Cost-effective scenarios for reaching transport climate targets

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SHORT SUMMARY

We explore cost-effective scenarios for reaching climate targets for the transportation sectors in the EU and Sweden, calculating cost-efficient relative contributions to emissions reductions from electrification, biofuels and traffic reduction. Cost-effective scenarios, or roadmaps, are important not only for for climate policy; they have implications for traffic planning, biofuel production and the transformation of the vehicle industry. Our results indicate that electrification is the most important factor for reaching the climate targets. With the recent EU vehicle regulations in place, it is possible to reach the climate targets at a moderate cost; with slow electrification, the long-run targets are virtually impossible to reach. Reaching the targets also require considerable amounts of biofuel volumes, especially in the short and medium term. Traffic reduction contributes only marginally. Hence, other negative externalities need be handled by other policy measures; climate policy only makes a marginal contribution to reducing other traffic externalities.

Keywords: carbon emissions, climate policy, transportation, roadmap, climate targets.

1. INTRODUCTION

Several countries have specified reduction targets for specific sectors. We analyze scenarios for reaching European and Swedish reduction targets for the road transportation sector, assessing the social cost of reaching these targets and optimal adaptation mechanisms to achieve the targets at minimal social cost. To do this, we model the evolution of vehicle fleets (cars, vans and heavy vehicles) over time, taking into account current and forecast fuel prices and taxes and EU emissions regulations. We also model how aggregate vehicle kilometers (by vehicle type) are affected by changes in fuel prices, GDP per capita and population growth.

Theoretically, a carbon tax is a sufficient policy instrument to achieve a given target. However, in applied policy making, climate policy usually consists of policy packages targeting specific adaptation mechanisms, such as vehicle emissions regulations or biofuel mandates. There may be valid pragmatic arguments for using several policy instruments at once, for example to provide a common "roadmap" to coordinate an industry undergoing rapid transformation. If (for any reason) several policy instruments are used to micro-manage adaptations, it is important to establish the optimal combination of adaptation mechanisms. The analyses in the paper are hence useful for determining the welfare-optimal adaptation combinations, which can be used as a roadmap to achieve a given target.

2. METHODOLOGY

We first forecast the traffic increase for three types of vehicles cars, light vehicles, and heavy vehicles 2020-2050, applying elasticities with respect to GDP, population and fuel prices from the literature (Bastian et al., 2016; Bento et al., 2009; Goodwin et al., 2004; Graham and Glaister, 2004), and forecasts for these variables in the EU (European Commission, 2021) as a whole and for Sweden. We then forecast average emissions per vehicle km (by fuel and vehicle type) of the vehicle fleet for each future year, based on a vintage model taking into account how new vehicles enter the fleet and how vehicle kilometers vary by vehicle age.

To forecast the composition of vehicles entering the market in future years, we take the emission requirements for new vehicles as binding in the EU but not necessarily in individual countries. On the national level we assume that the share of electric vehicles is sensitive to the fuel price of that year, using a simple vehicle choice model (Fridstrøm, 2019; Pyddoke et al., 2019).

Based on the forecast transport demand and the average emission per kilometer in by year, we forecast the emission reduction to 2030 and to 2050, respectively, accomplished by increased energy efficency of fossil vehicles, transition to electric vehicles, reduced transport demand of fossil vehicles due to carbon tax increase, and an increased share of biofuel.

3. RESULTS AND DISCUSSION

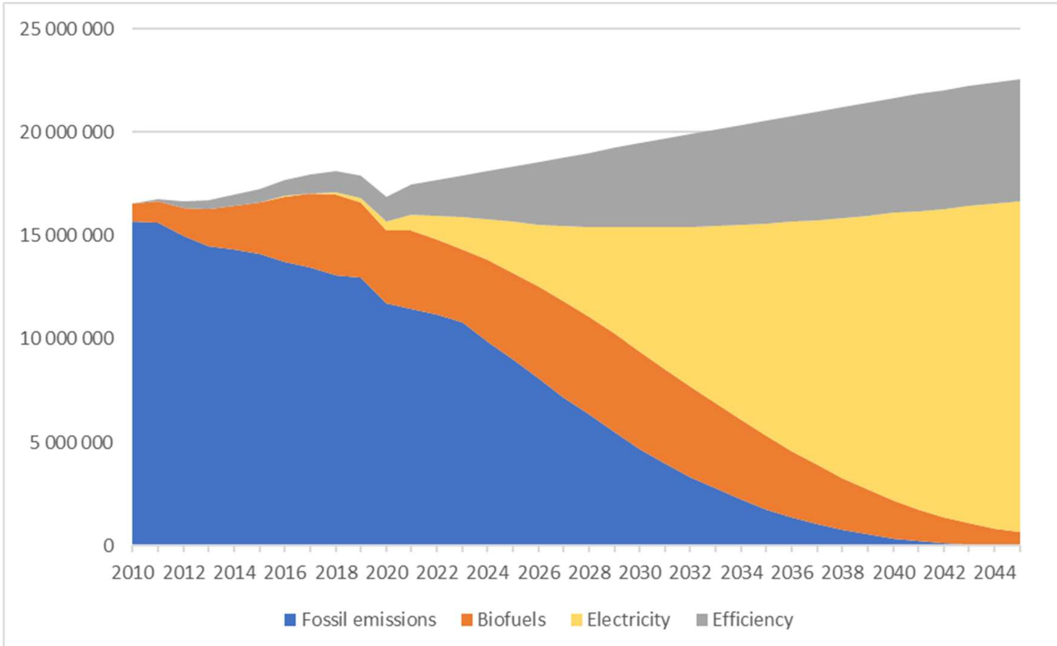
The optimal policy to reach a given target is to set a tax on fossil fuels equivalent to the cost difference between

The EU

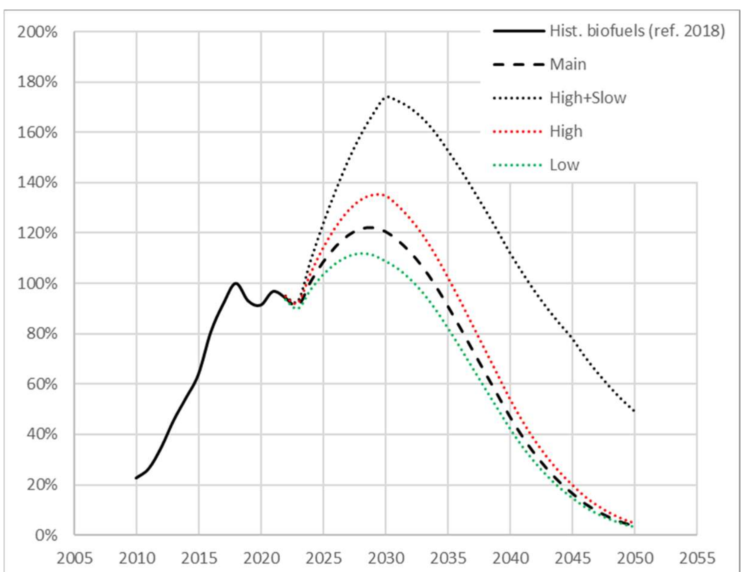
Assuming currently decided policies, regulations and technological trends, the emission from the road transport sector will decrease by 26 percent and will thus not reach the 40 percent reduction target. To 2050 the emissions will decrease by 68 percent. The emissions from the cars decrease the fastest and are closer to reaching the targets, while heavy-vehicle emissions decrease the slowest. To reach the targets, the carbon tax on fuel (constituting 55 percent of the fuel pump price) will have to increase almost 3 times, implying a carbon price of 0.6 €/kg. At this level, it is cost efficient to replace fossil fuels with biofuels. The main reason why such a high carbon price is needed is that the heavy vehicles are relatively insensitive to price increases. The diagram below summarizes the results for the EU, showing the relative contributions to reaching the reduction targets of 2030 and 2050 from reduced traffic volumes, more efficient fossil vehicles, more electric vehicles, and biofuels.

Sweden

The diagram below summarizes preliminary results for Sweden, showing the relative contributions to reaching the reduction targets of 2030 and 2045 from more efficient vehicles, electrification and replacing fossil fuels with biofuels. (Reduced vehicle kilometres are not shown in the diagram.) The carbon tax necessary for reaching the targets is sufficiently high to make biofuels a cost-effective way to reduce emissions at the margin. Assuming that there is enough supply of of biofuels, the short-run marginal cost of reaching the target hence coincides with the marginal cost of biofuels.



As an example of the conclusions, we observe that reaching the Swedish 2030 target requires substantial volumes of biofuels for some years around 2030. The diagram below shows aggregate biofuel consumption over time (for different scenario assumptions).



Since Sweden already has a high biofuel consumption (almost 30% in the transportation sector currently, and nearly half of the global production of isomerized HVO), the sustainability of an increased use may be questioned. The high share of biofuels necessary to reach Sweden's 2030 target for the transport sector is effectively impossible for other countries to replicate in the short term, since the global supply of sustainable biofuels is far too low. On the other hand, the required biofuel volume falls rapidly after 2030, in spite of a further rising share of biofuel, due to fast electrification.

4. CONCLUSIONS

Targets for reducing carbon emissions can be reached by a combination of less traffic (VKT), increased share of biofuels, and decreasing vehicles' emissions per kilometre. In a perfect economy, there is no need to decide their relative contributions beforehand: simply put a high enough price on carbon emissions, and the optimal combination of adaptation mechanisms will emerge. In reality, it is often useful to know the optimal adaptation combination beforehand, for example for coordination reasons (e.g. coordinating battery and vehicle manufacturers) and for designing additional supporting policies. This paper explores the cost-effective relative contributions of the different adaptation mechanisms, by choosing the fossil fuel tax and biofuel share optimally and calculating the resulting responses.

For the EU, the compulsory vehicle emissions regulations that manufacturers need to comply with means that average fleet emissions are given. For the foreseeable future, it will be costly for manufacturers to comply with the regulations, and additional policies such as higher fuel taxes will not decrease vehicle emissions further below the regulated levels. Future average emissions per kilometer in the EU hence follow from the regulations and the vehicle fleet turnover. For a single country like Sweden, on the other hand, policies which increase the fuel price will affect the sales of new vehicles by making electric vehicles more attractive. However, our results indicate that this effect is almost negligible relative to other adaptation mechanisms. This is partly because the effect on the relative attractiveness of electric vehicles is relatively small, and partly because it takes a long time to affect the average emissions from the entire fleet. This observation also suggests that policies aimed at regulating new vehicles' emissions directly are required to reach a sufficiently rapid electrification; high fossil fuel prices contribute to faster electrification, but this effect is fairly modest compared to the pace required to reach the climate targets, unless fossil fuel prices are set at unrealistically high levels.

Higher fuel prices reduces emissions by reducing vehicle kilometers. This effect is larger but still relatively small. In the optimal scenarios, the VKT by ICE vehicles is reduced in the order of 10 percent. From the point of view of traffic planning, the effect on overall traffic volumes is much smaller, especially in the long run, since ICE traffic make up a decreasing share of traffic. If the fuel tax is also used to internalize other traffic externalities (which may be a questionable policy in practice, since other externalities vary so much in time and space), the VKT reduction for ICE traffic increases to nearly 30 percent in the EU (although less in Sweden, where average externalities are lower). With a steadily decreasing share of ICE vehicles, using other policy measures than the fuel tax to internalize other externalities will become increasingly important.

Increasing the biofuel share is an important measure to reach the short-term emissions targets in 2030. Our calculations suggest that the EU needs to replace over 15 percent of remaining fossil fuels with biofuels to reach its 2030 target, resulting in a biofuel consumption of nearly 30 Mtoe per year. Sweden, with its more ambitious reduction target, needs a biofuel share around 50 percent and a total biofuel consumption of nearly 2 Mtoe to reach its 2030 target. After 2030, the biofuel volumes needed decline quickly, despite the an increasing bioful share, reaching 100 percent in 2045 in Sweden and 2050 in the EU. The discussion about the cost and supply of sustainably produced biofuels is hence important for the possibility to reach the 2030 targets. Acieving cost-effective and sustainable production of biofuels is also important for reducing emissions from sea and air transport, where there is less potential for near-term electrification than for road transport.

The largest reduction by far comes from electrification. With the assumed vehicle regulations in our main scenario, 90 percent of EU carbon emissions have been eliminated by 2050. Sweden is ahead of the EU average, so the reduction is even larger and earlier. The pace of the electrification of the vehicle fleets is the most important determinant of future carbon emissions by far. Comparing the slow electrification scenario to the main scenario, this conclusion is strengthened further. In the slow scenarios, the necessary amounts of biofuel to reach the targets increases to very high levels.

Different assumptions about traffic growth or biofuel shares pale in comparison to the effect changing the rate of electrification. This further implies that policies that aim at reducing overall traffic – which might be beneficial for other reason – can only make a small dent in total emissions.

The main strategy for reducing carbon emissions thus needs to be rapid electrification. Complementary measures such as traffic reduction and biouels may help to some extent, but their contributions are small in comparison, and especially in the long run. In order to reach the long-run emissions targets, pursuing rapid electrification is hence of fundamental importance.

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