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Quantifying CO2 savings of cycling

List of acronyms

- CDM: Clean Development Mechanism
- CO2: Carbon dioxide
- CO2e: Carbon dioxide equivalent
- EU ETS: European Union Emissions Trading Scheme
- GHG: Greenhouse Gas
- IPCC: Intergovernmental Panel on Climate Change
- ITDP: Institute for Transportation and Development Policy
- kt: kilo-tonnes (or 100 metric tonnes)
- NAMA: Nationally Appropriate Mitigation Actions
- PKT: Passenger kilometres travelled
- SLoCaT: Sustainable Low Carbon Transport partnership
- SUTP: Sustainable Urban Transport Project
- TDM: Transportation demand management
- t: tonnes
- TTW: ‘Tank To Wheel’ emissions
- UITP: International Union for Public Transport
- UNFCCC: United Nations Framework Convention on Climate Change
- VKT: Vehicle kilometres travelled
- WTT: ‘Wall To Tank’ emissions (or production phase: crude oil production, refining and distribution) account for about 17% of “Wall to Wheel” emissions
- WTW: ‘Wall To Wheel’ emissions, represent the addition of WTT and TTW emissions

Cooling down the planet on 2 wheels

Cycle more Often 2
Cool down the planet!

Quantifying CO2 savings of Cycling
Quantifying CO2 savings of cycling

Table of Contents

Executive summary ........................................................................................................... 5
Introduction ...................................................................................................................... 7

1. CO2 savings at current levels of cycling ...................................................................... 9
   1. Lifecycle assessment of different mode of transport ......................................................... 9
   1.2 How much CO2e is cycling saving at current levels? .......................................................... 16
   1.3 How much CO2e is cycling saving if bicycles share was to increase? .............................. 16

2. Approaches to reduce transport GHG emissions ............................................................. 17
   2.1 Improving .................................................................................................................... 18
   2.2 Avoiding ....................................................................................................................... 19
   2.3 Shifting ........................................................................................................................ 19
   2.4 Shortening .................................................................................................................... 20
   Advantages of shifting compared to improving measures ...................................................... 20

Factors influencing modal choice .................................................................................... 21
Multimodality, intermodality and co-modality ................................................................... 21
Maximizing the potential of intermodality ......................................................................... 21
Cycling and public transport ............................................................................................... 22
Bicycle share schemes ....................................................................................................... 22

Pedelecs .............................................................................................................................. 24

2.5 Cost effectiveness of transport GHG reduction policies ................................................ 25
2.6 Shifting and rebound effect .......................................................................................... 26

3. Cycling and carbon finance .......................................................................................... 27

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Executive summary

Between 1990 and 2007, greenhouse gas emissions from transport in the EU increased by 36%, while greenhouse gas emissions from other sectors decreased by 15% during the same period. Meanwhile, climate mitigation has moved to the very heart of transport policy and to the heart of broader EU policy. By 2050, the EU has set about reducing its greenhouse gas emissions (GHGs) by 80 to 95% compared to 1990 levels. Consequently, the transport sector will have to reduce its emissions by an estimated 60%.

When evaluating different transport modes, it is the bicycle that allows for important greenhouse gas savings. Although not a carbon free mode of transport, the bicycle’s GHG emissions are over 10 times lower than those stemming from individual motorized transport. Pedelecs, despite their electric assistance, are also found to have greenhouse gas emissions in the same range as ordinary bicycles.

This study shows that if levels of cycling in the EU-27 were equivalent to those found in Denmark, bicycle use would help achieve 12 to 26% of the 2050 target reduction set for the transport sector, depending on which transport mode the bicycle replaces.

Most if not all projections and scenarios conclude that measures focusing on improvement alone will fail to meet EU midterm and long-term climate change objectives. Improvement measures are only estimated to deliver a 20% decrease in transport emission by 2050, using 1990 levels as the baseline.

In addition to technological developments and innovations, achieving the EU’s objectives will require ambitious plans which foresee an EU-wide modal shift away from individual motorized transport. Ordinary bicycles, pedelecs and bicycle-share schemes, on their own and in combination with mass transportation, all have the potential to further contribute to a much needed modal shift.
How far can you go within the EU CO2 target

Based on the following assumptions
In 1990, EU27 GHG transport emissions represented 771 million of tones CO2e.
So, by 2050, EU27 GHG transport emissions should not exceed 308 million of tones CO2e, or 588 kg CO2/year/person, equivalent to
- 28000 km with the bicycle
- 5822 km with the bus
- 2170 km with the car

Introduction

Transport is a source of substantial and rapidly increasing greenhouse gas emissions (GHG). Between 1990 and 2007, EU GHG emissions of all sectors bar transport fell by 15%, whereas transport emissions actually increased by 36% in the same period. In 2007, the sector accounted for around one quarter of all EU emissions, with EU road transport GHG making up approximately one fifth of overall EU emissions.

Current EU emissions

- Manufacturing and construction: 30.0%
- Industrial processes: 8.0%
- Residential: 8.0%
- Commercial: 10.0%
- Energy: 4.7%
- Agricultural: 7.0%
- Other: 0.2%
- Road transport: 24.3%
- Int’l maritime: 0.2%
- Int’l aviation: 3.1%
- Rail transport: 2.6%
- Domestic aviation: 0.4%
- Other transport: 0.4%

Source: EEA

www.ecf.com
By 2020, the EU agreed to cut overall EU greenhouse gas emissions by 20% compared to 1990 levels. In sectors that are not covered by the European Union Emissions Trading System (EU ETS) – such as transport – emissions are to be collectively reduced by 10% below 2005 levels. The EU also has the objective of reducing greenhouse gas emissions by 80-95% by 2050 compared to 1990 levels.

The next Commission needs to maintain the momentum towards a low carbon economy in 2050 - COM(2011) 112 final

C02 savings at current levels of cycling

Introduction

What is the potential of cycling when it comes to lowering EU greenhouse gas emissions? And how does cycling compare with other modes of transport? It is often said that cycling is a zero-emission mode of transport. While this is true for air and noise pollution, the same cannot be said about cycling and greenhouse gas emissions. In order to accurately answer this question on cycling and GHG emissions, it is important to assess a bicycle's 'life cycle', and then determine levels of cycling across the EU.

Life cycle assessment of different modes of transport

Generally speaking, great care should be taken when comparing data among different forms of transport. Inherent differences between the transportation modes such as the nature of services, routes available and many other additional factors make it difficult to obtain a truly comparable figure for energy intensity. Nevertheless, it is possible to approximate these GHG emissions, integrating these differences wherever possible or making note of any limitations.

When comparing modes of transport and their impact on climate change, the life cycle should be taken into consideration as much as possible: each type of mode of transport requires a certain level of energy to produce, manufacture, operate and dispose. The same can be said for the construction and maintenance of the infrastructure required for their use.

The life cycle of transport mode can be divided into different phases:

- The production phase which includes the energy and material inputs required to manufacture the vehicle.
- The operation phase, which includes fuel production and utilisation.
- The maintenance phase, which includes all activity required to keep a vehicle as safe as possible on the road.

Such long-term emissions targets can only be met if transport emissions are also drastically reduced. The commission estimated the transport sector needs to reduce its emissions by 54% to 67% by 2050, compared to 1990 levels. It appears that climate mitigation has moved to the heart of transport policy and indeed to the heart of EU policy.

This report will also look at the potential of the bicycle to reduce greenhouse emissions. While the bicycle cannot lower its own GHG emissions, there’s little doubt that bicycle use could certainly increase.

Finally, this report will have a very brief look into cycling and carbon finance. How can the amount of carbon that bicycle use could certainly increase.

Using current levels of cycling as a basis, this report aims to estimate the greenhouse gas emissions of the bicycle and its use. It aims to answer the question: how does cycling compare with other modes of transport?

Using these assumptions, it is estimated that bicycle production and maintenance accounts for approximately 5 grams CO2e/km.

The following sections of a transport mode’s life cycle fall outside the scope of this study:

- **Infrastructure** is generally not included in a Life Cycle Assessment (LCA) and was not included in this study because there is a lack of recent evidence on GHG impact and lifespans of roads and bicycle paths.
- **Disposal**, including the impact of waste material, is also neglected because of standard practises in reuse and recycling of materials, and because of its marginal impact on overall GHG emissions in terms of Transport.

This study therefore calculates the impact of the production, maintenance, operation and fuel production phases for 4 different modes of transport: the bicycle, the paselec (electrically assisted pedal bicycling), the car and the bus.

The bicycle

In studies which look at the life cycle of different modes of transport, walking and cycling are rarely included. When they are included, they’re often portrayed as zero emission options, implying that these modes don’t emit any GHG. While there is some truth in this, i.e. cycling does not need fuel to operate, the production of a bicycle alone also entails GHG emissions. For cycling to be taken seriously amongst key decision makers, it is important to quantify its impact and ability to reduce GHG emissions.

Production and maintenance

Portraying the bicycle as the zero emission option is clearly misleading with respect to its production: GHGs are linked to the extraction and manufacturing of the raw material needed to produce a bicycle. TNO calculated this using data from the Eco-invent database. They did so on the assumption that the average commuter bicycle weighs 19.9kg, that it is composed of 14.6 kg aluminium, 3.7 kg steel and 1.6 kg rubber and that the bicycle will last 8 years and cover a distance of 2400 km each year.

Using these assumptions, it is estimated that bicycle production and maintenance accounts for approximately 5 grams CO2e/km.

1. **Commission communication ‘A Roadmap for moving to a competitive low carbon economy in 2050’ - COM(2011) 112 final
2. **The next Commission needs to maintain the momentum towards a low emission economy, and in particular towards decarbonising our electricity supply and the transport sector”, European Commission President Barroso, Political guidelines for the next Commission, 3 September 2009

Quantifying CO2 savings of cycling

Coley D.A, emission factors for human activity, energy policy 30 (1), 2008

Operation
Calculating GHG linked to the operation of a bicycle means looking at additional dietary intake of a cyclist compared with a motorised transport user. One could conclude and many studies do that most cyclists will not eat more when cycling. It is also often cited that the fuel - the fat in other words - is already there, waiting to be burned. Yet such conclusions overlook the reality that cyclists must find their energy somewhere. Research - the fat in other words - is already there, waiting to be burned. Finally, it would be short-sighted to dismiss the energy production, distribution and consumption is far from negligible. Finally, it would be short-sighted to dismiss the energy production, distribution and consumption is far from negligible. Finally, it would be short-sighted to dismiss the GHG emission linked to these additional calories? These figures incorporate all aspects of food production, including farm machinery, irrigation, production, and the application of fertilizers and pesticides.

"Fuel" calculations for cyclists are as follows:
At 16 km per hour, a cyclist is burning about 4 kilocalories per kilogram per hour, while the relative metabolic rate of "driving to work" requires no more energy than somebody going about their daily activities: 1.5 kilocalories per kilogram per hour.

An adult of 70 kg will therefore burn 175 kilocalories more per hour when cycling compared with driving. Following this logic, for each kilometre cycled this adult will need an additional 11 kilocalories.

The question therefore remains, how do we calculate the GHG emission linked to these additional calories? The carbon intensity of food varies greatly as can be seen in the graph below. These figures incorporate all aspects of food production, including farm machinery, irrigation, production, and the application of fertilizers and pesticides.

![CO2 intensity of various foods](image)

**Figure 3 CO2 intensity of various foods**

<table>
<thead>
<tr>
<th>Food</th>
<th>CO2e (grams per 100 calories)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>1431</td>
</tr>
<tr>
<td>Lamb</td>
<td>70</td>
</tr>
<tr>
<td>Salmon</td>
<td>483</td>
</tr>
<tr>
<td>Eggs</td>
<td>394</td>
</tr>
<tr>
<td>Pork</td>
<td>308</td>
</tr>
<tr>
<td>Milk</td>
<td>247</td>
</tr>
<tr>
<td>Chicken</td>
<td>52</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>46</td>
</tr>
<tr>
<td>Potatoes</td>
<td>23</td>
</tr>
<tr>
<td>Corn</td>
<td>11</td>
</tr>
</tbody>
</table>

Source: Pimentel and Pimentel (2008)

If the additional calories were to be found in beef only, this would add 157 grams CO2e to each km cycled. On the other hand, soybean calories would add only 0.8 grams onto each km cycled. The question therefore remains, which figures should be used?

If we consider that in the EU the daily kilocalorie intake is 3466 and that food has an impact of 1.83 tons CO2e per year per person, this puts the kilocalories at 16 grams CO2e/km.

To summarize the impacts of production, maintenance and operation phases, the life cycle inventories of a bicycle reveals that bicycles release about 21 grams of CO2e per passenger kilometre travelled.

How does this compare with the pedelec, the passenger car and the bus?

The pedelec
According to EU regulations, pedelecs (short for 'pedal electric cycling') are cycles with pedal assistance which are equipped with an auxiliary electric motor having a maximum continuous rated power of 0.25 kW, of which the output is progressively reduced and finally cut off as the vehicle reaches a speed of 25 km/h, or sooner, if the cyclist stops pedalling.

Pedelecs are sometimes referred to as e-bicycles, or electric bicycles. However, pedelecs only work if the driver is pedalling. E-bikes on the other hand differ in that the electric motor can still power the vehicle even if the driver does not pedal.

A study by TNO estimates CO2e emissions of pedelecs at around 17 grams per kilometre. This includes 7 grams for production and maintenance and 10 grams linked to the production of the electricity that is needed to assist the cyclist. Assumptions include a life cycle of 8 years and a yearly distance of 2400 km. In the Netherlands the study took place. Therefore CO2e emissions linked to the electricity used by the pedelec are actually 9 grams per kilometre.

Assuming the cyclist on his pedelec is burning about 2.5 kilocalories per kilogram per hour, an adult of 70 kg will therefore burn 7070 calories more per hour than when cycling, or 4.4 kcal/km, therefore this cyclist will emit an additional 6 grams CO2e/km.

For each kilometre cycled, pedelecs therefore have CO2e emissions of about 22 grams, in the same range as those of a normal bicycle.
The passenger car

A car’s carbon footprint cannot be based on fuel consumption alone. The production of raw material and the process of manufacturing a car have an important impact on its overall GHG emissions. When looking at the overall lifecycle of CO2e emissions, 9% of overall emissions can be allocated to manufacturing; 90% to use; and 1% to disposal.

Life Cycle Analysis of passenger car

- Production
- Parts
- Wall to Tank
- Tank to Wheel
- End of Life

Source: EEA

Figure 5: Tailpipe emissions of passenger cars for different fuels and traffic conditions:

<table>
<thead>
<tr>
<th>Car</th>
<th>MJ/Km</th>
<th>CO2 (g/Km)</th>
<th>NOx (g/Km)</th>
<th>PM10 (g/Km)</th>
<th>SO2 (g/Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2.69</td>
<td>194</td>
<td>0.35</td>
<td>0.008</td>
<td>0.006</td>
</tr>
<tr>
<td>Urban</td>
<td>3.59</td>
<td>259</td>
<td>0.48</td>
<td>0.012</td>
<td>0.008</td>
</tr>
<tr>
<td>Extra urban</td>
<td>2.25</td>
<td>162</td>
<td>0.27</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Motorway</td>
<td>2.58</td>
<td>186</td>
<td>0.38</td>
<td>0.008</td>
<td>0.006</td>
</tr>
<tr>
<td>Diesel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2.42</td>
<td>180</td>
<td>0.57</td>
<td>0.061</td>
<td>0.003</td>
</tr>
<tr>
<td>Urban</td>
<td>3.11</td>
<td>231</td>
<td>0.85</td>
<td>0.097</td>
<td>0.004</td>
</tr>
<tr>
<td>Extra urban</td>
<td>2.09</td>
<td>155</td>
<td>0.46</td>
<td>0.043</td>
<td>0.002</td>
</tr>
<tr>
<td>Motorway</td>
<td>2.41</td>
<td>179</td>
<td>0.54</td>
<td>0.060</td>
<td>0.003</td>
</tr>
<tr>
<td>LPG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2.48</td>
<td>165</td>
<td>0.47</td>
<td>0.008</td>
<td>0.000</td>
</tr>
<tr>
<td>Urban</td>
<td>3.48</td>
<td>232</td>
<td>0.62</td>
<td>0.010</td>
<td>0.000</td>
</tr>
<tr>
<td>Extra urban</td>
<td>2.20</td>
<td>146</td>
<td>0.46</td>
<td>0.006</td>
<td>0.000</td>
</tr>
<tr>
<td>Motorway</td>
<td>2.38</td>
<td>159</td>
<td>0.45</td>
<td>0.008</td>
<td>0.000</td>
</tr>
<tr>
<td>Total</td>
<td>2.60</td>
<td>188</td>
<td>0.43</td>
<td>0.023</td>
<td>0.005</td>
</tr>
<tr>
<td>Urban</td>
<td>3.49</td>
<td>252</td>
<td>0.56</td>
<td>0.030</td>
<td>0.007</td>
</tr>
<tr>
<td>Extra urban</td>
<td>2.21</td>
<td>160</td>
<td>0.33</td>
<td>0.014</td>
<td>0.004</td>
</tr>
<tr>
<td>Motorway</td>
<td>2.50</td>
<td>182</td>
<td>0.44</td>
<td>0.028</td>
<td>0.004</td>
</tr>
</tbody>
</table>

Source: STREAM

---

28 Average weight of cars sold in 2001.
29 Maintenance might actually have a very significant GHG impact, as is assessed by ADEME in its Guide des facteurs d’émissions.
30 Assuming a lifespan of 160,000 km. Other assumptions include CO2e emissions for electricity of 0.222 tep/MWh and 389g CO2e/ kWh (source IEA); and that the 1.19 ton car is composed of 119 kg plastic, 83 kg aluminium, 48 kg glass, 595 kg steel, 59 kg rubber, 83 kg liquids, and 202 kg of other components.
31 STREAM (Studie naar Transport Emissies van Alle Modaliteiten), CE Delft, 2008; the figures are for the following mix of traffic conditions: 25% city; 40% out of the city; 35% highways.
Greenhouse gas emissions per passenger-kilometre also relate to the average occupancy of the car, which will vary significantly between countries and will largely depend on trip distance. While the overall average occupancy is 1.57, for commuting trips it stands at 1.16.

The chart below provides a summary of direct and indirect GHG emissions for the car for different traffic conditions and car occupancy. Because GHG emissions levels are to be compared with short bicycle trips of up to 7.5 km, the total GHG reflects the following mix of traffic conditions: 70% city kilometers, 25% km on roads and 5% km on highways.

The above figures do not take into consideration air-conditioning in cars, which add an additional 10-20 grams per vehicle-kilometre. Cold starts are not included either, while these can significantly increase fuel consumption GHG emissions.

So, considering the following mix of traffic conditions: 70% city kilometers, 25% km on roads and 5% km on highways, ‘well to wheel’ CO2e emissions will reach 229 g per passenger-kilometre.

Reviewing the CO2e emissions linked to the production and operation phases reveal that, for trips that compete with the bicycle, the passenger car emits about 271 g CO2e per passenger-kilometre.

Other aspects influencing GHG levels of different modes of transport

Beyond the various life cycle phase outlines (production, maintenance and operation) there are other aspects influencing GHG levels of different modes of transport. This includes construction, operation and maintenance of road infrastructure as well road accidents and much more. Some of these aspects might have a significant impact on GHG emissions of different modes of transport. It has for instance been calculated that taking parking spots into account increases an average car’s per mile carbon emissions by as much as 10%. Nevertheless, assessing the respective importance of these various other aspects falls outside the scope of this report.

32 Average of available data for European western countries, EEA.
33 ‘Well To Wheel’ emissions (WTW) represents the total of ‘Well To Tank’ (WTT) and ‘Tank To Wheel’ emissions (TTW).
34 TNO, Fietsen is groen, gezond en voordelig, 2010.
35 H. van Essen, O. Bello, J. Dings, R. van den Brink (RIVM), To shift or not to shift, that’s the question, CE Delft, 2003.
36 When the engine is cold, the fuel consumption is higher. The above figures do not reflect higher fuel consumption levels linked to cold starts, which indeed have a higher impact for short trips, which bicycle trips are compared to.
How much CO2e is cycling saving at current levels?

The bicycle’s modal share

It is difficult to calculate the annual distance cycled every year in the EU. The last time this figure appeared was in the 2003 edition of Eurostat’s ‘European Union Energy and Transport in Figures’ with figures for the year 2000 in the EU-15. The distance cycled stands at 71 billion kilometres. This implies an average cycling distance of 188 km per person per year. Taking a conservative approach, and assuming that cycling modal share has not increased since 2000, the EU27 population in 2011 can be estimated to cycle 94 billion kilometres per year.

The bicycle’s share translated into CO2e

Assuming all the bicycle trips would otherwise be done by car, these bicycle trips would save 34 million tonnes of CO2e. In practice, however, this would not be the case. Therefore, when using the following ratios: bus 42%, car 32% and walking 26%4, bicycle trips save 11 millions of tonnes CO2e.

So what does this figure mean in reality? It is a substantial amount of CO2e saved. Under the Kyoto Protocol, the EU-15 agreed to collectively lower their GHG emissions by an average of 8%, or a collective reduction of 341 Mt CO2e. With this average, CO2e savings if the level of cycling was to triple, this would simply triple CO2e savings if the bicycle’s share translated into CO2e. Therefore, if all the bicycle trips would otherwise be done by private cars, the EU-15 could save 33 million tonnes CO2e with a conservative approach, and assuming that cycling modal share would not be higher since 2000.

In December 2008, EU Member States adopted a series of targets as part of a package of concrete measures to fight climate change. These include a commitment to cut, by 2020, overall EU greenhouse gas emissions by 20% compared to 1990 levels. In sectors not covered by the European Union Emissions Trading System (EU ETS) – such as transport – emissions are collectively to be reduced by 10% below 2005 levels by 2020.

2020 and 2050 targets

What if Europeans cycled on average as much as the Danish?

If the level of cycling was to triple, this would mean 481 billion of km cycled per year, and between 55 and 120 million tonnes of CO2e saved annually. This would represent 5 to 11% of the overall target for EU GHG emissions (20% by 2020, compared to 1990 levels), and it would account for 57 to 125% of the transport target (10% by 2020 compared to 2005 levels).

If EU cycling modal share was to reach the same levels seen in Denmark in 2000,4 this would mean 481 billion of km cycled per year, and between 55 and 120 million tonnes of CO2e saved annually. This would represent 5 to 11% of the overall target for EU GHG emissions (20% by 2020, compared to 1990 levels), and it would account for 57 to 125% of the transport target (10% by 2020 compared to 2005 levels).

Enhancing EU energy security

Considering the average barrel of crude oil yields a total of 100.73 kg of liquid fuels, and that a carbon-based fuel will emit 3.15 times its own weight in CO2 when burnt, one average barrel crude oil will produce 317 kg CO2.

27 million tons CO2 are produced by 85 million barrels of crude oil. At 100 USD/barrel this is 8.5 billion USD, or 6.4 billion EUR per year.

With EU crude oil imports at 955 million barrels of crude oil per year, EU citizens cycling at Danish levels would reduce EU oil imports by 9%.

In Denmark, the average cycling distance was 936 km/year/person in 2000 (Eurostat 2003). By 2020, EU27 population is expected to be 514 million (Eurostat). 1990 EU27 global emissions were 5589 million of tons CO2e (Eurostat). 2005 EU27 transport emissions were 962 million of tons CO2e (Eurostat). By 2050, EU27 population is expected to be 524 million (Eurostat).

Approaches to reduce transport GHG emissions

There is a growing consensus that policies should be framed to allow more sustainable forms of transport to flourish. The “avoid, shift and improve” approach to climate change mitigation is referred to as the basis for this new policy paradigm.

Figure 8 Potential strategy responses – Reducing GHG emissions

Approaches to reduce transport GHG emissions

Approaches to reduce transport GHG emissions

Approaches to reduce transport GHG emissions

Approaches to reduce transport GHG emissions

Approaches to reduce transport GHG emissions
Improving ‘improving’ as a strategy response for reducing GHG emissions, can be done in three different ways.

Firstly, it is possible to improve the GHG intensity of the energy used. This can principally be achieved.

Secondly, the transport system as a whole can be improved upon. The focus should be on the speed of vehicles and reducing the number of vehicles driven. This can be done through improved spatial planning (ensuring that the origins and destinations of trips are as close together as possible) or by internalising the external costs of transport.

Thirdly, it is possible to improve the efficiency of transport vehicles by employing both technical and operational means. This requires reducing the amount of energy used to travel given distances, for instance by making vehicle more technically efficient. This approach also looks at reducing the amount of energy used to undertake given trips, for instance by improving the operational efficiency of vehicle use. Improving efficiency of vehicle use includes optimizing route choice, speeds, making sure the vehicle is suited for its intended use (e.g. 4WD are not suited to city use) and improving upon the utilization of the vehicle (efficient driving etc.).

The extent to which GHG efficiency can deliver savings is questionable, as there is the risk of a rebound effect. Take for example the fact that new passenger cars are expected to produce 95g CO₂/km by 2020 — an almost 50 per cent cut compared to 1990. Yet traffic levels are growing at a faster rate than average emissions are declining. Indeed, any measures that make transport cheaper run the risk of generating additional travel.

Even if we were to exclude the rebound effect, most if not all projections and scenarios conclude that improvements in vehicles and fuels will not be able to achieve EU-long term climate change objectives. In other words, the EU can’t count on technology alone to meet its targets.

Avoiding

Avoiding or reducing trips can for instance be done through integration of land use and transport planning. Avoiding or reducing trips only has a limited potential in the short and medium-term when it comes to reducing GHG emissions.

Shifting

Shifting and maintaining trips can contribute to lower GHG in three different ways:

• Firstly, there might be a shift from motorised mobility to less carbon-intensive means of transport or to non-motorised transport, like walking and cycling;

• Secondly, the shift from private motorised mobility to a combination of public transport and bicycle, for distances deemed too long to be covered by bicycle only;

• By preventing a shift from non-motorised transport – like walking and cycling – to motorised transport.

Figure 9 Fuel consumption of average car and total fuel consumption of private cars

Figure 10 Effect of a combination of ‘improve’ measures

There is a need for a “silver buckshot” strategy – as opposed to a “silver bullet” approach. This means that instead of relying on a number of key technologies (i.e. the silver bullet approach), transport policy should take a comprehensive and varied policy approach, pursuing both technical and non-technical options and include measures that curb demand. This approach should be followed if the EU is serious about reaching its self-proclaimed GHG emission reduction targets. This ‘silver buckshot’ strategy includes producing incremental solutions, aggregating many small gains and securing immediate greenhouse gas emission reductions.

55 IEA, 2010; Skinner et al., 2010; Netherlands Environmental Assessment Agency, 2009, according to which the EU — to meet its climate change objectives — will have to reduce its overall GHG transport emissions by a factor of 12 by 2050, while for road passenger the factor would have to be somewhere between 20 and 25. Parsons Brinckerhoff, Strategies for Reducing the Impacts of Surface Transportation on Global Climate Change: A Synthesis of Policy Research and State and Local Mitigation Strategies, 2009.

56 The different scenarios are as follows: scenario 1: improved engine design (estimated to lead to a 9% reduction in CO₂ emissions from cars in 2050); scenario 2: improved vehicle design (estimated to lead to an 8% reduction in CO₂ emissions from all vehicles); scenario 3: electric cars (estimated to lead to a 25% reduction in transport CO₂ emissions); scenario 4: low carbon fuels (estimated to lead to a 4% reduction in CO₂ emissions from cars and 12% from HGVs and buses); scenario 5: technologies encouraging behavioural change (estimated to lead to a 9% reduction in CO₂ emissions from cars and 4% from HGVs and buses).

57 It should be stressed that ‘curbing demand’ does not imply ‘curbing mobility’. What is at stake here is increasing accessibility.

58 A shift from motorised transport to less carbon-intensive means of transport will obviously also result in decreased levels of GHG emissions.

59 Obviously, a shift from motorised transport to more carbon-intensive means of transport would as well result in increased levels of GHG.
Shortening

In some instances, trip lengths will be shortened due to the modal shift. Cycling permits shorter trips, allowing a cyclist to cover a shorter distance yet still arrive at the same destination. Even when origin and destination are the same, the bicycle and, say, the car often take different routes, with the car trip being a few percentage points longer than a bicycle. This difference is because systems do not always have the same network density.

Therefore, a correction factor, called a route factor, is needed to be able to compare transport distances. The resulting route factors differ per transport system and from country to country. A typical route factor for the car is 1.05, resulting in route factors differing per transport system and from shorter distance and, say, the car often take different routes,60 with the car the preferred choice over the shop further away.

Advantages of shifting compared to improving measures

Shifting trips to cycling has many advantages in comparison with improvements in energy efficiency. Firstly, the bicycle, as a very low-emission mode of transport, already exists; its level of GHG is not hypothetical, while level and pace of GHG reductions through improving efficiency measures are uncertain.

Secondly, the bicycle is immediately available; its GHG reduction potential immediately accessible, while GHG reduction through improving measures is a long-term process.

Thirdly, GHG linked to the bicycle and its use is only marginal when compared to motorised transport. This is especially the case when compared with private motorised transport, while improving efficiency measures bring only comparatively marginal reductions.

Last but not least, the bicycle has important co-benefits, which improving measures will not bring, or at least not to the same extent. These benefits are namely to be found in the following policy areas or domains: health, planning, time, cost, street safety, congestion, air pollution, noise pollution, energy security. When compared with some of these ‘co-benefits’ of GHG emissions important as they may be, can only be considered as marginal benefits. Still, further efforts are required to better understand the costs and benefits of transport modes.

It has been estimated that a combination of ‘avoid and shift measures’ could allow for a 21% GHG reduction from ‘business as usual’ baseline, though the different scenarios of this combination pay little attention to the potential of the bicycle.

Factors influencing modal choice

Modal choice is influenced by different factors. The main factors are: real and perceived security; real and perceived comfort; status of modes of transport; marginal price of trips, by mode; real and perceived travel time.

Multimodality, inter-modality and co-modality

Multimodality refers to the use of different modes for different trips, for instance using the bicycle to cycle to work and the taxi to go to the restaurant. Inter-modality refers to the seamless use of different transport systems. Inter-modality can serve as a policy principle or it can be a characteristic of a transport system. Co-modality is a notion introduced by the European commission in the field of transport policy and refers to the use of different modes on their own and in combinations in the aim to obtain an optimal and sustainable utilisation of resources.

Maximising the potential of inter-modality

Harnessing the potential of less carbon intensive modes of transport can help deliver GHG emission reductions from the transport sector. However, the actual GHG benefits that co-modality could deliver is dependent on two factors. Firstly, it relies on differences in GHG intensity (measured in grams per passenger-kilometre) of the concerned modes and secondly on the potential volumes of passengers that can be moved between the respective modes.

For passenger transport, the highest potential for GHG reductions from co-modality exists in dense urban areas. It is in this topography that GHG-efficient modes, particularly cycling, are relatively speaking more attractive than other modes. In addition to making some modes more attractive, it is also important to improve intermodal connections, both in a physical and commercial sense. For example, transport should be made seamless with a user being able to have the same ticket for any kind of transport, bicycle sharing included.

Overall, it has been estimated that a combination of ‘improve, avoid and shift measures’ could allow for a 84% GHG reduction by 2050, but this reduction is in respect to the ‘business as usual’ baseline. Compared to 1990 levels, this would ‘only’ represent a 49% reduction.

Figure 12 Effect of a combination of ‘improve’, ‘avoid’ and ‘shift’ measures

<table>
<thead>
<tr>
<th>Year</th>
<th>Baseline</th>
<th>Improve</th>
<th>Avoid &amp; shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2000</td>
<td>120</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>2010</td>
<td>140</td>
<td>120</td>
<td>20</td>
</tr>
<tr>
<td>2020</td>
<td>160</td>
<td>140</td>
<td>40</td>
</tr>
<tr>
<td>2030</td>
<td>180</td>
<td>160</td>
<td>60</td>
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<td>2040</td>
<td>200</td>
<td>180</td>
<td>80</td>
</tr>
<tr>
<td>2050</td>
<td>220</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: EEA, “Towards a resource-efficient transport system”, 2009

60 Wiltens F. “Evaluating the reliability of reported distance data in urban travel behaviour analysis”, J Transport Geogr. 15:172-183.
61 This correction factor is called route factor, and is defined as the measured distance between two points travelling over an infrastructure network divided by the distance between these points in a direct line (Bouwman). Route factors used are based on theoretical considerations (Beckett 1976, Vaughan 1987).
63 The different scenarios are as follows: scenario 1: shifting to public transport; includes reducing distance to amenities (estimated to lead to a 23% reduction in CO2 transport emissions in 2030); scenario 2: fuel efficient driving (estimated to lead to a 5% reduction); scenario 3: national road pricing & increasing duty of fuel (estimated to lead to a 25% reduction); scenario 4: low mobility, including increasing population density in cities (estimated to lead to a 25% reduction in car CO2 emissions).
Cycling helps increase the uptake of public transport, and vice versa. This increases the potential of cycling as a means of reducing GHG. Some car drivers travelling longer distances might leave their cars for multimodal transport (cycling plus public transport). The reduction of CO2e is then not only linked to more cycling, but also to a higher use of public transport. When combined with mass transport, the potential of the bicycle is no longer limited to short trips. Cycling can contribute to a better performance of public transport. As cycling is 3 to 4 times faster than walking, the number of public transport ‘stops’ available within reach thus becomes 9 to 16 times larger. It is therefore sound to build an integrated “cycling and public transport” system. Such an integrated transport system would optimise both the public transport route network and the more local cycling route networks. The latter should be optimally connected to the important public transport stations or public transport ‘stops’, and should feature proper services, like bicycle parking facilities.

Bicycle share schemes

What is the potential of bicycle share schemes (BSSs) in reducing GHG emissions? Do BSSs only increase demand for travel or do they induce modal shift? And if they induce modal shift, what kind modal shift do they bring about? What are the key steps required to shift trips away from the most/more carbon intensive modes of transport?

A study from the OBIS project outlined the extent to which BSSs were able to shift trips. It found that BSSs were a substitute for motorised private transport between 4% (Berlin) to 77% (Senigallia, Italy) of the time, and public transport 8% (Barcelona) to 58% (Stockholm) of cases. In total, BSSs were a substitute for motorised transport for 52% (in Rimini) to 77% of users (in Milan).

For privately-owned bicycles, the substitution rate is found to be between 2% (Rennes, France) to 22% (Bari, Italy), with most cities falling into the 5-10% range. For walking, the substitution rate spans from 10% (in Milan) to 42% (in Parmal). When substituting cycling and walking for these trips, which together account for a 21% (Senigallia, Italy) to 48% (Rimini, Italy) shift, the contribution of BSSs in lowering GHG emissions is zero.

Finally, BSSs trips account for new trips 0% to 44% of the time, most with cities noting figures from 5 to 20%. For this share of trips, the impact of BSSs on GHG emissions is actually negative as BSSs increase demand for travel.

The main factors which explain such a disparity in data include the existence of a public transport network, the density of BSS stations, the congestion level and the size of the city in question. With the given data, it is not possible to accurately uncover which measures would increase substitution rates away from more carbon intensive modes of transport.

In terms of GHG emissions, BSSs presents certain disadvantages when matched up to private bicycles. Most BSSs use trucks to move their bicycles through the system and the bicycles also require docking stations. Although the emissions linked to these systems are most likely outweighed by the benefits (i.e. a reduction in use of motorised transport), they should still be factored into to any GHG emission impact assessment.

It should also be remembered that BSSs can replace car trips of greater distances, as people are likely to travel further when combining bike sharing with other forms of transport. Also, shared bicycles seem to act as catalysts for more cycling in general. In Lyon, the use of bicycles increased by 44 per cent within the first year of the Vélo’v operations and in Paris there was a 70 per cent increase after the launch of Vélib’mo.

![Figure 13: Transport modes substituted by BSSs](image)

<table>
<thead>
<tr>
<th>City provided with BSS</th>
<th>Barcelona</th>
<th>Lyon</th>
<th>Milan</th>
<th>Stockholm</th>
<th>Rennes</th>
<th>Bari</th>
<th>Rimini</th>
<th>Parmal</th>
<th>Brasilia</th>
<th>Cuneo</th>
<th>Bolzano</th>
<th>Senigallia</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of Users who substitute other Transport Modes with BSS</td>
<td>NA</td>
<td>98.00</td>
<td>71.05</td>
<td>100.00</td>
<td>83.00</td>
<td>80.77</td>
<td>71.43</td>
<td>92.31</td>
<td>67.86</td>
<td>90.00</td>
<td>70.00</td>
<td>56.25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>City provided with BSS</th>
<th>Barcelona</th>
<th>Lyon</th>
<th>Milan</th>
<th>Stockholm</th>
<th>Rennes</th>
<th>Bari</th>
<th>Rimini</th>
<th>Parmal</th>
<th>Brasilia</th>
<th>Cuneo</th>
<th>Bolzano</th>
<th>Senigallia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport Mode substituted by BSS (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motorised Private Transport</td>
<td>65.77</td>
<td>10.00</td>
<td>29.03</td>
<td>5.15</td>
<td>19.00</td>
<td>28.04</td>
<td>36.36</td>
<td>20.83</td>
<td>12.50</td>
<td>44.44</td>
<td>23.82</td>
<td>79.22</td>
</tr>
<tr>
<td>Motorised Public Transport</td>
<td>7.79</td>
<td>46.00</td>
<td>48.39</td>
<td>58.06</td>
<td>46.00</td>
<td>27.26</td>
<td>15.15</td>
<td>33.33</td>
<td>50.00</td>
<td>16.67</td>
<td>35.72</td>
<td>0.00</td>
</tr>
<tr>
<td>Own Bike</td>
<td>5.12</td>
<td>6.00</td>
<td>12.90</td>
<td>9.71</td>
<td>2.00</td>
<td>21.98</td>
<td>15.15</td>
<td>4.17</td>
<td>20.83</td>
<td>11.11</td>
<td>4.73</td>
<td>4.13</td>
</tr>
<tr>
<td>Walking</td>
<td>21.22</td>
<td>38.00</td>
<td>9.68</td>
<td>26.62</td>
<td>33.00</td>
<td>22.71</td>
<td>33.33</td>
<td>41.67</td>
<td>16.67</td>
<td>27.78</td>
<td>35.72</td>
<td>16.65</td>
</tr>
<tr>
<td>Motorised Transport</td>
<td>73.56</td>
<td>56.00</td>
<td>77.42</td>
<td>63.21</td>
<td>65.00</td>
<td>55.30</td>
<td>51.52</td>
<td>54.17</td>
<td>62.50</td>
<td>61.11</td>
<td>59.54</td>
<td>79.22</td>
</tr>
<tr>
<td>Non-Motorised Transport</td>
<td>26.44</td>
<td>44.00</td>
<td>22.58</td>
<td>36.33</td>
<td>35.00</td>
<td>44.70</td>
<td>48.48</td>
<td>45.83</td>
<td>37.50</td>
<td>38.89</td>
<td>40.46</td>
<td>20.78</td>
</tr>
</tbody>
</table>

Source: OBIS project

Pedelecs

To what extent can the pedelec help reduce GHG emissions? Do pedelecs increase demand for travel or do they induce modal shift? And if they do induce modal shift, what kind of modal shift? The key steps required to induce modal shift from the most carbon intensive modes of transport.

Pedelecs can affect the way people move around cities, the distance they cover with their bicycle and their use of other modes of transport, like normal bicycles and private passenger cars. Pedelecs are especially appealing to people who would otherwise not cycle without power assistance.

According to a Dutch study, on a weekly basis pedelecs cover, for all purposes, on average 22% more kilometres than normal bicycles. For commuters, this difference extends to 75%. The reason for that might be that a majority of commuters (51%) started to commute by bicycle more often since they bought a pedelec.

For commuters, substituted modes of transport are almost on par, with 39% of pedelec trips replacing bicycle trips and 41% replacing car trips. It is obvious that in countries with lower cycling modal shares pedelecs would be more likely to replace motorized transport.

Furthermore, the average pedelec commuting distance is 56% higher (9.6 km) than for commuters using a normal bicycle (6.3 km), suggesting that pedelecs allow for 56% longer daily commutes.

The use of a pedelec also influences the use of other modes of transport. Pedelecs most often are a substitute for the bicycle (45%) or the car (39%).

Cost effectiveness of transport GHG reduction policies

Cost effectiveness is a key consideration in the design of policies for GHG reduction. Resources are ideally focused on measures where the marginal costs of GHG reduction are lowest. In this context, marginal abatement cost curves (MACCs) are often used to rank various policy or technology interventions in terms of their costs in abating one ton of CO2e. Existing work on MACCs have labelled transport as an "expensive" sector for mitigation actions to take place.

However there is a consensus amongst transport and climate professionals: that this is a result of interventions in the transport sector being assumed to be limited to expensive, technological options, for example to electric vehicles, and that current MACCs are not reflective of the wide range of policy interventions that would allow significant GHG reductions in this sector to occur. In particular, there is consensus that current MACCs are not reflective of GHG reductions associated with inducing behavioural changes such as reduction in the number and distance of trips or shifts in modes of transport.

70 TNO, Elektrisch fietsen, Marktonderzoek en verkenning toekomstmogelijkheden, 2008
71 A cost curve for greenhouse gas reduction, McKinsey, 2009
72 Bellagio Declaration on Transport and Climate Change, 2009
Quantifying CO2 savings of cycling

Shifting and rebound effect

Maximising modal shift or inter-modality has the potential to reduce GHG emissions if the reductions are “locked in”. In other words, if more people opt for cycling, this would lead to reduced congestion. This may however lead to more motorized trips to be taken, as motorized transport becomes more attractive with fewer cars on the road. Effectively, investment in modal shift could lead to increased capacity, more travel and therefore more GHG emissions. Stimulating inter-modality or modal shift is not on its own a sufficient condition for delivering GHG reductions.

Rebound effects have actually the potential to undermine the GHG reduction potential of many policy instruments. Any option that potentially makes transport cheaper could stimulate travel and thereby undermine potential reductions in GHG. For instance, improved fuel efficiency leads to reduced travel costs that in turn can encourage further growth in traffic unless countered by pricing mechanisms.

In order to avoid such rebound effects, complementary policy instruments to constrain demand would have to be enacted. This would reduce and ideally eliminate any rebound effects, ensuring that the potential GHG reductions are delivered in practice.

Policy options to limit the rebound effect include road pricing - which would ensure that road users pay for the negative externalities – including emissions and congestion impacts – of their behaviour encouraging them to use the road network more efficiently. Non-price levers around network use - like dedicated bicycle lanes or parking policies - could also discourage increased car travel.

Cycling and carbon finance

Each bicycle trip is a potential motorised trip, and therefore has an intrinsic value in terms of avoided CO2 emissions. Thus, increasing bicycle traffic not only has clear mobility and environmental arguments in its favour, but also a clear-cut economic case.

Globally speaking, how does the bicycle fare vis-à-vis the current trend of capitalizing CO2 emission reductions through carbon finance?

On a global level, the transport sector accounts for around a quarter of carbon dioxide emissions, and global transport energy-related CO2 emissions are projected to increase by 1.7% a year, up to 2030. The increase in CO2 emissions is primarily caused by the growth in the global urban population and increased motorization of the global urban population. This trend is more pronounced in emerging economies (with projected transport GHG growth of 2.8% a year) meaning that the abatement of road transport emissions in these countries requires extra attention.

Under the Kyoto protocol to the UNFCCC, the countries listed in its Annex 1 committed to reducing their collective emissions of GHG by 5.2% by 2008-2012, compared to 1990 levels.

The Kyoto Protocol defines flexible cost-effective mechanisms that allow Annex 1 countries to meet their GHG commitments by purchasing emission reduction credits: the Clean Development Mechanism (CDM) with CDM compliant projects generating Certified Emissions Reductions (CERs), the Joint Implementation (JI) with JI compliant projects generating Emissions Reduction Units (ERUs) and International Emissions Trading (IET).

Policy options to limit the rebound effect include road pricing - which would ensure that road users pay for the negative externalities – including emissions and congestion impacts – of their behaviour encouraging them to use the road network more efficiently. Non-price levers around network use - like dedicated bicycle lanes or parking policies - could also discourage increased car travel.

Non-Annex 1 countries don’t have any binding commitments in terms of emission reduction but have a financial incentive to establish projects which reduce emissions in order to create carbon credits which can be sold on the international markets.

Projects that consolidate or increase the size of the CO2 sink of bicycle traffic could namely be facilitated by the CDM, nationally appropriate mitigation actions (NAMAS) or the voluntary carbon market (VCM). So far, the CDM has not worked to catalyse mitigation actions in transport. As of May 2011 only 0.6% of CDM project activities are transport projects, and of the projects registered only 0.2% take place in the transport sector. This limited application of transport projects under the current CDM is in large part due to difficulties in methodology and finance.

NAMAs are voluntary emission reduction measures by developing countries that are directly reported to the UNFCCC. NAMAs are not limited by sector and can include any local, regional and national policies and measures that will reduce GHG emissions from business as usual scenario. These are increasingly being seen as the framework under which non Annex 1 countries are to mitigate their GHG and to receive international support for their efforts.

For the further development of cycling as a sustainable mode of transportation, the empowerment of bicycle stakeholders is necessary. This empowerment is stimulated when the economic benefits of bicycle projects can be monetised within a solid evaluation framework. Monetising the CO2 sink of bicycle traffic strengthens the political argument towards implementation of bicycle projects because the benefits of bicycling become clearer.


74 Prices varying by time of day and location.

75 “Building a low-carbon economy - the UK’s innovation challenge”, Committee on Climate change, 2010

76 International Energy Agency (IEA), ‘Emissions from Combustion’, 2005

77 IEA, World Energy Outlook 2006

78 United Nations Framework Convention on Climate Change United Nations Framework Convention on Climate Change having as ultimate objective to achieve “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.”

79 Annex 1 countries are the industrialised countries that were members of the OECD in 1992, plus countries with economies in transition.

80 The limitations differ by country and range between 0% and 8%

81 Clean Development Mechanism.

82 Joint Implementation (JI)

83 Emissions Trading

84 A well-known emission trading scheme is the EU Emissions Trading Scheme (EU ETS).

85 Difficulties in methodology include setting baselines, lack of recognition of co-benefits and proving additionality of GHG emissions, compared to the business as usual scenarios.

86 Difficulties in finance include volatile carbon price, low cost effectiveness of mechanism, revenues representing a small proportion of total project costs.
Quantifying CO2 savings by cycling

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Fietsverbond vzw | GRACQ asbl | Pro Velo asbl | Toervlaeke Vlaanderen | The European Federation for Transport and Environment

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Mission Statement

Founded in 1983, the European Cyclists’ Federation (ECF) is the umbrella federation of the national cyclists’ associations in Europe, represented by similar organisations from other parts of the world. On behalf of our members, we are pledged to ensure that bicycle use achieves its full potential so as to bring about sustainable mobility and public well-being. To achieve these aims, the ECF seeks to change attitudes, policies and budget allocations at the European level. ECF stimulates and organises the exchange of information and expertise on bicycle related transport policies and strategies as well as the work of the cyclists’ movement.

For further information about ECF projects and activities please contact office@ecf.com - www.ecf.com