

**TOWARDS SUSTAINABLE PARKING:
decision making of governmental and commercial stakeholders**

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*Based on graduation research
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**Bijdrage aan het Colloquium Vervoersplanologisch Speurwerk
21 en 22 november 2013, Rotterdam**

Samenvatting

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Duurzaamheid van de stedelijke omgeving is zeer afhankelijk van vervuiling en emissies die veroorzaakt worden door mobiliteit. De laatste jaren groeit de aandacht voor duurzaamheid in relatie tot parkeren. Als gevolg, implementeren en ondersteunen de overheid en parkeer industrie een groot scala aan duurzame ontwikkeling. Om succesvol samen te kunnen werken in projecten die als doel hebben parkeren duurzamer te maken, moeten gemeenten en parkeerexploitanten samen inzetten op de meest kansrijke ontwikkeling. Binnen dit onderzoek wordt MCDA en AHP gebruikt om zes belangrijke duurzame parkeerontwikkelingen aan de hand van criteria te beoordelen. Dit resulteert in een prioritering waarbij 'introductie van navigatie gecombineerd met betaalapplicatie' als belangrijkste duurzame ontwikkeling wordt gezien door de stakeholder groepen overheid en markt partijen.

Steekwoorden: *Parkeren, Beslissingsgedrag, Duurzaamheid, MCDA, Analytic Hierarchy Process.*

1. Introduction

Mobility in general, and car usage in particular have a negative impact on the environment due to the use of (fossil) fuels, and the emissions of particulate matter [fijnstof] and exhaust gasses including CO₂ (Q-Park NV, 2012). The energy consumption in urban districts, related to traffic and mobility, accounts for almost 20% of the total of energy use in the urban environment (Energiebureau.nl).

Sustainability of the urban environment highly depends on the pollution and emissions caused by mobility: in 27 European countries the transport sector is responsible for 19% of the greenhouse gas emission. The situation in the Netherlands is even more extreme: the transport sector is responsible for 35% of the total emission. Overall, the transportation sector is responsible for 30% of all fossil fuel emissions in the European Union (European Union, 2007).

Parking is an important aspect of mobility in the context of the urban environment. Parking facilities, as elements of the built environment, provide users with spaces for their cars nearby their destinations. As a result, it affects urban planning, spatial use, the convenience of transportation and sustainability of the city is growing. Recently, more attention is given to sustainability in relation with parking. For example way finding to a parking space: "On a daily basis, it is estimated that 30% of vehicles on the road in the downtown area of major cities are cruising for a parking spot and it takes an average of 7.8 minutes to find one" (Arnott, et al., 2005). As a result, the parking industry and government are embracing a large number of developments ranging from sustainable innovations to environmental oriented parking policy.

In general, four types of sustainable developments can be identified (e.g., Van der Waerden, 2012; Farla, et al., 2010; Q-Park NV, 2012):

1. Sustainability by technological improvement of personal vehicles;
2. Sustainability by construction of sustainable buildings;
3. Sustainability by improving the efficiency of traffic and way finding;
4. Sustainability by mobility and parking policy.

1.1 Decision making

The increase of traffic congestion combined with a societal focus on environment and sustainability, lead to challenges in how mobility and parking have to be managed. For example, municipalities are eager to reduce traffic congestion for the improvement of the quality of life by solving problems related to pollution and noise (Giuffrè, et al., 2012). Governmental bodies like municipalities, national governments and the European Union have "an important role to play in building a system of sustainable mobility, through regulatory policies, and strategic incentives and disincentives" (Vergragt & Brown, 2007).

A market party's willingness to embrace developments and innovation towards a more sustainable society is a function of the following aspects: its attitude towards cleaner technology (based on the party perception of environmental and economic risks); the pressure that the party perceives itself to be under; and the control the firm believes it actually has over the innovation of cleaner technologies (Montalvo, 2002).

1.2 Problem statement

Given the indicated developments; differences of interests; and governmental policies in the field of mobility and parking, it is difficult for cooperating stakeholders to choose, invest in, or predict the effects of (long term) sustainable developments. In order to successfully cooperate in a project, individual actors should be able to predict preferences and decision making of partners and competitors. Therefore, an analysis of attributes, characteristics, and decision criteria is required in order to enable stakeholders to anticipate in future developments. The problem statement is divided in two parts which are presented below.

1. The aspects, characteristics, and attributes of developments in the context of sustainable mobility are not clear. Most effects of developments on mobility and sustainability are assumed but not quantified in detail.
2. Actors in mobility and parking embrace specific developments in the context of sustainable parking, but also need the cooperation of other stakeholders. Therefore, the most promising developments according to decision makers are required. A ranking of sustainable developments in parking is currently not available.

1.3 Relevance

As far as the author knows, limited scientific research is available regarding the decision making in and evaluation of multiple sustainable developments in the field of parking. Limited literature is available on decision making in parking (e.g. Litman, 2013; May, 2003) and decision making regarding sustainable innovations (e.g. Montalvo, 2002). On the other hand, sustainable developments are individually assessed by researchers (e.g. Bakker, 2011; Dijk & Montalvo, 2011; Giuffrè, et al., 2012). A certain combination of both approaches could not be found during the preparation of this research.

This research aims to find criteria to compare and evaluate sustainable developments in parking with respect to the decision making process. Besides insight in different criteria, developments could be evaluated using these criteria and help to identify the most promising developments.

The parking industry continuously adopts new innovations and developments in parking (KpVV, 2013). Generally, these developments are initiated by financial benefits (efficiency), technological innovation, societal change or policy by legislators (e.g. Farla, et al., 2010; VROM, 2010; Montalvo, 2002).

In order to decide which developments should be implemented in business planning, developments have to be prioritized according to the stakeholders' interest. As stated in this introduction, governmental and market parties influence decision making in parking. Therefore, it is necessary to find the influential criteria, current developments in parking, and priorities of both stakeholder groups. Comparing these priorities, should provide the parking industry insight in the most interesting developments that are supported by both stakeholders. Consensus on priority could support the decision making process and improve the financial benefits en outcome of adopted developments.

2. Methods

The main question in this research is: "What are the most promising developments regarding sustainable parking according to governmental and commercial decision makers?"

In order to answering the central question four sub-questions have been defined: Which stakeholders are involved in the decision making process regarding to sustainable parking?; Which criteria can be used to evaluate developments regarding sustainable parking?; What are important developments in the context of sustainable parking?; What is the importance of selected criteria regarding developments in sustainable parking?

2.1 Research Framework

An extensive review of literature is elaborated as start of this research (Phase 1, figure 1). It provides background information on the subjects parking, sustainability in parking, and decision making. Besides a description of the subjects and relevant mechanisms, the literature review is conducted to identify a number of current sustainable developments in parking; important stakeholders and their incentives, and decision criteria. These three elements will be used as key ingredients for the adopted research method in the next phase and to answer the first three sub-questions.

Decision making in parking by governmental and commercial stakeholders is a complicated process. Together, parking operators and municipalities, led by specific incentives, decide over new developments in sustainable parking. An Analytic Hierarchy Process decision framework (Saaty, 1980) is built to capture decision criteria with respect to both stakeholders (Phase 2). The framework is used as a base for the next steps in the research. The second phase consists of Multi Criteria Decision Analysis (MCDA) based on the methods included in Analytic Hierarchy Process (AHP). Qualitative Dominance scores (QD) are used to synthesize the results.

By using MCDA, multiple criteria of alternatives can be considered comprehensively. The method combines criteria weights and evaluation scores of alternatives, resulting in a general value for each alternative. In order to find the criteria weights AHP is adapted to a specific quantitative form of multi criteria analysis. QD is used to evaluate the developments, on a qualitative base.

An on-line questionnaire is used to gather data from governmental and commercial stakeholders in parking. Experts, working for both stakeholder groups, are asked to complete the questionnaire in which criteria weights are determined and developments are evaluated. After the synthesis and analysis of data results are available, and developments are prioritized.

In the final phase of the study (Phase 3) results from the literature review and Multi Criteria Decision Analysis are used to answer the research questions. Recommendations for practice and science will show the relevance of the research findings for both fields.

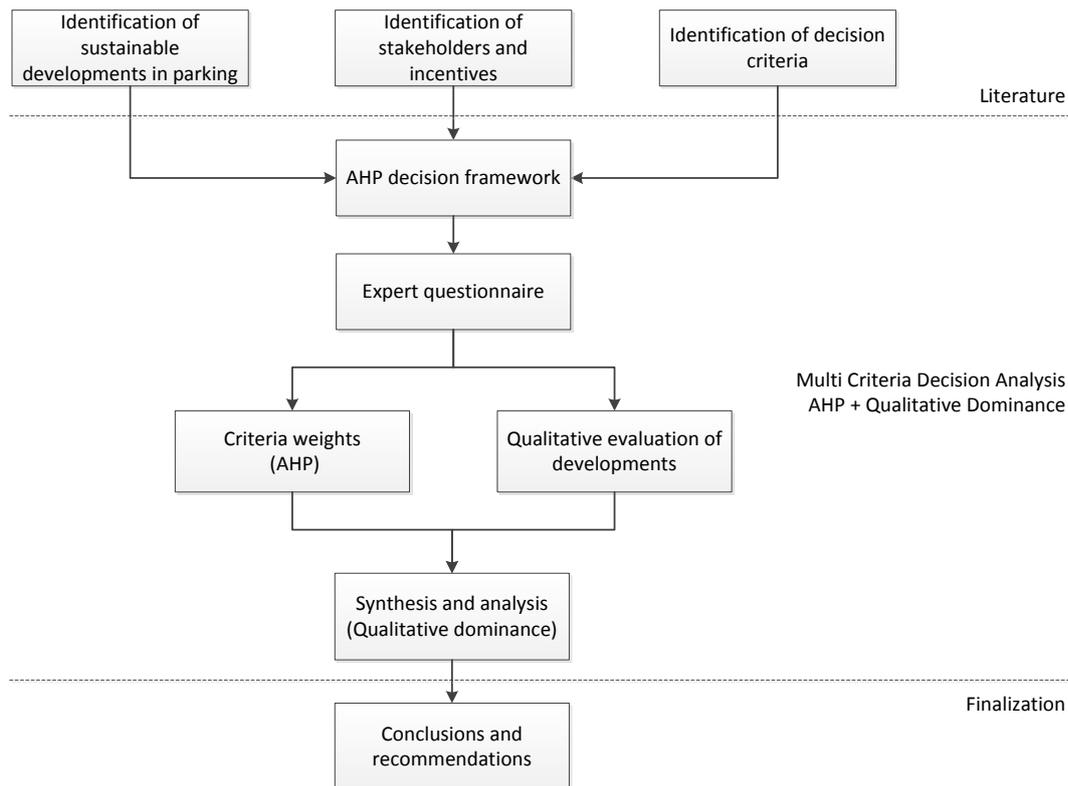


Figure 1: Research framework

3. Findings

The results of the research are presented in this section. First, the results from the review of literature, the selection of stakeholders, developments and criteria, are presented. Next, the criteria weights are established using the analytic hierarchy process and an example of a development evaluation is provided. Finally, qualitative dominance scores provide a ranking of developments for governmental and commercial stakeholders.

3.1 Review of literature

Extensive review of literature took place to find the most important decision makers in parking that influence sustainable developments. Next, criteria are elaborated which enable one to evaluate developments. Finally, six developments are presented which are evaluated in by the experts using a questionnaire.

Selection of stakeholders

Stakeholders in parking are divided in 'Government', 'Market', and 'Society'. The first two stakeholders influence decision making in parking directly. Municipalities (Government) enforce parking policy and Parking operators (market) exploit parking facilities and provide management services. Users (Society) and other stakeholders are indirectly involved. Generally speaking, decision making in parking is controlled by the government who develops policy and market parties that perform activities with facilities, services, or products related to parking. Two parties decide directly on the implementation of new developments in sustainable parking: Municipalities (government) and parking operators (market). Other stakeholders, for example investors, are involved in this process indirectly. The direct and indirect relationships towards the subject are presented in

figure 2. As a result of this analysis, this research focuses on municipalities and parking operators.

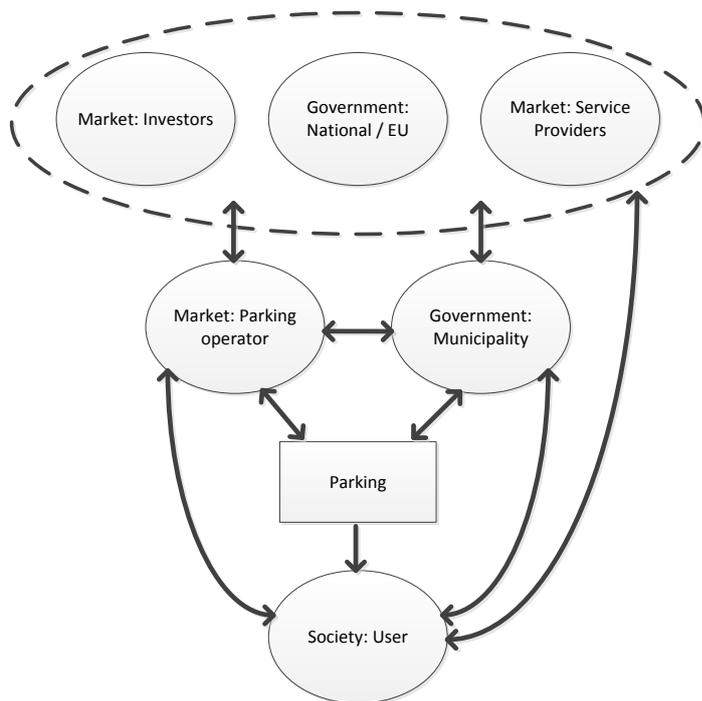


Figure 2: Relationships between stakeholders

Selection of developments

The developments are categorized by type of sustainable development as suggested in the introduction. A recent publication (KpVV, 2013) about noteworthy developments in parking provided six important developments. These developments are described below and reflect on a theme as suggested by the KpVV publication (2013).

1. Improving the sustainability of the existing parking stock (Theme: Sustainability): Replacement of facilities and equipment by new and more sustainable solutions, e.g. LED, innovations and efficient technology, at on-street and off-street parking locations;
2. Developing charging networks for electricity driven vehicles (Theme: Alternative energy sources): A charging network at on- and off-street parking locations is introduced for hybrid and electric cars such as low and high voltage charging stations;
3. Introduction of electronic navigation, way finding and payment systems (Theme: Influence of IT): An electronic navigation and payment processing application introduced by payment providers offers customers the ability to navigate to an available on-or off-street parking location, to make a reservation and pay wireless;
4. Increasing number of P+R and K+R areas in order to support Car-Sharing (Theme: Car-Sharing): The number of Park and Ride (P + R) and Kiss and Ride (K + R) areas with favorable rates and services increases for the purpose of Car-Sharing initiatives;
5. Introducing policy in order to enable flexible parking standards (Theme: Location specific parking standards): The introduction of flexible parking standards which are strongly related to the function, the use, and the configuration of urban buildings in the immediate vicinity;

6. Increasing number of functional changes in inner city built environment as a result of demographic change and internet shopping (Theme: Functional change of the built environment): The number of properties in inner city areas with a store function decreases due to shrinkage and internet shopping.

Selection of criteria

Review of literature showed that multiple decision criteria are available that represent stakeholders’ incentives, sustainable goals in society, and presumed effects of developments. In this research, potential sustainable developments are evaluated to find differences and similarities in opinion between stakeholders.

Selection rules are used to find the most important criteria involved in the assessment of the developments in parking: criteria should be applicable to evaluate all types of developments; criteria represent incentives of both stakeholder groups; and vagueness of criteria has to be prevented. Payoff and outcomes of developments related to the decision criteria can be divided as impacts and effects. An ‘impact’ is described as the influence that something has on a situation or person. While ‘effect’ describes a more direct and intended result of a development.

The two definitions described above help to define the final decision criteria for this research. Impact criteria are used to describe the impact on the stakeholders’ business plan: the ‘financial aspects’ and ‘control aspects’ that may be affected by the developments. On the other hand, effect criteria, are used to describe the outcome of a development regarding mobility and sustainability. The criteria, presented and described below, are selected from business planning and control criteria, policy criteria and EMAT (NL: EMVI) criteria for parking (figure 3).

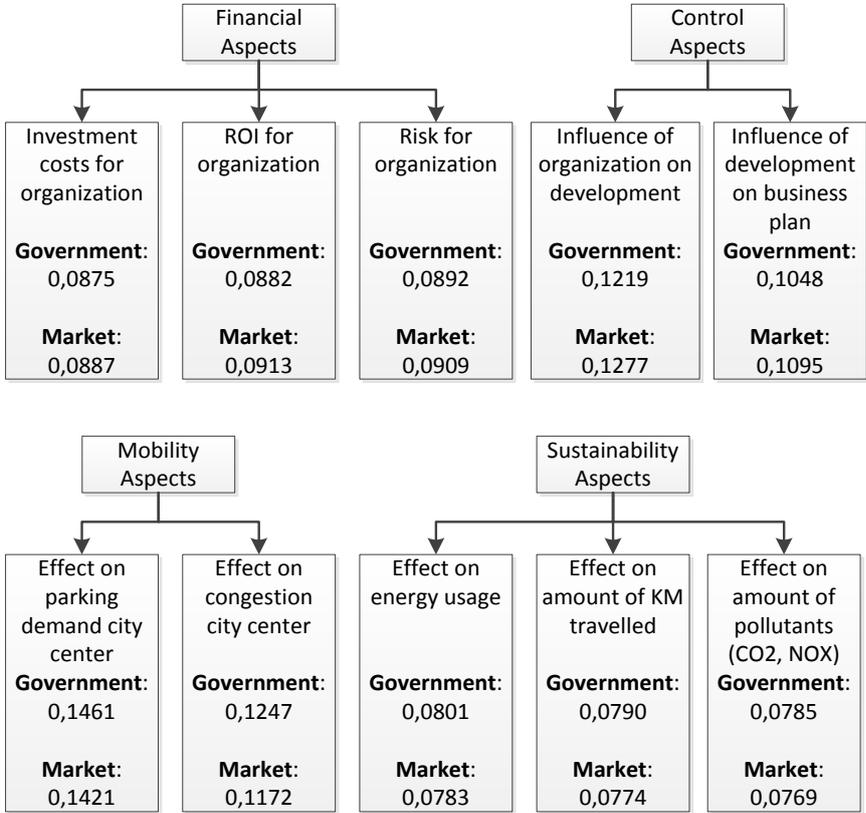


Figure 3: Hierarchy containing criteria and weights by government and market

3.2 Analysis

The approached experts are selected from a group of decision makers of both municipalities and parking operators. A third group, 'Consultants' was targeted as experts who provide services to both key decision makers. A total of 109 respondents were approached. Approximately, 30% of the respondents finished the questionnaire. 45% of the respondents provided results that are usable for the prioritization of criteria. Background variables confirm that the majority of the experts are considered decision makers given their working field and professional activities.

AHP analysis is performed to find the weights of the decision criteria. First, a consistency check is carried out on the individual datasets of the questionnaire. It appeared that a consistency index of 0,15 is necessary to incorporate at least 10 respondents per stakeholder group. The AHP analysis on the stakeholder groups results in criteria weights (figure 3) that slightly differ from each other. Small differences in priority are presented for the 'criteria-groups', 'control aspects' and 'mobility aspects'. On criteria-group level, municipalities prefer the 'effect on mobility' above others while parking operators consider 'financial aspects' of more importance. Consensus is reached for 'control aspects'. The 'influence of the organization on the development' is considered more important compared to the 'influence of the development on the business plan'. It emerged from the results for 'mobility aspects' that both stakeholder groups consider 'effect on parking demand in city center' more significant compared to 'effect on congestion in city center'.

Criteria	Government			Market		
	Mode	Outcome	WgtSum	Mode	Outcome	WgtSum
Investment costs for organization	High	-1	-9	High	-1	-6
ROI for organization	Low	-1	-1	Medium	0	3
Risk for organization	Medium	0	2	Medium	0	2
Influence of organization on development	Medium	0	-1	Medium	0	-1
Influence of development on business plan	Low	1	3	Medium	0	-5
Parking demand city center	Neutral	0	5	Increase	1	8
Congestion city center	Decrease	1	14	Decrease	1	6
Energy usage	Decrease	1	12	Decrease	1	9
Amount of KM travelled	Decrease	1	13	Decrease	1	12
Amount of pollutants	Decrease	1	16	Decrease	1	14

Figure 4: Example of evaluation scores: introduction for electronic navigation, way finding and payment systems

By combining the criteria weights (figure 3) and finding the modes of the evaluation scores (figure 4) for these criteria the Qualitative Dominance scores (Si scores) are calculated. The outcome in figure 4 represents the positive, neutral or negative resulting effect of the evaluations' mode while the Weighted sum (WgtSum) shows the strength of the group decision: Extreme distances between the positive or negative value and '0' show high consensus on the mode and outcome.

The Si scores (figure 5) for the governmental and market stakeholder result in a first priority for 'introduction of electronic navigation, way finding and payment systems'. 'Introducing policy in order to enable flexible parking standards' is prioritized second for

the governmental stakeholder followed by 'improving the sustainability of the existing parking stock. The latter is prioritized second by the market stakeholder. A third position is given to 'increasing number of P+R and K+R areas in order to support car-sharing'.

Development (prioritized by government)	Si	Rank
Introduction of electronical navigation, way finding and payment systems	0,0496	1
Introducing policy in order to enable flexible parking standards	0,0054	2
Improving the sustainability of the existing parking stock	-0,0019	3
Increasing number of P+R and K+R areas in order to support Car-Sharing	-0,0022	4
Developments (prioritized by market)		
Introduction of electronical navigation, way finding and payment systems	0,0427	1
Improving the sustainability of the existing parking stock	0,0161	2
Increasing number of P+R and K+R areas in order to support Car-Sharing	0,0131	3
Increasing number of functional changes in inner city built environment as a result of demographic change and internet shopping	-0,0189	4

Figure 5: Ranking of developments by QD scores for stakeholder groups

4. Discussion

The identification of important decision criteria and sustainable developments in parking are major results from this research. The identified criteria can be used to evaluate and characterize sustainable developments. The results, summarized in the previous paragraph, answer the sub-questions of this research. These sub-questions provide the basic elements that are required to conclude on the main question of this research: "What are the most promising developments regarding sustainable parking according to governmental and commercial decision makers?"

The results of this research (figure 5) showed which developments regarding sustainable parking are preferred most by the governmental stakeholder group (represented by decision makers of municipalities) and the market stakeholder group (represented by decision makers of parking operators). The rankings of developments by both stakeholder groups show the 'introduction of electronic navigation, way finding and payment systems' as highly preferred. The prioritizations confirms the high number of related developments the parking industry such as the integration of parking information, mobile payment services and reservation services of parking operators.

On one hand, this research showed which developments are most promising regarding both stakeholder groups. On the other, the evaluation of the developments provide underlying criteria scores that affected the final prioritization. These underlying expectations of decision makers could be considered as strengths and weaknesses for the implementation of sustainable developments in parking.

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