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Review

Are We Satisfying the Right Conditions for the Mobility Transition? A Review and Evaluation of the Dutch Urban Mobility Policies

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Abstract: Global climate agreements call for action and an integrated perspective on mobility, energy and overall consumption. Municipalities in dense, urban areas are challenged with facilitating this transition with limited space and energy resources, and with future uncertainties. One important aspect of the transition is the adoption of electric vehicles, which includes the adequate design of charging infrastructure. Another important goal is a modal shift in transportation. This study investigated over 80 urban mobility policy measures that are in the policy roadmap of two of the largest municipalities of the Netherlands. This analysis consists of an inventory of policy measures, an evaluation of their environmental effects and conceptualizations of the policy objectives and conditions within the mobility transitions. The findings reveal that the two municipalities have similarities in means, there is still little anticipation of future technology and policy conditions could be further satisfied by introducing tailored measures for specific user groups.

Keywords: electric vehicles; urban mobility; modal shift; mobility transition; policy analysis; system analysis

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1. Introduction

Innovations in mobility, together with a climate crisis-fueled acceleration of policy measures, have led to a number of mobility transition strategies at the European, national and municipal levels. An important element in the mobility transition is the adoption of e-mobility. The use of electric vehicles (EVs) has high potential to reduce local emissions [1], and parked electric fleets could potentially play a role in the efficient use of energy and grid stabilizations [2]. The Dutch Climate Agreement contains a 'Mobility' chapter [3] which includes a strategy to increase EV adoption. This strategy describes the deadlines for sales of new traditional internal combustion engine (ICE) vehicles, electrifying the fleet of specific sectors and the establishment of the National Agenda of Charging Infrastructure [4]. Municipalities will have to work towards these national mobility goals, which include the increase in EV adoption and the roll-out of a public charging network.

Municipalities need functioning charging networks for EV users and their charging requirements. Although ~74% of current Dutch EV owners have their own driveway to place charging infrastructure [5], this percentage tends to be lower in urban areas and will decrease as adoption increases among residents without driveways. Dense urban areas have additional challenges such as the allocation of charging infrastructure in a built environment with little space, and less driveway parking compared to rural areas. EV users prefer to have their charging point close to their destination: less than 300 m from home and less than 100 m from a supermarket [6]. Therefore, it is important that the charging ecosystem is arranged carefully. The system should be able to provide EV users and users of adjacent systems (such as parking) with sufficient resources. Urban e-mobility can be categorized into user groups with distinct charging behaviors and preferences. Helmus et al. [7] observed a number of distinct user group behaviors, such as shorter connection times for cab drivers and shared vehicles (as opposed to personal vehicles), and differences in time windows across user groups. Five user groups were distinguished in total for public charging: personal (residents, commuters, visitors), shared (vehicles) and cabs. Other groups (non-public charging) include logistics and public transport.

There are also mobility objectives that municipalities have to address in the upcoming years. Especially in dense urban areas, where streets can be crowded and street parking spots can be hard to find, additional mobility policies are necessary to safeguard the city habitability for residents, as well as for future generations. Some of these policies can be summarized as incentives to promote a modal shift [8], which aims to move residents away from the traditional 'car ownership' model of transport. Others can be summarized as smart mobility developments, which aim for a more automated and tailored experience, using new technologies. Urban mobility patterns are affected in numerous ways and to a different extent because of this transition. For example, car sharing affects mobility patterns [9] and charging behavior, while light electric vehicles can be simply charged from work or home [10], and autonomous vehicles require other charging methods altogether (e.g., inductive charging [11]). These developments can also affect other mobility factors such as travel times, driver comfort and road safety [12] and require distinct parking strategies [10,13,14]. Municipal policy makers have the challenge of implementing policy measures to address these various aspects of the mobility transition.

Although systematic reviews and analyses of EV and urban mobility policies have been executed in the past (e.g., [15,16]), and Dutch EV policies have previously been investigated [17], these studies address the challenges in EV policies themselves, but not the broader context of the contemporary policy maker, who also needs to consider other aspects of the mobility transition, as well as their local parameters, in dense urban areas with limited spatial resources. This study aims to contribute a novel, detailed mobility policy analysis of the policies in two municipalities which both have a relatively mature charging network. The Netherlands currently has spatial challenges, a more dedicated charging network than many other countries [18,19], available charging transaction data [20], and non-confidential municipality documents are available online. Policies and developments affecting mobility behavior in the Netherlands, such as the use of P&R parking garages that aim to keep cars outside of city centers, the widespread adoption of biking and the roll-out of charging infrastructure, are frequently discussed as best practices in European policy documents [21–23]. We aim to benefit from these best practices in terms of the learning potential of the Netherlands in reviewing novel urban mobility policies. Additionally, our translated categorizations could improve the accessibility of Dutch policy documents for international stakeholders and researchers.

This study explores which policies are implemented to address the mobility transition, and how these policies contribute to the objectives of the transition. The aim of this study is to summarize and evaluate a wide variety of urban mobility policies. For this purpose, we present an overview of urban mobility policies in two Dutch municipalities: Amsterdam and The Hague. This overview contains a description of local mobility policy roadmaps, an evaluation of their effects on the local environment and literature-based conceptualizations of the objectives and environmental interactions, using policy and system analysis. The following section describes the methods that were used in this research. Next, we present our findings, evaluations and conceptualizations of the policy and environmental interactions of urban mobility transition. The final chapter discusses future implications for the two municipalities.

2. Materials and Methods

The methods used in this study are discussed in the following paragraphs. This study mainly used (municipal policy) the literature (inventory, literature evaluation) and is therefore a review of the state-of-the-art urban mobility policies in the Netherlands. An additional system analysis was used to summarize the findings and reveal the underlying conditions and challenges.

The set-up, as illustrated in Figure 1, was derived from steps that are familiar in both policy and system analysis [24–26]. Whereas traditional policy analysis suggests or implements a 'best alternative', our aim was to describe the mechanisms behind the policies and their expected effects on the urban environment. System analysis methods were used to summarize and conceptualize the system interactions in urban mobility policies. The criteria that were selected for policy evaluation were also used in the system analysis. Additionally, we constructed objective trees and identified external factors in the scope of the system. We ended by suggesting a conceptual diagram that summarizes the system interactions.

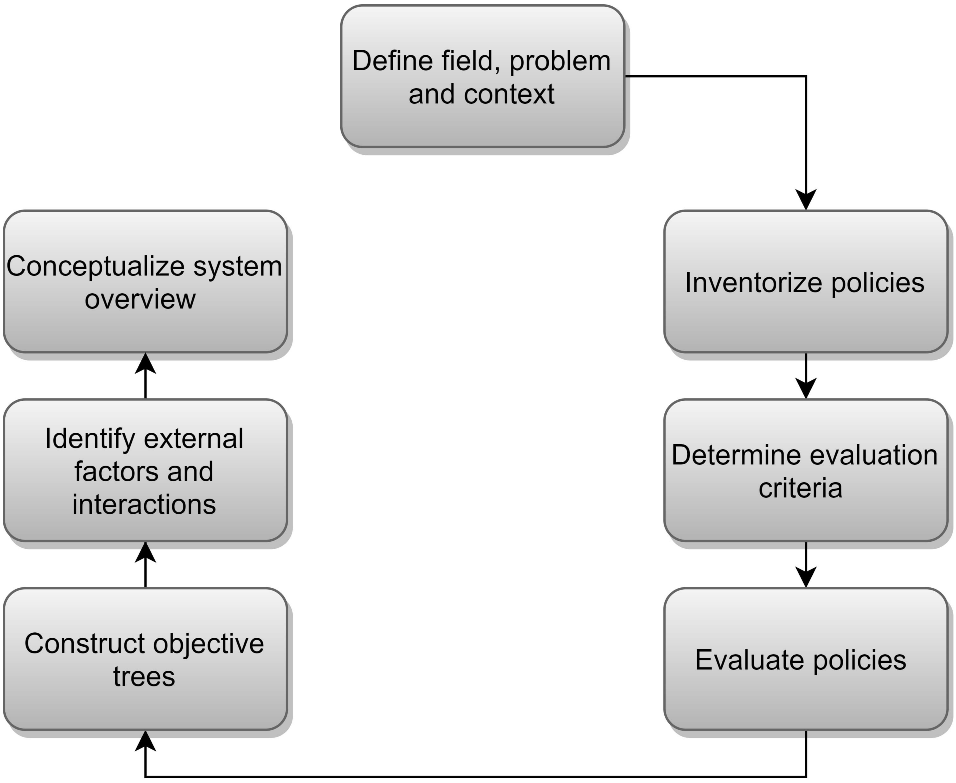

Figure 1. Methodological Set-Up, Adapted from [24–26].

2.1. Decision Context

The case study area for this study is the Netherlands. We focused on two of the largest municipalities: Amsterdam and The Hague. These municipalities currently have a dedicated public charging network, a group of EV drivers and mobility service companies. We summarized the recent public EV charging transactions to determine the decision context (Table 1). The summary below was formulated using a Dutch EV charging transaction database from 2020. For each municipality, we calculated the number of unique users by counting the unique radio frequency identifications (RFIDs) associated with transaction cards, the number of sessions on the public charging point, the number of charging locations (area level), the number of public charging points, the average daily occupation (users/charging point, then divided through the year) and the amount of kilowatt-hours (kWh) charged during the session (sessions with 0 kWh filtered).

Table 1. Descriptive Statistics of the Case Study Environments between 2018 and 2020.

Summary	Amsterdam			The Hague		
	2018	2019	2020	2018	2019	2020
Unique # of RFID cards	43,518	57,987 *(+14,469)*	63,953 *(+5966)*	24,033	31,600 *(+7567)*	31,356 *(−244)*
# of public charging sessions	981,515	1,161,469 *(+179,954)*	1,202,222 *(+40,753)*	390,118	488,654 *(+98,536)*	547,095 *(+58,441)*
Daily occupancy (avg)	1.95	1.84	1.39	1.09	1.11	0.76
kWh charged (avg)	10.98	12.77	15.73	9.63	12.49	15.14
Connection time (avg)	9.69	9.53	12.01	10.47	10.16	11.70
# of utilized charging points	1380	2479	2370	984	1215	2729

Between 2018 and 2019, there was a growth in users (number of unique RFIDs) and sessions. In Amsterdam, an increase of nearly 14,500 unique RFID cards was observed, and the amount of charging sessions also increased, with almost 180,000 extra sessions for Amsterdam and almost 100,000 extra sessions for The Hague. In 2020, the growth trends declined. The Hague had less unique RFID users than in 2019, and the growth of users and sessions in Amsterdam stagnated to roughly one third of the growth that we witnessed between 2018 and 2019. Connection times increased in 2020. A smaller number of public charging points were utilized in Amsterdam. In The Hague, this number increased because of the extra infrastructure, which lowered the occupancy rates. The decline in growth could be attributed to the COVID-19 lockdown effects, when tourist attractions were closed and residents were asked to work from home. We expect this decline to diminish over time. The average kWh charged also had an increasing trend, presumably because of changes in the vehicle composition in the charging network (e.g., hybrid vs. full-electric or battery improvements). This trend is likely to continue in the future.

2.2. *Policy Inventory*

Policy documents were identified through online search engine research. The search terms that were used to identify policies were as follows: electric vehicle (EV), mobility, car free, parking, charging infrastructure, sustainability, smart and shared mobility, traffic and transport. The search portals of the municipality of Amsterdam [27], municipality of The Hague [28], the Green Deal website [29] and the metropolitan region of Rotterdam–The Hague [30] were used to gather policy documents. Table 2 contains descriptions of the scope that was used in selecting policy documents.

Table 2. Scoping of the Policy Inventory.

Dimension	In Scope	Out of Scope
Problem	EV (adoption, infrastructure, restrictions), parking, public space (parking and charging), (smart) mobility	Energy transition (except for EVs) Traffic or building permits
Spatial	Amsterdam and The Hague	Highways
Sector (user groups)	Personal, professional, public transport, logistics, shared mobility	Aviation, waterborne, specialized services
Temporal	Later than 2018 or a temporary measure or in implementation stage in 2020	Older than 2018 Permanent measures of which implementation stage is finished before 2020

Policies were categorized into the categories described in Table 3, adapted from previous studies [31,32]. Borras and Edquist [31] acknowledged the relevance and widespread use of the policy typology of regulatory, economic and soft. Regulatory instruments are used to regulate aspects of the policy domain such as markets and behaviors. Economic instruments include financial resources such as cash, budgets and financial (dis)incentives. Soft instruments are voluntary and consist of agreements, recommendations and knowledge exchanges, among others. Mundaca et al. [32] used a slightly differently named typology with similarities in the interpretation, which consists of the instrument typology of economic/financial/market, regulatory and informative/voluntary (p327).

Table 3. Policy Categorization.

Policy Measure	Specification
Economic/Market	Subsidy, discount, tax, loans, fines, allocation
Regulatory	Permits, preferential treatment, restrictions, standards, laws
Soft	Pilots, R&D, informative, code of conduct, monitoring, impact analysis

We validated some assumptions based on policy measures with two municipality workers: CTO Smart Mobility Amsterdam and The Hague Coordinator Electric Transport. An overview of the validated assumption can be found in the Appendix (Table A1).

2.3. Evaluation Criteria

Table 4 contains the criteria that were selected for evaluation of the mobility policies. Effects of policies on these local criteria were determined using local reports and the scientific literature. For the evaluation, we determined effect directions (decreasing, increasing or no effect). When the effect is only expected under specific circumstances, these circumstances are also mentioned.

Table 4. Description of Evaluation Criteria.

Evaluation Criteria	Description (Units)	Relevance
Occupancy rate	The percentage of occupied public charging points in an area.	The occupancy rate tells us about the performance of the charging network. When the occupancy rates in an area become too high, users have trouble finding a charging point near their location. When the occupancy rates are low, the affected charging points will make less profit and can become obsolete over time.
Parking pressure	The percentage of occupied parking spots in an area. For this study, parking pressure was scoped on street parking.	The parking pressure tells us about the availability of street parking spots for drivers (including drivers of traditional vehicles). When the parking pressure becomes too high, drivers may have trouble parking their vehicles on the streets. When the parking pressure becomes low, parking spots may become obsolete.
Car ownership	The number of vehicles owned by inhabitants.	The number of owned cars will influence most of the domain indicators in some way. For example, more owned vehicles will increase the need for parking spots, and depending on vehicle types, the need for charging pressure and the energy consumed.
Energy consumed	The amount of kWh that is consumed by charging, or, in the case of non-electric mobility, the energy (fuel) that is consumed.	The energy consumed tells us about the amount of energy that is needed at a certain time and location for users and their charging or mobility needs. When the electricity demand becomes too high, it may affect the speed and success rate of EV charging.

Table 4. *Cont.*

Evaluation Criteria	Description (Units)	Relevance
Adoption rates of EVs	The percentage of electric vehicles in the full vehicle fleet.	The adoption rate of EVs is relevant to estimate the necessary resources such as energy and parking.
Local air pollutants	The penetration rates of air pollutants and greenhouse gas emissions (e.g., CO_2).	Municipalities want to avoid pollutants and greenhouse gas emissions as much as possible to increase the local air quality in dense urban areas. A high percentage of local CO_2 emissions can be partly attributed to (fossil) mobility and transport.

2.4. System Analysis

System analysis can structure policy papers by creating a system overview of the policy problem. We selected objective trees and system diagram construction [33] as additional methods to determine and summarize the system. The system demarcation can be derived from Table 2. The means were clustered from the policy measures that were identified in the policy inventory stage. Mobility goals (annotated for each user group) were also determined from policy documents and summarized in objective trees. Causal relationships were determined from the policy evaluation stage, and additional literature was consulted to determine external factors and interdependencies between evaluation criteria. This provided the necessary input to construct the system diagram. Intermediate results, such as the policy conditions table, can be found in the Appendix (Table A4).

3. Results

This section describes the results of this paper according to the steps presented in Section 2. We first report on the policy inventory (Section 3.1), followed by our findings on evaluation criteria (Section 3.2), and conclude with a system overview (Section 3.3), which includes goals, conditions and a conceptualization of the system relationships.

3.1. Policy Inventory

Section 3.1 first discusses the national policy context, before specifying the local policy landscape for the municipalities of Amsterdam and The Hague. We end this section by presenting mobility policy measures that were associated with EVs and mobility in these municipalities.

3.1.1. European and National Strategy

The Paris Agreement was drafted to ensure that the post-industrial temperature does not surpass an increase of 2 degrees (Celsius), limiting the increase to a maximum of 1.5 degrees Celsius [34]. The Netherlands ratified the Paris Agreement in 2016. The national goals for the Netherlands include a CO_2 reduction of 49% in 2030 and a reduction of 95% in 2050 (compared to 1990). Additionally, the district court of The Hague has the power to rule additional measures, such as the reduction in greenhouse gas emissions between 2015 and 2020. The national strategy has been drafted in the Dutch Climate Agreement [35], which includes the themes 'Built Environment', 'Mobility', 'Industry', 'Agriculture' and 'Electricity'. Goals that are related to the mobility transition and the future of e-mobility can be found in the 'Mobility' chapter. The goal is to reduce local mobility emissions, stimulate the use of renewable sources in mobility and reduce vehicle ownership by further developing mobility services in urban areas. The agreement also states that in 2030, all new vehicles sold must be emission free. The National Agenda of Charging Infrastructure (NAL) was established to determine national goals for charging infrastructure (such as the goal of 1.7 million charging points in the Netherlands by 2030) and to facilitate pilots that increase knowledge [4]. Amsterdam and The Hague are also involved in mobility projects at the European level. For example, earlier this year, Amsterdam released its Sustainable Urban Mobility Plan (SUMP) [36], which focuses on inhabitants and environments, rather than vehicles and traffic. Amsterdam is also involved in Horizon 2020-funded mobility projects such as the digital platform of Mobility Urban Values (MUV) [37] and the Atelier project [38], which contains the development of a positive energy district including electric cars. The Hague is one of the hosts of the CIVITAS living lab project [39] to solve the last mile problem in logistics. This list is not exhaustive. The main focus of analysis in the upcoming sections is the municipal (and sometimes regional) level of policies.

3.1.2. Local Policies

We identified green deals, local policies and regional policies for the municipality of Amsterdam and The Hague, using the scoping criteria mentioned in Table 2. We summarized the policy measures in the categories described in Table 3. For both municipalities, the most commonly targeted user group is personal drivers. The city of Amsterdam has soft measures as the most common policy category (40%). The most common policy category for The Hague is regulatory (42%). Both municipalities have measures addressing hubs. Hubs were not categorized for one specific user group because the policy documents and assumption validation interviews (Table A1) implied hub access for multiple user groups (e.g., residents, logistics and/or shared vehicles). Table 5 contains the entire statistical summary of the identified policy measures. This table contains the number of accessed documents, the number of identified measures through these documents and the policy categorization at the measure level. The table also contains the number of measures that were introduced for each user group.

Table 5. Statistical Summary of the Identified Policy Measures [40–56].

Policy Measures	Amsterdam	The Hague
# of full policy documents	**10**	**11**
# of policy measures	**47**	**34**
Soft measures	19 (40%)	9 (27%)
Economic measures	11 (23%)	10 (30%)
Regulatory measures	10 (21%)	14 (42%)
Targeted user group	**Amsterdam**	**The Hague**
Personal drivers	18 (38%)	11 (32%)
Cab drivers	2 (4%)	2 (5%)
Logistics	2 (4%)	4 (11%)
Shared vehicles	7 (15%)	9 (26%)

We categorized all identified policy measures on what they intend or promote. This enabled us to categorize the measures in groups (Table 6). We only focused on the policy measures that could have a tangible effect on at least one of the criteria. We excluded a few subgroups such as communicative and informative measures, and car-free streets from this part of the analysis (Section 3.3 describes their role in the system, and Appendix Table A4 describes these measures in the context of conditions).

Table 6. Policy Measure Groups.

Measure Groups	Definition	Amsterdam (# of Occurrences)	The Hague (# of Occurrences)
New charging infrastructure	Roll-out of new charging points	8	6
New hubs	Roll-out of hubs, including clustered charging/mobility points	4	3
Shared vehicles	Roll-out of the shared vehicle fleet or market	7	9
Mobility budgets	Budgets made available to promote modal shift with residents and employees	2	1

Table 6. *Cont.*

Measure Groups	Definition	Amsterdam (# of Occurrences)	The Hague (# of Occurrences)
Mobility-as-a-service (MaaS)	Roll-out of incentives to develop MaaS market	3	2
Subsidies and preferential treatment	Subsidies or benefits for EV drivers to incentivize emission-free driving	2	3
Sector electrification	Incentives to electrify a sector	4	4
Fast chargers	Roll-out of fast chargers in the urban environment	1	1
Sustainable/alternative charging methods	Charging methods that promote sustainable energy use, such as vehicle-to-grid (V2G), photovoltaic solar (PV) charging and smart charging	3	1

3.2. Evaluation Criteria

Section 3.2.1 summarizes the effect directions of these measure types on each domain indicator in a table. The following paragraphs describe the literature, prognoses and pilot outcomes that were used to determine these effects. Section 3.2.2 discusses the way domain indicators affect each other, and in Section 3.2.3, we identify important external and system factors that interact with these domain effects.

3.2.1. The Effects of Policy Measures on Evaluation Criteria

For each of the measure groups, as selected in Table 6, an evaluation was conducted using the literature and local pilot outcomes. Table 7 summarizes these evaluations. Evaluations are discussed in the paragraphs below.

Table 7. Evaluation of Policy Measures.

Policy Measure Groups	Occupancy Rates	Parking Pressure	Car Ownership	Energy Consumed	Adoption Rate (EVs)	Local Air Pollutants
New charging infrastructure	Decreases	No direct effect	No direct effect	Electricity use increases	Increases [57]	No direct (local) effect
Hubs	Decreases	Decreases for 'park and charge' hubs	No direct effect	Electricity use increases, but more efficient than street infrastructure [58]	Increases [57]	No direct effect
Shared vehicles	Increase temporarily (EV sharing)	Likely to decrease over time [59]	Decreases [59]	Electricity use increases temporarily (EV sharing)	No direct effect	Decreases [60]
Mobility budget	Depends on market composition	Likely to decrease [61]	Likely to decrease [61]	Depends on selected modality	Depends on market composition	Decreases with use of shared vehicles [59,60]
Subsidies and preferential treatment	Likely to increase [57,62]	No direct effect	No direct effect	Electricity use likely to increase [62]	Likely to increase [57,62]	No direct (local) effect
Fast chargers	Likely to decrease (shorter sessions)	No direct effect	No direct effect	Electricity use increases (short-term spike, kWh at location)	Increases [62–64]	No direct (local) effect
Alternative sustainable charging	No effect [65]	No direct effect	No direct effect expected	Decreases peak consumption, increases use of RES [65,66]	No direct effect	Likely to decrease [65]

Table 7. *Cont.*

Policy Measure Groups	Occupancy Rates	Parking Pressure	Car Ownership	Energy Consumed	Adoption Rate (EVs)	Local Air Pollutants
Mobility-as-a-service	Depends on market composition	Likely to decrease over time [59,67]	Decreases [67]	Depends on market composition	Depends on market composition	Decreases with use of shared vehicles [59,60]
Sector electrification	Likely to increase (more users)	No direct effect expected	No direct effect expected	Electricity use increases, but more efficient than fuel [68]	Increases by definition	Decreases [69]

(1) *New Charging Infrastructure and New Hubs*

One of the main issues in the context of EV adoption is the chicken and egg problem (adoption first, vs. available infrastructure first). This problem could be (at least partially) remedied by pro-actively installing charging infrastructure in public spaces, which increases EV adoption [57]. New charging infrastructure can be placed to lower occupancy rates, and to anticipate future users. Energy consumption increases with more charging transactions. Global as well as local CO_2 emissions can be reduced when drivers give up their fossil-fuel cars to adopt EVs, but CO_2 emissions are not directly affected by the placement of infrastructure. Clustered charging (hubs) could redirect pressure on charging and parking, allow for more efficient use of space, allow for more efficient use of the grid capacity and are up to 20% more profitable than street charging [58].

(2) *Shared Vehicles, Mobility-as-a-Service and Mobility Budgets*

A shared vehicle could replace four to six cars in the Netherlands, lowering both car ownership and parking pressure [59]. The amount of car-related CO_2 emissions for a vehicle sharer in the Netherlands is 8 to 18% lower compared to car owners [59,60]. Car sharers also drive up to 20% less kilometers. In the ZuidAs Mobility Experience [61], a local 2018 pilot in Amsterdam, participants gave up their car for a budget, which included a personal assistant for travel planning. On average, participants spent EUR 606 per month (similar to a car renting contract). At the end of the pilot, roughly 50% of participants indicated that they would give up their car for the budget. To summarize, car ownership could be decreased by offering drivers mobility budgets [61], sharing vehicles [60] and dedicated MaaS platforms [61]. Hensher [67] stated that in MaaS ecosystems, the (reduced) fleet of vehicles is also used more extensively, leading to less vehicles that stand still, and, in the long run, lowers the need for parking spaces.

(3) *Sector Electrification, Subsidies and Charging Techniques*

Electrifying fleets in the Netherlands is associated with high investments costs for user groups and benefits in air quality, as well as progress in climate goals, lowered CO_2 emissions and an increased consumption of electricity per municipality. Mersky et al. [57] did not find significant effects of preferential treatment on EV adoption; however, economic considerations were relevant, indicating a potential for subsidies. Lieven [62] compared policy preferences in many countries including the Netherlands. Grants were more effective than tax returns, and preferential treatments (access to lanes) as well as sufficient infrastructure affected preferences in this study. Fast chargers are one of the indicated needs for Amsterdam-based cab drivers [64]. From a global perspective, Lieven found that freeway chargers are also crucial for personal drivers (independent of driving distances). Another European survey found that installing fast chargers throughout Europe could lead to increased adoption [63]. Alternative sustainable charging such as solar (PV) charging, smart charging and vehicle-to-grid (V2G) charging can lead to better control over the energy system. This may lead to potentially higher penetration of renewable energy use by allowing charging adaptations, energy storage and/or grid support. Smart charging is an intelligent adaptation of the interaction between EVs and charging points, which can help in managing the electricity demand [65]. An example of smart charging is the

Flexpower project, where the charging of EVs was matched with the availability of locally generated renewable energy. The results of the Flexpower project, where 432 public smart chargers were placed in Amsterdam, indicate that there is no significant longer charging time for smart charging, and that the average load was reduced with 1.1 kW per charging point (leading to a 470 kW peak reduction per evening in the case study environment), leading to reduced CO_2 emissions [65].

3.2.2. Interdependencies of Evaluation Criteria

Some of the evaluation criteria also affect each other or correlate with each other. Figure 2 illustrates which criteria affect each other.

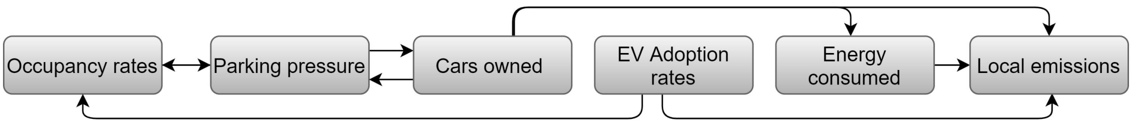

Figure 2. Overview of Interactions between Evaluation Criteria.

We consulted the following literature to determine additional relationships between parking pressure [70], adoption rates [71] and car sharing emissions [60]. Holding other things constant, the following interactions were expected across the criteria (see Table 8).

Table 8. Interactions between Evaluation Criteria.

Evaluation Criteria	Interactions
Occupancy rates	Correlates with parking pressure Increase in EV adoption can lead to an increase in occupancy rates
Parking pressure	Correlates with occupancy rates Increase in owned cars leads to increased parking pressure
Cars owned	Increased parking pressure leads to a decrease in owned cars [70]
Energy consumed	Electricity consumption is increased by an increase in occupancy rates
Adoption rates	An increase in occupancy rates can lead to a decrease in adoption [71]
Local air pollutants	A decrease in car ownership leads to lower emissions [60] A decrease in energy consumed leads to lower emissions An increase in adoption rate leads to lower CO_2 emissions (under the assumption a previous vehicle was consuming fossil fuel)

3.2.3. External Factors

In the previous sections, we illustrated how policies relate to the objectives, to what extend they contribute to the objectives and how criteria are affected by policy measures, as well as other criteria. However, there are also other components of the mobility system that can affect these criteria; these are the external factors. Occupancy rates of the charging network are affected by the charging preferences of users [72], the battery size and the charging speed of vehicles [73]. Parking pressure is affected by neighborhood factors such as family composition and the growth of residents in a neighborhood [74]. Similar neighborhood factors are relevant for car ownership, as well as ownership percentages of neighbors and socio-economic factors [75]. EV adoption rates are influenced by the quality of the charging infrastructure, the battery range, the total cost of ownership and socio-economic factors [76]. The energy consumed is influenced by other modes of urban transport (e.g., fuel), and these other modes can also influence the level of local CO_2 emissions.

3.3. System Overview

In the following section, we describe two key policy objectives, emission-free inner city and modal shift, in an objective tree to determine the subgoals, conditional settings and measures. The coding (e.g., D7) for policy measures can be found in Appendix Tables A2 and A3. Coding that starts with a 'D' corresponds to The Hague (Den Haag, Appendix Table A3), and the coding that starts with an 'A' corresponds to Amsterdam (Appendix Table A2). An overview of policy conditions and matching policy measures can be found in Appendix Table A4.

3.3.1. Policy Objectives

The goals of the municipalities include emission-free touring cars (Amsterdam), shared vehicles, professional traffic (such as logistics and cab drivers) and, ultimately, completely emission-free traffic in the inner city (Amsterdam). Requirements for these goals are other subgoals, as well as a number of conditions that need to be satisfied. We followed the implemented measures here to define the critical success factors that were addressed through policies in Amsterdam and The Hague. Most conditions hold true for multiple user groups or mobility goals, which are annotated in the aggregated measures.

Figure 3 is an objective tree. An objective tree can be read from left to right. On the left, the municipality goals on electrification can be found. Before this goal can be achieved, subgoals should be met, which can be found after the goals. To meet these subgoals, the right conditions should emerge first; these can be found after the subgoals. On the right side, the necessary types of measures to create the right conditions can be found. In the following paragraphs, we discuss the objective trees for electrification as well as a modal shift and mention the applicable measures (as identified in Section 3.1).

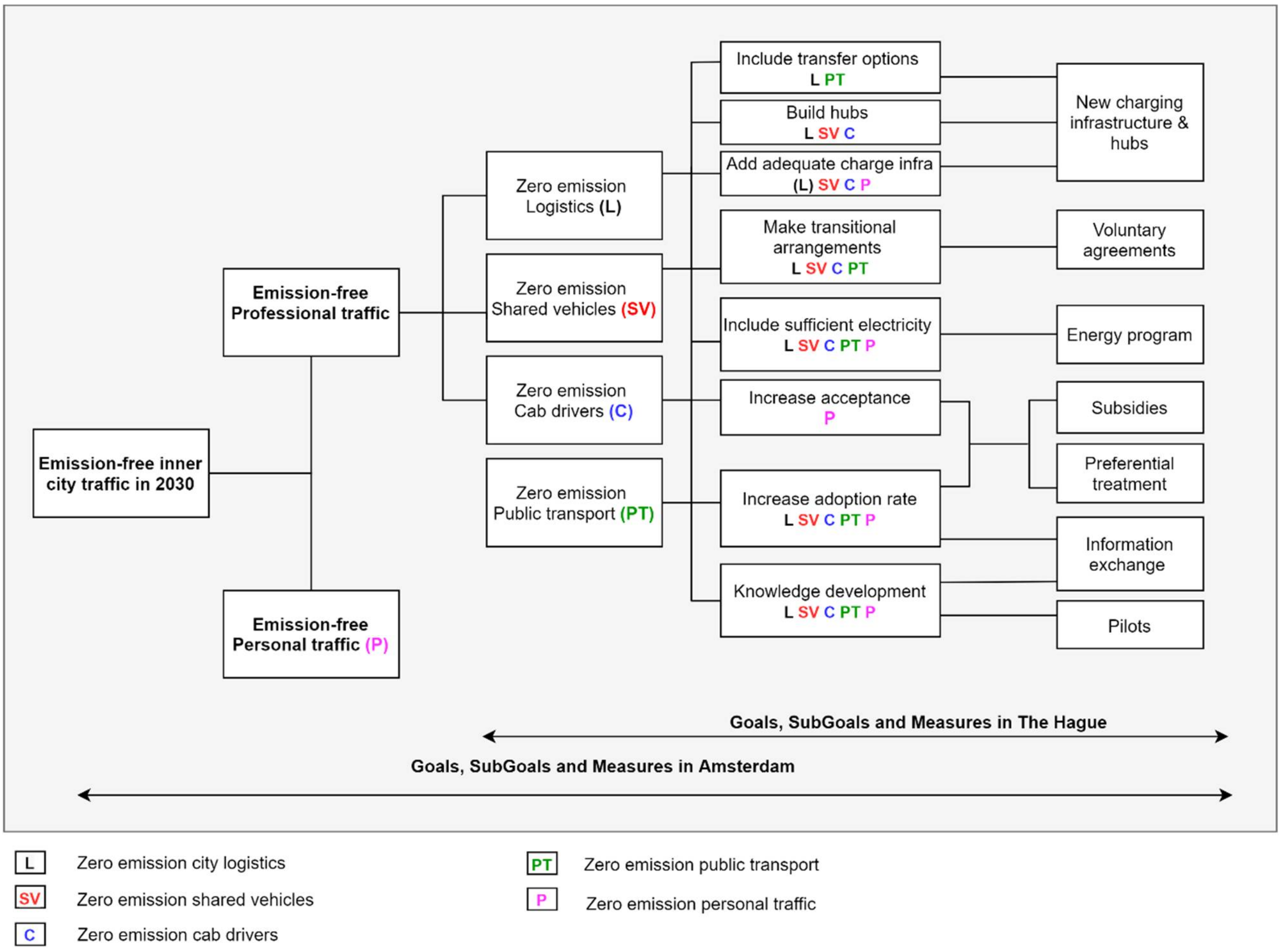

Figure 3. Objective Tree of Emission-Free Inner City Traffic.

The identified conditions for emission-free inner city traffic include user group requirements (clustered), voluntary agreements, transfer points, attractive options, knowledge development, information exchange and adequate charging and electricity supply (Figure 3).

Amsterdam and The Hague addressed some user group requirements: the charging hub needs of logistics (A31, D9), as well as the fast charging needs of cab drivers (A41, D24). Amsterdam has voluntary agreements for logistics (A21) and cab drivers (A1, A20) and has announced future policies for light electric vehicles (A8). The Hague has an agreement for logistics (D7) and has plans for agreements with cab drivers (D26) and shared vehicles (D25) in 2021. There are policies addressing transfer points for visitors/personal traffic in Amsterdam (A31, A34) and for logistics in both municipalities (A5, D9). There are some attractive options for electrification of personal drivers (A10) as well as public transport (A47) in Amsterdam. The Hague offers a trade-in budget for old vehicles (D13) and subsidies for public transport operators who want to install PV chargers (D29). Knowledge is being developed on charging (A13, A27) in Amsterdam. An information exchange incentive was identified for decreasing CO_2 emissions in The Hague and surrounding municipalities (D30). Adequate charging is being addressed in Amsterdam for personal vehicles and logistics (A31), cab drivers (A41) and shared vehicles (A9). In The Hague, there are policies addressing charging for personal drivers (D10) as well as cab drivers and logistics (D9, D24). Electricity supply is addressed in Amsterdam with a city-wide program (A44), and in The Hague, the electricity challenge is being addressed for electrifying built hubs (D14). We identified seven conditions for logistics, six for shared vehicles and cab drivers and five for personal vehicles and public transport.

Another goal that was clear from the mobility documents of both municipalities is to create a successful alternative mobility market to promote a modal shift. This would decrease the use of public spaces (such as parking spots or roads), and electrified fleets without personal owners could be used for storage. Car ownership and CO_2 emissions could decrease, as investigated in Table 7. In order to develop this market, policy makers have to facilitate progress by bringing providers together, work on interoperability of the MaaS market, attract users and take into account other resources that are necessary for this progress, such as mobility hubs or supply and demand platforms.

The conditions that we identified for a successful modal shift were attractive options, knowledge development, adequate infrastructure (parking and charging), low-car/car-free streets and public transport expansions (Figure 4).

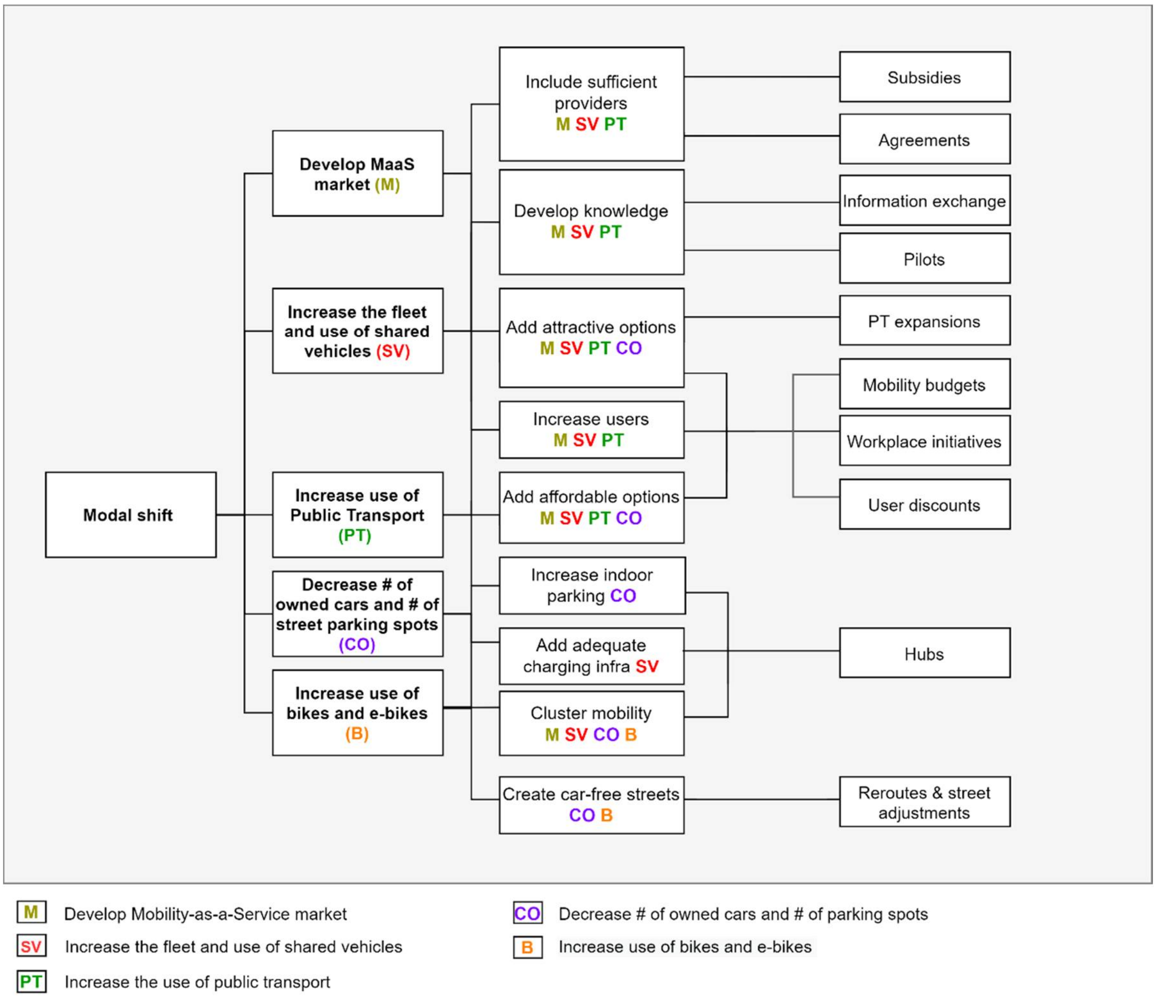

Figure 4. Objective Tree of Modal Shift.

Attractive options were found in Amsterdam in the form of mobility budgets (A2), financial incentives for alternative transport (A7) and the roll-out of cheaper shared mobility (A33). In The Hague, shared mobility providers are attracted with parking permits (D1) and shared fleet expansions (D18). Both municipalities are developing a service mobility market by developing mobility-as-a-service platforms (A4, D27). Knowledge is being developed on shared mobility (A12, A13, D23) in both municipalities, and on living–sharing combinations (D22) in The Hague. Amsterdam has initiated pilots that anticipate drones (A18) and autonomous vehicles (A16). Information exchange takes place for shared vehicle initiatives in both municipalities (A39, D20). Adequate parking is addressed by P&R (A34) in Amsterdam, and indoor parking spaces (A24, D4) in Amsterdam and The Hague (please consult the previous paragraph for charging policies). Low-car streets are developed in the market area (A32) and by cutting the main street (A14) in Amsterdam. In The Hague, traffic is redirected (D3) with reduced maximum speeds (D21), and there is a pilot for a car-free neighborhood (D17). Public transport expansions are mentioned for The Hague (D2), and Amsterdam specified a night metro (A6) as well as a new metro line (A23).

Appendix Table A4 describes the different policy measures that could be used to satisfy conditions. It also provides insight into the extent to which conditions are addressed—and for which user group.

3.3.2. Summarizing Mechanisms in a System Diagram

We combined the domain effects (on evaluation criteria), external factors and policy measures of the two municipalities in a simplified system diagram (Figure 5). We also added some relevant system factors to explain the mechanisms behind the policy effects. Effect directions are summarized as + (will increase), +/− (both directions possible), ? (effect unknown) and − (will decrease). 'No effect' was not included in the diagram. The diagram is directed towards the evaluation criteria. The effect of these criteria on other factors is not included. On the left side, the gray boxes indicate the common measure types (aggregated). The colored boxes (middle) represent some of the system factors that are influenced by both measures, as well as external factors, and directly influence the evaluation criteria. The gray boxes on the right contain the evaluation criteria. Finally, the external factors can be found on the far right, in purple boxes.

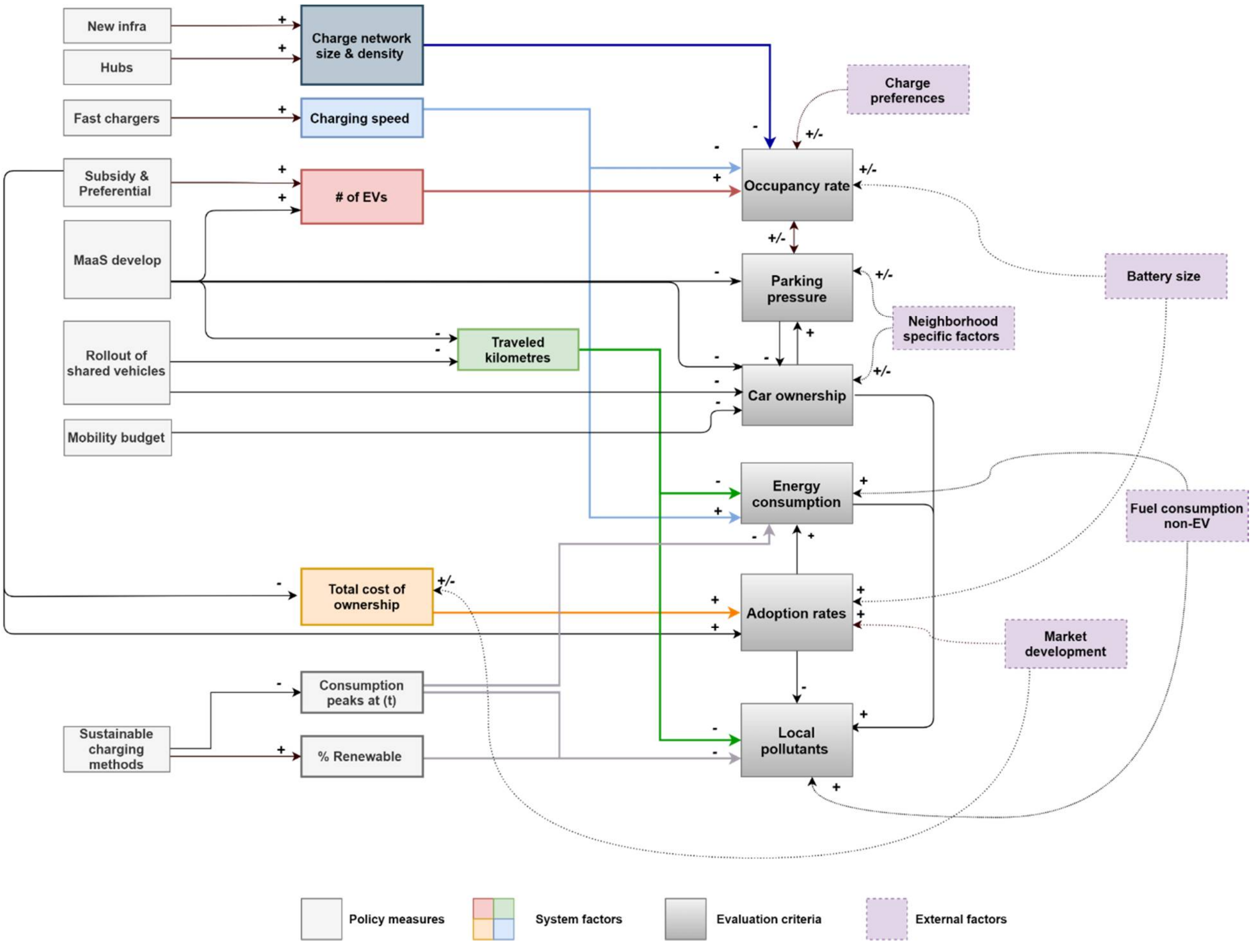

Figure 5. Simplified System Diagram.

We illustrate the use of the diagram with a step-by-step description of one of the evaluation criteria: occupancy rate. In Table 7, we found that fleet compositions and adoption rates affect the influence of policy measures on the occupancy. The intermediate factors in the diagram further illustrate how occupancy takes place in the public charging system. The occupancy rate is influenced by the number of EVs, the charging network size and density, the number of and distance between charging points and by measures that influence the adoption rate (and therefore the number of EVs), such as subsidies and preferential treatment. The charging network size and density can be increased by new infrastructure, and fast chargers could increase the charging speed which can lower connection times of charging sessions. There are also factors that we do not control that influence the occupancy rates, such as the charging preferences of users and the battery size of vehicles, which can increase adoption rates (less range anxiety) but also affect connection times and the frequency of charging. Market developments, another external factor, can influence adoption rates directly by attracting more consumers, or indirectly by lowering the total cost of ownership. These influenced adoption rates also affect the occupancy rate.

There are some notable relationships in Figure 5. The measure mobility-as-a-service draws direct as well as indirect lines to almost all evaluation criteria. This illustrates the potential of MaaS platforms to increase the use of electric mobility, decrease car ownership, and therefore parking pressure, and decrease the amount of kilometers driven, which decreases energy consumption as well as local emissions. Energy consumption and local emissions do not only correlate as criteria, but they are also affected by similar measures and the same external factors. Parking pressure and car ownership are also affected by similar external factors, measures and system factors.

4. Discussion

In this paper, we analyzed mobility policies of two of the largest Dutch municipalities, Amsterdam and The Hague. Afterwards, we evaluated these policies on relevant criteria for the municipalities. We also constructed the objective trees for two of the key mobility objectives (modal shift, and EV and infrastructure roll-out), which revealed the conditional settings for the policies to succeed. Finally, we summarized the policy mechanisms and interactions that were identified through different parts of the analysis, in a system diagram. This enabled us to illustrate the different goals of the case study environments, and the extent to which these goals have been addressed in policies. We were also able to illustrate some important interactions between the policies and goals while considering other aspects such as the local environment, external factors, interdependencies and system interactions. The results led us to a number of identified challenges, as well as recommendations.

We first discuss the case study outcomes. Then, we discuss the challenges in urban mobility transitions. We end this chapter with recommendations for municipalities' strategies for the mobility transition, and recommendations for future work. It is important to consider the scope (Table 2) and assumptions that were made (Appendix A) while interpreting the results and discussion.

4.1. Case Study: Amsterdam and The Hague

The analysis of mobility policies was executed using two case study environments: Amsterdam and The Hague. The use of a case study environment, as opposed to a traditional literature review, enabled us to apply the findings of prior research to a case study context, while considering local challenges, data, and pilot outcomes. The case study also increased our understanding of how relationships can be strengthened or diminished by environmental factors. Using two case studies, instead of one, enabled us to compare different municipalities and explain their overlaps and differences (see next paragraphs).

We found similarities between the case study environments. The mobility strategy for Amsterdam and The Hague largely overlaps, despite differences in their policies towards electrification. We also observed an overlap in Green Deal and City Deal participation for car sharing, and both municipalities have detailed regulations for the logistic sector and public transport. The policy measures that were most common for both municipalities were measures addressing the construction of new charging infrastructure and measures addressing the roll-out of shared vehicles (Table 6). Both municipalities provided attractive mobility options for their citizens and made an effort to start voluntary agreements with different user groups. The municipalities both had a focus on shared mobility pilots.

There are also substantial differences. The city of Amsterdam is stricter in electrification requirements and deadlines for visitors, touring cars, logistics, public transport and personal and shared mobility, whereas The Hague mainly focuses on strict zoning and deadlines for logistics and public transport, and is less strict in deadlines for other user groups. There is no 'hard' electrification requirement yet for new shared mobility providers in The Hague (Appendix Table A1). Knowledge development measures were more common in the analyzed documents of Amsterdam, and Amsterdam had more pilots addressing new technological development in these documents. Pilots addressing shared mobility in Amsterdam were focused on increasing accessibility and affordability, whereas shared mobility pilots in The Hague were more focused on the integration of shared mobility in streets, neighborhoods and living spaces. We can explain some of these differences by the environmental context. Amsterdam is a touristic hotspot that deals with a lot of visitors and touring cars, whereas The Hague had more growth in new building projects (0.6% vs. 1.1%, [77]) in 2020 than Amsterdam, which provides more opportunity for projects and pilots that include new streets or buildings.

4.2. Challenges in Urban Mobility and Public EV Infrastructure Expansion

We anticipate challenges in aligning the mobility policy objectives related to EV adoption and a modal shift, especially in the case of competing goals and temporal sensitivities. There is potential for synergy between the implementation of a modal shift and EV adoption. At the same time, there is an increased layer of complexity, which can lead to a policy risk: competing goals may undermine policy effectiveness. A key example is the car ownership decrease goal vs. the increase in the adoption rate goal. Potentially competing conditional settings may also undermine other policies' workings (e.g., sufficient nearby charging infrastructure vs. car-free streets) in this stage of the transitional period. Finally, there is the dilemma of clustered activities (e.g., parking and charging), and to what extent different types of mobilities and users can benefit the most from these activities.

Lack of awareness of temporal interdependencies could lead to suboptimal investments and, ultimately, stranded assets. This is applicable for the expansion of charging infrastructure itself: the best location for charging infrastructure is temporally dependent on the extent to which car ownership is decreased/car-free streets are introduced (locations may become obsolete), as well as the extent to which autonomous fleets are adopted (the distance to a location becomes less relevant). Electricity requirements and charging requirements are temporally dependent on the extent to which EVs are adopted, and the technological developments in ranges and batteries. Facilities that were introduced for the transitional periods, e.g., transferring points for inter-urban fossil vehicles, will become obsolete over time (but highly anticipative and creative policy makers may be able to re-use the facilities to satisfy a new condition). This challenge could be addressed in future studies by selecting policy analysis methods that explicitly address the temporal interdependencies of policies (see Section 4.4).

4.3. Recommendations for Municipalities

Municipalities have to work on increasing EV acceptance for different user groups by satisfying their (specific) conditions. User groups have their unique set of conditions that need to be fulfilled in order to transition to a new mobility system. The specifics of these conditions may be different for other municipalities over the world, e.g., in terms of the energy capacity, amount of public space and the level of private parking that users have available. Implementing policy measures per user group or specific policy goal does not always enable the right policy conditions. The inventory summary (Table 5) showed how policy measures were mostly addressed to citizens/personal vehicle users (38% in Amsterdam, and 32% in The Hague). However, we found that the measures addressed more conditions for logistics, cab drivers and shared mobility (Figure 3; Appendix, Table A4), as opposed to personal vehicles or goals that concern residents (such as car ownership decrease).

Amsterdam and The Hague also showed room for improvement in addressing specific conditions. In the future, they could aim for a more elaborate mix of charging modalities to increase security and comfort. An example of an overlooked modality is urban fast chargers. Urban fast chargers are still rare, and only 3% of national public chargers can be considered a fast charger [5]. Meanwhile, the kWh that is charged in a session is increasing yearly (see Table 1). Although both municipalities have a policy addressing fast chargers, the target numbers are still quite low compared to normal chargers. Fast chargers can increase acceptance and comfort for cab drivers [64], as well as personal drivers [62]. Urban fast chargers require less charging time, which could reduce occupancy rates and therefore reduce one of the main reasons not to get an EV: not enough charging points [78]. We recommend aiming for a proper mix of charging modalities that fit the activities of the driver (e.g., a fast charger for shopping, a smart charger for overnight parking garages), in order to increase acceptance, charging comfort and charging security while still taking the grid impact into account. Another example from the case study is that both municipalities have a limited number of measures addressing the information exchange policy sub-condition (Appendix, Table A4). Despite knowledge exchange taking place between parties that are in a pilot, additional information exchange measures could be introduced to include residents, as well as smaller municipalities with decreased pilot opportunities and other stakeholders.

Municipalities will have to anticipate technological developments by considering their impact on charging requirements, parking requirements, energy requirements and mobility service models. At the time of writing, neither Amsterdam nor The Hague included many pilots with disruptive technology in their mobility policies. Amsterdam mentions a few specific use cases: drones as a delivery service, and the use of a test location for autonomous vehicles (AVs) in a closed mobility system (office area). However, what happens if, for example, AVs are included in a city-wide mobility system? There are implications for autonomous charging (cable requirements, decreased charging station hogging), as well as potential for autonomous delivery options, and AVs could increase the accessibility (flexibility in location and driver's license) of shared mobility and other mobility services. Earlier developed scenarios suggest that AVs are to be expected on the Dutch roads between 2025 and 2045 [79] and emphasize the importance of policy making in the successful adoption of AVs. The policy making on AVs is still limited in both case study municipalities. It is likely that the introduction of AVs will be accompanied by the adoption of other disruptive technologies such as wireless charging [11] and space-efficient self-automated parking lots [80] Another technological development which may disrupt the current charging infrastructure is battery development. An increase in battery size has already been shown to influence the amount and length of charging sessions [73]. Municipalities, as well as other stakeholders, have to make a continuous effort in identifying and anticipating these new developments, in order to avoid unsatisfying conditions or stranded assets.

4.4. Future Work

In Section 4.2, we identified some temporal interdependencies as a challenge for urban mobility policy alignment. Future work could include the selection of policy analysis methods that explicitly address these interdependencies. Pierson [81] wrote about the difficulties of determining relevance and identifying path dependencies. Webster [82] illustrated how the roll-out of one policy affects the possibility landscape for future decision making (irreversibility). Taeihagh et al. [83] introduced a method for policy sequencing, which considers not only conditions but also contradictions and synergies between policies. These views and approaches could be especially helpful when a researcher can consult the policy maker prior to the roll-out of a policy roadmap, emphasizing the importance of involving a wide variety of experts in policy consultation.

Additional evaluation criteria could be added to broaden the context for the analysis. Additional data could be used to estimate policy effectiveness in more detail. The suggested evaluation framework could be expanded, for instance, by adding acceptance or maturity levels, implementation and maintenance costs and the use of public spaces. This could provide further insight in the long- and short-term costs and benefits that are associated with the implementation of different policies. Municipalities could be further supported by stimulating the monitoring of these types of criteria in their local context, for example, by designing a decision support tool. Such a tool could be designed with the help of experts in mobility, transport, climate and urban planning.

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Appendix A. Assumption Validation

Policy documents typically have a clear description of the policy goals. However, the policy measures are often less detailed and can be subject to change. For example, a pilot that requires collaboration with an industry partner may still change in scope, depending on the constraints of the involved parties. This is why we drafted a number of assumptions to verify with both municipalities. The following assumptions were validated with two policy makers of Amsterdam (CTO Smart Mobility) and The Hague (Coordinator Electric Transport). The verified assumptions can be found in Table A1 below.

Table A1. Assumption Validation with Municipal Policy Makers.

Assumption	Amsterdam	The Hague
Commercial shared mobility providers will make (partial) use of the public charging network	*X*	*Depends on Parking Strategy*
Cab drivers will make (partial) use of the public charging network	*X*	*X*
Light electric vehicles (LEV) will not make use of the public charging network (other resources or not provided)	*X*	*X*
New commercial shared mobility providers should be electric	*X*	*Preferred*
Mobility-as-a-service platforms will include at least: public transport, shared mobility and e-bikes	*X*	*X*
Hubs are categorized per user group and sometimes clustered for more than 1 user group. Exchanges between hubs will be worked out based on business case, accumulation of vehicles and other complex factors.	*X*	*X*

Table A2. Policy Measure Table For Amsterdam [27,38,40–48,56].

ID	Policy Measure (Amsterdam)	Document (Name Translated)	Timespan
A1	Cab driver agreement	Clean Cab Drivers Agreement	2019–2019
A2	Pilot: Mobility budget	Smart Mobility	2020–2020
A3	Decrease inner city touring cars	Car Free	2020–2020
A4	Pilot: Mobility-as-a-service	Smart Mobility	2020–2020
A5	Pilot: Operational mobility center	Smart Mobility	2020–2020
A6	Pilot: Night metro	Car Free	2020–2020
A7	Financial incentives: Kids tickets, attractive alternative options	Car Free	2020–2020
A8	New policy on LEV parking	Car Free	2020–2020
A9	E-neighborhood hubs	Green Deal Carsharing II	2020–2020
A10	EV gains parking permit (no waitlist)	*Municipality website*	2020–2020
A11	Pilot: Neighborhood cars	City Deal Carsharing	2021–2021
A12	Pilot: Impact, behavior and governance	City Deal Carsharing	2021–2021
A13	Pilot: Fast chargers, shared e-mobility and technology experiments	Smart Mobility	2022–2022
A14	Pilot Weesperstraat (cutting the street halfway) to reduce traffic	Car Free	2022–2022
A15	Public transport and touring cars are emission free	Clean Air	2022–2022
A16	Test location for autonomous vehicles	Smart Mobility	2023–2023
A17	Neighborhood e-hubs	Smart Mobility	2025–2025
A18	Pilot: Drone delivery	Smart Mobility	2025–2025
A19	All non-personal traffic is emission free	Clean Air	2025–2025
A20	Dynamic cab access tool	Smart Mobility	2030–2030
A21	EU-VI, PHEV (2030) and non-EV (2025) access deadlines. Extensions (~2027) and subsidy for delivery vans.	Green Deal Zero-Emission City Logistics	2030–2030
A22	All traffic in built-up areas is emission free	Clean Air	2040–2040
A23	Public transport: East-west metro line	Structure vision 2040	2019–2021
A24	Underground building: living space and parking spaces	Structure vision 2040	2019–2023
A27	Pilot: DC charging square	*AUAS internal project records*	2019–2025
A28	Pilot: Positive Energy Districts	Smart-atelier (EU)	2020–2022
A29	Labs: reducing parking spots, enabling pilots, developing standards	Smart Mobility	2020–2025
A30	Public transport timetable additions (increased ride frequency) and diminished double boarding rates	Car Free	2020–2025
A31	Shared bikes at metro stations and urban e-bike sharing	Car Free	2020–2025
A32	Car-free market area (Albert Cuyp)	Car Free	2020–2025
A33	Development of hubs for city logistics and passenger traffic	Car Free	2020–2025
A34	Stimulating use of indoor parking and P&R spots	Car Free	2020–2025
A35	Cheaper shared mobility options and increasing focus area to outside neighborhoods (2020–2040)	Car Free	2020–2040
A36	More P&R locations in city borders	Car Free	2020–2040
A37	More space for pedestrians and bikes (9 focus areas)	Car Free	2017–2022
A38	Train rail expansions (phases)	Structure vision 2040	2020–2025

Table A2. *Cont.*

ID	Policy Measure (Amsterdam)	Document (Name Translated)	Timespan
A39	Flexpower: smart charging pilot	Charge Infrastructure Strategy	2020–2025
A40	Pilot: Multiple parking permits on 1 car (peer-to-peer sharing)	Green Deal Carsharing II	2020–2025
A41	Information and subsidy point to start sharing initiatives	Green Deal Carsharing II	2020–2030
A42	100% electric shared fleet in 2025	Green Deal Carsharing II	2020–2030
A43	790 fast chargers (tank stations, highway exits)	Charge Infrastructure Strategy	2020–2030
A44	Pilot: Battery Hub P&R	Charge Infrastructure Strategy	2020–2030
A45	Pilot: V2G (ArenA)	Charge Infrastructure Strategy	2020–2030
A46	Program Plan for Electricity Supply (to be released)	Charge Infrastructure Strategy	t.b.a.
A47	Investment for electric public transport in the city	Vervoerregio (Traffic region) Amsterdam	2020–2025

Table A3. Policy Measure Table for The Hague [43–46,49–55].

ID	Policy Measure (The Hague)	Document (Name Translated)	Timespan
D1	Subsidized parking permits for shared mobility providers	Mobility Agenda	2017–2030
D2	Public transport expansions and more bike stalling options	Mobility Agenda	2017–2030
D3	Traffic redirection	Mobility Agenda	2017–2030
D4	Flexibility in using living space for parking	Mobility Agenda	2017–2022
D5	Stimulating shared mobility	Mobility Agenda	2017–2030
D6	Designing fast bike lanes	City Logistics Agreement The Hague	2018–2025
D7	'Clean-only' logistics slot in the evenings	City Logistics Agreement The Hague	2018–2025
D8	Grace period for biofuel vehicles	City Logistics Agreement The Hague	2018–2025
D9	Logistics hubs and drop-off points to reduce last mile traffic	Sustainability 2021	2021–2021
D10	400+ extra charging points in 2021	Sustainability 2021	2021–2025
D11	Zero-emission cab drivers	Clean Traffic Approach	>2020
D12	Declined entry for specific (high-emission) vehicles	Clean Traffic Approach	2020–2025
D13	Subsidized vehicle trade-in	Clean Traffic Approach	2018–2025
D14	On-site charging hubs, and energy supply plan for clean construction	Clean Traffic Approach	2025–2025
D15	New vehicles in metropole region emission free by 2030	Coalition Agreement	2021–2021
D16	EV-only parking at time slots	Green Deal Carsharing II	2018–2022
D17	Pilot: Car-free streets (with shared mobility solutions)	Green Deal Carsharing II	2021–2021
D18	Every neighborhood min. 10 P2P or FF shared vehicles	Green Deal Carsharing II	2018–2022
D19	Car sharing as requirement for new house building projects	Green Deal Carsharing II	2018–2022
D20	Inform and support smaller municipalities	Agenda Traffic Safety (regional)	2020–2020
D21	Adjust max speeds (50 to 30, and 100 to 80) for problem areas	City Deal Carsharing	2018–2020
D22	Pilot: Energiekwartier (neighborhood-based car sharing)	City Deal Carsharing	2018–2022
D23	Pilot: Cost-benefit analysis and resilience measures for new neighborhoods	Sustainability 2021	2021–2021
D24	Roll-out of urban fast chargers	Sustainability 2021	2021–2021

Table A3. *Cont.*

ID	Policy Measure (The Hague)	Document (Name Translated)	Timespan
D25	Charging strategy for shared vehicles	Sustainability 2021	2021–2021
D26	Agreement with cab drivers	Board report 2020	2021–2021
D27	Mobility-as-a-service platform for MRDH	Board report 2020	2021–2030
D28	Emission-free buses in 2030 (with supportive incentives)	Board report 2020	2021–2030
D29	Subsidies for public transport PV station charging	Board report 2020	2021–2021
D30	Network for smaller municipalities who are lowering CO_2	Green Deal Zero-Emission City Logistics	2018–2025
D31	Zero-emission inner city logistics by 2025	Clean Traffic Approach	2025–2025
D32	Zero-emission inner city buses by 2025	Green Deal Carsharing II	2018–2022
D33	Mobipoints (multimodal hubs)	Green Deal Carsharing II	2018–2022

Table A4. Policy Conditions Table.

Clustered Condition	Condition for	Applicable Measures: Amsterdam	Applicable Measures: The Hague
User group requirements	Emission-free subgroups	A31: Development of hubs for logistics and passengers A41: 790 fast chargers (tank stations, highway exits)	D24: Roll-out of urban fast chargers D9: Logistics hubs and drop-off points to reduce last mile traffic
User group (voluntary) agreements	Emission-free subgroups	A21: Access deadlines and transitional arrangements (logistics) A1: Cab driver agreement A20: Dynamic cab access tool A8: Policy on light electric vehicle (LEV) parking and charging	D25: Development of a charging strategy for shared vehicles D26: Draft a covenant with cab drivers D7: 'Clean-only' logistics slot in the evenings
Transferring into city	Emission-free inner city logistics	A5: Pilot: Operational mobility center A31: Hubs for city logistics and passenger traffic A34: More P&R locations in city borders A31: Hubs for city logistics and passenger traffic A34: More P&R locations in city borders	D9: Logistics hubs and drop-off points to reduce last mile traffic
Attractive options	Developing MaaS market, increasing SV and PT, emission-free	A2: Pilot: Mobility budget instead of car A7: Financial incentives (alternative transport) A10: EV driver gains parking permit immediately (skip waiting list) A33: Cheaper shared mobility options and increasing focus area to outside neighborhoods A47: Investment for public transport electrification	D1: Subsidized parking permits for shared mobility providers D13: Subsidized trade-in D18: Every neighborhood min. 10 P2P or FF shared vehicles D27: Mobility-as-a-service platform D29: PV station subsidy for public transport providers
Knowledge development	Emission-free inner city and subgroups, modal shift	A27: Labs: Reducing parking spots, enabling pilots, developing standards and tools A4: Pilot: Mobility-as-a-service A6: Pilot: Night metro A12: Pilot: Impact analysis, behavior analysis and government role definition (shared) A13: Pilot: fast chargers, shared e-mobility and technology experiments A16: Test location for autonomous vehicles A18: Pilot for drone deliveries	D17: Pilot: Low-car street (shared) D22: Pilot: Mobility and building combinations D23: Pilot: Cost-benefit and impact analysis for shared vehicle areas

Table A4. *Cont.*

Clustered Condition	Condition for	Applicable Measures: Amsterdam	Applicable Measures: The Hague
Information exchange	Emission-free inner city, modal shift	A39: Information and subsidy point to start sharing initiatives	D20: Inform and support smaller municipalities (car sharing) D30: Smaller municipalities (CO_2)
Electricity supply	Emission-free inner city and subgroups	A46: Development of Program Plan for Electricity Supply	D14: On-site charging hubs and energy supply plan for clean construction logistics
Adequate charging- and parking infrastructure	Emission-free inner city and subgroups, indoor parking	A31: Development of hubs for city logistics and passenger traffic A24: Underground buildings: Living space and parking spaces A9: E-neighborhood hubs (park and charge shared vehicles) A11: Pilot: Neighborhood cars	D10: 400+ extra charging points in D2: Extra bike stalling options D4: Flexibility in using living space for parking D33: MobiPoints
Low-car/car-free streets	Modal shift	A14: Pilot Weesperstraat (cutting the street halfway) A32: Car-free market area (Albert Cuyp)	D17: Pilot: Low-car street (shared vehicles) D3: Traffic redirection D21: Adjust max speeds for problem areas
Public transport expansions	Modal shift	A23: Public transport: East-west metro line	D2: Public transport expansions and more bike stalling options

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