Ministry of Economic Affairs
and Climate Policy

Smart and Green Mobility in Istanbul

Commissioned by the Netherlands Enterprise Agency

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Smart and Green Mobility in Istanbul

Netherlands Enterprise Agency

About
This report has been commissioned by the Netherlands Consulate General in Istanbul as a part of the Public Private Partnership programme of the Netherlands Enterprise Agency, RVO. This Fact-Finding Study Pre-PPS was coordinated by Eda Beyazit Ince (Istanbul Technical University – IstanbulON Urban Mobility Lab) and Kenan Aksular (Clearwater Innovations B.V.).

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Foreword

This study about the need of - and potential for - Smart and Green mobility in İstanbul addresses one of the biggest challenges for the number one Metropole in Europe and its new City Government. You might wonder why we, the Consulate General of the Netherlands in İstanbul, show such an interest to initiate this study. Like any other inhabitant of İstanbul, we too suffer in daily traffic jams, lose hours of productivity, face the same air quality issues and have to struggle on our bikes (the braves amongst us) or as a pedestrian for every meter in public space that was given so generously to automobiles in the past.

But that is obviously not the main reason to initiate this study. Driven by the need of its citizens, the Metropolitan Municipality of Istanbul and its 39 district municipalities are taking these issues seriously. Building on the necessary investments made on very public transport systems by former governments; now it is time to invest in smarter and greener solutions. The results of this study show that İstanbul Metropolitan Municipality is committed to such solutions and is looking for international collaboration to make the transition to smarter and greener mobility happen. Both Mayors, Ekrem İmamoğlu and Femke Halsema, picked this topic as the core theme for cooperation between Amsterdam and Istanbul.

The purpose of this study is to pave the way for the most promising fields for cooperation, on the city level and in involving business and knowledge institutes. This collaboration is based on demand (Istanbul) and potential supply (Netherlands), but this is definitely not seen as a one-way street. In our view, İstanbul will grow into a living lab for innovations in Smart and Green Mobility.
Therefore, we attach great importance to the fact that İstanbul is a core partner of the Knowledge & Innovation Community (KIC) Urban Mobility Program of the European Institute for Innovation & Technology (EIT). Many Dutch organizations, such as City of Amsterdam, City of Eindhoven, City of Helmond, Amsterdam Institute for Advanced Metropolitan Solutions, Technical University of Delft, Technical University of Eindhoven, University of Amsterdam and Achmea are also part of this KIC. This provides a good opportunity for collaboration and financial back up in bringing innovations into practice for the benefit of our cities.

I hope this study, thanks to our partners Istanbul Technical University – IstanbulON Urban Mobility Lab and Clearwater Innovations B.V., will inspire you to partner up in making this transition happen.

Bart van Bolhuis
Consul General of the Netherlands in Istanbul

Executive Summary

The aim of this report is to create a collaboration bridge between Dutch and Turkish Mobility sectors, especially among related organizations of Istanbul Metropolitan Municipality (IMM) regarding smart and green mobility. Drawing on the discussions on sustainable mobility and transport, this report brings out the challenges Istanbul is facing and investigates the ways in which IMM's ambitions in tackling these challenges may meet the Dutch expertise in order to open up channels for mutual learning and knowledge exchange. The conceptual framework of smart and green mobility is based on the three "Grand Narratives" suggested by Holden et al. (2020): electromobility, collective transport 2.0, and low-mobility societies. In this way, report develops a thorough review of the ways in which socio-technical transition towards smart and green mobility can be achieved and evaluates the recent developments in Istanbul within the given framework.

The methodology adopted in this study also includes a review of existing (officially published and non-official) plans and projects of the IMM regarding transport and mobility, and face-to-face interviews with five selected IMM officials as well as a follow-up meeting with the Deputy Secretary General responsible for transport, Head of Transportation Planning Directorate, Head of Smart City Department and Head of Transport Coordination Department who is also the EIT representative. As a result of the analysis of the gathered reports and interviews, partnership potentials and also the list of potential stakeholders have been revealed. The report is complete with an evaluation of Dutch consultants of the current gaps in IMM's plans regarding smart and green transport and the areas where collaboration between the mobility sectors in Istanbul and the Netherlands could be strengthened.

Overall, tools for the transition of Istanbul towards low-carbon mobility have been found as an important area to be further developed collaboratively including smart-city developments, electrification and designating congestion charging zones. Moreover, governing mobility is another area which Istanbul could benefit from the Dutch experience. Providing an agile, sustainable and resilient transport system is the foremost priority of IMM. In this sense, capacity building of not just local authorities but also citizens, NGOs and other institutions would be crucial for increasing awareness in sustainable and smart mobility of future cities.

Introduction:

(Un)sustainability of the transport system

Much of the debate in the last three to four decades has been on how transport can be made more sustainable since it has been one of the foremost consumers of the world's resources (Banister, 2005). From energy to land, from financial resources to social relationships, from natural resources to technological advancements, transport sector consumes a substantial amount of human and non-human resources. In this economic growth-driven world we live in, transport infrastructure and planning are encouraged to provide faster, greater, more efficient, even door-to-door transport systems that transforms the living environment by and large. Smart mobility, primarily suggesting technology (businesses) and governance (local & national governments) to collaborate in order to overcome the environmental burdens of increasing levels of mobility, is one way of tackling the adverse impacts of transport – but it alone is not sufficient. Instead, "greening passenger transport" (Moriarty and Honnery, 2013) should also continue to be in the agenda of transport policy makers, planners and practitioners more than ever in order to ease the transition from unsustainable transport to sustainable mobility and transport. By reviewing the existing evidence worldwide and providing insights from Istanbul Metropolitan Municipality (IMM), this report aims to create a bridge for collaboration between Dutch and Turkish mobility sectors regarding smart and green mobility.

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In his analysis of the unsustainability of transport, Banister (2005) proposed seven principles for transport systems to be sustainable. These are (i) traffic congestion, (ii) air pollution, (iii) traffic noise, (iv) road safety, (v) degradation of urban landscape, (vi) use of space by traffic (car ownership) and (vii) global warming and additionally three land-use and development factors as (i) decentralisation of cities, (ii) development pressures and (iii) globalisation and the relocation of industry. A fresh and brief look at the worldwide data regarding these principles and assessing where we are now after decades of warnings by the experts would reveal the current (un)sustainability of transport systems.Traffic congestion has become a global issue not only due to increasing levels of air pollution it generates but also great economic losses it causes. Every year reports are published to demonstrate the impacts of traffic congestion on national economy. For example, a transport data firm, INRIX, in their 2019 Global Traffic Scorecards, illustrates American drivers lost $88billion that is equivalent of 99 hours per year while British drivers lost £5.2billion for 115 congested hours and German drivers €2.8billion for losing 46 hours in traffic (INRIX, 2019). According to TomTom Traffic Index in 2019, 15 cities around the world were subject to more than 50% of congestion, while 25-49% congestion level was observed in 201 cities, 165 cities experienced 15-29% average congestion levels while only 35 cities had congestion below 15% (TOMTOM, 2019a). Almost 40% of cities that encountered 25-49% congestion had population less than 800 thousand inhabitants (ibid). While Beijing hits the record with 12-days of traffic jam in 2010 ironically due to heavy trucks carrying supplies for new road work (Gorzelany, 2013), the seminal research of Cervero and Landis (1997) once again sheds light to the fact that more roads to ease the congestion only ends up generating induced travel demand and leads up to a cycle of no solution. Therefore, increasing car ownership which is a global phenomenon and likely to double up to 2 billion by 2040 (Smith, 2016) continues to be one of the reasons for unsustainable transport leading also to cumulative air pollution in cities and their surroundings. The last two centuries have witnessed a colossal increase in the world's land and ocean surface temperature at around 1oC, with CO2 levels rising by 40% in the atmosphere since 1750 (IPCC, 2014). As one of the consequences of the Industrial Revolution, anthropogenic emissions have accumulated largely in the atmosphere, some being emitted by oceans and land, and since 1970s they have risen to the highest in history as CO2 emissions hitting 2040GtCO2 in 2011 (ibid.).

In this alarming picture calling evidence for global warming, transport sector has a major role to play. Transport sector accounts for about 20% of total CO2 emissions worldwide[1] . Moreover, transport consumes almost 30% of world's energy production (Figure 1). As also seen in Figure 1, greenhouse gas emissions from transport are increasing at a faster rate than any other energy-using sector and road transport with as high as 71.7% of all transport-related population in Europe (EEA, 2019a), is a major contributor to local air pollution and smog in the atmosphere that spread around the world (Global Energy Perspective, 2019). In fact, transport related air pollution became one of the major reasons of premature deaths and chronic illnesses, WHO estimates, as small particulate matters (PM10 and PM2.5) bypass body's defences easily, and along with O3, to which also road transport is a major contributor, harm human health by and large (WHO, 2015). Figure 2 demonstrates the spatial distribution of daily concentration of PM10 in Europe where especially Northern Italy, Poland, Eastern Europe and Turkey are the leading countries with high levels of PM10 (EEA, 2019b). Turkey and Poland have also experienced the largest growth in total greenhouse gas emissions from transport between 1990 and 2017, with an increase of 250% and above 200% respectively (EEA, 2019a). Road transport being the foremost contributor to CO2 emissions as well as other gases and particles, aviation and maritime transport are posing even a larger threat regarding climate change.

1 Total CO2 emissions worldwide in 2018 is 37.1 Gt (https://www.icos-cp.eu/GCP/2018). Transport sector's CO2 emissions by the same year was 8 Gt (https://www.iea.org/reports/tracking-transport-2019) making 21.5% of CO2 worldwide.

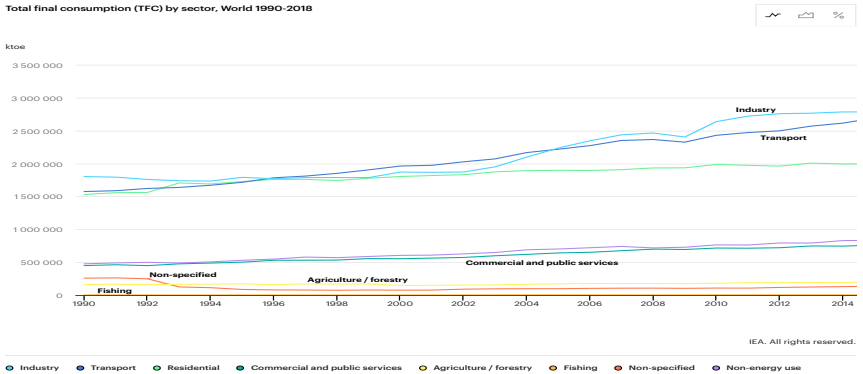


Figure 1. World energy consumption by sector (1990-2017) International Energy

For example, in 2017, road transport was responsible for almost 72 % of total greenhouse gas emissions from transport (including international aviation and international shipping). Of these emissions, 44 % were from passenger cars, 9 % from light commercial vehicles and 19 % came from heavy-duty vehicles. However, due to increasing levels of air travel and growth of air logistics, greenhouse gas emissions from international aviation more than doubled within 30 years (a 129% increase compared to 1990 levels), followed by increases in international shipping (32 %) and road transportation (23 %) emissions (EEA, 2019a).

Traffic noise causes serious health impacts including sleep disturbance, headache, high blood pressure, dizziness and fatigue. According to European Environment Agency (EEA, 2019a) 20 million Europeans experience annoyance from noise while 8 million suffer sleep disturbance and at least 10 thousand premature deaths occur due to traffic noise. Moreover, aviation is another source of noise disturbance as it affects large number of people and children who mostly suffer reading impairment in Europe. According to World Health Organization (WHO), every year the lives of approximately 1.35 million people are shortened as a result of a road traffic accident and between 20 and 50 million more people suffer non-fatal injuries, with many incurring a disability as a result of their injury (WHO, 2018). Road traffic injuries mostly affect children and young people, leading to higher rates of death between ages of 5 – 29. Moreover, risks of road traffic deaths are not even across the world as it hits developing countries at a higher rate, in fact one of the important determinants of mobility injustice (Sheller, 2018). For instance, the number of children under fourteen die in China is 2.5 times than the number in Europe and 2.6 the number in the USA (ibid.). Last but not least, unsustainability of transport causes degradation of urban landscape and urban fabric due to construction of new roads and other transport facilities (Banister, 2005). As cities become more populated, mass transport systems requiring larger land in urban areas become necessary for most cities. In addition to building roads and bridges, the cities that choose the sustainability path build more transit systems including metros, trams, train lines which also create significant changes in the urban fabric. As Kennedy et al. (2005) discuss while aiming a vibrant urban economy, it is also essential to make communities, shopping areas, and business locations accessible and attractive for pedestrians and cyclists. With regard to the above mentioned facts, transition from an unsustainable mobility system to a sustainable one, or strengthening and developing available sustainable mobility plans play a crucial role in transport planning practices. Banister (2008) defined the sustainable mobility as a new paradigm in planning, which sets a better set of goals than previous approaches in transportation planning due to its focus on change and difference. One of the main goals in the new paradigm is to reduce the number of motorised trips in global and local cities. Reducing motorised trips has recently become one of the main objectives of international transport policies. The European commission aims to halve the use of conventional fuel vehicles in urban transport by 2030 (EC, 2011). Banister (2008) argued four key elements of sustainable mobility as (I) making the best use of technology for fuel reduction and behavioural change; (II) demand management and pricing in order to reduce the number of motorised trips, trip distance and changing the modal split; (III) integrated land use and transport policies to reduce the distance travelled; and (IV) increased awareness and acceptability of sustainable policies.

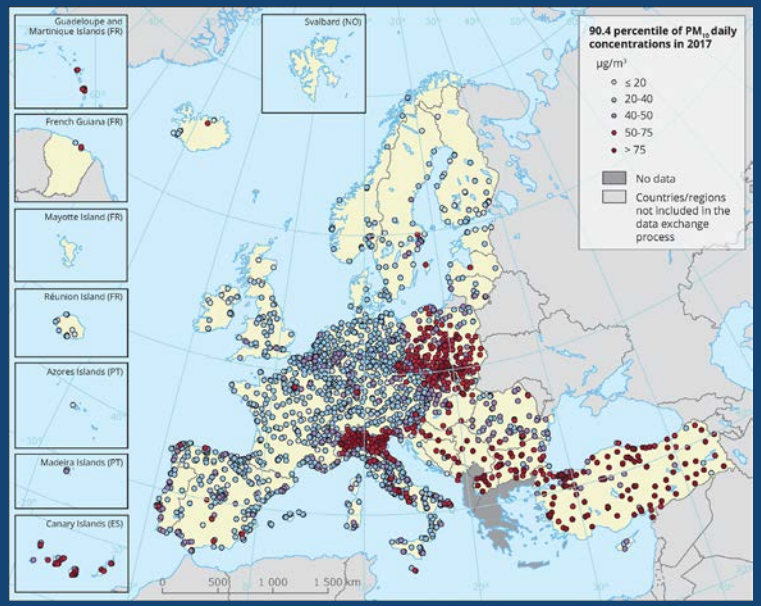


Figure 2. Concentrations of PM10, 2017 — daily limit value EEA, 2019b.

Although these arguments are still valid, "the unsustainable mobility system still exists today" (Holden et al., 2020). Yet, transport policy, planning and technology are well equipped with the necessary tools and knowledge to transform the transport and mobility system into a sustainable one.

Drawing on the discussions on sustainable mobility and transport, this report brings out the challenges Istanbul is facing as the largest metropolitan area within its near geography with a population reaching up to 16 million as of 2019 and investigates the ways in which Istanbul Metropolitan Municipality's (IMM) ambitions in tackling these challenges may meet the Dutch expertise in order to open up channels for mutual learning and knowledge exchange. In the following section, first of all, theoretical background of green and smart mobility is explained. This is then followed by the presentation of the methodology used for the Public Private Partnership programme (pre-PPS) Smart and Green Mobility Istanbul and the study carried out between January – March 2020 is explained. Section 4 gives an overview of the existing situation in Istanbul regarding plans and projects that promote smart and green transport. Section 4 also draws the ambitions of the newly elected Mayor of Istanbul (June 2019) and his team in diverting Istanbul's transport policies to a more sustainable path. Section 5 discusses how these ambitions and future expectations can be met with the Dutch expertise framing the potential areas for partnership as well as potential partners from public and private sector as well as civil society. Section 6 concludes with the steps forward to realise the future areas for collaboration.

The way forward: Green and smart mobility

Electromobility

Collective transport 2.0

Low-mobility societies

Discussions in the previous section demonstrated that there is a need for a change in the ways in which practitioners, politicians, planners and citizens think about transport and mobility. In a more recent attempt to develop a state-of-the-art framework for sustainable transport the Holden et al. (2020) propose three "Grand Narratives", as they call it, for achieving sustainable mobility: electromobility, collective transport 2.0, and low-mobility societies – none of which would present comprehensive solutions when applied on their own, therefore, a combination of all three would be crucial for the success of sustainable mobility.

Electromobility focuses mainly on transition to vehicles that uses new/alternative energy sources as opposed to fossil-fuels. This implies not only electric vehicles (EVs) that "come in many configurations including battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV), range-extended electric vehicles (REV), and fuel-cell electric vehicles (FCEV)" but also hydrogen vehicles, and not only regarding private cars but all fossil-fuel based vehicles such as "vans, buses, heavy-duty vehicles, rail, ships, and short distance planes with corresponding EV drive-trains" (Holden et al., p.5). Authors draw attention to two most important criteria for EVs to become robust alternatives to fossil fuels: clean source of energy which should be carbon-free, and sufficient grid capacity.

Clean source of energy is the first rule of mobility based on electric vehicles. From high spectrum EVs with 600km range and 100kWh lithium ion battery (Tesla S) to a typical EV with about 60kWh battery and 400km range (Renault Zoe), EVs consume about total energy equivalent of lighting up a small flat for one to two months. These light duty vehicles (LDVs) may cut CO2 greatly but they would be very ineffective in countries with carbon-intensive electricity policies (Tran et al., 2012). Although there is a shift from high-carbon sources and other greenhouse gas emitters to renewables especially in Northern and Western European countries, in 2018 worldwide energy consumption was primarily based on petroleum and other liquids (32%), coal (26%) and natural gas (22%) while renewables generated only 15% of global energy (EIA, 2020). With increasing uses of smart grids based on renewable energy (Teixeira et al., 2015) and advancements in vehicle-to-grid (V2G) operations (Mwasilu et al., 2014), as well as development of super charging stations, EVs are likely to gain more presence on roads. This not only includes private EVs but also EV buses, trucks and other vehicles.

Although EVs may take over once technological advancements are in place, private EVs would still be replacements of automobiles. Since cars are not only consumers of clean air but also consumers of land, urban space and social relations (e.g. Jacobs, 1992). Therefore, it would be a missing attempt to just focus on the technological side of EVs and not to the social transition side of them. For "socio-technical transitions to sustainability" to take place, technological advancements should be accompanied by cultural changes, policy support including regulations and other instruments (Geels, 2002). In the case of EVs, one way of bringing them as alternatives to private cars is the three revolutions: electric, automated and shared (Sperling, 2018). This revolutionary thinking leads us to the second narrative, collective transport 2.0.

Collective transport 2.0 builds on the necessity to advance the use of public transport but also proposes a shift from 'ownership' to 'usership' forms. The former involves increasing ridership levels in public transport while the latter refers to the same issue regarding the private cars, leading to shared mobility as discussed earlier.

Public transit will have to continue to be the backbone of transport systems since "only public transit can address" issues of traffic congestion as well as impacts of transport on health and quality of life (Currie, 2018). Yet, as Holden et al. (2020) suggest it is likely to upgrade to a newer version. Some operators already mix conventional public transport with newer business models of shared mobility. As Currie (2018) reports, especially rail operators provide feeder options such as bike sharing (which has been adopted in the Netherlands for some time) and car sharing (e.g. Germany).

Different combinations between conventional public transport and new sharing models make the system more attractive while increasing ridership levels and reduce transit costs. Therefore, shared mobility especially as a feeder system to public transport has the opportunity to captivate car users to shift to from private mobility to public transport.

Much has been said about the autonomous vehicles (AVs) in the past decade. Although their impacts are less known – anticipated impacts regarding issues such as travel demand, changes in accessibility, land-use implications and job losses are still in the shade (Milakis et al, 2018) – AVs are likely to be used in cities in different modes (buses, BRTs, shared cars). Their involvement in the shared mobility schemes may also create attractiveness of public transport.

Another novelty that brought much excitement to the transport field has been Mobility as a Service (MaaS). MaaS "combines different transport modes to offer a tailored mobility package, similar to a monthly mobile phone contract and includes other complementary services, such as trip planning, reservation, and payments, through a single interface" (Jittrapirom et al., 2017). Mobility as a Service (MaaS) is the integration of various forms of transport services into a single mobility service accessible on demand.

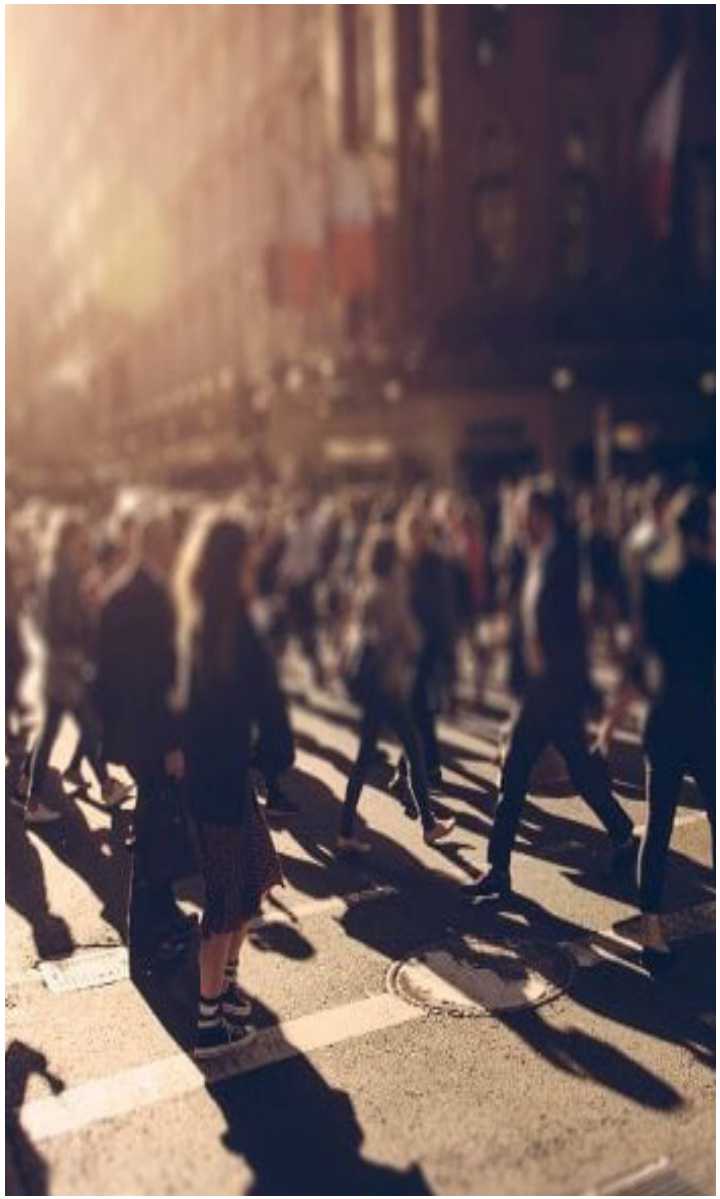


photo source: iStock

To meet a customer's request, a MaaS operator facilitates a diverse menu of transport options, be they public transport, car-, ride- or bike-sharing, taxi or a combination thereof. For the user, MaaS can offer added value through use of a single application to provide access to mobility, with a single payment channel instead of multiple ticketing and payment operations. While strong opposition arise to the current applications of MaaS firstly, for encouraging mobility for those who can pay for it due to its service packaging and secondly due to the privatisation of public services under MaaS (Pangbourne et al., 2020), robust regulations and governance are crucial for the system to support sustainability. Therefore, green and smart mobility has an important prerequisite for success, that is sustainable governance of transport systems.

Smart cities concept, and as one of its sub-areas, smart mobility, comes with a governance package in addition to all the technological advancements and uses of ITS in transport and mobility. Smart city concept taking over the agendas of local and national authorities more than the academics in the last decade (Eremia et al., 2017), focus on a range of characteristics that transforms the city into a smart one: environmental, economic, climate friendly, innovative, sustainable, resource efficient, resilient, inclusive and liveable cities achieved through tools of ICT, integrated planning, participatory approach and smart financing (ibid.). Smart cities that are believed to play an important role in the construction of a better future, use digital technologies or information and communication technologies to increase the quality and performance of urban services, reduce costs and resource consumption and provide more effective services to their citizens. Having said that, the concept met a large criticism especially from academia as too much emphasis has been made to the smart city concept which is another way of describing digital and sustainable development. As Batty (2018) highlights what makes a smart city is its citizens. Therefore, without participatory and democratically driven human-oriented and just policies, cities would not become any smarter.

The aforementioned implications of smart mobility such as uses of EVs combined with smart energy distribution grid, AVs that give freedom to passengers, shared mobility for first and last mile solutions and MaaS where ownership is replaced by usership all need a "strong regulatory posture" (Docherty et al., 2018) and good governance capacity especially at the local level for long-term inclusive strategies for the majority of societies.

Low-mobility societies are more about challenging the way of life than the way of travelling (Holden et al., 2020 p. 6). Holden et al. (2020) makes a great emphasis on car-free cities and call for replacing the need to travel by car with walking, cycling and well-functioning public transport systems. There are several examples of car-free areas in and around Europe with squares connecting with parks, pedestrian areas and high-quality urban spaces. There are in fact car-free islands right in the heart of Istanbul, the Prince's Islands. Similarly, home-zones schemes that originated in the Netherlands over three decades ago which was then followed by Germany and Britain, with low speed limits provide a healthy and safe environment for children and the elderly (Nash and Whitelegg, 2016). Other planning and policy-related implementations include congestion charging schemes and low-emission zones that not only help reducing the amount of carbon emissions significantly in selected zones but also leave large areas in cities to pedestrians, cyclists and public transport riders (Beevers and Carslaw, 2005; Nash and Whitelegg, 2016; Henriksson et al., 2011).

In addition to car-free zones, one may propose that urban development with more mixed uses and poly-centric structures also reduce the need to travel longer distances and therefore, contribute to low-mobility levels (Banister, 2008).

Making shorter trips but also travelling less with the help of communication technologies and the internet (for shopping, teleconferencing and alike), in addition to replacing motorised travel with non-motorised modes of travelling would contribute to "the reduction strategy" (Holden et al., 2020) that would contribute to a low-carbon, low-mobile and greener transport system.

Holden et al. (2020) call for 'thinking inside the box' for a change, as we are already quite advanced in technology and knowledge. In this sense, we should be making use of existing systems more efficiently while satisfying basic transport needs of citizens, ensuring transport justice and respecting environmental limits (ibid.). Building on existing knowledge on transport and mobility, Figure 3 presents a smart and green mobility framework which will guide our evaluation of Istanbul's existing plans and policies in Section 4.

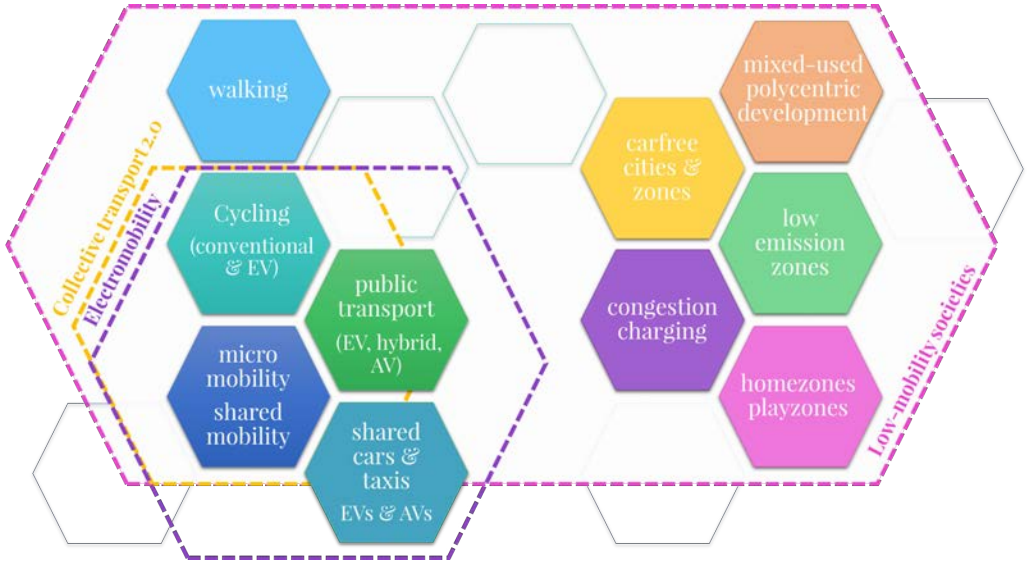


Figure 3. A framework for smart and green mobility (based on Holden et al., 2020)

Methodology

In order to bring out the possible partnership fields between the Dutch partners and the Istanbul Metropolitan Municipality (IMM) that will enable transition to a green and smart urban mobility and also to reveal the current gaps and lack of expertise in green and smart mobility in Istanbul, the methodology adopted in this study includes a thorough review of existing reports of the IMM and face-to-face interviews with selected IMM officials.

First of all, online local reports such as governmental documents, websites, books and academic dissertations were collected and the available information were extracted from these studies. Secondly, in order to understand the IMM's aspirations for green and smart mobility, in-depth, one to one interviews were carried out with five IMM officials. During February 2020, Head of Transportation Planning Directorate, Head of Transport Planning Department, Head of Smart City Department, Head of Transport Coordination Department and IMM's EIT representative have been interviewed regarding IMM's ongoing and future plans . In addition, interviewees have been asked for their permission to have access to the unpublished reports of the IMM related to their short-term, medium-term and long-term urban mobility plans. As a result of the analysis of the gathered reports and interviews, partnership potentials and also the list of potential stakeholders have been revealed.

Thirdly, IMM officials have been consulted to acquire access to the unpublished plans and projects regarding transport and mobility. Some of the relevant reports and documents of IMM that have never been implemented (according to the IMM officials), have examined thoroughly and the contents related to keywords such as "smart cities", "smart mobility", "sustainable urban transport", "sustainable development", "public transit" and "non-motorised transport" have been extracted. Finally, Dutch consultants have defined the current gaps in the IMM's plans regarding smart and green transport and determined the areas where collaboration between the two countries' mobility sectors could be sustained. A follow-up meeting based on the initial findings of the study was conducted with the Deputy Secretary General responsible for transport, Head of Transportation Planning Directorate, Head of Smart City Department and Head of Transport Coordination Department along with the Consulate in order to discuss further areas for collaboration.

Mobility in Istanbul:
Green and Smart?

According to the data of the Turkish Statistical Institute (TurkStat, 2020), almost 20% of total motor vehicles and almost 25% of total cars in Turkey are registered in Istanbul (Figure 4). The data of Energy Market Regulatory Authority indicated that the city of Istanbul consumed 18% of total fuel used in Turkey. Such high level of fuel consumption and subsequent emissions impose massive environmental costs. In Istanbul alone, traffic congestion accounts for $3.12 billion in wasted time. In addition to this, the total length of vehicle queues has reached 1100 km on the congested roads during the morning peaks (between 8:00-10:00 AM) in Istanbul (sirket.yandex.com.tr, 2015 in Kilavuz and Kisla, 2016). Furthermore, it takes 2.5 times longer for Istanbulites to return their homes between 18:00-20:00 PM, compared to journeys in free-flowing traffic (Kilavuz and Kisla, 2016). In a global scale, Istanbul with 55% of congestion level (Figure 5) which is an indicator of the travel time percentage that people are spending in congested traffic, is among the first six megacities with more than 8 million inhabitants and over 50% congestion time (TomTom, 2019b).

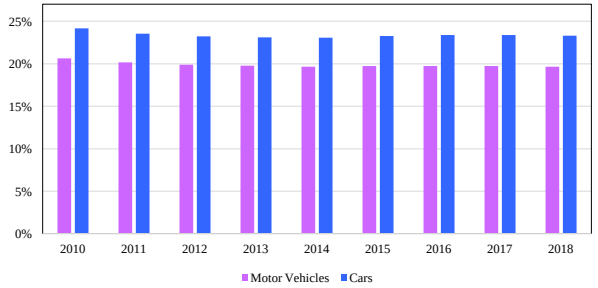


Figure 4: Ratio of all motor vehicles and automobiles in Turkey that are registered in Istanbul by year

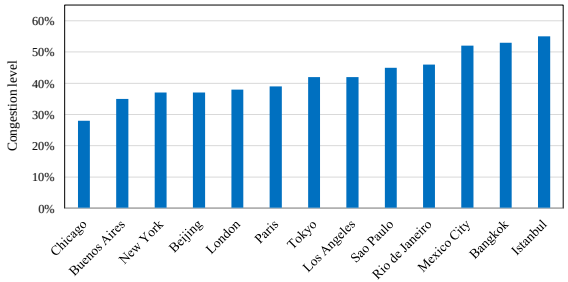


Figure 5: Congestion levels of megacities with more than 8 million inhabitants (Url-2)

In Turkey, especially in planning projects carried out by ministries and municipalities, problems of the existent transportation systems such as increasing private car ownership, inadequacy of the public transport network and parking have been discussed by and large. Reports indicate that existing mobility and transport problems arise from similar reasons; failures to adopt the smart and sustainable transportation principles and thereof, unsustainable transport policies based on road transport and fossil fuels that generate not only social and economic burdens on society but also irreversible impacts on the environment. Therefore, it is crucial to find solutions that can decrease the impact of private vehicles in traffic and lead to sustainable mobility systems in Istanbul by means of new technologies and sustainable transport.

An Evaluation of Existing Plans and Projects

Sustainable Mobility Issues in Istanbul

In the pre-PPS study for Istanbul, overall 21 plans and projects have been analysed with reference to smart and green mobility concepts;

1 ISTANBUL CLIMATE ACTION PLAN (2018)

Istanbul Climate Action Plan (2018) is prepared to make Istanbul resilient, ready to adapt strategies to mitigate climate change. The plan includes strategies and principles based on international and national frameworks. Contributing to the 10% of all CO2 emissions in Turkey, the report highlights that the city requires a smart and sustainable urban management approach.

2 CONGESTION CHARGING REPORT (2017)

The amount of private car trips in Istanbul was 4.2 million in 2009 and is expected to reach 11.1 million in 2023 due to increasing automobile ownership. Moreover, the demand public transport is lower other developed countries. Therefore, Congestion Charging Report (2017) is prepared to encourage people to use public transport and reduce car dependency.

3 ASSESSING ISTANBUL'S QUALITY OF URBAN LIFE (2014)

Assessing Istanbul's Quality of Urban Life (2014) was carried out to investigate the level of satisfaction and quality of life in Istanbul. The analysis was based on a survey of 2532 residents. The report includes an in-depth analysis citizens' satisfaction about the built environment, urban facilities, transportation, shopping, economy, safety, environmental problems, governance and participation.

4 IMM'S STRATEGİC PLAN (2020-2024)

The main goals of IMM's Strategic Plan for 2020-2024 period were based on the visions of the new city administration. In order to achieve these goals, that are categorised in 9 main groups, each sub-aim's budget, time horizons and time schedules have been presented. The second main aim is "Improving Urban Transport within the Scope of Sustainable Mobility" which is divided to 6 sub-aims.

5 ROADMAPS FOR ENERGY (R4E)

Roadmaps for Energy (R4E) is a European Union Project which is funded by the Horizon 2020 Programme. The aim of the project is to develop a new energy strategy called "Energy Road Map" about smart mobility, smart buildings and smart urban areas.

6 ISTANBUL CAR PARKING MASTER PLAN (2016)

The aim of the Istanbul Car Parking Master Plan (2016) is to analyse the problems, demand and supply of parking lots and provide solutions via regulations. Within the scope of the project, car park policies around the world and successful examples of practices have been examined. The plan includes short term (2014-2019) and long term (2019-2023) solutions to Istanbul's parking problems.

7 ISTANBUL TRAVEL SURVEYS (2012)

The aim of the Istanbul Travel Surveys (2012) was to update the surveys conducted in 2006 which collected information for the Istanbul Transport Master Plan (2011). In order to update the results, a new questionnaire was carried out with approximately 50000 individuals and the previous travel demand estimation models were calibrated again based on the new results.

8 TRAFFIC SAFETY MASTER PLAN (2016)

With the extensive urbanisation and economic growth in Istanbul, the use of motor vehicles has increased rapidly. Eventually, the traffic safety problems have reached significant levels. Therefore, in order to ensure high levels of traffic safety in the highway transportation network, the Traffic Safety Master Plan (2016) prepared. Policies and strategies in the plan mainly aim to establish a sustainable transport system in order to reduce the car use through improvements in the public transport system, technological advancements and regulations.

9 TRANSIT FARES INTEGRATION MODEL (2017)

Transit Fares Integration Model (2017) makes an analysis of the fares of all public transportation modes and their payment methods. A literature review on transit fare payment models and their integration among different modes with examples from different metropolitans were presented in the report. Based on the collected information, different scenarios and alternatives for transit fare payment integration were suggested.

10 ISTANBUL METROPOLITAN MUNICIPALITY TRANSPORTATION MASTER PLAN (ITMP) (2011)

Istanbul Metropolitan Municipality Transportation Master Plan (ITMP) (2011) was aimed to follow the planning decisions of Istanbul Master Plan (2009) which is a land use plan at 1/250000 scale. The ITMP studies started in 2007 and lasted about 4 years throughout the land use plan preparations. Although the ITMP should have accepted all the land use decisions of the land use plan, due to political reasons (the Third Bridge, Eurasia Tunnel and changes in the location of the Third Airport) the proposed land use pattern was transformed at large and land use plans and travel demand estimation models were revised based on different scenarios for 2023 horizon.

11 TAXİ MANAGEMENT SYSTEM (2017)

The purpose of the Taxi Management System (2017) study was to provide legal and administrative arrangements for taxi services currently carried out by individual operators. Also the aim was to improve service quality by providing solutions to citizens' needs, expectations and wishes through developing technology and new practices.

12 PARK MANAGEMENT SYSTEM (2017)

The purpose of the Park Management System (2017) is to prevent the uncontrolled use of public spaces, increase comfort and quality of public transportation vehicles by highlighting parking processes. The plan provides strategies for more efficient uses of existing parking lots.

13 ISTANBUL CARD (KART) MANAGEMENT SYSTEM (2017)

Istanbul Card (Kart) Management System (2017) report consists of an analysis of the current situation, user-survey, case studies from different countries and legal assessment. In the report, it is aimed to facilitate city life, ensure sustainability and inclusiveness within the city and enhance passenger comfort.

14 DIGITALIZATION INTEGRATION MODEL (2017)

Digitalization Integration Model (2017) aims to introduce a scheme that will enable Istanbul's public transportation to be integrated with other institutions, stakeholders and actors in a digital framework.

15 SHARED (MOBILITY) MODEL DEVELOPMENT (2017)

Shared (mobility) Model Development (2017) study provides different types and models of shared mobility, their definitions based on worldwide examples. Also, all the available Istanbul's shared mobility infrastructures such as bike-, car- or trip- sharing were investigated and the necessary infrastructures and regulations were analysed.

16 INTEGRATED TRANSPORT PLANNING (2017)

Integrated Transport Planning (2017) report focus on all formal and informal public transportation modes (including highway, sea transport and railways) in Istanbul. Following a brief information about transit fleets and their schedules, the required process for their amendments were discussed in this report. Examples from other metropolitan cities were discussed and based on their criterias, policies and main goals towards achieving an integrated public transport system in Istanbul was suggested.

17 SMART TRANSPORT MODELS (2017)

Smart Transport Models (2017) report makes a brief introduction about Istanbul's smart transportation authorities, provides information on the existing situation in Istanbul and presents a literature review on smart transportation models from all around the world. As a conclusion, based on the gathered data, the basic requirements and brief road map in order to achieve a smart transportation system in Istanbul were discussed.

18 ENVIRONMENT AND ENERGY MANAGEMENT SYSTEM REPORT (2017)

In the Environment and Energy Management System Report (2017), the focus is on implementing an advanced, efficient and environmentally friendly public transportation system in Istanbul. With this, it is aimed to encourage more citizens to prefer public transportation instead of private vehicles and to make more efficient use of low-emission public transportation vehicles with alternative fuel.

19 ISTANBUL DEVELOPMENT OF PUBLIC TRANSPORT STRATEGIES MASTER PLAN REPORT (2019)

Istanbul Development of Public Transport Strategies Master Plan Report (2019) analyses all existing public transportation modes in Istanbul in detail based on their usage statistics and available infrastructures. The report presents a literature review on integration models and transfer centres all through the world. The report also defines the long-term vision for public transport in Istanbul as the city's public transport system shoud be more accessible to meet the needs of its citizens while supporting economy and improving the quality of life in Istanbul.

20 THE INFORMATION INTEGRATION SYSTEM MODEL (2017)

The Information Integration System Model (2017) presents a comprehensive plan for the integration of public transport through informing public for example regarding transportation-related issues such on lines regarding vehicles, disruptions, construction works, delays and alike. The model aims to improve the credibility of public transport for citizens while making a positive contribution to the users' use of time.

21 TRANSPORT ACADEMY STUDY (2017)

Transport Academy study (2017) was carried out by the IMM in order to increase the standards and the awareness of the employees and all active stakeholders such as different public transit operators. The study suggested that IMM could establish such an academy in three phases; (I) with highway public transport stakeholders, (II) with sea transport operators and (III) freight transport stakeholders.

Although the reports numbered between 10-20 were not approved by the IMM Council, we have reviewed them only to extract valuable data mainly regarding the existing situation in Istanbul. Table 1 demonstrates the distribution of green and smart mobility related concepts with regard to the evaluated reports. Infrastructure and integration are the most discussed issues as they are referred to in 18 reports out of 21. Meanwhile, mixed development schemes and MaaS are the least of concerns in the evaluated reports. In the next sections, these concepts are evaluated in detail.

Green and Smart Mobility Topics \ IMM Evaluated Reports		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	T
Electromobility	Evs / Avs	✓											✓		✓				✓				4
	Energy	✓				✓			✓										✓		✓		5
Collective Transport 2.0	Shared Mobility (inc. bikes & e-scooters)	✓				✓					✓	✓		✓	✓	✓		✓					8
	MaaS																	✓			✓		2
	Public Transport	✓			✓	✓			✓		✓			✓		✓	✓	✓	✓	✓	✓	✓	13
Low-Mobility Societies	Infrastructure & Integration	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	18
	Mixed Development																		✓				1
	Travel Behaviour & Cultural Norms		✓	✓				✓	✓			✓		✓				✓	✓	✓	✓	✓	11
	First & Last Mile (Walking, Cycling)	✓				✓	✓		✓	✓	✓				✓	✓			✓	✓	✓		11
Mobility Governance	Regulation		✓			✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	16
	Governance		✓			✓	✓		✓			✓				✓		✓	✓	✓		✓	8

Table 1. Evaluation of existing IMM reports with regard to green and smart mobility

IMM has a smart city concept developed by the Smart City Department. According to one of our interviews, within this strategy IMM has defined urban life in 8 main activities:

Smart Energy: Digital management of energy with smart grids, smart meters and smart energy stores;

Smart Structures: The formation of smart lighting and security buildings;

Smart Mobility: Traffic management, parking management, effective transportation pricing systems and intelligent transportation systems (ITS);

Smart Technology: Providing uninterrupted high speed online connection for mobile devices;

Smart Infrastructure: Digital management of infrastructures, water system and waste management with the help of sensors;

Smart Governance and Education: E-Governance, e-education, reactive disaster management;

Smart Citizens: Having conscious citizens who are proactive in adopting smart concepts and products and adopting a greener lifestyle;

Smart Health: Smart health technology, e-health services and use of policies that emphasize health care and monitoring in treatment.

Istanbul's comprehensive 'Smart City Plan' was developed in May 2016, managed by Directorate of Information Technologies Department of IMM and carried out by ISBAK, IMM's subsidiary company. This comprehensive plan was completed in November 2017 and the target plans and applications are being implemented since 2018. A process consisting of 5 stages, which enables the smart city journey to evolve into the right projects with clear outcomes, was planned and completed without interruption;

1. At the first stage, while obtaining a quick theoretical knowledge with literature review, the top 10 smart cities were thoroughly examined and the best practical examples of the world were obtained;

2. During the existing state analysis, with regard to the current situation of Istanbul, the competencies of the stakeholders, the technology infrastructure and the ongoing projects, the big picture of the situation was taken;

3. At the vision and strategy determination stage, the strategies that will ensure the achievement of Istanbul's vision and future goals, were established with the help of its stakeholders. These strategies and projects aimed to develop and raise the city in all the areas and scopes;

4. With the Information Technologies Architecture phase, a detailed technical structure was designed so that new technologies specific to Istanbul and which had already become evident could work together in harmony; and

5. With the use of the roadmap as the last phase of the project, all the information gathered in the previous phases were combined and the priorities, resource requirements, governance principles and performance indicators of the project were clarified.

Istanbul's smart city initiatives are divided into eight functional areas: "mobility, environment, energy, governance, economy, life, human and security". In the Smart City Plan, each focus area is evaluated within the framework of three activators, namely "Information and Communication Technologies, Organization and Human Resources and Finance", where the city will develop strategies and related initiatives. Within the scope of the study, noble practices in leading smart cities that could set an example for the city were identified and reported, and a smart city vision was created, which would enable the city to use its existing potentials based on the prevailing situation findings and future expectations of all stakeholders. Short-term (2019), medium-term (2023) and long-term (until 2029 and in subsequent years) strategic goals and smart city road map were created.

These goals support the smart city vision of Istanbul which was described as "becoming a smart city that contributes to the quality of life in the world by 2029". The most important element of the road map is that, it is supported not only by social and economic benefits, but also by projects that mobilise all stakeholders and adopt a collaborative nature. According to the smart city strategy, Istanbul focuses on 3 main points (Smart Cities, 2018):

- Producing together with stakeholders and citizens;
- Using technology with innovative methods; and
- Focusing on efficiency.

101 projects have been put forward which will ensure that Istanbul reaches its targets for 2029 and will raise the city in all the fields. These 101 projects are not just random policy areas but they were initiated as real needs. They are not specific to certain organizations, but take into account the developing global trends that stakeholders can realise together in harmony. While Istanbul offers smart city services that anticipate its current and future needs, by providing opportunities to all stakeholders of the city, it also aims to encourage the stakeholders to produce together, use technology in innovative ways and focus on efficiency. In this project, the stakeholder structure of Istanbul consisted of the central and provincial organisations of the ministries, IMM and its affiliates, district municipalities, public institutions and organisations, private companies, universities, non-governmental organisations and citizens.

When the whole process was reviewed, the project being carried out within the IMM enabled a range of professions to find a place in the project and the development of local expertise experiences. The Istanbul Smart City Project has already led to the formation of an ecosystem and the inclusion of smart city technologies by entrepreneurial institutions and organizations.

As another example, one of our interviewees mentioned that they have established a Big Data Platform among IMM's 30 affiliated organisations such as ISKI and IETT. Data flowing from all the IMM's organisations are collected in this 'big data platform' and all the other organisations have right to access their needed data under the concept of the smart city. Our interviewee also mentioned that they will be unveiling IMM's open data platform to provide the opportunity for researchers and investors to examine the existing situation data of the Istanbul and try to develop new and innovative solutions with the use of provided data. The platform was recently launched as IMM Open Data Portal (https://data.ibb.gov.tr/).

It has been underlined in our interviews that the IMM is always open to knowledge transfer and in this regard they have established a new innovation platform website (tech.istanbul) to bring together entrepreneurs from different areas of transportation, environment and energy. Applications from these areas will be evaluated and selected projects will be supported by the IMM without funding. ISBIKE and CEPTRAFIK are some of the projects that are carried out by Directorate of Information Technologies to optimise cycling and to decrease travel time in traffic, under the concept of the smart city.

Finally, it has been emphasised in our interviews that that IMM is totally open for any kind of possible partnership and collaboration which can result in prestigious outcomes in short-term or mid-term.

Electric and autonomous technology

Electric and hybrid vehicles market is growing in Turkey. According to TEHAD's report (TEHAD, 2020), the sales of EVs and hybrid vehicles increased by 79% in 2020 compared to the first quarter of 2019. Regarding EVs' collective use, the section on shared mobility within this report explains business models emerging in Istanbul.

In Istanbul Climate Change Action Plan, it is stated that the number of charging units would be increased from 13 to 122 in central car parks by 2019, covering 4% of all parking areas. IMM also had the aim of replacing 15% of its vehicle fleet with electric and hybrid vehicles by 2020, 30% by 2023 and 50% by 2030. Similarly, in Istanbul Car Park Master Plan car parking areas were aimed to accommodate more electric vehicle charging stations. Current charging stations can be found on a map developed by Esarj Ltd (Figure 6). Finally, in the Taxi Management System report plans were mentioned to give incentives for electric and/or hybrid taxis.

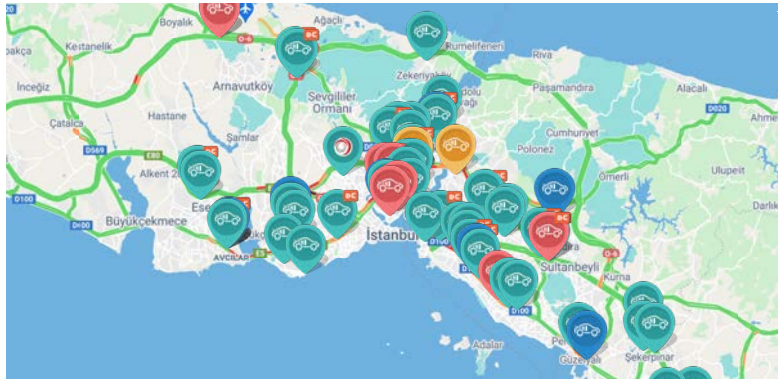


Figure 6: Electric vehicles charging stations in Istanbul, https://esarj.com/

Figure 7: Autonomous bus of IETT, November 2018 Transit Congress and Fair, Istanbul

Regarding EVs' use in public transport, IMM has had some plans to introduce EV and hybrid technology in its bus fleet. In the Climate Change Action Plan, it was aimed to provide one electrically powered boat as part of Şehir Hatları fleet. There was also a plan to transform the BRT fleet with electric vehicles. According to the director-general of Şehir Hatları Ltd., feasibility studies for electric boats are underway (T24, 2020).

In terms of autonomous technology, in addition to tests conducted by some research institutions such as Okan University's Transportation Technologies and Intelligent Automotive Systems Application and Research Center (TTIS), that has achieved Level 3 autonomous technology within the university campus and also conducted a simulation for making Metrobuses autonomous, there is very little progress in the field of AVs. In the summer of 2018, IETT has conducted a trial for its autonomous bus and later on showcased it in Istanbul Transist Congress and Fair (Figure 7, November 2018). However, not much is known regarding the specifications of this vehicle, let alone the testing results and current situation.

In addition to IETT's initial efforts to autonomising buses, private companies in Turkey are quite keen on developing and using autonomous technology in transport accompanied by advances in artificial intelligence (AI), Internet of Things (IoT) and 5G technology. In a project conducted by Novusens in 2018-2019, more than 20 companies, some of which are also included within Section 5.2, demonstrated their interest in developing smart mobility projects in Turkey (Novusens, 2019). Moreover, in various meetings IMM hosted in the past years, car manufacturers such as Ford Otosan in Turkey, that is highly interested in implementing autonomous technology in the logistics sector, may also be likely to support autonomous technology in passenger mobility.

Collective transport 2.0

Public Transport

Istanbul, due to its unique geographical features and its wide area, has a huge network of public transportation in three different types of highway, railway and seaway. Each type is functioning in different modes such as buses, metros, trams, funiculars, Bus Rapid Transit (BRT), ferries, sea buses, cable-cars and paratransit modes which are not within the formal fleet, such as minibuses and dolmus (8-passenger minibuses). The share of public transport ridership among all modes is 28% while private car use is 20% (IMM, 2018a). Within this, 77.1% is done through road transport, 18.6% is through rail transport and only 4.3% is via sea transport (IETT, 2019). Increasing the share of public transportation modes in Istanbul's daily traffic and also decreasing the private car ownership and its usage is one of the IMM's main strategies which it can be seen in almost all of the investigated reports and plans and also almost all the IMM official interviews have confirmed these strategies.

Table 2. Ridership of Public Transportation Modes in Istanbul, 2019 (IETT, 2019)

Public Transport Mode	2019 Average Daily Ridership	Percentage (%)	Istanbul Mobility Report September 2019	Percentage (%)
Road transport (rubber-tyred)	**11,682,191**	**77.1**	**11,251,553**	**81.2**
İETT Bus/ BRT (Metrobus)	2,059,151	13.4	907,778/848,962	12.7
ÖHO (Privately operated)	1,607,036	10.6	1,526,860	11
OAŞ (Privately operated)	860,801	5.7	785,339	5.7
Minibus	2,911,163	19.2	2,911,163	21
Company/school buses (servisler/services)	2,867,502	18.9	2,867,502	20.7
Taxi / Dolmuş	1,403,949	9.3	1,403,949	10.1
Rail transport	**2,822,291**	**18.6**	**2,382,513**	**17.2**
Metro	1,654,777	10.9	1,365,490	9.8
Tram	677,222	4.5	585,338	4.2
Cable-Car/Nostalgic Tram/Funicular	59,674	0.4	42,541	0.3
Marmaray (TCDD – National railways)	430,618	2.8	389,144	2.8
Sea transport	**644,851**	**4.3**	**228,989**	**1.7**
İDO (Sea Bus, private company)	163,434	1.1	5,404	0
Şehir Hatları (Ferry company)	231,444	1.5	108,496	0.8
Passenger Boats (private companies)	249,973	1.7	115,089	0.8
Total	**15,149,333**	**100**	**13,863,055**	**100**

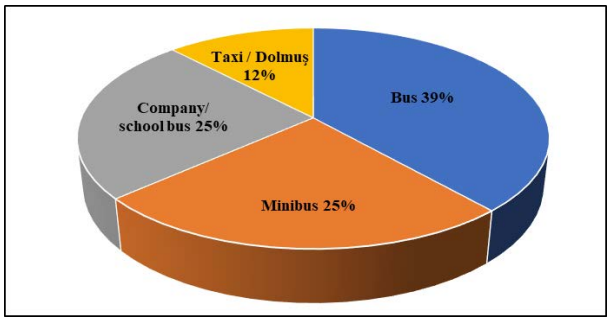
Due to variety of public transport modes and their managerial systems as well as the morphology of the city, the public transport is slightly fragmented in urban space, creating difficulties for a smooth transfer between modes. Not only spatial integration lacks at certain points but also temporal and institutional (as in responsibility of different institutions) integration gaps pose important problems. In this sense, IMM takes various steps to improve intermodal connectivity and therefore, increase the efficiency and livability of public spaces. One of the main goals of IMM 2020-2024 Strategic Plan (IMM, 2019a) is to increase the amount of physical integration between formal public transportation modes such as railways, BRT and buses as well as the informal modes such as minibuses and dolmuş networks. Additionally, in the project Roadmap for Energy (R4E), redesigning urban areas in order to make them more pedestrian-friendly and to increase the efficiency of transfers between different modes was mentioned. Moreover, the Istanbul Car Parks Master Plan has targeted to redesign the reduced parking spaces on the streets as pedestrian pathways and bicycle paths.

Recently, the IMM has announced international competitions for Taksim and Bakırkoy squares by early 2020. These competitions are important in demonstrating IMM's ambition to create more liveable pedestrian areas in the city. Especially, Taksim square where also different transport modes meet in the underground, has lost its identity over 8 years when access to buses were taken underground and all car traffic was diverted into the tunnels rupturing the urban fabric. Contestants are advised to create a 24-hour living contemporary square connected to its layers of history and identities embedded within. In addition to the international competitions around the city, after years of opposition from experts and public, the new IMM management has also withdrawn the design of the Kabatas Transfer Centre which previously favoured car access to an intermodal transfer centre where buses, tram, funicular and ferries meet. IMM supports a participatory approach to the design of the transfer centre and aims to limit car access and parking in the area. In this sense, designing pedestrian-oriented public spaces has become one of the top priorities of Istanbul.

Road Transport (rubber-tyred)

Rubber-tyred public transportation modes in Istanbul operate in three different types of buses, minibuses, taxis and company/school buses, which all together carry almost 77% of Istanbul's daily public transportation load. Figure 8 shows the share of these modes among rubber-tyred public transportation.

Figure 8. Share of different modes among Highway Public Transportation



Buses

While the whole bus network of Istanbul is planned, managed and controlled by IMM, it has been running with the collaboration of two companies, ÖHO and OAŞ in conjunction with IETT (Istanbul Electric Tram and Tunnel establishments) which is an organization of IMM providing public transportation services in Istanbul. ÖHO is a private company with a fleet of 2154 buses and OAŞ is a subsidiary company of IMM with a fleet of 1079 vehicles (IMM, 2020a). There are almost 3070 bus vehicles in the IETT's fleet (ibid). According to IMM's annual activity report (2018), there are 772 bus routes and 13,494 bus stops in all through the city. Transforming the bus stops to modern and smart ones is within IMM's current plans and almost 1050 stop have been transformed to smart bus stops so far (IMM, 2019b). Also, in the investigated IMM's plans, it is mentioned that in order to maximize the efficiency of the IETT fleet, average life length of the fleet is aimed to be kept under 5 years.

BRT (Metrobus)

Bus Rapid Transit or with its Turkish name "Metrobus", running 24/7 between Anatolian and European sides of the Istanbul, plays a vital role in the city's public transport system. The system consists of 8 different nested routes which the longest one is "Beylikdü-zü-Söğütlüçeşme" with 52 km length and 44 station. Based on few of IMM's examined reports, such as Istanbul Climate Change Action Plan (IMM, 2018b), and also according to one of the interviews, in order to increase the efficiency and comfort of the metrobus fleet and also to reduce the amount of emissions, it is aimed to transform the BRT conventional fleet to an electrical fleet, gradually.

Minibus

Minibuses with a maximum capacity of 16 passengers (sitting) are one of the main paratransit modes in Istanbul (in addition to Dolmuş) and is not part of the IETT's formal bus fleet. 6460 minibus vehicles are running over 456 different routes in all of Istanbul (Istanbul Development of Public Transport Strategies Master Plan Report, 2019). As seen in Table 2, this fleet carries 19.2% of the total daily public transportation load in Istanbul. As an informal transport mode, the main task of minibus system should be to operate as a feeder and distributer for the formal modes, such as buses and metros (Cervero, 2000), but in Istanbul minibuses have been operating as competitors to the formal transport modes. Moreover, the quality of service and passenger satisfaction is very low. Yet, due to their flexibility (no regular stops and providing highly frequent services) and availability, considerable number of passengers prefers this mode. Consequently, in the IMM's plans there have always been many goals and strategies regarding the minibus operation system, such as enhancement of its service quality, passengers' safety increase, integration with other formal modes, transforming its fair payment system from cash payment to IstanbulKart, increasing the quality and comfort of its vehicles. Although there has been some progress in collaborating with minibus service providers, resolving such issues may take time as operators may be reluctant to make necessary adjustments that may result in less profits.

Company/school Buses (Services)

On average, 18.9% of daily public transport in Istanbul is carried by company and school buses. According to Public Transportation Services Directorate (IMM, 2020b), there are 66,269 company/school buses in Istanbul. These vehicles are managed by private companies for schools as well as public and private sectors. Since most of these vehicles are just running for a limited period of time each day, and staying in a parked situation in rest of the day (IMM, 2011), their usage in an optimized way could bring many advantages for Istanbul's traffic flow and the public transportation. Despite all negativities, company/school buses are one of the least addressed modes in almost all plans and strategies, thus, poses an important challenge for the future of transport system in Istanbul.

Taxi

The size of taxi fleet in Istanbul is 17,395 and it has remained constant since 1991. According to IMM's annual activity report (IMM, 2019c), preventing taxis from circulating without passenger especially in the peak hours, diminishing their negative impacts on traffic flow, prohibiting their stopping at random points on the road and minimizing economic and environmental loss are part of IMM's strategies and aims in regard to taxi services in Istanbul.

Under the concept of smart city strategies, IMM put "iTaksi" (phone application) into practice in 2017, in order to overcome a part of the above mentioned problems and increase the passengers satisfaction level. Calling a taxi from wherever you are, estimating the fee before taking the taxi, showing the alternative routes between origin and destination, the possibility of online payment or even with credit cards are some of the opportunities this app is providing to passengers and taxi owners. Setting cameras inside the taxis that would record video (without sound) 24/7 for security reasons (iTaksi, 2020) is another part of "iTaksi" implementation. The review score of the app on Google Play and App Store is 3.1 and 3.2 out of 5.0, respectively (by April 2020).

Dolmuş

Dolmuş is a shared mobility mode with 8-passenger seats. Unlike the minibus, dolmuş waits for departure at its origin station until the vehicle is full, and runs between the determined origin and destination and stops for passengers alighting. There are 572 taxi dolmus vehicles in Istanbul which run among 42 different routes all through the Istanbul, 24/7 (IMM, 2020b).

Rail Transport

Expanding the railway network of Istanbul is one the main priorities of IMM, as it has been addressed and discussed in most of the investigated reports and plans such as "IMM's Strategic Plan for 2020-2024", "Istanbul Climate Action Plan, 2018", "Istanbul Metropolitan Municipality Transportation Master Plan, 2011" and "Istanbul Development of Public Transport Strategies Master Plan Report, 2019". Currently 18.6% of the total public transportation use in Istanbul is done by rail transport, and this is aimed to increase to 30% by 2024, following the launch of the under-construction metro lines (IMM, 2019a).

Existing railway network of the Istanbul is consisted of 7 metro lines, 2 cable-cars (funiculars), 4 tram and 3 funicular lines, all adding to 233.05 km in total. Meanwhile, 221.70 km length of new metro lines are in the construction phase (Metro Istanbul, 2020). Although all of the mentioned railway modes are regulated and managed by Metro Istanbul Inc. (IMM's affiliate company), there is another railway public transport mode called "Marmaray" which is constructed and managed by Turkish State Railways (TCDD). Marmaray with 76.3 km length and 43 station connects the Anatolian and European side of the Istanbul. It is the deepest immersed tunnel of the world that runs under the Bosphorus Strait.

Sea Transport

Istanbul is the only city in the world which is located on two different continents. The city is divided into Asian and European continents by the Bosphorus Strait, which connects the Black sea in the North with the sea of Marmara that runs into the Aegean through an approximately 30 km length of waterway. This unique nature gives the opportunity of benefiting from sea transport as a daily public transportation mode. As can be seen in Table 2, the share of sea transport, among all public transportation modes, is 4.3% and according to IMM's Strategic Plan for 2020-2024, it is aimed to increase this share up to 10% by 2024.

In order to cross between Anatolian and European sides of Istanbul, there are three bridges, Eurasia tunnel, Marmaray tunnel and sea transport (ferries and private passenger boats regulated by local authority). The share of public transport modes which crosses the Bosphorus Strait is 55.9% by BRT, 16.4% by Marmaray and 27.7% by sea transport (IMM, 2019c). In addition to this, sea transport can potentially be used to carry passengers along the coastlines between different areas along the Bosphorus (each direction North-South).

There are different companies and operators running sea transport in Istanbul, which "Şehir Hatları Inc." is the most important one. The number of vessels, routes and piers belong to each company can be seen in Table 3. Although İDO (Istanbul Fast Ferries Co. Inc.) was very much used by passengers in Istanbul to avoid congested hours and still cross from European to Asian side under 30 minutes, following the privatization of the company in 2011, İDO diverted most of its fleet from inner city services to intercity services (such as Istanbul-Bursa; Istanbul-Bandırma).

Table 3. Information of Seaway Public Transport Companies (IMM, 2019b)

	Vessel	Route	Pier
İDO	52	15	35
Şehir Hatları	28	21	50
Private passenger boats (DENTUR, TURYOL)	394	15	30

Shared Mobility

Achieving a sustainable and green urban mobility without sharing systems is almost impossible for all the cities. It can be car-, trip-, bike- and/or e-scooter-sharing which public organisations and private companies can carry out these implementations by themselves or even by each other's collaborations.

Car Sharing

Accumulation of population in cities and metropolitan areas results in a sharp increase of car ownership ratio in these areas. According the data of the Turkish Statistical Institute (TSI), the passenger/car ownership ratio in Istanbul in 2018, with a steady increase was 185 per 1,000 inhabitants. The escalating rate of the passenger car ownership per 1,000 inhabitant between 2012-2018 can be seen in Figure 3. Even though the car ownership ratio in Istanbul is less than most of the European cities, the congestion level of this megacity is among the most congested cities of the world (see Figure 2).

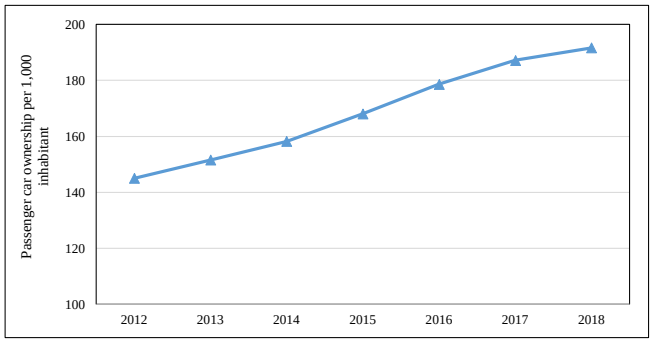


Figure 9: Istanbulites' passenger car ownership per 1,000 inhabitant

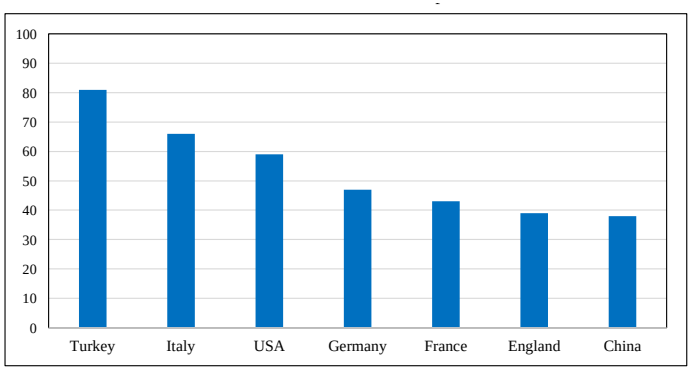


Figure 10: Personal car usage frequency percentage (Deloitte, 2019)

In 2019, Deloitte carried out a global automotive consumer research in more than 20 countries with the participation of more than 25,000 people. In Turkey they surveyed 2,988 people. When personal car usage was examined, it is seen that Turkish consumers prefer to use their own cars with the highest rate of 81% (Figure 7). Again, the vast majority of Turkish consumers predict that they will use their vehicles every day within the next 3 years (79%). Italy with 66%, follows Turkey, while China ranks last with 38% (Deloitte, 2019). With regard to this data, it is crucial to find solutions which would lead to a decrease in the rate of car ownership or would lead to a decrease in the redundant usage of private cars, especially with single passengers. Car sharing is a solution that could control or even decrease the car ownership ratio.

In Istanbul, currently there is no announced transportation policy for car sharing implementation and in the same way, car sharing implementations are not included within current regulations and other legal regulations. Although it is not mentioned among the municipality's policies, there are different car rental and car sharing options offered by the private sector on its own initiative. "Electrip", "Budget", "enterprise" "Avis", "Zipcar", "YOYO", "Garajyeri" and "Rentiva" are some of the examples of car sharing companies that operate in Istanbul and Turkey. "Electrip" is a car sharing platform established by Zorlu Energy which unlike the other car sharing platforms, has a fleet of electric vehicles. It is Turkey's first electric car sharing platform. They provide short-term rentals, which allows users to pay only for the time that the car is used, not the whole day and this makes them different from other car sharing companies (Url-4). It would not be appropriate to say that vehicle sharing systems are common in Istanbul. The main reasons for this, are lack of marketing and awareness, security, privacy, complex payment systems and limited supply. Besides, the fact that no level of integration has been achieved with public transportation can be considered as one of the most important reasons of this result.

With regard to car sharing implementations, one of our interviewees stated that car sharing concept has a safety and trust problem in Turkey. In Istanbul, if IMM would act to restrict the private car usage and promote car sharing and public transport instead, our interviewee believed that people would object immediately. Yet, car sharing may be a good opportunity that IMM may invest in as several implementations for car sharing could be done such as those in European countries (e.g. devoted car sharing parking lots in inner city areas). Our interviewee also suggested that since municipalities in Turkey are able to define borders for low emission areas, implementation of car-sharing and e-car sharing options would be viable. Yet, implementing low-emission zones would need a strong leadership, yet, the new IMM administration is quite keen on implementing low-emission and/or congestion charging schemes.

Ride Sharing

Ride sharing (trip sharing) is similar to car sharing, but it is a fundamentally different implementation. In principle, ride sharing starts at the very beginning of a trip - there is always more than one passenger in the vehicle. Unlike car sharing, the cars are not open to be shared physically. According to Istanbul Metropolitan Transportation Master Plan (2011) the occupancy rate of passenger vehicles, as an indicator of the shared mobility is 1.57. This rate potentially can be increased if ride sharing becomes more popular. The demand for sharing models has been increasing in recent years with the development of mobile applications that enable the communication of car owners who travel with those who want to travel on a common platform. In Istanbul's transportation policies, a road map has not been created in terms of trip sharing and it is seen that private sector companies undertake the activities in the field of trip sharing. "BlaBlaCar", "twogo" "OrtakAraba" and "Volt Lines" are some the existing examples in Istanbul. Most of these companies have focused on intracity trip sharing in Istanbul, some of them such as BlaBlaCar has focused on intercity trips and offers the opportunity to share trips on travels from Istanbul. During the 2015th Ramadan Feast, 134,631 seats were advertised over BlaBlaCar and the occupancy rate was 60% on the most popular routes. It is also noted that every 1 minute, one shared trip has been recorded in all through Turkey. Regardless of the abovementioned few initiatives in trip sharing, in Turkey there is no legal basis for the trip sharing applications and it can be considered as "counterfeit taxi service" ("korsan taksi", literally "pirate taxi" in Turkish).

Bike Sharing

In Istanbul, in terms of bicycle sharing, ISBIKE, run by ISPARK, a subsidiary company of IMM has been operating 380 bicycles in 38 stations on the Asian side of the city and 1120 bicycles in 102 stations on the European side. ISBIKE has stated the purpose of its system as to ensure that 3 to 5 km long intermediate distances that can be reached without having to drive a motor vehicle. In this way, the effect of greenhouse gases that harm the environment and the load on public transportation will be reduced, and society will have the opportunity to use healthier and more environmentally friendly means of transportation (Url-5). Smart bicycle stops were put into service in the entire sections of Zeytinburnu under E-5 and also Karaköy - Beşiktaş - Sarıyer strait line. Stop routes and bicycle capacities are as follows (Url-6), and also the geographical distribution of these stops can be seen in.

- 350 bikes in 34 stops across Zeytinburnu district;
- Karaköy-Beşiktaş-Sarıyer region 22 stops, 220 bikes;
- Bakırköy-Yenikapı region 28 stops, 280 bikes;
- Florya-Avcılar-Küçükçekmece region 17 stops 170 bikes;
- Kadıköy-Maltepe region 22 stops, 225 bikes;
- Kartal-Pendik region 21 stops, 200 bikes;
- Umraniye region 3 stops 35 bikes;
- Beykoz region 2 stops 20 bikes.

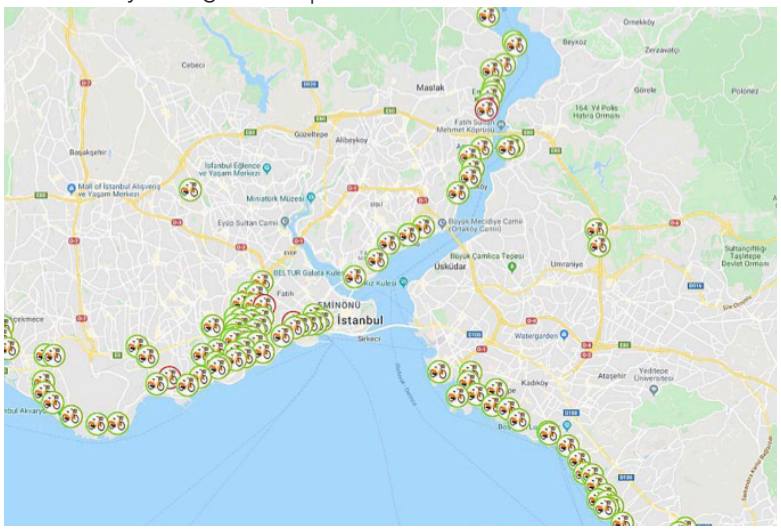


Figure 11: Geographical distribution of ISBIKE stops in Istanbul

Pedestrians and bicycles are the main priorities of the IMM's Transportation Planning Directorate. According to one of our interviewees, there are a number of previously done projects related to bikes, but all of them are scattered around the city, therefore, integration is necessary. In this regard it has been highlighted that there may be a common cooperation with Dutch experts in this field that can help them to gather all the existing plans together. Even a micro level collaboration such as bike to work or bike to school promotion could be carried out that are common practices in Europe.

IMM has its own bike sharing system, ISBIKE, and the transportation planning directorate believe that having another private company enter to the market could be risky. One of our interviewees stated that if the IMM wants to improve the bike usage in Istanbul, they would have to hand one million bikes out Istanbul. Although this suggestion could be supported the issue is to find the responsible body that will be responsible of these bikes. It has been suggested by one of our interviewees that it could be ISBIKE or a private Dutch company.

Currently, IMM's ISBIKE has almost 1,500 new bikes that are not used. Under the new administration, these bikes will be gradually distributed around the Istanbul. Moreover, the IMM is strongly seeking to improve their systems and bicycle network plans will be developed. However, it will be more about managing the system then building roads and infrastructure. There are thousands of cyclists around Istanbul which IMM has no information and data about. Planning should start, first of all, by gathering this data and involving cyclists to the whole process.

IMM's new Bicycle Unit established within the Department of Transport held a bicycle workshop on February 7 2020. Although the workshop minutes have not been published yet, IMM invited all relevant NGOs and initiatives to the workshop to increase the share of cycling in Istanbul.

In addition to bike sharing, e-scooters has become quite popular in Istanbul. Two main companies Marti (operating in some selected districts in Istanbul) and Palm (operating in university campuses) offer fast solutions to those who do not want to be stuck in traffic. However, as our interviewee highlights the newfound electric scooters such as Marti and similar brands have lots of problems as they are not legally allowed in traffic and their relations with other vehicles and pedestrians are quite problematic as well as the way they are parked. Scooters are already scattered around Istanbul and therefore, IMM needs to prepare regulations and/or guidelines for their use.

Mobility as a Service (MaaS)

According to Deloitte's global automotive consumer research in 2019, using different transportation modes on the same trip is an infrequent habit. However, in Turkey using multiple modes on the same trip is very common, even among car owners. As it can be seen in Figure 9, multimodal trip's proportion in Turkey is higher than Europe countries and USA. In Turkey, 27% of car owners regularly benefit from multiple models of mobility (Deloitte, 2019). This shows the great potential of MaaS applications which are able to fill large gaps of mobility in Istanbul metropolitan area that has huge volume of mobility in all around the city and almost all through the day. Despite this situation, there is no plan and activity regard to any kind of MaaS application in Istanbul and even in Turkey. One of our interviewees mentioned that MaaS is something that can be done by the private sector and if the Dutch companies would want to enter the market IMM could support them by establishing new collaborations.

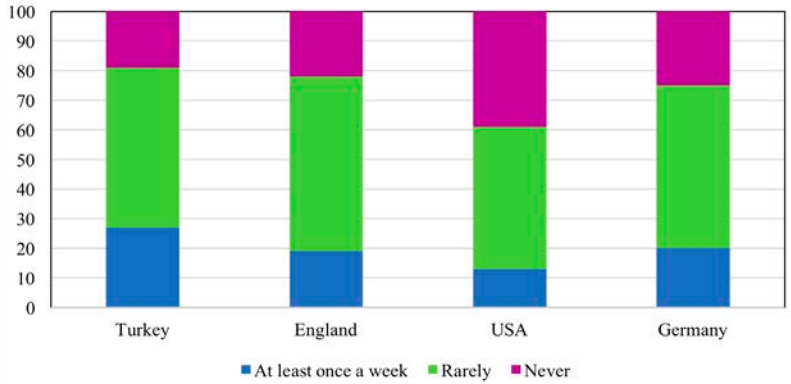


Figure 12: Frequency of multiple transport modes usage among car owners (Deloitte, 2019)

photo source: https://tripit.wpengine.com/blog/travel-tips/10-sustainable-travel-tips.html

Walking is the primary mode of transportation in Istanbul with 45% of all trips are done by walking. Although this data can be regarded as if the city has very low mobility levels, it is in fact an indicator of uneven mobilities that is experienced in city's peripheries by and large. Regarding the pedestrian-related issues, one of our interviewees mentioned that that there is a great need for a macro scale plan or well-developed design criteria in order to increase walkability in the city. In addition to the new administration's bicycle unit, the IMM has also set up a pedestrian unit within the Department of Transport and they welcome knowledge transfer between Turkish and Dutch experts.

Since the inauguration of the new administration in IMM, the municipality has held several analyses and workshops including the analysis of international city indexes, analysis of global risks and opportunities that cities face in the near future, strategic priorities, several transport workshops and meetings with internal and external stakeholders. According to IMM's 2020-2024 Sustainable Development Strategic Plan, a matrix has been created that has linked this strategic plan and the United Nations Sustainable Development Goals as a road map for the sustainable development of Istanbul. The 9 main goals of this strategic plan are as below:

G1- To create a durable city by developing qualified and functional living spaces
G2- Improving urban transport within the scope of sustainable mobility
G3- Strengthening sustainable environment and energy management
G4- Contributing to the increase of the economic value of the city
G5- Creating a sharing city by meeting social needs equally and inclusively
G6- Creating a living city by improving social life opportunities
G7- Protecting and improving cultural, architectural and natural city heritage
G8- Ensuring financial sustainability
G9- Improving the corporate structure and business model with fair, participatory and innovative methods.

In order to reach these goals in the planned period, each goal has been divided to sub-goals. The sub-goals (SG) of the "Improving Urban Transport within the Scope of Sustainable Mobility (G2)" are listed below. Correspondingly, the estimated costs and the "Gaps to Fulfil" for each one of these sub-goals are given in Table 2.

SG1- Increasing the network and the share of the rail transport mode in public transportation
SG2- Increasing integration, accessibility and quality in public transport
SG3- Increasing the capacity of sea freight and its share in public transport
SG4- Managing traffic effectively by increasing intelligent transportation systems and transportation infrastructure applications
SG5- New methods for minimising infrastructure excavation works - improving technology applications and integration in infrastructure management
SG6- Strengthening the road systems infrastructure and making it sustainable

Table 4: Estimated costs and gaps to fulfil (G2's sub-goals)

Sub-Goals	Estimated Costs (Turkish Lira)	Gaps to Fulfil
SG1	36,104,726,087	• Increasing the share of rail system in transportation and converting transportation systems to more environmentally friendly systems
SG2	108,880,695	• Dissemination of technological and environmentally friendly innovations such as driverless transportation and electric vehicles; • Supporting formal transportation modes through increasing the number of transfer centres and informal transportation modes; • Strengthening integration between public transport systems
SG3	541,317,711	• Increasing the share of maritime transport and converting transportation systems to a more environmentally friendly level; • Establishment of common scaffolding system; • Planning of time-fare-route integration considering other transportation modes; • Planning sea transport by taking into consideration passenger capacities according to piers, strategic locations and time
SG4	1,728,825,893	• Increasing the training and awareness studies on traffic; • Managing traffic management from a single centre with a holistic approach
SG5	12,041,859	• Making collaborations more effective with other infrastructure organisations; • More investments in infrastructure; • Ensuring that the location accuracy of the infrastructure lines of the institutions are reviewed again
SG6	12,853,292,737	• Increasing and promoting bicycle path applications; • Arranging the transportation infrastructure to provide more effective and safe services to the elderly, children and disabled; • Creating income generating models

Mobility Governance

Governance is defined as coordination of interdependent functions and has a multilayered structure (Rhodes, 2007). "Good governance" has eight elements to be achieved to provide sustainable development: To be efficient, consensus oriented, inclusive, responsive, transparent, accountable, participatory and to follow the rule of law (United Nations, 2009). Accordingly, as Docherty et al. mentioned, "...in thinking about governance of the 'Smart Mobility' transition, there is a need to pay attention simultaneously to the why (the public policy function), what (the rules of the game), who (the networks of actors and their position, power and objectives) and how (the manner in which the public is involved and accountability and transparency are maintained) of the governance system." (Docherty et al., 2018, p.117).

As governance is one of the key challenges of smart mobility, specific questions were addressed to our interviewees regarding future collaborations between Dutch and Turkish companies and the IMM in terms of governance. The management scheme of Istanbul Metropolitan Municipality is explained in detail, in the following section. First of all, monitoring has been one of the main issues regarding governance. In this regard, one of our interviewees believed that knowledge transfer is quite needed at these latest stages of project development as this leg is usually missing in planning and policies in Istanbul. Collaboration could be established with regard to monitoring from the beginning of new projects.

Another area for collaboration regarding governance is the issue of scale. Since macro scale plans and policies require a number of regulations to be met at the same time, collaboration with Dutch partners at the micro scale would be much more efficient. Last but not least, sustainability of projects is quite important. Hence, capacity building of not only the IMM but also communities should be of at most importance. IMM has been working to establish a mobility academy to educate taxi, minibus and bus drivers. It already has traffic education parks for children where they can go and learn about traffic rules. These educational, capacity building programmes could be developed with the Dutch partners.

Istanbul Metropolitan Municipality's Management Scheme

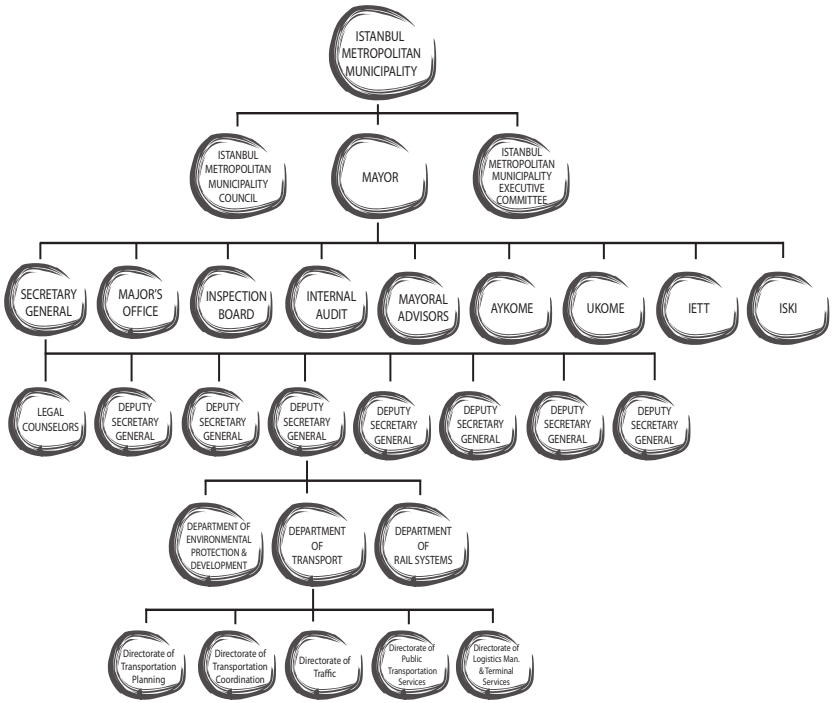
Istanbul Metropolitan Municipality consists of three main executive authorities: The Mayor, Istanbul Metropolitan Municipality Council and Istanbul Metropolitan Municipality Executive Committee. Details of the management scheme are visualised in Figure 13. The Mayor of Istanbul Metropolitan Municipality leads the municipality as the top administrative officer, prepares strategic plans and sets the budget. There are nine different units that work with the Mayor and assist him. Secretary-General, UKOME and IETT are the most relevant ones of these nine units regarding transportation planning. The Secretary-General has seven deputies one of which is responsible for transport planning. Deputy Secretary General for transport foresees the activities of the Department of Transport which consists of five directorates: Directorate of Transportation Planning, Directorate of Transportation Coordination, Directorate of Traffic, Directorate of Public Transportation Services and Directorate of Logistics Management & Terminal Services. Additionally, there are three committees called "Transportation and Traffic Regulation Board (UTK)" and "Commission of Plan Amendment (PDK)" under the department of transport and "Transport Coordination Centre (UKOME)" under the Mayor. These three bodies are in charge of the decision-making process of transport plans (IMM, 2020c).

UKOME: The Metropolitan Municipalities Law No. 5216 commissions UKOME to fulfill the municipality's secretarial duties (TBB, 2014a). In other words, UKOME is responsible for providing coordination between transportation services (IMM, 2011). For instance, the transport master plan is not approved without the UKOME decision. All public institutions related with transportation are involved in UKOME meetings and they have their own regulations to follow up. However, all UKOME decisions are implemented with the approval of the metropolitan mayor (TBB, 2014b).

UTK: Transportation and Traffic Regulation Board is charged with Istanbul's transport and investment plans. The board evaluates projects and states their decisions. Both 1/5.000 and 1/1.000 plans are examined in UTK (IMM, 2014).

PDK: The head of the Department of Transport acts as chairman of the Commission of Plan Amendment. Only 1/5.000 projects are evaluated in PDK and those projects are not being approved without the decision of PDK.

Figure 13: Management Scheme of IMM



Transport management in local authorities, as seen in the example of IMM above, is highly hierarchical. However, there are some attempts in IMM to establish a more horizontal decision-making structure especially through particular projects (e.g. Sustainable Urban Mobility Plan). Newly established Bicycle and Pedestrian Commissioners (Chiefs) within the Transport Department are also examples to these efforts not only to distribute decision making power to micro levels but also to institutionalise sustainability within the department.

Regarding project and plans, aside from the conventional approach to Transport Master Plans that are regulated by the Ministry of Transport and Infrastructure, planned and implemented by Metropolitan Municipalities, when new projects or new ideas emerge the department that proposes the project is likely to take the lead it. Yet, expertise may be needed from other departments. In this regard, the Department of Transport communicates at a greater extend with the Directorate of Urban Planning, Directorate of Environmental Protection, Directorate of Geographic Information Systems, Directorate of Smart City as well as IMM subsidiaries such as ISBAK, BIMTAS and ISPARK.

An important aspect of mobility governance is the issue of budgeting of investments and finance of plans and projects. IMM receives the highest income in Turkey through residential and commercial taxes. However, its expenditures (due to the amount of subsidies and expenses regarding construction and maintenance) are extremely high. Therefore, sustainable finance mechanisms are quite crucial.

Transport takes an important part of the budget. In 2020, approximately 30% of the 25billlion TL budget was allocated for transport infrastructure development and maintenance (IMM 2020 Budget). In order to overcome the burdens of ever growing costs of transport operation and maintenance due to increasing population, inflation, taxes and needs for new infrastructure, IMM may use international funding. Recently, Deutsche Bank and France Development Agency (AFD) have been the two sources for metro constructions. Moreover, EBRD and EU are some of the other sources for international funding. Regarding R&D projects for instance, €1.2 million of EU funding was allocated to R4E project. Moreover, collaborative projects with institutions from Europe may be funded by the European Institute of Innovation and Technology (EIT) which is explained in the next chapter.

Project Potentials Under EIT

The European Institute of Innovation and Technology (EIT) is an independent body of the European Union that established in 2008, to increase Europe's ability to innovate by supporting entrepreneurs, students, innovators and all new ideas. The main goal of the institute is to deal with global challenges, especially sustainable economic growth and job creations, by integrating business, education and research. Therefore, EIT trains entrepreneurs, promotes innovative products and services and supports and encourages start-ups (Url-8).

One of the EIT representatives of IMM mentioned that before EIT project, they had carried out a 3 year project, called R4E (a roadmap for energy) which was a corresponding project to smart and green mobility belong to European Union. Within the scope of this project, it was aimed to create the 2050 vision of smart public transportation of cities. The study was carried out between 2015 and 2018, and as a result two documents has published the vision of 2050 smart public transportation in Istanbul. The outcomes were not implemented.

Developing a consortium for the EIT was their second project as the urban mobility community. In 2017, a consortium called Mobilus included 50 institutions and organisations. This consortium came together to prepare a proposal for EIT's 2018 project call. Mobilus was found successful to set the urban mobility agenda for the next 7 years in Europe and IMM, as one of the founding members, will be within the executive body of the urban mobility community.

In the first year, the consortium spent the whole year to establish the required legal processes and at the same time prepared the 2020 business plan. In 2020 business plan, the IMM has been involved in two projects. One is called Karolina and is under the IMM's environment protection directorate. The main goal of this project is to develop a new air quality sensor, which allows municipalities to embed the sensor on the moving vehicles and measure the air quality from different points of the city. Currently, the measurement of air quality in Istanbul can be done from fixed and very limited (approximately 30) points. By collecting data with these sensors, municipalities would be able to make the necessary policies, depending on the situation. This project which is planned to be completed in a year, has just begun with the collaboration of EPFL and Catalonia universities from Switzerland and Spain.

Supporting entrepreneurs and startups in the field of urban mobility, is the IMM's second EIT project. EIT has 5 strategic goals, one of which is the IMM's second project. In this context, IMM received a 3-year funding in predetermined concepts for Zemin Istanbul and five other similar city labs. These are two concrete projects that IMM has received and they are preparing for the last meeting of the 2021 business plan at Eindhoven, early March.

Previously the basics of the project on EIT were innovation, academia and national, but now there are two new topics called RIS and Citizen Engagement. RIS (Regional Innovation Scheme) is a concept for transferring knowledge from developed countries of Europe to the relatively underdeveloped countries. Another project concept related to Citizen Engagement was opened and there is a wide range of project titles and topics such as academic and innovation projects. As a result of continuous development of new project concepts and topics, IMM's new administration has decided to establish a team, especial for EIT. Since urban mobility is a broad subject that most of the departments in the IMM deal with, the EIT special team would consist of Transport Planning Department, Public Transportation Department and the Traffic Directorate Coordination's Department. The team aimed to take part in the last meeting of the 2021 business plan at Eindhoven with a group of 8-10 expert.

Our interviewee stated that, in the last EIT meeting at the end of 2019 in Germany, ISBAK employees submit three different projects based on IMM's needs. These three projects were on accessibility to public transit nodes by walking and cycling, optimisation of the Metrobus and optimisation of traffic lights in Istanbul. In the upcoming meeting in March by the urban mobility community, new partners will be found for the new projects that are proposed for the next budget period.

According to the EIT Urban Mobility rules, while developing a project a minimum of two innovation hubs are required to collaborate. Since IMM is in the Central Innovation Hub and The Netherlands is in the Western Innovation Hub, this scheme provides a good opportunity for future collaborations. Our EIT representative highlighted the IMM's much needed expertise from the Netherlands as cycling and walkability as well as improving accessibility for all.

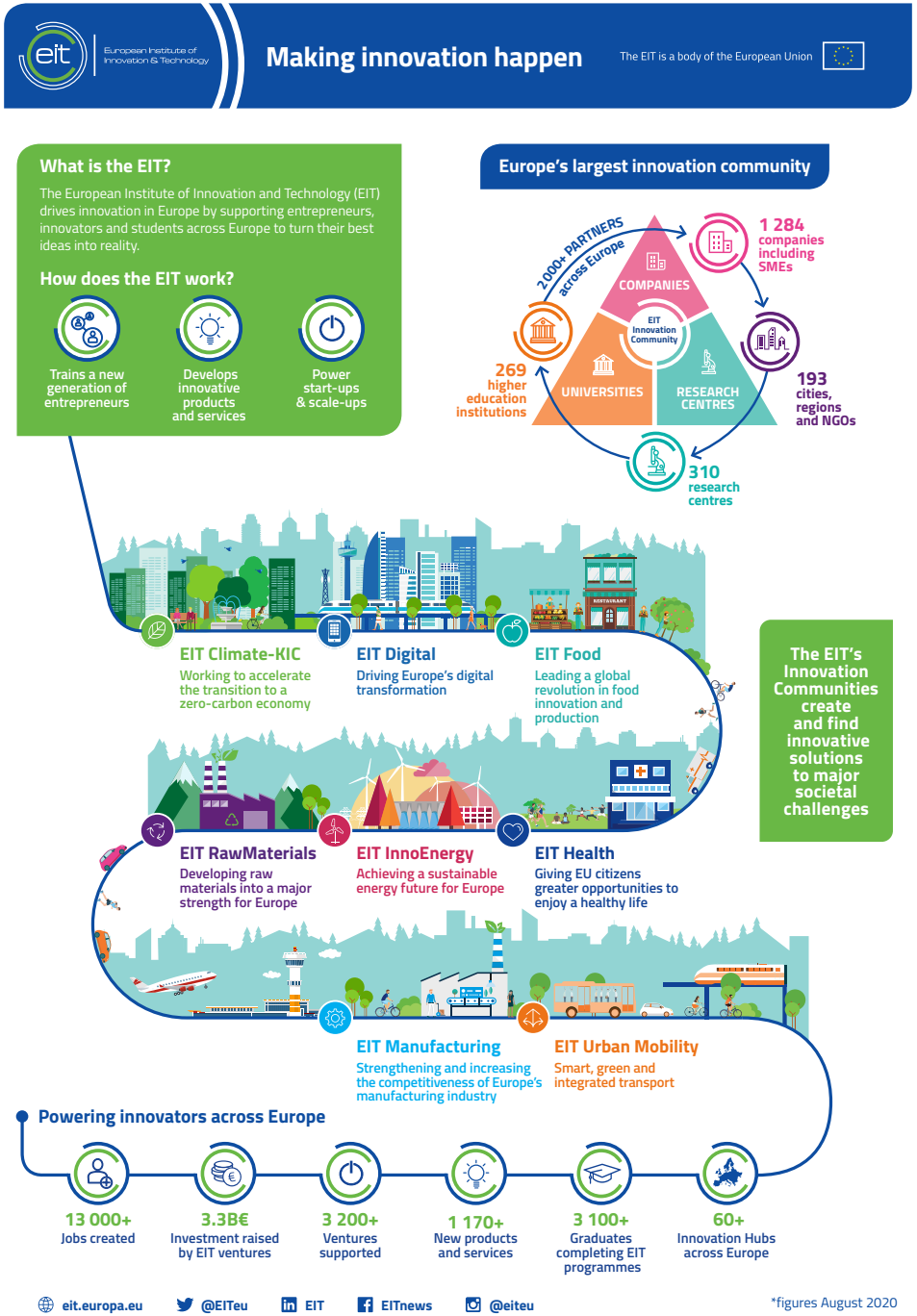


Figure 14: European Institute of Innovation and Technology

A Summary of Challenges and Short-term and Long-term Priorities

In the meeting conducted with the Deputy Secretary General responsible for transport, Head of Transportation Planning Directorate, Head of Smart City Department, Head of Transport Coordination Department who commented on the initial draft of this report, a list of challenges and priority areas have been pronounced:

Infrastructure and Planning

- IMM should have a long-term vision but also have short term projects in line. In this sense, a comprehensive urban mobility plan is necessary. Arup Turkey is currently working on a sustainable urban mobility plan for Istanbul, which IMM is the primary beneficiary. The project is funded by the UK FCO under the Prosperity Fund Global Future Cities Programme. The project is currently in the phase of producing a long-term vision and strategies for Istanbul's transport.
- Cycling and walking infrastructure planning and policies should be integrated in both the short term and the long-term plans
- In relation to this, e-bikes and charging infrastructure should be planned and promoted (ISPARK is currently working on developing an e-bike scheme)
- Comfort parameter is highly important in buses and other public transport vehicles to be able to create a transition from private to public transport. In this regard, IMM should provide "seat guarantee" for passengers.
- Low-emission zones and congestion charging zones have been on the agenda of IMM for some time. Historical Peninsula is a good example where congestion charging could be applied. Parts of Kadikoy could be designated as another area where a congestion charging scheme could be developed.
- Improvement of taxi services is also another item on the agenda. Recently, IMM decided to increase the number of taxis in Istanbul which has remained as approximately 18.000 since 1990s. IMM also has plans to transform 6000 taxis operated by the municipality to e-vehicles.
- BRT line (Metrobus) carries about one million passengers per day on a normal weekday with a headway of 17 seconds. The electrification of the current rubber-tyred system would bring huge benefits for the air quality.
- On-street parking is an important issue in Istanbul. Car-parks, largely operated by ISPARK, need a transformation. Instead of increasing the number of car parks in the city centre, a more restricted approach (including decreased car-park space and increased fees) would encourage the use of public transport. In this sense, park and ride areas around transit centres outside the core of the city need to be developed further.
- Minibuses and service vehicles (company and school services) generate an important congestion problem as the former runs off-schedule and with very low standards and the latter generates optimisation issues as the vehicles wait on stand-by on the streets during off-peak hours. This system needs to be optimised.
- There is currently charging infrastructure around the city for e-vehicles. This infrastructure could be developed along with parking options that prioritises e-vehicles and shared mobility.
- Although some district municipalities have developed semi-on-demand services in the past for certain purposes such as access to district open markets, this is an area that could be developed to increase accessibility for all. Demand-based transport system is a potential area to be developed.
- COVID-19 pandemic brought the necessity to rethink about public spaces and transit areas. Design of multi-modal transit areas as well as public transport stations is another priority for IMM.
- IMM has been planning an urban consolidation centre for logistics. After the pandemic urban logistics gained even more importance.

Smart solutions

As explained in earlier sections of this report, IMM's Smart City department in collaboration with its subsidiary companies have extensive experience in smart urban solutions. Bringing smartness to all projects IMM is working on is one of the key priorities. In this regard, key areas for potential collaboration are;

- Smart transport coordination
- Smart transport mobile applications
- Continuous air quality monitoring
- Establishing V2X communication systems
- Smart parking system
- Providing safe distance for pedestrians, measuring and managing pedestrian flow

Governance and Communication
IMM is taking important steps to ensure the participation of key stakeholders from different sectors as well as public in planning phases. In this sense, IMM prioritises mobility governance through engagement of multiple actors;

- Plans need to lay out strategies to overcome cultural resistance to transition towards low-carbon mobility
- Projects with the aim of increasing creating a smart and green transport system need to consider how communication will be ensured with public. Strategic plans for public and stakeholder engagement need to be integrated into planning phases.

Analysis of current mobility trends
Following the pandemic, mobility trends have shown a tendency to shift towards private mobility as public transport is considered as unsafe. In this sense, there is a necessity to understand the changing demand in order to be able to prevent unsustainable mobility options take over the transport system;

- Demand analysis need to be conducted regularly with real-time data collection through smart applications in order to understand the changing travel behaviour
- Understanding price elasticity is an important issue to be able to distribute demand from peak hours to off-peak hours
- Traffic may be detected by censors to analyse abnormalities

Finance
The latest pandemic generated further financial challenges especially on public transport as the ridership declined immensely. There is an urgency to meet these challenges with new financing methods as municipality's budget is scarce also as a result of political dynamics between the central government and the IMM.
Next section outlines the Dutch expertise in smart and green mobility and suggests areas for collaboration between IMM and Dutch institutions and companies regarding Istanbul's priorities in transport and mobility.

Dutch expertise and potentials for knowledge exchange

Dutch expertise and mobility trends

Over the past years The Netherlands has been a guiding country regarding the development and implementation of policies and means in relation to Smart & Green Mobility. Within several administrations mobility was a recurring topic over the past decades and partly driven by climate goals.
Different policy papers and research were executed in order to cope with the issues around congestion and air quality. This was initiated by the Dutch Government in cooperation with consultancy companies often in a triple helix configuration. These studies and innovative experiments have resulted in The Netherlands being a frontrunner in the area of Smart mobility. The results created new insight and a future vision and trends around smart mobility. These transitions are distinguished as follows according to Smart & Green Mobility:

From fossil fuels towards renewable energy
This trend accelerated the introduction of EVs over the past few years. Prior to tackle the chicken/egg situation the Dutch government offered incentives for SMEs, taxis and private owners in order to get things started. These incentives consist of a lower tax addition for the corporate & lease drivers. Taxis were offered priority pick-up locations at the airport and subsidy on purchase of newly purchased vehicles.
Charging-infrastructure implementation was a necessity even though there were ample EV fleets available in the early days (2010-2014). Currently, the total Dutch car park consists of around 8M passenger vehicles of which 209.006 are EVs (BEV & PHEV). In order to charge these vehicles the charging infrastructure consists of 53,036 (semi) public charging point and 1,319 fast chargers along strategic points through the country (source: RVO February 29th, 2020).

The ambition of the Dutch Government is to sell only zero-emission vehicles by 2030 in order to achieve improvement of air quality and to meet climate goals. This translates into an increase of electric vehicles and thus increasing the charging infrastructure for fleets. In order to meet these goals, a variety of means and policies have been created to stimulate the adoption of electric vehicles. Corporate (lease) fleets have a reduced tax scheme for the end-users resulting in a soaring amount of electric lease vehicles. Taxis have incentives for electric vehicles as well and thus, creating a positive example towards its users and public acceptance of this new technology. These incentives will be applicable for private individuals as well, i.e. promote second hand market for electric vehicles.

The aim to charge these vehicles with renewable energy (sun & wind) and/or hydrogen is part of the strategy (CBS, 2019). Hydrogen solutions are being developed for transportation means and ferries (MARIN, 2018).

Hydrogen will be seen as a solution for heavy duty transport and/or transport over water. Technology has been developed for both retro-fit and innovative solutions. In order to cover the newly to be developed eco-system there is also knowledge on the entire implementation phase for hydrogen applications. More mature solutions consist of the use of LPG/ CNG technologies. These technologies have been thoroughly developed in The Netherlands for decades and offers the opportunity to retrofit existing fleets (implementing the use of biogas as an option). Adjacent policies also include the instalment of environmental zones which can only be used by vehicles with a certain energy label.

The City of Amsterdam has founded a project organization called MRA-e (Metropoolregio Amsterdam) consisting of multiple municipalities working together to increase the charging network in public private partnerships (https://laadkaart.mrae.nl). This project organization makes sure knowledge will be shared and it is relatively easy for municipalities to step in and benefit from certain ongoing initiatives. Tenders for charging infrastructure are being combined. Data output is shared and subject to research involving knowledge partners. Besides this MRA-e is part of international partnerships and EU pilots. Istanbul and the Marmara municipalities could benefit from such an approach.

Alternative Modes of Transport – transition from ownership towards usage:

The Netherlands is a frontrunner regarding Smart Mobility: traveling based on information and communication technology. The Dutch Government is looking for smart means to gain throughput in traffic and exploring all kinds of ways to increase the use of multi modal travel options. In the past years many pilots have been introduced in which the Dutch have learned from and adapted towards better solutions.

Urban planning, urban design and transport planning (and TOD, transport oriented development) are important aspects in order to enable mobility solutions on both road and rail transport. The Netherlands are having huge experience in developing large scale infrastructural projects like the Noord-Zuid lijn (Iamsterdam) in Amsterdam bringing together civil, urban and mobility engineering capabilities. These are the backbones for efficient urban mobility, improving accessibility and managing mobility costs.
In the Netherlands people tend to gain status about the car they are driving. Over the past years congestion figures have risen enormously (CBS, 2019) and nowadays for some people the status of owning a car is more about being smart and making use of smart mobility solutions. From a governmental perspective creating more roads is not the answer to congestion. Public transport is the backbone for mass transit. There is a need for more efficiency regarding assets and infrastructure.

The Dutch government initiated some MaaS pilots (Dutch Mobility Innovations, 2019) involving different mobility providers, employers and employees in order to make travelling more efficient. This also involves distributed starting times for employees, cycling, ride-sharing and increased use of public transportation. Dedicated focus on first- and last mile solutions are key for a successful implementation. Not only for people but also for goods. These pilots will start over the course of 2020. City of Amsterdam is also one of the most popular EU cities to experiment and test new ride/vehicle sharing solutions and its adoption is quite high. The concept of vehicle sharing even emerged in Amsterdam in the 1970s. Besides free floating car schemes (Amsterdam), some start-ups such as WeDriveSolar and Amber Mobility, offer e-carsharing for corporates and urban development projects.

The Netherlands has quite a heritage regarding the use of bicycles. Currently, there are around 21 million bicycles in The Netherlands for a total population of 17 million inhabitants. This is part of the Dutch culture. Because cycling is a good alternative for both public transport and automobile, the Dutch government recently created a fund of 100M Euros for co-financing bike lanes and bike parking around public transport junctions. The Dutch railway company NS offers a bike sharing scheme which can be accessed by its mobility card, facilitating a one stop shop for the end-users. The combination of bikes and trains/metros is quite important to stress and unique to Netherlands. The Dutch have very high accessibility of public transport services and network, specifically in the large cities. Public transport is the backbone in combination with bikes (sharing), and this is one of the primary reasons that it is possible to reduce congestion on the roads, because the public transport alternatives are very good. The Netherlands has been quite successful in exporting the knowledge about implementing cycling in other countries. A variety of knowledge around infrastructure, policies and implementation are available.

Intelligent Transportation Systems (ITS)

The Netherlands is paving the way for the traffic management system of the future. A future in which vehicles communicate with one another and with roadside systems.
The Netherlands has experimented and implemented means to improve throughput, both by implementing policies and also digital mobility management to steer and direct accessibility of cities at preferred timeslot, thus, being a part of the total solutions.

The introduction of 5G as a technology can boost the development of self-driving (autonomous) vehicles for both logistic or human purposes. These technologies could be used for the delivery of certain goods during the night using electric vehicles. In addition, we have the leading research groups and large capabilities and competencies in traffic flow management and ITS based in the Netherlands, that enable much more effective ITS solutions being implemented in NL. There is a strong collaboration between industry, research institutes, universities, infrastructure owners, government in this area, enabling innovation.

Both congestion and air quality can be significantly reduced by ITS in combination through public transport and first- and last mile solutions. Dutch knowledge and expertise can help Istanbul tailor the long-term vision that is translated to short term successes.

Solutions for railway development in combination with mobility hubs are widely available. ITS tools for implementing congestion charging as a system or making use of traffic light technology is available and increases throughput and reducing congestion and air pollution.

Governing mobility in Amsterdam: The example of AMS Institute

The Amsterdam Institute for Advanced Metropolitan Solutions – AMS Institute – was launched in 2014 by Wageningen UR (WUR), Delft University of Technology (TUD) and MIT, after these three renowned universities put in the winning bid in an international competition (by the municipality of Amsterdam in 2013) to design a new institute for applied technology focused on urban challenges. A ten-year contract, between TUD, WUR and the city of Amsterdam, supports the institute in becoming a highly valuable and truly structural part of the local and regional Amsterdam knowledge ecosystem.

AMS Institute has a very close working relation with the city of Amsterdam and uses the city as its living lab: a valuable context for experiments that helps develop and test advanced solutions for challenges in urbanized metropolitan areas around the globe. The institute revolves around six urban challenges, and integrating these themes to create an innovative, sustainable and just city. Each challenge is addressed with talent, idea building and collaboration in mind: 'Smart Urban Mobility', 'Urban Energy', 'Climate Resilient Cities', 'Metropolitan Food Systems', 'Responsible urban digitization', and 'Circularity in Urban Regions'. AMS Institute has an education program (incl. a 2-year MSc program and Life Long Learning/professional education), a Research and Innovation program (portfolio of 120 projects, >80MEuro), Partnership and entrepreneurship program (incl. corporate partnerships and a pre-incubation program).

For the city of Amsterdam, AMS Institute is a partner and a platform for research and innovation, for building and attracting human capital and creating new partnerships, start-ups and spin-outs. AMS Institute is an open platform for quadruple helix collaboration (industry, knowledge institutions, government and citizens) built on core academic partners WUR, TUD and MIT. The city and greater metropolitan area and AMS Institute collaborate on many of the most pressing, long term, interdisciplinary and often data-driven challenges. Collaborations include the Future Proof Assets program (e.g. bridges, quay walls), the Responsible Sensing Lab and the Innovation center for Digital Mobility management. For the core academic partners connecting science to pressing urban challenges increases their ability to pursue their mission to have true societal impact.

Today, big societal challenges – in the fields of energy, circularity, digitization, climate resilience, mobility, food – dominate the agenda. These urban challenges are interconnected, multi-perspective, multi-disciplinary and multi-scale. Cities have a clear need to transform its systems, on a metropolitan scale, for its citizens to live, work, recreate, learn and care. A need that is felt all around the world. Such complicated transformations require collaboration between local, regional and national government, private companies, public organizations, knowledge institutions and citizens. Roles of these actors are changing constantly, blurring the boundaries and prerogatives of traditional positions. Collaboration is key and it is a search for new configurations to govern, do business and to develop ideas and talent. This is the context of AMS Institute and herein lies the mission for AMS Institute.

With Amsterdam, TU Delft, Wageningen UR and MIT and its public and private partners, AMS Institute is uniquely positioned to contribute, through engineering and design, to solving pressing metropolitan challenges. Connecting science to societal challenges, and solving those together. At AMS Institute researchers believe that by generating ideas, talent and collaborations, and closely interacting with cities, they can help analyze, design and engineer solutions for the cities. As it will be discussed in the conclusion section, AMS Institute may be a model for a similar institute within the IMM.

Existing and Potential Stakeholders and Their Dutch Counterparts

As a result of interviews and researches, a list of existing and potential stakeholders of smart and green mobility has been created in Table 5. The stakeholders have been divided into five different groups as "Public Corporations, NGOs, University-Industry Partnerships (R&D), Academia and Private Companies".

Table 5. Existing and potential stakeholders and their Dutch counterparts

Name of the Stakeholder	Smart Mobility	Green Mobility
Public Corporations		
Istanbul Metropolitan Municipality	✓	✓
Ministry of Transport and Infrastructure	✓	✓
BELBIM	✓	
ISBAK	✓	
IETT	✓	✓
Şehir Hatları Inc.	✓	✓
Metro Istanbul Inc.	✓	✓
Istanbul Ulaşım Inc.		
TÜBİTAK	✓	✓
TÜBİTAK Marmara Research Center	✓	✓
MARKA - East Marmara Development Agency	✓	✓
Dutch counterparts: MRA Smart Mobility (Amsterdam Metropolitan Area)		
NGOs		
ITS Turkey - Intelligent Transportation System Association of Turkey	✓	
Marmara Municipalities Union	✓	✓
Novusens Innovation and Entrepreneurship Institute	✓	
TEHAD (Turkey Association of Electric and Hybrid Vehicles)	✓	✓
TESID (Association of Turkish Electronics Industry)	✓	
UCLG - MEWA (United Cities and Local Governments - Middle East and West Asia)	✓	✓
WRI	✓	✓
Dutch counterparts: The Urban Future; Dutch Cycling Embassy; BYCS		
University-Industry Partnerships (R&D)		
Bilkent University Cyberpark	✓	✓
ITU NOVATTO	✓	
ODTU Technopark	✓	✓
YTU Technopark	✓	
Dutch counterparts: AMS Institute (Advanced Metropolitan Solutions); Elaad; TNO Smart Mobility		
Academia		
Istanbul University Urban Policies Research Centre	✓	✓
ITU Artificial Intelligence and Data Science Application and Research Centre	✓	
ITU IstanbulON Urban Mobility Lab	✓	✓
METU BILTIR Centre	✓	
Okan University Transportation Technologies and Intelligent Auto	✓	
Dutch counterparts: TU Delft; TU Eindhoven/ Smart Mobility		
Private Companies		
Altinay e-Mobility and Energy Technologies Inc.	✓	
Anadolu Isuzu	✓	✓
Ardictech	✓	
Avikon	✓	
Başarsoft	✓	
BIAS Engineering	✓	
blink	✓	
Borusan Logistics		✓
CADEM Innovative Solutions	✓	
COMODIF	✓	
CSUM	✓	
Duckt	✓	✓
Ekin Safe City Technologies	✓	
Elektronet	✓	
EMPA	✓	
Entes		✓
Eyedius	✓	
F Plus Ventures	✓	
Fark Labs	✓	
Ford Otosan	✓	
iUGO Technology	✓	✓
Koc Sistem	✓	✓
Martı	✓	✓
Mikroelektronik Research Development Design and Commerce Limited Company	✓	
Mobese	✓	
Netaş	✓	
Ölçsan	✓	
Palm	✓	✓
Proline	✓	
Seyisco	✓	
Tam Bilişim	✓	
Turkcell	✓	
Dutch counterparts: Arcadis; Movares; Mobycon; RHDHV; DTV Consultants; Overmorgen; Arup; Vialle; Ekinetics; Witteveen & Bos; NedStack; Move Mobility/ GoudappelCoffeng; Mobyshare;VDL;Connekt;Humankind;Amber;Spike Technologies; Technolution; TomTom; VenhoevenCS		

CONCLUSION:

Roadmap for Smart and Green Mobility in Istanbul

The aim of this study was to understand the urban mobility plans and ambitions of the IMM and to identify the existing knowledge and experience gaps which can be addressed by the Dutch partners. In this regard, a thorough review of existing reports of the IMM and face-to-face interviews with IMM officials demonstrate that the main goal of the new administration is to move in a way to fulfil the determined sub-goals of "improving urban transport within the scope of sustainable mobility" as stated in IMM 2020-2024 Strategic Plan (IMM, 2019a). However, almost all the officials explicitly declared that they would welcome any potential collaboration with Dutch experts which can help them to achieve their goals quickly, or any other innovative project which can bring high prestige outcomes for IMM.

The Netherlands has been seen as a guiding country regarding its innovative approach on mobility for the past decades. What can be defined as being successful on Smart & Green Mobility? The answer is not that simple but if being down drilled it has to do with creating a future vision and from that perspective create short term goals.
Cycling is already within the Dutch culture for a long time and has been addressed in policies. Part of the success is to invest in infrastructure in order to endorse people to use bicycles for their commute to work. This can be achieved by not only infrastructure development but also by soft policies like incentives and/or the creation of multi modal traveling combined with cycling.
Part of the challenges The Netherlands is facing are around the global transitions to …? like:

- the shift from fossil fuels towards the use of renewable energy:
Regarding mobility, a shift from conventional vehicles to EVs was seen necessary. Regarding this transition, The Netherlands needed to decide whether to introduce electric vehicles followed by electric charging infrastructure, or the other way around. A cocktail of policies and incentives have been used to progress with this transition. The long-term vision helped creating the future eco-system including energy systems and urban planning.

-the shift from ownership towards usage (subscription based models):
The average utilization of a car in The Netherlands is roughly 5% per day, thus cars are parked 95% of the time (taking up public space). Most of the vehicles only carrying one person per car results in congestion and thus, an inefficient use of existing infrastructure and assets. Part of this transition includes making use of alternative modes of transport in order to manage the in- and outflow of urban commuters.

For many years 'congestion charging' has been on the governmental agenda but has never been implemented. Meanwhile, MaaS (Mobility as a Service) has been embraced and endorsed by the government resulting in several pilots. This is accompanied by new policies and incentives for both end-users and employers. This can only be successful if the end-user will adopt these new means of transportation, so behavioural interventions are key. Old fashion behaviour is quite hard to change, however making a combination of policies and incentives based on end-user perspective will offer future proof results.
Multi modal transportation requires a holistic view in which a variety of public transport combined with shared mobility solutions and a focus on walking and cycling are the ingredients to cope with a growing city.

As mentioned in this report, although there are similarities between the mobility challenges of the Netherlands and Istanbul, the scale of these challenges for the latter calls for a specific approach. Planning and managing more than 25million trips per day through a combination of more than ten different transport modes, gathering continuous data via smart cards, addressing the passenger complaints daily while planning for the future of mobility in the city with a limited budget is not an easy task and should be dealt with carefully. In Section 4, the ever-growing expertise of IMM's departments in smart city solutions and planning helps the municipality to overcome so much of these problems. However, there are some areas that may need further development.

Transition towards low-carbon mobility

is one of the main challenges that does not only have to do with using alternative fuels but also with socio-technical transition including altering the travel behaviour. In this sense, parallel to the technological development, public transport needs to be made more favourable especially for car-captives but also for the majority who do not have other options. Therefore, in addition to increasing comfort, efficiency and punctuality of public transport, integrating it with active transport modes and improving walkability and bikeability to and from public transport nodes are quite important. In this sense, creative and innovative urban design including transfer centres as well as vehicle interiors would bring a holistic approach to the system.

Governance of mobility

in Istanbul is another challenge. Due to the scale of the city, there is a variety of stakeholders including civil society, academia, private and public sectors. The management of public transport is quite fragmented between different departments and beneficiaries of IMM but also the representatives of central government. A comprehensive participatory governance approach to mobility would help adoption of transport policies easier by public and other interested bodies creating a more sustainable path. Additionally, regular monitoring of projects and plans and their expected impacts is highly important. Both issues, transition towards low-carbon mobility and participatory governance, may largely benefit from capacity building of IMM and external stakeholders. It is highly crucial for stakeholders including public to be aware of the benefits of sustainable and smart mobility solutions. Therefore, public awareness rising campaigns and programmes could be established with the contribution from NGOs. Moreover, capacity building programmes could be established especially for creative data collection, analysis as well as setting up regulations for active transport modes, EVs and AVs. Regarding the latter, regulations for AV tests both in testing grounds in Istanbul (Yenikapı and Maltepe meeting areas could be suggested for this purpose) and public spaces could be established.

In order to create successes in the potential collaboration of Dutch expertise in conjunction with IMM the following steps would be beneficial:

1. Create future vision including a roadmap how to get there:
How does Istanbul want to grow in the next decades and to cope with the abovementioned challenges? Backcasting from the future context resulting in a roadmap towards this 2030 horizon may be a useful approach to identify the policies that are needed to achieve sustainability goals.

2. Create short term successes (quick wins):
Following the different transitions regarding smart and green mobility, several innovations and services have been implemented in The Netherlands:
From fossil fuels towards renewable energy: A wide array of knowledge on both policy making and organizational/ implementation is available through our Dutch partners. A future vision on this topic in combination with a roadmap would help creating not only the long term goals but also short term successes. Within this roadmap the low-hanging fruit and relevancy towards the Istanbul citizens can be obtained.

Alternative modes of transport and transition from ownership towards usage: The increase of the use of public transportation and expansion of infrastructure is essential for Istanbul in the coming years. Dutch partners can assist in further develop the long term planning in combination with short term successes by implementing relevant solutions and needed policies.
Furthermore, there is an aim for increasing bicycle use in the next few years in Istanbul. This involves, besides an infrastructural need, also behavioural changes. Istanbulites could be getting familiar with cycling for example in cut-off areas and creating bike lanes. This can be done during the weekends and/ or specific time frames dedicated for cyclists. Communication programs are key within this respect and also here low hanging fruits can be obtained in the short term. When increasing the availability and usage of public transport, the necessity of first- and last mile solutions are obvious. Carsharing and ridesharing schemes need to part of the total offering. Regarding infrastructure, Istanbul has the opportunity to further develop the ferry boat (electric or hydrogen) integration within the Mobility as a Service offering. Last but not least these services need to be integrated as being a one stop shop for the user. Not only infrastructural but also policy wise Dutch partners are very well equipped for these challenges.

3. Istanbul (Centre for) Advanced Metropolitan Solutions

(Centre for) Advanced Metropolitan Solutions, as described below, could serve as a reference on innovation form a city perspective. It could be advised to:

- Create a platform on urban innovation which brings both talent, ideas and partners together and has a direct interaction with the city.
- Endorsement from the municipality giving it a recognized status as being a player within the newly developed eco-system.
- Create an open-source environment in order to flourish collaboration.
- KPI's based on impact not input.

It is important to set up a new curriculum which will be the basis of this new movement. Based on the expertise of Amsterdam, this will take time so create a road map of at least 10 years.

The AMS Institute (Amsterdam Institute for Advanced Metropolitan Solutions) model as explained earlier could serve as an example of organizing and facilitating innovation on all kind of Metropolitan Solutions.

Added to this, by positioning Istanbul as an international living lab on innovative, smart & green mobility solutions and providing facilities for such a living lab (such as public space open for testing), Istanbul could position itself internationally as an attractive city for R&D intensive foreign direct investment (FDI) related to smart & green mobility. In the same sense as Singapore has positioned itself as an international R&D hub for smart & green mobility.

4. Implementing technologies and solutions

As far as available implementing technologies and solutions concerned The Netherlands has a proven track record on the following:

-from vision towards implementation including policy making
-various short-term solutions regarding multi-modal solutions both policy wise and physical implementations
-infrastructural technologies regarding congestion and air-quality issues
-from fossil fuels to zero-emission; renewable energy implementations for several mobility modalities (e-bikes, scooters, ev's, biogas, hydrogen)
-behavioral and adaptation programs (cycling, walking, multi-modal in designated area's)
-urban planning incorporating mobility effects (car-free areas, walkable and cyclable)
-ITS solutions, road-pricing, throughput solutions, digital mobility management
-Public Transportation (infrastructural, incorporating urban planning)

An important enabler of suitable transporting is TOD (Transit Oriented Development). It is a sort of holistic urban+mobility planning, that requires a change in governance at different levels. Developments around Zuidas (Amsterdam) or Utrecht car-free Merwede are great examples. Not only mixed-used and dense but also impressive modal-split. It is a proven philosophy to break the vicious circle of car dependency. Istanbul could benefit from this experience and could start small scale, in neighborhood design, especially next to train stations.

5. Financial and organizational support

Financing transport projects as well as R&D activities is not an easy task. EIT is an important hub that supports short-term projects as well as R&D activities. Partners from the Netherlands may collaborate with IMM in order to create meaningful projects for sustainable and smart mobility.

The Dutch companies and NGOs as well as institutions have a great experience in working collaboratively, which is in fact embedded in the Dutch culture. Financial and organizational collaboration frameworks may be created by Dutch partners in order to ensure the sustainability of urban mobility projects and plans. Currently, the following budget provisions are already available:

Funding for science collaboration

- **Horizon 2020/ Horizon Europe**: Dedicated workshops and meetings between Dutch and Turkish partners (triple helix) can provide the groundwork for consortium forming for the upcoming Horizon Europe framework program. A possible Istanbul Center for Advanced Metropolitan Solutions could make use of the Horizon Europe Spreading Excellence and Widening Participation Program by twinning itself with a Dutch counterpart for capacity building purposes.
- **NWO Dutch Science Diplomacy Fund**: the Dutch research organization NWO has launched the Dutch Science Diplomacy Fund that aims to connect Dutch and Turkish researchers on specific topics for matchmaking purposes. Smart & green mobility could be one of those topics. Calls for proposals are launched yearly and the aim is to connect active projects to the Knowledge and Innovation Convenants of the topsectors to secure long term bilateral research funding.

Funding for market oriented R&D/innovation

- **KIC Urban Mobility**: With Istanbul as a core partner of the KIC Urban Mobility a major goal is to translate the challenges of Istanbul with regard to smart & green mobility and to make use of the funding available.
- ***NWO Dutch Science Fund***: see above, it is also oriented at market oriented R&D, but for matchmaking purposes.
- **EUREKA clusters**: EUREKA is a program for international market oriented R&D that stimulates technological collaboration between companies and to come up with solutions for societal challenges. The most relevant EUREKA clusters for smart & green mobility are:
    - o **EUROGIA** is a bottom-up, industry driven, market oriented program which addresses all areas of the energy mix, from renewable energy to efficiency, and reduction of carbon footprint of fossil fuels.
    - o **Eurostars** is aimed at SMEs in the high tech R&D sector that would like to collaborate with partners from abroad for technology development. Eurostars offers the possibility to launch a joint promotional call on smart & green mobility between Turkey and The Netherlands.

Funding for market introduction

The **Partners for International Business (PIB)** Program of the RVO provides support for a group of organizations (companies, knowledge institutions, governments) that would like to explore business opportunities within a specific sector in a specific country. It is a specific form of public private collaboration that helps companies build a market presence in a specific country.

The **Demonstration, Feasibility and Investment (DHI)** program of the RVO supports SMEs that would like to make a market introduction or an investment in a target country. Especially the Demonstration part is interesting, as it allows a Dutch company to demonstrate a technology or an innovation with the help of local partners.

Other funding possibilities to pursue

For more substantive, strategic and long term programs, talks could be initiated with the European Bank for Reconstruction & Development (EBRD) and/or Worldbank and/or FMO.

Making urban mobility systems resilient to pandemics

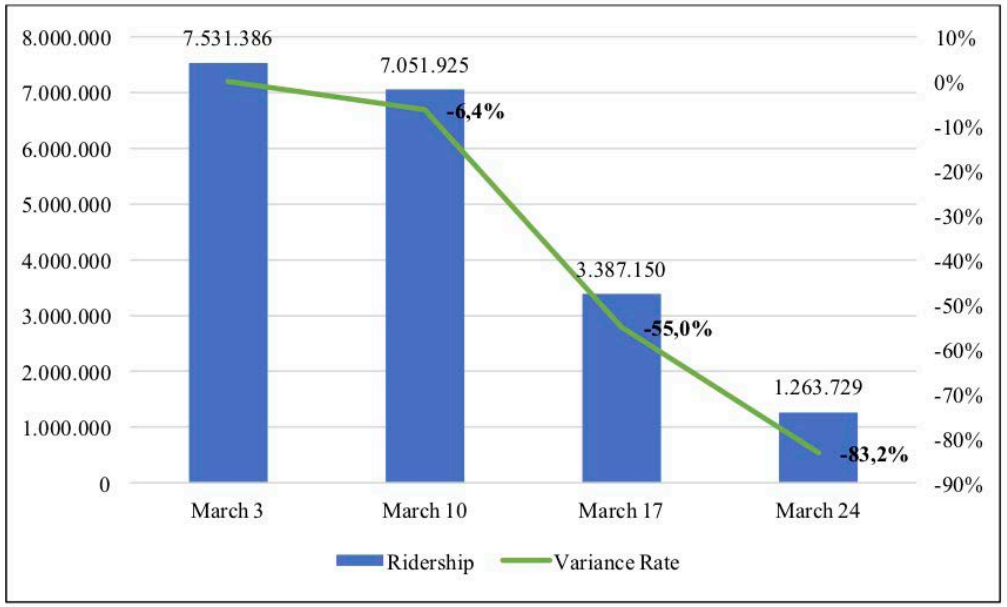
Recently, with the global coronavirus (COVID-19) outbreak, transport systems have proven to become highly vulnerable, which can be seen as a rehearsal for future pandemics and/or climate change-driven crises. Although this study had laid out its theoretical framework and completed its fieldwork before the first cases were reported in Turkey, the project team had the urge to devote a final section to the developments in Istanbul with regard to the pandemic.

The first case of COVID-19 was reported in December 2019, in Wuhan, China and gradually spread all around the world. Since the geographical spread rate of the coronavirus has been much wider than other viral diseases, all countries, governments, public and private industries and people were obliged to change their routines and make new plans and strategies immediately, otherwise due to the shortage of necessary health infrastructures in almost all countries and cities, the infection and consequently death rates would be irrecoverable.
On March 11st 2020, Turkey's Minister of Health announced the first identified case of COVID-19 in the country, and until June 28th, the number of confirmed infections has reached 195,883 (CoronaTracker, 2020). The Turkish government started to make provisions in many different aspects to decrease the spread rate of the virus e.g. shutting down all the schools and universities, weekend lockdowns all through the country, determining curfew for under 20 and over 65 years old persons, closing all shopping malls and similar closed areas, restricting restaurants and the entertainment sector.

Since coronavirus is transmitted primarily through close contact between individuals, public transport vehicles have posed an important threat for urban communities. Despite the lockdowns and teleworking policies which almost all the governments and countries have applied, large populations had to continue commuting to their workplaces during the pandemic period public transportation has been the only option for the majority of urban population. Yet, as can be seen in Figure 15, in March 2020, immediately after announcing the first positive identified case of coronavirus in the country, the ridership rate of public transportation decreased by 83% (IMM, 2020d).

Although Turkey's health ministry has not announced the pandemic statistics related to each city separately, it is estimated that almost 60% of the announced infection and death cases are belong to Istanbul (Istanbul Metropolitan Municipality Covid-19 Scientific Advisory Board Report, May 2020). Therefore, in order to mitigate the effects of coronavirus pandemic in Istanbul, IMM has taken careful measures to prevent the virus from spreading not only during its peak, but also to be followed afterwards.

Figure 15. Public transportation ridership decrease in March, 2020 (IMM, 2020d)



The followings are a summary of some of the transportation related policies, actions and provisions that have been made by IMM before, during and after coronavirus outbreak in Istanbul, until the end of the May 2020 (IMM, 2020e):

- While informing people about the prevention methods of virus spread was among the first priorities of the IMM, from March 6th on, IMM started to disinfect all public transportation vehicles and the related closed areas. In this regard, all metro trains have been disinfected with the nano technology in three layers, its protection effect lasting one month. With the collaboration of Şehir Hatları Inc. all ferries have been disinfected with a two-month protection effect. All surfaces of buses have been cleaned on a daily basis by IETT's 420 staff team. Also, a total of 65 hand disinfection units in 44 BRT stations and a total of 4 units in 2 stations in Taksim-Tunnel tram line have been installed.
- In order to prevent the contact of bus drivers and passengers, on March 22nd, the drivers' cabins have been placed in IETT buses.
- On March 24th, the capacity of allowable IETT buses reduced to 50 percent and the social distance regulation took place within the Metrobus (BRT).
- Despite the decrease in public transportation ridership by 70%, in order to prevent morning and evening peak crowdedness, the number of bus fleet were increased in the required routes.
- It has been ensured that the occupancy of all bus vehicles was maintained around 25-30% of its capacity in the worst case.
- In April 2020, following the obligatory use of masks in public areas, IMM's transportation department distributed 100,000 masks in metro stations in the first day and then increased the number to 200,000 in the next days, meanwhile they started to produce 1 million masks on April 4th.
- In order to control the fever of the passengers, on from April 5th, thermal cameras were installed at Yenikapı, Üsküdar, Kirazlı, Aksaray, Şişli, Bağcılar, Ataköy, Taksim, Ünalan and Zeytinburnu metro stations. Passengers with high fever were directed to the nearest healthcare organisation.
- As part of the coronavirus measures, the metro services planned in a way that the crowdedness level would not exceed 25% of the capacity. Meanwhile, from April 6th, the work hours of the rail systems changed to 6:00 - 21:00 instead of 6:00 - 24:00.
- Despite the great loss of IMM's budget due to the outbreak, mayor İmamoğlu dedicated 30 million Turkish Lira support to the Private Public Bus (ÖHO) tradesmen who had financial hardship due to the sharp decrease in the bus ridership rates.
- In order to maintain the physical distance, bus and BRT services have been re-planned on April 7th. In cases where the number of passengers would exceed 50% of the vehicle capacity, drivers were not allowed to get new passenger and have to make call for backup vehicles.
- On lockdown days, M1, M2, M3, M4, M5, T1 and T4 lines served, at half an hour intervals between 07:00-10:00 and 17:00-20:00.
- On April 27, the pedestrian buttons at the traffic lights were changed to contactless push buttons throughout Istanbul.

After the government's decision for easing the restrictions and constraints as a transition towards a "new normalization period" from June 1st, IMM took all the necessary precautions. In this regard, IMM re-opened all the rail transit, road transit and sea transport facilities in full capacity under the "normalization process" precautions. Followings are some of the IMM's taken actions in this respect (IMM, 2020f):

- IETT started to serve with a fleet of 6,100 bus.
- In order to compensate the shortage of drivers who have been on sick leave due to coronavirus, 400 retired drivers joined the fleet based on a daily wage (Sözcü, 2020).
- Metro lines started to serve from 6:00 to 24:00.
- BRT began to serve 24/7, while in the peak hours 535 vehicles serve with 17 second headways in most crowded directions.

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The latest pandemic has shown that there is an urgent need, maybe more than before, to lay the foundations of a sustainable and smart future in cities as well as establishing stronger networks between cities to learn from each other. Current challenges pose a cry for rethinking our conceptualization of urban mobility. We are urged to rethink the "Grand Narratives", which formed the theoretical framework of this report, and reestablish our relationship with various modes of urban transport as well as with spatial, social and economic development of our cities.

We can achieve that by exchanging experiences and knowledge through well-established networks between cities, civil society, academic institutions and private sector. This report is an initial step toward promoting green and sustainable urban mobility in Istanbul, through strengthened bonds between Istanbul Metropolitan Municipality and Dutch cities, institutions and experts.

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