PBL Netherlands Environmental Assessment Agency

IMPACT OF CAR SHARING ON MOBILITY AND CO_2 EMISSIONS

PBL Note

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July 2015

PBL Publication number: 1842

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1 Introduction

In September 2013, over 40 Dutch organisations, including local governments, employers, unions, nature and environment organisations and financial institutes, entered into an Energy Agreement on sustainable growth (SER, 2013). The base of the agreement is formed by widely shared agreements on energy saving, clean technology and climate policy. Implementation of the agreed measures are to result in an affordable and clean energy supply, and will boost employment and opportunities for the Netherlands on the market for clean technology. The mobility and transport sector has a key role in the agreement. For 2020, the sector aims for a sizeable energy saving that, in addition to other measures, is to be achieved by the introduction of 100,000 very low-emission vehicles for car sharing.

Whether and to what degree the introduction of this number of car-sharing vehicles in practice will contribute to energy and climate targets is unknown. The only comprehensive Dutch study into the environmental and mobility impact of car sharing is fairly dated (Meijkamp, 1998). Today, we know that that study's estimation of the impact of car sharing was based on overly optimistic assumptions on technological developments.[1] Moreover, the environmental impact of changes in car ownership was not taken into account, and the study was based on the behaviour of a limited group of early adopters, possibly with deviating behaviour; car sharing in those days was still in its infancy. However, even current car sharers do not represent the average Dutch person. Usually, they live in cities and, compared to the average, are higher educated, do not own their own car, and are single or have a young family.[2] The reasons most often mentioned for car sharing appear to be the costs and hassle of car ownership (De Gier et al., 2014). In an intermediary assessment by Suiker and Van Elshout (2013) of Car2Go in Amsterdam, attention is paid to the car-sharing impact on air quality but not on CO_2 emissions. In North America, research has been done on car sharing that points to reduced automobility and positive environmental effects (Chen et al., 2015; Lovejoy et al., 2013; Martin et al., 2011; Shaheen, 2012), but circumstances over there cannot easily be compared with those in the Netherlands.

Therefore, PBL has studied the impact of car sharing on mobility and the environment for the Dutch situation. The study involved the same groups as those involved in the Energy Agreement, namely the people who were renting a car via an organisation such as Snappcar or Mywheels (the so-called peer-to-peer sharing), and those who were using a specific car via, for example, Greenwheels or Car2Go (business to consumer, the 'traditional' system of car sharing). We did not take into account people who share cars with friends without the involvement of an official organisation. Also excluded were the car rental sector and other forms of car sharing (e.g. carpooling, Uber taxi services and 'catch-a-ride' Blablacar).

[1] It was for example assumed that shared cars in 2010 would have an average fuel use of 1 litre per 25 kilometres, whereas the actual use today is twice as high.
[2] See http://www.crow.nl/vakgebieden/verkeer-en-vervoer/bibliotheek/kennisdocumenten/dashboard-autodelen.(inDutch)

2 Study set-up

PBL drafted a questionnaire and assigned TNS-NIPO to conduct a survey of 363 car sharers selected from a representative panel of TNS-NIPO. On the basis of this survey and the larger panel of TNS-NIPO and considering age, gender, education and degree of urbanity of the residential area of participants, the number of 'official' car sharers in the Netherlands was estimated at around 90,000 (thus excluding people sharing a car with friends, neighbours or family). This amounts to nearly 1% of all people in the Netherlands who own a driving licence.

The purpose of our study was to estimate the change in mobility as a result of car sharing. Survey participants were asked about their current car ownership and car use and that of before they began car sharing. We also looked at what this ownership and use would have been if they had not entered into car sharing. In spatial planning and economic studies this is called the 'counterfactual'.
For example, the effect of car sharing for participants who used to own a car and still own one today seems to be zero. However, perhaps these respondents would have bought a second car if they had not started car sharing. In such cases, the effect on car ownership is definitely there, although it cannot be observed. Shaheen (2012), therefore, made a distinction between observed and unobserved effects, and both were included in our study. Moreover, survey participants were not only asked about car *use*, as the shared car is likely to fulfil a mobility need that was otherwise addressed by other modes of transportation, such as bus, train or borrowed car. This was also included.

To answer the question about the impact of car sharing on mobility and the environment, we thus compared situations before and after car sharing as well as a hypothetical counterfactual. The resulting difference, ideally, would be that impact. There are however also other factors that influence mobility behaviour. Major changes in people's personal lives, such as beginning to live together with a partner, divorce, a new job, a new baby, are often reasons why people change their mobility habits (e.g. see Oakil et al., 2014; Prillwitz et al., 2006; Verhoeven et al., 2005). To isolate the impact of car sharing from any of these other factors, as much as possible, we excluded the participants who indicated to have had one of these major personal changes in their lives. Disadvantage of this method was that it caused a decline in the number of participants, from 363 to 165. The final section of this note presents what would have been the conclusions if we had also included this group in the analysis.

Changes in mobility behaviour also cause changes in CO_2 emissions. In order to determine the CO_2 emissions, we had to take into account the actual emissions involved in the use of various modes of transport (e.g. train, (shared) car, bus). There are three commonly used calculation methods for CO_2 emissions:

- The *tank-to-wheel* method (TTW), which only calculates CO_2 exhaust emissions. Advantage of this method is the large availability of reliable data on various modes of transport. This method does not include emissions from electric trains, as these emissions are emitted from the power plant and not by the train itself.
- The *well-to-wheel* method (WTW), which also includes the emissions involved in fuel production (both for petrol and electricity). Train kilometres are also counted.
- The *life-cycle analysis* (LCA), which also takes into account the emissions from construction and demolition of the various modes of transport, in addition to the emissions related to their use.

In our study, we used the WTW method to compare the kilometres travelled (Otten et al., 2014), supplemented with the life-cycle analysis (LCA) to calculate the effects of changing car ownership. Later this year, the KiM Netherlands Institute for Transport Policy Analysis will publish a report that will also include the results from this PBL study. That report will elaborate on the calculation methods in greater detail; and, in it, PBL will also discuss nitrogen oxide (NO_x) and particulate matter (PM_{10}) emissions, in addition to CO_2, while KiM will provide additional information on the profiles of car sharers and the possibilities for and barriers to car sharing.

3 Results

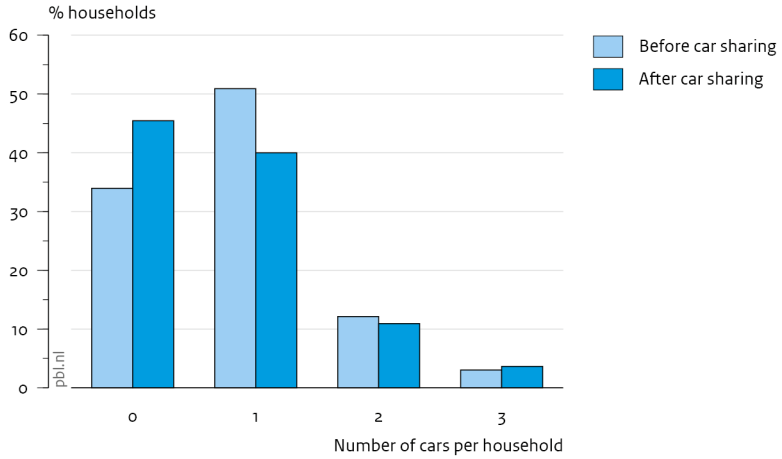
3.1 Mobility effects

In our study, we distinguished two types of mobility effects; those on car use and on car ownership.

Car ownership

Compared with the period before they began car sharing, the observed degree of car ownership of the survey respondents had decreased by 2014; from an average 0.85 cars per household to 0.72 (Figure 1). This decrease can mostly be attributed to the traditional car sharers. Furthermore, 37% of respondents who already owned a car indicated that they would have purchased another one if they had not started car sharing. For them, the shared car functions like a additional car. Although car ownership among this group has not visibly changed, car sharing has had a curbing effect. Of those who did not own a car, 8% would have bought one if they had not started car sharing. If we also include the 'invisible' effect for both groups, car ownership decreased from 1.08 cars per household in the counterfactual, to 0.72 in 2014.

Figure 1
Impact of car sharing on the observed number of cars per household, 2014



Source: PBL

Car use

In 2014, car sharers, on average, drove around 9,100 kilometres per year by car, before they started car sharing. By 2014, they were driving considerably fewer kilometres, namely around 7,500 per year, a difference of 1,600 kilometres. This decrease is mostly because owners who disposed of their privately owned car began to drive far less.

Of the 7,500 kilometres, 1,500 were driven by shared car. Before, these kilometres by shared car were either not made at all or other modes of transport were used. Table 1 shows that shared cars mostly replaced the use of other cars (borrowed or rented) and trains.

Furthermore, 16% of the kilometres driven by shared car would not have been made if respondents had not had a shared car at their disposal. On balance, however, car sharers were found to drive fewer kilometres by car.

Table 1 Distribution of the kilometres travelled before car sharing, by the modes of transport that were replaced by a shared car (in%)

Mode of transport	Kilometres (in %)
Car	38
Train	35
Bus, tram, rapid transit	4
Bicycle	2
Car passenger	1
Other	4
Untravelled	16

3.2 Impact on CO_2 emissions

Driving a car involves CO_2 emissions. For car sharers, an average reduction of 1,600 car kilometres per year was found, compared to before they started sharing. This resulted in a reduction of 250 kilograms of CO_2. However, a certain number of the kilometres now driven in shared cars, before, would have been travelled using more environmentally friendly modes of transport, or they would not have been travelled at all. By choosing the car over other modes of transport, car sharers in 2014 cause an additional 160 kilograms in CO_2 emissions.[3] When we take both the number of car kilometres driven and the change in mode of transport into account, the reduced car *use* of car sharers yields an annual CO_2 reduction of 90 kilograms on average.

However, car *ownership* also involves CO_2 emissions, as vehicle manufacturing and demolition require resources and energy, as well. If we also take this fact into account, then the decline in car ownership has led to an additional reduction in CO_2 emissions of 85 to 175 kilograms per year, per household.[4] Table 2 summarises the impact of the change in car ownership and car use on CO_2 emissions. It shows that using a shared car has led to an average reduction of between 175 and 265 kilograms in CO_2 per respondent. This equals a reduction of around 8% to 13% in emissions related to car ownership and car use.

[3] The figures are based on emissions in actual practice, and have been corrected for capacity utilisation.
[4] Assuming that 10% to 20% of the CO_2 emitted during the lifespan of a vehicle is related to its production and demolition (e.g. see Gbeghaje-Das, 2013; Samaras et al., 2008). We assumed a vehicle lifespan of 15 years and an average 10 users per shared car.

Table 2 Change in annual CO_2 emissions due to changed car ownership and car use

	Kg CO_2 per year
Change in car kilometres	-250
Change in mode of transport	160
Change in car ownership	-85 to -175
Total	**-175 to -265**

4 Conclusions and discussion

Our findings can be summarised as follows:

- There is over 30% less car ownership among car sharers than before they began car sharing. The 'traditional' car sharers, in particular, often indicated that they had since disposed of a privately owned car. The shared car mostly replaces a second or third car.
- Car sharers drive around 15% to 20% fewer car kilometres than before they started car sharing. This is mostly due to the fact that people who have disposed of a car now drive considerably less. The journeys that are now being made by shared car, before were made predominately by train or by using a borrowed or rented car.
- Car sharers emit between 175 and 265 fewer kilograms of CO_2 per person, per year, due to their reduced car ownership. This is between 8% and 13% of the CO_2 emissions related to car ownership and car use. About half of this reduction can be ascribed to less car use; the other half to the lower degree of car ownership.

In March 2014, there were around 10,000 shared cars on the Dutch roads.[5] Scaling up to 100,000 shared cars would therefore mean a tenfold increase in the current number. If the number of people per shared car would remain the same, this would equal around 10% of all motorists becoming car sharers.[6] This, in turn, would lead to a 0.2 to 0.3 Mt reduction in CO_2 emissions. Around half of this reduction can be counted towards the reduction target in the Energy Agreement.[7] It is therefore likely that scaling up car sharing, as is the Energy Agreement's intention, will contribute to a reduction in greenhouse gases.

Our study was aimed at estimating the isolated impact of car sharing on car ownership and car use. That is why the car sharers who had experienced major personal events since they began car sharing were excluded from the analyses. After all, such events often cause people to change their mobility behaviour. For those respondents it would not be clear whether a change in mobility could be attributed to the fact that they started car sharing or to the particular life-changing event. If we had included them in our analysis, the impact on car

[5] See http://www.crow.nl/vakgebieden/verkeer-en-vervoer/bibliotheek/kennisdocumenten/dashboard-autodelen. (in Dutch)
[6] Various studies have shown that around 20% of people would possibly be prepared to participate in a car sharing scheme (e.g. see Kien Onderzoek 2015; http://www.crow.nl/vakgebieden/verkeer-en-vervoer/bibliotheek/kennisdocumenten/dashboard-autodelen (in Dutch)). Thus, there appears to be a market that justifies a scale up to 10%.
[7] The Energy Agreement contains a target for 2020, for the transport sector, to reduce CO_2 emissions by 1.3 to 1.7 Mt. Here, only the *tank-to-wheel* emissions are included. Emissions related to fuel production or vehicle manufacturing and demolition are not included.

ownership and car use would have been slightly larger.[8] This could possibly be related to the fact that a number of such events, for example divorce or job loss, involve a loss of income. Seeing that financial motives are the main reasons for car sharing, it is not unlikely that newly divorced or unemployed people start car sharing.

There is some uncertainty involved, as the survey included only a limited number of people and offers no certainty about causality – did respondents reduce the amount of kilometres they were driving because they started car sharing, or was there another reason involved? In order to address this problem, another set up for the experiment would have been better (using a control group or a longitudinal study). However, all the observed differences in car ownership and car use between the times before and after car sharing are statistically significant. At the very least, the results are strongly indicative of car sharing being the reason for those differences.

Another point of caution is that we used the respondents' own estimations of their previous number or car kilometres, also if that had already been some years ago. People's memories could have been blurred or they could have provided socially acceptable answers about their current car use. This last possibility could mean that the impact of car sharing in this study has been overestimated.

Many respondents indicated that they would have bought an additional car if they had not started car sharing. Because of a lack of reliable reference material, we decided against attributing any kilometres to the not-purchased, additional vehicle. Yet, it is imaginable that if they would have had such a vehicle at their disposal, they would have used it more often. This last fact would mean that the results presented here are more likely to represent an underestimation than an overestimation.

[8] Car ownership, on average. would not have decreased by 0.36 cars per household, but by 0.41. And care use would not have decrease by over 1,600 kilometres per year, but by close to 1,800.

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