# Urban Transition Experiments for Global Climate Goals

Learning from effective interventions to reduce car use in Lund municipality

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## Abstract

To limit global warming to 1.5°C, concerted efforts to drastically reduce GHG emissions by 2030 are needed. Lund municipality has ambitious climate goals for 2030, however, high emissions from transport and especially private car use endanger their achievement. Building on transition management, this thesis aimed at supporting Lund's climate goals by developing a knowledge base for the implementation of transition experiments that reduce car use. By means of a systematic literature and document review (N=28 documents), 12 intervention types combining different measures and policy instruments were identified as effective in reducing car use. Most interventions were planned and decided in collaboration with different urban stakeholders. Based on interviews with four experts of Lund's transport sector, six interventions were identified as high or moderate potential transition experiments. The thesis recommends three transition experiments to reduce car use in Lund: Parking & Traffic Control, Workplace Parking Charge and Mobility Services for Commuters.

**Keywords:** transport transition, car use reduction, transport intervention, urban mobility, urban transition experiments, climate mitigation

**Word count:** 11.993

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*„Between always and never"*

— André Aciman

# Table of Contents

## List of Figures



## List of Tables

## Abbreviations

| | |
|---|---|
| E1 | Expert Number 1, Employee of Lund Municipality |
| E2 | Expert Number 2, Employee of Lund Municipality |
| E3 | Expert Number 3, Researcher at Lund University |
| E4 | Expert Number 4, Researcher at Lund University |
| EU | European Union |
| GHG | Greenhouse Gas Emissions |
| IPCC | Intergovernmental Panel on Climate Change |
| TM | Transition Management |
| TP | Travel Planning |
| SDG | Sustainable Development Goal |

# 1. Introduction

## 1.2 Urban Climate Action for Global Climate Goals

According to the Intergovernmental Panel on Climate Change (IPCC), global emissions must decline drastically in this decade to limit global warming within the terms of the Paris Agreement. By 2030, a decrease of greenhouse gas (GHG) emissions by about 50% is needed to limit global warming to 1.5°C (IPCC, 2018). Exceeding 1.5°C warming will increase climate-related risks and may lead to long-lasting and irreversible impacts for human and natural systems (IPCC, 2018). Reducing emissions that drastically by 2030 requires wide-ranging transitions of societal systems and sectors (IPCC, 2018). Globally, collective efforts for climate action are needed to realise the scale and speed of these immense systems transition (IPCC, 2018).

Cities have increasingly been discussed and recognised as leverage points in combating global warming (Bulkeley, 2010; Bulkeley et al., 2011; Kern & Alber, 2009; Neij et al., 2015). While cities are responsible for 50-60% of global GHG emissions (UN Habitat, 2021), they also offer promising focal points for policy and societal action to lower emissions. “Cities are centres for creativity and innovation”(Neij et al., 2015, p.3) that have the possibilities to experiment with new forms of policy and planning (Bulkeley et al., 2011). City governments are closer to citizens than national governments and can take decisions in shorter timeframes (Bulkeley, 2010; Rotmans et al., 2001). Further, many cities possess competencies in key sectors for system transitions, such as waste, transport, and land-use planning (Bulkeley, 2010). Many cities have developed their own climate action plans and strategies - often more progressive then those of the respective nation-state – and became members of national and transnational city networks to collaboratively fight climate change (Kern & Alber, 2009; Neij et al., 2015). Alternatives emerging from the local level can inspire climate actions in other cities and even be translated into governance at higher levels, thus having a global impact (Roorda et al., 2014).

A promising approach to promote local innovation, policy experimenting and alternative practices as urban climate actions which facilitate local transitions and support collective efforts for systems transitions is transition management (TM). TM was developed as an instrumental, action-oriented governance framework which allows to steer and promote transitions (Loorbach et al., 2015; Markard et al., 2012). To accelerate transition processes, TM highlights the potential of so-called transition experiments: innovative, near-term actions that address specific challenges in the transition process (Loorbach & Rotmans, 2010; Roorda et al., 2014).

Lund, a city in southern Sweden, has recognised the importance and potential of urban climate action. The city has developed its own climate action plan, adopted ambitious long-term climate goals and is part of the Swedish city network *Klimatkommunerna (Climate municipalities)* (Lunds Kommun, 2020a). At first, Lund committed to reduce GHG emissions by 80% until 2030 and to become climate-neutral by 2050 (Lunds Kommun, 2017). However, in the end of 2020, the city tightened its climate goal and now aims to become climate-neutral already by 2030 (Lunds Kommun, 2020). This goal makes Lund an important climate leader in Sweden and role model for other cities in the European Union (EU).

Lund has successfully cut its emissions by half in 2020, compared to 1990 (Lunds Kommun, 2020b). However, emissions are not declining rapidly enough to meet the remaining goals. With the current trend of emission reductions, Lund will miss its climate goal for 2030 (Neij et al., 2020). One of the major challenges is the transition of the local transport sector: transport emissions have hardly declined in the past 30 years and today contribute nearly half of the local emissions in Lund's geographical boundaries, about three quarters of which come from car use (Neij et al., 2020).

Effective measures to rapidly reduce GHG emissions in Lund's transport sector are required to meet local climate goals and thereby contribute to national, European, and ultimately global efforts to fight global warming. Beside the fact that most emissions in Lund come from private car use, recent studies show that reducing car use has amongst the highest potential to reduce per capita emissions in general (Ivanova et al., 2020; Wynes et al., 2018). Thus, to promote the transition of Lund's transport sector, measures are needed to reduce local car use.

### 1.2 Research Aim

This thesis aims to support the transition of Lund's transport sector and thus the achievement of the local climate goal for 2030, by developing a knowledge base for the implementation of transition experiments to reduce local car use.

More specifically, the research aims to identify city-level interventions that have effectively reduced car use in other cities in the EU, as well as to identify the stakeholder types and collaborations involved in the planning and decision-making of these interventions, to subsequently evaluate the potential of these interventions to function as transition experiments to reduce car use in Lund.

This thesis will answer the following research questions (RQ) to achieve the research aim:

> **RQ1.** *Which city-level interventions have effectively reduced car use in cities in the EU?*
>
> **RQ2.** *What stakeholders and collaborations are involved in the planning and decision-making of effective city-level interventions to reduce car use?*
>
> **RQ3.** *What potential do the effective city-level interventions have to function as transition experiments to reduce car use in Lund?*

Since high emissions from car use are generally a challenge in Sweden and the EU (European Commissions, n.d.; Ministry of the Environment and Energy, n.d.), it is hoped that the present research will not only support Lund's transport transition but can also be transferred to promote sustainable transport transitions in other cities.

### 1.3 Contribution to Sustainability Science

Connecting science and politics is a core step to advancing Sustainability Science (Kates et al., 2003). Science is required to produce well-founded, useable knowledge for political processes where strategies to address sustainability challenges are developed and implemented (Jerneck et al., 2011). By developing a knowledge base for the implementation of transition experiments to reduce car use, this thesis seeks to contribute problem-driven and action-oriented knowledge that supports local decision-making for actions that promote the transition of urban transport sectors towards a carbon-neutral society.

This thesis further aims to contribute meaningfully to transdisciplinary research as understood by Lang et al. (2012). It will do so by seeking to overcome disciplinary and interdisciplinary boundaries of academia through integrating insights of different academic fields such as transition, transport, and climate mitigation studies, as well as through integrating non-academic, local sources of knowledge by engaging with employees of Lund municipality as experts of Lund's transport transition.

## 2. Setting the Scene: Lund Municipality

Lund is a municipality located in the region of Skåne in southern Sweden (Figure 1). The municipality counts nearly 126.000 inhabitants (Statistics Sweden, 2020) and consists of the main city of Lund where around three quarters of the population live, as well as eight small villages around the city of Lund (Lunds Kommun, 2021).

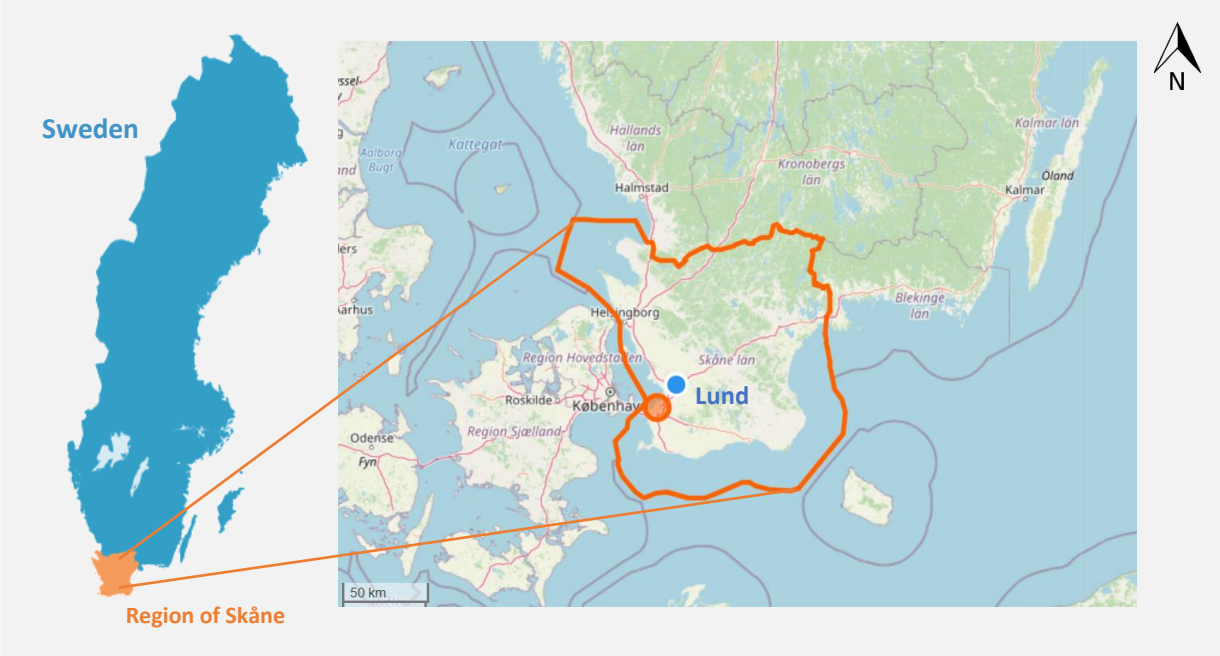



**Figure 1.** Map of the location of the Skåne region in Sweden (left) and the location of Lund municipality within the Skåne region (right) (map created by the author based on ©OpenStreetMap and ©REGIONFAKTA 2021).

A main characteristic of Lund is its international University: Lund University is the 3rd largest employer of the municipality and counts over 40.000 students per year, 20% of which are international (Lund University, 2020; Lunds Kommun, 2021). Besides, the campus of the University takes up large areas of the city (Lund University, 2020).

### 2.1 Lund's Climate Goals and Strategies

Lund's climate work is embedded in the municipality's progressive, long-term work for improved environmental conditions and a sustainable development. Since the 1990s, Lund has been working with different strategy documents on sustainable development to provide policy strategies and set ambitious goals for relevant societal sectors, such as energy, waste, transport and water (Lunds Kommun, 2017, 2020a). Today, a municipal level programme for ecological sustainability and a programme for social sustainability together form a holistic governance tool for a sustainable development according to the Brundtland definition (Lunds

Kommun, 2020a). Lund's sustainability programmes are informed by the Agenda 2030 for Sustainable Development from the United Nations and its 17 Sustainable Development Goals (SDGs) (Lunds Kommun, 2020a). The vision *Lund creates the future - with innovation, knowledge and openness* based on the actions *listening, learning, leading* (translated from Swedish) lays the foundation of all short- and long-term work in the municipality (Lunds Kommun, 2017).

Lund's climate goals are part of the municipality's strategy document for environmental sustainability (LundaEko) and aim to contribute to achieving SDG 13, climate action, nationally and internationally (Lunds Kommun, 2020a). The environmental strategy paper for 2014-2020 defined the long-term climate goal to become climate-neutral by 2050 and set the interim targets to decrease GHG emissions within Lund's geographical boundaries 50% lower than 1990 by 2020 and 80% lower by 2030 (Lunds Kommun, 2017). In 2018, the city achieved the goal to halve their emissions (Lunds Kommun, 2020b). In the end of 2020, the municipality tightened their already ambitious climate goals in a new strategy document and now aim to become climate-neutral by 2030 (Lunds Kommun, 2020a). With this, Lund's current climate goals are more progressive than Swedish and EU climate goals. Sweden aims for zero net greenhouse gas emissions by 2045 and the EU has the goal to become a climate neutral continent by 2050 (European Commissions, 2020; Ministry of the Environment and Energy, n.d.). This makes Lund an important leader for urban climate actions.

Lund collaborates with various local stakeholders to promote their climate work, including Lund University and local companies that are part of the local climate alliance *Lund Klimatallians* (Viable Cities, 2020). Besides, Lund was the first municipality in Sweden to introduce a climate policy council in 2018. The council consists of local scientific experts who evaluate the compatibility of Lund's politics with their climate goals in form of an annual report (Nej et al. 2019).

### 2.2 Lund's Transport Transition

According to the last report of Lund's climate policy council, the historical rate of emission reductions (1990-2017) is too slow to meet the climate goal for 2030; thus, more ambitious policies are needed (Neij et al., 2020). A major challenge to accelerate emission reductions is the sustainable transition of the local transport sector. GHG emissions from transport have only declined by 10% since 1990 and today contribute nearly 50% of the GHG emissions within

Lund's geographical boundaries. High car use is a particular problem: 72% of all emissions from transport in Lund come from car use (Neij et al., 2020). The climate policy council emphasises that "to reduce the climate impact of transport, the municipality needs to implement measures to reduce car use […]" (translated from Swedish) (Neij et al., 2020)

Lund's transport department is actively working on the reduction of GHG emissions from transport. Lund's long-term strategy for a sustainable transport system (LundaMATS) includes long-term goals and interim targets related to the reduction of car use and the number of private cars in the municipality (Lunds Kommun, n.d.). Lund's long-term vision of a sustainable transport sector is based on the six pillars Environment, Health, Equality, Traffic Safety, Accessibility, and Safety and envisages walking, biking, and public transport as the main mobility modes in the municipality's future. However, the latest statistics of the Climate Policy Council reveal that Lund has difficulties to translate their climate goals and vision of the transport sector into effective measures to reduce car use (Neij et al., 2020). Therefore, the research of this thesis seeks to support Lund in translating their ambitions into effective actions to rapidly reduce local car use. The following chapter introduces the concept of transition management which forms the theoretical entry point this thesis is building upon to support the transition of Lund's transport sector.

# 3. Theoretical Entry Point

## 3.1 Transition Management

TM is a sub-discipline of transition studies, a field of research which aims at better understanding and explaining fundamental, systemic long-term changes in societal systems. Transition studies have gained increasing attention in light of the wide-ranging changes of societal systems which are necessary to promote a more sustainable development (Markard et al., 2012).

From the view of transition studies, the climate challenges we face in different societal sectors such as the transport sector are produced and reinforced by lock-ins and path dependencies (Geels, 2011; Loorbach et al., 2015). Lock-ins develop when dominant technologies in societal sectors become highly intertwined with policies, institutions, and infrastructure as well as consumer practices and preferences - thereby lock-ins produce path dependencies that powerfully stabilise the respective sector (Geels, 2011; Markard et al., 2012). In the transport sector, policies, infrastructure and mobility practices are strongly interlinked to fossil resources and the combustion engine (Köhler et al., 2009; Loorbach et al., 2015). Lock-ins and path dependencies impede fundamental, systemic changes of societal sectors, referred to as transitions (Geels, 2011). However, as stated by the IPCC (2018), rapid and drastic systems transitions are needed to achieve global climate goals.

TM was developed as a novel governance approach to support transitions of societal systems and sectors (Loorbach & Rotmans, 2010). As an instrumental, action-oriented approach, TM can not only be applied to analyse transitions, but most importantly to steer and accelerate ongoing transition processes (Kemp et al., 2007; Loorbach & Rotmans, 2010; Markard et al., 2012; Roorda et al., 2014). TM is a versatile approach that can be utilised by researchers and practitioners and is applicable for transitions on the national, regional, and the urban level (Loorbach & Rotmans, 2010). In the EU project MUSIC (Mitigation in Urban areas: Solutions for Innovative Cities) for instance, TM was applied in the cities Aberdeen (UK), Montreuil (FR), Ghent (BE), Ludwigsburg (DE) and Rotterdam (NL) to promote urban climate actions (Roorda et al., 2014). Among other things, the project achieved temporary highway closures (Montreuil), conversions of streets into car-free zones (Ghent) and experiments with remote working hubs (Aberdeen) (Roorda & Wittmayer, 2014).

The action-oriented, instrumental characteristics of TM, its applicability by researchers and practitioners and its potential to promote ongoing sectoral transitions on the urban level, make TM a valuable approach to support the ongoing transition of Lund's transport sector. Importantly, TM does not replace existing policies. Instead, as exemplified in the following chapter, principles and practices of TM are applied complementary to ongoing governance activities with the aim to introduce a long-term perspective in the policymaking, inspire new initiatives and enable actors to address specific challenges which impede the transition process (Roorda et al., 2014; Rotmans et al., 2001).

### 3.2 Principles and Practices of Transition Management

Principles and practices of TM enable a short-term coordination of stakeholders and measures to promote transitions despite given complexities and uncertainties associated with such fundamental long-term changes (Rotmans et al., 2001). This characteristic of TM is crucial for the transition context in Lund as measures to promote the local transport transition must be implemented near-term to achieve rapid emission reductions and meet the climate goal for 2030.

Important principles of TM are (Roorda et al., 2014; Rotmans et al., 2001):

- understanding and acknowledging the complexity and challenges of a societal system
- using long-term thinking as a framework for developing short-term policies
- engaging participation and interaction between multiple stakeholders
- applying a learning philosophy (learning-by-doing and doing-by-learning)

When TM is applied by researchers and/or practitioners in practice, it consists of the following steps and groups of activities (Kemp et al., 2007; Loorbach & Rotmans, 2010; Rotmans et al., 2001):

1) *strategic activities*: problem-analysis, problem-structuring, formulation of a transition objective, creation of a long-term vision
2) *tactical activities:* making a transition agenda, setting of interim targets based on the long-term vision, stakeholder engagement, network-building
3) *operational activities:* supporting innovation and conducting transition experiments informed by the interim targets and long-term vision
4) *reflexive activities:* monitoring and evaluation of the experiments and the overall transition progress, facilitation of learning

In each step, different competencies, stakeholders and strategies are needed to implement the activities (Loorbach & Rotmans, 2010). Governments, however, play a key role in facilitating and supporting all steps and activities (Rotmans et al., 2001).

In practice, TM is utilised to complement existing policies through the introduction of new governance activities, often with the aim to address a particular transition challenge (Loorbach et al., 2015). Usually a transition team is formed to manage the application of TM in the local context (Roorda et al., 2014). The city of Ghent for example utilised TM to promote its transition towards a climate-neutral city: in 2010, Ghent established a transition team with municipal employees which identified transition challenges, established a long-term vision for Ghent, and engaged the participation of different stakeholders to implement transition experiments (e.g. car-free streets) (Roorda & Wittmayer, 2014). In this light, the utilisation of TM in Lund could beneficially complement existing governance activities to promote the local transport transition as a particular problem area for Lund's transition to a climate-neutral city.

Indeed, although Lund is not officially committed to a TM approach, their climate work (Chapter 2.2, 2.3) coincides with many principles and steps of TM: Lund's long-term climate goals and interim targets are embedded in a holistic, long-term, sustainability framework that guides the local policymaking; Lund has a long-term vision connected to innovation and the conduct of learning; local sectors such as the transport sector have their own vision, long-term goals, and transition agenda; the municipality engages with different stakeholders to promote their climate work.

Hence, TM can not only beneficially complement existing governance activities in Lund, but it also suits the present political landscape very well. Therefore, it is suggested that the application of principles and practices of TM is a suitable approach to support the transition of Lund's transport sector. By developing a knowledge base for the implementation of transition experiments to reduce car use in Lund, the research of this thesis focuses on the operational and reflexive activities of Lund's transport transition.

### 3.3 Transition Experiments

Transition experiments play a key role in TM (Bertolini, 2020). Transition experiments are innovative, short-term interventions or initiatives that aim at tackling a specific societal challenge to facilitate the transition process (Roorda et al., 2014). Informed by the vision and long-

term goals of a transition, transition experiments are conducted to explore innovative practices and structures related to the challenge that is being addressed (Roorda et al., 2014). An integral part of transition experiments is the learning process: insights and knowledge related to shifting practices and structures can be gained and incorporated in future policymaking to further improve and accelerate the transition process towards the envisioned future (Loorbach et al., 2015; Nevens et al., 2013; Roorda et al., 2014). Usually, different stakeholders are involved in transition experiments, including the government, public and private institutions, businesses and citizens (Loorbach et al., 2015; Nevens et al., 2013).

Although transition experiments bear the risk of failure (Loorbach et al., 2015), they have the potential to significantly accelerate a transition process by linking the envisioned future with near-term, real-life actions (Nevens et al., 2013). To realise this potential, transition experiments should be 1) new approaches that differ from dominant, existing practices, 2) suitable to address the targeted societal challenge, and 3) feasible to implement in the near-term and with the available resources (Loorbach et al., 2015; Roorda et al., 2014).

In practice, the aim of TM is to develop a portfolio of different transition experiments that mutually reinforce their effect and together support the transition goals in a measurable way (Loorbach et al., 2015). In Lund, high car use is a major societal challenge to reducing GHG emissions in the transport sector and to achieving the climate goal for 2030 (Chapter 2). Therefore, this thesis focuses on developing a knowledge base for transition experiments aimed at the reduction of car use which promote the transition of the local transport sector towards a climate-neutral society.

Based on the learning philosophy of TM, it is suggested that learning from interventions which have effectively reduced car use in other cities is a useful way to inform the development of transition experiments to support Lund's transport transition. Knowing what types of interventions are effective in reducing car use in other cities in the EU (RQ1) and which stakeholders and collaborations are involved in such interventions (RQ2) is thought to provide a helpful basis to evaluate the potential of interventions to function as transition experiments to reduce car use in Lund (RQ3) as well as to increase the probability of their success and reduce the risk related to transition experiments.

# 4. Methods

## 4.1 Research Design

The data collection of this research combined a systematic literature and document review with qualitative, semi-structured expert interviews. The data analysis involved the classification and categorisation of interventions, the identification and classification of stakeholder types and collaborations and a thematic content analysis of the interviews (Figure 2).

The research design is inspired by action-research which allows the combination of different methods and incorporation of local knowledge to promote action in a community (Bryman, 2012; Leavy, 2017). It thus complements the action-oriented, transformative focus of TM.

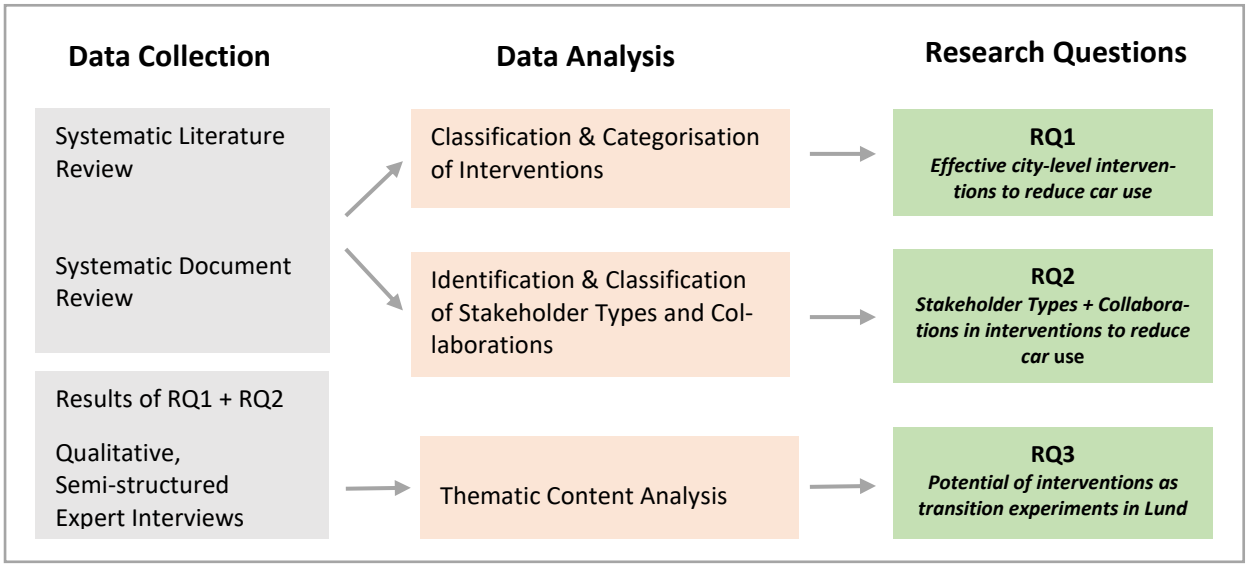



**Figure 2.** Visualisation of the Research Design. To answer each of the three Research Questions (RQs), a specific combination of Data Collection and Data Analysis was employed (Figure created by the author).

## 4.2 Data Collection

The data collection consisted of three phases: 1) a systematic literature review 2) a systematic document review and 3) qualitative, semi-structured expert interviews.

### *4.2.1 Systematic Literature Review*

A systematic literature review of peer-reviewed, scientific articles was conducted to answer RQ1 and RQ2. Systematic literature reviews are a useful method to collect information about a specific type of intervention from a large number of scientific articles (Mertens, 2018).

First, a scoping review was conducted using *Google Scholar* and the databases of *Case Studies on Transport Policy* and *Transport Review*, both influential, multidisciplinary journals for research about transport policies. The scoping review was aimed at gaining an understanding for the range of published literature and developing inclusion criteria (Table 1). N= 1 article was retained which met the inclusion criteria (Figure 3).

**Table 1.** Inclusion Criteria. The five inclusion criteria were developed during the scoping review of the systematic literature review. The inclusion criteria were used to select articles in the systematic literature review (Chapter 4.2.1) as well as reports in the systematic document review (Chapter 4.2.2) (Table created by the author).

| **Inclusion Criteria** |
|---|
| The article should: |
| **a)** be published after the year 2010 |
| **b)** study an intervention to reduce car use that was conducted in a city in the EU.<br>To limit the search to cities in the EU is thought to increase the transferability of the intervention to Lund, since other cities in the EU are subject to the same overarching political regulations and goals with respect to the transport sector and climate goals as Lund. |
| **c)** contain an intervention in the form of a purposive attempt by an urban stakeholder to reduce local car use or to reduce car ownership, which a study of more than 100 cities in the EU found can be expected to reduce car use as well (Santos et al., 2013) |
| **d)** represent an ex-post analysis (not an ex-ante analysis, simulation, or model) of an intervention |
| **e)** provide quantified evidence of the intervention's effectiveness in reducing car use or car-ownership |

Second, a systematic review of scientific articles was conducted with various search terms (Appendix A) on *Web of Science*. The titles, abstracts and, if necessary, the results sections were reviewed to assess if the article meets the inclusion criteria. After reviewing N= 369 articles, N= 20 articles were retained (Figure 3). It is common in the field to find a small number of suitable articles: Graham-Rowe et al. (2011) reviewed 3486 articles to find interventions related to private car use and retained only 69.

Third, "backward snowballing" (Teixeira et al., 2020) was applied to the retained articles which means that references cited in the 21 articles selected were examined for relevant literature. N= 10 articles met the inclusion criteria and were retained (Figure 3).

Fourth, all retained articles from the scoping review, systematic literature review and backward snowballing (N= 31) were subjected to a Final Selection Process. It was decided to conduct a final selection process, since it was notable during the review process that articles used very different outcome measures to quantify an intervention's effectiveness in reducing car use. To reduce the heterogeneity of outcome measures in the retained articles, the most

common outcome measures used in articles were identified (Table 2) and used as Final Selection Criteria in the Final Selection Process. Table 3 gives examples for exclusion of articles in the final selection process. After the Final Selection Process, N=10 articles remained which constituted the final selection of peer-reviewed, scientific articles used for the analysis of RQ1 and RQ2 (Figure 3).

**Table 2.** Final Selection Criteria. The final selection criteria contain the most common outcome measures to quantify an intervention's effectiveness in reducing car use used in articles identified by the systematic literature review (Chapter 4.2.1) and the systematic document review (Chapter 4.2.2). Only articles which included one or more of listed outcome measures were retained for the analysis (Table created by the author).

| **Final Selection Criteria** |
|---|
| The article should include quantified evidence to demonstrate an intervention's effectiveness with reliable quantitative data in line with any of the following outcome measures:<br>• the reduction of car traffic across the cordon (border of a charged zone or restricted zone for cars)<br>• the reduction of car traffic in the city centre<br>• the reduction of commuters travelling by car<br>• the reduction of share of car use among commuters to workplace<br>• the reduction of share of car use among commuters to university<br>• the reduction of share of car use among trips to school<br>• the reduction of share of car use among individual residents<br>• reduced number of trips during morning rush-hours<br>• percentage of individuals with reduced share of car use<br>• replaced number of private cars replaces per car-sharing car |

**Table 3.** Exemplification of reasons for the exclusion of articles in the final selection process of the systematic literature review according to the Final Selection Criteria (Table created by the author).

| **Reasons for Exclusion of Articles** | **Examples** |
|---|---|
| *Lack of reliable data* | • small sample size of car user group (e.g., <50 individuals)<br>• no reference (e.g., an area of a city or a car user group) for the stated reduction of car use<br>• lack of methodological description of data generation |
| *Outcome measures not in line with defined set of outcome measures* | • increase of bike use in the city<br>• increase of public transport use in the city<br>• increase of willingness to reduce car use among certain target group |

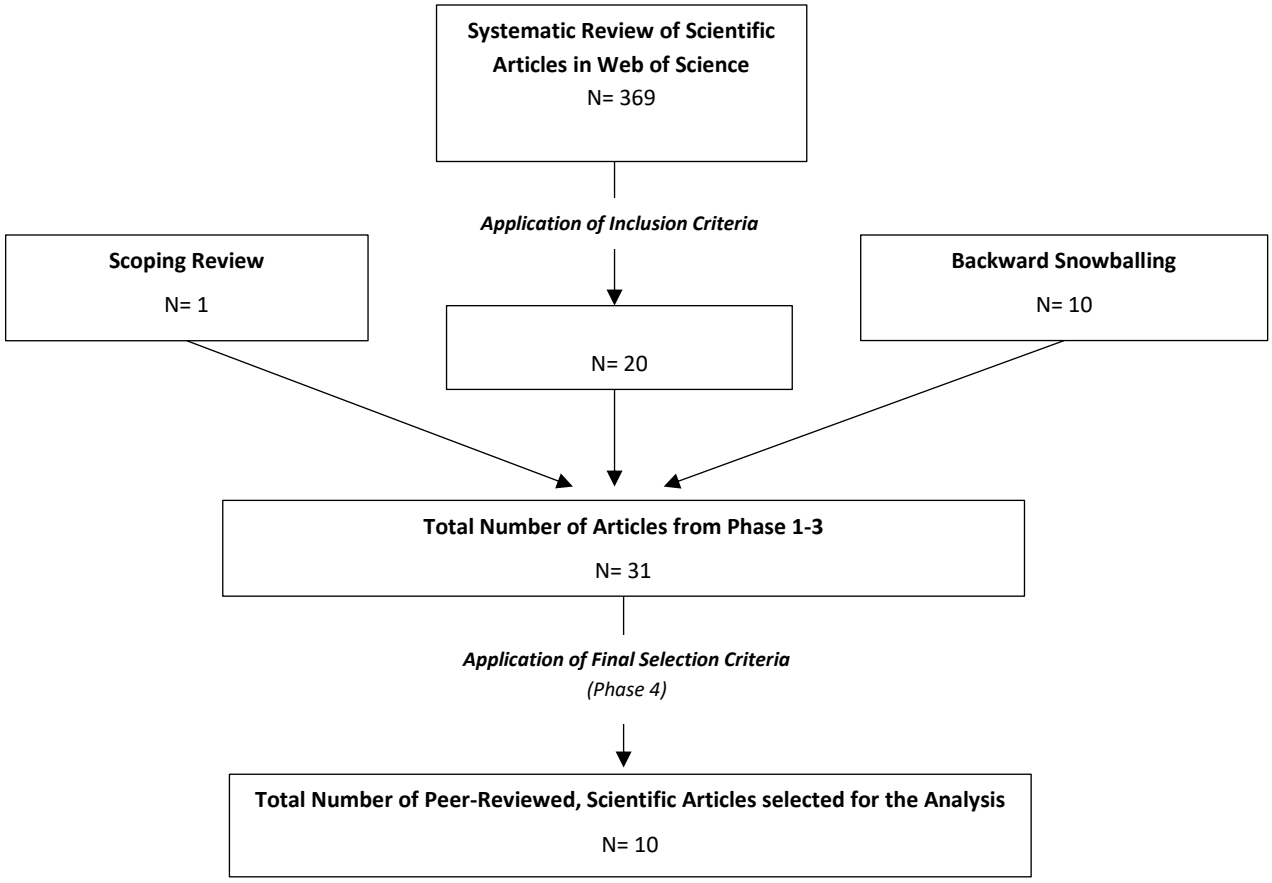



**Figure 3.** Visualisation of the Systematic Literature Review. See methods for Inclusion Criteria (Table 1) and Final Selection Criteria (Table 2) and Appendix A for search terms (Table created by the author).

### *4.2.2 Systematic Document Review*

Many evaluations of interventions to reduce car use are not published in peer-reviewed journals (Graham-Rowe et al., 2011). Therefore, alongside the review of peer-reviewed, scientific articles, a systematic document review of case-study reports from public and private institutions was conducted to answer RQ1 and RQ2. I applied the same set of inclusion criteria (Table 1) and final selection criteria (Table 2) developed during the systematic literature review to (1) a scoping review, (2) EU databases; and (3) additional reports.

First, a scoping review (Figure 4) was conducted on *Google* to gain an overview of the reports available and of the institutions publishing such reports. It was decided to conduct the systematic document review using the databases of *Eltis* and *CIVITAS*, two EU flagship initiatives on sustainable urban mobility (European Commission, 2017). Both initiatives offer extensive database for reports of urban transport interventions conducted in cities in the EU. N= 3 reports of the scoping review met the inclusion and final selection criteria and were retained.

Second, a systematic review of reports on *Eltis* and *CIVITAS* (Figure 4) was conducted using various search terms and filters (Appendix B and C). N= 407 reports were reviewed and directly checked against both the inclusion and final selection criteria. N= 11 reports were retained.

Third, additional stakeholder-focused reports about the stakeholder involvement in interventions were searched in a targeted manner to fill information gaps that were discovered during the analysis of RQ2 (N= 4 reports) (Figure 4).

After the scoping review, systematic review and targeted search, N=18 reports were retained which constituted the final selection of case-study reports for the analysis (Figure 4).

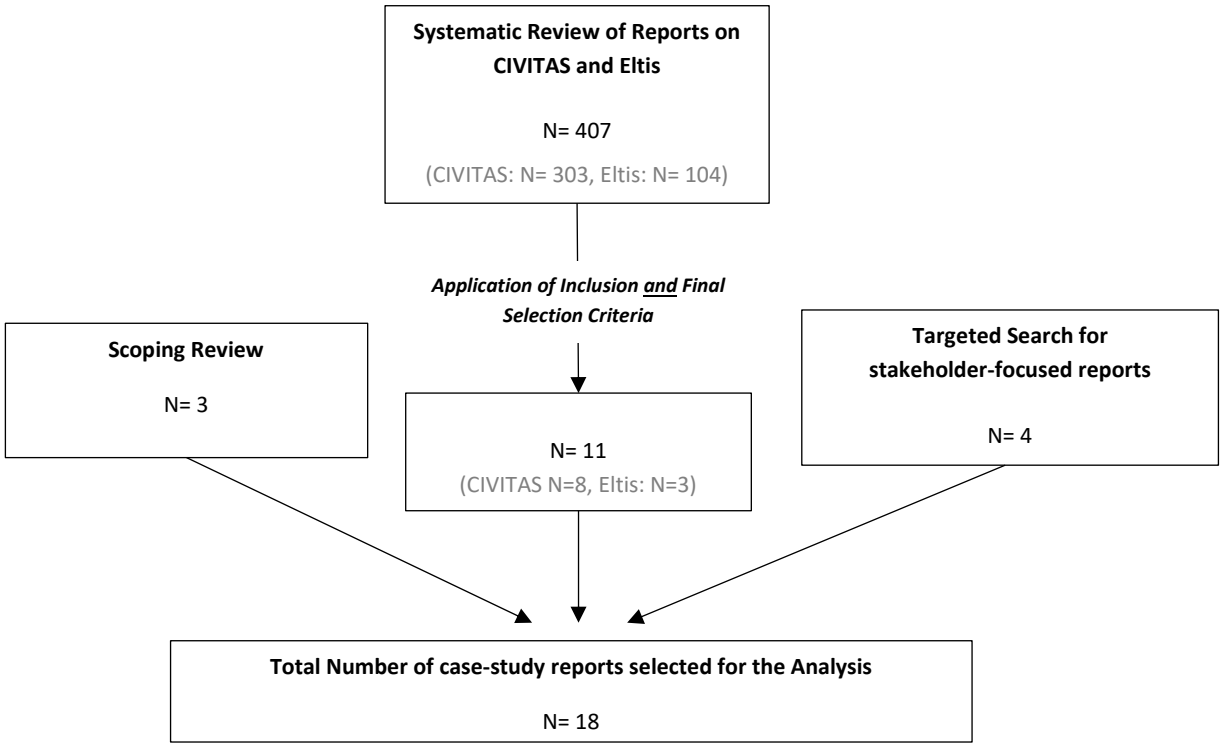



**Figure 4.** Visualisation of the Systematic Document Review. See methods for Inclusion Criteria (Table 1) and Final Selection Criteria (Table 2) and Appendix B and C for search terms (Figure created by the author).

After the completion of both the systematic literature and document review, a total of 28 documents was retained for the analysis of RQ1 and RQ2: 10 peer-reviewed, scientific articles and 18 institutional case-study reports. From this database of 28 documents, 24 documents were used for the analysis of RQ1. The four stakeholder-focused reports retained in the targeted search of the systematic document review were not included for the analysis of RQ1, since they only provided relevant information for the analysis for RQ2. For the analysis of RQ2, all 28 documents were used.

### *4.2.3 Semi-Structured Qualitative Expert Interviews*

TM emphasises the value of introducing different types of knowledge and competencies from different stakeholders throughout the transition process (Loorbach & Rotmans, 2010). For the evaluation of the potential of the effective city-level interventions to function as transition experiments to reduce car use in Lund (RQ3), it was therefore considered important to include knowledge and competencies from local experts of Lund's transport transition.

Two types of local experts were consulted: (1) practitioners who work with transport as employees of Lund municipality; (2) researchers from Lund University who closely studied Lund's climate work in the transport sector. Two local practitioners (abbreviated: E1 and E2 [E= Expert]) and two researchers (abbreviated: E3 and E4) were interviewed on Zoom. Each interview lasted 45-60 minutes and was recorded with consent by the interview partner.

The interviews were designed as qualitative, semi-structured interviews, an interview type that is based on a guideline but allows the flexibility to vary the order of questions and ask spontaneous questions if relevant (Roulston & Choi, 2018). The interview guideline was composed as a PowerPoint Presentation (Appendix D) and screenshared during the interview. The interview questions were developed based on the results of RQ1 and RQ2 to ask the experts if the identified city-level interventions are 1) new measures for Lund, 2) suitable to reduce local car use, and 3) feasible to implement. Thereby, all interventions were tested against the three criteria which transition experiments require to fulfil their potential (Chapter 3).

## 4.3 Data Analysis

The data analysis was conducted in two phases. In the first phase, the academic articles and case-study reports selected by the literature and document review were analysed to categorise and classify city-level interventions which have been shown to effectively reduce car use (RQ1) and to identify and classify stakeholder types and collaborations involved in these interventions (RQ2). The results of the data analysis for RQ1 and RQ2 were then used to inform the interview guideline of the semi-structured expert interviews. After the interviews were conducted, the second phase of the data analysis started, where the interviews were analysed with a thematic analysis to answer RQ3.

### *4.3.1 Categorisation and Classification of Interventions*

First, all cases of city-level interventions which were identified as effective in reducing car use (RQ1) were categorised into *intervention types* and *intervention categories*. All cases that employed the same main measures to reduce car use were categorised as one *intervention type*. For example, five cases of interventions conducted travel planning for local companies and businesses and were summarised under the intervention type "Workplace Travel Planning". The *intervention categories* further summarise the intervention types and were developed in an inductive approach, allowing the intervention types to determine the categories. For example, the intervention types "Workplace Travel Planning" and "School Travel Planning" were summarised under the intervention category "Travel Planning".

Second, the *intervention approach* and *policy instrument* were classified for each intervention type. The *intervention approach* was classified according to the Push- and Pull approach (Bongardt et al., 2011; Broekhoff et al., 2018), also named Push- and Pull effect (Dijk et al., 2018). Push-measures discourage private car use, for example with charges and regulations, while pull-measures incentivise travel alternatives to the car, for example by improving public transport and bike infrastructure (Table 4).

**Table 4.** The push- and pull approach used to classify the intervention approach of each intervention type (Table created by the author. Sources: Bongardt et al. (2011); Broekhoff et al. (2018); Dijk et al. (2018)).

| Intervention Approach | Explanation | Examples |
|---|---|---|
| *Push* | Discouragement of private car use by increasing the costs of car use or imposing regulations to control or prohibit car use | charges, taxes, fees, regulations, rules |
| *Pull* | Incentivising the use of low-carbon or non-motorised modes of travelling as alternatives to the car | monetary incentives, improvement of public transport, improvement of walking and biking infrastructure |

The *policy instrument* was classified using an IPCC classification of subnational policies into four policy instruments: regulatory instruments, economic instruments, information policies and public goods & services (Somanathan et al., 2014). This classification was already used by Moberg et al. (2019) to classify policy interventions for deep decarbonisation pathways in the transport sector. Inspired by Gärling & Schuitema (2007) who use a similar classification to distinguish measures that aim at reducing car use, the IPCC policy instrument "information policies" was expanded to "information & education policies". Table 5 presents the final list of policy instruments used for the analysis.

**Table 5.** The policy instruments used to classify the policy instruments of each intervention type (Table created by the author. Sources: IPCC (2014), Moberg et al. (2019), Gärling & Schuitema (2007)).

| Policy Instrument | Examples |
|---|---|
| *Regulatory Approach* | Rules, Standards, Prohibitions |
| *Economic Instrument* | Taxes, Subsidies, Charges |
| *Information & Education Policies* | Information Campaigns, Marketing, Persuasion, Feedback |
| *Public Goods & Services* | Physical Infrastructure, Planning, Provision of Services |

Third, the effectiveness of each case of intervention was classified based on the provided outcome measures for the reduction of car use. Due to the different outcome measures provided in the articles and reports, no comprehensive ranking of the interventions' effectiveness in reducing car use could be made. Instead, the effectiveness of the interventions was ranked across intervention types for the same outcome measures.

### *4.3.2 Classification of Stakeholder Types and Collaborations*

The identification and classification of stakeholder types and collaborations (RQ2) was done using a classification approach inspired by Castán Broto & Bulkeley (2013) and Bulkeley & Castán Broto (2013), who identified and classified stakeholders involved in urban climate change experiments.

First, the stakeholders involved in the planning and decision-making of the interventions identified in RQ1 were classified as one of the *Stakeholder Types* listed in Table 6. Stakeholders who were solely involved to implement or finance an intervention but were not part of the planning and decision-making process were not included.

**Table 6**. The stakeholder types used to classify the stakeholders involved in the identified interventions (Table created by the author, Sources: Bulkeley & Castán Broto (2013), Castán Broto & Bulkeley (2013)).

| Stakeholder Type | Stakeholders assigned to Stakeholder Type | References for Stakeholder Types |
|---|---|---|
| *National Government* | National authorities/ministries/delegates | Bulkeley & Castán Broto (2013) |
| *Regional Government* | Regional authorities/ministries/delegates | Bulkeley & Castán Broto (2013) |
| *Local Government* | Practitioners or delegates of a municipality | Bulkeley & Castán Broto (2013) |
| *Civil Society* | Private individuals, civil societal forums and organisations | Castán Broto & Bulkeley (2013) |
| *Private* | Private companies and businesses | Castán Broto & Bulkeley (2013) |
| *Educational Institution* | Universities and schools (public + private) | developed by author (inductively) |

Second, as done by Bulkeley & Castán Broto (2013) and Castán Broto & Bulkeley (2013), the previously classified Stakeholder Types were further classified as *Leading Stakeholders* or as *Partner Stakeholder*. Leading Stakeholders are stakeholders that initiate and lead interventions while Partner Stakeholders are stakeholders that work in close collaboration with the Leading Stakeholders to support their work.

Third, the Leading Stakeholders were further classified into *Single Leading Stakeholders*, when only one Leading Stakeholder initiates and leads an intervention, and *Multiple Leading Stakeholders*, when several leading stakeholders together initiate and lead an intervention.

Fourth, the number of Leading and Partner Stakeholders involved in collaborations of individual cases of interventions was determined as well as the overall number of Leading and Partner Stakeholders involved in all cases calculated.

### *4.3.3 Thematic Analysis of Interviews*

The interviews were transcribed verbatim using MAXQDA based on transcription rules proposed by Kuckartz & Rädiker (2019). A thematic analysis (Bryman, 2012) was then applied to analyse the interview transcripts in order to assess the potential of the interventions identified in RQ1 to function as transition experiments to reduce car use in Lund (RQ3).

The thematic analysis was done in a deductive approach. As described in Chapter 3.3, three criteria should be fulfilled for a transition experiment to realise its potential. These three criteria were operationalised as *Transition Experiment Criteria* to assess the potential of interventions to function as a transition experiments to reduce car use in Lund (Table 7). The criteria were used as themes in the analysis, each theme included four coding possibilities (Table 7). Since the interview guide was structured according to the intervention types identified in RQ1, the *Transition Experiment Criteria* were coded for each identified intervention type.

**Table 7**. The themes and codes of the thematic analysis of the expert interviews based on the Transition Experiment Criteria derived from the theory of transition experiments (Chapter 3.3) (Table created by the author).

| Transition Experiment Criteria | Themes | Codes |
|---|---|---|
| 1) new approach that differs from dominant, existing practices | Novelty | new/ partly new/ not new/ uncertain |
| 2) suitable to address the targeted challenge (high car-use) | Suitability | suitable/ partly suitable/ not suitable/ uncertain |
| 3) feasible to implement in the near-term and with the available resources | Feasibility | feasible/ partly feasible/ not feasible/ uncertain |

To assess the potential of the identified intervention types to function as a transition experiment to reduce car use in Lund, it was evaluated to what extent the intervention types fulfil the three *Transition Experiment Criteria*. Therefore, based on the coded themes of the interview transcripts, each of the three *Transition Experiment Criteria* was evaluated as fulfilled, partly fulfilled, or not fulfilled (Table 8) for each identified intervention type.

**Table 8.** Approach used to evaluate to what extent an intervention type fulfils the *Transition Experiment Criteria* based on the coded themes of the interview transcripts (Table created by the author).

| **Themes (as the three Transition Experiment Criteria)** | **Code** | **Evaluation** |
|---|---|---|
| Novelty/ Suitability / Feasibility | novel / suitable / feasible | fulfilled |
| Novelty/ Suitability / Feasibility | partly novel / partly suitable /partly feasible | partly fulfilled |
| Novelty/ Suitability / Feasibility | not novel / not suitable/ not feasible | not fulfilled |

For every intervention type, the evaluation of the three *Transition Experiment Criteria* was done by summarising the coded themes of the four interview transcripts. If *more* than half of the experts' answers within a theme was coded with the same code, then this code determined the evaluation of the respective criterion. If *less* than half of the expert's answers within a theme was coded with the same code, then a) the criterion was ranked as 'partly fulfilled, when the experts' answers were undecided between 'fulfilled' and 'not fulfilled' or b) the lower ranking was chosen if the experts' answers were undecided between 'fulfilled' and 'partly fulfilled' as well as between 'partly fulfilled' and 'not fulfilled'. Answers that displayed uncertainty or did not provide sufficient information were not considered in the analysis.

Based on the evaluation of the *Transition Experiment Criteria* for each intervention type, the potential of every intervention type to function as a transition experiment to reduce car use in Lund was assessed as high, moderate, or low according to the principles listed in Table 9.

**Table 9.** Principles applied to assess the potential of each intervention type as a transition experiment to reduce car use in Lund based on the evaluated Transition Experiment Criteria (Table created by the author).

| **Potential of an Intervention Type** | **Principles to assess the potential of an Intervention Type** |
|---|---|
| High potential | • at least two fulfilled criteria and at most one partly fulfilled criteria<br>• not one unfilled criteria |
| Moderate potential | • two or more partly fulfilled criterion<br>• not one unfilled criteria |
| Low potential | • at least one unfulfilled criteria |

# 5 Results

## 5.1 Effective City-Level Interventions to Reduce Car Use

*(RQ1.) Which city-level interventions have effectively reduced car use in cities in the EU?*

### *5.1.1 Intervention Types, Measures, Approaches and Policy Instruments*

Overall, I identified 26 cases of effective city-level interventions to reduce car use (or car-ownership) in 23 different cities. As three cities conducted not just one but two of the 26 cases of interventions, it is 23 and not 26 different cities. I classified the 26 cases of effective interventions in 12 intervention types and summarised them into seven intervention categories based on the cases' *main* measures which also determined the intervention approach and the policy instrument(s) of each intervention type (Table 10). Appendix E entails a detailed list of the 26 cases of effective interventions including *all* measures the respective city implemented.

In the first category *Charging & Pricing*, I classified two intervention types. The first is a congestion charge that introduces charges for cars that cross the border of a defined charging zone which usually roughly corresponds to the city centre. The revenues are used for infrastructure or public transport investments (Beria, 2016; Börjesson & Kristoffersson, 2015; Eliasson, 2014; Metz, 2018). The second is a Workplace Parking Charge (WPC) that includes parking fees for workplace parking places of local employers. In Rotterdam the charge was combined with a cash-out scheme for employers that use public transport, in Nottingham with investments in the local public transport system (Dale et al., 2019; Strompen et al., 2012). I classified both intervention types as a combined Push- and Pull-approach as well as combination of the Economic policy instrument with Public Goods & Services.

In the second category *Access-Limitations*, I classified one intervention type, a Limited Traffic Zone which introduces entrance restrictions for cars in a defined zone of the city centre. During restricted hours, the entrance by car is only allowed for residents or with a special entrance permit which is linked to an annual fee (CIVITAS, 2013c). I classified the intervention as a Regulatory policy instrument and a Push-approach.

**Table 10**. Overview of the 26 cases of effective city-level interventions grouped in 7 intervention categories and 12 intervention types. The table further presents the intervention approach and policy intstrument(s) of each intervention type based on the main measures introduced by the cities (cases) of each intervention type. If a measure was not implemented in all cities listed after an intervention type, then the name of the cities which introduced this measure is named specifially in brackets (Table created by the author based on the 24 listed references).

| **Intervention Category** | **Intervention Type** | **Intervention Approach** | **Policy Instrument(s)** | **Main Measures** | **Cities** (treated as cases of effective interventions) | **References** |
|---|---|---|---|---|---|---|
| *1) Charging & Pricing* | 1) Conges-tion Charge | Push & Pull | Economic, Public Goods & Services | - Daily/ time-dependent charges for cars in defined charging zone (cordon-based system)<br>- Revenues for public transport or infrastructure investments | 1) Gothenburg (SE)<br>2) London (GB)<br>3) Milan (IT)<br>4) Stockholm (SE) | (Börjesson & Kristoffersson, 2015)<br>(Metz, 2018)<br>(Beria, 2016)<br>(Eliasson, 2014) |
| | 2) Workplace Parking Charge | Push & Pull | Economic, Public Goods & Services | - Charges for car parking spaces at workplace<br>- Cash-out scheme for employee (Rotterdam)<br>- Revenues for public transport expansion (Nottingham) | 5) Nottingham (GB)<br>6) Rotterdam (NL) | (Dale et al., 2019)<br>(Strompen et al., 2012) |
| *2) Access-Limitations* | 3) Limited Traffic Zone | Push & Pull | Regulatory, Public Goods & Services | - Time- and weekday dependent access restrictions in city centre<br>-Access only with special entrance permit based on an annual fee<br>- Revenues from entrance permit + violation fines for public transport investments | 7) Rome (IT) | (CIVITAS, 2013c) |
| *3) Parking & Traffic Control* | 4) Parking & Traffic Control | Push & Pull | Regulatory, Public Goods & Services | - Removal of parking spaces in + around city centre<br>- Introduction of car-free streets<br>- Alteration of traffic routes<br>- New bike lanes + pedestrian-friendly infrastructure | 8) Oslo (NO) | (Modijefsky, 2021) |
| *4) Mobility Services* | 5) Mobility Services for Commuters | Pull | Economic, Public Goods & Services, Information & Education | - Free public transport pass for employees<br>- Private Shuttle Bus from local companies to Park' n' Ride stations, train stations, etc.<br>- marketing of measures + communication plan | 9) Utrecht (NL) | (Stumpel-Vos et al., 2013) |
| | 6) Mobility Services for University | Pull | Economic, Public Goods & Services | - Fare-free public transport for (Erasmus, Ph.D.'s) students<br>- Bus Rapid Transit and a metro-shuttle bus to campus site outside the city centre | 10) Catania (IT) | (Inturri, 2019) |

| | | | | | | |
|---|---|---|---|---|---|---|
| *5) Car-Sharing* | 7) Integrated Car-Sharing Action Plan | Pull | Public Goods & Services, Information & Education | - Increase of number of car-sharing cars + stations<br>- Introduction of car-sharing service for employees<br>- Integration of car-sharing into residential areas, public transport, bike infrastructure, parking spaces<br>- awareness-raising for car-sharing services | 11) Bremen (DE)<br>12) Genoa (IT) | (Glotz-Richter, 2016)<br>(CIVITAS, 2013a) |
| *6) Travel Planning* | 8) Workplace Travel Planning | Push & Pull | Information & Education, Regulatory, Economic, Public Goods & Services | - Travel plans + advice for companies and employees<br>- Parking management (Norwich, 20 cities in GB)<br>- Company shuttle busses (Norwich, 20 cities in GB)<br>- Discounts for public transport (Nantes, 20 cities in GB)<br>- Improved bike infrastructure (B&H, Norwich, 20 cities in GB) | 13) Brighton & Hove (GB)<br>14) Graz (AT)<br>15) Nantes (FR)<br>16) Norwich (GB)<br>17) 20 cities in GB (GB) | (CIVITAS, 2013g)<br>(ITL, 2018)<br>(CIVITAS, 2013b)<br>(CIVITAS, 2013f)<br>(Cairns et al., 2010) |
| | 9) School Travel Planning | Pull | Information & Education, Public Goods & Services | - Travel plans + advice for pupils and their parents<br>- Promotion of walking + biking + car-pooling<br>- Improved bike infrastructure<br>- Promotional events + awareness-raising | 18) Brighton & Hove (GB)<br>19) Norwich (GB) | (CIVITAS, 2013g)<br>(CIVITAS, 2013f) |
| | 10) University Travel Planning | Push & Pull | Information & Education, Regulatory, Economic, Public Goods & Services | - Travel plans + advice for staff and students<br>- Promotion of car-sharing, walking, biking, public transport<br>- Parking management on/around the campus<br>- Improved bike infrastructure (Bristol)<br>- Discounts for public transport (Bristol)<br>- Information + awareness-raising (San Sebastián) | 20) Bristol (GB)<br>21) San Sebastián (ES) | (Brockman & Fox, 2011)<br>(CIVITAS, 2013d) |
| | 11) Personal-ised Travel Planning | Pull | Information & Education, Economic | - Personal travel analysis and plans for individuals<br>- Public transport discount offers (San Sebastián, Munich, Maastricht) | 22) Marseille (FR)<br>23) Munich (DE)<br>24) Maastricht (NL)<br>25) San Sebastián (ES) | (Thaler et al., 2018)<br>(Bamberg & Rees, 2017)<br>(Modijefsky, 2019)<br>(CIVITAS, 2013e) |
| *7) Gamification* | 12) App for Sustainable Mobility Competition | Pull | Information & Education, Economic | - App for individual users + teams of local companies<br>- Collection of points for sustainable mobility behaviour through mobility tracking of the app<br>- Rewards from local businesses for the achievement of a certain threshold of points | 26) Bologna (IT) | (ITL, 2018) |

In the third category *Parking & Traffic Control,* I classified one intervention type under the same name which includes the removal of parking spaces in the city centre and surrounding areas, the alteration of traffic routes, the introduction of car-free streets and the extension of the pedestrian-friendly infrastructure and bicycle lanes (Modijefsky, 2021). I classified the intervention type as a combined Push- and Pull-approach and a combination of the Regulatory policy instrument with Public Goods & Services.

In the fourth category *Mobility Services,* I classified two intervention types. The first, Mobility Services for Commuters, includes a free public transport pass for employees in the city-region, a private shuttle bus for transfers between companies and public transport hubs as well as marketing and awareness-raising measures (Stumpel-Vos et al., 2013). The second, Mobility Services for the University, includes Shuttle Busses to campus sites and a fare-free public transport for students (Inturri, 2019). I classified both intervention types as Pull-approaches and combinations of the Economic policy instrument with Public Goods & Services and Information & Education.

In the fifth category *Car-Sharing*, I classified the intervention type Integrated Car-Sharing Action Plan. It comprises the expansion of car-sharing stations and cars, awareness-raising for car-sharing, the integration of car-sharing into the urban transport system and the option to use car-sharing as a private households *and* as employees (CIVITAS, 2013a; Glotz-Richter, 2016). I classified the intervention type as a Pull-approach and a combination of the policy instruments Public Goods & Services and Information & Education.

In the sixth category *Travel Planning* (TP), I classified four intervention types: a Workplace TP, a School TP, a University TP, and a Personalised TP. They all include travel plans and advice in combination with various other measures, which can be looked at in Table 10 (Bamberg & Rees, 2017; Brockman & Fox, 2011; Cairns et al., 2010; CIVITAS, 2013b, 2013g, 2013d, 2013e, 2013f; ITL, 2018; Modijefsky, 2019; Thaler et al., 2018). I classified the Workplace and University TPs as a combined Push- and Pull-approach and a combination of the Regulatory and Economic policy instruments with Information & Education and Public Goods & Services. The School and Personalised TPs were classified as a Pull-approaches. The first combines the policy instruments Information & Education and Public Goods & Services, the latter the Economic policy instrument with Information & Education and Public Goods & Services.

Finally, in the category *Gamification*, I classified the intervention type App for Sustainable Mobility Competitions which enables competitions between private individuals and teams of local companies in terms of choosing sustainable modes of transports. The App tracks all trips made by the users and awards points for trips made by foot, bike, public transport, and car-sharing. Users are incentivised with rewards for reaching a certain threshold of points (ITL, 2018). I classified the App as a Pull-approach and a combination of the Economic policy instrument with Information & Education.

### *5.1.2 Comparison of the Interventions' Effectiveness*

All 26 cases of interventions effectively reduced urban car use (or car-ownership) either by reducing the overall car use in the city or the car use in a specific city-district, among a certain population group or at a specific time of day (Table 11). The grouping of the cases across intervention types for the same category of outcome measure (Table 11) allows a comparison of their effectiveness for each category of outcome measures.

With a reduction of 33% (Metz, 2018), the Congestion Charge in London was the most effective in reducing car traffic across the cordon of a charging zone (Table 11). Since the charging zones of all congestion charges roughly covers the city centre, I concluded that London's congestion charge was also most effective in reducing car traffic in the city centre. The Limited Traffic Zone in Rome and the Parking & Traffic Control in Oslo reduced car traffic in the city centre by 10-20% and 11-19%, respectively (CIVITAS, 2013c; Modijefsky, 2021).

To reduce the *number* of commuters travelling by car, the Mobility Service for commuters in Utrecht was the most effective (Table 11) with an achieved reduction of 37% (Stumpel-Vos et al., 2013). However, in reducing the *share* of car use among commuters, the Workplace TPs of the 20 different British cities were most effective: on average across all cities, car use was reduced by 18% (Cairns et al., 2010).

**Table 11**. Ranking of the effectiveness of the 26 cases of interventions from the most to least effective across intervention types for the same outcome measure (Table created by the author based on the 24 listed references).

| **Categories of outcome measures** | **Intervention Type** | **Cities** (cases of interventions) | **Effectiveness** | **References** |
|---|---|---|---|---|
| *Reduction of car traffic across the cordon to the charging zone (~city centre)* | Congestion Charge | London | 33% | (Metz, 2018) |
| | | Milan | 31.1% | (Beria, 2016) |
| | | Stockholm | 22% | (Eliasson, 2014) |
| | | Gothenburg | 12% | (Börjesson & Kristoffersson, 2015) |
| *Reduction of car traffic in the city centre* | Parking & Traffic Control | Oslo | 11% (in first two years)<br>19% (in third year) | (Modijefsky, 2021) |
| | Limited Traffic Zone | Rome | 10% (during unrestricted hours)<br>20% (during restricted hours) | (CIVITAS, 2013c) |
| *Reduction of commuters travelling by car* | Mobility Services for Commuters | Utrecht | 37% | (Stumpel-Vos et al., 2013) |
| | Workplace Parking Charge | Rotterdam | 20-25% | (Strompen et al., 2012) |
| | | Nottingham | 8.6% | (Dale et al., 2019) |
| *Reduction of share of car use among commuters to workplace* | Workplace Travel Planning | 20 cities in GB | 18% | (Cairns et al., 2010) |
| | | Norwich | 17.7% | (CIVITAS, 2013f) |
| | | Graz | 12-14% | (ITL, 2018) |
| | | Nantes | 12% | (CIVITAS, 2013b) |
| | | Brighton & Hove | 3% | (CIVITAS, 2013g) |
| *Reduction of share of car use among commuters to University* | University Travel Planning | Bristol | 27% (*only* staff) | (Brockman & Fox, 2011; University of Bristol, 2018b) |
| | Mobility Services for University | Catania | 24% (*only* students) | (Inturri, 2019) |
| | University Travel Planning | San Sebastián | 7.2% (staff *and* students) | (CIVITAS, 2013d) |
| *Reduction of share of car use among trips to school* | School Travel Planning | Norwich | 10.9% | (CIVITAS, 2013f) |
| | | Brighton & Hove | 5% | (CIVITAS, 2013g) |
| *Reduction of share of car use among individual residents* | Personalised Travel Planning | San Sebastián | 8-12% | (CIVITAS, 2013e) |
| | | Marseille | 6% | (Thaler et al., 2018) |
| | | Munich | 5.6% | (Bamberg & Rees, 2017) |
| *Reduced number of trips during morning rush hours* | Personalised Travel Planning | Maastricht | 3.800 | (Modijefsky, 2019) |
| *Percentage of app-users with reduced share of car use* | App for Sustainable Mobility Competition | Bologna | 73% | (ITL, 2018) |
| *Number of private cars replaced per car-sharing car* | Integrated Car-Sharing Action Plan | Bremen | 15 | (Glotz-Richter, 2016) |
| | | Genoa | 12 | (CIVITAS, 2013a) |

Comparing the three intervention types with the outcome measure "reduction of share of car use among commuters to University" is difficult since the effectiveness is measured for different target groups: the University TP in Bristol reduced the share of car use among *staff* by 27%, the University TP in Catania reduced the share of car use among *students* by 24% and the University TP in San Sebastian reduced the share of car use among staff *and* students by 7.2% (CIVITAS, 2013d; Inturri, 2019; University of Bristol, 2018b).

In reducing private car use for trips to school, the School TP in Norwich was the most effective (Table 11) with an achieved reduction of 10.9% (CIVITAS, 2013f).

The Personalised TPs in San Sebastián was the most effective in reducing the share of car use among individual residents (Table 11), with a reduction between 8-12% (CIVITAS, 2011). In reducing the overall number of private cars in a city, the Integrated Car-Sharing Action Plan in Bremen was the most effective (Table 11). It replaced 15 private cars per car-sharing car (Glotz-Richter, 2016).

The effectiveness of the Personalised TP in Maastricht and the App for Sustainable Mobility Competitions in Bologna could not be compared since both are the only intervention types in their respective category of outcome measures (Table 11).

### 5.2 Involvement of Stakeholder Types and Collaborations

> *(RQ2) What stakeholders and collaborations are involved in the planning and decision-making of effective city-level interventions to reduce car use?*

The great majority of the 26 cases of effective interventions involved a collaboration between the Leading Stakeholder of the intervention with at least one Partner Stakeholder who supported the planning and decision-making: 20 cases involved a collaboration between the Leading Stakeholder with between one to four Partner Stakeholders (Figure 5). Only six cases did not involve any collaboration between a Leading and Partner Stakeholder (Figure 5). Hence, collaborations between different types of urban stakeholders in form of Leading and Partner Stakeholders seem overall important for the planning and decision-making of effective interventions to reduce car use.

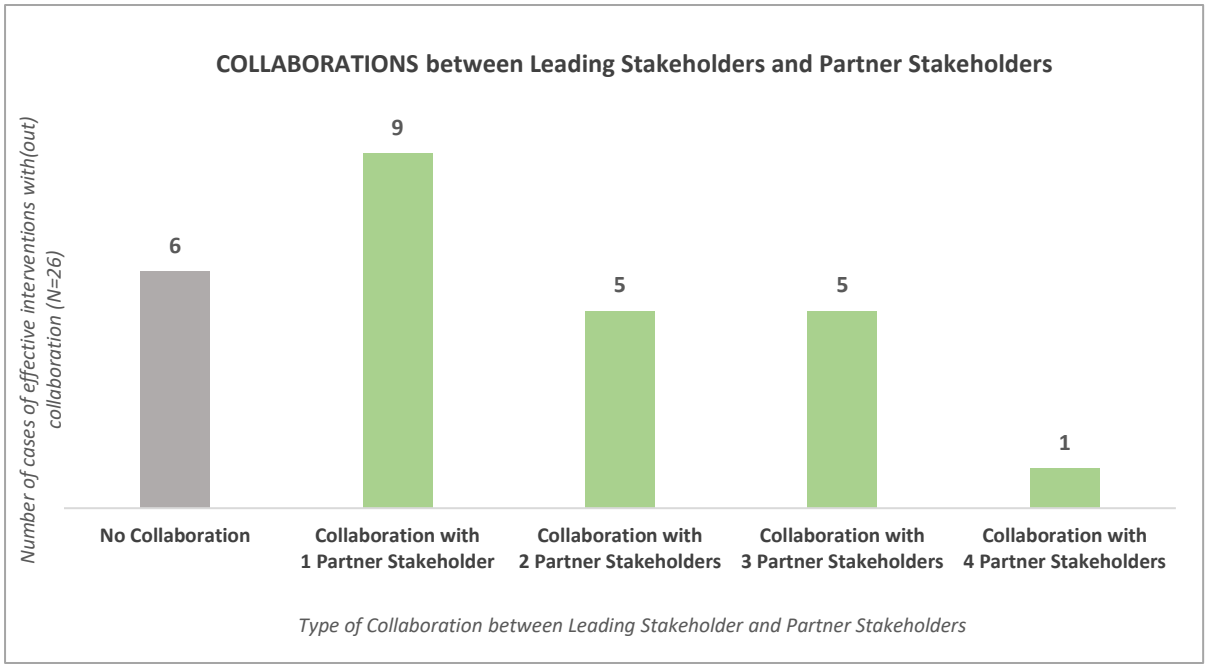



**Figure 5**. Type of collaborations between Leading and Partner Stakeholder involved effective interventions to reduce car use. Presented as the number of cases in which a Leading Stakeholder collaborated with zero, one, two, three or four Partner Stakeholders (Figure created by the author based on the 24 references listed in Table 11 as well as the four stakeholder-focused reports identified in the targeted search of the systematic document review: Centre for Public Impact (2016), DeRobertis & Tira (2016), Nottingham City Council (2008), Programme office Zuid-Limburg Bereikbaar (2021)).

In total, 26 Leading Stakeholders were involved in the 26 identified cases of effective interventions (Figure 6) - one Leading Stakeholder per case. The great majority of Leading Stakeholders are *Single* Leading Stakeholders, who alone initiated and led an intervention. Of these, two-thirds (17 out of 26) were Local Governments (Figure 6). However, some cases of interventions also had Educational Institutions and Private Stakeholders as Single Leading Stakeholders (Figure 6). Only four of the 26 cases were initiated and led by *Multiple* Leading Stakeholders, two of them Public-Private-Partnerships (Figure 6).

Since most cases of interventions involved a collaboration between the Leading Stakeholder with at least one Partner Stakeholder, it is of interest to know with what type of Partner Stakeholders the Leading Stakeholders collaborated. In total, 37 Partner Stakeholders were involved in the 26 cases (Figure 7). Since several Leading Stakeholders collaborated with two to four different Partner Stakeholders (Figure 5), the total number of Partner Stakeholder is higher than the total number of Leading Stakeholders. The type of Partner Stakeholder that is most often involved in collaborations are Private Stakeholders, thus, local companies and businesses. Besides, the Public Transport Provider and Civil Society are also common Partner Stakeholder (Figure 7).

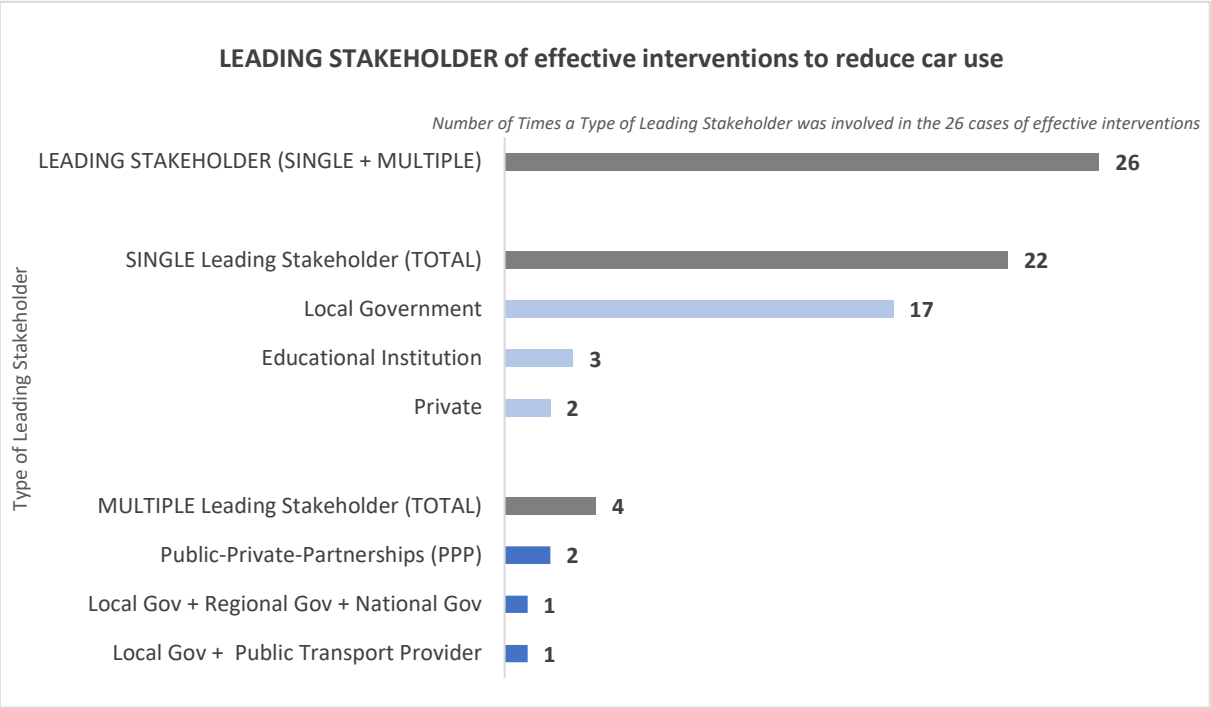



**Figure 6.** Leading Stakeholders of effective city-level interventions to reduce car use. Presented as the number of times a type of Leading Stakeholders is involved in the 26 cases of effective interventions. The Figure distinguishes between Single and Multiple Leading Stakeholders. Disaggregated data shown in blue and aggregated in grey (Figure created by the author based on 24 references listed in Table 11 as well as the four stakeholder-focused reports identified in the targeted search of the systematic document review: Centre for Public Impact(2016), DeRobertis & Tira (2016), Nottingham City Council (2008), Programme office Zuid-Limburg Bereikbaar (2021)).

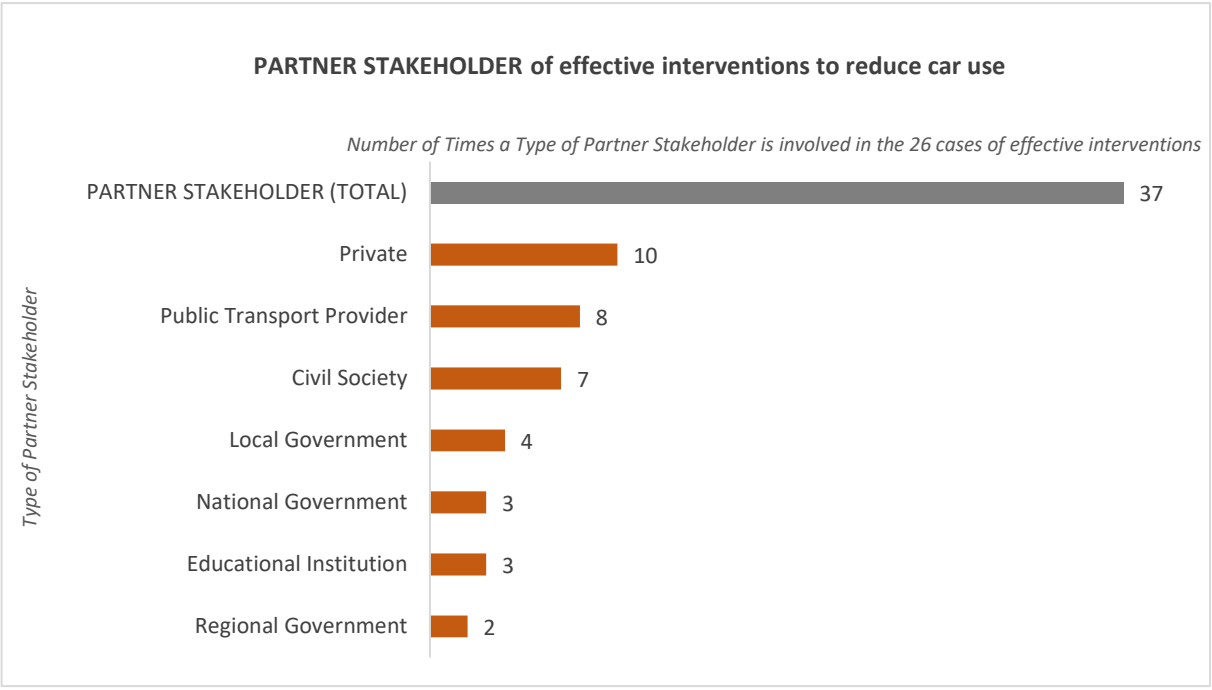



**Figure 7.** Partner Stakeholders of effective city-level interventions to reduce car use, presented as the number of times a type of Partner Stakeholders is involved in the 26 cases of effective interventions to reduce car use. (Table created by the author based on the 24 references listed in Table 11 as well as the four stakeholder-focused reports identified in the targeted search of the systematic document review: Centre for Public Impact(2016), DeRobertis & Tira (2016), Nottingham City Council (2008), Programme office Zuid-Limburg Bereikbaar (2021)).

Overall, I concluded that Local Governments display the most important type of Leading Stakeholder when it comes to initiating and leading effective city-level interventions to reduce car use, while Private Stakeholders, Public Transport Providers and the Civil Society are the most important type of Partner Stakeholders to support the planning and decision-making process.

Appendix F lists the number and type of Leading and Partner Stakeholders as well as the references separately for each of the 26 cases of effective interventions.

## 5.3 Potential of Interventions as Transition Experiments

> *(RQ3) What potential do the effective city-level interventions have to function as transition experiments to reduce car use in Lund?*

Based on the analysis of the expert interviews with two employees of Lund municipality (E1, E2) and two local researchers (E3, E4), four intervention types were found to have a high potential, two a moderate potential, and six a low potential to function as transition experiments to reduce car use in Lund (Table 12). Appendix G shows a detailed visualisation of the coded answers of all four interview partners.

### *5.3.1 High Potential Intervention Types*

*App for Sustainable Mobility Competition.* According to the experts, the company Trivector and the project MaaS Skåne work with apps in the realm of sustainable mobility (E1, E3, E4). However, the existence of an app that tracks mobility, enables a competition, and provides discounts as incentives was not known to the experts (E1, E2, E3, E4). I therefore assessed the intervention type as a new approach. All experts considered the intervention type suitable to reduce car use in Lund (E1, E2, E3, E4). “I think these types of campaigns need to be done in order to start affecting people” (E3). Three experts considered the intervention type feasible to implement in the near-term (E2, E3, E4), especially since many companies with app development competencies are based in the region as a researcher mentioned (E4). However, one practitioner emphasised that such an app is not included in the current municipal budget (E1).

**Table 12.** Potential of the 12 classified intervention types to function as transition experiments to reduce car use in Lund. For each intervention type (left column), the evaluation of the three Transition Experiment Criteria (column in the middle) as well as the overall potential to function as a transition experiment (right column) is presented (Table created by the author based on the interviews with E1, E2, E3 and E4).

| **Intervention Type** | **Evaluation of Transition Experiment Criteria based on the Expert Interviews (E1, E2, E3, E4)** | **Potential of Intervention Type as a Transition Experiment to reduce car use in Lund** |
|---|---|---|
| App for Sustainable Mobility Competition | new ✓<br>suitable ✓<br>feasible ✓ | High |
| Integrated Car-Sharing Action Plan | partly new ✓<br>suitable ✓<br>feasible ✓ | High |
| School Travel Planning | partly new ✓<br>suitable ✓<br>feasible ✓ | High |
| Workplace Parking Charge | new ✓<br>suitable ✓<br>partly feasible ✓ | High |
| Mobility Services for Commuters | partly new ✓<br>partly suitable ✓<br>feasible ✓ | Moderate |
| Parking & Traffic Control (City Centre) | partly new ✓<br>partly suitable ✓<br>partly feasible ✓ | Moderate |
| Workplace Travel Planning | not new ✗<br>suitable ✓<br>feasible ✓ | Low |
| Congestion Charge | new ✓<br>partly suitable ✓<br>not feasible ✗ | Low |
| Personalised Travel Planning | not new ✗<br>partly suitable ✓<br>feasible ✓ | Low |
| University Travel Planning | new ✓<br>partly suitable ✓<br>not feasible ✗ | Low |
| Mobility Services for University | new ✓<br>not suitable ✗<br>not feasible ✗ | Low |
| Limited Traffic Zone (City Centre) | partly new ✓<br>partly suitable ✓<br>not feasible ✗ | Low |

*Integrated Car-Sharing Action Plan*. Three experts reported isolated cases of car-sharing in Lund: car-sharing is integrated in some newly built areas (E1, E3, E4) and the municipality uses car-sharing for its employees (E1). However, car-sharing is "not like a plan and very widespread" (E2). I therefore assessed the intervention type as a partly new approach. All experts found the intervention type suitable to reduce local car use (E1, E2, E3, E4), especially among "people who own a car to carry out leisure trips or to do purchases [….] car-sharing could lower car use" (E2). Further, all experts viewed the intervention type feasible to implement (E1, E2, E3, E4), one practitioner emphasised that "of course we [the municipality] want to support it and we will make it possible" (E1).

*School TP.* According to one practitioner the municipality worked with School TPs for individual schools in the past (E1). However, both researchers considered the past work of the municipality as isolated cases of support rather than a planned approach or strategy (E3, E4). I therefore assessed School TP as a holistic approach which includes *all* local schools as a partly new approach. All experts found School TPs suitable to local reduce car use (E1, E2, E3, E4), one researcher perceived car traffic to local schools as a problem and mentioned that "somebody has to do something progressively here" (E4). Besides, most experts considered School TPs feasible to implement near-term (E3, E2, E4). However, a practitioner emphasised that more economic resources and disposable time are needed to implement the intervention at *every* school (E1).

*Workplace Parking Charge.* According to Swedish tax regulations, free parking in Sweden should be taxed as a benefit, however, both researchers questioned whether local companies actually carry out the taxation (E3, E4). All experts considered a Workplace Parking Charge that combines parking charges with monetary incentives for public transport use or infrastructure reinvestments a new approach (E1, E2, E3, E4). Most experts found the intervention type suitable to reduce local car use (E2, E3, E4), especially "since you see a clear connection between what you are paying and where the money goes to" (E3). According to the researchers, a near-term realisation could be feasible when the municipality employs strong leadership and clear communication (E3, E4) since "[…] it will not go without opposition […] having free parking is not only in Lund but in general in Sweden by some groups of employees seen as an important employee benefit" (E4).

### *5.3.2 Moderate Potential Intervention Types*

*Mobility Services for Commuters* are partly new in Lund: some larger companies offer shuttle busses (E3) and free public transport trials for new employees in the area were offered in the past (E2). One researcher considered the intervention type "a really good idea" to reduce local car use (E4), while two experts found it only partly suitable (E2, E3). One of them raised the concern that "very often when you offer free public transport […] the people who use it are the pedestrians and cyclists, not the car users" (E2). Two experts considered the intervention type feasible to implement (E3, E4).

A *Parking & Traffic Control* that is focused on the city centre is not overall new since Lund has some car-free streets in the city centre (E3, E2, E4) and is constantly extending the pedestrian and bicycle network (E4). One practitioner questioned the suitability if the intervention type is solely focused on the city centre, he emphasises only a small share of car use is caused in the centre (E1). However, the intervention type could be suitable if extended to outer areas of Lund (E2, E4). While one expert viewed it politically feasible to increase investments to implement this intervention (E4), three experts question a near-term implementation. They emphasised that incumbent politicians are not supportive for parking and traffic control measures (E1, E2, E3).

### *5.3.3 Low Potential Intervention Types*

*Workplace TP* is not a new practice: the municipality worked with travel strategies for companies for about 20 years (E1) and local companies worked with transport consultancy firms to facilitate travel planning (E3). However, all experts viewed Workplace TPs as suitable to reduce car use in Lund and feasible to implement near-term (E1, E2, E3, E4), especially since "we [the municipality] have the resources for doing this work" (E1).

*A Congestion Charge* has never been introduced in Lund (E1, E2, E3, E4) and would thus constitute a new approach. Both practitioners did not consider a congestion charge suitable for Lund (E1, E2). After the congestion charge was introduced in Stockholm "somebody at the municipality did look at it and the answer we got was that Lund is not big enough for this" (E2). The researchers contradicted the practitioners, they assumed a congestion charge could be suitable to reduce local car use, however, they agreed that it would neither be feasible to implement near-term nor with the available resources (E3, E4).

All experts considered the *Personalised TP* suitable to reduce local car use (E1, E2, E3, E3), however, two experts raised doubts as to whether this measure alone can produce a significant decrease of car use (E1, E2). Furthermore, the approach is not a new practice in Lund: in the past, campaigns and incentives were used to encourage residents to use sustainable transport modes (E1, E2, E4) and residents who have recently moved to Lund receive travel planning information packages (E3).

Most experts regarded *University TP* as a new approach in Lund (E3, E2, E4). However, the experts did not regard the intervention type suitable since students do not cause a major share of local car use (E1, E2, E3). Only "if all the other employees are included, maybe it would be interesting" (E2). Besides, most experts did not regard a near-term realisation of University TP feasible since the University is physically very dispersed (E2), has a complex organisational and administrative structure (E4) and since "the University has been very reluctant to work with work trips or the trips carried out by the staff" (E3).

*Mobility Services for the University* are a new approach in Lund (E3, E2, E4). However, most experts did not consider this intervention type suitable when it is solely focused on students who are not causing much car use in Lund (E1, E2, E3). Besides, most experts perceived the public bus system to the campuses in Lund as already well developed (E1, E2, E3). One practitioner even feared that an extended shuttle bus system could cause students who formerly biked to use the bus instead (E1).

All experts agreed that a *Limited Traffic Zone* in the city centre would only be a partly novel in Lund since several streets in the centre are already restricted for private cars (E1, E2, E3, E4). Further, due to the small size of Lund and the low share of total car use that is caused in the city centre compared to surrounding living and business areas, most experts considered the intervention type only partly suitable for the local context (E1, E2, E3).

# 6 Discussion

## 6.1 Summary of Main Findings

26 cases of effective city-level interventions were identified and grouped into 12 intervention types in seven categories. All intervention types entail various measures and apply at least two different policy instruments. Half of the intervention types apply a Pull-approach to reduce car use, the other half combines a Pull- and Push-approach. Despite different measurement outcomes, I conclude that the Congestion Charge, Parking & Traffic Control, and Limited Traffic Zone were the most effective to reduce car use since all three significantly reduced the *overall* car use in a city and not only the car use of a specific car user group. Most interventions were initiated and led by local city-governments, often in collaboration with private stakeholders (e.g., local companies) as well as local public transport providers and civil society. Supported by the knowledge of local experts, six intervention types were identified as high or moderate potential transition experiments for Lund: an App for Sustainable Mobility Competition, an Integrated Car-Sharing Action Plan, School Travel Planning, a Workplace Parking Charge, Mobility Services for Commuters, and a Parking & Traffic Control.

## 6.2 Integration of Findings in the Body of Existing Knowledge

### *6.2.1 Effective Interventions to Reduce Car Use*

Regarding the effective city-level interventions to reduce car use it is interesting that *all* intervention types combine between two and four different policy instruments while none of them relies on a single policy instrument (Table 9). This finding contributes to recent discussions that packages of different policy instruments might be more effective than single policy instruments when it comes to shifting urban travel from car use to other transportation modes and to promote a sustainable urban transport sector (Buehler et al., 2017; Dijk et al., 2018; Givoni, 2014; Glazener & Khreis, 2019; Scheepers et al., 2014). In transition studies, too, so-called policy mixes have been discussed as beneficial to stimulate innovations and support sustainability transitions through complementary and mutually supportive interactions between different policy instruments (Kivimaa & Kern, 2016; Nykamp, 2020; Rogge & Reichardt, 2016).

The policy instrument Public Goods & Services was found to be part of almost every intervention type, most often in combination with economic or regulatory instruments (Table 9). This resembles findings from a study in the USA that the combination of “carrots and sticks”, thus,

the expansion of public transport, walking and pedestrian networks while implementing restrictions or disincentives to use the car might be the most effective to reduce car use (Piatkowski et al., 2019). The policy instrument Information & Education is part of every intervention type that follows a Pull-approach to reduce car use. It could therefore be argued that awareness-raising and promotional events are important to support measures that incentivise voluntary mode shifts to low-carbon travel alternatives. Interestingly, all intervention types either applied a pure Pull-approach or combined a Push- and Pull-approach to reduce car use, while no intervention type applied a pure Push-approach. This might be the case as purely coercive measures to reduce car use are often problematic to implement due to public opposition, making them politically infeasible (Gärling & Schuitema, 2007).

While it is difficult to compare effectiveness given the use of different outcome measures, the Congestion Charge, Parking & Traffic Control, and the Limited Traffic Zone achieved the greatest scope of car use reductions by significantly reducing the *overall* car traffic within the *entire centre* of a city (up to 33%) (Table 10). However, the Mobility Service for Commuters, the Workplace Parking Charge and the University Travel Planning are among the most effective to reduce the car use of a specific group of car users - commuters (Table 10). This parallels recent findings that commuters are a relevant target group to effectively reduce car use (Wittwer et al., 2019). The App for Sustainable Mobility Competitions reduced car use among 73% of app-users (Table 10), but *how much* they reduced car use was not reported, so overall effectiveness is difficult to assess (e.g., if each user reduced car use by 1% it would not be a promising intervention). When it comes to the Car-Sharing Intervention, a study from the Netherlands supports the finding that car-sharing is effective in reducing car ownership and car use (Nijland & van Meerkerk, 2017). However, a recent report on low-carbon lifestyles emphasises that car-sharing entails the risk of rebound effects when previously car-free residents start using car-sharing and increase their car use (Lettenmeier et al., 2019).

Overall, due to the scope of their impact on the reduction of urban car use, the Congestion Charge, Parking & Traffic Control, and Limited Traffic Zone might have the greatest potential to reduce local GHG emissions. However, if car use from commuting is a challenge to reducing local GHG emissions, then the Mobility Services for Commuters, the Workplace Parking Charge and - if particularly commuting to University is a problem - the University Travel Planning might also have a great potential to reduce local GHG emissions.

### *6.2.2 Stakeholder Involvement and Collaborations*

The stakeholder analysis of the effective city-level interventions to reduce car use reveals that collaborations between different types of urban stakeholders, including government, private sector, and civil society, are relevant for the planning and decision-making of most interventions. This parallels findings of two global surveys of purposive interventions in urban sectors to foster urban climate action and promote urban transitions, so-called urban climate change experiments (Bulkeley & Castán Broto, 2013; Castán Broto & Bulkeley, 2013). Both surveys identify collaborations between different urban stakeholders as a main characteristic of such urban interventions and suggest that collaborations between multiple actors benefit the introduction of different interests and values in the urban climate change governance (Bulkeley & Castán Broto, 2013; Castán Broto & Bulkeley, 2013). On a broader level, the findings represent the increasing shift of urban climate politics from mere top-down approaches to "collaborative and communicative planning" (Neij et al., 2015).

In these collaborations, the findings show that the local city-government is the most important stakeholder when it comes to initiating and leading interventions. Not only in cities in the EU, as the ones studied in this paper, but globally, local governments are known to be the most prominent Leading Stakeholders for interventions that promote systemic change and GHG emission reductions on the local level (Bulkeley & Castán Broto, 2013).

Thus, to promote transitions of urban transport sectors, local governments should take a leading role, however, not by enforcing top-down decisions, but by initiating and facilitating climate actions and actively engaging in collaborations with other local stakeholders. Based on the findings, especially private stakeholders such as local companies and businesses, local transport providers, and civil society are relevant partner stakeholders to collaborate with.

### *6.2.3 Potential of Interventions as Transition Experiments*

According to Bertolini (2020), transition experiments differ to varying degrees from existing practices - some experiments are considered more far-reaching and therefore more radical than others. Different degrees of radicality in terms of differing from existing measures are also reflected in the evaluation of the potential of interventions to function as transition experiments in Lund. Intervention types that would introduce a completely new approach to reduce car use in Lund, such as the Congestion Fee, can be considered more radical compared

to intervention types that would introduce new measures but are not entirely different from ongoing practices, such as the Integrated Car-Sharing Action Plan.

The different degrees of radicality lead to an important discussion about the difficult balance between radicality and feasibility when developing transition experiments, an aspect that is also emphasised in the guidance manual of TM by Roorda et al. (2014). The results demonstrate that completely new and thus more radical intervention types as the Congestion Fee are often not viewed as feasible to implement near-term and with the available resources. Instead, intervention types which do not entirely differ from ongoing practices and are therefore less radical, such as the School Travel Planning, are often considered more feasible.

Besides the radicality, the lack of support from relevant stakeholders and the currently available resources are two challenges to the near-term implementation of interventions as transition experiments in Lund. When it comes to implementing more restrictive intervention types to reduce car use (e.g., Workplace Parking Charge, Parking & Traffic Control) local experts expect opposition from local employees and incumbent politicians (Chapter 5.3). To develop support and commitment of stakeholders, setting up a transition team with three to five employees of the municipality that develops a process plan and takes care of the internal and external communication of the experiments can be valuable (Roorda et al., 2014; Wittmayer et al., 2018). Besides, a transition team is useful to set up a budget plan for the experiments (Roorda et al., 2014). This aspect is relevant to address the challenge of the currently available resources.

In transition studies, the costs of transition experiments are known to put potential constraints on the feasibility of their implementation (Wittmayer et al., 2018). In line with this, both interviewed practitioners name the currently available financial and human resources as a potential constraint to the near-term implementation of interventions. Besides, Lund municipality is working with long-term economic frames that are decided about four years in advance, as one practitioner mentioned. Hence, transition experiments should ideally be planned early to introduce them into the municipal budget plans as soon as possible.

When it comes to the suitability of interventions, interventions that solely target car use reductions in the city centre were generally judged less suitable by the experts (Chapter 5.3.3). As one expert mentioned, most car use in Lund is not caused in the city centre but by transport demands of surrounding residential areas or from commuting within Lund's outer areas where

companies and businesses are located. This corresponds to recent findings of Lund's Climate Policy Council who reported an increase of car use in living and business areas outside the city centre (e.g., Brunnshög, Nova, Tetra Pak) and identified commuting as a main contributor to high car use (Neij et al., 2020). Hence, to reach their potential in reducing car use, transition experiments in Lund should especially be introduced in living and business areas beyond the city centre.

### 6.3 Policy Implications for Lund

In practice, TM suggests to develop a portfolio of different transition experiments that collectively support the achievement of transition goals (Loorbach et al., 2015). Which interventions could be part of a portfolio of transition experiments for Lund's transport sector to support the reduction of local car use and thus, of local transport GHG emissions?

A comparison of the interventions judged to have a moderate and high potential to function as transition experiments in Lund, with those identified as having the highest potential to reduce local GHG emissions, reveals tensions between feasibility and potential effectiveness. The Congestion Charge and the Limited Traffic Zone, two of the three intervention types which were found to be the most effective in reducing car use and therefore assessed the most likely to reduce local GHG emissions, were not considered feasible to implement near-term and with the available resources. Both intervention types were found to have a low potential as transition experiments in Lund (Table 12).

However, the Parking & Traffic Control intervention type might offer a good trade-off between its potential to function as a transition experiment and its potential to reduce local GHG emissions. The Parking & Traffic Control is the third intervention type which was found to be the most effective in reducing local car use and most likely to reduce GHG emissions. Apart from expected opposition of incumbent politicians, this intervention type was considered feasible to implement. Therefore, supported by measures that develop support from politicians, e.g., the introduction of a transition team as suggested in the previous chapter, the Parking & Traffic Control displays a promising intervention to be implemented as a transition experiment in Lund.

Which other intervention types might best support a Parking & Traffic Control transition experiment in reducing local car use as part of a transition experiment portfolio? Since

commuting was discussed as a main contributor to car use in Lund (Chapter 6.2.3), the Mobility Services for Commuters and the Workplace Parking Charge might beneficially support the Parking & Traffic Control experiment. Besides, both intervention types offer a good trade-off between being moderate potential transition experiments (Chapter 5.3.1) and having a great potential to reduce local GHG emissions (Chapter 6.2.1).

Building on the insights of TM, the research findings and their discussion, the development and implementation of the above-mentioned intervention types as transition experiments in Lund to promote the transition of the transport sector by reducing local car use could entail the following activities:

- *Formation of a transition team* (Chapter 3.2, 6.2.3) with employees of Lund municipality. The transition team represents the Leading Stakeholder (Chapter 3.2, 5.2) to initiate, lead, facilitate, and implement the experiments.
- *Assessment of the best possible translation* of the measures and policy instruments contained in the intervention types into local transition experiments. The assessment should not only consider how the greatest short-term effect on the reduction of car use can be achieved, but also how to ensure the compatibility of the transition experiments with the long-term sustainability vision and goals of Lund's transport sector and Lund municipality (Chapter 3.2, 3.3).
- *Engagement and Involvement of Partner Stakeholders* to ensure the inclusion of different interests, values, and competencies in the planning, decision-making and implementation of the experiments (Chapter 3.2, 5.2, 6.2.2). Private stakeholders such as Lund Climate Alliance, the civil society, and the public transport provider Skånetrafiken might be relevant actors.
- *Development of a process and budget plan* (Chapter 6.2.3) for the implementation of the experiments which can be discussed for the next budget plan of the municipality.
- *Internal and External Communication of the Transition Experiments* to develop support of relevant stakeholders (Chapter 6.2.3).
- *Ensuring monitoring and evaluation* of the transition experiments to assess their utility for GHG emission reductions in the local transport sector and to ensure the coherence of their outcomes with the long-term sustainability vision and goals in Lund. Identifying challenges and opportunities enables a "learning-by-doing" process where insights can

be translated into strategic, long-term policies to support the sustainable transition of Lund's transport sector (Chapter 3.2, 3.3).

### 6.4 Research Limitations

Although 26 cases of effective city-level interventions were found, three major challenges were identified during the systematic literature and document review: 1) a lack of scientific ex-post analysis which evaluate the effectiveness of interventions based on observed rather than estimated or simulated car use reductions, 2) a lack of quantified evidence and reliable data of achieved car use reductions in both academic and grey literature, and 3) a great heterogeneity of outcome measures of the reduction of car use. In consequence, after reviewing 369 scientific articles and 407 case-study reports, only 28 documents met the inclusion criteria, of which only 10 represented peer-reviewed, scientific papers. Hence, the database to identify and analyse the interventions is not extensive. Besides, the heterogeneity of outcome measures prevented the creation of an encompassing ranking of the interventions' effectiveness which would have benefited the production of actionable knowledge for policymaking.

The inclusion of literature about interventions was not limited to cities with a similar size or similar infrastructure characteristics to Lund. This was done, to compile as much evidence of effective interventions as possible and to ensure the relevance and applicability of findings for policymaking in other cities than Lund. However, since the literature review was not customised to Lund, the transferability of interventions into local transition experiments is limited to the extent that certain measures might not be equally effective or implementable due to variations in local conditions.

The data of Lund's GHG emission levels and trends reported in this thesis is mostly data from 1990-2017 which was reported by Neij et al. (2020). I recognise that the global COVID-19 pandemic that reached Sweden in spring 2020 might have impacted recent emission trends and current transport emissions levels. According to a study from July 2020, global transport emissions declined by 50% by April 2020 (compared to mean 2019 levels) (Le Quéré et al., 2020).

### 6.5 Future Research

The research limitations just identified point to three needs for future research: 1) more scientific ex-post analysis of interventions, 2) more quantified evidence of the effectiveness of interventions, and 3) standardised outcome measures of car use reductions.

A great part of scientific studies of interventions to reduce car use presents *expected* outcomes (ex-ante analysis) based on simulations rather than *actual* outcomes from monitoring and evaluations (ex-post analysis). The latter, however, are more valuable for policy learning and translation processes (Dijk et al., 2018). Nevertheless, it was noticeable that more ex-post analysis exist in non-scientific, institutional case-study reports. Thus, to expand the body of scientific ex-post analysis of interventions to reduce car use, it could be beneficial to translate relevant evidence of institutional reports into scientific articles.

The lack of quantified evidence in evaluations of interventions to reduce car use was already reported by Graham-Rowe et al. (2011) and Scheepers et al. (2014). Hence, the evidence basis of effective interventions to reduce car use has not improved notably in the past 10 years. To support evidence-based policymaking in the transport sector, it is vital that future studies of interventions *always* include quantified outcome measures of the reduction of car use, ideally covering several follow-up measurements over time.

Finally, future research should aim at finding a standard outcome measure to report car use reductions to facilitate the comparison of effective interventions and thus, the production of actionable knowledge for policymaking. Graham-Rowe et al. (2011) suggest the outcome measure kilometres-per-person-travelled-per-day. Furthermore, as emphasised by Wynes et al. (2018), studies are more useful to compare the effectiveness of interventions and to determine their utility if the reported outcome measures allow calculations of GHG emission reductions or directly report emission reductions themselves.

# 7 Conclusion

To support the achievement of local climate goals in Lund, this thesis applied a transition management approach to develop a knowledge base for the implementation of transition experiments that reduce local car use and foster the transition of Lund's transport sector, which produces about 50% of local GHG emissions. For this purpose, effective city-level interventions to reduce car use as well as relevant stakeholder types and collaborations involved in these interventions were identified. The insights were then used to assess the potential of the interventions to function as transition experiments to reduce car use in Lund.

This thesis identified 12 intervention types that are effective in reducing urban car use: Congestion Charge, Workplace Parking Charge, Limited Traffic Zone, Parking & Traffic Control, Mobility Services for Commuters, Mobility Services for Students, Integrated Car-Sharing Plans, Workplace Travel Planning, School Travel Planning, University Travel Planning, Personalised Travel Planning, and an App for Sustainable Mobility Competitions. All 12 intervention types apply a mix of different policy instruments to reduce car use. The policy mixes mostly entail the instruments Public Goods & Services or Information & Education in combination with an Economic or Regulatory instrument. Half of the intervention types combine a Push- and Pull approach to reduce car use by discouraging car use while providing incentives for travel alternatives, the other half relied solely on a Pull-approach. No intervention type only applied a Push-approach.

The great majority of the interventions was planned and decided upon in collaborations between a Leading Stakeholder and at least one Partner Stakeholder. Local governments are the most common Leading Stakeholders to initiate and lead interventions in two-thirds of cases. Private stakeholders, civil society and public transport providers are the most common Partner Stakeholders who collaborate with and support the Leading Stakeholders. Based on interviews with two local researchers and two employees of Lund municipality, four intervention types were identified as high potential and two as moderate potential transition experiments to reduce car use in Lund.

This thesis recommends a portfolio of three transition experiments to reduce car use and GHG emissions in Lund and to thereby facilitate the transition of Lund's transport sector: Parking & Traffic Control, Workplace Parking Charge and Mobility Services for Commuters.

The research contributes to the study of sustainability transitions, by providing a concrete example how a theoretical framework to analyse and promote transitions can be utilised to generate solution-oriented knowledge for policymaking that supports the development of concrete actions to tackle the pressing sustainability challenge of climate change.

# 8 References


Bamberg, S., & Rees, J. (2017). The impact of voluntary travel behavior change measures – A meta-analytical comparison of quasi-experimental and experimental evidence. *Transportation Research Part A: Policy and Practice*, *100*, 16–26. https://doi.org/10.1016/j.tra.2017.04.004

Beria, P. (2016). Effectiveness and monetary impact of Milan's road charge, one year after implementation. *International Journal of Sustainable Transportation*, *10*(7), 657–669. https://doi.org/10.1080/15568318.2015.1083638

Bertolini, L. (2020). From "streets for traffic" to "streets for people": can street experiments transform urban mobility? *Transport Reviews*, *40*(6), 734–753. https://doi.org/10.1080/01441647.2020.1761907

Bongardt, D., Breithaupt, M., & Creutzig, F. (2011). *Beyond the Fossil City: Towards low Carbon Transport and Green Growth: Sustainable Urban Transport Technical Document # 6*. German Corporation for International Cooperation GmbH (GIZ). https://www.changing-transport.org/wp-content/uploads/2011_Bongardt_etal_BeyondtheFossilCity.pdf

Börjesson, M., & Kristoffersson, I. (2015). The gothenburg congestion charge. Effects, design and politics. *Transportation Research Part A: Policy and Practice*, *75*, 134–146. https://doi.org/10.1016/j.tra.2015.03.011

Brockman, R., & Fox, K. R. (2011). Physical activity by stealth? The potential health benefits of a workplace transport plan. *Public Health*, *125*(4), 210–216. https://doi.org/10.1016/j.puhe.2011.01.005

Broekhoff, D., Piggot, G., & Erickson, P. (2018). Building Thriving, Low-Carbon Cities: An Overview of Policy Options for National Governments. *Coalition for Urban Transitions*, 124. http://newclimateeconomy.report/workingpapers/wp-content/uploads/sites/5/2018/02/Building-Thriving-Low-Carbon-Cities-An-Overview-Full-Paper-1.pdf

Bryman, A. (2012). *Social Research Methods* (4th ed.). Oxford University Press Inc.

Buehler, R., Pucher, J., Gerike, R., & Götschi, T. (2017). Reducing car dependence in the heart of Europe: lessons from Germany, Austria, and Switzerland. *Transport Reviews*, *37*(1), 4–28. https://doi.org/10.1080/01441647.2016.1177799

Bulkeley, H. (2010). Cities and the governing of climate change. *Annual Review of Environment and Resources*, *35*, 229–253. https://doi.org/10.1146/annurev-environ-072809-101747

Bulkeley, H., Broto, V. C., & Maassen, A. (2011). Governing urban low carbon transitions. In H. Bulkeley, V. Castán Broto, M. Hodson, & S. Marvin (Eds.), *Cities and Low Carbon Transitions* (pp. 29–41). Routledge. https://doi.org/10.4324/9780203839249

Bulkeley, H., & Castán Broto, V. (2013). Government by experiment? Global cities and the governing of climate change. *Transactions of the Institute of British Geographers*, *38*(3), 361–375. https://doi.org/10.1111/j.1475-5661.2012.00535.x

Cairns, S., Newson, C., & Davis, A. (2010). Understanding successful workplace travel initiatives in the UK. *Transportation Research Part A: Policy and Practice*, *44*(7), 473–494. https://doi.org/10.1016/j.tra.2010.03.010

Castán Broto, V., & Bulkeley, H. (2013). A survey of urban climate change experiments in 100 cities. *Global Environmental Change*, *23*(1), 92–102. https://doi.org/10.1016/j.gloenvcha.2012.07.005

Centre for Public Impact. (2016). *London' s congestion charge*. Centre for Public Impact. Retrieved February 19, 2021, from https://www.centreforpublicimpact.org/case-study/demand-management-for-roads-in-london/

CIVITAS. (2011). *Donostia – San Sebastian T 34 . 1 Personalised Travel Plans in Donastia - San Sebastian*. CIVITAS Initiative. https://civitas.eu/sites/default/files/deliverable20t34_1donostiasansebastian.pdf

CIVITAS. (2013a). *Car Sharing Service in Genoa*. CIVITAS Initiative. https://civitas.eu/sites/default/files/civitas_insight_car_sharing-new_forms_of_vehicle_use_and_ownership.pdf

CIVITAS. (2013b). *Creating 246 company travel plans*. Retrieved February 11, 2021, from https://civitas.eu/measure/creating-246-company-travel-plans

CIVITAS. (2013c). *Implementing access restrictions*. Retrieved February 11, 2021, from https://civitas.eu/measure/implementing-access-restrictions

CIVITAS. (2013d). *Mobility Management For University Campus Donastia-San Sebastian*. CIVITAS Initiative. https://civitas.eu/sites/default/files/11-320norwich.pdf

CIVITAS. (2013e). *Personalised Travel Plans*. CIVITAS Initiative. https://civitas.eu/sites/default/files/arc_mert_34_f_dss_personalisedtravelplans.pdf

CIVITAS. (2013f). *Travel Planning Norwich*. CIVITAS Initiative. https://civitas.eu/sites/default/files/11-320norwich.pdf

CIVITAS. (2013g). *Travel Plans in Brighton & Hove*. CIVITAS Initiative. https://civitas.eu/sites/default/files/bhcc20school20travel20plans_20deliverable20report.pdf

Dale, S., Frost, M., Ison, S., & Budd, L. (2019). The impact of the Nottingham Workplace Parking Levy on travel to work mode share. *Case Studies on Transport Policy*, *7*(4), 749–760. https://doi.org/10.1016/j.cstp.2019.09.001

DeRobertis, M., & Tira, M. (2016). The Most Widespread Traffic Control Strategy You've Never Heard Of: Traffic-Restricted Zones in Italy. *ITE Journal*, *86*(12), 44–49.

Dijk, M., Givoni, M., & Diederiks, K. (2018). Piling up or packaging policies? An ex-post analysis of modal shift in four cities. *Energies*, *11*(6), 1–20. https://doi.org/10.3390/en11061400

Eliasson, J. (2014). The stockholm congestion charges: an overview. *Stockholm: Centre for Transport Studies CTS Working Paper*, *7*(42).

European Commissions. (n.d.). *Transport Emissions. A European Strategy for low-emission mobility*. Retrieved March 31, 2021, from https://ec.europa.eu/clima/policies/transport_en

European Commission. (2017). *Sustainable Urban Mobility: European Policy, Practice and Solutions*. European Commission. https://ec.europa.eu/transport/sites/transport/files/2017-sustainable-urban-mobility-european-policy-practice-and-solutions.pdf

European Commissions. (2020). *Proposal for a Regulation of the European Parliament and of the Council. Establishing the framework for achieving climate neutrality and amending Regulation (EU) 2018/1999 (European Climate Law).* European Commission. https://eur-lex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:52020PC0080&from=EN

Gärling, T., & Schuitema, G. (2007). Travel demand management targeting reduced private car use: Effectiveness, public acceptability and political feasibility. *Journal of Social Issues*, *63*(1), 139–153. https://doi.org/10.1111/j.1540-4560.2007.00500.x

Geels, F. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, *1*(1), 24–40. https://doi.org/10.1016/j.eist.2011.02.002

Givoni, M. (2014). Addressing transport policy challenges through policy-packaging. *Transportation Research Part A: Policy and Practice*, *60*, 1–8. https://doi.org/10.1016/j.tra.2013.10.012

Glazener, A., & Khreis, H. (2019). Transforming Our Cities: Best Practices Towards Clean Air and Active Transportation. *Current Environmental Health Reports*, *6*(1), 22–37. https://doi.org/10.1007/s40572-019-0228-1

Glotz-Richter, M. (2016). Reclaim Street Space! - Exploit the European Potential of Car Sharing. *Transportation Research Procedia*, *14*(2), 1296–1304. https://doi.org/10.1016/j.trpro.2016.05.202

Graham-Rowe, E., Skippon, S., Gardner, B., & Abraham, C. (2011). Can we reduce car use and, if so, how? A review of available evidence. *Transportation Research Part A: Policy and Practice*, *45*(5), 401–418. https://doi.org/10.1016/j.tra.2011.02.001

Inturri, G. (2019). *You study , you travel free*. Retrieved February 10, 2021, from https://www.eltis.org/resources/case-studies/you-study-you-travel-free

IPCC. (2018). Summary for Policymakers. In V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, & T. Waterfield (Eds.), *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change*. In press.

ITL. (2018). *EU good practices on sustainable mobility planning and SUMP*. Institute for Transport and Logistics Foundation (ITL). https://www.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1522246472.pdf

Ivanova, D., Barrett, J., Wiedenhofer, D., Macura, B., Callaghan, M., & Creutzig, F. (2020). Quantifying the potential for climate change mitigation of consumption options. *Environmental Research Letters*, *15*(9). https://doi.org/10.1088/1748-9326/ab8589

Jerneck, A., Olsson, L., Ness, B., Anderberg, S., Baier, M., Clark, E., Hickler, T., Hornborg, A., Kronsell, A., Lövbrand, E., & Persson, J. (2011). Structuring sustainability science. *Sustainability Science*, *6*(1), 69–82. https://doi.org/10.1007/s11625-010-0117-x

Kemp, R., Loorbach, D., & Rotmans, J. (2007). Transition management as a model for managing processes of co-evolution towards sustainable development. *International Journal of Sustainable Development and World Ecology*, *14*(1), 78–91. https://doi.org/10.1080/13504500709469709

Kern, K., & Alber, G. (2009). GOVERNING CLIMATE CHANGE IN CITIES: MODES OF URBAN CLIMATE GOVERNANCE IN MULTI-LEVEL SYSTEMS. *The International Conference on Competitive Cities and Climate Change*, 171–196.

Kivimaa, P., & Kern, F. (2016). Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions. *Research Policy*, *45*(1), 205–217. https://doi.org/10.1016/j.respol.2015.09.008

Köhler, J., Whitmarsh, L., Nykvist, B., Schilperoord, M., Bergman, N., & Haxeltine, A. (2009). A transitions model for sustainable mobility. *Ecological Economics*, *68*(12), 2985–2995. https://doi.org/10.1016/j.ecolecon.2009.06.027

Kuckartz, U., & Rädiker, S. (2019). *Analyzing Qualitative Data with MAXQDA (1st ed.)*. Springer International Publishing. https://doi.org/10.4135/9781849208901.n5

Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., & Thomas, C. J. (2012). Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science*, *7*(1), 25–43. https://doi.org/10.1007/s11625-011-0149-x

Le Quéré, C., Jackson, R. B., Jones, M. W., Smith, A. J. P., Abernethy, S., Andrew, R. M., De-Gol, A. J., Willis, D. R., Shan, Y., Canadell, J. G., Friedlingstein, P., Creutzig, F., & Peters, G. P. (2020). Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement. *Nature Climate Change*, *10*(7), 647–653. https://doi.org/10.1038/s41558-020-0797-x

Leavy, P. (2017). *Research Design. Quantiative, Qualitative, Mixed Methods, Arts-Based, and Community-Based Participatory Research Approaches*. The Guilford Press.

Lettenmeier, M., Toivio, V., Koide, R., & Amellina, A. (2019). *1.5-Degree Lifestyles: Targets and Options for Reducing Lifestyle Carbon Footprints. Technical Report.* Institute for Global Environmental Strategies, Aalto University. https://www.iges.or.jp/en/publication_documents/pub/technicalreport/en/6719/15_Degree_Lifestyles_MainReport.pdf

Loorbach, D., Frantzeskaki, N., & Lijnis Huffenreuter, R. (2015). Transition Management: Taking Stock from Governance Experimentation. *Journal of Corporate Citizenship*, *2015*(58), 48–66. https://doi.org/10.9774/gleaf.4700.2015.ju.00008

Loorbach, D., & Rotmans, J. (2010). The practice of transition management: Examples and lessons from four distinct cases. *Futures*, *42*(3), 237–246. https://doi.org/10.1016/j.futures.2009.11.009

Lund University. (2020). *Lund University. Education, Research and collaboration since 1666*. Lund University, Corporate Communications. https://www.lunduniversity.lu.se/sites/www.lunduniversity.lu.se/files/lu-presentation-brochure-2020.pdf

Lunds Kommun. (n.d.). *LundaMATS III. Strategy for a sustainable transport system in Lund Municipality*. Lunds Kommun. https://www.lund.se/globalassets/lund.se/traf_infra/lundamats/lundamats_iii_eng.pdf

Lunds Kommun. (2017). *Lundaeko II. Lunds Kommuns Program för ekologiskt hållbar utveckling 2014-2020 [Lundaeko II. Lund Municipality's program for an ecologically sustainable development 2014-2020]*. Lunds Kommun. https://www.lund.se/contentassets/25a80242a210412a9d894d274ff726ec/lundaeko-ii-till-hemsidan.pdf

Lunds Kommun. (2020a). *LundaEko. Lunds kommuns program för ekologisk hållbar utveckling 2021-2030 [LundaEko. Lund Municipality's program for an ecologically sustainable development 2021-2030]*. Lunds Kommun. https://www.lund.se/globalassets/lund.se/bygg_bo/klimat-miljo-och-hallbarhet/ lundaeko/beslutad-remissversion-lundaeko-2020-09-16-inklusive-bilaga-med-indikatorer.pdf

Lunds Kommun. (2020b). *Ny statistik: Lund nådde sitt klimatmål för 2020 redan 2018 [New statistics: Lund reached its climate goal for 2020 already in 2018]*. Retrieved March 31, 2021, from https://www.lund.se/nyheter-och-nyhetsarkiv/2020/ny-statistik-lund-nadde-sitt-klimatmal-for-2020-redan-2018/

Lunds Kommun. (2021). *Kommunfakta [Facts about the municipality]*. Retrieved March 31, 2021, from https://www.lund.se/kommun--politik/kommunfakta/

Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, *41*(6), 955–967. https://doi.org/10.1016/j.respol.2012.02.013

Mertens, D. M. (2018). *Mixed Methods Design in Evaluation*. SAGE Publications, Inc. https://doi.org/10.4135/9781506330631.n5

Metz, D. (2018). Tackling urban traffic congestion: The experience of London, Stockholm and Singapore. *Case Studies on Transport Policy*, *6*(4), 494–498. https://doi.org/10.1016/j.cstp.2018.06.002

Ministry of the Environment and Energy. (n.d.). *The Swedish climate policy framework*. Government Offices of Sweden. https://www.government.se/495f60/contentassets/883ae8e123bc4e42aa8d59296ebe0478/the-swedish-climate-policy-framework.pdf

Moberg, K. R., Aall, C., Dorner, F., Reimerson, E., Ceron, J. P., Sköld, B., Sovacool, B. K., & Piana, V. (2019). Mobility, food and housing: responsibility, individual consumption and demand-side policies in European deep decarbonisation pathways. *Energy Efficiency*, *12*(2), 497–519. https://doi.org/10.1007/s12053-018-9708-7

Modijefsky, M. (2019). *Maastricht Bereikbaar: integrated mobility management targeting employers and commuters*. Eltis. https://www.eltis.org/discover/case-studies/maastricht-bereikbaar-integrated-mobility-management-targeting-employers-and

Modijefsky, M. (2021). *Oslo – Promoting Active Transport Modes*. Eltis. https://www.eltis.org/resources/case-studies/oslo-promoting-active-transport-modes

Neij, L., Bulkeley, H., & McCormick, K. (2015). Cities and climate change: The great decarbonisation challenge. *Climate in Focus*, 1–5. https://lup.lub.lu.se/search/publication/4393558

Neij, L., Hildingsson, R., Alkan Olsson, J., Andersson, F. N. G., Hiselius, L., Peterson, A., Rummukainen, M., & Sternudd, C. (2020). *Rapport 2020 [Report 2020]*. Lunds Kommun. https://www.lund.se/contentassets/9b2829c0c9cf4de8b98eff406bb5fd61/klimatpolitiska-radets-arsrapport-2020.pdf

Nevens, F., Frantzeskaki, N., Gorissen, L., & Loorbach, D. (2013). Urban Transition Labs: Co-creating transformative action for sustainable cities. *Journal of Cleaner Production*, *50*, 111–122. https://doi.org/10.1016/j.jclepro.2012.12.001

Nijland, H., & van Meerkerk, J. (2017). Mobility and environmental impacts of car sharing in the Netherlands. *Environmental Innovation and Societal Transitions*, *23*, 84–91. https://doi.org/10.1016/j.eist.2017.02.001

Nottingham City Council. (2008). *Workplace Parking Levy Business Case April 2008*. Nottingham City Council. http://committee.nottinghamcity.gov.uk/Data/City Council/20080512/Agenda/$WPLBusCase - 33021.doc.pdf

Nykamp, H. (2020). Policy mix for a transition to sustainability: Green buildings in Norway. *Sustainability (Switzerland)*, *12*(2), 15–17. https://doi.org/10.3390/su12020446

Piatkowski, D. P., Marshall, W. E., & Krizek, K. J. (2019). Carrots versus Sticks: Assessing Intervention Effectiveness and Implementation Challenges for Active Transport. *Journal of Planning Education and Research*, *39*(1), 50–64. https://doi.org/10.1177/0739456X17715306

Programme office Zuid-Limburg Bereikbaar. (2021). *About us Zuid-Limburg Bereikbaar*. Retrieved March 18, 2021, from https://www.zuidlimburgbereikbaar.nl/en/about-us/

Rogge, K. S., & Reichardt, K. (2016). Policy mixes for sustainability transitions: An extended concept and framework for analysis. *Research Policy*, *45*(8), 1620–1635. https://doi.org/10.1016/j.respol.2016.04.004

Roorda, C., & Wittmayer, J. (2014). *Transition management in five European cities – an evaluation*. DRIFT (Dutch Research Institute for Transitions, Erasmus University Rotterdam). https://drift.eur.nl/app/uploads/2016/11/DRIFT_MUSIC_Transition-management-in-five-European-cities-an-evaluation.pdf

Roorda, C., Wittmayer, J., Henneman, P., van Steenbergen, F., Frantzeskaki, N., & Loorbach, D. (2014). *Transition Management in the Urban Context*: *Guidance Manual*. DRIFT, Erasmus University Rotterdam. https://drift.eur.nl/app/uploads/2016/11/DRIFT-Transition_management_in_the_urban_context-guidance_manual.pdf

Rotmans, J., Kemp, R., & Van Asselt, M. (2001). More evolution than revolution: transition management in public policy. *Foresight*, *3*(1), 15–31. https://doi.org/10.1108/14636680110803003

Roulston, K., & Choi, M. (2018). Qualitative Interviews. In U. Flick *The SAGE Handbook of Qualitative Data Collection* (pp. 233–249). SAGE Publications Ltd. https://doi.org/10.1515/9783110545982

Santos, G., Maoh, H., Potoglou, D., & von Brunn, T. (2013). Factors influencing modal split of commuting journeys in medium-size European cities. *Journal of Transport Geography*, *30*, 127–137. https://doi.org/10.1016/j.jtrangeo.2013.04.005

Scheepers, C. E., Wendel-Vos, G. C. W., den Broeder, J. M., van Kempen, E. E. M. M., van Wesemael, P. J. V., & Schuit, A. J. (2014). Shifting from car to active transport: A systematic review of the effectiveness of interventions. *Transportation Research Part A: Policy and Practice*, *70*, 264–280. https://doi.org/10.1016/j.tra.2014.10.015

Somanathan, E., Sterner, T., Sugiyama, T., Chimanikire, D., Dubash, N. K., Essandoh-Yeddu, J., Fifita, S., Goulder, L., Jaffe, A., Labandeira, X., Managi, S., Mitchell, C., Montero, J. P., Teng, F., & Zylicz, T. (2014). National and Sub-national Policies and Institutions. In O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel, & J. C. Minx (Eds.), *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1141–1206). Cambridge University Press. https://doi.org/10.1002/zamm.19860660603

Statistics Sweden. (2020). *Kommuner i siffror [Municipalities in numbers]*. Retrieved March 31, 2021, from https://kommunsiffror.scb.se/?id1=1281&id2=null

Strompen, F., Litman, T., & Bongardt, D. (2012). *Reducing Carbon Emissions through Transport Demand Management Strategies A review of international examples Final Report*. German Corporation for International Cooperation GmbH (GIZ). http://tdm-beijing.org/files/International_Review.pdf

Stumpel-Vos, P., Oostrom, C., & van den Berg, V. (2013). *Focus Measure Evaluation Results UTR 4.1 Mobility Managment Policy*. CIVITAS Initiative. https://civitas.eu/sites/default/files/measure_evaluation_results_4_1_mobility_management_policy.pdf

Teixeira, J. F., Silva, C., & Moura e Sá, F. (2020). Empirical evidence on the impacts of bikesharing: a literature review. *Transport Reviews,* 1–23. https://doi.org/10.1080/01441647.2020.1841328

Thaler, R., Ehrnleitner, I., Raimund, W., Briesner, I., Auwerx, P., Walschap, S., Castagne, D., Ministry of Infrastructure and Water Managment, Schade, M., Norbech, T., Botelho, I., Tavares, M., Martins, R. V., Bertuccio, L., Gävermark, S., Gent, R., Chanut, S., & Viinikainen, T. (2018). *Mobility Management Strategy Book*. European Platform on Mobility Management (EPOMM). http://epomm.eu/sites/default/files/files/EPOMM_strategy_book.pdf

UN Habitat. (2021). *Energy*. United Nations Human Settlements Programme. Retrieved March 31, 2021, from https://unhabitat.org/topic/energy#:~:text=To run their activities%2C cities,the world's total greenhouse gases.

University of Bristol. (2018a). *Combined Travel Plan 2018 – 2023 March*. University of Bristol. http://www.bris.ac.uk/media-library/sites/transportplan/documents/university-of-bristol-travel-plan-2018- to-2023.pdf

University of Bristol. (2018b). *STAFF TRAVEL SURVEY 2016. ANALYSIS REPORT*. University of Bristol. https://www.bristol.ac.uk/media-library/sites/transportplan/0879 UoB Staff Travel Survey Report FINAL.pdf

Viable Cities. (2020). *Klimatkontrakt 2030. Mellan Lunds Kommun och Myndigheterna Energimyndigheten, Vinnova, Formas och Tillväxtverket samt Viable Cities*. Viable Cities. https://static1.squarespace.com/static/5dd54ca29c9179411df12b85/t/5fd9d2ec8024af0ae448d1c8/1608110831496/Lunds_kommun_PDF-A.pdf

West, J., & Börjesson, M. (2020). The Gothenburg congestion charges: cost–benefit analysis and distribution effects. *Transportation*, *47*(1), 145–174. https://doi.org/10.1007/s11116-017-9853-4

Wittmayer, J. M., van Steenbergen, F., Frantzeskaki, N., & Bach, M. (2018). Transition Management: Guiding Principles and Applications. In N. Frantzeskaki, K. Hölscher, M. Bach, & F. Avelino (Eds.), *Co-creating Sustainable Urban Futures* (pp. 88–101). Springer, Cham. https://doi.org/https://doi.org/10.1007/978-3-319-69273-9_4

Wittwer, R., Gerike, R., & Hubrich, S. (2019). Peak-Car Phenomenon Revisited for Urban Areas: Microdata Analysis of Household Travel Surveys from Five European Capital Cities. *Transportation Research Record*, *2673*(3), 686–699. https://doi.org/10.1177/0361198119835509

Wynes, S., Nicholas, K. A., Zhao, J., & Donner, S. D. (2018). Measuring what works: Quantifying greenhouse gas emission reductions of behavioural interventions to reduce driving, meat consumption, and household energy use. *Environmental Research Letters*, *13*(11). https://doi.org/10.1088/1748-9326/aae5d7

# 9 Appendix

### Appendix A. Search Terms for Systematic Literature Review

The table lists the search terms and filters that were used to find peer-reviewed, scientific articles about effective city-level interventions to reduce car use on *Web of Science* during the Systematic Literature Review as well as the number of hits generated.

| Search Term | Filter | Number of Hits |
|---|---|---|
| reduce car use AND urban AND lessons | 2010-2021 | 20 |
| best practice AND reduce car use AND urban | 2010-2021 | 12 |
| restrict car use AND Urban AND policy | 2010-2021 | 29 |
| car restrictive policy AND city | 2010-2021 | 16 |
| reduce traffic volume AND policy AND city | 2010-2021 | 27 |
| reduce travel distance with car AND policy AND city | 2010-2021 | 29 |
| reduce frequency of car use AND policy AND city | 2010-2021 | 19 |
| intervention to reduce car use AND city | 2010-2021 | 61 |
| change car use habits AND policy | 2010-2021 | 45 |
| modal shift from car AND policy | 2010-2021 | 35 |
| reduce car use AND policy | 2010-2021<br>reviews only | 76 |

### Appendix B. Filter for Systematic Document Review (Eltis)

The table displays the filters that were used to find institutional case-study reports of effective interventions to reduce car use on the data base of Elits (Eltis > Resources > Case Studies > Advanced Search) during the Systematic Document Review and the number of hits generated.

| Filter | Number of Hits |
|---|---|
| Mobility Management; 2010-2021 | 78 |
| Traffic and Demand Management; 2010-2021 | 26 |

**Appendix C. Search Terms for Systematic Document Review (CIVITAS)**

The tables display the search terms that were used to find institutional case-study reports of effective interventions to reduce car use on the data base of CIVITAS during the Systematic Document Review and the number of hits generated.

a) CIVITAS Resource Library (CIVITAS > Resources > Case Studies > Advanced Search)

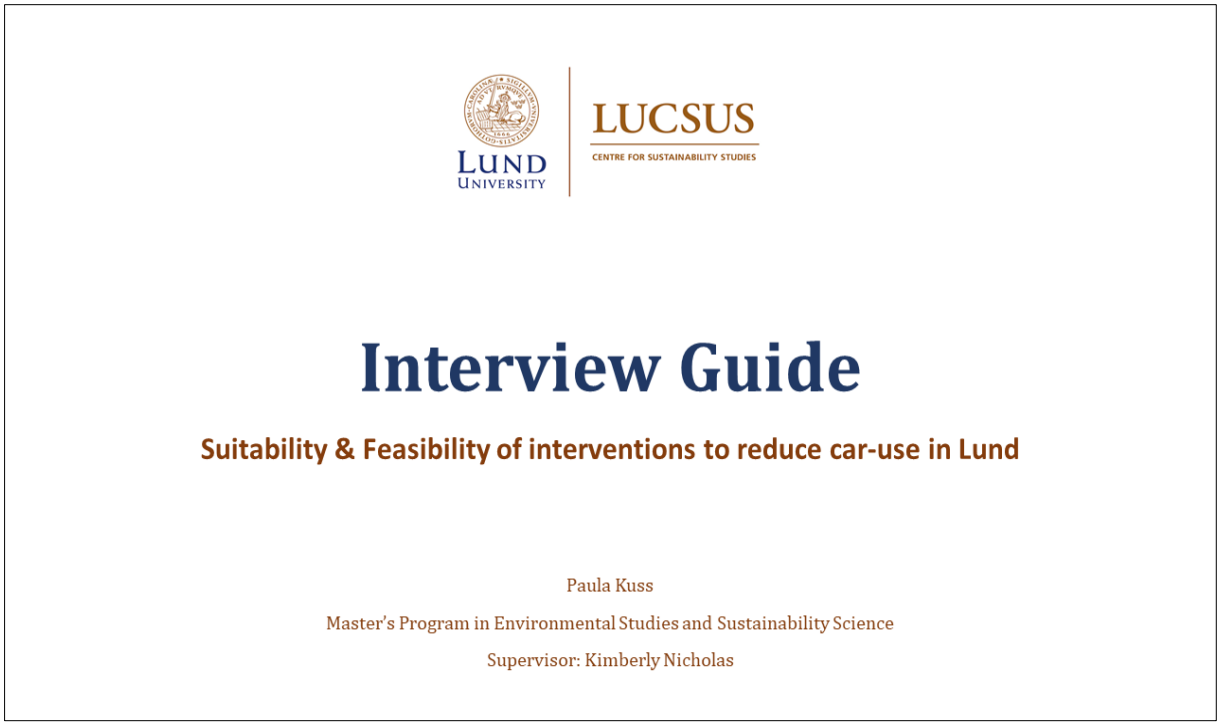
| Search Term | Number of Hits |
|---|---|
| reduce car use | 6 |
| reduce car traffic | 4 |
| reduce traffic volume | 0 |
| reduce vehicle | 10 |

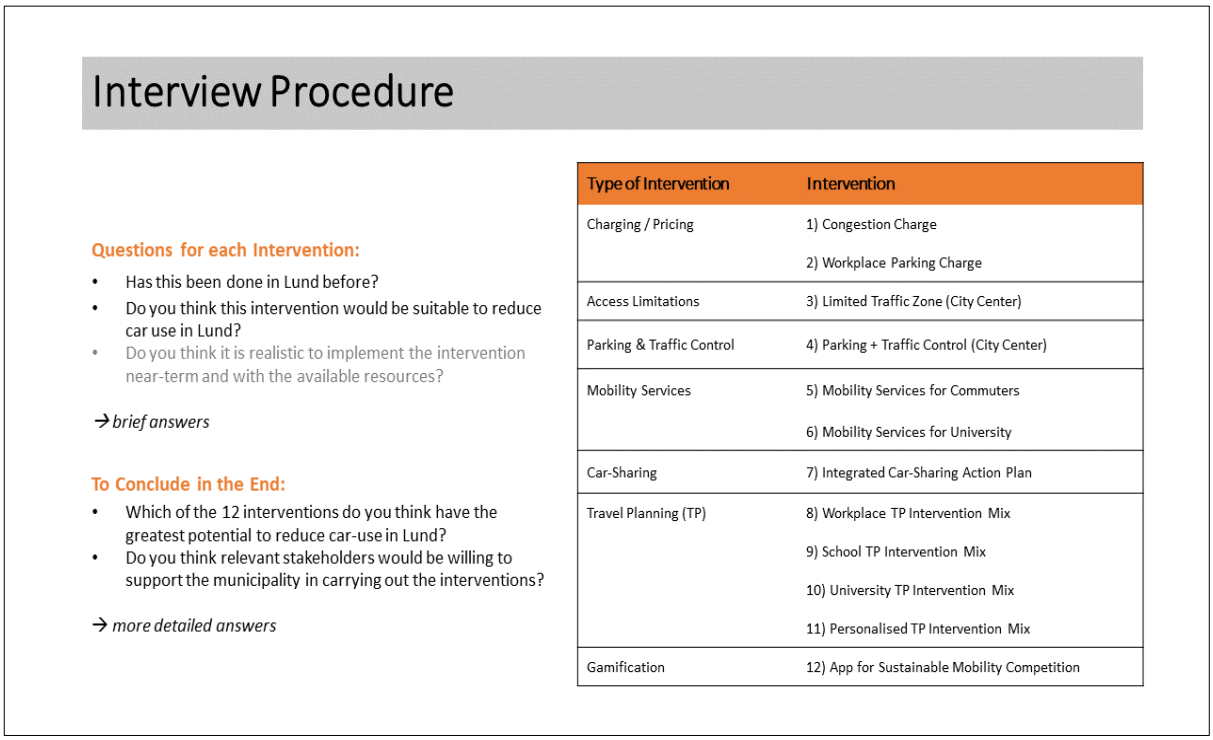
b) CIVITAS Mobility Solutions (CIVITAS > Mobility Solutions)

| Search Term | Number of Hits |
|---|---|
| reduce car use | 158 |
| reduce car traffic | 103 |
| reduce traffic volume | 20 |
| reduce vehicle | 52 + 2 additional documents hyperlinked to two case studies |

**Appendix D. Interview Guide for Expert Interviews**

The pictures on the following four pages display Screenshots of the PowerPoint presentation which was screenshared during the expert interviews and functioned as an interview guide.



## 1) Congestion Charge

| Intervention | Intervention Type | Measures | Where it was effective? |
|---|---|---|---|
| **Congestion Charge** | Charging / Pricing | • Charges for cars within specific zone of the city<br>• Revenues often used for infrastructure investments | Stockholm, Gothenburg, London, Milan |

## 2) Workplace Parking Charge

| Intervention | Intervention Type | Measures | Where it was effective? |
|---|---|---|---|
| **Workplace Parking Charge** | Charging / Pricing | • Charges for car parking spaces at the workplace<br>• Incentives: monetary rewards for employees for every km not travelled with car<br>• Revenues for public transport / bike infrastructure | Rotterdam, Nottingham |

## 3) Limited Traffic Zone (City Centre)

| Intervention | Intervention Type | Measures | Where it was effective? |
|---|---|---|---|
| **Limited Traffic Zone** (City Centre) | Access Limitation | • Restricted entrance to city centre for cars during specific times of the day (6.30 – 18.00)<br>• Entrance to restricted zone only for residents or with special entrance permit | Rome |

## 4) Parking & Traffic Control (City Centre)

| Intervention | Intervention Type | Measures | Where it was effective? |
|---|---|---|---|
| **Parking & Traffic Control** (City Centre) | Parking & Traffic Control | • Reduction of parking spaces<br>• Car-free streets<br>• Alteration of traffic routes<br>• Extension of pedestrian-network and bicycle lanes | Oslo |

## 5) Mobility Services for Commuters

| Intervention | Intervention Type | Measures | Where it was effective? |
|---|---|---|---|
| **Mobility Service for Commuter** | Mobility Service | • Free public transport pass for employees<br>• Private Shuttle-Bus transfer between companies and Park'n'Ride facilities, train stations, public transport hubs, etc. | Utrecht |

## 6) Mobility Services for University

| Intervention | Intervention Type | Measures | Where it was effective? |
|---|---|---|---|
| **Mobility Service for University** | Mobility Service | • Free public transport pass for students, Ph.D. , trainees etc.<br>• Shuttle-Bus transfer between University Campus and train stations, public transport hubs, etc. | Catania |

## 7) Integrated Car-Sharing Action Plan

| Intervention | Intervention Type | Measures | Where it was effective? |
|---|---|---|---|
| **Integrated Car-Sharing Action Plan** | Car-Sharing | • Increase of car-sharing cars + stations<br>• Car-sharing services for employees<br>• Integration of car-sharing into residential areas, public transport hubs, parking management and bike infrastructure | Bremen, Genoa |

## 8) Workplace Travel Planning Intervention Mix

| Intervention | Intervention Type | Measures | Where it was effective? |
|---|---|---|---|
| **Workplace Travel Planning Intervention Mix** | Travel Planning | • Mobility plans + advice for companies<br>• Parking Management<br>• Promotion of car-sharing + car-pooling<br>• Expansion of bike infrastructure at workplace<br>• Company Shuttle-Bus<br>• Agreements with public transport provider (e.g.discounts, service expansion) | Brighton & House, Graz, Nantes, Norwich |

## 9) School Travel Planning Intervention Mix

| Intervention | Intervention Type | Measures | Where it was effective? |
|---|---|---|---|
| **School Travel Planning Intervention Mix** | Travel Planning | • Mobility plans + advice for pupils and parents<br>• Promotion of car-pooling<br>• Expansion of bike + scooter infrastructure at schools | Brighton & House, Norwich |

## 10) University Travel Planning Intervention Mix

| Intervention | Intervention Type | Measures | Where it was effective? |
|---|---|---|---|
| **University Travel Planning Intervention Mix** | Travel Planning | • Mobility plans + advice for students and stuff<br>• Parking management on/around the campus<br>• Expansion of bike infrastructure on the campus<br>• Promotion of car-sharing, biking, walking<br>• Bus-shuttle from/to the campus<br>• Agreements with public transport provider (e.g.season ticket) | Donastia-San Sebatian, Bristol |

## 11) Personalised Travel Planning Intervention Mix

| Intervention | Intervention Type | Measures | Where it was effective? |
|---|---|---|---|
| **Personalised Travel Planning Intervention Mix** | Travel Planning | • Personalised mobility analysis + plans<br>• Promotion of travel alternatives<br>• Discount offers for public transport<br>• Emphasis on marketing + communication to the public | Donastia-San Sebastian, Maastricht, Marseille, Munich |

## 12) App for Sustainable Mobility Competition

| Intervention | Intervention Type | Measures | Where it was effective? |
|---|---|---|---|
| **App for Sustainable Mobility Competition** | Gamification | • App enables mobility competition between private users + between local companies<br>• Users can collect points for sustainable mobility behaviour (mobility tracked by app) → ranking of users according to points<br>• Incentives for sustainable mobility (e.g. discounts in local shops) | Bologna |

**Appendix E. Overview of the effective city-level Interventions to reduce car use**

The table presents a detailed list of *all* measures introduced by each of the 26 cases of effective interventions to reduce car use. While Table 10 (Chapter 5.1.1) presents a summary of the *main* measures (bold in this table) introduced by the cities (cases) that were classified as one intervention type, this table presents *all* measures each city (case) within an intervention type introduced when implementing the intervention.

| Intervention Category | Intervention Type | **Cities** (treated as cases of interventions) | Measures a city (case of intervention) introduced when implementing the intervention | References |
|---|---|---|---|---|
| **Charging & Pricing** | ***Congestion Charge*** | (1) Gothenburg (SE) | • introduced 2013 (after referendum)<br>• **congestion pricing in defined charging zone (cordon-based system)**<br>• **co-funding of large infrastructure package with revenues of the charges**<br>• time-of-day dependent charges (charging from 6.00-18.30; costs between 8SEK-18SEK in both directions) | (Börjesson & Kristoffersson, 2015) |
| | | (2) London (GB) | • introduced 2003<br>• **congestion pricing in defined charging zone (cordon-based system)**<br>• **80% of revenues used for public transport investments**<br>• fixed daily charge (initial charge 5£ per day, price raised in 2005 (to 8£/day) and 2011 (10£/day) and in 2014 (11.50£/day))<br>• discounts + exemptions for certain groups + vehicles | (Metz, 2018) |
| | | (3) Milan (IT) | • introduced 2011 (after referendum)<br>• **congestion pricing in defined charging zone (cordon-based system)**<br>• **reinvestment of charge in public transport**<br>• fixed daily charge<br>• discounts + exceptions for certain groups + vehicles | (Beria, 2016) |
| | | (4) Stockholm (SE) | • introduced in 2007 (after referendum)<br>• **congestion pricing in defined charging zone (cordon-based system)**<br>• **revenues of congestion fee as part of infrastructure package**<br>• weekday and time-of-the-day dependent charge | (Eliasson, 2014) |

| | | | | |
|---|---|---|---|---|
| | ***Workplace Parking Charge*** | (5) Nottingham (GB) | • introduced 2012<br>• **workplace parking fee** for car parking spaces used by major employers within city boundaries that have more than 10 workplace parking spaces<br>• **revenues from parking fee used to part-fund transport initiatives** (e.g., expansion of tram line)<br>• public consultation process before introduction | (Dale et al., 2019) |
| | | (6) Rotterdam (NL) | • introduced 2004<br>• **workplace parking fee** for Erasmus Medical Centre (approx. 10.000 employees)<br>• parking fee according to arrival time and living distance to hospital<br>• **cash-out scheme:** credit for employees for every km not travelled by car | (Strompen et al., 2012) |
| **Access-Limitations** | ***Limited Traffic Zone*** | (7) Rome (IT) | • **restricted zone for cars in city centre** (electronic gates at entry points)<br>• introduced 2001, expansion of size in 2007<br>• time-of-the-day and weekday dependent restrictions (restrictions between 6.30-18.00 on weekdays and between 14.00 and 18.00 on Saturdays)<br>• access for residents and other users who pay an annual fee for the entry permit<br>• **revenues from entrance fee + violation fines for investments in public transport services** | (CIVITAS, 2013c) |
| **Parking & Traffic Control** | ***Parking & Traffic Control*** | (8) Oslo (NO) | • implementation between 2015-2019<br>• **Removal of on-street parking spaces in + around city centre**<br>• **Introduction of car-free streets**<br>• **Alteration of traffic routes**<br>• **New bike lanes + extension of pedestrian-friendly infrastructure** (pedestrian network, terraces, playgrounds etc.) | (Modijefsky, 2021) |
| **Mobility Services** | ***Mobility Services for Commuters*** | (9) Utrecht (NL) | • launched 2008-2012<br>• based on Public-Private Cooperation "Foundation Utrecht Accessible"<br>• **free public transport pass (UB pass) for employees in Utrecht** (since 2011 companies from the whole region could by the pass); pass for local buses and trams in the region as well as for a bicycle rental service<br>• **Green Shuttle Bus: private bus which transfers between train stations, park'n'ride facilities and business areas** (must be paid extra)<br>• **marketing + communication plan**, awareness-raising of companies for urban mobility (e.g., creation of website) | (Stumpel-Vos et al., 2013) |
| | ***Mobility Services for University*** | (10) Catania (IT) | • **Bus Shuttles**: Bus Rapid Transit to Campus (2013) + Metro-Bus-Shuttle (2017)<br>• **free access to all public transport** (2018) for students, Ph.D., trainees, Erasmus students etc. | (Inturri, 2019) |

| | | | | |
|---|---|---|---|---|
| **Car-Sharing** | ***Integrated Car-Sharing Action Plan*** | (11) Bremen (DE) | • launched in 2009<br>• **increase of car-sharing cars + stations** (city-centre + residential areas)<br>• **car-sharing services for private households + employees** (e.g., municipality)<br>• bicycle stands at car-sharing station<br>• **proximity of car-sharing stations to public transport nods (e.g., train station)**<br>• **awareness-raising + PR campaigns**: billboards, media reports, campaigns etc<br>• possibility to purchase Public Transport Season Ticket in combination with Car-Sharing Card | (Glotz-Richter, 2016) |
| | ***Integrated Car-Sharing Action Plan*** | (12) Genoa (IT) | • launched 2005-2008<br>• **increase of car-sharing cars + stations** (city centre + residential areas)<br>• **car-sharing service for private household + employees** (e.g., municipality)<br>• **proximity of car-sharing to public transport nods (e.g., train station)**<br>• **promotion + awareness-raising** activities for car-sharing: media coverage (local radio, newspaper), direct marketing campaigns, street events | (CIVITAS, 2013a) |
| **Travel Planning (TP)** | ***Workplace TP*** | (13) Brighton & Hove (GB) | • **development of travel plan for local companies + businesses**<br>• **improvement of bike infrastructure at workplaces (e.g., bicycle storage)**<br>• promotion + awareness-raising events: Bike + Walking promotion events, Bike Maintenance Workshops<br>• Social Media engagement on different platforms to promote the travel plans and encourage participation | (CIVITAS, 2013g) |
| | | (14) Graz (AT) | • **travel advice + development of travel plans for small + medium-sized local companies** (information handbook, free consultation, individual support etc.)<br>• monetary awards from municipality for five best travel plans which can be used by companies to implement travel planning | (ITL, 2018) |
| | | (15) Nantes (FR) | • **travel advice + development of travel plans for companies** (analysis of mobility needs + habits and accessibility of public transport, advice for alternative travel modes)<br>• **discounts of public transport ticket for employees**<br>• follow-up assessments | (CIVITAS, 2013b) |

| | | | | |
|---|---|---|---|---|
| | ***Workplace TP*** | (16) Norwich (GB) | • **travel advice + development of travel plans for local companies + businesses**<br>• **support for improving bicycle infrastructure**<br>• **parking management at workplaces (e.g., restricted car parking)**<br>• introduction of **company shuttle busses**<br>• annual travel plan awards<br>• promotion + awareness-raising: events, flyer, newsletter, development of website to guide travel plans | (CIVITAS, 2013f) |
| | | (17) 20 cities in GB (GB) | • **development of travel plans for local companies**<br>• **parking management at workplaces (e.g., restricted car parking)**<br>• introduction of **company shuttle busses**<br>• **discounts of public transport ticket for employees**<br>• **improvement of bike infrastructure + services at workplaces**<br>• awareness-raising + promotional events | (Cairns et al., 2010) |
| **Travel Planning (TP)** | ***School TP*** | (18) Brighton & Hove (GB) | • **travel advice + development of travel plans for local schools**<br>• **improvement of bicycle + scooter storages at schools**<br>• **promotion of walking + biking + car-pooling**<br>• scooter training for school children, support of School Travel Teams<br>• promotion + awareness-raising events: Bike + Walking promotion events, Bike Maintenance Workshops Walk to School Event<br>• Social Media engagement on different platforms to promote the travel plans and encourage participation | (CIVITAS, 2013g) |
| | | (19) Norwich (GB) | • **travel advice + development of travel plans for local schools**<br>• **promotion of walking + biking + car-pooling**<br>• **improvement of bike infrastructure**<br>• promotion + awareness-raising: promotional events, flyer, newsletter, development of website to guide travel plans | (CIVITAS, 2013f) |

| | | | | |
|---|---|---|---|---|
| | ***University TP*** | (20) Bristol (GB) | • launched by and for University of Bristol in 1998 (targeted at staff + students)<br>• **parking management**: limiting parking spaces + conditions for parking permits on University Campus, and surrounding areas of University, increased parking charges<br>• **promotion of car-sharing, car-pooling, biking, public transport**<br>• **discounted season ticket for public transport**<br>• **improved bicycle infrastructure + services** (e.g., improving changing facilities for walkers + cyclists; new, secure cycling storage) | (Brockman & Fox, 2011) |
| | | (21) San Sebastián (ES) | • launched 2008-2012<br>• **promotion public transport, bicycle, walking, carsharing and carpooling**<br>• **information + awareness campaigns for students + staff**<br>• inclusion of sustainability mobility in university learning processes | (CIVITAS, 2013d) |
| | ***Personalised TP*** | (22) Marseille (FR) | • **travel advice + plans for individual residents of the city**<br>• individualised mobility assessment<br>• personalised advice<br>• formal commitment to travel plan | (Thaler et al., 2018) |
| | | (23) Munich (DE) | • **travel advice + plans for new residents of the city** (information package for new residents with information about public transport, walking, cycling, city map etc.)<br>• one-week **free public transport pass**<br>• follow-up assessment via phone to report about mobility experience | (Bamberg & Rees, 2017) |
| **Travel Planning (TP)** | ***Personalised TP*** | (24) Maastricht (NL) | • launched 2012-2017<br>• **travel advice + plans for residents of the city** (analysis of mobility patterns, route planning, travel information)<br>• **mobility pass offers (includes public transport)**<br>• target groups: individual residents from different population groups (commuters, students, visitors, logistics service providers etc.)<br>• marketing + communication tools (e.g., financial incentives, gamification, off-peak points saving system etc.)<br>• branding of project with own portal, identity, communication channel, etc. | (Modijefsky, 2019) |
| | | (25) San Sebastián (ES) | • launched 2010-2011<br>• **personalised travel advice plans for thousands of households** in 2 city districts<br>• 3 months **free public transport pass**<br>• promotion + awareness-raising: newspaper coverage, mails, phone calls, etc. | (CIVITAS, 2013e) |

| | | | | |
|---|---|---|---|---|
| **Gamification** | ***App for Sustainable Mobility Competition*** | (26) Bologna (IT) | • **App** (BetterPoints) for individual users + teams of local companies<br>• App facilitates **mobility competitions between individuals as well as between companies**: app gives scores for trips made by foot/bike/ public transport → **collection of points for sustainable mobility behaviour**<br>• collected data can be used by public administration for planning purposes | (ITL, 2018) |

## Appendix F. Detailed Stakeholder Classification

The table presents the type and number of Leading Stakeholder and Partner Stakeholder involved in each of the 26 cases of effective interventions to reduce car use. Thus, the table presents the Stakeholder Types and Collaborations involved in the effective interventions to reduce car use.

| **Leading Stakeholder** | **Partner Stakeholder** | **Intervention Type** | **Cities** (treated as cases of interventions) | **References** |
|---|---|---|---|---|
| **Single Leading Stakeholder** | | | | |
| Local Government | No Partnership | Limited Traffic Zone | Rome | (CIVITAS, 2013c; DeRobertis & Tira, 2016) |
| | No Partnership | Personalised TP | Marseille | (Thaler et al., 2018) |
| | No Partnership | Personalised TP | San Sebastian | (CIVITAS, 2013e) |
| | Private | App for Sustainable Mobility Competition | Bologna | (ITL, 2018) |
| | Private | Workplace TP | Graz | (ITL, 2018) |
| | Private | Workplace TP | Norwich | (CIVITAS, 2013f) |
| | Educational Institution | School TP | Norwich | (CIVITAS, 2013f) |
| | Civil Society | Congestion Charge | Milan | (Beria, 2016) |
| | Public Transport Provider | Congestion Charge | London | (Centre for Public Impact, 2016; Metz, 2018) |
| | National Government, Regional Government | Congestion Charge | Gothenburg | (Börjesson & Kristoffersson, 2015; West & Börjesson, 2020) |
| | Civil Society<br>Private | Workplace Parking Charge | Nottingham | (Dale et al., 2019; Nottingham City Council, 2008) |
| | Civil Society<br>Private | Parking & Traffic Control City Centre | Oslo | (Modijefsky, 2021) |
| | Private<br>Public Transport Provider | Integrated Car-Sharing Action Plan | Bremen | (Glotz-Richter, 2016) |
| | National Government<br>Civil Society<br>Private | Integrated Car-Sharing Action Plan | Genoa | (CIVITAS, 2013a) |
| | National Government<br>Private<br>Public Transport Provider | Workplace TP | Nantes | (CIVITAS, 2013b) |
| | Civil Society<br>Private<br>Public Transport Provider | Workplace TP | Brighton & Hove | (CIVITAS, 2013g) |
| | Civil Society<br>Educational Institution<br>Public Transport Provider | School TP | Brighton & Hove | (CIVITAS, 2013g) |

| | | | | |
|---|---|---|---|---|
| Educational Institution | Local Government | University TP | Bristol | (Brockman & Fox, 2011; University of Bristol, 2018a) |
| | Local Government<br>Public Transport Provider | Mobility Service for the University | Catania | (Inturri, 2019) |
| | Local Government<br>Regional Government<br>Public Transport Provider | University TP | San Sebastian | (CIVITAS, 2013d) |
| Private | No Partnership | Workplace Parking Charge | Rotterdam | (Strompen et al., 2012) |
| | Local Government<br>Public Transport Provider<br>Civil Society<br>Private | Workplace TP | 20 cities in UK | (Cairns et al., 2010) |
| **Multiple Leading Stakeholder** | | | | |
| Local Government<br>Public Transport Provider | University | Personalised TP | Munich | (Bamberg & Rees, 2017) |
| National Government<br>Regional Government<br>Local Government | Civil Society | Congestion Charge | Stockholm | (Eliasson, 2014) |
| Public-Private-Partnership:<br>(Local Gov., National Gov., Regional Gov., Private) | No Partnership | Mobility Service for Commuters | Utrecht | (Stumpel-Vos et al., 2013) |
| Public-Private-Partnership:<br>(Local Gov., Private, Public Transport Provider) | No Partnerships | Personalised TP | Maastricht | (Modijefsky, 2019; Programme office Zuid-Limburg Bereikbaar, 2021) |

## Appendix G. Coded Themes (Transition Experiment Criteria) of Expert Interviews

The table presents the colour-coded themes (Transition Experiment Criteria) for each intervention type from all four expert interviews as well as the evaluation of the Transition Experiment Criteria based on the coded themes as explained in the Methods (Chapter 4.3.3).

| Intervention Type | Coded Themes (Transition Experiment Criteria) | Expert 1 (E1) *Practitioner* | Expert 2 (E2) *Practitioner* | Expert 3 (E3) *Researcher* | Expert 4 (E4) *Researcher* | Evaluation of the Transition Experiment Criteria |
|---|---|---|---|---|---|---|
| App for Sustainable Mobility Competition | *Novelty* | | | | | new |
| | *Suitability* | | | | | suitable |
| | *Feasibility* | | | | | feasible |
| Integrated Car-Sharing Action Plan | *Novelty* | | | | | partly new |
| | *Suitability* | | | | | suitable |
| | *Feasibility* | | | | | feasible |
| School Travel Planning | *Novelty* | | | | | partly new |
| | *Suitability* | | | | | suitable |
| | *Feasibility* | | | | | feasible |
| Workplace Parking Charge | *Novelty* | | | | | new |
| | *Suitability* | | | | | suitable |
| | *Feasibility* | | | | | partly feasible |
| Mobility Services for Commuters | *Novelty* | | | | | partly new |
| | *Suitability* | | | | | partly suitable |
| | *Feasibility* | | | | | feasible |
| Parking & Traffic Control (City Centre) | *Novelty* | | | | | partly new |
| | *Suitability* | | | | | partly suitable |
| | *Feasibility* | | | | | partly feasible |
| Workplace Travel Planning | *Novelty* | | | | | not new |
| | *Suitability* | | | | | suitable |
| | *Feasibility* | | | | | feasible |
| Congestion Charge | *Novelty* | | | | | new |
| | *Suitability* | | | | | partly suitable |
| | *Feasibility* | | | | | not feasible |
| Personalised Travel Planning | *Novelty* | | | | | not new |
| | *Suitability* | | | | | partly suitable |
| | *Feasibility* | | | | | feasible |
| University Travel Planning | *Novelty* | | | | | new |
| | *Suitability* | | | | | partly suitable |
| | *Feasibility* | | | | | not feasible |
| Mobility Services for University | *Novelty* | | | | | new |
| | *Suitability* | | | | | not suitable |
| | *Feasibility* | | | | | not feasible |
| Limited Traffic Zone (City Centre) | *Novelty* | | | | | partly new |
| | *Suitability* | | | | | partly suitable |
| | *Feasibility* | | | | | not feasible |

new / suitable / feasible

partly new / partly suitable / partly feasible

not new / not suitable / not feasible

uncertainty of expert / no suitable answer of expert