}} P_{i,e,t}^{dis} \quad , \qquad \forall i, \forall t$$

$$P_{i,t}^{load} = \sum_{\boldsymbol{d}} u_{i,t}^{d} . \delta_{t,d} . h_{i,d} \quad , \qquad \forall i, \forall t$$

$$u_{i,t}^{d} \leq h_{i,d} \quad , \qquad \forall i, \forall d, \forall t$$

Güç Kaybı Denklemleri

$$0 \le f_{l,t} \le f_l^{max} \quad , \qquad \forall l, \forall t$$

$$P_{l,t}^{loss} = x.f_{l,t} + y.f_{l,t}^2 \quad , \qquad \forall l, \forall t$$

$$P_{l,t}^{loss} = x.f_{l,t} + y.F_{l,t} \quad , \qquad \forall l, \forall t$$

$$\sum_p z_{l,t,p} = 1 \quad , \qquad \forall l, \forall t$$

$$f_{l,t} = \sum_p X_p.z_{l,t,p} \quad , \qquad \forall l, \forall t$$

$$F_{l,t} = \sum_p Y_p.z_{l,t,p} \quad , \qquad \forall l, \forall t$$

$$P_{i,t}^{f} = P_{i,t}^{f,load} + \lambda_t \quad , \qquad i = 1, \forall t$$

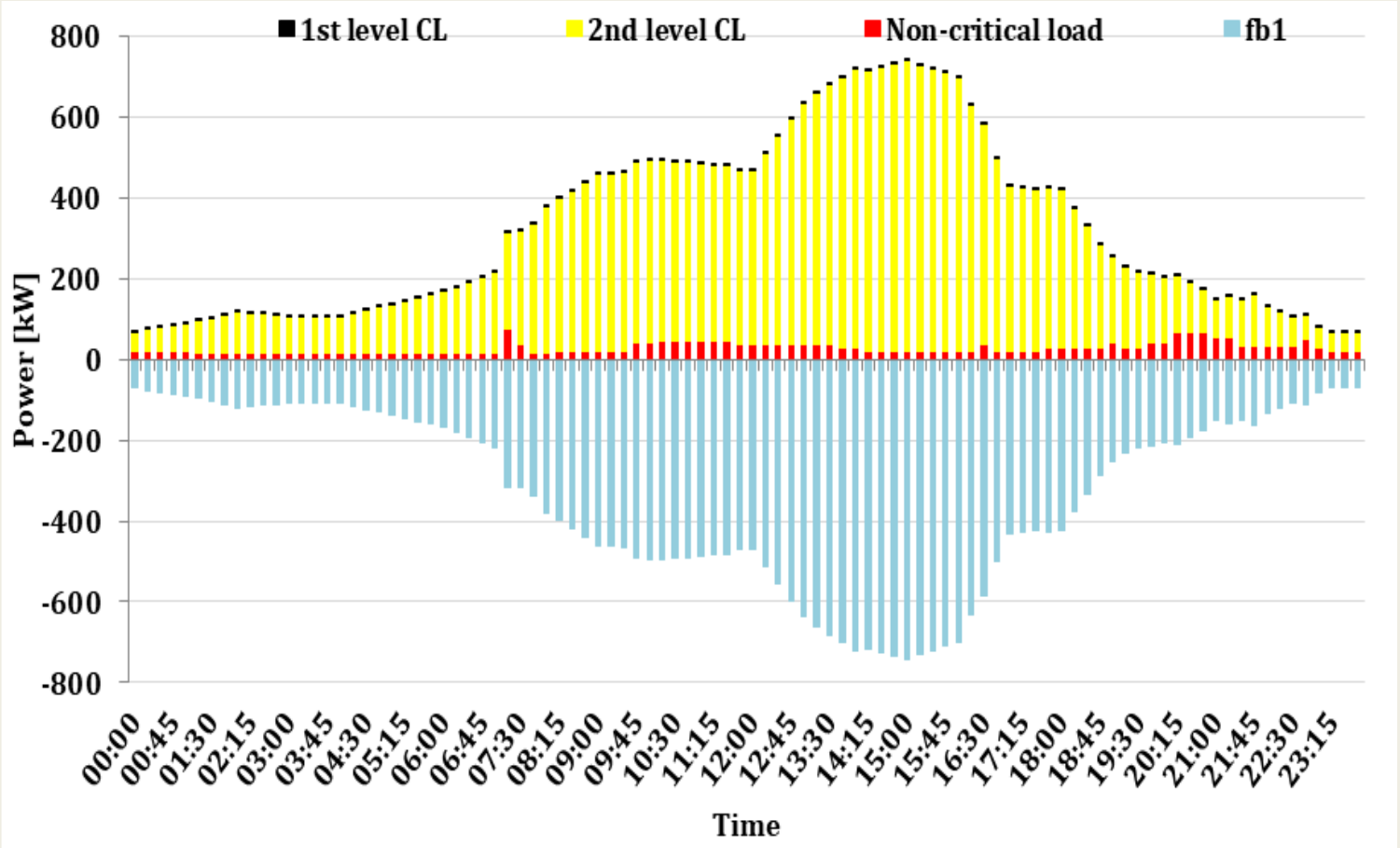
$$0 \le P_{i,t}^{f} \le P_i^{f,max} \quad , \qquad i = 1, \forall t$$

$$\lambda_t = \sum_{l \in L} P_{l,t}^{loss} \quad , \qquad \forall t$$

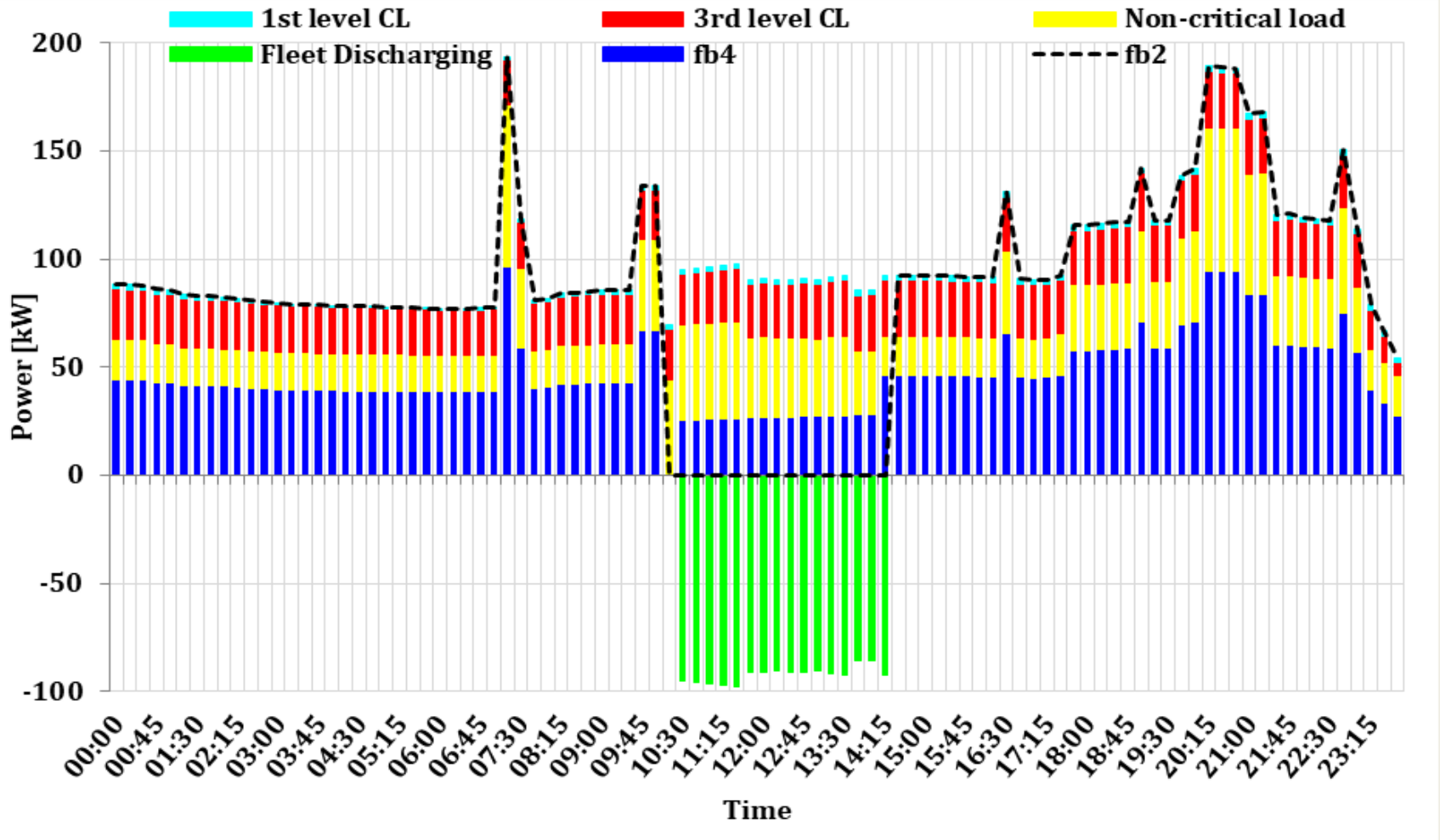
$$P_{i,t}^{f,load} = 0 \quad , \qquad i \neq 1, \forall t$$

$$P_{i,t}^{f} = 0 \quad , \qquad i \neq 1, \forall t$$

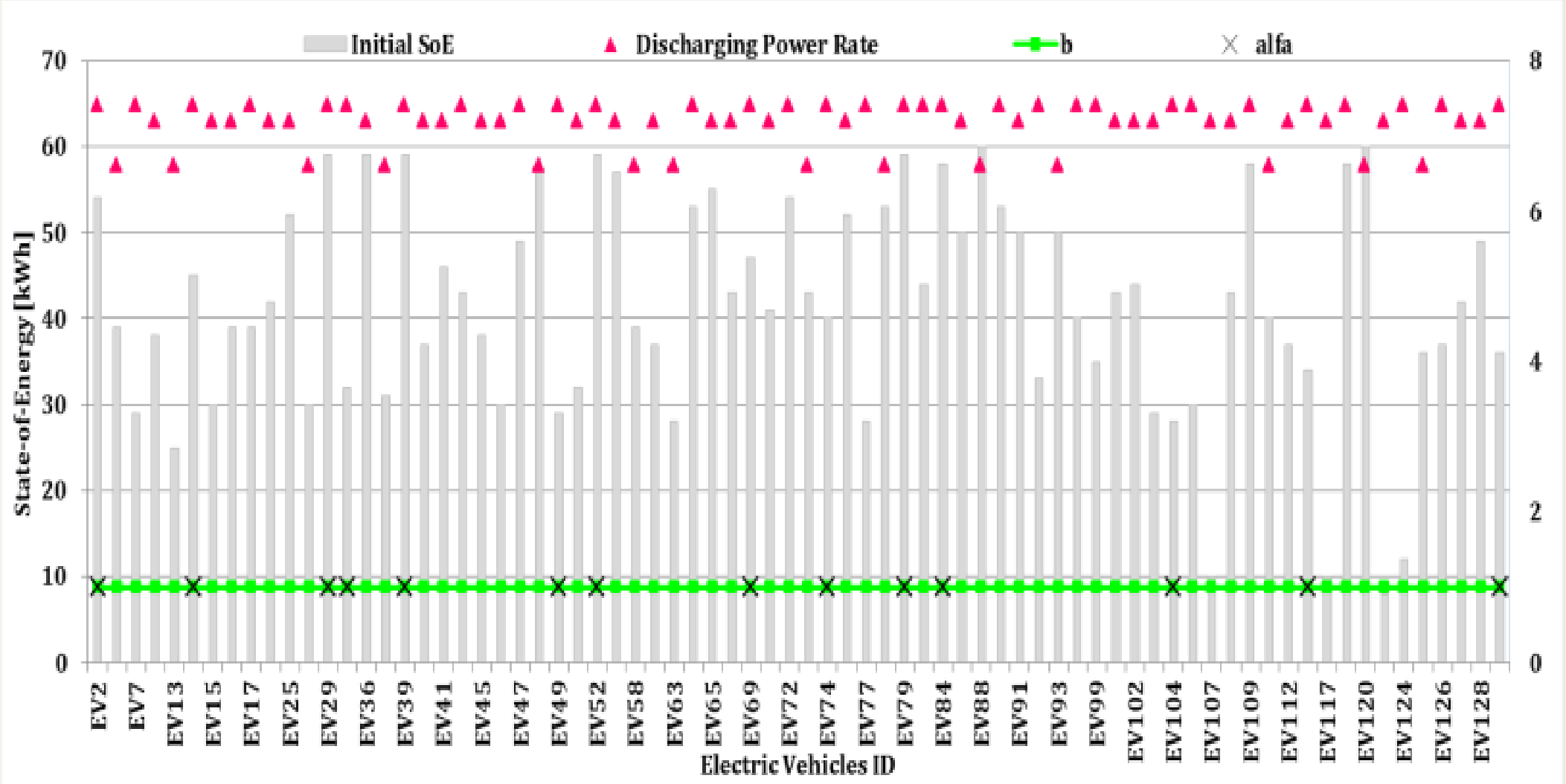
SONUÇLAR



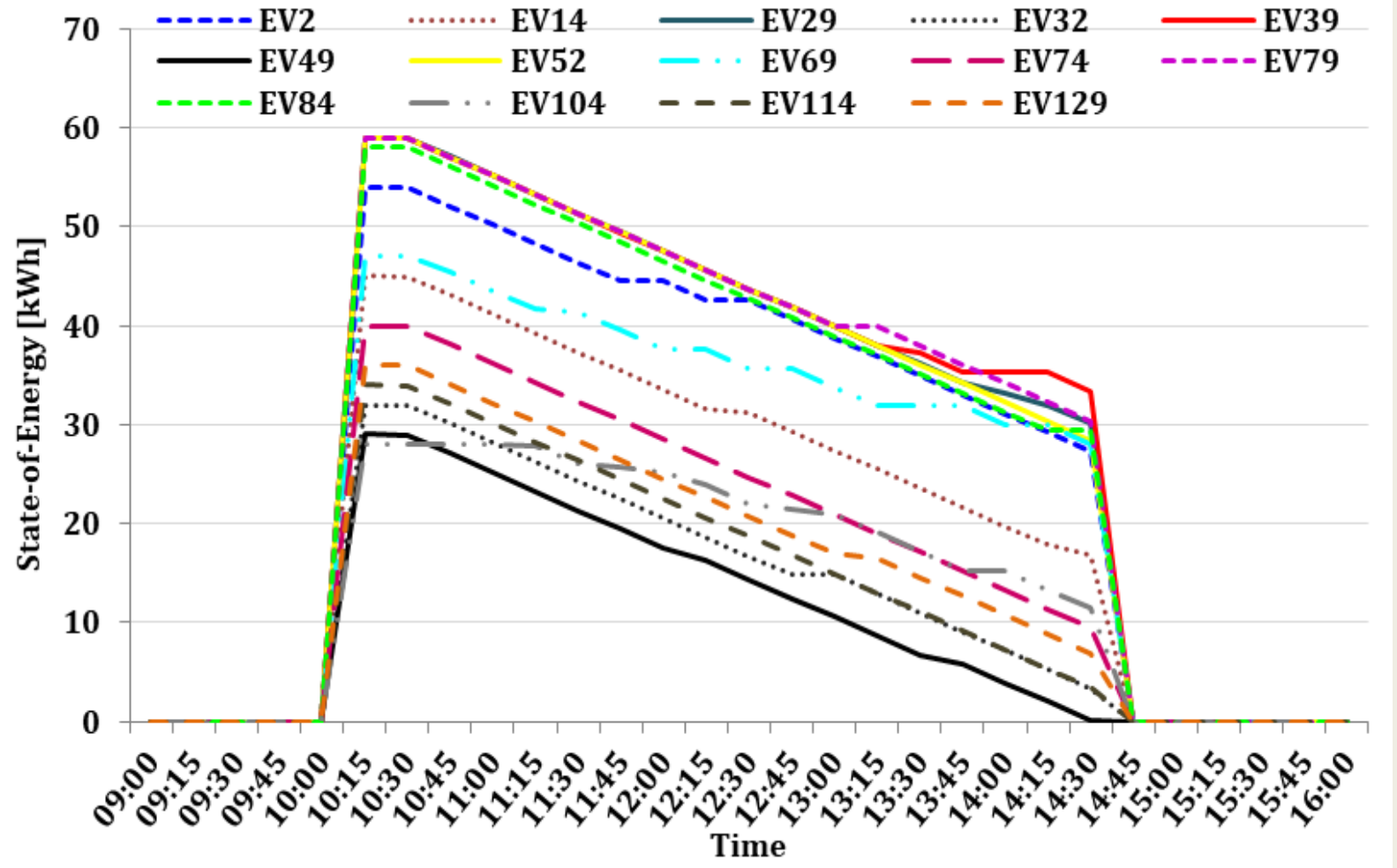
5 Baralı Sistemde i2 Barasının Simülasyon Süresince Güç Dengesi



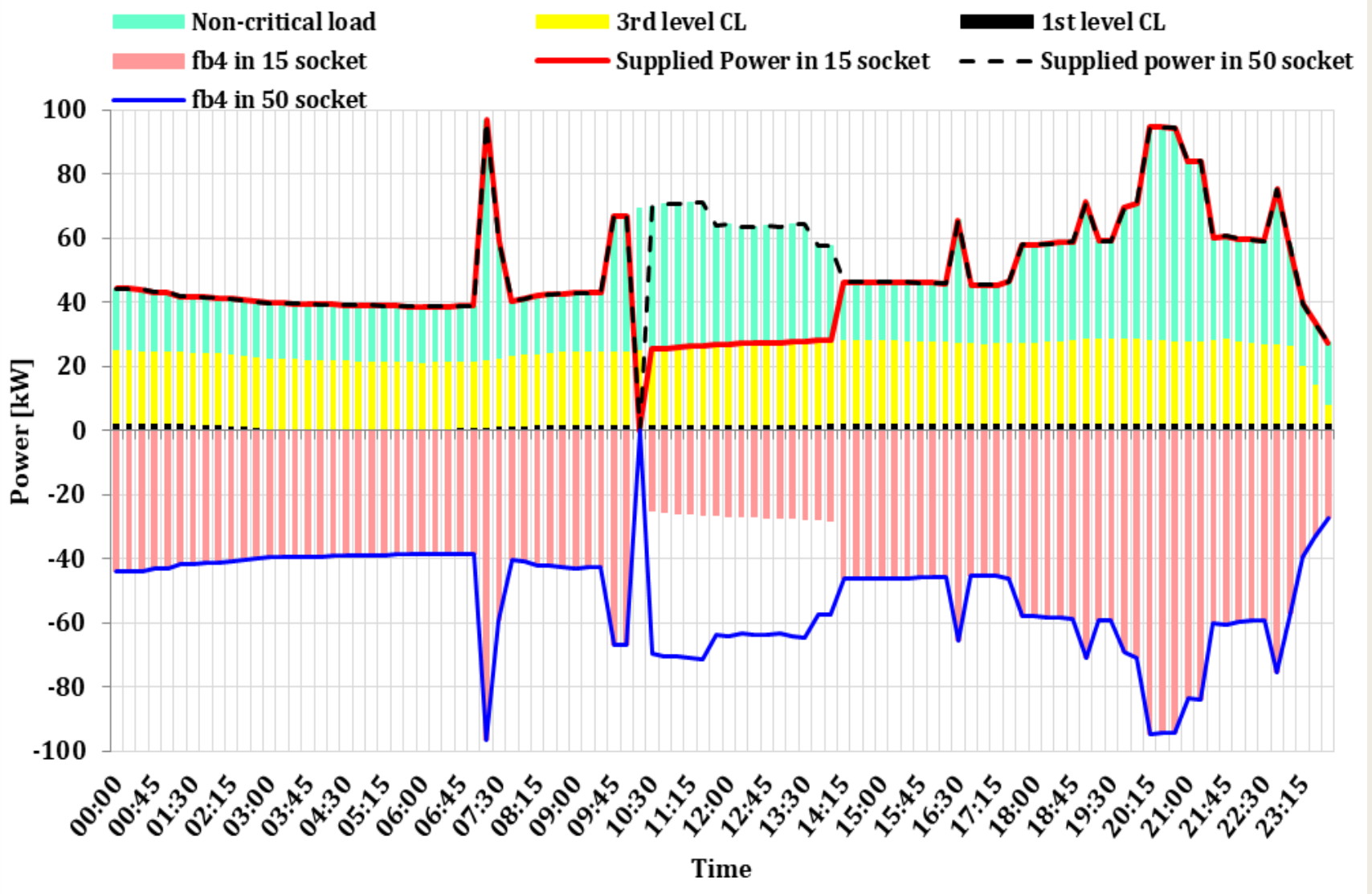
5 Baralı Sistemde i3 Barasının Simülasyon Süresince Güç Dengesi



5 Baralı Sistemde i3 Barası İçin EV Arızaya Yönlendirme Karar Verileri

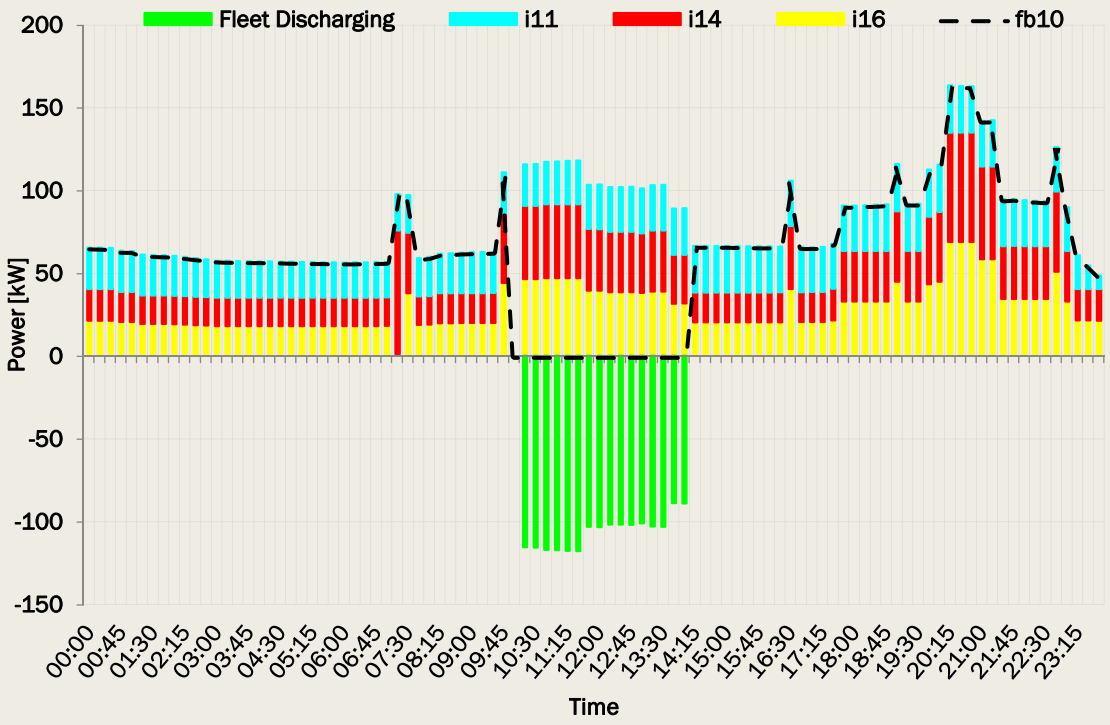


5 Baralı Sistemde i3 Barası İçin Etkinliğe Katılan Taşıtların SOE Durumları

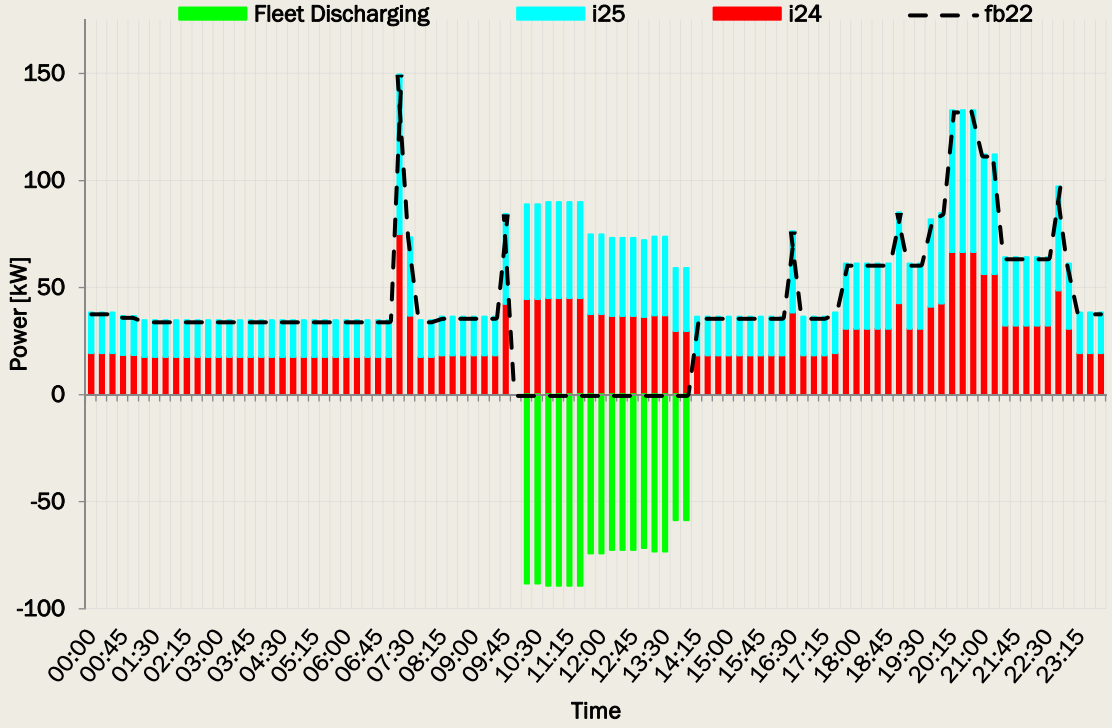


5 Baralı Sistemde i5 Barası İçin Güç Dengesi

IEEE-33 Bara 1. Etkinlik

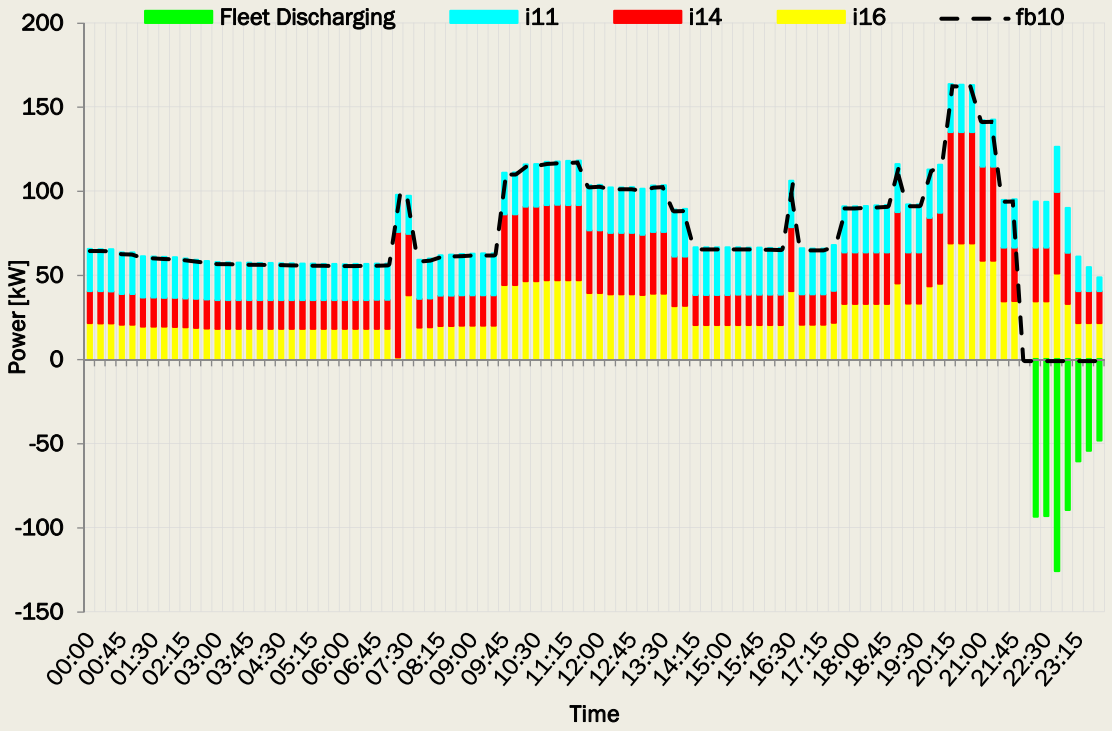


33 Baralı Sistemde i11 Barası İçin Güç Dengesi

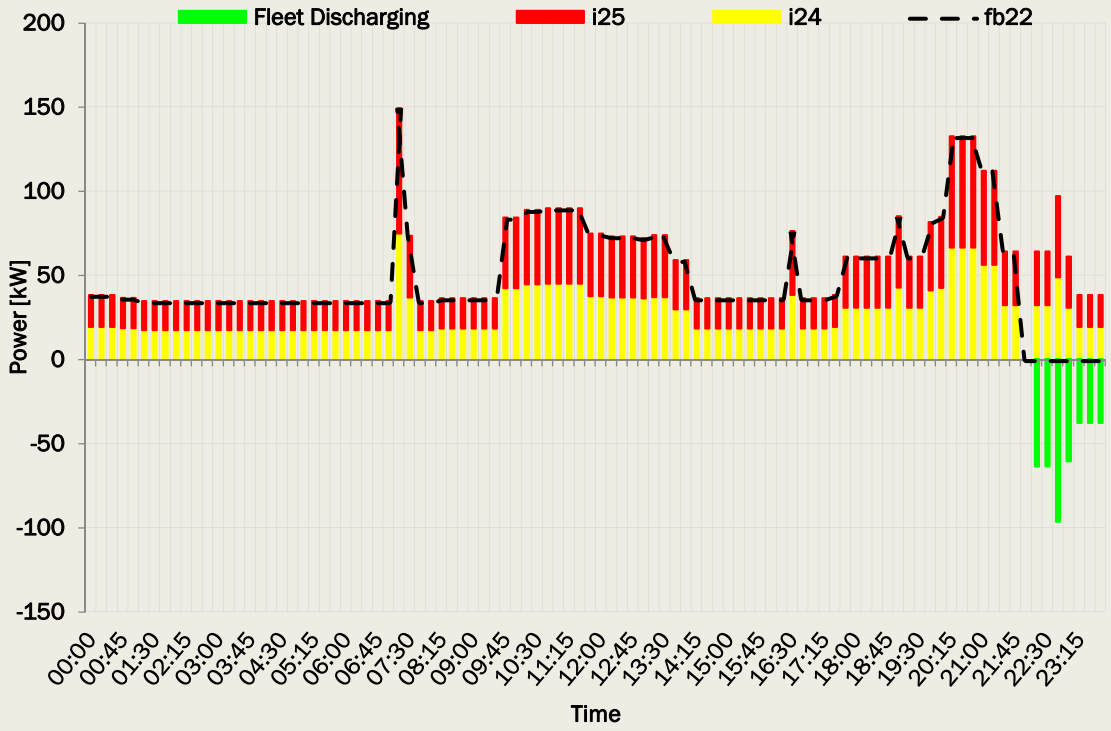


33 Baralı Sistemde i23 Barası İçin Güç Dengesi

IEEE-33 Bara 2. Etkinlik

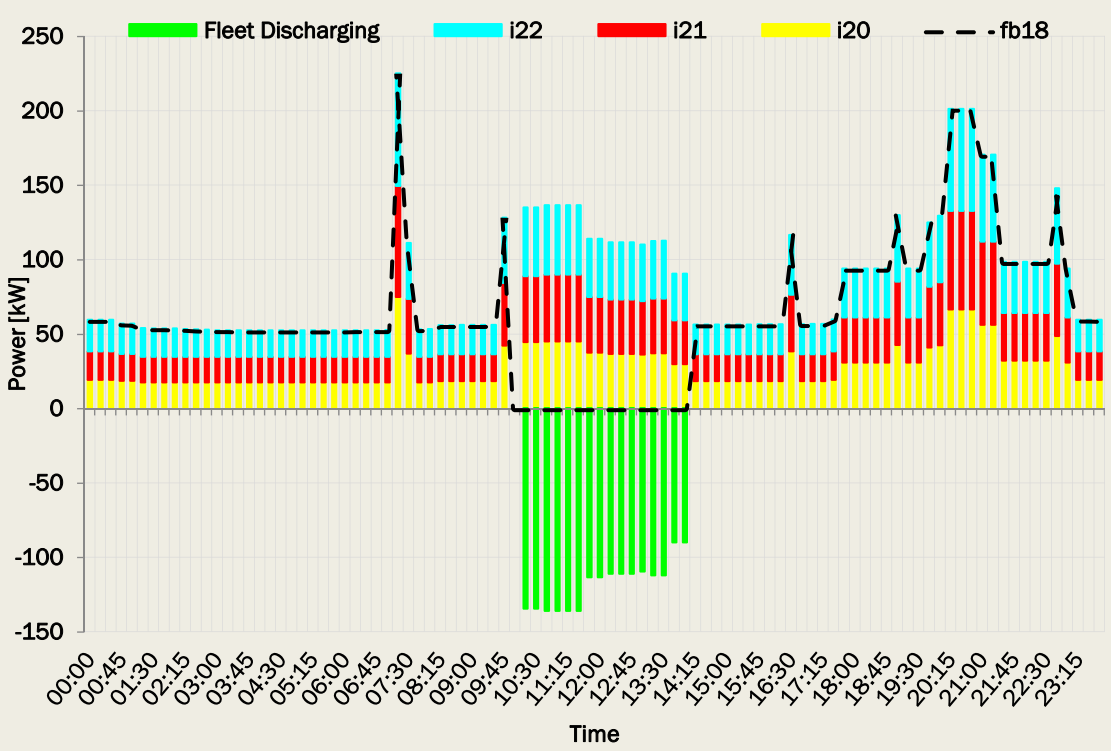


33 Baralı Sistemde i11 Barası İçin Güç Dengesi

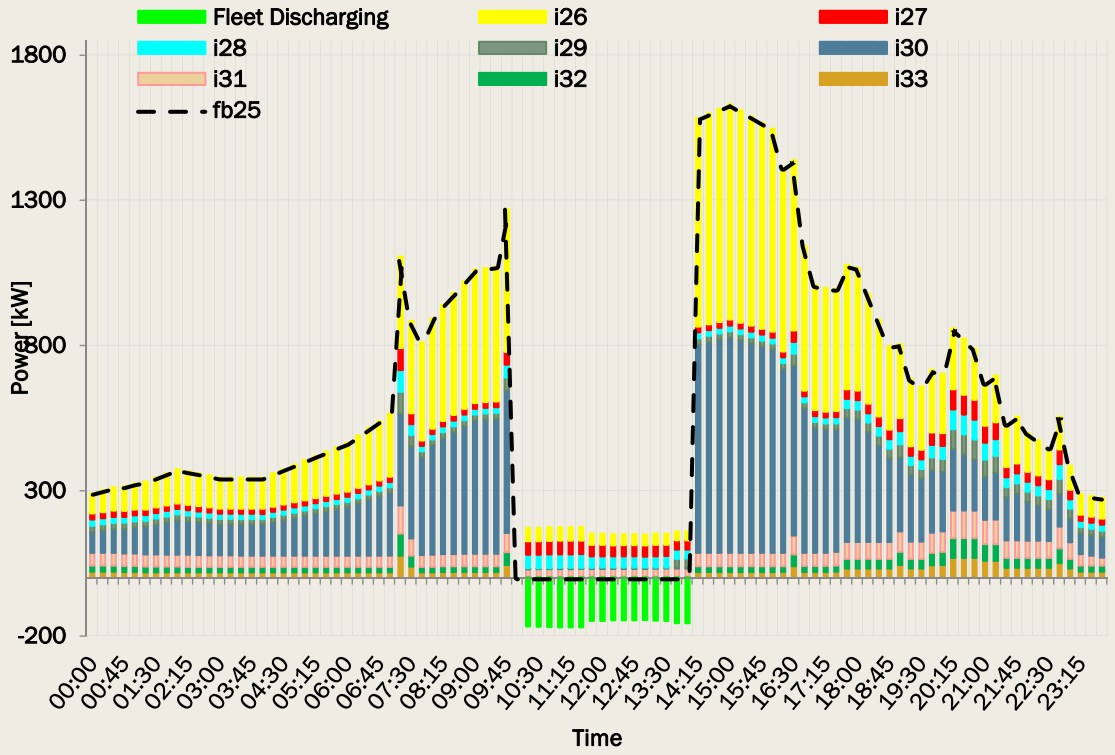


33 Baralı Sistemde i23 Barası İçin Güç Dengesi

IEEE-33 Bara 3. Etkinlik



33 Baralı Sistemde i19 Barası İçin Güç Dengesi



33 Baralı Sistemde i26 Barası İçin Güç Dengesi

Bara Sistemi	Arıza Oluşan Bara	Soket Sayısı	Arıza Oluşan Saat	Arıza Süresi	Toplam Enerji Talebi [kWh]	Evlerden Karşılanan Toplam Enerji [kWh]	%
5 Bara	i3	15	10:15	2	4377,79	2948,95	67,36161397
5 Bara	i3	50	10:15	2	4377,79	4100,29	93,66118521
33 Bara	i11 , i23	25 , 25	10:00	4	6270,14	5880,37	93,78371137
33 Bara	i11 , i23	25 , 25	22:00	2h15m	2568,28	1933,22	75,27294532
33 Bara	i19 , i26	10 , 25	10:00	4	11654,66	8863,65	76,05241165