Air Emissions and Health Risks from Vegetable Oil Burning

November 2009

This briefing summarises information about air emissions and their direct health impacts from burning virgin, 'straight' vegetable oil, such as palm oil and rapeseed oil, particularly in biofuel power stations. It does not include information about greenhouse gas emissions from the growing and production of vegetable oil. There are serious concerns about air emissions from any large-scale biomass burning. For information about emissions and health impacts of large-scale wood burning, see www.energyjustice.net/biomass/ .

Although emissions can be abated (often at a high cost), they cannot be prevented altogether. Abatement of NOx in power station emissions using urea-based Selective Catalytic Reagent (SCR) systems produces Nitrous Oxide, a potent green house gas. SCR treatment does not reduce emissions of particulates which are particularly important in considering human health impacts.

Most independent evidence applies to emissions from biodiesel and pure plant oil/straight vegetable oil used in cars, however those findings can be largely applied to power stations, too. As a study commissioned by the Dutch government confirms, emissions from vegetable oil burning are relatively similar to those from burning mineral diesel, although there is some recent evidence that they may be even worse as far as nitrous oxide and carcinogenic and mutagenic PAH emissions are concerned. Overall, the emissions from a power station which burns 10,000 tonnes of vegetable oil a year – which is approximately what is needed to run an efficient 10MW power station continuously - are roughly equivalent to adding 10,000 diesel cars to the road.

Small particulate emissions (PM2.5) have so far not been regulated in the UK nor until very recently in the EU and they appear not to have been modelled in respect of any UK biofuel power station planning application. However, by 2011, the European Directive on Ambient Air Quality and Cleaner Air for Europe must be implemented in all member states. It mandates PM 2.5 reductions in all urban areas and sets a target value (25 μ g/m3 by 2010), to be replaced by legal limits. Ironically, applications for power stations are being assessed on the basis of legislation which ignores some of he most dangerous particulate emissions even though by the time they would, if approved, start operating new legal limits could be breached.

In the USA, the Environmental Protection Agency already defines exposure levels limits for PM2.5. EPA's 24-hour and annual exposure standards for PM2.5 are 35 micrograms per cubic meter and 15 micrograms per cubic meter.

Particulate Matter (PM)

Burning fossil fuels or biomass (including vegetable oil) emits small particulates, including PM 10 (particles of a diameter of 10 micrometres or less) and PM 2.5 (particles of a diameter of 2.5 micrometres of less), and even smaller ones. The smaller particles are, the further they travel.

According to a 2006 report by the World Health Organisation[1], particulate air pollution and above all PM 2.5 causes "a wide range of acute and chronic health problems and…a reduction in life expectancy of 8.6 months on average", as well as around 100,000 hospital admissions a year across the EU. According to the World Health Organisation report, there is evidence of both acute and chronic PM exposure leading to cardiovascular and respiratory disease. PM 2.5 appears more clearly linked to reduced life expectancy, whereas PM 10 appears to have a more obvious impact in terms of respiratory illness. "Health effects are observed at all levels of exposure, indicating that…some people are at risk even at the lowest end of the observed concentration range. People with pre-existing heart and lung disease, asthmatics, socially disadvantaged and poorly educated people and children belong to the more vulnerable groups." Very young children and probably unborn babies are particularly vulnerable to some pollutants, as are elderly people. The largest available cohort study found that each increase in PM 2.5 by 10 µm/m3 increases the overall mortality risk by 6%. The World Health Organisation summarises the effects of short-term

[1] WHO, Health risks of particulate matter from long-range transboundary air pollution, www.euro.who.int/document/e88189.pdf

exposure to particulate matter as follows: Lung inflammatory reactions, respiratory symptoms, adverse affects on the cardiovascular system, increase in medication usage, increase in hospital admissions, increase in mortality and the effects of chronic exposure as: increase in lower respiratory symptoms, reduction in lung function in children, increase in chronic obstructive pulmonary disease, reduction in lung function in adults, reduction in life expectancy, owing mainly to cardiopulmonary mortality and probably to lung cancer. "The available evidence is also sufficient to assume a casual relationship between exposure to PM and aggravation of asthma, as well as a causal link between increased prevalence and incidence of cough and bronchitis due to particulate exposure." Those findings are based on epidemiological studies.

There has been some evidence to suggest that there may be a link between PM levels and the rate of SIDS (cot death), although the evidence is clearer regarding a link between particulates and infant death from respiratory causes. [2]

The European Directive on Ambient Air Quality and Cleaner Air for Europe 2008 confirms : "Fine particulate matter (PM2.5) is responsible for significant negative impacts on human health. Further, there is as yet no identifiable threshold below which PM2,5 would not pose a risk."

In 2001, the UK Committee on the Medical Effects of Air Pollutants (COMEAP) reported to the Department of Health on PM2.5 saying,

> "18 µg/m3 $PM_{2.5}$ could be responsible for an average loss of life expectancy from birth of about 2-20 months. This compares with an estimate of around 7 years if all the population were smokers (using the relative risk of 2.07 for smokers from the HEI reanalysis and the same methodology)."

In Feb 2006 COMEAP commented again on the link between PM2.5 and cardiovascular disease:

> "Annual average concentrations of $PM_{2.5}$ are of the order of 7-10 µg/m3 in the UK generally and 18 µg/m3 in London today. Our current thinking is that the great majority of the effect described in the above extract is attributable to effects on the cardiovascular system." (www.advisorybodies.doh.gov.uk/comeap/statementsreports/CardioDisease.pdf)

In London, according to the Campaign for Clean Air in London, between 3,000 and 6,900 premature deaths occurred in 2005 due to PM 2.5, representing one in eight deaths in London that year.[3]

It is not clear whether or in how far Particulate Matter emissions from vegetable oil burning differ from those from mineral oil or diesel burning. There is some evidence that they are very similar[4], although in one trial they appeared to be higher.[5]

A recent study which compares a small wood gasification power station with a coal power station[6] found that more of the particulate emissions from biomass burning were very fine particulates (PM 2.5), compared to those from coal burning, with fine particulates posing a particular risk to human health. It is not known whether the same applies to vegetable oil burning.

Nitrogen oxides

Nitrogen oxides (NOx) are a precursor of small particulates as well as ozone.

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[2] Tracy Woodruff et al, Air Pollution and Postneonatal Infant Mortality in the United States 1999-2002, Environmental Health Perspectives. 2008;116(1):110-115

[3] Campaign for Clean Air in London, Letter to Mayor Boris Johnson, 17th November 2009, www.cleanairinlondon.org/

[4] Senternovem, The Road to Pure Plant Oil?, 2005, www.senternovem.nl/mmfiles/eindrap_juiste%20opmaak_ENversie_5aug.doc_tcm24-280270.pdf

[5] Scottish Government, Review of Greenhouse Gas Life Cycle Emissions, Air Pollution Impacts and Economics of Biomass Production and Consumption in Scotland, 2006, www.scotland.gov.uk/Publications/2006/09/22094104/6

[6] E. Lamminen and H. Isherwood, Comparison of fine particle emissions from a modern small-scale biomass burner and from a large-scale coal-firing power plant, European Aerosol Conference 2007, www.gaef.de/eac2007/EAC2007abstracts/T14Abstractpdf/T14A032.pdf

Biodiesel has been shown to emit more NOx than burning mineral diesel.[7] The reason for higher NOx emissions is that biodiesel burns at a higher temperature than mineral diesel. Straight vegetable oil also tends to burn at higher temperatures than mineral oil, suggesting that a similar trend for NOx emissions from vegetable oil burning can be expected. This is confirmed by a recent US study[8] as well as by measurements carried out by the Folkcenter, although one other study showed no obvious differences.[9] Regardless of a comparison with mineral oil, however, biofuel power stations will constitute additional sources of NOx.

According to the World Health Organisation, high levels of ozone "can cause breathing problems, trigger asthma, reduce lung function and cause lung diseases. In Europe it is currently one of the air pollutants of most concerns." There is evidence that daily mortality rises by 0.3% and that for heart disease by 0.4% for each 10 $\mu g/m^3$ increase in ozone exposure. Nitrogen dioxide itself has been shown by epidemiological studies to increase symptoms of bronchitis in children with asthma and to reduce lung function growth, including at levels currently observed in European cities.[10] A systematic scientific review by the World Health Organisation in Europe[11] also found that high ozone levels and high nitrogen dioxide levels are linked to increased medication usage and increased hospital emissions.

Some evidence suggests that N_2O levels may affect the rate of SIDS[12], although different studies reach different conclusions. There further evidence of a link between levels of ozone and SIDS[13] as well as of a link between ozone and respiratory illness in infants.[14]

PAH

A study commissioned the US Department of Agriculture which has been submitted for peer-review [15] suggests that emissions of carcinogenic and mutagenic polycyclic aromatic hydrocarbons (PAH) are three times higher in the case of straight vegetable oil burning compared to biodiesel or mineral diesel burning. This confirms findings from a previous trial that shows increased formaldehyde emissions.[16] Formaldehyde is one of the PAH emitted from burning vegetable oil, others are acetaldehyde and benzopyrene.

Other air emissions

One trial which looked at cars converted to and running on straight vegetable oil found significant increases in hydrocarbon and carbon monoxide emissions. Carbon monoxide is a relatively stable gas. Carbon monoxide binds to haemoglobin and reduces the oxygen-carrying capacity of the blood and thus impacts on cardiac health. Unborn babies and people with certain underlying diseases are particularly vulnerable to elevated carbon monoxide levels, which can affect brain development before birth.[17]

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[7] EPA, A comprehensive analysis of biodiesel impacts on exhaust emissions

[8] Jurgen Krahl et al, Comparison of Exhaust Emissions and Their Mutagenicity from the Combustion of Biodiesel, Vegetable Oil, Gas-to-Liquid and Petrodiesel Fuels, January 2009, www.ars.usda.gov/research/publications/publications.htm?SEQ_NO_115=229651

[9] The Scottish Government, Environmental Impacts of Biomass Energy Options, www.scotland.gov.uk/Publications/2006/09/22094104/6

[10] World Health Organisation, Air Quality and Health, www.who.int/mediacentre/factsheets/fs313/en/index.html

[11] World Health Organisation, Health Aspects of Air Pollution, June 2004, www.euro.who.int/document/E83080.pdf

[12] Ritz B, Wilhelm M, Zhao Y. 2006. Air pollution and infant mortality in southern California, 1989-2000. Pediatrics 118:493–502

[13] See footnote , also

[14] Triche EW, Gent JF, Holford TR, Belanger K, Bracken MB, Beckett WS, et al. 2006. Low-level ozone exposure and respiratory symptoms in infants. Environ Health Perspect 114:911–916.

[15] See footnote 5

[16] See footnote 9

[17] WHO Regional Office for Europe, Air Quality Guidelines, Second Edition, www.euro.who.int/document/aiq/5_5carbonmonoxide.pdf

Smell and noise

In Germany, smell and noise nuisance from palm oil CHP plants has been of concern to communities living in close proximity. On 9th April 2008, a court revoked the planning permission granted for a palm oil CHP plant in St Ingbert, Saarland which had been in operation since 2007 due to those noise and smell nuisance.[18]

What others say

+ ***American Lung Association in Massachusetts***: "The American Lung Association in Massachusetts views biomass burning as a significant source of air pollution…For vulnerable populations, such as people with asthma, chronic respiratory disease, and those with cardiovascular disease, biomass and diesel emissions are particularly harmful. Even short exposures can prove deadly. An increasing number of studies are pointing to the direct impact of increased particle pollution levels and an increase in heart attacks. The particles produced by biomass and diesel emissions are extremely small and are unable to be filtered out of our respiratory system. Instead, these small particles end up deep in the lungs where they remain for months, causing structural damage and chemical changes. In some cases the particle can move through the lungs and penetrate the bloodstream."[19] [Note: Although the letter primarily relates to wood burning, the statements regarding particle emissions are also relevant to vegetable oil burning.]

+ ***Jim Fitzpatrick, Minister for Food, Farming and Environment, Defra***: "The use of biomass for heat and power can pose a significant air quality problem. Large scale heat or combined heat and power schemes should not normally be used in heavily built-up areas…unless they are of high quality (20g/GJ PM10 or less) or have efficient abatement equipment specified."[20]

[18] www.ngo-online.de/ganze_nachricht.php?Nr=17711 (Note that the court judgment has since become binding.)

[19] Letter by Scott Keays, Public Policy Manager fort he American Lung Association to Senator John Kerry, 16th November 2009

[20] House of Commons Written Answers and Statements, 2nd November 2009