Transportation Research Part D 41 (2015) 160–164

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

Pathways for GHG emission reduction in Norwegian road transport sector: Perspective on consumption of passenger car transport and electricity mix

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ARTICLE INFO

Article history:
Available online 18 October 2015

Keywords:
Electric vehicle
Greenhouse gases
Climate change
Life cycle assessment
Electricity mix
Guarantee of Origin

ABSTRACT

Electrification of the transport sector is considered as a solution to reduce greenhouse gases (GHGs) emissions and achieve sustainable mobility. Specifically in the case of electrification of passenger vehicles, various industrial and policy initiatives have been introduced. In this article, we present and assess three approaches – *pro-technology*, *pro-simplicity* and *mix* (of the aforementioned approaches) – to achieve target emission reductions in the Norwegian road transport sector. We also assess the influence of including 'Guarantee of Origin' certification for the electricity production in accounting for typical consumption electricity mix in Norway.

Results show that for the same reductions in tail-pipe GHG emissions, pro-technology, pro-simplicity, and the mix scenario offer 22%, 29% and 28% reduction in the life cycle GHG emissions respectively, compared to the reference scenario in year 2020. However, the pro-simplicity scenario requires 25% reduction in vehicle-km driven compared to the pro-technology scenario, which provides the same passenger car mobility as in the reference case. When the GHG intensity of the electricity mix used to power EVs is corrected to account for actual consumption mix in Norway, a 13% reduction in the net GHG benefit of pro-technology scenario is observed.

Introduction

Use of electric vehicles (EVs) is proposed to provide a solution for reducing greenhouse gas emissions (GHGs) from the road transport sector. The Norwegian government supports the electrification of road transport as an important element in its policy aiming to achieve a reduction of 25% in comparison with the 2020 reference scenario, which projects the GHG emissions from the passenger car sector to increase to 8 Mt CO_2 eq/year (Norwegian Ministry of Transport and Communications, 2010). In our earlier work (Singh and Strømman, 2013), we developed scenarios for introduction of EVs in the Norwegian passenger vehicle fleet to achieve Norwegian GHG emission targets and assessed their environmental implications, over a broad range of impact categories. In addition to the Norwegian target, we also assessed a mid-term policy target as proposed by European Commission (2012), in line with the long term reductions deemed necessary for

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http://dx.doi.org/10.1016/j.trd.2015.09.028
1361-9209/

limiting global temperature change to 2 °C. Such reductions in the GHG emissions can be obtained via different strategies ranging from the perfect technical solution of zero-emission vehicles like electric vehicles or hydrogen vehicles where any CO_2 emission in production of electricity/hydrogen is sequestered or some renewable energy source is used for its production; shift toward an efficient public transport with high speed trains; urban planning to develop compact cities thereby reducing travel distances; radical shift in lifestyle so as to travel only when absolutely essential; and others or a combination of above mentioned different strategies (Holden et al., 2009).

In this article, we propose three pathways to attain emission reductions: (i) pro-technology – when the reduction is made possible by intensive introduction of new technology, (ii) pro-simplicity – when the reduction is made possible by avoiding consumption altogether and (iii) mix – by simultaneous introduction of electric vehicles and reduction in passenger car transport consumption. We apply these alternative approaches to develop scenarios for GHG reduction to reach the 2 °C target i.e. to reach the target of 4.2 Mt CO_2 eq tail-pipe emissions from passenger cars in Norway in 2020 (for more details refer scenario S3 in Singh and Strømman, 2013) and then evaluate their life cycle GHG emissions. We also study the role of the electricity mix, extending the perspective to the significant difference in primary energy source share in the consumption and production electricity mixes in Norway.

Method

Scenario projections

We develop three scenarios to reach the 4.2 Mt CO_2 eq emission target in 2020: *S*1 – pro-technology scenario – the tail-pipe GHG emission reductions is assumed to be made possible by intensive deployment of EVs in the passenger vehicle fleet; *S*2 – pro-simplicity scenario – the reduction is achieved by decreasing the mobility i.e. consumption of passenger car vehicle-km altogether, with no alternative transportation for the reduced demand from the passenger cars; and *S*3 – mix scenario – the tail-pipe GHG reductions from the passenger car sector are obtained by combining the EVs deployment as per Norwegian road transport electrification target (Singh and Strømman, 2013) and reduction of the passenger car mobility. In the reference scenario (*R*) where no such GHG reduction strategy is adopted coupled with a business-as-usual increase in demand and a 1% vehicle efficiency increase each year, the tail-pipe GHG emissions in 2020 are evaluated to be 6.1 Mt CO_2 eq (Singh and Strømman, 2013). Table 1 presents specific parameters for the different scenarios.

Table 2 presents the passenger car mobility available each year in the different scenarios and it is observed that the vehicle mobility demand needs to be reduced by 25% and 19% in 2020 for scenario S2 and scenario S3 respectively. For S1, the available passenger car mobility (vehicle-km driven) is assumed to be the same as in the reference scenario R.

Life cycle assessment

The vehicle inventory for life cycle assessment is based on the conventional vehicle (gasoline/diesel) and Li-NCM battery type electric vehicle inventories from Hawkins et al. (2013). The background electricity mix for use in the value chain is

Table 1
Parameters for different scenarios.

	Unit	2012	2020			
			R	S1	S2	S3
New gasoline vehicle efficiency	%	23	25	32	32	32
New diesel vehicle efficiency	%	23	24	32	32	32
CO_2 emission from new gasoline vehicle	gCO_2/km	132	122	95	95	95
CO_2 emission from new diesel vehicle	gCO_2/km	135	125	95	95	95
Electric car share in vehicle fleet	%	0.4	0.3	39	0.3	15

Table 2
Available passenger car mobility in different scenarios.

	2012	2013	2014	2015	2016	2017	2018	2019	2020
S1 pro-technology (same as in reference scenario – R)									
Million km	34,143	35,030	35,916	36,803	37,689	38,576	39,463	40,349	41,236
S2 pro-simplicity: with reduced mobility									
Million km	34,143	33,765	33,369	32,958	32,533	32,096	31,648	31,190	30,724
% change w.r.t reference scenario	0	−4	−7	−10	−14	−17	−20	−23	−25
S3 mix: with EV technology and reduced mobility									
Million km	34,143	33,572	33,085	32,692	32,412	32,273	32,318	32,616	33,274
% change w.r.t reference scenario	0	−4	−8	−11	−14	−16	−18	−19	−19

km – kilometer; w.r.t – with respect to.
Values are shaded only to signify the same available car mobility in the base year (in million km) for all the three scenarios.