Transport sector transformation:
Integrating Electric Vehicles into Turkey's Distribution Grids

Next steps for systems integration:

Linking policy and practice for clean energy transitions across sectors

2 April 2020

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Key findings

- Total EV number increases to **2.5 million and 1 million by 2030 according to the «High Growth» and «Moderate Growth» scenarios**
- Around **1 million charging points by 2030** at homes, workplaces and public places
- Hourly resolution distribution grid model developed to **assess the investment and operational impacts on distribution grid in the four regions of Aegean, Central Anatolia, Marmara and Mediterranean regions where Turkey's initial EV markets are expected to be developed between 2018 and 2030,** considering different charging behaviour, charging point locations and sales numbers
- **Assuming distribution grid operators invest in their grid capacity to meet an annual 5% growth in electricity demand, limited additional investments are needed for grid integration of EVs**
- This outcome is only possible **if planned grid investments continue** and **if mechanisms and electricity tariffs are available to support charging during hours to minimise impacts on the distribution grids** (particularly in work and public places), **improvements in electricity markets take place** and **regional planning of charging points is optimised**
- **Renewable energy is key and distributed generation (+ battery storage) helps to minimise impacts especially during summer days**

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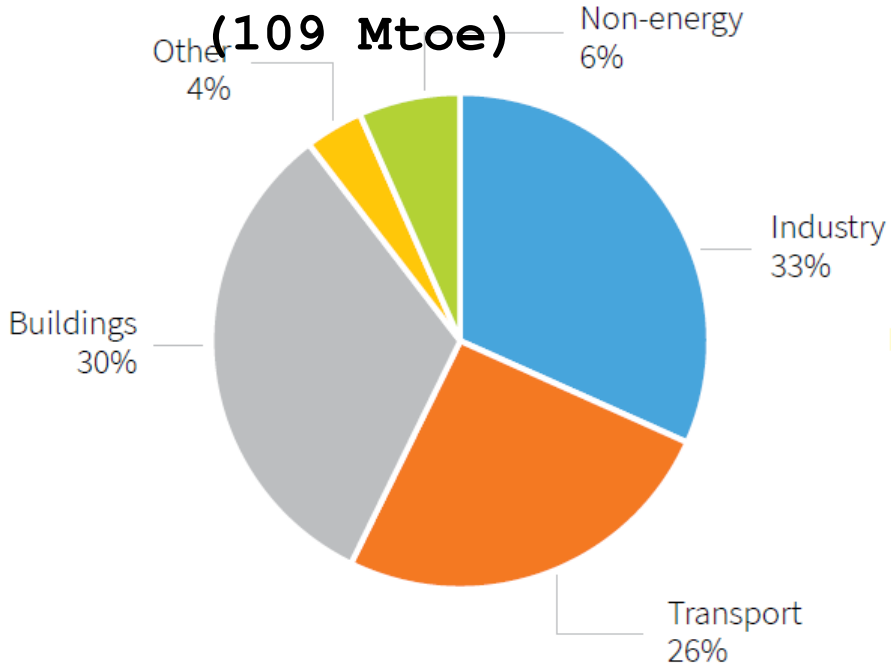
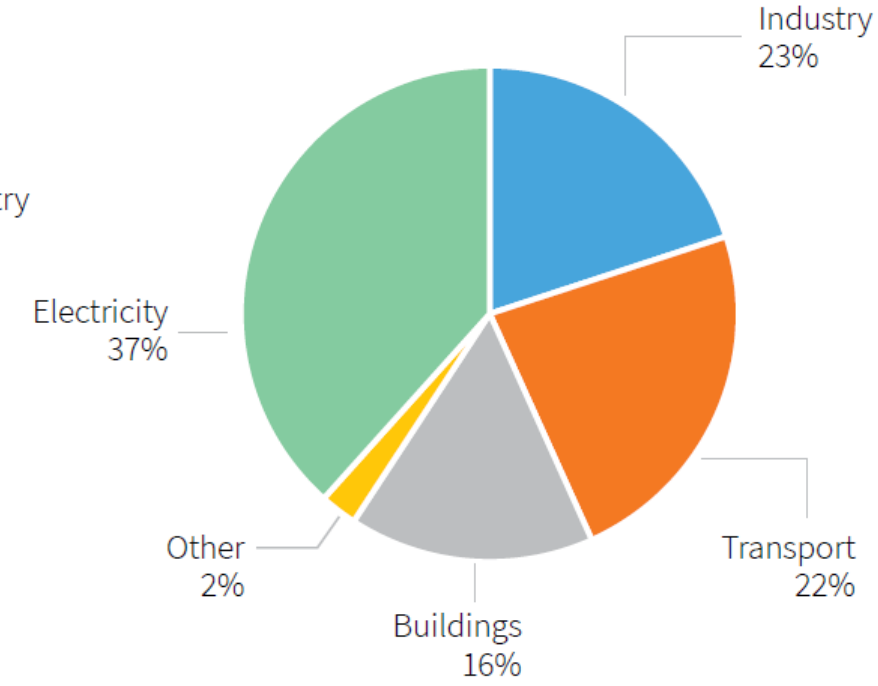
December 2019

Transport sector represents a quarter of Turkey's total final energy consumption (2017/18)

Total final energy consumption (109 Mtoe)



Energy-related CO_2 emissions (378 Mt)



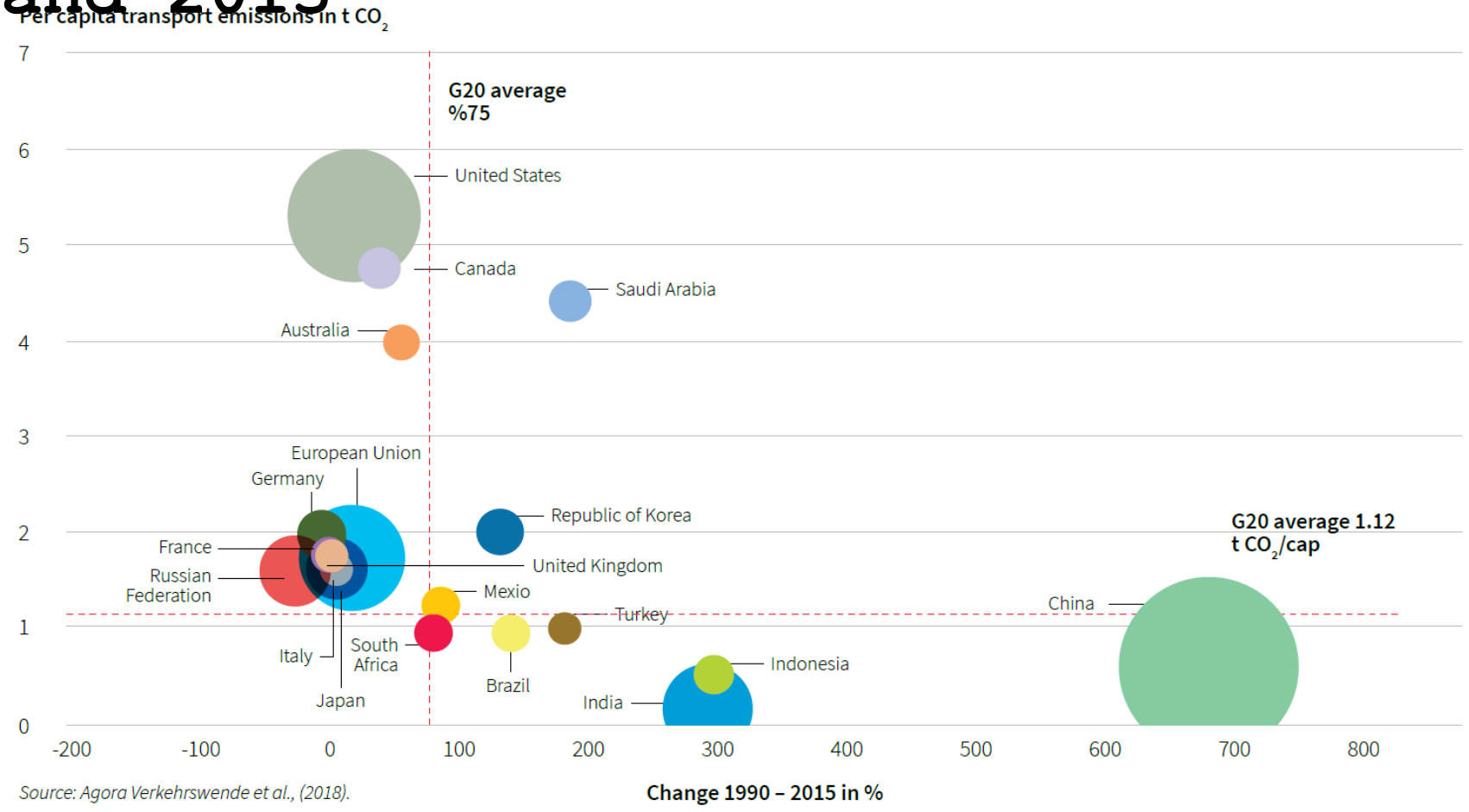
Sources: Enerji İşleri Genel Müdürlüğü (2019); IEA (2019a)

99% of transport sector's total energy demand sourced from fossil fuels

Ranks third in terms of CO_2 emissions

Sources: ETKB/EİGM (2019); OECD/IEA (2019)

Change in transport sector CO_2 emissions of the G20 countries between 1990 and 2015



Source: Agora Verkehrswende et al., (2018).

With an increase of 200%, Turkey transport sector CO2 emissions per capita grew among the highest between 1990 and 2015

Source: Agora Verkehrswende (2018)

Scope of the study

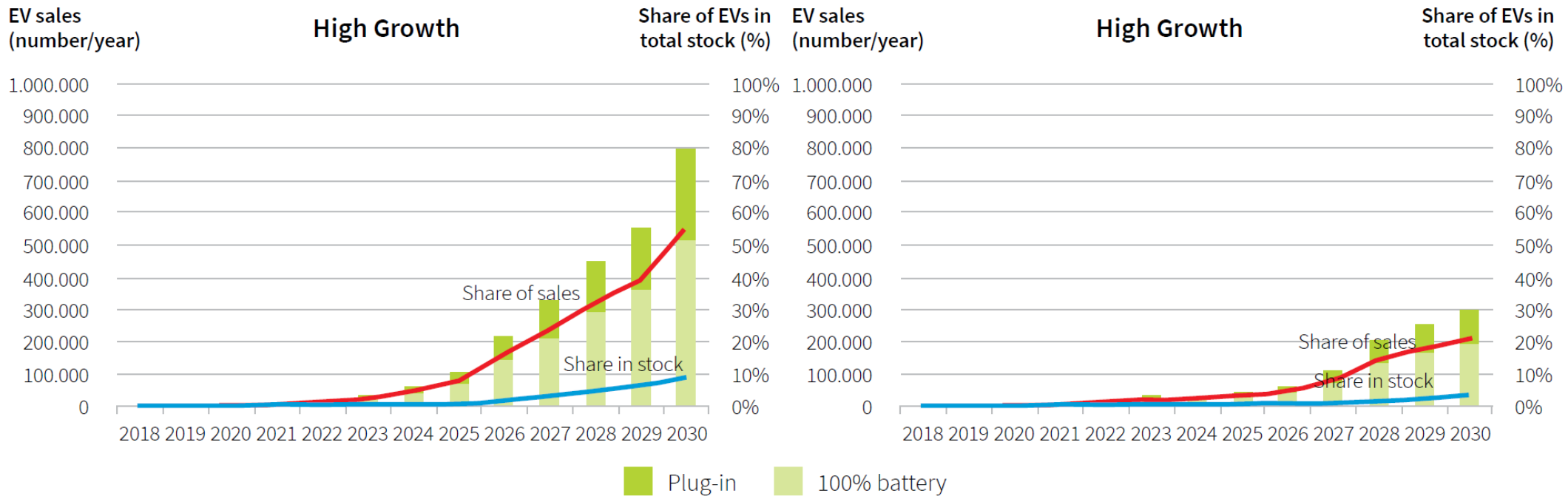
- Two distinct EV sales scenarios have been assessed, namely «High Growth» (2.5 million) and «Moderate Growth» (1 million) by distinguishing total number of charging stations and locations for the 2018-2030 period
- EV scope includes passenger vehicles only (BEV and PHEV) and excludes trucks, buses, 2/3 wheelers, bikes, tractors and fleets
- 8 pilot regions represented by Ayedaş, Başkent, Gediz and Toroslar distribution grids (4 metropol and 4 rural regions) as well as İstanbul-Ankara highway
- For each pilot region the following has been determined:
  - Number of EVs, driving and charging behaviour
  - Number of charging points, technology type and locations
- For each EV sales scenario, charging behaviour has been assessed through «Home-based» and «Public-based» charging support scenarios
- Daily charging behaviour has been assessed at hourly resolution as an addition to the existing electricity load for 4 seasons of the year and for 4 full days within each season
- To assess the EV integration on the distribution grids, 4 indicators have been evaluated:
  - Overloadig
  - Voltage violation
  - Capacity factors of distribution grids

Distribution grid model

- «High Growth» and «Moderate Growth» scenarios have been developed to assess the EV integration impacts on operation and investments of distribution grids as well as a Reference Model where no EV sale has been foreseen

- **Load data:** between December 2017 and December 2018 (at hourly resolution)
- **Load growth:** on average 5% per year (from 2018 until 2030)
- Load characteristics have been estimated for 2030 and have been used as input in the model

Projections in EV sales



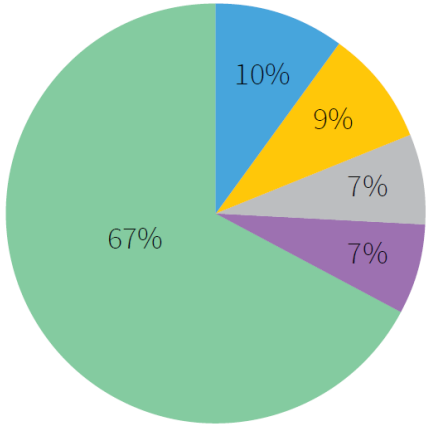
- Vehicle ownership has been assumed to increase to 300/1000 capita by 2030 up from 154/1000 capita in 2018
- Share of total EV sales (battery and plug-in) has been assumed to increase to 20%-55% by 2030
- Total number of EVs reach 1-2.5 million by 2030
- Breakdown of total EV and hybrid vehicle sales by 2030
  - High Growth: 15% hybrid, 55% BEV, 30% PHEV
  - Moderate Growth: 30% hybrid, 45% BEV, 25% PHEV
- Assumed characteristics of the average EV: 17 kWh/100 km ; 10,000 km/year total distance driven

Projections in charging infrastructure

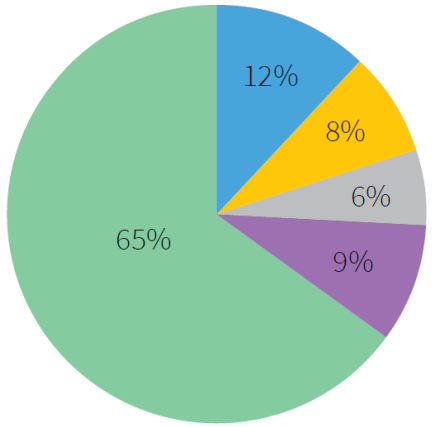
Scenario	Rating (kW)	Moderate-growth		High-growth	
Charging case		Home charging	Public charging	Home charging	Public charging
AC1 – home (AC1 H)	2.3	78,160	78,160	193,953	193,953
AC2 – home (AC2 H)	3.7	182,372	182,372	452,557	452,557
AC2 – work (AC2 W)	22	52,106	52,106	129,302	129,302
AC2 – public (AC2 P)	22	46,896	93,791	116,372	232,744
DC3 – public (DC3 P)	100	5,211	10,421	12,930	25,860
Total		**364,745**	**416,580**	**905,114**	**1,034,416**

Distribution grid regions that were included in the assessment (2017)

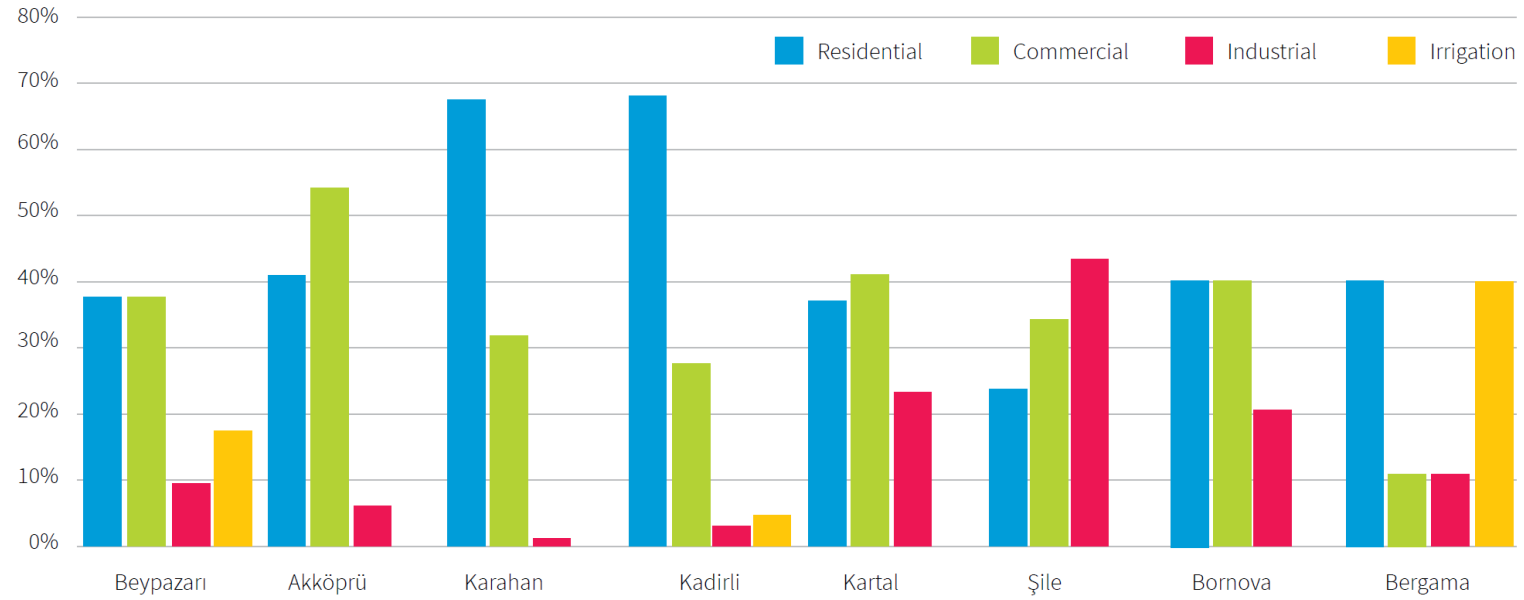
Population (2017)



Electrical Energy Consuption(2017)

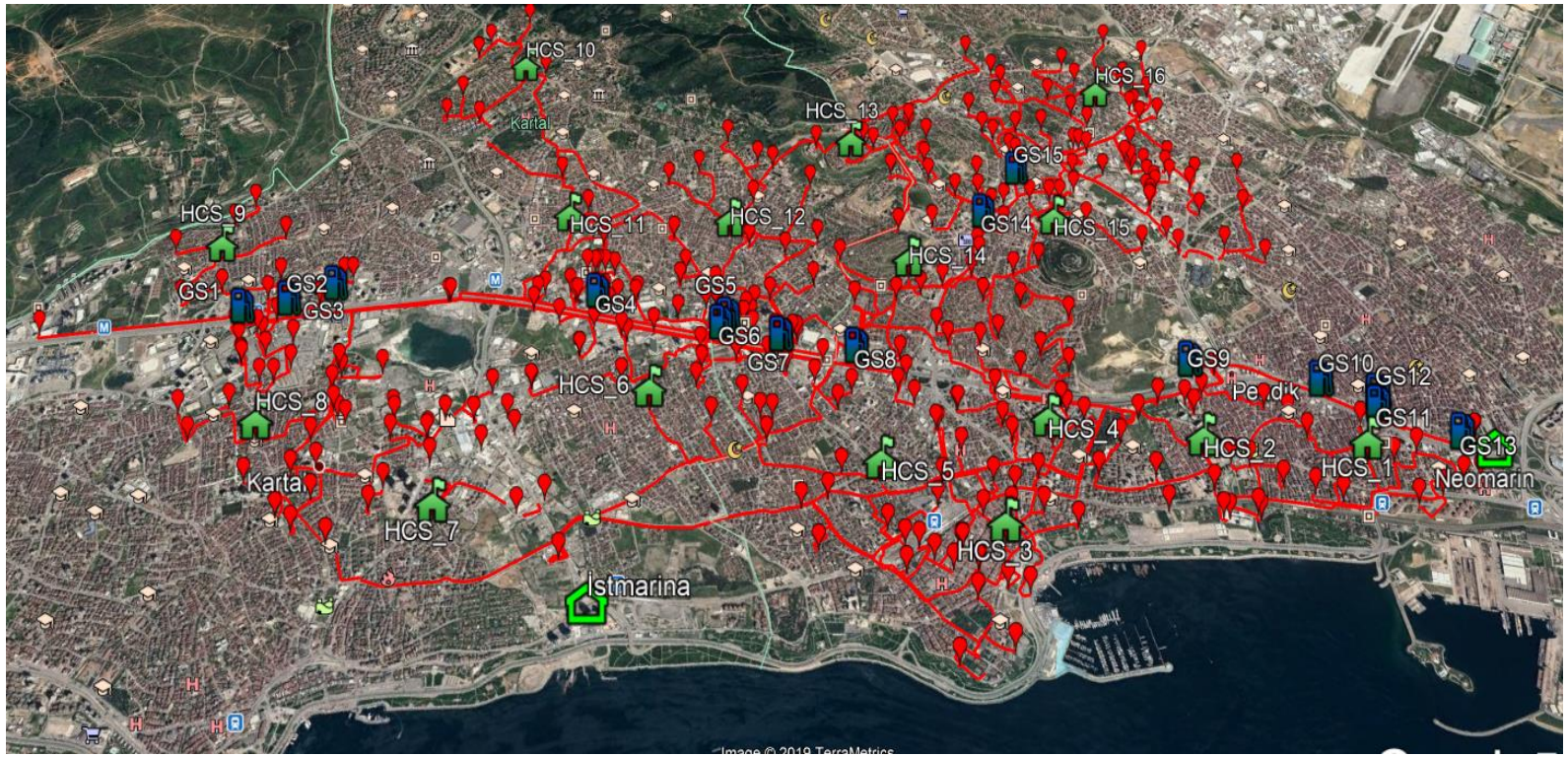


ribution of subscriber groups in each distribution gri



Toroslar Başkent Ayedaş GDZ Remaining Regions in Turkey

Geographical distribution of charging stations in pilot regions (Kartal/Istanbul example)



Home charging points (HCS)

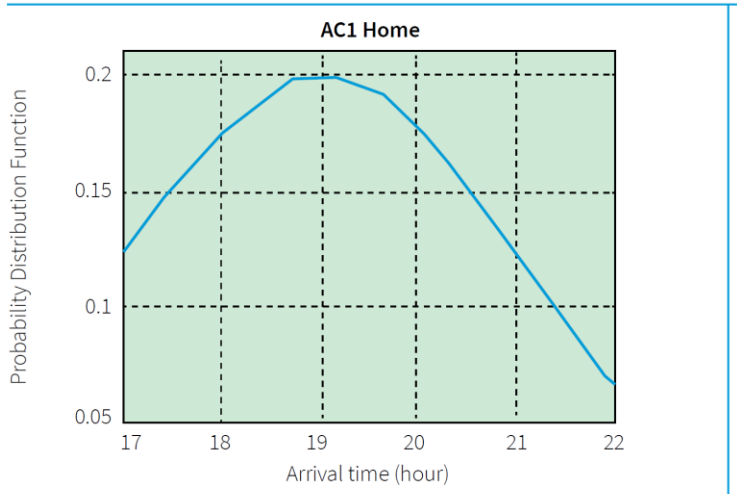
Shopping malls – public charging point

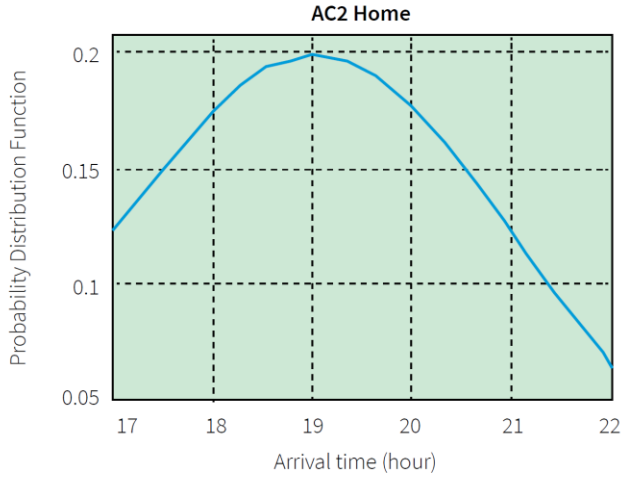
Gas stations (GS) – public charging points

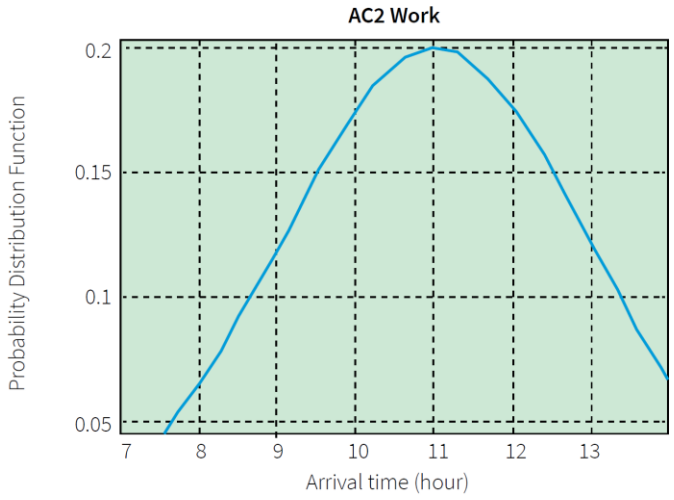
Consumption points

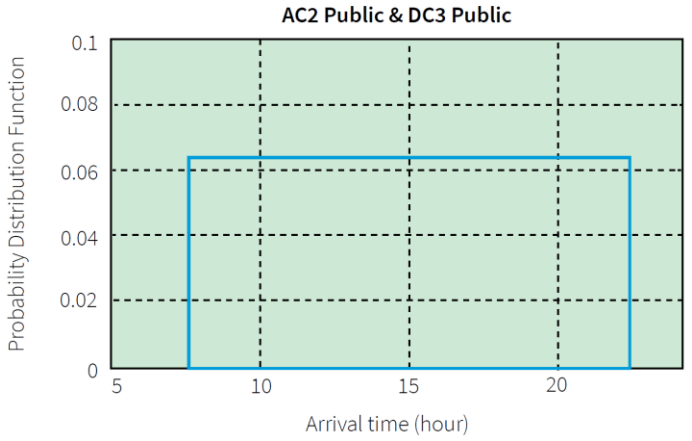
Medium voltage lines

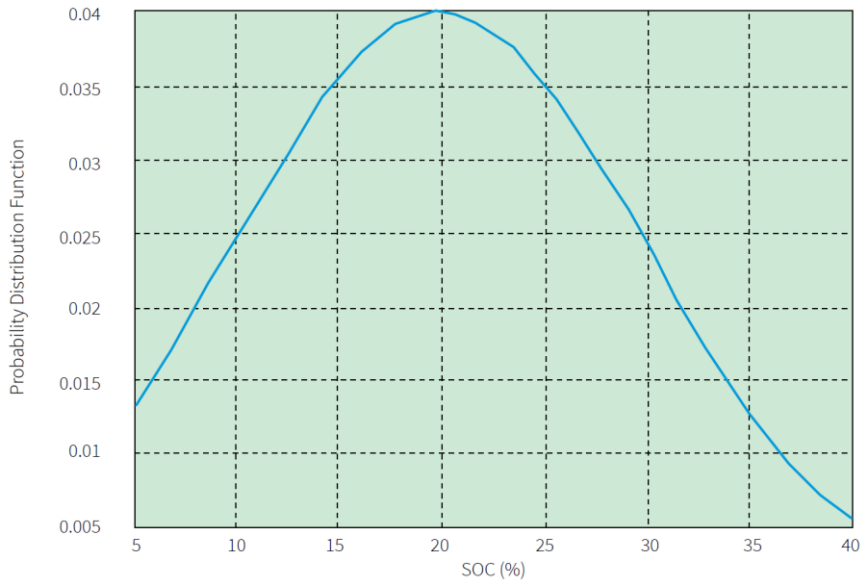
Stochastic approach for daily charging behaviour

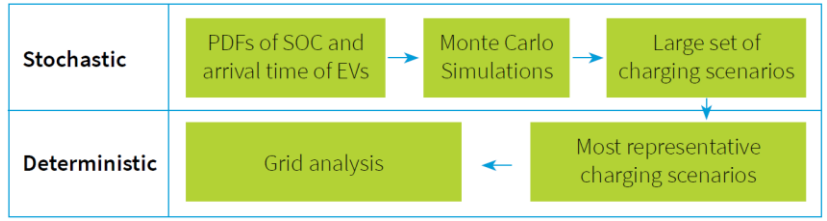






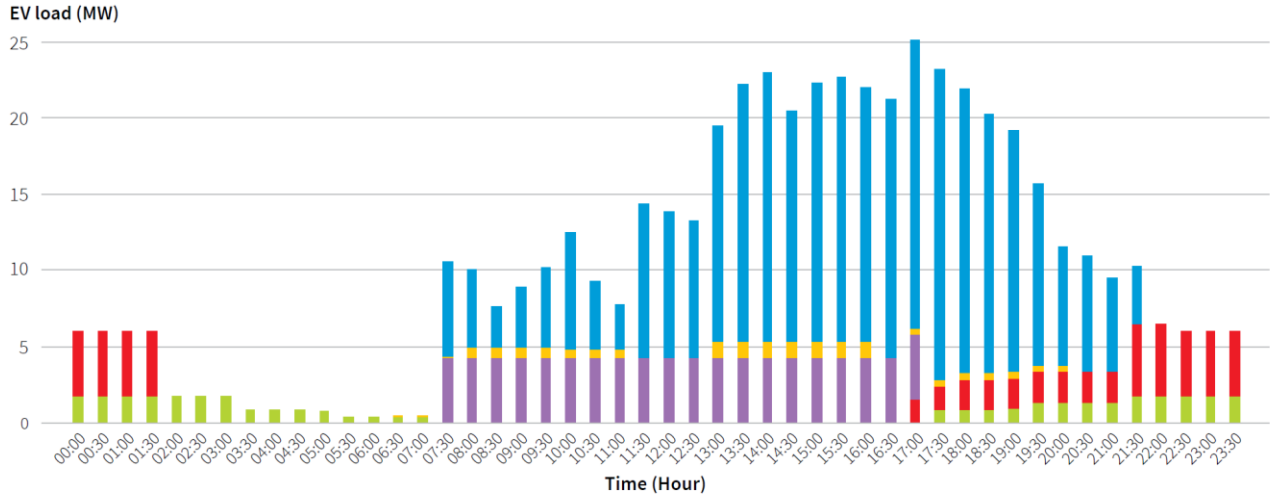




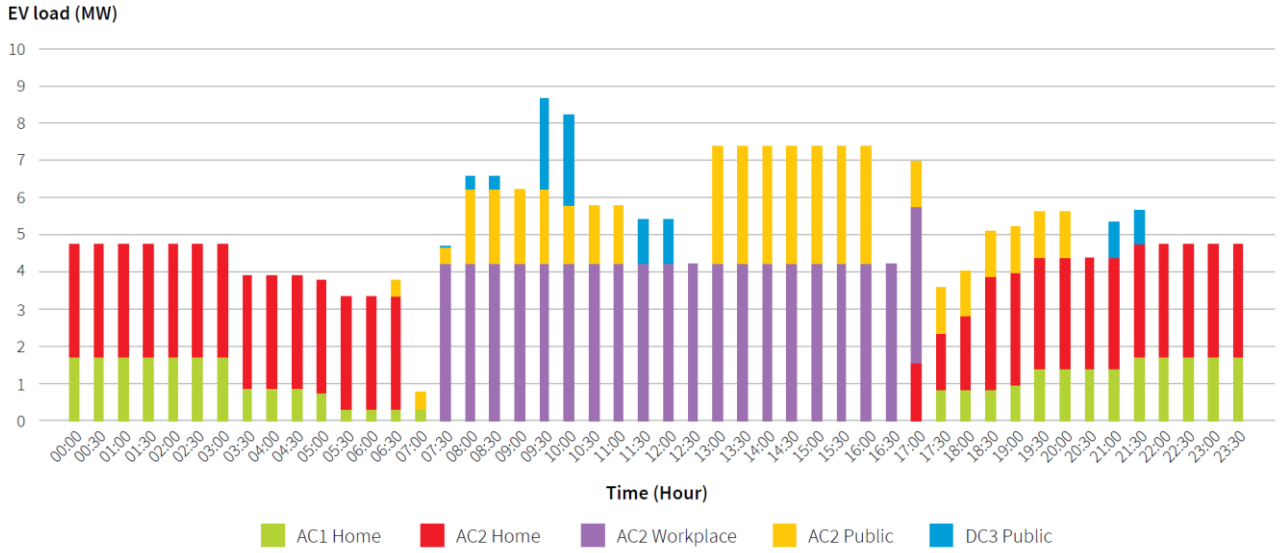


Distribution of charging behaviour according to different charging support scenarios

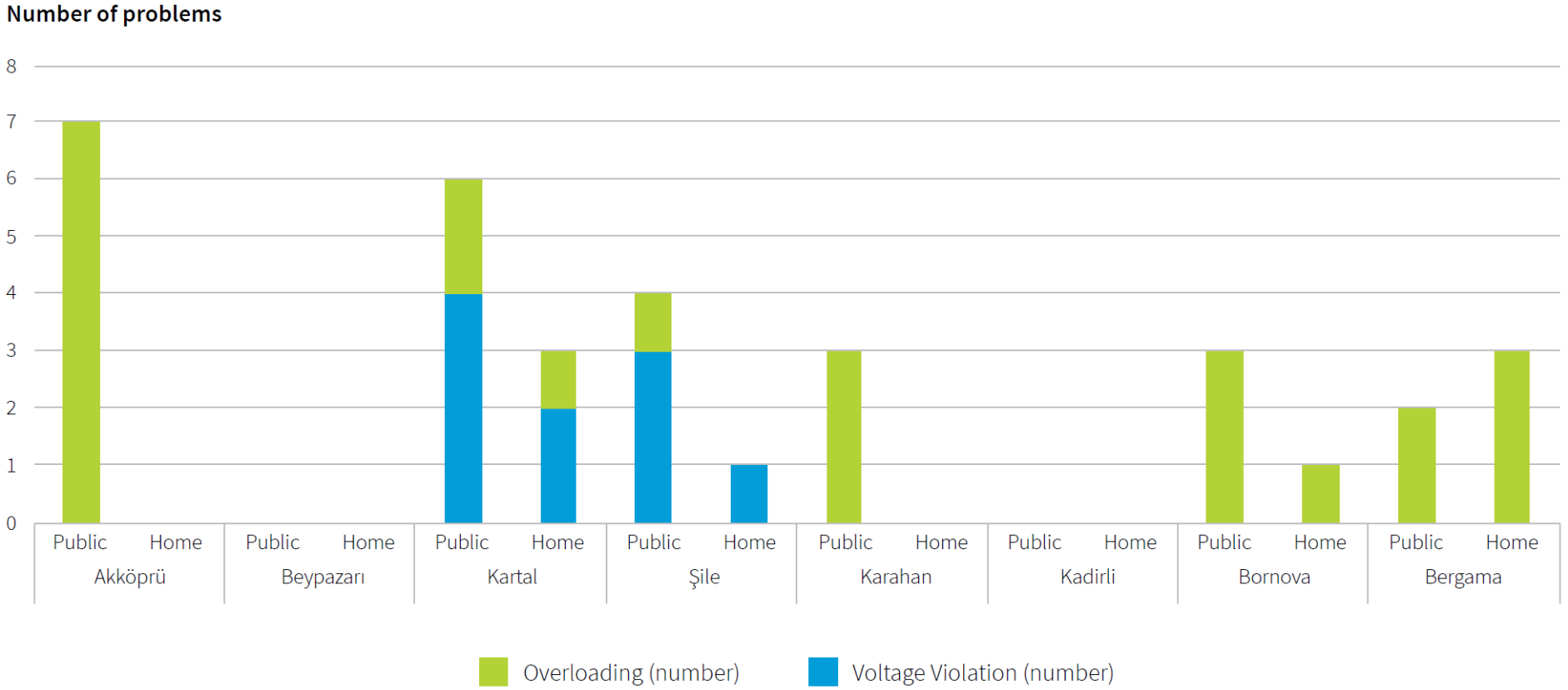
Public-based charging support



Home-based charging support



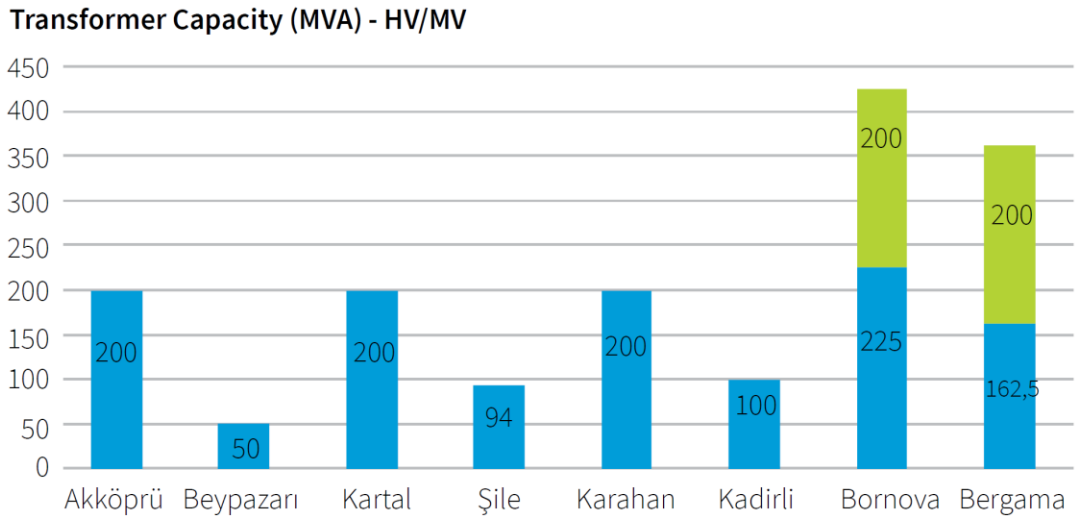
Impact of EV integration (High Growth scenario)

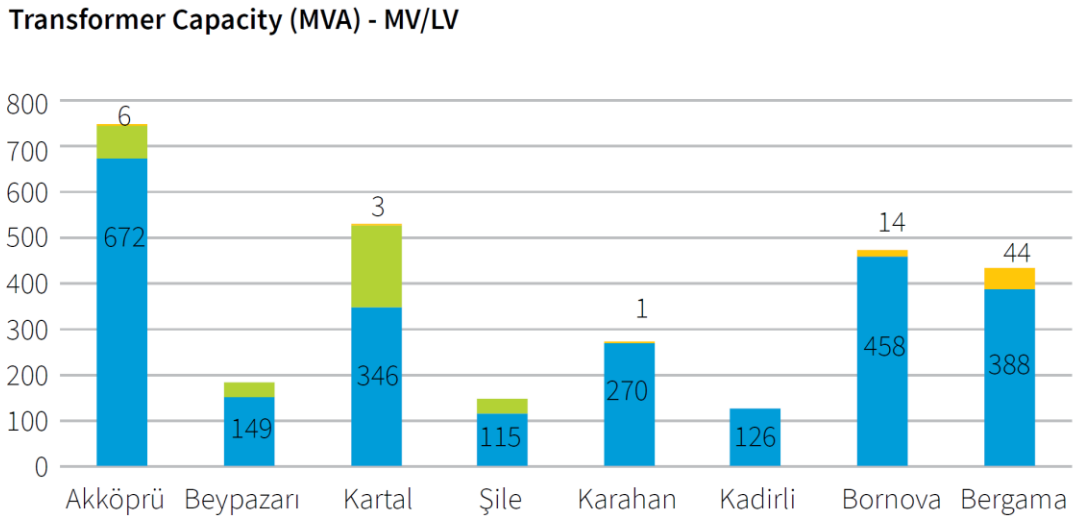


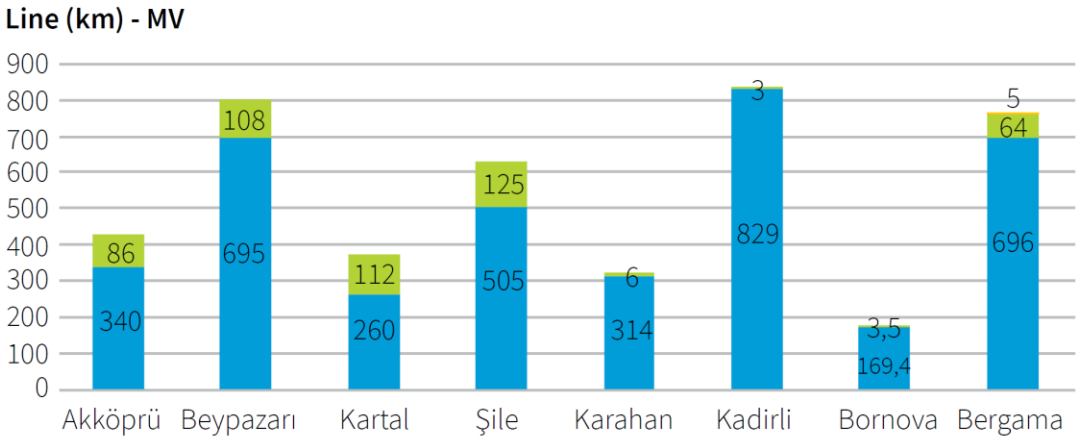
There is sufficient LV and MV distriubtion grid capacity available according to the investments in the Reference Model

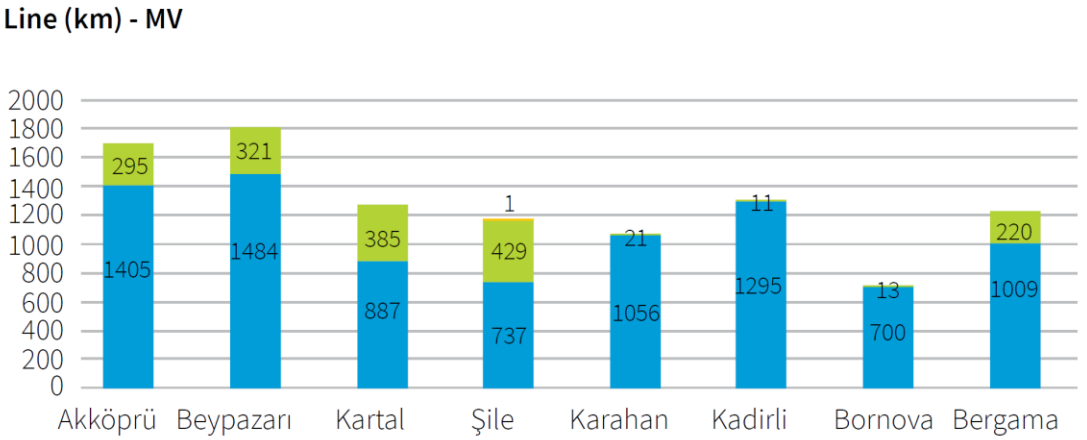
As a result, there is no additional investment needed in grids for EV integration, however, to minimise overloading limited additional investments may be needed in LV/MV transformer stations

Impact of EVs (High Growth scenario)



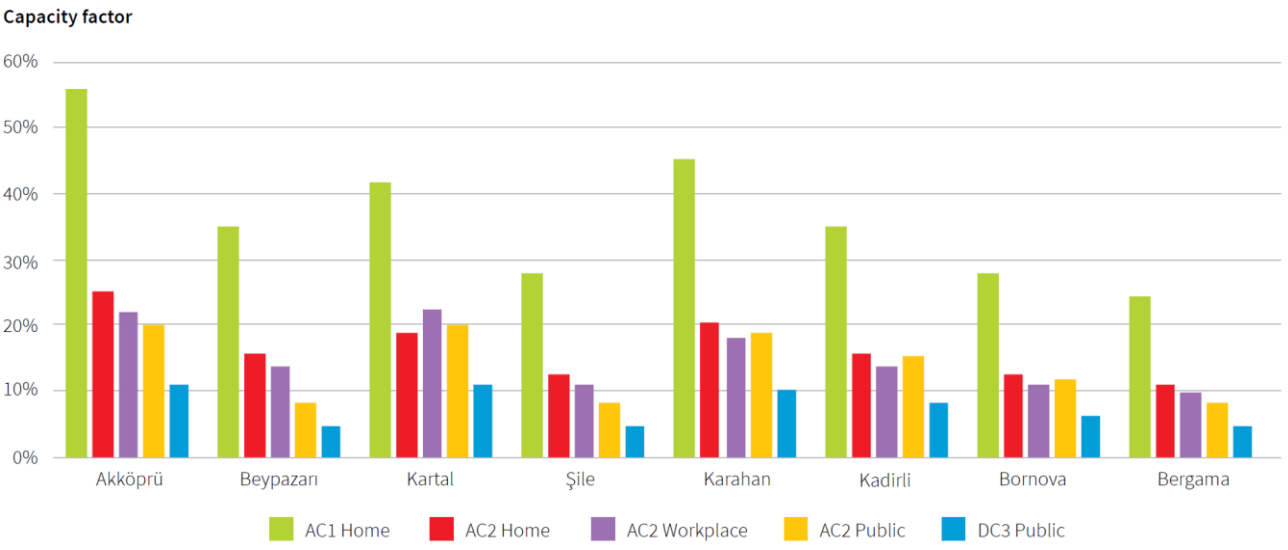




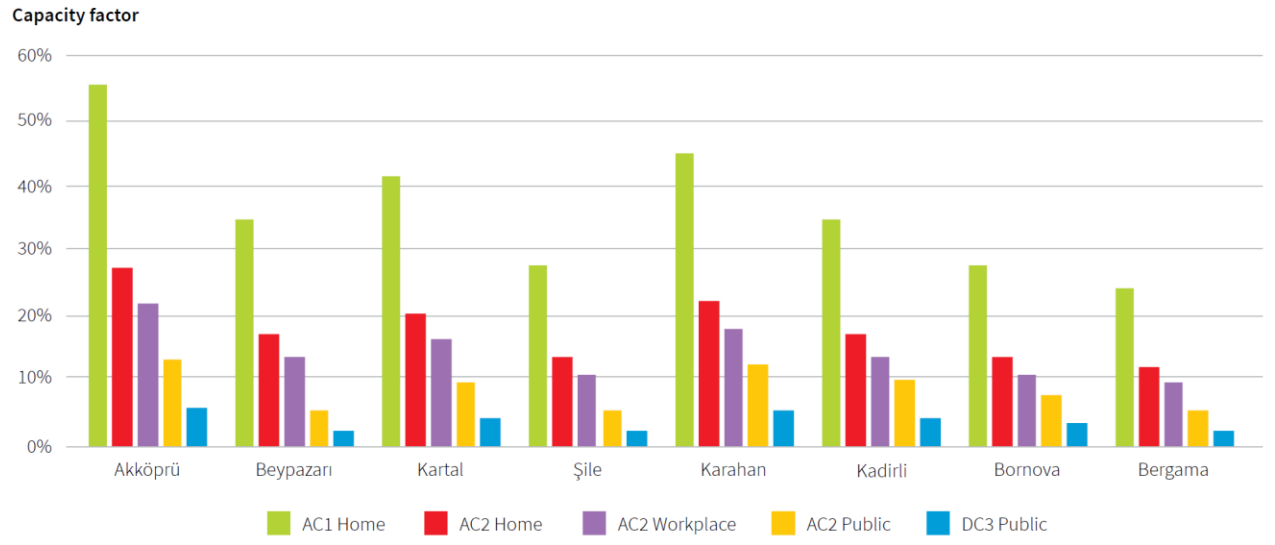


2018 Reference Model EV integration

Impact of EVs (High Growth scenario)



Public-based charging support

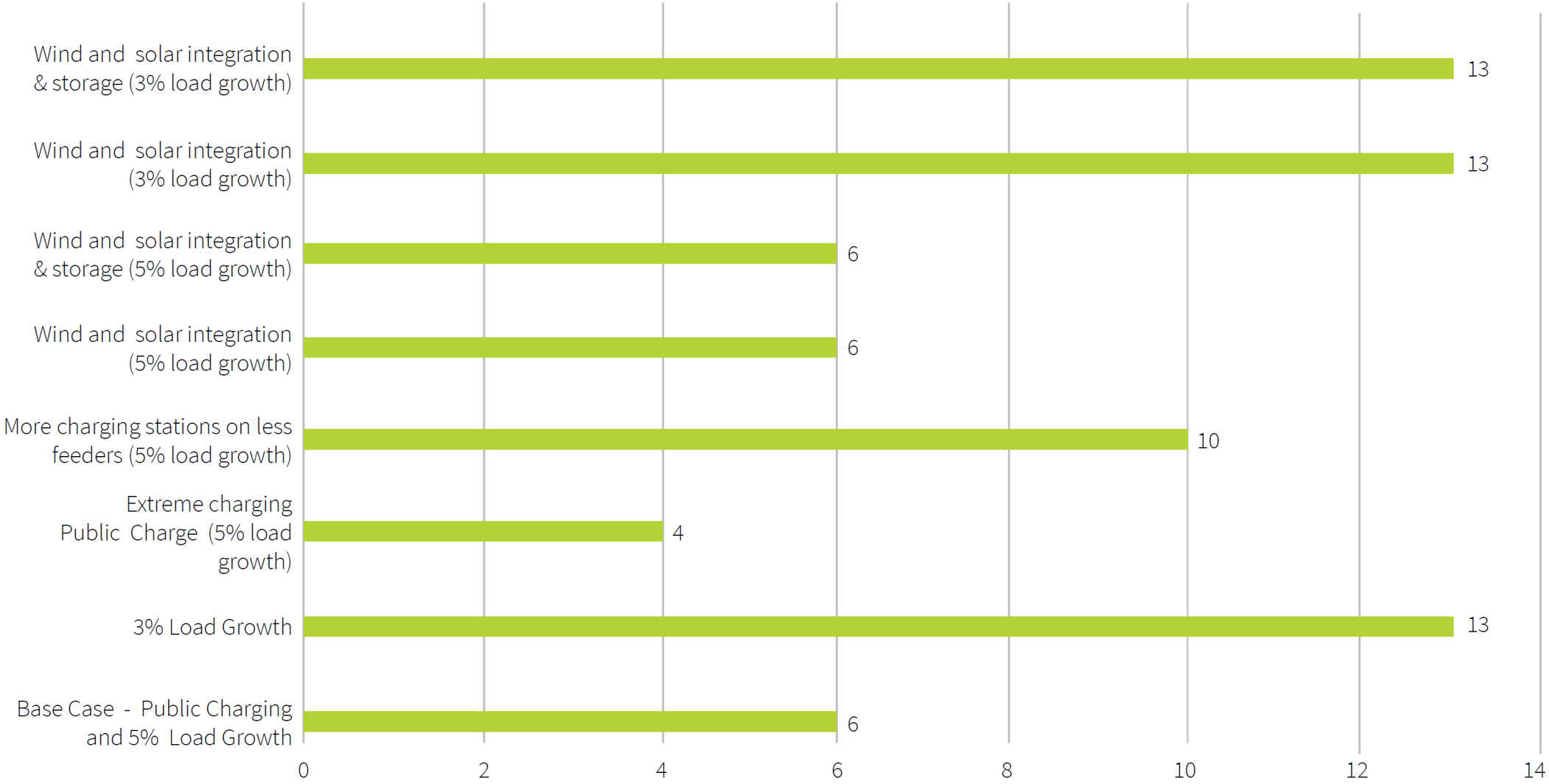


Home-based charging support

Sensitivity analysis: For Kartal pilot region and High Growth scenario

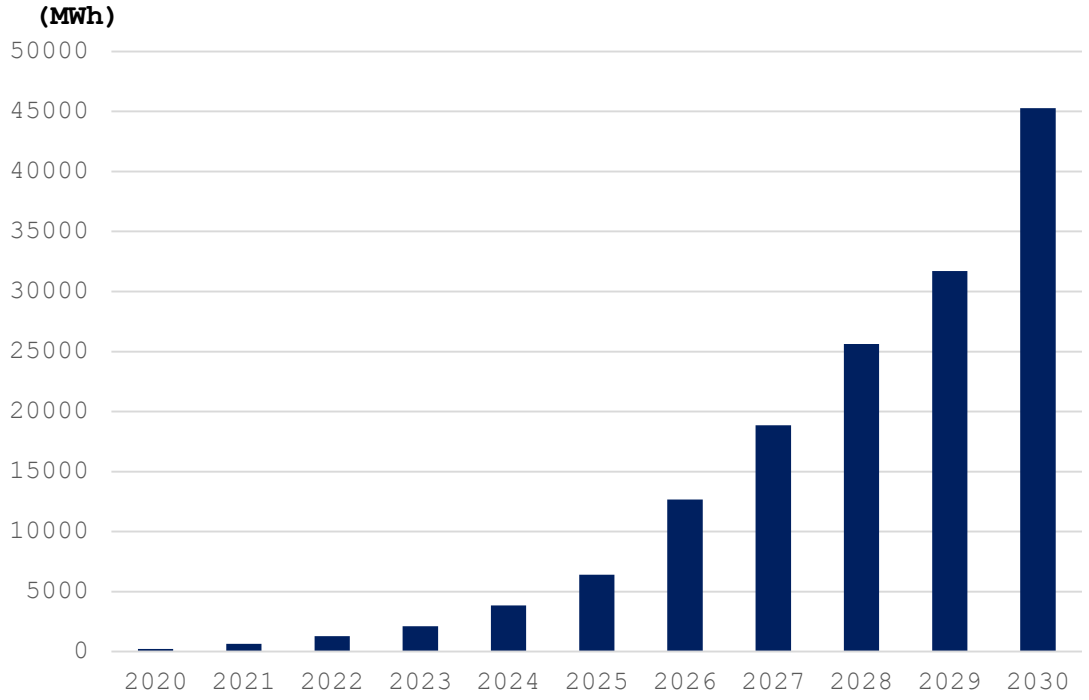
No	Key parameter	Default Assumption	Sensitivity	Explanation
Case I	Load increase	5% per year	3% per year	Reference Model is reconstructed with 3% load increment
Case II	Public charging behavior	Normal behaviour	Extreme behavior	More public fast charging during peak time
Case III	Distribution of charging points on MV feeders	Distributed uniformly	Concentrated (More chargers on few feeders)	Public charging points are reduced considering fixed amount of total EV load
Case IV	Renewables integration	Capacity of renewables in 2030 is equal to that of 2018	Additional renewables in 2030 (wind and solar)	10 MW renewable-based generation capacity (50% solar, 50% wind)
Case V	Storage integration	No storage in 2030	Storage in 2030	Storage with 5 MWh energy capacity

Sensitivity analysis: Number of voltage violation and overloading problems

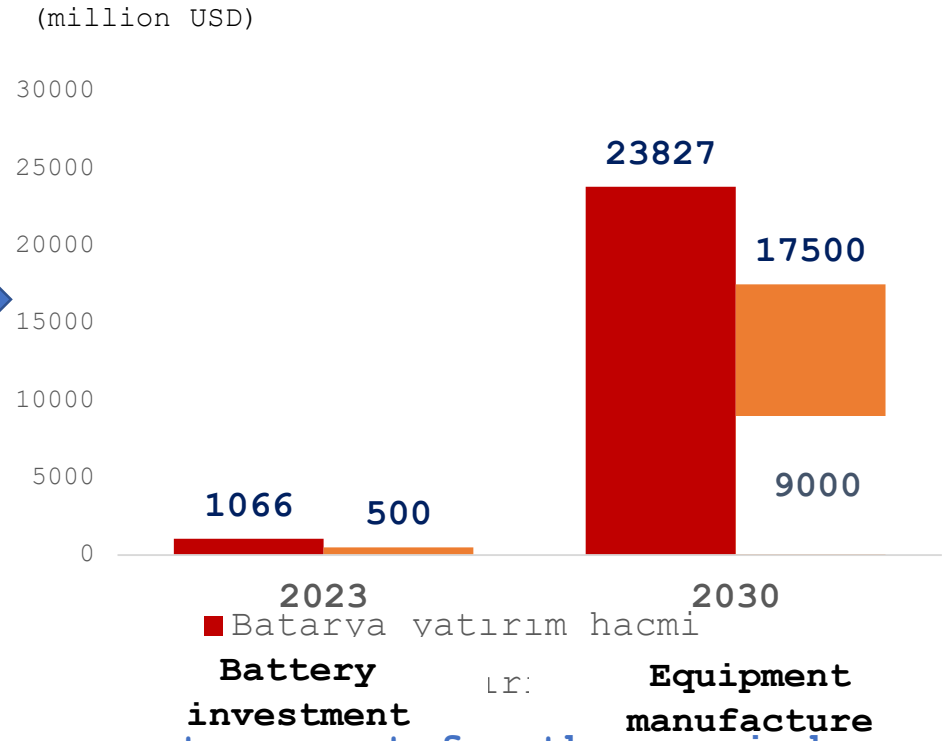


EV and energy transition battery storage development and investment needs

Total estimated battery storage capacity



Total estimated investment needs



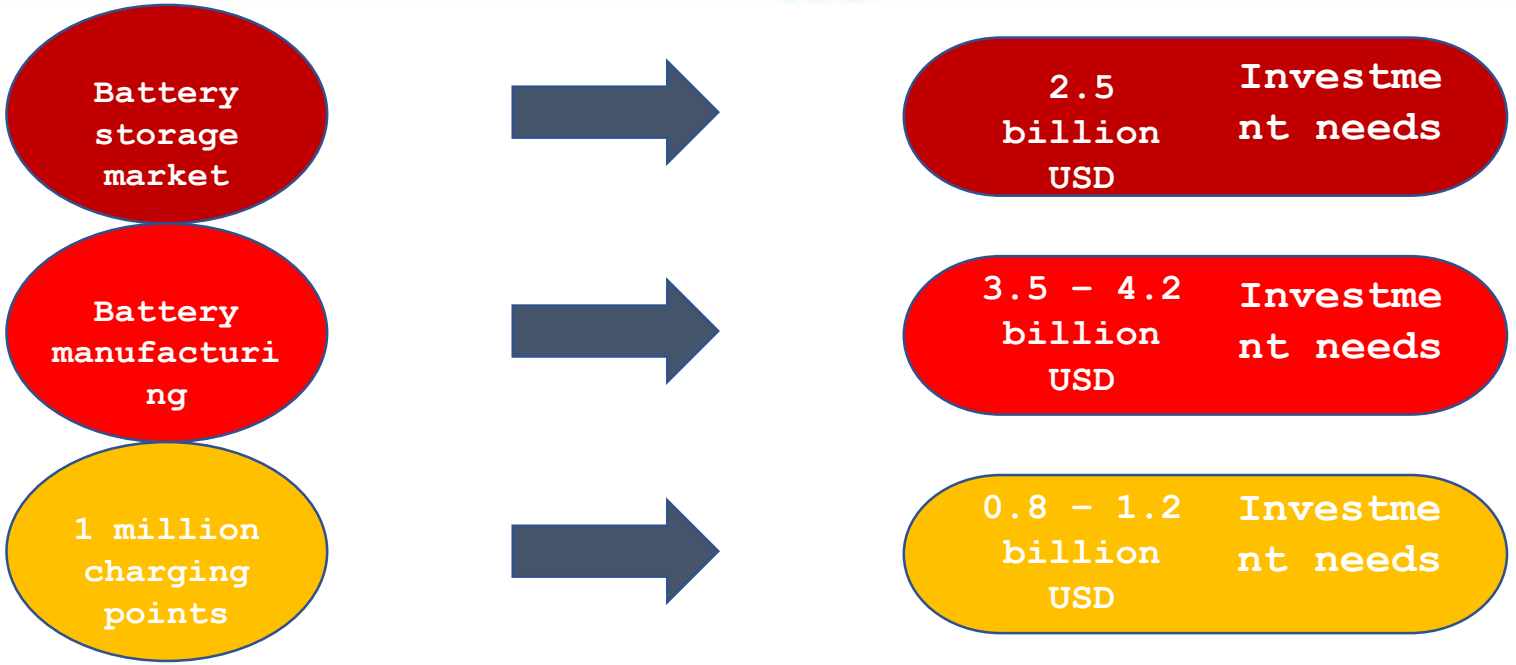
24 bn USD battery market – energy sector 3% with transport account for the remainder

Investment needs for equipment manufacutre 9.5-18 bn USD (all produced in Turkey)

Global battery market (2018/19): Power sector 4-5 bn USD & EVs 20-25 bn USD

Investment and Financing Needs for Energy and Transport Sector Transition

Share of renewable energy in electricity generation



Priority areas for transport sector transformation of Turkey

- Accelerate the market for EVs and charging services in parallel
- Develop and implement smart charging mechanisms for load management
- Develop region-specific measures to avoid overloading and voltage violations
- Assess, develop and implement new business models for EV charging
- Continue the planned investments in distribution grids in line with the growth in electricity demand
- Utilise synergies between EV charging and renewable energy integration and energy storage
- Assess and plan for utilising the benefits of EV development jointly with other sectors

Thank you!
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