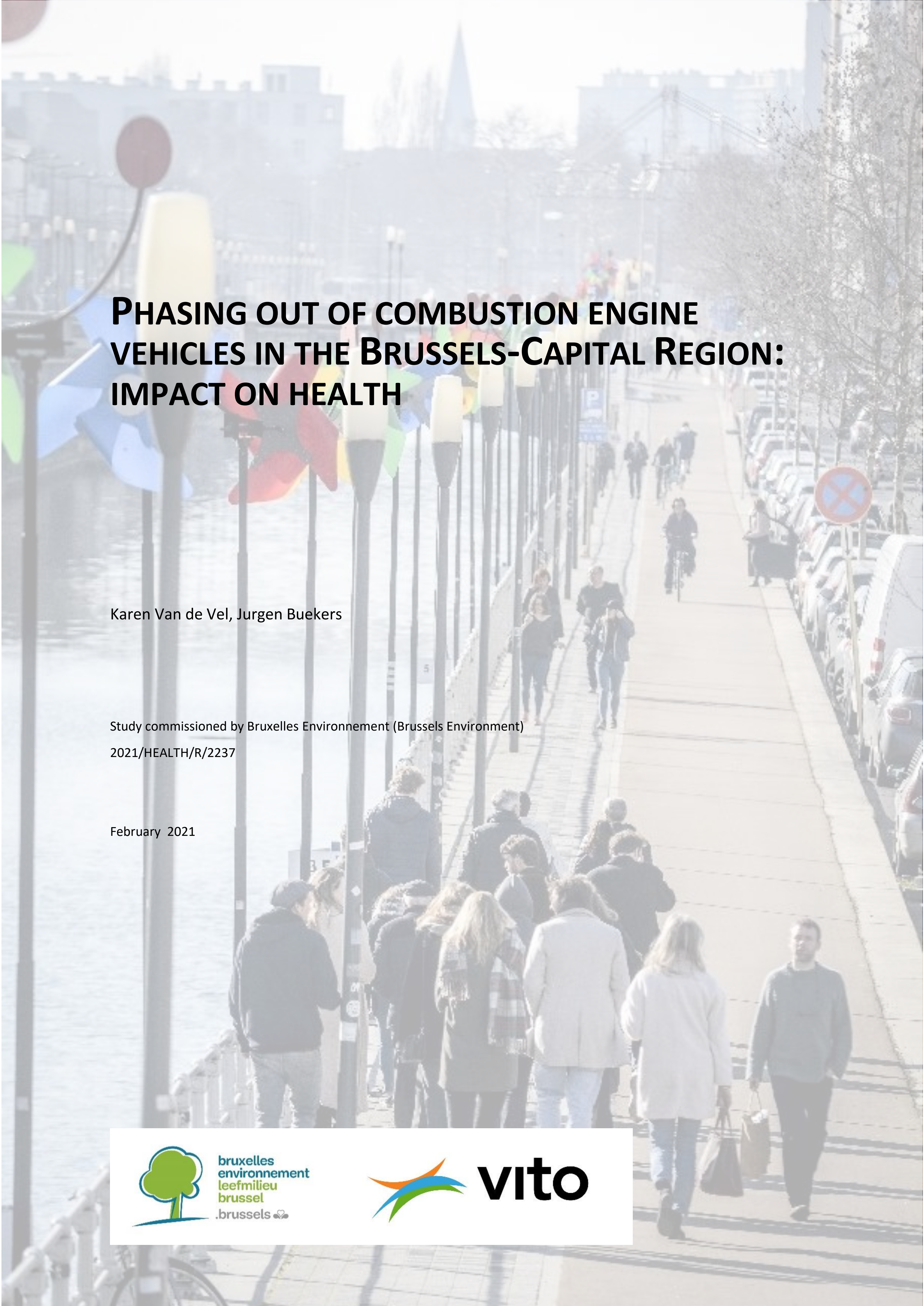

PHASING OUT OF COMBUSTION ENGINE VEHICLES IN THE BRUSSELS-CAPITAL REGION: IMPACT ON HEALTH

Karen Van de Vel, Jurgen Buekers

Study commissioned by Bruxelles Environnement (Brussels Environment)

2021/HEALTH/R/2237

February 2021

Colophon

Title

Phasing out of combustion engine vehicles in the Brussels-Capital Region: impact on health.

This report is also available at https://leefmilieu.brussels/
This report reflects the views of the authors and not necessarily those of Bruxelles Environnement.
Cover photo: © Bénédicte Maindiaux

Authors

Van de Vel Karen, Buekers Jurgen
Unit Health, VITO NV

Reference

Van de Vel K., Buekers J. (2021) Phasing out of combustion engine vehicles in the Brussels-Capital Region: impact on health, Study commissioned by Bruxelles Environnement (Brussels Environment), 2021/HEALTH/R/2237, VITO NV.

Responsible editor

VITO NV
Unit Health
Van de Vel Karen, Buekers Jurgen
Boeretang 200
B-2400 MOL
Tel. general: 014 33 55 11
E-mail: karen.vandevel@vito.be

SUMMARY

Background

Despite significant progress in reducing emissions in recent decades, air pollution remains the largest environmental health risk in Europe. Exposure to air pollution leads to a wide range of health effects, including premature death, stroke, lung cancer and other diseases. In Belgium, in 2018, air pollution was responsible for about 7,400 premature deaths due to exposure to particulate matter ($PM_{2.5}$), 1,200 premature deaths due to exposure to nitrogen dioxide (NO_2) and 350 premature deaths due to exposure to ozone (O_3)[1]. In the Brussels-Capital Region (BCR), in 2018, exposure to concentrations of $PM_{2.5}$, NO_2 and O_3 was responsible for 627, 323 and 19 premature deaths respectively[2].

A large part of air pollutants' emissions comes from road traffic. In the BCR, road traffic was responsible for 63% of nitrogen oxide (NO_x) emissions, 34.5% of PM_{10} emissions, 28.5% of $PM_{2.5}$ emissions and 56% of black carbon (BC) emissions in 2018[3]. These emissions are projected to decrease significantly over the next decade, but road traffic will still be responsible for more than 30% of NO_x emissions in the BCR in 2030[4]. Finally, the International Agency for Research on Cancer (IARC) classifies air pollution caused by exhaust emissions from diesel engines as carcinogenic to humans[5].

The BCR government is therefore taking measures to tackle traffic emissions. Since 2018, the BCR is a low-emission zone (LEZ), where the most polluting vehicles are no longer allowed to circulate. Projections show that progressive LEZ access restrictions could reduce NO_2 concentrations in the entire BCR below the European annual limit of 40 µg/m³ between 2025 and 2030[6]. A recent analysis shows that the LEZ already has a strong influence on the composition of the vehicle fleet and has already contributed to a decrease in emissions of traffic-related pollutants NO_x and BC[7].

However, further actions are still needed to better protect the health of Brussels citizens. Scientific evidence shows that serious health effects also occur below the legal standards set by the EU. At the same time, the transport sector needs to be decarbonised in order to mitigate climate change effects and meet the commitments of the 2015 Paris Agreement. In 2018, a quarter of carbon dioxide (CO_2) emissions in the BCR was caused by road traffic.

In this context, the Brussels Region's government is striving to accelerate the transition to zero-emission road vehicles, and has already announced various measures that should help to achieve this objective:

- The regional mobility plan 'Good Move', which aims to reduce the motorised transport of persons and goods;
- A gradual phase-out of diesel vehicles by 2030 at the latest;
- A gradual phase-out of petrol and LPG vehicles by 2035 at the latest;
- A regional strategic vision for the deployment of charging infrastructure for electric vehicles[8].

---

[1] EEA air quality report 2020: https://www.eea.europa.eu//publications/air-quality-in-europe-2020-report

[2] IRCELINE, 2020. Note: the numbers of premature deaths due to $PM_{2.5}$ and NO_2 (627; 323) are related to long-term exposure in the population over 30 years of age and are corrected for double counting. The number of deaths due to O_3 exposure is related to short-term exposure for the whole population and therefore cannot be added to the rest, as there would be a risk of double counting.

[3] Annual emission inventories by Brussels Environment: https://environnement.brussels/thematiques/air-climat/qualite-de-lair/les-emissions-de-polluants-qui-affectent-la-qualite-de-lair

[4] Projections made under the National Emission Ceilings Directive

[5] IARC 2012: https://www.iarc.fr/wp-content/uploads/2018/07/pr213_E.pdf

[6] Expected effects of the low-emission zone on the vehicle fleet and air quality in the BCR, 2018, available here: https://lez.brussels/mytax/fr/practical

[7] LEZ 2019 annual report, available here: https://lez.brussels/mytax/fr/practical

[8] https://environnement.brussels/sites/default/files/user_files/note_vision_regionale_bornes_fr.pdf

Several studies have been carried out in order to assess the impact of the diesel and petrol phase-out on a number of areas (socio-economic, energy, mobility, air, climate, health, public fleet) and thus assist in the implementation of this policy.

The aim of this study is to estimate the health benefits of the combustion engines' phase-out for people living in the BCR.

To this end, health effects in terms of premature mortality, morbidity and health-related costs have been calculated for a reference scenario in 2015 and for four scenarios up to 2030:

- Business as usual (BAU): implementation of existing measures until 2030;
- Good Move (GM): reduction of motorised traffic because of the implementation of the region's new mobility plan adopted in March 2020[9];
- Thermic Ban (TB): reduction of motorised traffic (GM scenario) combined with a complete phase-out of diesel (except for heavy-duty trucks) and an already initiated phase-out of petrol and LPG[10];
- Thermic Ban Plus (TB+): TB scenario, heavy-duty trucks included.

Effects on air quality and people's exposure

The four 2030 scenarios show an improvement in air quality compared to the reference year 2015 (all pollutants considered) as well as a reduction in exposure for people living in the BCR. This is mainly due to the transition to a more sustainable energy system.

- In the BAU scenario the annual average population-weighted exposure for **$PM_{2.5}$** is just above the recommended value of 10 $\mu g/m^3$. In the other scenarios, the value decreases to about 9.5 $\mu g/m^3$. Looking at the individual exposure of all people living in the BCR, we find that the two Thermic Ban scenarios score best, with only 3-4% of the population exposed to $PM_{2.5}$ concentrations above 10 $\mu g/m^3$.
- For **PM_{10}**, the annual average population-weighted exposure for all scenarios complies with the health advisory value of 20 $\mu g/m^3$. However, only the Thermic Ban scenarios make it possible to respect the limit value for the entire Brussels population.
- For **NO_2**, the annual average population-weighted exposure also complies with the health advisory value of 20 $\mu g/m^3$ for all scenarios. In the BAU scenario this value reaches 18 $\mu g/m^3$, and decreases to about 13 $\mu g/m^3$ in the Thermic Ban scenarios. Again, in terms of individual exposure, only the Thermic Ban scenarios make it possible to respect the limit value for the entire Brussels population.
- For the pollutant **soot** (measured in the form of black carbon - BC) there are no advisory values, nor legal standards. This is despite the fact that IARC, the World Health Organisation's cancer research institute, considers diesel soot to be carcinogenic to humans[11]. The average exposure to BC in the GM scenario is 10% lower than in the BAU scenario, while the Thermic Ban scenario results in an additional 30% reduction. In terms of individual exposure, the lowest exposure is achieved in both Thermic Ban scenarios, where the maximum exposure is 0.12 $\mu g/m^3$. In the BAU and GM scenarios, 54% and 20% of the Brussels population, respectively, were still exposed to values above 0.12 $\mu g/m^3$.

---

[9] In this study, we assume that the impact of GM translates in a 24% reduction in kilometres driven by car compared to 2015.

[10] Gradual reduction towards a complete ban on petrol and LPG in 2035.

[11] IARC 2012: https://www.iarc.fr/wp-content/uploads/2018/07/pr213_E.pdf

The reduction in concentrations is greater for the pollutants NO_2 and BC than for fine particles (PM). There are two reasons for this:

- The contribution of traffic emissions to overall emissions is much greater for NO_X and BC than for PM. Consequently, mobility measures have a greater impact on emission and hence also concentration levels of NO_2 and BC than on those of PM;
- Concentration levels of NO_2 and BC are dominated by local emissions, while concentration levels of PM are largely determined by more distant emission sources.

Finally, one should keep in mind that, even at concentrations below the recommended limits, negative health effects are being observed[12]. It is therefore relevant to keep general exposure as low as possible, as is the case with the Thermic Ban scenarios.

Effects on health

The mobility measures planned by the BCR have a positive effect on the number of people who die prematurely and the number of people who become ill as a result of exposure to air pollution.

The Good Move scenario achieves the following heath gains in 2030, compared to the BAU scenario:

- On an annual basis, 76 fewer premature deaths due to chronic exposure to $PM_{2.5}$ and NO_2, i.e. a reduction of 11%;
- A reduction in the number of ill people of about 16% due to chronic exposure to NO_2 and a reduction of around 7% due to exposure to fine particles ($PM_{2.5}$ and PM_{10}). This concerns both the incidence of certain illnesses without hospitalisation as well as with hospitalisation. As an example, this means 238 fewer new asthma cases in adults on an annual basis due to chronic exposure to NO_2 and a decrease of 19 hospital admissions due to low respiratory infections in children between 0-4 years due to chronic $PM_{2.5}$ exposure.
- The associated health gains amount to between 71 and 242 million euros on an annual basis. For the low estimate the median value of the VOLY approach (VOLY: Value of Life Year) has been used, and for the high estimate the VSL approach (VSL: Value of Statistical Life) has been used[13].

The Thermic Ban scenarios allow for even higher benefits compared to the BAU scenario:

- On an annual basis, 102-110 fewer premature deaths due to chronic exposure to $PM_{2.5}$ and NO_2, i.e. a reduction of approximately 15%;
- A 25 to 28% reduction in the number of ill people due to chronic exposure to NO_2 and a 7.5% reduction in the number of ill people due to PM exposure ($PM_{2.5}$ and PM_{10}). This concerns both the incidence of certain illnesses without hospitalisation as well as with hospitalisation. As an example, this means 440 fewer new asthma cases in adults on an annual basis due to chronic NO_2 exposure and a decrease of 21 hospital admissions due to low respiratory infections in children between 0-4 years due to chronic $PM_{2.5}$ exposure.
- The associated health gains amount to between 100 and 350 million euros on an annual basis. For the low estimate the median value of the VOLY approach (VOLY: Value of Life Year) has been used, and for the high estimate the VSL approach (VSL: Value of Statistical Life) has been used.

The health gains for PM related health effects are smaller than for NO_2 because PM concentration levels are less affected by road transport measures, as mentioned above.

[12] See results of Canadian and European studies:
https://www.healtheffects.org/sites/default/files/Hoek-low-levels-elaspe-brussels-2020.pdf
https://www.healtheffects.org/sites/default/files/Brauer-MAPLE-brussels-2020_0.pdf

[13] The VOLY method is based on the monetisation of one year of life, whereas the VSL method is based on the estimation of the value of a life (VSL). More information can be found in chapter 3.

Finally, it is important to note that there are other benefits in addition to those presented in this study:

- In this study, we determine the health impact for people who live in the BCR, but one can also expect health gains for commuters working in Brussels as well as for other visitors.
- The implementation of the Good Move plan will bring additional health gains through reduced exposure to traffic noise and improved fitness of the population through increased active travel.
- By reducing its emissions, the BCR also generates health benefits outside its territory which are not included in this study.

Conclusion and policy recommendations

The implementation of new regional mobility plan Good Move combined with a phase-out of diesel and petrol engines make it possible to significantly reduce the exposure of Brussels residents to harmful pollutants emitted by road transport, in particular NO_2 and BC.

It is only with the combination of these measures that, in 2030, no inhabitant of the BCR will be exposed to NO_2 concentration levels above the recommended limit (20 µg/m³). These improvements will lead to between 102 and 110 fewer premature deaths each year and a 25 to 28% reduction in the number of ill people due to chronic exposure to NO_2 in 2030, compared to the BAU scenario. This translates in a monetary savings estimated at between 100 and 350 million euros annually. In this study, benefits are calculated for a period of one year. In reality, the total expected benefits are cumulative and therefore higher. Therefore, the sooner these policies are implemented, the greater the cumulative benefits will be.

In addition, the implementation of Good Move and the diesel and petrol ban will lead to additional health gains that have not been quantified in this study: reduction in commuters' exposure, reduction in traffic noise, increased physical activity. These benefits will be greater if the space initially dedicated to traffic is redeveloped into green-blue spaces. These will also have a beneficial effect on the physical and mental health of the inhabitants.

In order to achieve a full implementation of these measures, it is crucial that Brussels residents and commuters opt for alternative means of transport such as walking, cycling and public transport. The success of active modes of transport requires a high-quality infrastructure for pedestrians and cyclists, as described in the mobility plan Good Move. Similarly, the way in which the future "zero-emission zone" will be implemented and enforced will strongly influence whether or not the benefits listed in this study materialise.

Finally, we want to draw the attention to a number of additional actions that the Region can implement to monitor and further reduce emissions of atmospheric pollutants:

- Continue to improve knowledge on real emissions of vehicles, for example through tests using "remote sensing" along roads, while also monitoring the "non-exhaust" emissions of vehicles;
- Introduce as soon as possible the checking of particulate filter fraud in periodic technical inspection centres (PTI);
- Implement a strategy to reduce the number of kilometres driven by light commercial vehicles, through the development of waterborne traffic and distribution centres in the Brussels periphery;
- Act on emission sectors other than road transport, especially household emissions, as well as on emissions occurring outside the region (such as agriculture) through the participation of the region in national and supranational decision-making bodies.

- Advocate the introduction of a European air quality standard for black carbon. This would allow to better target this fraction of PM which is particularly harmful to health and on which local policy has a direct impact.
- Monitor air quality and its long-term effects on the health of the Brussels population, based on regularly updated scientific data.

1. POLICY RECOMMENDATIONS

In this study, we have determined exposure to air pollutants for the population of the Brussels-Capital Region, as well as the impact on various health effects. The calculations were carried out for 5 scenarios. The reference scenario reflects the situation in 2015. The Business as Usual scenario for 2030 takes into account a continuation of the current policy on the continuous transition towards more sustainable mobility. The following three scenarios reflect different mobility measures:

- Mobility scenario Good Move (GM): decrease in motorised traffic due to the implementation of the Good Move mobility plan adopted in March 2020[14], calculations for the year 2030;
- Mobility scenario Thermic Ban (TB): reduction in motorised traffic (Good Move scenario) combined with a gradual reduction in the number of diesel, petrol and LPG vehicles, excluding heavy trucks, calculations for the year 2030;
- Mobility scenario Thermic Ban Plus (TB+): Thermic Ban scenario including electrification of heavy trucks, calculations for the year 2030.

Compared to the Business as Usual (BAU) scenario, these mobility scenarios achieve additional health gains for the population of the BCR due to a lower exposure to air pollutants.

Based on the results described above, we will formulate policy recommendations for the mobility policy of the Brussels-Capital Region below.

1.1. THE IMPORTANCE OF PHASING OUT COMBUSTION ENGINE VEHICLES AND THE IMPLEMENTATION OF GOOD MOVE

1.1.1. ADVANTAGES OF PHASING OUT COMBUSTION ENGINE VEHICLES AND THE IMPLEMENTATION OF GOOD MOVE

This study shows that the phasing out of combustion engine vehicles and the implementation of the Good Move regional plan are expected to bring important benefits to the Brussels-Capital Region: better air quality, fewer premature deaths and illnesses, and significant savings on expenditures related to these health benefits.

The GM, TB and TB+ scenarios have clear benefits for the protection of the health of the inhabitants of Brussels. They make it possible to significantly reduce exposure so that it is below the health advisory value for all inhabitants of Brussels in the Thermic Ban scenarios for NO_2 and PM_{10}. For $PM_{2.5}$ the lowest exposure is achieved in both Thermic Ban scenarios. However, in these scenarios 3-4% of the population is still exposed to a value higher than the health advisory value of 10 $\mu g/m^3$. Recent research shows that health effects also occur at concentrations below the advisory and limit values, so it is very important to keep general exposure as low as possible. This is achieved in the Thermic Ban scenarios.

Consequently, the implementation of the Regional Mobility Plan Good Move and the phasing out of combustion engine vehicles are essential to achieve the recommended exposure levels for all pollutants.

In this way, the Thermic ban scenarios would lead to between 102 and 110 fewer premature deaths each year and a 25 to 28% reduction in the number of cases of illnesses due to chronic exposure to NO_2 in 2030, compared to the BAU scenario. This would translate in a monetary savings estimated at between 100 and 350 million euros annually. In this study, benefits are calculated for a period of one

[14] https://goodmove.brussels/nl/

year. In reality, the total expected benefits are cumulative and therefore higher. Therefore, the sooner these policies are implemented, the greater the cumulative benefits will be.

The extent to which Good Move can be implemented depends on the extent to which the inhabitants and commuters of Brussels opt for alternative means of transport such as public transport, cycling, scooters and walking. The success of these physically active forms of travel is linked to the quality of the infrastructure for cyclists, scooter riders and pedestrians. The conditions for this (e.g. sufficient and safe cycle lanes and footpaths, sufficient capacity for active shared mobility) have already been described in the Regional Mobility Plan Good Move. The extent to which the measures contained in the GM plan are implemented and enforced will determine the magnitude of the health benefits.

The benefits resulting from the ban on combustion engine vehicles will also depend on its implementation and enforcement. In the TB+ scenario, we see that the more vehicles are affected by the diesel phase-out, the greater the health benefits will be. Policy choices such as the type of vehicles affected, the number of exemptions allowed, the timing and the enforcement system are important parameters that influence the overall impact of the regulations.

1.1.2. ADDITIONAL HEALTH GAINS

The current study has quantified the health effects of exposure to air pollutants for the population of Brussels. However, one can expect even greater health gains because:

- The many commuters who work in Brussels during the daytime on weekdays will be exposed to lower concentrations and consequently develop fewer health complaints.
- The reduction of traffic emissions within the Brussels territory has a positive impact on concentration levels in Flanders and Wallonia, leading to reduced exposure there.
- The mobility measures improve air quality but at the same time have a positive effect on traffic noise. Reduced exposure to traffic noise provides additional health benefits (independently of the effect of improved air quality).
- Most inhabitants of Brussels (and Belgians) are currently not physically active enough and will, as a result of the implementation of the Good Move mobility plan, opt for alternative active travel options more often in the future. Several studies (Buekers et al., 2015; Dons et al., 2018; Mueller et al., 2015) show that the positive effect of more physical activity on health is many times greater than the health risk of air pollution. This is especially true if pedestrians and cyclists can choose routes where they are less exposed to exhaust fumes. Therefore, any policy measure that promotes active mobility should, in addition to the figures in this report, also take into account the health benefits of cycling and walking. Because this health benefit is so great, even a small increase in the number of cyclists and walkers may have an effect in monetary terms of the same order of magnitude or greater than the figures in this report.

  On the other hand, the health costs of accidents may be of the same order of magnitude as the health benefits of increased physical activity. Every effort should be made to avoid an increase in the number of accidents as the use of the bicycle increases. If fatal accidents are also taken into account, any investment in safe cycling infrastructure is certain to be cost-efficient[15].

[15] The health benefits (and the related economic gains) of the shift from passive to active mobility can be calculated via a calculation tool developed for the Flemish Agency for Care and Health (https://www.zorg-en-gezondheid.be/gezondheidscalculator-modal-shift). A recent VITO study (Castro et al., 2019) has shown that the use of e-bikes also leads to a significant increase in the physical activity of e-bikers switching from private motor vehicles and public transport. The net loss of physical activity among e-bikers switching from regular bikes was much less due to the increase in total travel distance.

- If space is freed up in Brussels due to the reduction of traffic volumes (e.g. streets that can be closed off, parking space that is no longer needed), the (re)design of the public space can take into account the creation of green/blue spaces. There is a lot of scientific evidence showing that the proximity of (urban) green spaces has a positive effect on the physical and mental health of local residents, see (WHO Regional Office for Europe, 2016). There is also a positive effect on possible heat stress in the future. For exposure to green spaces there are recommendations in the areas of design, actual use of vegetation and accessibility for target groups (Buekers et al., 2020).

1.2. Focal points

1.2.1. Real emissions data for road traffic

The COPERT 4 methodology used in the emission modelling takes into account the recent results relating to Real Driving Emissions. However, a recent study (Suarez-Bertoa et al., 2019) has shown that under certain circumstances the actual emissions differ significantly from the results of Real Driving Emissions tests. No possible reasons are given in the study, but actual emissions may differ from test conditions. In addition to direct exhaust emissions released through the exhaust pipe, non-exhaust emissions are also released through e.g. braking, brake, tyre and road surface wear, and windblown dust as a result of air circulation. Research is being carried out into the magnitude of the contribution of non-exhaust emissions as well as their chemical composition. Furthermore, there is no consensus on the difference in non-exhaust emissions between combustion engine cars and electric vehicles. Some studies[16] argue that a battery electric vehicle generates more non-exhaust emissions than a combustion engine vehicle because an electric vehicle is usually heavier and therefore causes greater tyre and road surface wear.

The Institut Scientifique de Service Public (ISSeP), Flemish department for the environment and more recently Brussels Environment[17] measured emissions of passing vehicles along the road[18], using so-called 'remote sensing' technology. Such projects are recommended to improve the knowledge of “real” emissions of road transport.

1.2.2. Control of diesel particulate filter fraud

In the BAU and Good Move scenarios, a significant proportion of passenger cars still run on diesel. This is also the case for heavy trucks in the Thermic Ban scenario. The emission models used take account of the fact that most diesel cars are equipped with a soot filter, which drastically reduces soot and particulate emissions. However, when replacing the soot filter, the costs can be high, which is why these filters are sometimes removed from diesel vehicles. Opacity measurements are currently being carried out in the Belgian inspection centres to check emissions through the exhaust pipe. However, this measurement method is not suitable for the detection of soot filter fraud. There is a better monitoring method, but it is not yet applied. It is important to introduce this new measurement method as soon as possible in the three regions and not to wait for a European directive on the subject.

---

[16] https://theicct.org/sites/default/files/publications/ICCT_Pocketbook_2018_Final_20181205.pdf
[17] https://environnement.brussels/thematiques/mobilite/projet-remote-sensing
[18] https://www.issep.be/wp-content/uploads/Projet-PEMSWALL.pdf

1.2.3. URBAN FREIGHT TRANSPORT

A possible indirect effect of the phasing out of diesel engines for heavy commercial vehicles (as in TB+) could be a shift from heavy to light commercial vehicles. In parallel with the thermic ban, it is important for the Region to implement a general strategy to reduce the number of vehicle kilometres travelled by light commercial vehicles.
The Good Move scenario projects a 48% reduction in the number of vehicle kilometres travelled by light trucks compared to the BAU scenario. This can only be achieved through a different approach to urban freight transport. Water traffic is only possible for certain types of products, such as e.g. building materials. The EEA report mentioned above (European Environmental Agency, 2018) focuses on the establishment of distribution centres in the urban periphery, from which joint deliveries can be made using less polluting vehicles or electric delivery bicycles. However, the additional transfer requires extra time and costs and often reduces economic efficiency. The report proposes several ways to address the cost challenge and achieve sustainable urban freight transport, such as the creation of micro hubs and delivery points, but also the use of drones.

1.2.4. EMISSIONS FROM OTHER SECTORS

In order to further improve air quality in the Brussels-Capital Region, it is not enough just to reduce emissions from local traffic. This was discussed in section 6.1.2 and was also investigated in the (Joaquin, 2015) project. Measures need to be taken in other areas:

- The emission sector 'households' will become the most important emission sector for the pollutants NO_x and particulate matter in 2030. Wood combustion is a particularly important emission source for building heating. Moreover, many homes in Brussels (and generally in Belgium) are poorly insulated. An action plan for this sector seems appropriate.
- Emission sources outside Brussels make an important contribution to concentrations of e.g. particulate matter. After all, in addition to the primary, directly emitted, particulate matter, there is an important proportion of secondary particulate matter that is produced when the pollutants present in the air react chemically. Ammonia (NH_3) is important in this respect. This is emitted by agriculture, especially in the period when farmers fertilise their fields (Buekers et al., 2014). Cooperation on a Belgian and European scale is needed to guarantee better air quality everywhere.

1.2.5. EC/BC STANDARD

At present, the European standards for particulate matter and NO_2 are the main guidelines for the Brussels clean air policy. There is no standard for soot in the form of elemental carbon (EC) or black carbon (BC), nor for ultra-fine particles (UFP). Although this fraction only accounts for a small proportion of $PM_{2.5}$, it is probably responsible for a (large) part of the health effects. However, no exposure-effect relationships are available for exposure to these pollutants, except for premature mortality (one study (Janssen et al., 2011)). In the current study, this study was used to estimate the number of premature deaths. However, because the overlap with the health effects of $PM_{2.5}$ and NO_2 is not known, the figures were not included in the economic evaluation. It would therefore be advisable for the Brussels authorities to promote the introduction of a European air quality standard for black carbon in the relevant forums. This can be done, for example, in consultation with the WHO. Such a standard would allow for a policy that focuses more efficiently on a health-relevant fraction of the particulate matter problem. Moreover, such standard fits in well with the powers and possibilities of the Brussels authorities because the concentration levels of soot are mainly influenced by local combustion sources and are much less affected by emissions outside Brussels.

1.2.6. METHODOLOGICAL POLICY RECOMMENDATIONS

The Belgian Interregional Environment Agency (IRCELINE)[19] has recently started to determine the number of cases of premature mortality due to various air pollutants at regional level on an annual basis. It is interesting to follow the time evolution of this health indicator. The exposure-effect relationships used in this study (and also by IRCELINE) were selected on the basis of a recent peer-reviewed literature study as well as studies by leading agencies. Scientific findings evolve over time. For instance, the WHO will publish new recommendations on health effects of air pollution in 2021. It is possible that this may (slightly) alter the findings in this study. Recent studies often determine dynamic exposure to air pollution, taking into account travel behaviour, rather than just looking at exposure at home, as in this study. However, there are currently no validated exposure-effect relationships to determine the health effects of this.

A second recommendation concerns the availability of health data for people living in the Brussels-Capital Region. In the calculations of the current study, incidence rates are needed for some health endpoints for the number of visits to general practitioners. These data could not be obtained for the Brussels-Capital Region. Therefore, Flemish data from the Intego database[20], a database which registers general practitioner visits for a patient population of 1.91% of the Flemish population, has been used. These data were combined with prevalence figures from the Health Survey conducted by Sciensano in 2018[21].

The creation of a Brussels health database makes it possible to monitor the time trends of certain health effects. These data can also be linked to other data, such as e.g. environmental data (air quality in this study). Investing in monitoring the effects of air pollution, climate and green space on health and making reviews ultimately pays off and translates into projects such as these, where up-to-date knowledge can be applied. Based on a good estimation of exposure and the application of adequate exposure-effect relationships, the policy can be supported on a knowledge basis.

---

[19] https://www.irceline.be/nl

[20] www.intego.be

[21] https://his.wiv-isp.be/nl/SitePages/Volledige_rapporten_2018.aspx

REFERENCES

Buekers, J., Deutsch, F., Veldeman, N., Janssen, S., Panis, L.I., 2014. Fine Atmospheric Particles from Agricultural Practices in Flanders: From Emissions to Health Effects and Limit Values. Outlook Agric. 43, 39–44. https://doi.org/10.5367/oa.2014.0153

Buekers, J., Dons, E., Elen, B., Int Panis, L., 2015. Health impact model for modal shift from car use to cycling or walking in Flanders: Application to two bicycle highways. J. Transp. Heal. 2, 549–562. https://doi.org/10.1016/j.jth.2015.08.003

Buekers, J., Van de Vel, K., De Nocker, L., Bierkens, J., Baken, K., 2020. Optimaliserne en actualiseren van het gebruik van gezondheidsindicatoren binnen de omgevingsbeleidscontext.

Castro, A., Gaupp-Berghausen, M., Dons, E., Standaert, A., Laeremans, M., Clark, A., Anaya-Boig, E., Cole-Hunter, T., Avila-Palencia, I., Rojas-Rueda, D., Nieuwenhuijsen, M., Gerike, R., Panis, L.I., de Nazelle, A., Brand, C., Raser, E., Kahlmeier, S., Götschi, T., 2019. Physical activity of electric bicycle users compared to conventional bicycle users and non-cyclists: Insights based on health and transport data from an online survey in seven European cities. Transp. Res. Interdiscip. Perspect. 1, 100017. https://doi.org/10.1016/j.trip.2019.100017

Dons, E., Rojas-Rueda, D., Anaya-Boig, E., Avila-Palencia, I., Brand, C., Cole-Hunter, T., de Nazelle, A., Eriksson, U., Gaupp-Berghausen, M., Gerike, R., Kahlmeier, S., Laeremans, M., Mueller, N., Nawrot, T., Nieuwenhuijsen, M.J., Orjuela, J.P., Racioppi, F., Raser, E., Standaert, A., Int Panis, L., Götschi, T., 2018. Transport mode choice and body mass index: Cross-sectional and longitudinal evidence from a European-wide study. Environ. Int. 119, 109–116. https://doi.org/10.1016/j.envint.2018.06.023

European Environmental Agency, 2018. The first and last mile — the key to sustainable urban transport. https://doi.org/10.2800/200903

Janssen, N.A.H., Hoek, G., Simic-Lawson, M., Fischer, P., van Bree, L., ten Brink, H., Keuken, M., Atkinson, R.W., Anderson, H.R., Brunekreef, B., Cassee, F.R., 2011. Black Carbon as an Additional Indicator of the Adverse Health Effects of Airborne Particles Compared with PM10 and PM2.5. Environ. Health Perspect. 119, 1691–1699. https://doi.org/10.1289/ehp.1003369

Joaquin, 2015. Source apportionment of pollutants over the Joaquin domain using model simulations.

Mueller, N., Rojas-Rueda, D., Cole-Hunter, T., de Nazelle, A., Dons, E., Gerike, R., Götschi, T., Int Panis, L., Kahlmeier, S., Nieuwenhuijsen, M., 2015. Health impact assessment of active transportation: A systematic review. Prev. Med. (Baltim). 76, 103–114. https://doi.org/10.1016/J.YPMED.2015.04.010

Suarez-Bertoa, R., Valverde, V., Clairotte, M., Pavlovic, J., Giechaskiel, B., Franco, V., Kregar, Z., Astorga, C., 2019. On-road emissions of passenger cars beyond the boundary conditions of the real-driving emissions test. Environ. Res. 176. https://doi.org/10.1016/j.envres.2019.108572

WHO Regional Office for Europe, 2016. Urban green spaces and health 92.