PATHWAYS project

Exploring transition pathways to sustainable, low carbon societies

Grant Agreement number 603942

Deliverable D2.3: 'Integrated analysis of D2.1 and D2.2 to assess the feasibility of different transition pathways'

Country report 7: The Dutch mobility system

Bruno Turnheim

Department of Geography

King's College London

December, 11, 2015

Executive summary

The purpose of this document is to make an interpretive assessment of the feasibility of sustainability transitions pathways within the Dutch mobility domain *today*, with reference to ideal pathways A and B, as part of PATHWAYS D2.3, and in accordance with the protocol agreed by all project partners. This document builds on the analysis of niche innovations and of regime stability in Dutch mobility, as presented in Deliverables D2.1 and D2.2 respectively.

We first provide an overview of the main task at hand, with particular reference to the mobility domain in the Netherlands.

The bulk of the document is concerned with assessing the 'breakthrough feasibility' of specific niche-innovations. This is mainly done with attention to a multi-dimensional understanding and evaluation of niche momentum-in-context, and in relation to the identification of specific opportunities presenting themselves at regime level. Given these evaluations of niche progress, we seek explanation as to the main barriers, mismatches, or misalignment with sustainability transitions dynamics in the mobility domain (see Table 1).

Table 1: Breakthrough potential analysis of 6 niche-innovations in the mobility domain in the Netherlands

Niche innovation	Internal momentum	Alignment with broader regime characteristics and developments	Likelihood of imminent breakthrough (and/or future potential)	Pathway A or B (or mixed)
Battery electric vehicles (BEVs)	**Moderate** Potential for **high momentum** in near future	Moderate alignment: - 'greening of car' - lack of infrastructure - political will	Moderate to high	A with elements of B
Hybrid electric vehicles (HEVs)	High (beyond niche)	High alignment (proven)	High but capped (upper limits to further expansion?)	A
Hydrogen fuel cell vehicles	Very low	Moderate alignment: - 'greening of car' - no of infrastructure - no exposure	Currently low Hopeful monstrosity?	A with elements of B
Biofuels	Moderate	Moderate/low alignment: - 'greening of petrol' - 'greening of car'? - legitimacy hurdles	Moderate/low	A with elements of B
Carsharing	High	Moderate alignment: - no technological or policy challenge - behavioural change	Moderate to high, but capped	B with elements of A
Compact cities	Moderate (past)	Initially low but turned upside down	Very low (unsuccessful niche of the past	A but could have enabled B

We then assess current and foreseeable regime dynamics, with specific attention to the kinds of regime reorientation activities and strategies that can be observed in automobility, but also public transport and cycling (see Table 2). This leads us to further specifying the scale of the transition challenge ahead.

Table 2: Assessment of regime trends in the mobility domain in the Netherlands (with indicative 'scores')

	Lock-in, stabilizing forces	**Cracks, tensions, problems in regime**	**Orientation towards environmental problems**	**Main socio-technical regime problems**
Automobility	Strong	Moderate	Moderate (some incremental change towards 'greening of cars')	Continued political support No urgent threat
Public transport	Strong	Weak (integrated and coherent planning)	Strong (regime oriented towards leaner mobility) Potential for further improvements (low-carbon for motorized transport, 100% renewable electricity for rail-based)	Cost (travel and investment) Inconvenience in less dense areas
Cycling	Strong	Weak	Strong (zero-carbon option)	Inconvenience, particularly over longer distances (addressed via multi-modality and electric cycling)

The existing **automobility** regime in the Netherlands is deeply entrenched and relatively stable. It is stabilised by reinforcing initiatives and institutions that contribute to existing lock-in. These include: a powerful industry, continued technical improvements and sophistication, and supporting policies. Despite strong inherent stability, the automobile regime in the Netherlands is showing some signs of change. Recent trends point to increasing recognition of external pressures and challenges by the automobile industry itself, with greater attention to environmental and safety issues, innovation strategies geared towards lesser emissions (catalytic converters), fuel efficiency improvements, the exploration strategies with different alternative fuels, and the emergence of new business models for mobility. The emission intensity of new cars is steadily decreasing.

There are signs of change ahead, as the prevailing automobile regime is increasingly being challenged on environmental, convenience, safety, economic, and technological grounds, as well as a growing disinterest in car ownership among younger people in the Netherlands. Most responses so far, however, are currently met by regime incremental responses, which points to an incremental regime change pathway, in a context of continued policy support and little urgency for radical transform.

Overall, **public transport** is an integrated and coherent affair in the Netherlands with a strong role for public planning and harmonisation. The Netherlands is striking in its ability to retain public control over public transport (from national government down to municipality), which is one main reason why lasting support and continuity can be expected. Multimodality has been successfully supported (e.g. through integration and simplification of ticketing and fares; increasing ease of connection between modes of transport). To date the emerging issues have been successfully addressed as they have emerged.

The Netherlands has the highest **cycling** rate in Europe; cycling is culturally deeply embedded and has profited from successful policy interventions. The Netherlands has a well-established extensive, safe and convenient cycling infrastructure network, all of which contributes to a strong stability of this regime. In recent years, e-cycling has been replacing some conventional bicycle journeys, particularly over longer distances and in older age groups. The cycling revival in the Netherlands over the past 4 decades can be seen as an exemplar of mobilisation and mobility transformation driven by 1) societal concerns (a mixture of safety and environmentalism), 2) strong policy involvement, and 3) the crucial role of infrastructure. It also is a telling (and hopeful) example of how leaner and greener alternatives may become deeply embedded in society. However, it is important to recognise that cycling (however widespread in the Netherlands) has not yet managed to substantially displace automobility although it may have contributed to the tempering of its growth.

We conclude by evaluating the foreseeable fate of niche-innovations, their potential for contributing to transitions dynamics (and qualification thereof), and reflecting on transitions dynamics in mobility in the Netherlands.

The Netherlands offers an interesting context for experimentation with low-carbon mobility. The Netherlands is characterised by a high degree of innovation along a 'greening of cars' trajectory, decades of successful (and world-leading) experience with alternative mobility modes (public transport, cycling, multi-modality), and a variety of local and national coalitions pressing for greater efficiency and sustainability of transportation. Together, these dynamic conditions and energies generate an enabling and hopeful stage for transitions towards low-carbon mobility. There is, nonetheless, a deeply engrained habit of supporting automobility in policy, which may stand in the way of or slow down these emerging trends by sending the wrong signals.

More radical pathways stepping away from automobility altogether are still difficult to envision at the horizon, as there is currently no materialisation of a fundamental questioning of automobility. Automobility is not challenged in mainstream discourse, and there is a relative shyness of policy to aggressively challenge a mobility mode that is still perceived as convenient by a majority of the Dutch population. There are promising exceptions to this (e.g. urban cores and younger generations, and general saturation) but these are not strong enough to overcome a generally risk-averse policy system that is generally happy to be seen actively promoting hopeful alternatives (EVs, multimodality) on discursive levels, but not yet ready to deliberately accelerate the destabilisation of automobility. In this context, we are likely to see Pathway A-type developments thriving, along with an increased contribution of new mobility modes, but may have to wait before we see a serious and unavoidable challenge to automobility in the Netherlands.

Nevertheless, the Netherlands is striking as a context that has made a head start towards sustainable mobility by 1) supporting the strong development of multiple modes of mobility, 2) seeking leadership in sustainable mobility innovation, and 3) hosting a variety of local and national coalitions pressing for greater efficiency and sustainability of transportation. These crucial developments are signs of a deep reflection within Dutch society about fostering greater flexibility of options for mobility, with particular emphasis on efficiency, accessibility (territorial and social), safety, and environmental concerns. A highly stable and effective public transport system, a mature cycling infrastructure, and an inclination towards multi-modality are deeply entrenched part of mobility practices in the Netherlands. They provide fertile ground for stepping away from unsustainable automobility.

So, the Netherlands is perhaps best positioned in Europe to enable and support sustainable mobility transitions in the medium to long term. Crucial requirements ahead are greater policy clarity and coherence about no longer supporting automobility-as-usual, and embracing the sustainable mobility possibilities in the making.

Contents

1 Introduction

The purpose of this document is to make an interpretive assessment of the feasibility of sustainability transitions pathways within the Dutch mobility domain *today*, with reference to ideal pathways A and B, as part of PATHWAYS D2.3, and in accordance with the protocol agreed by all project partners. This document builds on the analysis of niche innovations and of regime stability in Dutch mobility, as presented in Deliverables D2.1 and D2.2 respectively.

We first provide an overview of the main task at hand, with particular reference to the mobility domain in the Netherlands.

Section 2 is concerned with assessing the 'breakthrough feasibility' of specific niche-innovations. This is mainly done with attention to a multi-dimensional understanding and evaluation of niche momentum-in-context, and in relation to the identification of specific opportunities presenting themselves at regime level. Given these evaluations of niche progress, we seek explanation as to the main barriers, mismatches, or misalignment with sustainability transitions dynamics in the mobility domain.

In section 3, we assess current and foreseeable regime dynamics, with specific attention to the kinds of regime reorientation activities and strategies that can be observed. This leads us to further specifying the scale of the transition challenge ahead.

We conclude by evaluating the foreseeable fate of niche-innovations, their potential for contributing to transitions dynamics (and qualification thereof), and reflecting on transitions dynamics in mobility in the Netherlands.

2 'Breakthrough feasibility' of niche-innovations

The analysis presented in this section is structured around the niche-innovations presented in D2.1, and seeks to address three main **research questions**:

1) What is the internal momentum of the niche-innovation
2) How does the niche-innovation align with wider regime and landscape developments?
3) What us the current feasibility of a breakthrough of the niche-innovation?

We analyse the following six niche-innovations:

- Battery electric vehicles (BEVs)
- ICE/electric hybrid vehicles
- H2 fuel cell vehicles (FCVs)
- Biofuels
- Carsharing and car clubs
- Compact cities

2.1 Battery electric vehicles (BEVs)

2.1.1 Niche momentum

Techno-economic momentum. BEVs in the Netherlands have recently entered the market (see Table 3), in niches where the current limitations of BEVs (e.g. range) is minimised (van Bree et al 2010), such as in small urban cars, bicycles, mopeds, but also increasingly in more conventional passenger cars by experimental users and with the involvement of fleet operators (taxi, carsharing, company cars, etc.). The market is expanding, with a dominance of high-performance and small urban models. FEVs have experienced steady market growth since 2011, with over 4,000 registered FEVs in 2013 (see Table 3), although there are concerns of this levelling off due to changes in tax regimes. These figures, however, are dwarfed by an exponential growth of E-REVs and PHEVs to 24,512 by the end of 2013 (excluding 'full hybrid vehicles', such as the non-plug-ins).

Table 3: Electric vehicles registered in the Netherlands (Data: RVO)

	31/12/11	**31/12/12**	**31/12/13**	**31/01/14**	**28/02/14**
Personal car (FEV)	1124	1910	4161	4160	4172
Personal car (E-REV, PHEV)	17	4348	24512	24734	25880
Company car < 3.500	158	494	669	676	688
Company car > 3.500	22	23	39	41	44
Buses (incl. trolley and hybrid)	68	67	73	74	85
Quad- and tri-cycles	181	469	632	635	642
Electric motorbike	88	99	125	120	121
On-road total	**1658**	**7410**	**30211**	**30440**	**31632**
Moped	2.484	2.853	3.130	3.136	3.133
Slow moped	14.311	17.748	19.772	19.884	19.997
Motorised quadricycle	n.a.	107	141	144	145
Total on-road and limited	**18453**	**28118**	**53254**	**53604**	**54907**

Socio-cognitive momentum. There are no major legitimation issues, since the "new vehicles comply with current requirements for vehicles for use on public roads [… there are] no large change in the controls, so that consumers are not confronted with an unfamiliar device and do not have to learn a new set of user skills" (Köhler et al 2013:182-3). The main novelty, as far as users are concerned, relates to fuel infrastructure and related range issues. Dijk (2011) has shown that the Dutch consumer was mainly concerned with the range and price of EVs in the late 1990s. Such cultural and preference barriers are however rapidly being overcome.

Consumer education is often seen as an obstacle to the breakthrough of EVs. The consolidating commercial interests behind EVs recognise that a more solid argument has to be made to potential users, emphasising their emotive value (e.g. fun, fuel independence, consumer choice in charging place, time and rate, etc.). There is recognition of the need for articulating a 'net positive EV value proposition' in order for consumers to overcome the high initial investment costs of EVs (EY 2013). The main market focus is set where the existing barriers to development are small or easily overcome, such as high-intensity of localised short trips (taxis, deliveries, urban car sharing, etc.), predictable mobility patterns (public transport), high 'user willingness' and lower cost barrier (high-performance ground-breaking vehicles, Government procurement, etc.).

Governance and policy momentum. The main policy strategy is to anchor the Netherlands as an attractive early market for electric mobility, on the basis of policy support, the motivation of and federation actors, including in power generation. However, the lack of an indigenous automobile manufacturing industry means that there is a constant need to reaffirm attractiveness of the Netherlands as 'test-bed' for e-mobility, in order to attract foreign companies (RVO 2011). Policy support for electric mobility is fundamental to its potential deployment, as a form of niche protection and development encouragement. Such support concerns chiefly innovation (R&D), incentives for vehicle purchase, and the rollout of a charging infrastructure. In the Action Plan for electric transport 2011-2015, 'Elektrisch Rijden in de Versnelling' (RVO 2011), the Government has set ambitious targets for EVs (Table 4). Reaching 200,000 vehicles is seen as demonstrating that the system of electric mobility 'works', and will require an adequate charging infrastructure, a market, and safety guarantees.

Table 4: National EV targets in the Netherlands

Period	Market dvlpmnt	Expected EVs	Program stage
2009–2011	Laboratories	<100 to <1000	Program start-up
2012–2015	Scale-up	15,000 to 20,000	Program implementation
2015–2020	Continued roll-out	200	Program consolidation
2020-onwards	Mature market	1,000,000 by 2025	Program scaled down

Electric cars also benefit from a number of fiscal advantages, such as the exemption of registration tax (until 2018), road tax exemption, and tax deductions for investments EVs and charging infrastructure (RVO 2013). Owners of EVs also benefit from free parking in most cities. In more targeted measures, the Government supports the deployment of EVs by encouraging the development of charging and power infrastructure, attracting manufacturers of electric vehicles and components, and supporting a variety of platforms to bring actors together (RVO 2011). Public procurement (government fleets, etc.) at national (ministries) and local levels is intended to further support the development of markets.

A number of 'electric driving Green Deals' have been signed with SMEs and local organisations, helping projects pick up steam (RVO 2014). Local (concentration) strategies based on the development of focus areas for roll out and experimentation (e.g. Amsterdam Electric, etc.). A number of regions and municipalities are positioning themselves at the forefront of EV, with the multiplication of field trials and demonstration projects involving private, public/private, or public electric mobility options. The cities of Amsterdam and Rotterdam (seeking a breakthrough of electric mobility), and the region of Brabant (ambitioning to become a leading market, research and industrial pole for electric mobility) are notable efforts in that direction.

Overall momentum. EVs have followed a bumpy development pattern, with multiple hype/disappointment cycles. Currently EVs are experiencing renewed **moderate momentum**. The question is whether this is just another hype (Orsato et al 2012). A number of factors seem to indicate that a significant threshold has been passed, and that EVs are likely to gain **high momentum** in the near future. Signs of positive momentum include 1) the deployment of commercially viable vehicles, 2) promising steps towards charging infrastructure rollout, 3) the enthusiasm of fleet operators, 4) the deployment of hybrids vehicles acting as a ‘stepping stone’, and 5) increasing public exposure. Among other elements, it appears crucial to achieve high density and interoperability of charging opportunities for the stabilisation of BEV developmental trajectories. Cities and larger metropolitan regions are proving important in this respect.

2.1.2 Alignment with regime and landscape developments

Techno-economic dimension. BEVs are relatively aligned with the prevailing automobility regime, insofar as they imply technical changes in engines and their fuel supply without challenging the paradigm of automobility, and so fall within a ‘greening of cars’ narrative.

BEVs nonetheless require substantial infrastructure and allow for the entrance of new players in reconfigured supply chains (e.g. batteries, electric motors), and could lead to substantial re-thinking of design specifications and strategies (e.g. new vehicles classes, lightweight frames), which opens up opportunities for regime transformation within automobility. Furthermore, BEVs are linked to ICE cars via hybrid engines (see below), which can be seen as stepping-stones to address a number of technical challenges.

Socio-cognitive dimension. On a general level, BEVs do not generate major challenges to automobility practices, and indeed promise the continuity of automobility by addressing major environmental challenges. The main concern relates to range, due to battery autonomy and the current state of charging infrastructure. However, range anxiety is rapidly overcome, as battery performance increases and as the Netherlands rapidly deploys public and private charging points. There are limits to this process, and charging points are beginning to impede on public parking and driving space in urban centres.

There is an increasing exposure of users with electric vehicles, further reducing barriers to deployment. Car sharing schemes and fleet operators are leading adopters that are contributing greater acceptability of BEVs, particularly in an urban setting.

Governance and policy dimension. Local and national government have been particularly supportive of BEVs in the Netherlands, particularly in terms of charging infrastructure deployment. Furthermore, BEVs are seen as an industrial opportunity for the Netherlands to assert its international leadership.

2.1.3 Feasibility of breakthrough

Overall feasibility of breakthrough is relatively high, given moderate current momentum and expectable high momentum, and relative alignment with the current regime (particularly as the main technical issues are addressed).

2.2 ICE/electric hybrid vehicles

2.2.1 Niche momentum

Techno-economic dimension. The mass commercialisation of HEVs was initiated by Japanese car manufacturers, on relatively specialised markets. The commercial success of the Toyota Prius, including in the Netherlands where it has been available since 2000, led other OEMs to step into the market. The market has been growing steadily since 2007. In 2009, HEVs sales increased substantially in the Netherlands, "largely as a result of the decrease in the incremental income tax rate (from 25% to 14% of the car sales price) for employees who use company cars." (IEA 2010:216). These sales were made up almost entirely by Toyota Prius and Honda Civic Hybrid, with respectively around 8300 and 6000 units (IEA 2010:220). By 2013, 91196 hybrid vehicles were circulating in the Netherlands, representing over 1% of all registered vehicles (RAI 2013), of which nearly 25000 were EREVs or PHEVs (RVO 2014). Since 2012, the share of hybrid vehicles sales in the Netherlands is dominated by PHEVs and EREVs – a result that is attributed to generous fiscal incentives for low-emission vehicles.

Socio-cognitive dimension. The Dutch public has become quite familiar with hybrid vehicles, which are highly accepted and legitimate since they represent only a minor departure from conventional vehicles. This is particularly the case for FHEVs, which have become a commonplace vehicle option – albeit a slightly more expensive one. Familiarisation with electric driving with FHEVs is an important form of exposure that contributes to overcoming cultural barriers and gradual forming a positive connotation (Dijk and Yarime 2010).

Governance and policy dimension. HEVs require very little support to be commercially viable. HEVs receive smaller amounts of support than EVs, via tax exemptions for low-emission vehicles. Plug-in hybrids owners can benefit from financial assistance for the installation of charging infrastructure.

Overall momentum. There are clear indications that hybrid vehicles have moved towards the mainstream, representing a noticeable market share and a relatively stable design. This makes HEVs a very tangible mobility innovation, but one that has already broken out of its niche. So, HEV **momentum is currently high**.

2.2.2 Alignment with regime and landscape developments

Techno-economic dimension. HEVs are highly compatible with the prevailing automobility regime. Indeed, they no longer generate any challenge at all, aside from the still relatively high price they command.

HEVs are interesting insofar as they are an intermediate form of technology, adding some elements of electrification to conventional vehicles. The development of HEVs can be seen as the momentary result of a hybridisation strategy, qualified by the progressive introduction of novelty through technological compromises and overall risk reduction.

Socio-cognitive dimension. HEVs are well aligned with current perceptions and experience of automobility. They are conventional cars, with an additional back-up motor engine.

Governance and policy dimension. HEVs have been supported by policy incentives contributing to reducing their price. However, it is not clear that the environmental benefits from HEVs justify continued government support – which has been scaled back since 2013.

2.2.3 Feasibility of breakthrough

HEVs currently have high momentum, and are well aligned with the prevailing automobility regime. Arguably, they have already broken through, and are likely to continue growing and contributing an increasing share of automobility.

However, recognising their stepping-stone quality and their capped contribution in low-carbon transitions, it is also unlikely that HEVs will stabilise and remain relevant over the long run.

2.3 H2 fuel cell vehicles (FCVs)

2.3.1 Niche momentum

Techno-economic momentum. FCVs are not yet available on commercial markets. Given FCVs' relative immaturity, market penetration can only be evaluated ex-ante, based on projections, which vary significantly from 2-20% of vehicle stocks by 2030 to 5-50% by 2050 (Zubaryeva and Theil 2013). Demonstration and prototypes of fuel cell cars have been developed by major OEMs, including GM's Hy-wire, Toyota's FCV Concept, Hyundai's Intrado (SUV), Honda's Clarity and FCEV Concept.[1] GVB has been running a pilot project with Mercedes-Benz/EvoBus buses in Amsterdam on two lines since 2004, as part of the CUTE project. The Forze team at Delft University developed record-breaking FC prototypes since 2007. In a new step towards market, Hyundai introduced the first commercial fuel cell vehicle in the Netherlands in 2013, the Ix35 Fuel Cell,[2] in a move to propose a concrete experience to adventurous customers. While the Dutch Government announced expectations of several thousand fuel cell cars worldwide by 2015,[3] Hyundai brought this figure to between 500,000 and 1milion by 2020.[4]

Socio-cognitive momentum. Consumers have so far not had much interaction with FCVs, for only few models exists, and marketing is not yet a priority for carmakers. Prototypes and demonstrations are currently mainly reaching a small group of car enthusiasts (but also a more broader public by ways of local experimentations with FC buses). Foreseeable consumer-related issues to be addressed include safety concerns related to hydrogen refuelling and storing, and the availability of refuelling infrastructure (Zubaryeva and Thiel 2013).

Governance and policy momentum. The push for FCVs is mainly perceptible through large-scale government sponsored programs, initiated in the 1970s (oil shocks), although funding was reduced in the mid-1990s despite major technological progress (Budde et al 2012). Currently, the European Commission is engaged in supporting HFCVs, as demonstrated by contributions to R&D funding, and coherence with its long-term agenda. Solomon and Banerjee (2006) suggest that EU plans are more 'aggressive' than their counterparts. This is most notable in Germany (with positive links to the Netherlands and the North Sea basin in general).

---

[1] Dijk and Yarmin (2010) however, remind us that prototypes shown in industry events are often presented for PR purposes without intentions of entering production.

[2] http://www.hyundai.nl/ix35-fcev# accessed May 14, 2014.

[3] http://www.government.nl/news/2013/04/10/mansveld-the-netherlands-is-preparing-for-driving-on-hydrogen-fuel-cells.html accessed May 14, 2014.

[4] http://hygear.nl/news/hygears-fueling-station-provides-hydrogen-for-the-first-commercial-fuel-cell-vehicle/ accessed May 14, 2014.

Overall momentum. The development of FCVs is still at an experimentation (demonstration) stage, with precursor market experiments just emerging. FCVs are still much more expensive than any other alternative vehicles, and are considered an option for the medium and long term. Current demonstrations are mainly technical proofs of concept rather than broader exercises in market exposure. So, **current momentum is very low**, and it is unlikely that proper commercial deployment of the technology will materialise before 2030.

FCV development is still a relatively experimental venture and can only be judged by its potential. While some observers suggest that FCVs are "[t]he main alternative technology considered for the longer term" (Köhler et al 2013:176), others express some doubts over repeated hype cycles, suggesting that the high technological hopes around hydrogen technology as a transportation fuel in the Netherlands, particularly in the mid-2000s, have led to decreasing thereafter (Alkemade and Suurs 2012, Bakker and van Lente 2009).

2.3.2 Alignment with regime and landscape developments

Techno-economic dimension. FCVs are relatively aligned with existing automobility regime, as within a 'greening of cars' pathway, although a number of major technological uncertainties remain (e.g. fuel supply and distribution)

Socio-cognitive dimension. FCVs do not yet have market exposure. There are however no major foreseeable sources of misalignment, besides form potential concerns related to safety and range.

Governance and policy dimension. FCVs, currently at a demonstration stage, do not present any major challenge for policy. If they would to be deployed on a massive scale, issues of coordination and infrastructure investment would be expected (such as is currently observed in the area of BEVs).

2.3.3 Feasibility of breakthrough

Currently there is very low momentum, so the likelihood of breakthrough is limited. However, with no major foreseeable regime-level obstacles, a future breakthrough is imaginable.

2.4 Biofuels

2.4.1 Niche momentum

Techno-economic momentum. Dutch Biofuel consumption is above European average, but far from leading (European Commission, 2013). This consumption is almost evenly spread across bioethanol and biodiesel. The main form of biofuel consumption in Europe is through low blends, as flexi-fuel vehicles (FFVs) remain a fairly small niche market. Although there have been some development with flexible cars running on 100% biofuel, this niche market is currently fairly small when compared to the blending of biofuels with conventional oil. While flexifuel cars are available from a range of manufacturers, only a tiny fraction of registered cars were running on bioethanol in the Netherlands in 2013 (RAI 2014). The Dutch market is small when compared to countries like Germany, France and Sweden.

Socio-cognitive momentum. Low biofuel blends have no impact on driving practices. Flexi-fuel vehicles have been engineered to perform equally well on conventional fuels, which means that range anxiety is not an issue. Biofuels have, however, been the target of serious controversies, challenging their legitimacy and the ethical responsibility of their advocates, particularly in relation to controversies about competition with food production, deforestation, increased carbon emissions, and rising food prices, exacerbating the division between advocates of 1G and 2G biofuels.

Governance and policy momentum. Policy influence in the area of biofuels has been primarily for three motives: 1) innovation support, 2) market creation, and 3) regulation and certification.

Innovation support. Early experimentation with biofuels have been supported by the Dutch government and regional actors in the early 1990s, via research/trial funding and tax exemptions to support biofuel vehicle experiments (e.g. bioethanol buses in Groningen, and various biodiesel boat fleets), but also biofuel production from agricultural feedstock. This support was interrupted with the emergence of an anti-biofuel coalition from the mid-1990s. RD&D funding shifted to 2G biofuels around that period.

Market creation. The municipality of Rotterdam was involved in generating a local market for FFVs with its own fleet, but implementation was rather slow (Ulmanen et al 2009). The turning point in market creation came through the impulse of the EU. Dutch biofuels policy has mainly been driven by European directives (van Grinsven and Kampman 2013). The Biofuels Directive (2003) called for a step-wise increase of the share of biofuels (2% by 2005 and 5.75% by 2010). It was replaced in 2009 by the Renewable Energy Directive (RED), setting a target of 10% renewable energy in the transport sector by 2020, amended in 2013 to include sustainability requirements (biodiversity and land use). European prescriptions were translated into the Dutch biofuels obligation (introduced 2007), which required fuel suppliers to include a minimum share of biofuels in their sales, from 5,75% in 2010 (revised down to 4%) to 10% in 2020. The Dutch Emissions Authority (NEa) monitors the performance of individual companies and revises yearly objectives.

Legitimation: regulation and standards. Following controversy about the sustainability of biofuels, particularly heated between 2007 and 2009, a number of measures were taken to address this issue and raise the legitimacy profile of biofuels. The so-called ‘Cramer criteria’ (NTA 8080) are ‘verifiable sustainability requirements’ that were formulated in 2008 for the introduction of certified biomass on the Dutch market. In addition, Dutch companies signed a declaration of intent to voluntarily report on the nature, origin, and sustainability of biofuels, which is an important step towards transparency and traceability. A recent study found that biofuels on the Dutch market had on average a low ILUC impact, although there is high variability across distributors (van Grinsven and Kampman 2013).

In 2012, the EC proposed a number of sustainability measures in a recent legislative proposal (COM(2012)595), including a cap of 5% of food-based biofuels by 2020, the promotion of biofuels form food production waste and forestry residues, and the inclusion of ILUC criteria. There are worries that the materialisation of this proposal could depress a not so profitable 1G biofuels industry and provide positive incentives for 2G biofuels producers (Peters et al 2013). Reacting to the differentiation of 1G and 2G biofuels, and recent concerns about the possibility for scaling up sustainable biofuels, the European Parliament agreed on differentiated targets by 2020 (6% 1G biofuels, 4% 2G biofuels and other renewable transport options).

Overall momentum. Biofuel path creation in the Netherlands was initiated in the 1990s, and has been marked by a lack of continuity (Lovio and Kivimaa 2012), which has been interpreted as a hype/disappointment cycle (Alkemade and Suurs 2012). Since the early 2000s, however, biofuels have been driven by EU policy, as the Biofuels Directive created a solid (but capped) niche market for biofuels blending. The FFV niche is comparatively small and stagnant.

On the supply side, the field is marked by the distinction between 1G and 2G biofuels, erected as a frame to navigate the sustainability controversy. While considerable progress has been made towards the commercialisation of 1G biofuels, there are questions as to the commercial viability of 2G biofuels in the near future. The recent deployment of a number of pilot and commercial plants in the Netherlands seems to indicate that the field is stabilising, despite some ongoing concerns about traceability and the scope for sustainably scaling up production.

So, overall, biofuel **momentum is moderate** in the Netherlands, but the potential for expansion is capped in the case of blending, as well as in competition with agriculture.

2.4.2 Alignment with regime and landscape developments

Techno-economic dimension. Biofuels are in relative alignment with the prevailing automobility regime, as they are inscribed within a 'greening of cars' pathway. The current path in Europe (blending of biofuels) is fully compatible with existing cars, while a more ambitious path (flexifuel vehicles) calls for specialised engines. In both cases, the main technical challenge resides with the production and distribution of fuel in a way that does not limits sustainability impacts.

Socio-cognitive dimension. Biofuel cars present no direct challenge in terms of preferences or practices. However, there are substantial legitimacy issues related to the sourcing of biofuels, and competition with agriculture, that need to be addressed to gain widespread consumer acceptance.

Governance and policy dimension. The legitimacy issues related to biofuels generate challenges for coherent policy framework, which are related to certification in the liquid fuels business, including sourcing and technical processes.

2.4.3 Feasibility of breakthrough

Current momentum is moderate, but potentially capped. Besides being in relative alignment with automobility practices, biofuels present legitimacy issues that have already prevented more rapid development.

So, the feasibility of a breakthrough of biofuels (beyond blending) is currently dependent on overcoming legitimacy hurdles.

2.5 Carsharing and car clubs

2.5.1 Niche momentum

Techno-economic momentum. Netherlands is, with Switzerland, Germany and Belgium, among the leading carsharing countries in Europe. According to CROW-KpVV, carsharing is on the rise in the Netherlands, with 11,210 available cars in March 2014 (a 113% yearly rise), and around 110,000 carsharers. The development of new forms of carsharing, i.e. P2P and one-way, have greatly accelerated market growth since 2011. Carsharing is supported by new business and pricing models.

Recent advances in ICT have supported the development of carsharing to an increasingly credible alternative to private car ownership. Crucially, the development of ICT has enabled major leaps in user convenience through e.g. 24/7 access with electronic card (un-)locking, online or mobile interface, real-time geo-localisation of available vehicles, etc. These innovations together make carsharing a much stronger proposition in terms of user flexibility, convenience and trust. From the fleet operator perspective, ICT developments have also enabled leaner and more effective logistics, namely based on real-time geographical information data, on-board user control and tracking (fuel, mileage, position, etc.), and the automation of routinised tasks such as fleet management and maintenance.

Socio-cognitive momentum. CROW-KpVV notes positive user reaction and general public support for carsharing in the Netherlands. Carsharers tend to be greater users of public transport and other 'soft' mobility options. Carsharing is not often used for commuting, but rather for occasional trips on relatively long journeys, or in combination with other modes in an urban setting. Anxieties and negative expectations about vehicle availability and service convenience are important hurdles to reach potential users. The development of satisfactory customer service are proving key to a more positive image. The more innovative forms of carsharing are becoming highly popular and associated with positive symbolic meanings.

Carsharing may be associated with new forms of freedom and autonomy, in a context of decreasing perceived automobile convenience, and (material) commitments more generally. Carsharing's collaborative nature and its compatibility with a sharing economy contribute to its popularity, particularly with the younger urban population. Carsharing taps into an emerging trend towards less car dependence and lesser interest in car ownership amongst younger generations, whose stance tends to favour pragmatic utilitarianism over emotional attachment:

> "Car sharing is based on a belief that Generation Y is more interested in mobility as such than in car ownership, which opens up partial ownership as viable value proposition." (Bohnsack et al 2014:294)

Governance and policy momentum. In the Netherlands, local authorities have the right to determine the usage of public space (Loose 2010). They hence play an important role in enabling carsharing practices, by granting dedicated parking space or parking permits.

In terms of further encouraging the uptake of carsharing, national and local authorities can play a role to increase awareness (e.g. marketing and advertising strategies), and making carsharing business models more profitable (e.g. via targeted subsidies or incentives). Most incentives, however, are indirect and targeted at specific technologies, such as the EV niche nurturing. Carsharing is increasingly seen by official bodies as an integral part of future mobility trends, with a role to play in transition objectives. SER (the Social Economic Council of the Netherlands), for instance, in its Energy Agreement, signed by the Federation of Dutch municipalities, specifies a target of 100,000 carsharing cars by 2020.

There is scope for greater involvement of transport planning authorities and public transport operators to actively tap into the role of carsharing in an integrated multimodal transportation system in terms of "filling in the gaps left by the limited carrying capacity, timetables and inflexibility associated with other alternative modes" (Kent and Dowling 2013:87). Switzerland and Germany provide interesting examples in this respect.

Overall momentum. Although car sharing only accounts for a small fraction of overall mobility and remains concentrated in the most densely populated areas, there are positive signs of increasing momentum in recent years. More importantly, carsharing has increasingly become embedded in existing automobility networks (e.g. manufacturers, car hire services, municipalities), associated with positive symbolic meanings and aspirations (e.g. environmental, congestion), able to absorb and generate innovation (e.g. ICT, EVs, insurance, business model). Together, these elements suggest that carsharing is more than a passing fad (Kent and Dowling 2013), and that it may be envisioned as an integral part of future mobility systems with a different role to play in a variety of pathways (Marletto 2014). Carsharing can be seen as an important link in visions of multi-modal mobility chains and the development of a market for alternative vehicles, providing at once a source of continuity with the past and a bridge to the future.

So, carsharing currently enjoys **high momentum** in the Netherlands.

2.5.2 Alignment with regime and landscape developments

Techno-economic dimension. On a technical level, carsharing does not depart substantially from automobility, as it indeed relies on both conventional and more alternative cars (e.g. BEVs). However, it does rely heavily on ICTs and logistics for its centralised and seamless operation, as well as on dedicated infrastructure such as parking places.

Socio-cognitive dimension. Carsharing departs strongly form the prevailing automobility regime insofar as it presumes a shift from private and exclusive ownership-based to collective and accessibility-oriented mobility. It also supposes reduced automobile usage, and combination with other modes, which may currently be much more acceptable and feasible in and around urban cores.

Governance and policy dimension. In terms of formal institutions, carsharing exhibits a great deal of continuity with the automobility regime, and hence requires little change of policies and regulations. Notable exceptions include the availability of dedicated parking spaces, and special exemptions or negotiated parking fees, for which local authorities play an important role in the Netherlands.

2.5.3 Feasibility of breakthrough

Carsharing currently enjoys relatively high momentum in the Netherlands, and despite limited alignment with the current regime, is achieving to align with a number of emerging landscape trends, as well as carving a place for itself within changing mobility systems.

So, the feasibility of carsharing breakthrough is increasingly high. The question is rather how much potential does it have, how far can it spread, and in which combinations of mobility options.

2.6 Compact cities

2.6.1 Niche momentum

Techno-economic momentum. 'Compact city' most commonly refers to high-density, mixed-use urban form. It is associated with the promotion of non-motorised mobility, efficient public transport, and generally presented as an alternative to car-centric urban sprawl (Burton 2000). The notion has been influencing urban planning since the 1960s, spurred by rapid suburban expansions during the 1950s to 1970s (Alpkokin 2012), gaining momentum as planning concept during the late 1970s and early 1980s (Scheurer 2007). In particular during the 1990s, in line with the discourse on sustainable planning, it became a promising response to environmental, economic and social challenges in and around cities (Hofstad 2012). Despite disputed environmental benefits, compact development has been highly influential—particularly in Dutch spatial planning—and is often echoed in other sustainable city strategies (e.g. *eco-cities*).

In the Netherlands, compact development was the prevailing spatial planning strategy over several decades. Through four planning terms, the national government imposed a strict approach against dispersed urban form. The rationales changed over time (e.g. preserving agricultural land; decreasing inner-city decline), with a strong environmental agenda arising after 1980. This brought to the fore the assumed merits of compact growth with respect to promoting walking, biking, and using public transport while limiting car usage and hence tackling energy use and CO_2 emissions (Dieleman et al. 1999). In 2000, a major overhaul of the planning system, which aimed at decentralisation and a market approach for spatial planning, but also reacted to the doubted impacts of dense development on mobility patterns, led to a shifting focus away from the compact city to a wider *city network* model (Hanssen and Hofstad 2013; MIE 2011). Geographically, efforts for compact development were predominantly directed to the *Randstad* – a distinctive pattern of urban centres in the western Netherlands including Amsterdam, Rotterdam, The Hague and Utrecht as well as a substantial number of smaller cities, and encircles the rural *Green Heart*. Compact city strategies do not seem to have prevented massive use of private cars outside city centres (Van der Burg and Dieleman 2004), as the strategy of developing dense neighbourhoods in pre-determined growth nodes has been associated with higher car dependency and also with no reduction in commuting times

Socio-cognitive momentum. In the Netherlands, compact city development was primarily a national Government endeavour, resting on planning restrictions to be enforced by provinces. The Ministry of Housing, Spatial Planning and the Environment played a leading role both as developer and preservationist (Hanssen and Hofstad 2013). There was a successful alignment with interests especially from the housing and agriculture domains (Hajer and Zonneveld 2000). "From farmers to business people" (Keleher 2012), and environmentalists to planners, the compact city received broad support and was espoused also by the public (Dieleman et al. 1999). Implementation-wise, besides the national government, four provinces, some 165 municipalities, private organisations and lobbies were involved in the *Randstad* (Dieleman et al. 1999), via a hierarchical structure. Compliance was ensured by regulation under the national spatial planning law along with subsidies and covenants between different public actors, leading to the development of new towns and local growth centres in the 1970s, and extending to brownfield and greenfield sites from the mid-1990s. Since then, agreements have been made with private developers, who committed themselves to housing developments in exchange for subsidies for land and infrastructure (e.g. sanitation, public transport), under local area planning restrictions.

Generally speaking, the prevailing arguments in favour of compact development are: It can reduce energy, make public infrastructure investments more viable, reduce land usage, and preserve agricultural and natural areas. It has been positively associated with social diversity and cultural and economic development (Burton 2000). Clearly, proponents also maintained the positive correlation between compact urban form and a decrease in transportation needs, particularly car dependence. Viewed from a city level and a fixed point in time, compactness seems indeed to produce less automobile travel. However, long-term spatial development patterns are increasingly moving towards regional interdependencies, which makes the issue more complex (Scheurer 2007).

Compact city implementations were trial-and-error processes and policy enactments seem to often have preceded research insights. Regarding mobility, research has shown that socio-economic and cultural aspects have been underestimated. Income and car ownership are often more influential on travel behaviour than urban form is (Dieleman et al. 1999).

Governance and policy momentum. Since the period of post-war construction, when the state and provincial levels exerted their influence through subsidies, regulations, traffic planning, and agricultural modernisation (Keleher 2012), spatial planning was largely institutionalised and centralised in the Netherlands. Planning policy and political discourses often merged. In recent years, neoliberal logics, which embrace an underlying belief in individual freedom and choice, have been reflected in market-oriented spatial planning approaches but also in support of individual motorised transport (Ziljstra and Avelino 2012).

A whole range of policy measures to control urban sprawl were designed and put into action in the past. Regarding mobility, the *Fourth Report on Physical Planning* (1991) was perhaps the most significant policy document. Its policy dictated that the distance between place of residence, work, and services must decline by making locational choices subservient to considerations of mobility. Additionally, the use of public transport, cycling and walking should increase at the expense of car use. The *ABC location* policy was key here. *A* locations were central sites, often close to main railway stations and readily accessible by public transport. *B* locations—typically situated in nodes outside the larger centres—were reasonably well connected to public transport and accessible by car. *C* locations had good motorway access (Schwanen et al. 2004). The intention was to direct employment and public services towards *A* and *B* locations. Partly because of the attractiveness of *C*-locations and the fact that *B*-locations were often underserved, this policy failed in terms of mobility and led perhaps to even more car-dependent commuting patterns (Alpkokin 2012; Schwanen et al. 2004). The fourth planning term ended in the early 2000s and national transport policy abandoned the aim of a modal shift away from the car (van der Burg and Dieleman 2004).

Overall momentum. In terms of its development, the compact city can be considered a niche of the past (1960s-1990s) that has achieved a substantial degree of momentum in the Netherlands, influencing local planning regulations and practices through the national government's continuous reinforcement, along with extensive support and the involvement of major regime actors (e.g. local authorities, developers). Following disappointment as to the original objectives, support has dwindled and compact development ambitions have been revised. This has created space for the institutionalisation of the network city model, which is compatible with recent developments towards more market-led spatial planning.

2.6.2 Alignment with regime and landscape developments

The compact city departed substantially from automobility, and was meant to contribute to reducing car dependence. However, its experimental implementation in the Netherlands may have led to greater car-dependency, hence denoting a strong alignment with automobility practices.

2.6.3 Feasibility of breakthrough

Carsharing enjoyed moderate amount of momentum in the past, substantially influencing spatial planning principles and their implementation in practice. It was meant to radically address some of the issues with automobility, and so was only possible with strong policy support. Following disappointment as to its original objectives, support has dwindled and compact development ambitions have been revised.

2.7 Analysis of niche-innovation breakthrough potential

In this section, we provide an assessment of potential for breakthrough for each niche-innovation, based on the consideration of niche momentum and (mis-)alignment with regime, as discussed above. The results are presented in Table 5, which also tries to assess momentum by using a rating.

Table 5: Breakthrough potential analysis of 6 niche-innovations in the mobility domain in the Netherlands

Niche innovation	**Internal momentum**	**Alignment with broader regime characteristics and developments**	**Likelihood of imminent breakthrough (and/or future potential)**	**Pathway A or B (or mixed)**
Battery electric vehicles (BEVs)	**Moderate** Potential for **high momentum** in near future	Moderate alignment: - 'greening of car' - lack of infrastructure - political will	Moderate to high	A with elements of B

Hybrid electric vehicles (HEVs)	High (beyond niche)	High alignment (proven)	High but capped (upper limits to further expansion?)	A
Hydrogen fuel cell vehicles	Very low	Moderate alignment: - ‘greening of car’ - no of infrastructure - no exposure	Currently low Hopeful monstrosity?	A with elements of B
Biofuels	Moderate	Moderate/low alignment: - ‘greening of petrol’ - ‘greening of car’? - legitimacy hurdles	Moderate/low	A with elements of B
Carsharing	High	Moderate alignment: - no technological or policy challenge - behavioural change	Moderate to high, but capped	B with elements of A
Compact cities	Moderate (past)	Initially low but turned upside down	Very low (unsuccessful niche of the past	A but could have enabled B

3 Assessment of regime reorientation

The analysis presented in this section is structured around trends in mobility regimes presented in D2.2, and seeks to address two main research questions:

1) Are these trends continuing as Business as Usual, with limited regime change to address environmental problems?, or
2) Are existing regime actors implementing incremental changes to address environmental problems?

We analyse the following regimes and subaltern regimes:

- Automobility
- Public transport
- Cycling

3.1 Current trends in automobility

As described in PATHWAYS Deliverable D2.2, the automobility regime is facing a number of challenges. External pressures (environmental problems, saturating markets) and internal tensions (falling profit margins, fierce competition, etc.) have created difficult times for the automobile industry since the late 1990s. Alongside these changes, a number of alternative mobility practices and innovations are emerging that may open up significant new paths beyond automobility. The stabilisation of car use growth and ownership has been interpreted by Van de Waard et al. (2013) as a sign of 'saturation' of the car system, which can mainly be explained by changing mobility patterns (especially younger adults) and the rise of the Information Society. The gradual introduction of automobile restrictive policies in the Netherlands, such as rising fuel taxes and restrictions on parking and driving in urban areas, are gradually challenging the functionality of automobility.

Challenges to the automobility regime are also creating more space for alternative modes of transportation in subaltern regimes (e.g. public transport, cycling, walking), especially in urban areas. This is a two-way process: The more users adopt alternative mobility practices, the more convenient and acceptable these alternative regimes become, and the lesser the car's hegemony becomes in the multi-regime mobility scene.[5] Over the last 30 years, however, most of the increase in public transport has not replaced automobile usage but rather short distance cycling, walking, and student mobility via monthly passes (Alpkokin 2012).

At the same time, the automobile industry is trying to fend off these pressures via market and innovation strategies, addressing different threats.

Automobility regime change is likely to unfold as it may involve one of the following paths:

1) ***Incremental change and adaptation***. Wells et al. (2012) suggest that the current levels of pressure around the climate problem is overwhelmed by the sheer size and power of the automobile industry, which is likely to continue pushing for a 'greening of cars' trajectory, rather than more radical transformation.

[5] In the mobility domain, one should, however, keep in mind that mobility modes are often combined and overlapping, rather than mutually exclusive—whether in terms of infrastructure or in terms of individual practices—which complicates the identification of causal mechanisms in the adoption of alternative technological devices.

This path includes a number of innovation strategies pursued by the automobile industry over the last decade: improved engine performance (more efficient vehicles) and environmental performance (qualified by success with reducing polluting emissions[6] but no breakthrough with CO2 emissions which require more systemic change); a trend towards greater in-car information and communications technologies (ICT); and safety devices (Geels 2012). Such innovations can be seen as 'add-ons' that locally improve performance and attractiveness or isolate issues in a piecemeal fashion, temporarily addressing contradictions (Wells et al. 2012), rather than questioning the viability of the regime and engaging with developing sustainable mobility solutions for which so many interlinked barriers (technological, infrastructural and institutional) remain (Farla et al. 2011).

This is a trajectory that the automobility regime is clearly engaged on, which is not much different from business as usual and is unlikely to deliver substantially on decarbonisation targets.

2) ***Radical transformation***. If techno-economic and socio-political pressures become overwhelming, and substantial momentum is gathered in favour of new forms of mobility, we could see a fundamental transition unfold. Such a radical transformation could take up and compose with a number of emerging trends and innovations including new engines, vehicles, infrastructures, forms of ownership and organisation, services (Hyard 2013), norms and values, etc. (or any combination of the above). The lead actors driving such change could be:

2a) *New fringe players*. More radical innovation tends to come from new players, often stemming from outside the existing regime (see emerging trends in different niches described in PATHWAYS D2.1), or

2b) *Absorbed by automobile industry*. There is evidence of increasing interest from the traditional manufacturers to acquire new skills, competences and capabilities to cope with the demands for radical new forms of mobility. This is likely to occur through the acquisition of new companies dealing with radical mobility solutions.

FHA (2010), in a similar vein, suggests broadly two main adaptation strategies in the automotive sector: 1) a boost to developments already underway before the crisis (reducing vehicle weight, increasing the efficiency of ICE powertrains, cost reductions and more attention to global competitiveness, and 2) more radical change, involving paradigm shifts in the provision of mobility solutions (alternative propulsion technologies, redesign of supply chains, linkages between vehicles and infrastructure, new earning models for incumbents and new entrants).

The Dutch automobility regime has not yet embarked on a radical transformation trajectory, but there are encouraging signs that such paths may be opening up, particularly in the context of affluent urban areas, and amongst younger generations.

3.2 Current trends in public transport and cycling

3.2.1 The public transport regime in the Netherlands

As described in PATHWAYS Deliverable D2.2, public transport is thoroughly developed in the Netherlands with a number of options filling different market segments. While train is mainly used for commuting purposes (with over 50% of trips for this purpose) (KiM 2013),

[6] The recent scandal around Volkswagen's trumpeting of vehicle emissions testing (potentially an industry-wide practice) has put into question the industry's track record, and the current ability to enforce environmental standards.

the motives for bus, tram or metro uses are more varied. Every day in the Netherlands, 1 million journeys are made by train while 4.5 million journeys are made by bus, tram or metro (Ministry of Transport, Public Works and Water Management 2010).[7] Public transport use varies significantly with respect to urban concentration, with most bus, tram and metro journeys in denser areas.

Railways. Rail is the main public transportation means for long-range mobility, with a national network covering all major cities. Train is a functional option for travel between cities. With a large proportion of the population living in urban areas, train use is larger than in most European countries. Since 2001, overall quality of service has been substantially improved. The railway system is almost fully separated from the automobility regime although both have contributed to exponential growth in land-based mobility throughout the twentieth century and literally changed our relationships to the territory (e.g. travel, commute). The railway network covers most of the national territory with most mainlines being covered by NS, and secondary routes by a range of operators via regional and local railways lines.

Tram. While having very little overlap with automobility, the tram system bears much resemblance to the train system. It operates, however, at a much more local level (mostly urban), implying regional or municipal oversight, and a much smaller scale (networks and passengers) although there is some flexibility such as the Rotterdam-The Hague train-tram line.

Buses. The bus system shares technical and infrastructure elements (roads, petrol fuel, ICE) and some industry actors with the automobility regime (industry, road maintenance authority, etc.) but falls under the umbrella of public transport in terms of dedicated policy (subsidies, pricing, zoning, relevant authorities) and symbolic representations ('people transport', slow, set line and frequency, relative reliability, etc.). It increasingly benefits from dedicated lanes avoiding congestion and better punctuality. Bus routes and their relatively low infrastructural requirement provide much more flexibility in planning and operations than railways. This makes buses a mode of choice for both urban and lesser populated areas. Buses cover much shorter distances than the main train lines, and operate at a much more local level. There have been important efforts in recent years to improve the integration of train and bus services and routes in order to avoid duplication and make connections easier.

Public transport integration and multimodality. The Netherlands provides an interesting exemplar of a highly integrated public transport system offering different modes across the territory. There is a long tradition of both urban planning and public transport management. A number of trends and processes are worth highlighting here:

1) the importance of multimodality as illustrated by the diversity of transportation modes used to and from train journeys (Figure 1), with cycling and light public transport (bus, tram metro) making up a high proportion.

[7] The total population of the Netherlands is 16.5 million.

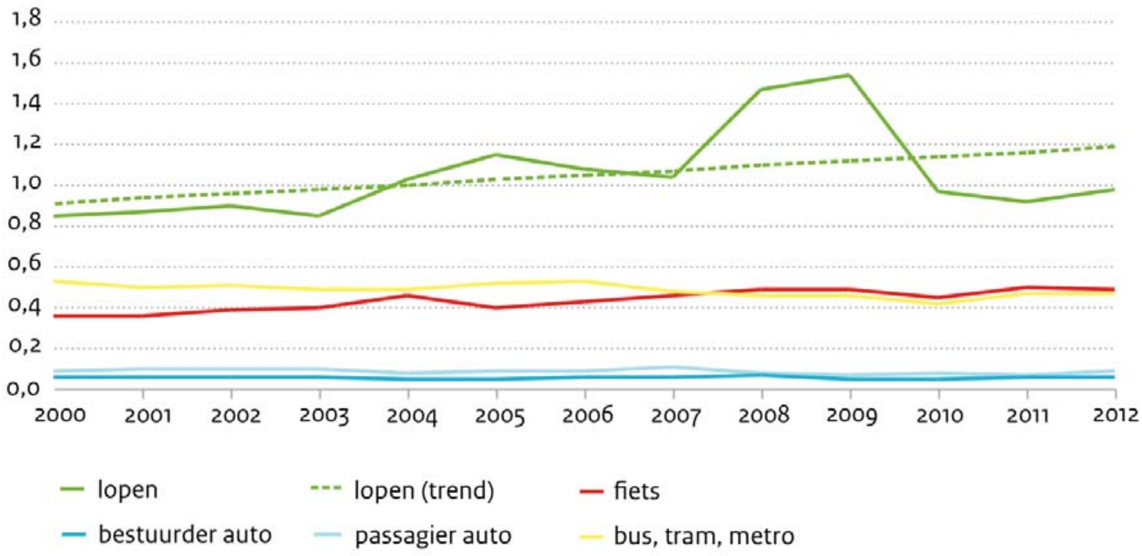

Figure 1: Modes of transportation to and from train journeys in the Netherlands[8] (Kim 2013:34)

2) the development of dedicated infrastructure, particularly in terms of facilitating integration of railways with car and cycling (cycle sheds, park and ride). Increasing the ease of connection between rail and other means to personal transport. A substantial parking infrastructure has been developed around train stations. This concerns both car use (Park and Ride) and cycling (cycle sheds). The extent and size of cycle sheds in major Dutch railway stations is without precedent or international comparison. Since 2000, more than 100,000 unmonitored and more than 25,000 monitored cycle shed spaces have been created, and an additional 100,000 new spaces are being planned (Ministry of Transport, Public Works and Water Management 2010).

3) concerted integration efforts between different public transportation modes. For instance, the 'fishbone integration principle' is sought for linking buses to mainline trains in more rural areas through 'feeders' (see right-hand of Figure 2)

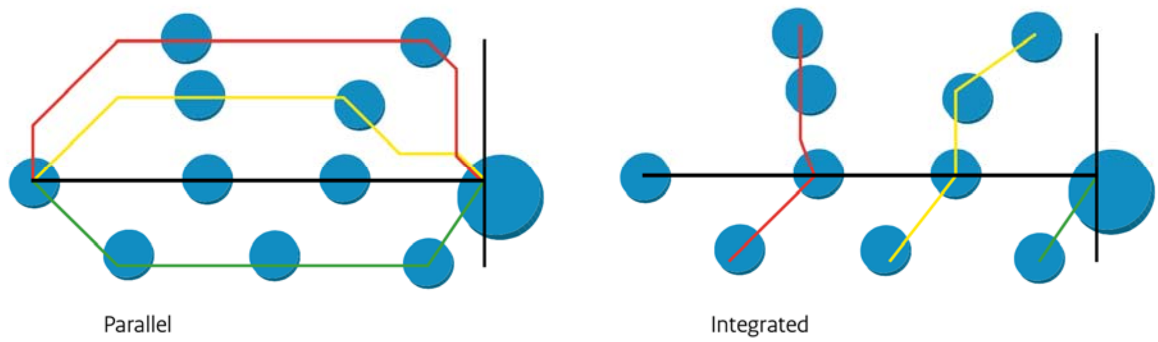

Figure 2: Parallel versus integrated bus and train services (Ministry of Transport, Public Works and Water Management 2010:77)

[8] Legend (from top left to bottom right): walking; walking (trend); cycling; car (driver); car (passenger); bus; tram; metro.

4) Ticketing simplification: The introduction of universal ticketing and tariffs in gradual steps since the 1980s has led to highly efficient and convenient public transport in the Netherlands. A national ticket, related to distance zoning, has bee introduced in 1980 and can be used in all bus, tram and metro as well as some rail services across the country. A similar system is in place specifically for the railways. More recently, thanks to improvements in ICT and logistics, a contactless electronic transport chip card (the OV Chipkaart) has been introduced, allowing universal access and ease of payments across all public transport services. The card can be topped up online or at dedicated points. This technology and supporting infrastructure has been generalised throughout the country, covering all users since July 2014.
5) Reliable travel information on multiple platforms. The tremendous improvements and diffusion of ICT in recent years (e.g. the widespread use of smart phones) have allowed public transport operators to provide real-time travel information, which is greatly enhancing ease of use and passenger experience.

Public transport governance. Public transport is an integrated and coherent affair in the Netherlands, with a strong role for public planning and harmonisation. While concessions have been opened to tenders for the operation of services, the Netherlands is striking in its ability to retain public control over public transport (from national government down to municipalities). Public transport is clearly seen as an area of public utility for which lasting support and continuity can be expected. The main rationales for public policy related to public transportation in the Netherlands are to improve accessibility (e.g. though improved speed, reliability and predictability), to provide a diversity of options (and alternatives to car-based transportation in light of negative effects like congestion), to improve overall wellbeing, and to maintain a high comfort and safety record. These objectives have been set out in two main recent strategic policy documents: Nota Mobiliteit (2004) 'Towards reliable and predictable accessibility", and Mobiliteitsaanpak (2008) 'Safely and smoothly from door to door" (Ministry of Transport, Public Works and Water Management 2010). An implicit objective of public transport policy in the Netherlands is to attract more users.

3.2.2 The cycling regime in the Netherlands

Cycling is technologically very different from the automobile although it shares the same basic components (wheels, rubber tires, etc.), partly uses the same infrastructure (roads and streets), and is associated with notions of freedom and individuality. Because traditional bicycles are human-powered, it tends to be a mobility mode with range restrictions (typically under 10km). While cycling may be associated with danger and inconvenience in specific national settings, a combination of long-standing cultural acceptance, high-density territorial organisation and dedicated infrastructure makes it a mobility mode of choice in the Netherlands, representing the highest cycling rate in Europe with 26% of all journeys (KiM 2013).

Dutch cities have long been seen as models for cycling developments throughout Europe (Oldenziehl and de la Bruhèze 2011). Interestingly, as can be seen from Figure 3, while bicycle use was very popular in the first half of the twentieth century, it has experienced a sharp decline from the 1950s to the 1970s throughout European capitals. This can be quite clearly attributed to pro-car urban planning. From the 1970s onwards, a countermovement emerged to reclaim urban cores and seek benefits in terms of urban life, health, and environment. Activists "demanded a regime shift from car-governed cities to public transport, bicycle-, and pedestrian-governed cities" (Oldenziehl and de la Bruhèze 2011:40). The development of cycling lanes infrastructure in Dutch and Danish cities have led to a larger number of cyclists.

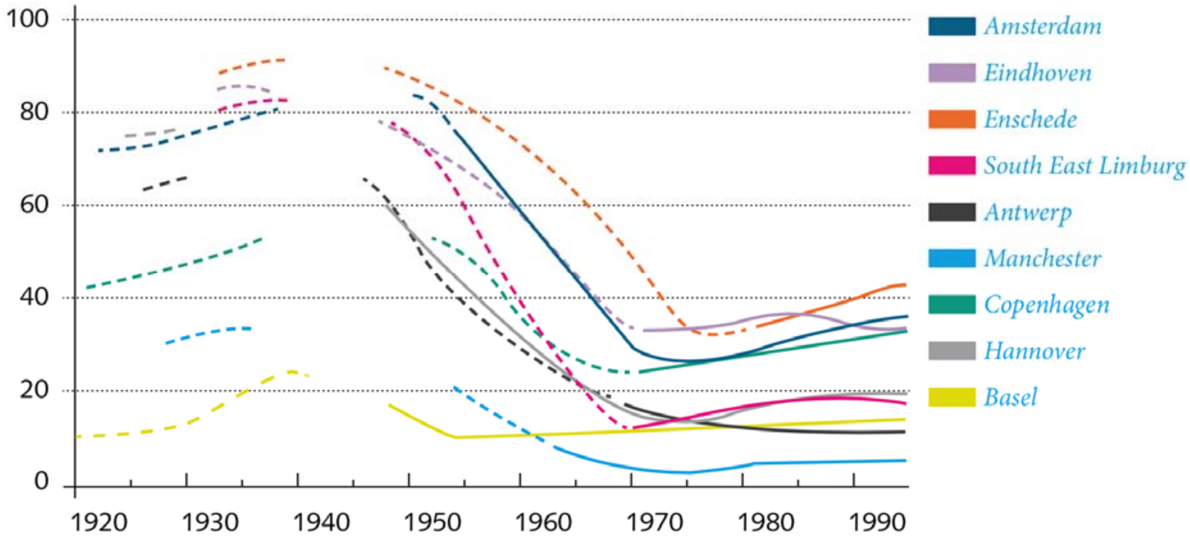

Figure 3: Historical development in bicycle share in 9 European cities (de la Bruheze and Vervaart 1999).

There are 18 million bicycles in the Netherlands. This number is so large that bicycle-related congestion is common in some areas. Cycling generates a major commercial market with more than 1million bicycles sold yearly. 1.04 million bicycles were purchased in 2012, 16% of which were e-bicycles. In fact, e-cycling is thought to be the main reason for increased cycling rates in recent years (KiM 2013). Despite allowing for cyclists to cover far greater distances (beyond 10km), the advent of e-cycling does not seem to be replacing car journeys but rather conventional bicycle journeys, especially over longer distances (KiM 2013). E-cycling seems to have led to more homogenous cycling speeds (as predominantly older e-cyclists are enabled to follow average cycling speeds of ca. 15km/h).

Infrastructure. Perhaps the most enabling aspect of cycling support in the Netherlands is the infrastructure, which has raised the standards of safety and functionality of this mode. Accumulated experience with cycling infrastructure and integrated traffic planning across all modes have resulted in comprehensive and highly functional cycle lanes, which minimise conflicts between different road and street users (motorists, pedestrians, and public transport). The Netherlands hosts a comprehensive network of 35,000 kilometres of bicycle paths, including 1) bicycle paths that are physically separate from other traffic (e.g. by verge or hedge), 2) on-road bike lanes demarcated on the ground (these are gradually being replaced by separate bicycle paths in cities like Amsterdam), and 3) cycling highways, which are mostly for commuting purposes. These are wider in order to accommodate overpassing, of better quality, and largely devoid of crossings. As a result, the safety record of cycling in the Netherlands is the highest in the world, with only 1.1 fatalities per 100 million km cycled (Pucher and Buehler 2007). There is a strong positive relationship between bicycle safety and bicycle usage, as greater safety comes with exposure (mediated by infrastructure investments).

Enabling factors and conditions. Civil society played a critical role in the reinvigoration of a cycling culture in the Netherlands. More importantly, environmental activities, together with cycling clubs, successfully lobbied government and planning authorities, and achieved the rollout of a consistent cycling infrastructure (cycling lanes, cycle parking, etc.) throughout the country. Hickman (2013) evokes the existence of a deep-seated ‘cycling culture’ in the Netherlands. Cycling is an integral part of the Dutch landscape—urban and rural. The bicycle has become a cultural reference for Dutch cities throughout the world, contributing to its image, but also export of know-how. More importantly, the bicycle is deeply seated in individual habits and daily practices, and an inherent part of the social fabric.

Cycling policy and governance. In the Netherlands, cycling policy results from a combination of national and local government but municipalities are the main actor in implementing cycling policy. In reaction to the detrimental effects of car-centred urban developments in the 1950-1975, the Netherlands experienced a "massive reversal in transport and urban planning policies" (Pucher and Buehler 2008). In 1975, at a time where inner cities were experiencing a revival, a large-scale cycling policy was initiated that focused especially on the rollout of bicycle lanes and bicycle parking spaces. In the 1990s, a new wave of improvements was initiated via the 'masterplan bicycle' with focus on local initiatives to further raise the attractiveness of the bicycle through improved lanes, parking space, safety and reduced thefts (de Vos 2015). More recently, further improvements of infrastructure quality have been pursued. Overall, success is attributed to the "attractive design of roads and bicycle lanes together with promotion of this travel mode" (de Vos 2015:187).

Cycling lanes, rather than an environmental measure per se, have been implemented as a way to minimise congestion and conflicts between road and street users. The success of cycling policy can be linked to the quality of infrastructure, which can be measured via the bicycle Balance Score. Higher scoring municipalities – usually those with longer-term experience – have higher bicycle usage shares than other cities (Ministry of Transport, Public Works and Water Management 2009). The Netherlands has developed a number of incentives to encourage bicycle use. These include tax exemptions via a cycle-to-work scheme as well as a tax-free commuting allowance, which financially rewards employees cycling to work (at EU 0.19 per km) (Kozluk 2010).

3.3 Potential for reorientation

In this section, we summarise findings concerning regime trends (in Table 6), before discussing regime reorientation potentials ahead.

Table 6: Assessment of regime trends in the mobility domain in the Netherlands (with indicative 'scores')

	Lock-in, stabilizing forces	Cracks, tensions, problems in regime	Orientation towards environmental problems	Main socio-technical regime problems
Automobility	Strong	Moderate	Moderate (some incremental change towards 'greening of cars')	Continued political support No urgent threat
Public transport	Strong	Weak (integrated and coherent planning)	Strong (regime oriented towards leaner mobility) Potential for further improvements (low-carbon for motorized transport, 100% renewable electricity for rail-based)	Cost (travel and investment) Inconvenience in less dense areas
Cycling	Strong	Weak	Strong (zero-carbon option)	Inconvenience, particularly over longer distances (addressed via multi-modality and electric cycling)

3.3.1 Automobility – challenges ahead

The existing automobility regime in the Netherlands is deeply entrenched and relatively stable. It is stabilised by reinforcing initiatives and institutions that contribute to existing lock-in. These include: a powerful industry, continued technical improvements and sophistication, and supporting policies. Despite strong inherent stability, the automobile regime in the Netherlands is showing some signs of change. Recent trends point to increasing recognition of external pressures and challenges by the automobile industry itself, with greater attention to environmental and safety issues, innovation strategies geared towards lesser emissions (catalytic converters), fuel efficiency improvements, the exploration strategies with different alternative fuels, and the emergence of new business models for mobility. The emission intensity of new cars is steadily decreasing.

There are signs of change ahead, as the prevailing automobile regime is increasingly being challenged on environmental, convenience, safety, economic, and technological grounds, as well as a growing disinterest in car ownership among younger people in the Netherlands. Most responses so far, however, are currently met by regime incremental responses, which points to an **incremental regime change pathway**, in a context of continued policy support and little urgency for radical transform.

3.3.2 Multimodal mobility – opportunities for sustainable mobilities

Other mobility modes are also readily available alternatives to automobility in the Netherlands. Their relative importance is likely to increase with restrictive policies on the car. Multimodal mobility is likely to gain importance as individuals seek alternatives to automobility yet need to combine long- with short-range trips. At present, multi-modal journeys in the Netherlands mostly combine intercity rail travel with other forms of transportation (around ½ walking, ¼ cycling, ¼ other public transport and 5% automobile) (KiM 2013:34).

3.3.2.1 <u>Public transport</u>

Overall, public transport is an integrated and coherent affair in the Netherlands with a strong role for public planning and harmonisation. The Netherlands is striking in its ability to retain public control over public transport (from national government down to municipality), which is one main reason why lasting support and continuity can be expected. Multimodality has been successfully supported (e.g. through integration and simplification of ticketing and fares; increasing ease of connection between modes of transport). To date the emerging issues have been successfully addressed as they have emerged.

Public transport is always a leaner alternative to car use. The train is considered to lead to around 75% less CO_2 emissions per passenger-km in the Netherlands. NS is planning a full transition to 100% green-powered electric trains by 2018.[9] Public transport has had a pioneering role in trialling cleaner fuels in the Netherlands. A number of bus lines operate on hybrid or natural gas engines, and there are plans to experiment with biogas on a wide scale.

3.3.2.2 <u>Cycling</u>

The Netherlands has the highest cycling rate in Europe; cycling is culturally deeply embedded and has profited from successful policy interventions. The Netherlands has a well-

[9] http://nsjaarverslag.nl/jaarverslag-2014/s1438_reizigers/a1380_Duurzame-mobiliteit

established extensive, safe and convenient cycling infrastructure network, all of which contributes to a strong stability of this regime. In recent years, e-cycling has been replacing some conventional bicycle journeys, particularly over longer distances and in older age groups.

The Netherlands is striking as a leading example in terms of the highly stable role of cycling, its integration in landscape, infrastructure, culture and lifestyle. The co-existence of cycling with other mobility modes in urban centres and for short-distance commuting is unprecedented in Europe, perhaps with the exception of Denmark. These two countries are decades ahead in the integration of cycling as a credible mainstream mobility alternative, and have accumulated a wealth of technical, administrative and policy experience in how to deal with this mode.

The cycling revival in the Netherlands over the past 4 decades can be seen as an exemplar of mobilisation and mobility transformation driven by 1) societal concerns (a mixture of safety and environmentalism), 2) strong policy involvement, and 3) the crucial role of infrastructure. It also is a telling (and hopeful) example of how leaner and greener alternatives may become deeply embedded in society. However, it is important to recognise that cycling (however widespread in the Netherlands) has not yet managed to substantially displace automobility although it may have contributed to the tempering of its growth.

There are opportunities ahead with 1) the rapid deployment of markets for electric cycling that contributes to displacing ever-longer commuter journeys, and 2) the combination of cycling and public transport that enables high degrees of flexibility in transport patterns.

4 Conclusions and wider discussion

4.1 Some niches have a strong breakthrough potential

A number of niche-innovations discussed in section 2 have a particular potential for breakthrough:

- HEVs are arguably the most advanced proposition. They have entered the market a decade ago, aided by subsidies and an eagerness (following from initial resistance) for most manufacturers to develop HEV models, and now contribute to a non negligible market share. HEVs currently have high momentum, and are well aligned with the prevailing automobility regime. Arguably, they have already broken through, and are likely to continue growing and contributing an increasing share of automobility. However, recognising their stepping-stone quality and their capped contribution in low-carbon transitions, it is also unlikely that HEVs will stabilise and remain relevant in the long-run.
- EVs have greater carbon reduction potential, and are developing fast in the Netherlands, which is the largest market in Europe, with nearly 20,000 new registered vehicles in 2013 (McKinsey 2014). The critical breakthrough consideration here concerns the deployment of charging infrastructure, something towards which national and local governments have set ambitious targets. EVs have gained additional recent momentum with the development of new opportunities and business models, e.g. innovation in charging services and linkages with electricity companies, as well as involvement of major automotive players.
- Carsharing is another promising niche innovation in the Dutch context, with rapidly growing adoption numbers. The innovation is comparatively less aligned with the automobility regime, as it does not fall within a ‘greening of cars’ narrative and presupposes important behavioural changes. Nonetheless, it is broadly in tune with a number of deeper landscape changes in consumption modes towards more collective practices of sharing, and presents some potential linkages with subaltern mobility regimes in the context of multi-modal transport – which is well developed in the Netherlands. Carsharing presents an interesting linkage to automobility regime transformation, as it provides new criteria[10] for the deployment of radical innovation in vehicles technology.
- It is yet unclear whether carsharing has the potential to be adopted more widely, and it is only through

4.2 What kinds of pathways?

So, there are encouraging signs of innovation-led changes ahead with respect to automobility. However, the more promising innovations analysed (those with most momentum) are aligned with a ‘greening of cars’ trajectory, which can be predominantly related to a Pathway A type development:

- Hybrid electric vehicles have many elements of a Pathway A development insofar as they are an add-on technology that complements existing ICE engines with an electric drivetrain, and are developed by large incumbent car manufacturers without challenging prevailing notions about automobility or its underlying infrastructure. They however provide an interesting ‘stepping stone’ opportunity towards BEVs.

---

[10] See Kemp and van Lente (2011).

- Battery electric vehicles have many elements of a Pathway A development insofar as they offer substantial improvement of propulsion technology within the frame of existing automobility (component substitution), and that most existing car manufacturers are now involved. However, they also have elements of a Pathway B development because they have been spearheaded by and generate space for new entrants, they require massive investments in charging infrastructure for which public authorities are most likely to be involved, they currently challenge drivers by requiring them to overcome or address their range anxieties, and are developing hand in hand with new forms of (service-oriented) mobility.
- Carsharing has many elements of a Pathway B development insofar as it is centred on new ways of considering (auto)mobility, operating a shift from material ownership to on-demand service, involves new entrants (fleet managers), encourages and builds on innovation across domains (e.g. ICT-intensive, compatibilities with BEVs, etc.), and is in greater alignment with visions of multi-modal transport. However, it also presents elements of a Pathway A development, insofar as it is based on automobility.

4.3 Wider discussion

Measuring the scale of the transition challenge. More radical pathways stepping away from automobility altogether are still difficult to envision at the horizon, as there is currently no materialisation of a fundamental questioning of automobility. Automobility is not challenged in mainstream discourse, and there is a relative shyness of policy to aggressively challenge a mobility mode that is still perceived as convenient by a majority of the Dutch population. There are promising exceptions to this (e.g. urban cores and younger generations, and general saturation) but these are not strong enough to overcome a generally risk-averse policy system that is generally happy to be seen actively promoting hopeful alternatives (EVs, multimodality) on discursive levels, but not yet ready to deliberately accelerate the destabilisation of automobility. In this context, we are likely to see Pathway A-type developments thriving, along with an increased contribution of new mobility modes, but may have to wait before we see a serious and unavoidable challenge to automobility in the Netherlands.

It is unclear that under these conditions we may achieve decarbonisation objectives in automobility. At any rate, we should be wary of even ambitious full electrification plans, as they may lead to the displacement of carbon and sustainability stress elsewhere, e.g. in the electricity domain, but also in resources related to the booming battery industry.

Enabling trends. Nevertheless, the Netherlands is striking as a context that has made a head start towards sustainable mobility by 1) supporting the strong development of multiple modes of mobility, 2) seeking leadership in sustainable mobility innovation, and 3) hosting a variety of local and national coalitions pressing for greater efficiency and sustainability of transportation. These crucial developments are signs of a deep reflection within Dutch society about fostering greater flexibility of options for mobility, with particular emphasis on efficiency, accessibility (territorial and social), safety, and environmental concerns. A highly stable and effective public transport system, a mature cycling infrastructure, and an inclination towards multi-modality are deeply entrenched part of mobility practices in the Netherlands. They provide fertile ground for stepping away from unsustainable automobility.

So, the Netherlands is perhaps best positioned in Europe to enable and support sustainable mobility transitions in the medium to long term. Crucial requirements ahead are greater policy clarity and coherence about no longer supporting automobility-as-usual, and embracing the sustainable mobility possibilities in the making.

References

Alkemade, F., Suurs, R.A.A., 2012. Patterns of expectations for emerging sustainable technologies, *Technological Forecasting & Social Change*, 79, 448-456.

Alpkokin, P., 2012. Historical and critical review of spatial and transport planning in the Netherlands. *Land Use Policy* 29, 536-547.

Bohnsack R., Pinkse, J., Kolk, A., 2014. Business models for sustainable technologies: Exploring business model evolution in the case of electric vehicles, *Research Policy*, 43, 284–300

de la Bruheze, A.A., Vervaart, F.C.A. 1999. *Bicycle traffic in practice and policy in the twentieth century*.

Budde, B., Alkemade, F., Weber, K. M., 2012. Expectations as a key to understanding actor strategies in the field of fuel cell and hydrogen vehicles, *Technological Forecasting & Social Change*, 79, 1072-1083.

van der Burg, A.J., Dieleman, F.M., 2004. Dutch urbanisation policies: From "compact city" to "urban network". *Tijdschrift voor Economische en Sociale Geografie*, 95(1), 108–116.

Burton, E., 2000. The compact city: Just or just compact? A preliminary analysis. *Urban Studies*, 37(11), 1969–2006.

Dieleman, F.M., Dijst, M.J., Spit, T., 1999. Planning the compact city: The randstad Holland experience. *European Planning Studies*, 7(5), 605–621.

Dijk, M., 2011. Technological frames of car engines. *Technology in Society*, 33, 165-180.

Dijk, M., Yarime, M., 2010. The emergence of hybrid-electric cars: Innovation path creation through co- evolution of supply and demand, *Technological Forecasting & Social Change*, 77, 1371-1390.

European Commission, 2013. *EU transport in figures. Statistical pocketbook 2013*, European Union, available at: http://ec.europa.eu/transport/facts-fundings/statistics/doc/2013/pocketbook2013.pdf

Farla, J., Alkemade, F., Suurs, R., 2011. Analysis of barriers in the transition toward sustainable mobility in the Netherlands, *Technological Forecasting & Social Change* 77, 1260-1269.

FHA (Federatie Holland Automotive), 2010. *Vision for the Dutch automotive sector 2010-2020: From vehicles to mobility: driving for value*.

Geels, F.W., 2012. A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. *Journal of Transport Geography* 24, 471-482.

van Grinsven and Kampman 2013

Hajer, M. and Zonneveld, W., 2000. Spatial planning in the network society - Rethinking the principles of planning in the Netherlands. *European Planning Studies*, 8(3), 337–355.

Hanssen, G.S., Hofstad, H., 2013. Compact city policies in England, Denmark, the Netherlands and Norway. *NBR-rapport*, 30. Norwegian Institute for Urban and Regional Research, Oslo.

Hickman, R., Hall, P., Banister, D., 2013. Planning more for sustainable mobility, *Journal of Transport Geography*, 33, 210-219.

Hofstad, H., 2012. Compact city development: High ideals and emerging practices. *European Journal of Spatial Development*, 49, 1–23.

Hyard, A., 2013. Non-technological innovations for sustainable transport, *Technological Forecasting & Social Change*, 80, 1375-1386.

IEA, 2010. Hybrid and electric vehicles: the electric drive advances, *IA-HEV Annual Report 2009*

Keleher, K., 2012. Green heart attack: An environmentalist's eulogy for the Randstad, Dutch grand planning, and the compact city. *Macalester International* 30(11), 110-131.

Kent, J., Dowling, R., 2013. Puncturing automobility? Carsharing practices, *Journal of Transport Geography*, 32, 86-92.

KiM (Kennisinstituut voor Mobiliteitsbeleid), 2013. *Mobiliteitsbalans 2013*, Ministerie van Infrastructuur en Milieu, available from www.kimnet.nl

Köhler, J., Schade, W., Leduc, G., Wiesenthal, T., Schade, B., Espinoza, L.T., 2013. Leaving fossil fuels behind? An innovation system analysis of low carbon cars, *Journal of Cleaner Production* 48, 176-186.

Kozluk, T., 2010. How the Transport System can Contribute to Better Economic and Environmental Outcomes in the Netherlands, *OECD Economics Department Working Papers*, No. 804, OECD Publishing.

Loose, W., 2010. The state of European car-sharing, Final Report D2.4, momo Car-Sharing project, Bundesverband CarSharing e.V.

Lovio, R., Kivimaa, P., 2012. Comparing Alternative Path Creation Frameworks in the Context of Emerging Biofuel Fields in the Netherlands, Sweden and Finland, *European Planning Studies*, 20(5), 773-790.

Marletto, G., 2014. Car and the city: Socio-technical transition pathways to 2030, *Technological Forecasting & Social Change*, 87, 164-178.

McKinsey 2014. *EVolution. Electric Vehicles In Europe: Gearing Up For A New Phase?*, Amsterdam: Amsterdam Round Tables.

Ministry of Infrastructure and the Environment (MIE), 2011. *Summary national policy strategy for infrastructure and spatial planning: Making the Netherlands competitive, accessible, livable and safe*. Online: http://www.government.nl/documents-and-publications/publications/2013/07/24/summary-national-policy-strategy-for-infrastructure-and-spatial-planning.html.

Ministry of Transport, Public Works and Water Management, 2010. *Public transport in the Netherlands*.

Oldenziehl, R., de la Bruhèze, A.A., 2011. Contested Spaces Bicycle Lanes in Urban Europe, 1900–1995, *Transfers*, **1**(2), 29-49.

Orsato, R.J., Dijk, M., Kemp, R., Yarime, M., 2012. The Electrification of Automobility. The Bumpy Ride of Electric Vehicles towards Regime Transition. In: Geels, F.W., Kemp, R., Dudley, G., Lyons, G. (Eds.), *Automobility in Transition? A Socio-Technical Analysis of Sustainable Transport*. Routledge, New York.

Pucher and Buehler 2007. At the Frontiers of Cycling- Policy Innovations in the Netherlands, Denmark, and Germany

RAI, 2013. Duurzaamheidsmonitor: Mobiliteit 2013. RAI Vereniging & BOVAG, available at: http://www.raivereniging.nl/markt-informatie/publicaties/~/media/RaiAssociation/Files/webmaster/2013/Duurzaamheidsmonitor%202013.ashx

RAI, 2014. Mobiliteit in cijfers 2013/2014, BOVAG-RAI Mobiliteit, Amsterdam.

RVO, 2011. Electric Mobility gets up to speed. 2011-2015 Action Plan, available at: http://www.rvo.nl/sites/default/files/bijlagen/Action%20Plan%20English.pdf

RVO 2014. *Electromobility in the Netherlands. Highlights 2013*, NL Enterprise Agency, Utrecht.

Scheurer, J., 2007. Compact city development: How Europe rediscovered its history and met resistance. *The Urban Reinventors*, 2.

Schwanen, T., Dijst, M., Dieleman, F., 2004. Policies for urban form and their impact on travel: the Netherlands experience. *Urban Studies*, 41(3), 579–603.

Solomon, B.D., Banerjee, A., 2006. A global survey of hydrogen energy research, development and policy, *Energy Policy*, 34, 781-792.

Ulmanen, J.H., Verbong, P.J., Raven, R.P.J.M., 2009. Biofuel developments in Sweden and the Netherlands – protection and socio-technical change in a long-term perspective, *Renewable and Sustainable Energy Reviews*, 13(8), 1406-1417.

de Vos, J., 2015. The influence of land use and mobility policy on travel behavior: A comparative case study of Flanders and the Netherlands, *The Journal of Transport and Land Use*, 8(1), 171-190.

Wells, P., Nieuwhuis, P., Orsato, R.J., 2012. The Nature and Causes of Inertia in the Automotive Industry: Regime Stability and Non-Change. In: Geels, F.W., Kemp, R., Dudley, G., Lyons, G. (Eds.), *Automobility in Transition? A Socio-Technical Analysis of Sustainable Transport*. Routledge, New York.

Zijlstra, T., Avelino, F., 2012. A Socio-Spatial Perspective on the Car Regime. In: Geels, F.W., Kemp, R., Dudley, G., Lyons, G. (Eds.), *Automobility in Transition? A Socio-Technical Analysis of Sustainable Transport*. Routledge, New York.

Zubaryeva, A., Thiel, C., 2013. Analyzing potential lead markets for hydrogen fuel cell vehicles in Europe: Expert views and spatial perspective, *International journal of hydrogen energy*, 38, 15878-15886.