Fossil free vehicle fleet in Stockholm – importance of air quality and health

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Introduction

Air pollution is today the largest environmental cause of disease and premature death in the world. Long-term sustainable transportation efforts have for a long time been focused on reducing carbon dioxide emissions while emissions of hazardous substances have been less prioritized. Still, the national limit protecting human health is exceeded for nitrogen dioxide (NO_2) in Sweden and traffic is a large contributor to the outdoor ambient levels of NO_2.

"Ambitious goal" – Is it possible to change from a vehicle fleet with vehicles running on gasoline and diesel to a fossil free fleet running on only renewable fuels and still recieve both climate and health benefits?

"There can't only be one" – Focus on the right combination of renewable fuels in the future fleet instead of comparing different fuels.

Method

A reference Business as usual (BAU) scenario for the years 2015 and 2035 were compared to 5 different fossil free (FFF) scenarios for the vehicle fleet in the county of Stockholm in 2035. The project focused on traffic emissions and the contribution from traffic to ambient air levels of exhaust particles and nitrogen oxides (NOx).

BAU→
- FFF biodiesel & electric (56/47 %)
- FFF biodiesel, electric & biogas (55/43/2 %)
- FFF biodiesel & biogas (55/45 %)
- FFF electric & biogas (44/56 %)
- FFF expert (mix of several biofuels)
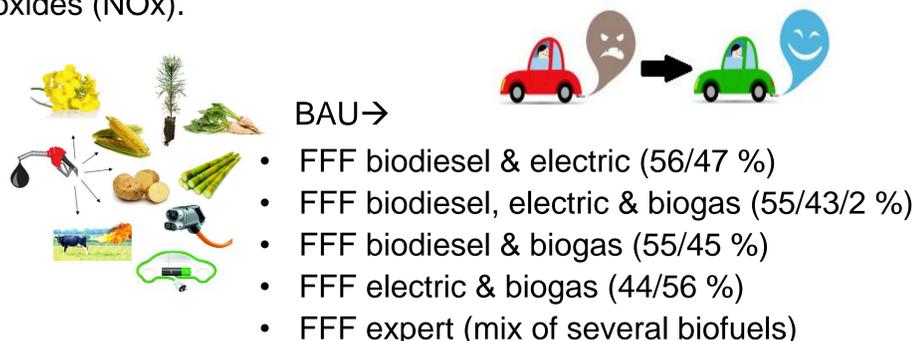
Emissions, modelling and health calculations

The project was divided into three parts; emission calculations using emission factors in HBEFA 3.2, dispersion and exposure modelling using a Gaussian dispersion model and health calculations of the number of premature deaths based on population exposure using response functions from the European ESCAPE study (Beelen et al., 2013).
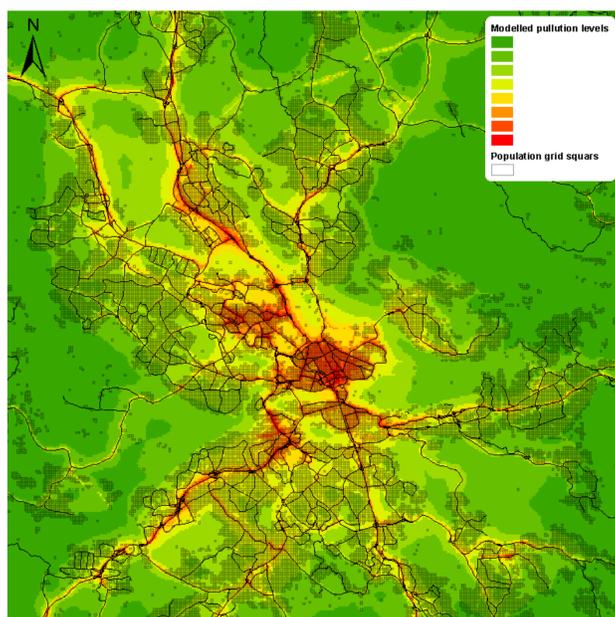
Figure 1. Modelled pollution levels together with populated grid squares giving data for population weighted exposure calculations for Stockholm county.

Population weighted exposure levels can be calculated using equation (1) were the calculated concentration is multiplied by the number of inhabitants in each grid square and divide with the total population of Stockholm county.

$$(1) \quad C_j = \frac{1}{P}\left[\sum_i^N C_{j,i}\, p_i\right]$$

Acknowledgement
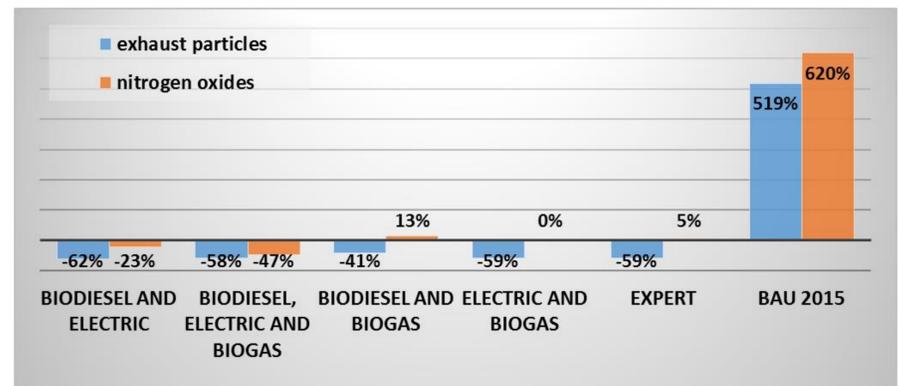
Figure 2. Change in population weighted concentration (µg/m³) for BAU 2015 and the different fossil free scenarios compared to BAU 2035.

The number of premature deaths per year can be calculated using equation (2).

$$(2) \quad \Delta N = \Delta C \times RR \times BLM \times P$$

ΔC = difference in concentration exposure (µg/m³) between BAU and FFF
RR = exposure response function for the specific pullutant
BLM = baseline mortality for individuals older than 30 years in Stockholm county
P = total individuals older than 30 years of age living in the county of Stockholm

Results

Changing to a fossil free fleet decreased levels of exhaust particles and NOx with 41-62 % and 33-47 % respectively, not including biodiesel to a high extent. Overall, a scenario with only electrification and biogas was found to be the most favorable reducing hazardous air pollutants from traffic. Highest health benefits was found between BAU 2015 and BAU 2035 reducing the number of premature deaths per year by 49 (NOx) and 10 (exhaust particles) respectively for BAU 2035. The right choice of fossil free fuel can further reduce these levels, as shown in Figure 3.
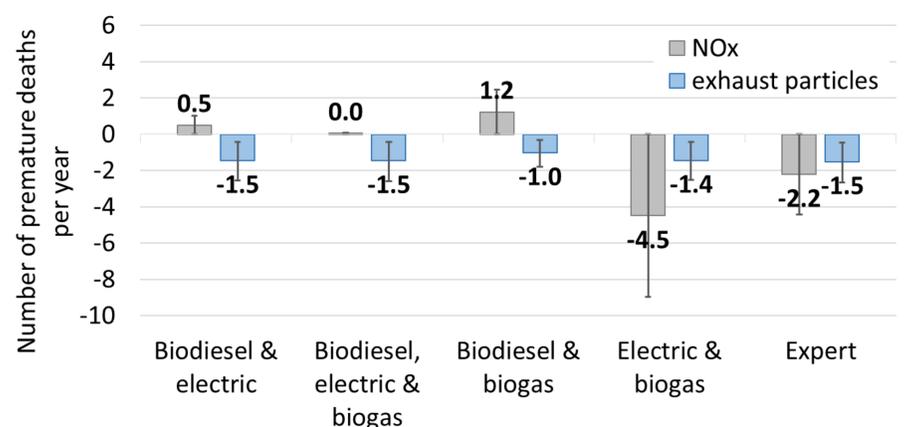
Figure 3. Health effect expressed as change in number of premature deaths per year changing from BAU 2035 to FFF 2035.

Conclusions

- The vehicle fleet composition, selection of fuel and the development of electrical vehicles is of importance of the emissions and air pollution levels of hazardous substances to human health.

- It is mainly technical development, control means and stricter emission requirements decreasing ambient air levels of traffic related air pollution. However, the right choice of fossil free fuel can further reduce these levels.

- Comparing the different FFF-scenarios electrification together with biogas was found to be most favourable to reduce NOx-levels in ambient air. Biodiesel can increase levels of NOx.