Executive Summary

The Netherlands has a relatively large aviation sector, with Schiphol Airport in particular attracting large numbers of passengers from all over the world. Flying has become a cheap way to travel resulting in fast growing passenger volumes. We have calculated that external costs that are not currently in a passengers purchase of an air ticket from The Netherlands equal on average 63% of the price paid.

- In this report we have calculated the True Price of a ticket for a one way flight from The Netherlands. The True Price is the fare a passenger would pay for a flight if all external costs, exempted taxes and subsidies are counted for.

- The average price paid by a passenger in the Netherlands is €195. This includes an average of €19 of “ancillaries” (extra bags, onboard refreshments etc.). Average airline costs are €186 per passenger, which means these ancillaries are crucial to providing a profit.

- Table 1 shows that the True Price of the average ticket from the Netherlands is 63% higher than the current actual price. Lifting the exemptions of VAT and fuel tax on flying would make the average ticket 35% more expensive. External costs caused by climate change, air quality effects and noise would make the flight 28% more expensive. Note that potentially large external costs like land take, ultra small particulates and subsidies to local airports are not included. The True Price in this report is therefore intended as a conservative calculation.

- When we multiply exempted taxes and external costs for all passengers travelling through a Dutch airport, the Dutch aviation sector is responsible for €5 billion of unaccounted for costs per year. The Dutch treasury misses €2 billion annually due to not received VAT and fuel taxes.

<table>
<thead>
<tr>
<th>Price Paid</th>
<th></th>
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<tbody>
<tr>
<td>Fare</td>
<td>€ 176.00</td>
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<tr>
<td>Ancillary Revenues</td>
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<tr>
<td><strong>Average Price of a Flight Ticket</strong></td>
<td><strong>€ 195.0</strong></td>
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<table>
<thead>
<tr>
<th>Exempted Charges</th>
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</thead>
<tbody>
<tr>
<td>VAT Exemption</td>
<td>€ 36.97</td>
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<tr>
<td>Fuel Tax Exemption</td>
<td>€ 31.68</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>€ 68.65</strong></td>
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</table>

<table>
<thead>
<tr>
<th>External Costs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Change</td>
<td>€ 48.51</td>
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<tr>
<td>Air Quality</td>
<td>€ 3.69</td>
</tr>
<tr>
<td>Noise</td>
<td>€ 1.93</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>€ 54.13</strong></td>
</tr>
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</table>

| True Price of a Flight Ticket | € 317.78 |

Table 1: Summary of Costs

<table>
<thead>
<tr>
<th>Total</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>VAT</td>
<td>€ 823,202,108</td>
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<tr>
<td>Fuel Tax (incl. added VAT)</td>
<td>€ 1,252,026,649</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>€ 2,075,228,757</strong></td>
</tr>
</tbody>
</table>

Table 2: Estimates of missed revenues to Dutch Treasury
Summary of Unaccounted Costs – average ticket

Climate change, noise and tax exemption are currently the main unaccounted for costs.

- **Average Ticket Price Paid** - €195, which includes an average €176 fare and €19 ancillaries (extra bags, onboard refreshments etc.)

- **Climate change caused by CO2** – €49, Carbon Dioxide emissions created throughout the flight and have an impact on global warming. Climate change costs are 25% of the average fare.

- **Air quality damage caused by NOX, CO, PM, SOx** – €4, aircraft emit pollution during landing and take off that cause damage to health and nature. Effects are calculated for the “LTO cycle” (the time in which an aircraft is arriving or departing an airport). Air quality damage costs are 1.9% of the average fare.

- **Noise** – €2, The disturbance generated through the sound of aircraft engines or aircraft during the LTO cycle has a negative impact on physical and mental health, stress, productivity and perception of quality of live. Air quality damage costs are 1.0% of the average fare.

- **Taxes exempted: VAT and fuel tax** – €69, Aviation is currently exempt from VAT and fuel tax, and we have calculated the effect that putting these taxes on fares would have. (Note: This is not the same as the amount potentially collected by the Dutch treasury).

- Some aspects not included in these calculations are: the cost of land take, emissions from surface access/infrastructure, external costs in the manufacture of aircraft, production of jet fuel, external costs of aviation-dependent industries (e.g. tourism), but also any economic benefits of aviation.

Figure 1. True Price of an average one-way flight from the Netherlands.
Summary of Unaccounted Costs – example tickets

The “long-haul” typical flight has the highest unaccounted for cost. In our example route (Amsterdam – Bangkok) this was 69% of the current ticket price.

Figure 2. True Prices of three typical one-way flights from the Netherlands.
Background
Introduction

Natuur & Milieu has commissioned Aviation Economics to undertake this report into the “true price” of a flight ticket.

• Airlines in Europe are primarily private-sector companies run to generate profits for shareholders, and are not state-sponsored entities for the wellbeing of the populace. This means that they are focussed on minimising financial cost and not typically accounting for any wider social costs that their operations may have.

• The thesis of this report is that there is a “true price” of a flight ticket, taking into account all the significant external effects that air travel has but is not currently accounting for.

• Many of these fall into the category of “environmental” or “health” costs (e.g. climate change, air quality, noise), but there are also tax exemptions, airport-airline discount agreements and subsidisations to consider.

• We have used all the publicly available resources on these effects to as best as possible understand and monetise the true cost of a flight ticket.

Who We Are

• Natuur & Milieu is a Dutch environmental organization committed to creating a healthy natural environment.

• Aviation Economics is a specialist aviation consultancy based in the United Kingdom, providing advisory services to airports, airlines investors, governments and other organisations.
Air Transport in The Netherlands

The Netherlands is a key player in the world of aviation - with enough seats available for each citizen to take 2.7 round trips in 2018

- Much of this is reliant on the connecting power of the KLM network, with the total Air France-KLM group controlling 56% of “seats” (tickets available for sale to the public) from The Netherlands.
- Amsterdam is by far the largest airport in the country, accounting for 89% of total seats from The Netherlands, and all of the country’s long haul flights. However, regional airports’ roles are increasing with the combined effect of capacity restrictions at Amsterdam, and the business model of low cost airlines searching for cheaper airports to operate from.

Source: RDCApex.com
Importance/Burden of Amsterdam Hub

KLM operates a “hub-and-spoke” model at Amsterdam – which is an economic catalyst for the airline, but at the cost of routing millions of air passengers through the country

• A “hub-and-spoke” model uses the “hub” airport as a central point through which to transfer passengers on to other destinations (e.g. New York–Amsterdam–Istanbul). The larger a hub grows, the greater the number of city pairs that can be connected over it.

• The existence of these transfer passengers effectively decreases the number of direct (or “point to point”) passengers required for a route to be financially viable, and therefore generally results in a much larger number of cities served from the hub airport.

• While the exact external benefit is a subject for debate and not part of this study, Amsterdam is undeniably connected with more cities across the globe as a result of KLM’s presence at Schiphol Airport and use of the “hub and spoke” system.

• The clear downside of this is that some external effects of these passengers’ air travel are burdened by the Netherlands as a result (e.g. through noise or emissions), even though the passengers may never leave the airport building.

Figure 5. KLM network from Amsterdam in 2018

Sources: KLM, RDCApex.com
Aviation’s Environmental Performance

Air travel is a contributor to climate change, local air quality and noise problems around airports

- In the Netherlands the aviation sector is responsible for 12% of climate change emissions, and up to 10% for other pollutants emitted in The Netherlands like NOx, SOx and particles. These percentages may increase over time as, while other industries are able to electrify and/or use sustainable fuels, these technologies are unlikely to be viable for aviation until much later.

- Since the jet-age of the 1950s and 60s, aircraft technology has been improving consistently and significantly. While this has been driven primarily by a desire to lower fuel burn (and therefore operating cost), as fuel burn is the main factor in the production of most emissions, aviation has (perhaps unintentionally) become more environmentally friendly over time on a per passenger basis. However this does also correspond with strong volume growth. Efficiency has increased by 0.5 – 1.5 % per year due to aircraft improvements and proces improvements. While growth in total flights is somewhat restricted (by capacity issues at major airports) the number of passengers have increased fast as the average number of passengers per flight has increased over this time. This has resulted in a higher fuel efficiency per passenger. The risk is that this process improvement has happened inorganically and could be undone if airport capacity restrictions are relieved.

Aviation Efficiency Gain

Air travel has become more efficient due to larger airplanes and improved technology. Below graph demonstrates the advances in aircraft technology and process efficiency (e.g. more passengers per flight) over time.

Figure 6. Aircraft Efficiency Gains since 1955

Approach
Approach of True Price Analysis

Air Travel is a wide and varied market, with costs differing significantly by route, airline, aircraft type and many other factors. As such we have split our analysis to calculate the true price of three example route types and for an average flight from The Netherlands.

In this report we calculate the True Price of a one way flight from the Netherlands. The costs are split in three categories:

- The actual fare of a one way ticket and costs covered by the airline.
- Exempted taxes and received subsidies.
- External costs:
  - Climate change: costs of emissions of the total one way flight (so not only emissions in Dutch air space).
  - Air quality and noise: The emission of NOx and noise cause damage to health and nature depending on the local situation. We have only calculated these costs caused in The Netherlands and in the arriving country.
  - Not all external costs have been included as data is missing.

We have also determined the true price of the average one way flight from the Netherlands and for three typical flights.

- **Actual 2018 ticket prices**: determined based on the RDC Apex database on fares and airline costs (fuel, maintenance, aircraft ownership etc.).
- **Climate costs and air quality costs**: determined based on a “bottom-up” approach. Costs are determined for all departing flights from Dutch airports and divided by the total passengers that travel from a Dutch airport to reach a per-ticket figure.
- **Exempted taxes**: determined based on actual ticket prices (VAT) and average fuel used (fuel tax).

Source: RDCApex.com
Stages of Flight

The diagram below demonstrates the key stages of flight and which environmental/health costs are analysis.

Figure 7. Aircraft Flight Cycle
Flights, passengers and travel classes

In this report we have made some assumptions about the market for air travel that are intended to simplify the complex nature of airline operations and ticketing.

Flights

- For The Netherlands in 2018 there are scheduled to be 534,906 passenger flight movements and 91,147,560 saleable seats, evenly split between arriving and departing flights.

Passengers

- We have estimated that in 2018 there will be 39,516,539 departing passengers from The Netherlands. This is based on the above capacity and assuming the same load factor (passengers/seats) achieved in 2017.

Transfer passengers

- As Schiphol is a major European hub, 37.8% of all passengers travelling via Schiphol are transfers. These passengers are effectively counted double when considering external costs, as they both arrive and depart from the airport in a single one-way trip. For the purposes of this report, a transfer passenger is treated as equivalent to two “point-to-point” passengers. This way the external costs of the transfer passenger’s trip are fully accounted for.

Class of Travel

- Airlines rely on market segmentation as a key tool for maximising revenue. Mostly this occurs by offering different “classes” of travel – namely economy, premium economy, business and first class. This occurs more on long-haul flights and with traditional “full service” carriers (such as KLM). A short-haul low-cost flight, for example, will almost always offer just economy seats.

- Although the fares paid by these passengers may be vastly different, in this report we treat all passengers as equal. So that, the external costs of a first class passenger are the same as those as a discounted economy passenger. However it is worth noting that as premium seats require more space on the aircraft, they are a less efficient means of transporting passengers and therefore may have greater external costs.
True Price of three routes

We have used the below three routes to calculate true prices. These are routes we have defined as “typical” for the categories of Long-haul, regional and low cost.

• Long-haul – Amsterdam (AMS) – Bangkok (BKK), 9,217km - Operated by KLM with a 425-seat Boeing 777-300ER
• Regional – Amsterdam (AMS) – London City (LCY), 336km - Operated by KLM Cityhopper with a 100-seat Embraer 190
• Low-cost – Eindhoven (EIN) – Malaga (AGP), 1,819km - Operated by Transavia with a 189-seat Boeing 737-800
  o Note that the low cost route differs from the regional route primarily in its business model – fitting a large number of people into a relatively efficient aircraft. Whereas a regional route typically operates with smaller aircraft and often with a higher proportion of empty seats.

Source: RDCApex.com
Typical Operating Costs
Airline Costs Accounted For

Airline costs are not necessarily directly attributed to the price a consumer pays for a ticket, however breakeven is important to the long-term success of the route.

- All values are one-way and calculated using the RDCApex airline performance software. This uses information from a variety of sources including airline financial reporting to calculate operating costs. Operating costs are based on a 2018 operation.

- The weighting used to calculate the average flight are based on the number of tickets within each category operated from The Netherlands in 2018. These are:
  - Long-haul – 29%
  - Regional – 39%
  - Low Cost – 32%

- **Aircraft Ownership (Weighted Average Cost = €23.29)** – This covers the cost of owning or leasing the aircraft asset, plus any associated insurance costs. For long-haul flights, larger aircraft must be operated, and the cost is split over fewer flights. Hence the cost for long-haul flights is greater than for short-haul.

- **Maintenance (€15.86)** – The cost required to keep the aircraft airworthy with both regular and unplanned services. Once again larger aircraft are more costly to maintain.

*Source: RDCApex.com – Costs are calculated specific to the airlines and aircraft operating the route*
Costs Accounted for (continued)

- **Crew (€20.91)** – This covers both cockpit and cabin personnel. European regulations stipulate that 1 cabin crew must be provided for every 50 passengers, and airlines do not generally provide more than they are required to. Two cockpit crew are required to fly an aircraft, and only on long-haul flights is a relief crew required to allow the first to rest – where this will generally be split among a greater number of passengers due to aircraft size. Therefore the only significant differentiator between the three route types here is the length of the flight.

- **Fuel (€59.32)** – While fuel burn varies somewhat depending on aircraft type (see CO2 analysis), generally larger aircraft burn more fuel but equally carry more passengers to split that cost between. Therefore by far the largest driver of fuel burn cost per passenger is the length of the flight, and this is reflected in our results. (global price at time of writing)

- **Navigation Fees (€10.12)** – Alongside charges for operating at airports, airlines must pay to fly through the airspace of whichever countries they operate over. While this is generally connected to flight distance, note that the airspace over the Atlantic Ocean is much cheaper than, for example, Germany.

- **Handling (€5.40)** – The fees payable to a service provider for aircraft pushback, cleaning, passenger processing etc.

- **Catering (€2.50)** – Fees payed to a catering provider, generally low on low cost or short distance flights due to absence of complimentary meals.

- **Airport Charges (€31.36)** – Airports historically have generated most of their revenue from charging airlines for operating from their site, generally in terms of landing fees (i.e. use of the runway) and passenger service charges. Smaller airports now lean on non-aeronautical forms of revenue, such as duty free concessions and car parking, to generate revenue. This business model is dependant on high volumes of passenger throughput, and therefore these airports lower their charges to encourage low cost airlines to operate. The result of this can be seen in the relatively small cost of airport charges for the “low cost” flight in the chart on the previous page. By contrast the “regional” flight takes a very high percentage cost of airport charges, as it operates between busy city airports and due to the short distance accrues fewer costs in other segments.

- **Indirect/Other (€16.98)** – This covers overheads and support costs of running the airline, that may not be directly applicable to the route but are still relevant in terms of profitability.

*Source: RDCApex.com – Costs are calculated specific to the airlines and aircraft operating the route*
Airline Ticket Prices and Yields

Using a comprehensive database of airline fares on routes from Netherlands to across the globe, we have calculated that the average economy fare is around €176 one-way

- Airlines do not make all their revenue through ticket sales alone, and we have calculated an average ancillary revenue (onboard sales, extra luggage, etc.) of around €19 (sourced from airline financial reports).
- The weighted average yield of €195 (€176 fare + €19 ancillaries), is slightly higher than our estimated weighted average cost of €186. This implies a profit of around €9 per passenger, or a margin of 5.2%.
- Understandably the fares vary significantly by route type. Long-haul flights cover a greater distance (and flight time) therefore these command higher prices. Low Cost flights by their nature offer lower prices, even if the average sector length is longer than for the regionals.
- In terms of profit margins, regional flights struggle to make a decent profit as relatively high costs are matched with strong competition (from surface travel and low cost airlines). However these flights typically provide transfer feed to long-haul flights so justify themselves in the wider context.
- The major low cost airlines generally are successful and profitable, and this is reflected here.

Definitions:

- **Fare** = The ticket price charged by an airline for a flight seat (excluding baggage if this is separated)
- **Yield** = The revenue per passenger achieved by the airline. The main differential from the fare is typically ancillaries such as extra baggage and onboard food and drink sales.

Source: RDCApex.com
Air travel is a highly seasonal business, and this is no more prevalent than in the costs associated with flight tickets, where variances in fares between high and low seasons can be as much as 300%.

- On this page we have split out the fares achieved by month on our three example routes. While the regional and long-haul examples we have used are not overly seasonal, the variances on the low-cost (Eindhoven to Malaga) route are substantial.

- In December 2017 Transavia achieved an average fare of €35 – when just 2 months earlier it had been charging €140 (+300%).

- This means that, while low fares may not be seen to cover the costs of air travel, this does tend to average out over the year.

**Figure 12. Fares across 2017 for low-cost route (Transavia EIN-AGP)**

**Figure 13. Fares across 2017 for long-haul route (KLM AMS-BKK)**
Environmental Costs
Summary of All Environmental Costs

The environmental costs we consider in this report are climate change and air quality.

• Emissions are calculated based on burned fuel and official emission conversion factors.... Emissions are then valued with environmental prices for The Netherlands derived from CE Delft Handboek Milieuprijzen. Environmental prices express the damage in caused to society in euro per kg emitted.

• Climate change:
  o For climate change costs we assume the pollutants are equally damaging regardless of where they are emitted and therefore calculate for the whole flight. We also assume a radiative forcing multiplier of 2.

• Air quality
  o The cost factors presented in the CE Delft report are mostly concerned with damage to the urban environment, where only a fraction of a flight occurs. To account for this we have analysed the time aircraft typically spend in lower airspace (<=10,000ft) on approach to and departure from airports in the Netherlands. Only this period of time has been analysed to calculate local air quality costs.

• In this study we have not included the cost of land take based on noise and safety contours (although this is described) and ultra small particles. To monetise these costs of aviation requires further research.

• We have also not included the positive economic effects of Dutch aviation. Several studies have been executed with very different outcomes, and this sits outside of the scope of this study.

Source: CE Delft
Emission Cost Factors

Our Emissions Cost Factors are all derived from those provided in the CE Delft “Environmental Prices Handbook 2017” – with the key figures summarised in the table below.

<table>
<thead>
<tr>
<th>Impact category</th>
<th>Unit</th>
<th>Environmental price as weighting factor</th>
<th>Environmental price as external cost</th>
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<tbody>
<tr>
<td>Climate change</td>
<td>€/kg CO₂-eq.</td>
<td>€ 0.057</td>
<td>€ 0.057</td>
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<tr>
<td>Ozone layer depletion</td>
<td>€/kg CFC-eq.</td>
<td>€ 123</td>
<td>€ 30.4</td>
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<td>Human toxicity</td>
<td>€/kg 1,4 DB-eq.</td>
<td>€ 0.158</td>
<td>€ 0.214</td>
</tr>
<tr>
<td>Photochemical oxidant formation</td>
<td>€/kg NMVOC-eq.</td>
<td>€ 2.1</td>
<td>€ 2.1</td>
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<tr>
<td>Particulate matter formation</td>
<td>€/kg PM₁₀-eq.</td>
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<td>€ 69</td>
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<tr>
<td>Ionizing radiation</td>
<td>€/kg kBq U₂₃₅-eq.</td>
<td>€ 0.0473</td>
<td>€ 0.0473</td>
</tr>
<tr>
<td>Acidification</td>
<td>€/kg SO₂-eq.</td>
<td>€ 8.12</td>
<td>€ 5.4</td>
</tr>
<tr>
<td>Freshwater eutrophication</td>
<td>€/kg P-eq.</td>
<td>€ 1.9</td>
<td>€ 1.9</td>
</tr>
<tr>
<td>Marine eutrophication</td>
<td>€/kg N</td>
<td>€ 3.11</td>
<td>€ 3.11</td>
</tr>
<tr>
<td>Terrestrial ecotoxicity</td>
<td>€/kg 1,4 DB-eq.</td>
<td>€ 8.89</td>
<td>€ 8.89</td>
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<tr>
<td>Freshwater ecotoxicity</td>
<td>€/kg 1,4 DB-eq.</td>
<td>€ 0.0369</td>
<td>€ 0.0369</td>
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<tr>
<td>Marine ecotoxicity</td>
<td>€/kg 1,4 DB-eq.</td>
<td>€ 0.00756</td>
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<tr>
<td>Land use</td>
<td>€/m²/a</td>
<td>€ 0.037</td>
<td>€ 0.0261</td>
</tr>
</tbody>
</table>

Table 3: Environmental prices for the European Union
(Source: CE Delft Environmental Prices Handbook 2017)
Climate Change - Calculations

Our approach to calculating CO2 involves a bottom-up methodology, using data on all flights to/from the Netherlands in 2018 and established cost factors

- We have produced an estimate of Netherlands passenger air transport fuel burn for 2018. While information on fuel uplift from Dutch airports is available, this includes other forms of aviation such as freight and private aviation.
- Data on all scheduled flights to/from The Netherlands in 2018 is sourced from RDCApex.com/OAG.
- This has then been combined with a comprehensive database of aircraft fuel burn rates (multiple sources - primarily aircraft manufacturers), with assumptions made on the LTO (landing/take-off) cycle based on flight distance.
- CO2 factor: conversion from ton kerosene to kg CO2, used by CE Delft and across the aviation industry.
- Applying a CO2 per tonne of fuel burned factor, a multiplier for radiative forcing and the average climate change cost of CO2 from CE Delft (adjusted for inflation), we have calculated that €1.9b is the estimated total cost of CO2 produced by scheduled passenger flights leaving The Netherlands.
- Cost factors sourced from CE Delft: €94/ tonCO2.
- Dividing this by the total number of passengers estimated to fly from The Netherlands in 2018 produces an average cost per one-way passenger of €49 for the average one-way flight from a Dutch airport in 2018.

Table 4: Climate Change Cost Calculations

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fuelburn (tonnes)</td>
<td>3,135,580</td>
<td>Aviation Economics</td>
</tr>
<tr>
<td>CO2 Emissions Factor</td>
<td>3.157</td>
<td>ICAO</td>
</tr>
<tr>
<td>Total CO2 emitted (tonnes)</td>
<td>9,899,025</td>
<td>CE Delft</td>
</tr>
<tr>
<td>Cost of CO2e/tonne (€)</td>
<td>€ 94.00</td>
<td>CE Delft</td>
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<tr>
<td>Adjustment for inflation</td>
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<td>Statbureau.org</td>
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<tr>
<td>CO2e Cost</td>
<td>€ 958,423,606</td>
<td>CE Delft</td>
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<tr>
<td>Radiative Forcing Multiplier</td>
<td>2</td>
<td>CE Delft</td>
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<tr>
<td>Total CO2e Effect</td>
<td>€ 1,916,847,211</td>
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<td>NL Annual Passengers</td>
<td>39,516,539</td>
<td>Statistics Netherlands</td>
</tr>
<tr>
<td>CO2 Cost per Passenger</td>
<td>€ 48.51</td>
<td></td>
</tr>
</tbody>
</table>

Source: RDCApex.com and CE Delft
Climate Change Costs - Results

We have calculated that the average cost of Climate Change for a passenger departing from (or arriving to) The Netherlands at €49 per passenger

- Costs vary significantly by route type – it is unsurprising that long-haul flights generate a much greater amount of CO2, as the pollutant is strongly correlated with fuel burn.

- Meanwhile, the costs associated for the shorter flights are relatively lower. Given the sector lengths, the low cost flight burns a relatively low amount of CO2e per passenger – this is because the low cost airline strategy of filling aircraft with more passengers is a more efficient strategy in terms of fuel burn, and therefore also CO2e burn.

Source: RDCApex.com and CE Delft

Figure 14. Climate Change Costs for three route types
EU Emissions Trading Scheme

The EU’s Emissions Trading Scheme currently covers all flights within the European Economic Area (EEA) and requires these to monitor, report and verify carbon emissions

- The current situation with the Emissions Trading Scheme in aviation is complex and the availability of information to the public on trading and auctions is limited.

- In essence, a large number of emissions “allowances” have been allocated to existing airlines based upon their operations in the previous year (a number are also kept available for new entrants, so as not to form a significant barrier to market entry). Additional allowances are available at auction and operators are also free to trade their allowances – providing an incentive for those most able to reduce their emissions to do so and trade excess allowances to an operator who may not be able to decrease emissions so easily.

- At present, the cost of these carbon emission allowances is relatively low. This is because the process is still in its relative infancy and the EU does not intend to cause any economic shocks with its introduction. At present, estimates suggest carbon trading could be costing around €0.25/passenger for short-haul flights and €1.13/passenger for long-haul flights.

- Over time, the number of allowances available will gradually decrease. This (alongside demand growth) increases the value of the remaining allowances, and therefore there is increased incentive for operators to decrease emissions. This is one of the key ways in which the aviation industry is being challenged to meet carbon emissions targets.

- Due to the complexities, lack of transparency and present low cost described above, we have elected not to attempt to put a fixed figure on the cost of emissions trading on the average airline ticket from The Netherlands.
Air Quality - overview

NOx has the largest effect on air quality costs. The costs of (ultra small) particles is yet unknown.

• Aviation influences air quality around airports with emissions including NOx, SOx, CO, NMVOC, particulates and ultra small particulates. The time that an aircraft spends in “lower airspace” (i.e. <=10,000ft/3,048m) on approach and departure determines its effect on air quality. Per passenger we have only calculated air quality costs caused in The Netherlands.

• The table below gives an overview of air quality emission volumes and costs. There are issues in calculating many of these emissions, including particulates where research into the impact from aviation is insufficient. Where we have been able to calculated volumes or costs, only NOx appears to have a measurable impact – therefore in the rest of our air quality analysis we are looking solely at NOx.

<table>
<thead>
<tr>
<th>Emissions (kg)</th>
<th>Emissions Factor</th>
<th>Cost (€)</th>
<th>Per passenger</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>4,077,895</td>
<td>34.7</td>
<td>€ 145,748,045</td>
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<tr>
<td>NMVOC</td>
<td>2.68</td>
<td>2.1</td>
<td>€ 5.79</td>
</tr>
<tr>
<td>CO</td>
<td>32.45</td>
<td>unknown</td>
<td></td>
</tr>
<tr>
<td>SOx</td>
<td>unknown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particulates</td>
<td>unknown</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5: Overview of air quality costs 2018
Air Quality - NOx

Our approach to calculating air quality involves a bottom-up methodology, using data on all flights to/from the Netherlands in 2018.

**Total NOx emissions (based on all landings and take-offs on Dutch airports in 2018):**
- Data on all scheduled flights to/from The Netherlands in 2018 is sourced from RDCApex.com/OAG.
- We have used Flight Radar data to average the time that aircraft spend in “lower airspace” (i.e. <=10,000ft/3,048m) on approach and departure, as we determine air quality effects on local scale.
- This has then been combined with data from the ICAO aircraft emissions databank on emissions produced by each engine type.

**Total NOx costs in 2018:**
- NOx cost = €34.70 per ton NOx (source CE Delft Environmental Prices Handbook 2017)
- This is adjusted for inflation: 3% inflation rate
- €145,748,032 is the total NOx cost in The Netherlands.

**Per passenger NOx costs in 2018:**
- Dividing total costs by the total number of passengers that arrive/depart in 2018.
- The average NOx cost per passenger not accounted = €3,69
- Transfer passengers included in this as making two separate trips, therefore the cost would be €7.38.

<table>
<thead>
<tr>
<th>Total Nox emitted (kg)</th>
<th>4,077,895</th>
<th>Aviation Economics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nox Cost (€/kg)</td>
<td>€ 34.70</td>
<td>CE Delft</td>
</tr>
<tr>
<td>Adjustment for inflation</td>
<td>1.03</td>
<td>Statbureau.org</td>
</tr>
<tr>
<td><strong>Total Cost of Nox (€)</strong></td>
<td><strong>€ 145,748,032</strong></td>
<td></td>
</tr>
<tr>
<td>NL Annual Passengers</td>
<td>39,516,539</td>
<td>Statistics Netherlands</td>
</tr>
<tr>
<td>Nox Cost per Passenger (€)</td>
<td>€ 3.69</td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Nox Calculations
Air Quality – ultra small particles

We have not included ultra small particles (PM2.5, PM10 etc.) as the research is insufficient at present to draw monetizable conclusions

- A study by TNO concluded that Schiphol is a source of ultra small particles in areas of Amsterdam and Amstelveen (TNO 2014 Ultra particulate matter around Schiphol). The health damage caused remains unknown and is currently researched by RIVM.

Figure 15. TNO 2014 Ultra small particles around Schiphol
Air quality costs per flight

We have calculated that the average cost of air quality for a passenger departing from (or arriving to) The Netherlands at €3.69 per passenger

- Costs vary significantly a little by route type – the larger aircraft (i.e. long-haul) generally emit more pollutants, and although there are more passengers on board to split this between – it is not enough to bring down to the levels of smaller aircraft.
- Regional and low cost flights on smaller aircraft perform noticeably better.
- There are a number of other emissions which have not been included here, such as CO, SO2, NMVOC and particulates. The reason these are not included in our calculations is due to comparatively small impact (in the case of CO, SO2 and NMVOC) and due to a lack of data availability on emissions levels from aircraft.

Source: Flightradar24.com and CE Delft

Figure 16. Air Quality costs for three route types
Noise

- Individual aircraft have become more quiet over the years. However due to the high growth in the number of flights, people are generally exposed on a more continuous basis than in the past.

- People that are continuously exposed to noise can generate mental and physical problems, become less content with quality of life and occasionally use more drugs for sleeping and relaxation (GGD 2014).

- Methodology is based on 2010 data of the Planbureau voor de Leefomgeving on the number of people affected by noise around Schiphol and regional airports. Source (CE Delft, Externe en Infrastructuur kosten verkeer 2014). The total number of persons affected will be higher today.

- CE Delft Environmental Prices Handbook 2017 puts the cost of noise for populations living in various noise contours (50db or greater) for aviation. By applying this to the number of residents in the contours we have arrived at an annual cost of €76 billion.

Figure 17. Schiphol Noise Contours
Noise - calculation

Number of houses within contours around airports:

- Luchthavenindelingbesluit Schiphol (LIB, 2017) determines the areas with development limitations around Schiphol Airport due to safety and noise.

- Planbureau voor de Leefomgeving provides data on the number of households in contours around Schiphol and regional airports. We have adjusted population figures with 10% due to increase of houses within the Lib 4 and Lib 5 nopise areas.

Cost of noise of Dutch airports

- CE Delft Environmental Prices Handbook 2017 report puts the cost of noise for populations living in various noise contours (50db or greater) for aviation.

- By applying this to the number of residents in the contours around Dutch airports we have arrived at an annual cost of €76 million.

- Dividing this among the 39.5million passengers gives a figure of €1.93 per passenger. Note that this is only per departing passenger so effectively counts as the cost of both the departing and arriving flight. But this also does not consider the noise impact at the opposite end of the route.

<table>
<thead>
<tr>
<th>dB Range</th>
<th>Cost/db/person</th>
<th>Population</th>
<th>Total Cost</th>
<th>Avg. Cost/Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-55</td>
<td>€ 52</td>
<td>222,484</td>
<td>€ 25,340,401</td>
<td>€ 114</td>
</tr>
<tr>
<td>55-60</td>
<td>€ 103</td>
<td>60,894</td>
<td>€ 37,724,708</td>
<td>€ 620</td>
</tr>
<tr>
<td>60-65</td>
<td>€ 103</td>
<td>8,665</td>
<td>€ 9,827,529</td>
<td>€ 1,134</td>
</tr>
<tr>
<td>65+</td>
<td>€ 196</td>
<td>999</td>
<td>€ 3,233,412</td>
<td>€ 3,237</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>293,041</td>
<td>€ 76,126,049</td>
<td>€ 260</td>
</tr>
</tbody>
</table>

Table 7: Noise Cost Calculations
Noise Costs - Results

We have calculated costs of €1.93 per passenger in terms of noise from flights arriving at or departing from Amsterdam Schiphol Airport

• We have estimated the variation in noise costs for the various aircraft types by splitting the cost by the number of aircraft movements (take-offs and landings), and then by the number of passengers on board.

• Clearly this favours operating larger aircraft less frequently, and therefore the long-haul flight. However the trade-off between operating more, quieter aircraft or fewer but louder aircraft is not a topic that is very well understood (and indeed may simply be a matter of subjectivity or situation dependent).
Landtake

Landtake of the airport is not only determined by the airport itself but also by the areas around the airport that cannot or less be used for housing, businesses, recreation, nature etc.

- In the Luchthavenindelingsbesluit Schiphol (LIB) the areas around the airport have been divided in LIB 1 t/m 5 based on noise and safety exposure.
- LIB 1 & 2 - Demolition zone due to safety and/or noise (>71dB(A) Lden)
- LIB 3 - No additional new houses possible
- LIB 4 - New houses in principle NOT allowed (responsibility of local authoritities) (58db(A) Lden)
- LIB 5 - Growth allowed but limited (48 dB(A) Lden)
- In the RIVM ‘Monitoring Luchtvaartgeluid 2009’, 10,2% of the surfaces of the provinces of Zuid-Holland, Noord-Holland and Utrecht are within 58 and 48 – 58 Lden noise contour. The cost due to restrictions on development in the area is not possible to calculated in this report and requires additioanl research.

Figure 18. Schiphol Land Take Contours
Other Unaccounted Costs
VAT Exemptions

Aviation is not subject VAT (Value Added Tax) in most countries, including the Netherlands, as a means to protect airlines and encourage international trade

- Some countries charge VAT on domestic tickets, however due to its size the Netherlands does not currently have domestic flights. Others use alternative forms of taxation, such as the UK’s Air Passenger Duty (APD). These can only apply to departing passengers.

- We are assuming Netherlands VAT (21%) on both departing flights only, as a proxy for calculating that which would be applicable to The Netherlands. However in practice with internet bookings and connecting flights, the situation is far more complex.

- We have taken the pure fare (€176), rather than yield (as this includes ancillary purchases, which may or may not be taxed depending on how and where they are purchased).

- Note that this is not the same as the amount that could be claimed by the Dutch treasury. This is explained further on the next page.

### Table 8: VAT Exemption Calculations

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Fare</td>
<td>€ 176.04</td>
</tr>
<tr>
<td>RDCApex.com</td>
<td></td>
</tr>
<tr>
<td>NL VAT Rate</td>
<td>21%</td>
</tr>
<tr>
<td>Government of the Netherlands</td>
<td></td>
</tr>
<tr>
<td>Applicable VAT per passenger</td>
<td>€ 36.97</td>
</tr>
<tr>
<td>NL Annual Passengers</td>
<td>39,516,539</td>
</tr>
<tr>
<td>Statistics Netherlands</td>
<td></td>
</tr>
<tr>
<td>Total Applicable VAT</td>
<td>€ 1,460,869,577</td>
</tr>
</tbody>
</table>

**Figure 19. VAT Exemptions for three route types**
VAT Claimable by the Dutch Treasury

The figures produced on the previous page are representative of the total amount of VAT a flight could be subject to, not necessarily the amount that could be claimed by the Dutch Treasury.

- This amount is more complicated to calculate, since at present suitable legislation is not in place to outline what a country can claim on a flight ticket, which typically covers travel between (and through the airspace of) multiple countries.
- The nearest precedent is that which applies to rail and coach travel in the EU – that VAT is claimed on the percentage of the total distance that is travelled in each country. However, this is wholly impractical for air travel due to the number of countries potentially involved (our Amsterdam-Bangkok route for example, travels through the airspace of 15 countries) and the daily variation of routing that occurs for reasons such as weather and congestion.
- Therefore for VAT to be claimed on flight tickets a more simple approach would be required, and has been suggested on previous occasions. This would be on a simple “point-of-departure” approach. For example on a flight from Amsterdam to London, the Dutch government would be able to claim all the VAT. On the reverse flight the VAT would be claimed by the UK.
- What would still be left to decide is how return flights are handled, who has jurisdiction over a connecting flight, transiting flight (e.g. a refuelling stop where some passengers do not deplane) or a multiple-city itinerary.
- The calculations on the previous page assumed that each individual sector is treated as its own ticket, and therefore all departing flights from The Netherlands are applicable for VAT by The Netherlands only.
- A more likely approach would be based upon the first departure point of a (one-way) trip. As Schiphol handles a large volume of transfer passengers, this would disadvantage The Netherlands significantly and lead to around 56% of the revenues calculated on the previous page.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAT</td>
<td>€ 823,202,108</td>
</tr>
<tr>
<td>Fuel Tax (incl. added VAT)</td>
<td>€ 1,252,026,649</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>€ 2,075,228,757</strong></td>
</tr>
</tbody>
</table>

Table 9: Estimates of missed revenues to Dutch Treasury
Fuel Tax Exemptions

As with flight tickets, aviation fuel is currently not taxed, although it is not forbidden by the 1944 Chicago Convention it is not a common practice across the world.

- We have applied the minimum fuel tax rate of 33 cent/ltr on kerosene as determined by the European Union.
- We have also applied the Netherlands VAT rate (21%) on top of this tax.
- This gives a figure of €1.25 billion, or €32 per passenger.

<table>
<thead>
<tr>
<th>Source: RDCApex.com and CE Delft</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Table 10: Fuel Tax Exemption Calculations</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Total Fuelburn (tonnes)</th>
<th>3,135,580</th>
<th>Aviation Economics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Price ($/USG)</td>
<td>2.1</td>
<td>IATA</td>
</tr>
<tr>
<td>Conversion Rate (USG/tonne)</td>
<td>264.17</td>
<td></td>
</tr>
<tr>
<td>Conversion Rate (EUR/USD)</td>
<td>0.86</td>
<td>XE.com</td>
</tr>
<tr>
<td>Total Cost of Fuel (€)</td>
<td>€1,495,956,908</td>
<td></td>
</tr>
<tr>
<td>Tax Rate (€/ltr)</td>
<td>€0.33</td>
<td>Government of the Netherlands</td>
</tr>
<tr>
<td>Conversion Rate (USG/ltr)</td>
<td>3.79</td>
<td></td>
</tr>
<tr>
<td>VAT Rate</td>
<td>21%</td>
<td>Government of the Netherlands</td>
</tr>
<tr>
<td>Total Applicable Fuel Tax (€)</td>
<td>€1,252,026,649</td>
<td></td>
</tr>
<tr>
<td>NL Passengers</td>
<td>39,516,539</td>
<td>Statistics Netherlands</td>
</tr>
<tr>
<td>Fuel Tax per Passenger (€)</td>
<td>€31.68</td>
<td></td>
</tr>
</tbody>
</table>

Figure 20. Fuel Tax Exemptions for three route types
Airport Incentives and Local Subsidies

In this report we are also looking at the assistance that airlines obtain from their relationships with the airports that they operate from, however data availability is very poor

- Traditionally airlines pay airports to operate flights in the form of landing charges and passenger charges, and this is how airports turn a profit. However with the increase in low cost airlines operating from smaller airports across Europe, the relationships have begun to change.

- A smaller airport cannot make money handling occasional regional flights, and instead will seek to generate volume in whatever ways it can. The volume can then be profited from by charging for car parking, food, beverages and other concessions while the passenger uses the airport. Therefore it is in the airports interest to offer these airlines a discount (and sometimes a “marketing incentive” on top) in order to benefit from these airlines’ traffic generating potential in the long-term.

- States with airport ownerships sometimes also participate in this, as they can subsidise the airport’s losses and seek benefits beyond simply making a long-term profit (in terms of connectivity and wider economic prosperity). However if this happens in the Netherlands, the information does not appear to be in the public domain.

- In practice this means that passengers are often not paying for the cost of using the airport in their flight ticket.

- None of the six airports (with scheduled passenger services) in the Netherlands have formal incentive agreements to reduce airport charges for airlines. While private commercial agreements may exist between particular airports and airlines, these are likely to affect only a small minority of flights.
Results and Findings
“Long-haul” Route

The long-haul example route (KLM Amsterdam to Bangkok) has the highest unaccounted for cost, at 69% of the current ticket price

- The long distance means the route has the highest amount of fuel burn as a proportion of cost, meaning unaccounted climate change costs are very high – at 32%.
- VAT exemption accounts for 20%, and Fuel tax a further 15%.

Figure 21. True Price of Long-Haul Ticket
“Regional” Route

The Regional route (KLM Amsterdam to London) shows the least amount of unaccounted external cost (37%) primarily due to the shorter sector length

- Noise and air quality are important factors for this route as the short sector length means that the flight spends more time in the LTO (Landing/Take-Off) Phase, and effectively performs more landings and take-offs each day. However, these still account for just 3% and 2% respectively.
- Climate change is a large contributor once again, albeit at a lower proportion of the ticket price here of 10%.

Figure 22. True Price of Regional Ticket
“Low Cost” Route

The Low Cost Route (Transavia Eindhoven to Malaga) has unaccounted costs equal to 49% of the current ticket price

- Climate Change accounts for 18%, while VAT exemptions account for 17%.
- The flight is relatively efficient due to the high number of passengers to spread the costs among. This leads to low costs in the noise and air quality categories.

Figure 23. True Price of Low Cost Ticket
Weighted Average

The average or typical route from the Netherlands has unaccounted costs equal to 63% of the current ticket price

• Climate Change costs account for 25% of the current ticket price.
• VAT and Fuel Tax exemptions account for 19% and 16% respectively.
• The remaining costs of noise and air quality equate to 1% and 2% of the ticket price respectively.

Figure 24. True Price of Weighted Average Ticket
Conclusions
Conclusions

In this report we have attempted to quantify the True Price of a flight ticket. We have calculated the external costs not counted for in a passengers purchase of an air ticket, taxes exempted and subsidies provided. Our results shows that on average these costs are equal to 63% of the current ticket price from the Netherlands

- Our other primary conclusions are:
  - Climate change (CO2) is a factor, equal to 25% of the current ticket price. However, this number varies significantly by the type of flight undertaken, with our regional and long-haul example flights showing 10% and 32% of the ticket price respectively.
  - Emissions effecting local air quality are a much lower contributor to the unaccounted costs. On the weighted average flight from the Netherlands these are equal to 2% of the current ticket price. The main reason for this is the limited time that aircraft spend at low altitude over urban areas relative to other phases of the flight.
  - The costs of aircraft noise equate to 1% of the current ticket price.
  - Unaccounted costs through VAT exemptions potentially equal 19% of the current ticket price. Fuel tax set at the EU minimum of 33ct/litr would raise the ticket price by 16% (after VAT).

<table>
<thead>
<tr>
<th></th>
<th>Total Cost</th>
<th>Cost/Passenger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Change</td>
<td>€ 1,916,847,211</td>
<td>€ 48.51</td>
</tr>
<tr>
<td>Air Quality</td>
<td>€ 145,748,045</td>
<td>€ 3.69</td>
</tr>
<tr>
<td>Noise</td>
<td>€ 76,126,049</td>
<td>€ 1.93</td>
</tr>
<tr>
<td>VAT Exempton</td>
<td>€ 1,460,869,577</td>
<td>€ 36.97</td>
</tr>
<tr>
<td>Fuel Tax Exemption</td>
<td>€ 1,252,026,649</td>
<td>€ 31.68</td>
</tr>
<tr>
<td>Total</td>
<td>€ 4,851,617,531</td>
<td>€ 122.78</td>
</tr>
</tbody>
</table>

Table 11: Total and Per Passenger Cost Breakdown
Key Sources

- CE Delft – “Environmental Prices Handbook 2017”
- CE Delft – “Estimated revenues of VAT and fuel tax on aviation”
- CE Delft – “External Costs of Transport in Europe”
- CE Delft – “Externe en infrastructuur – kosten van verkeet” (for Land Take – Dutch only)
- Flightradar24.com
- ICAO Aircraft Emissions Databank
- Independent Transport Commission – “The Sustainability of UK Aviation”
- RDCApex.com
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