HUMAN HEALTH EVALUATION OF EMISSIONS FROM THE PROPOSED STRAW AND WOODCHIP FIRED BIOMASS COMBINED HEAT AND POWER (CHP) PLANT, LEWISTOWN, NEWBRIDGE, CO. KILDARE.

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1. Introduction.

Dr. Maria Martinez Moratalla has prepared this report for a proposed straw and woodchip - fired combined heat and power plant development to be located in Lewistown, adjacent to Tougher Business Park, Ladytown, Newbridge, County Kildare as part of an Environmental Impact Assessment (EIA), which is required by the relevant Planning Authority (Kildare County Council).

The information contained within this report is concerned with the description of potential pollutants, their impact on health and the effects on health of the predicted emissions from the proposed Biomass plant. The predicted emissions are taken from the Dispersion Modelling Assessment performed by Odour Monitoring Ireland on behalf of Organic Power Ltd. The predicted emissions are then compared to the Irish Guideline / Limit values as set out in SI No. 271/2002 – Air Quality Standards, EU Limit values as laid out in the EU daughter Directive on Air Quality 99/33/EC and the WHO Air Quality Guidelines for particulate matter, ozone, nitrogen and sulphur dioxide, Global Update 2005.

2. Background

These days we are all very concerned about how pollution can damage air quality and moreover population's health. The effects of polluted air have been well studied in recent years, and have been researched all over the world. It is already well known, the relationship between the diferent pollutants and specific health damage.

As all these studies show, that the connection between pollution and its effect on health can be demonstrated. For example, severe air pollution during first years of life has detrimental effect on the development of children's pulmonary functions. Pollution causes or worsens respiratory disease, such as emphysema and bronchitis, and can aggravate existing heart disease. Also pollution leads to increased hospital admissions and increased visits to emergency departments for respiratory issues, especially asthma.

It is well known how each chemical compound contained in polluted air has a specific effect on health. The effects of each particular pollutant are also related to the time of exposure (short or long term exposure) and to the levels of this pollutant that people are exposed to.

Air quality is judged relative to the relevant Air Quality Standards, which are concentrations of pollutants in the atmosphere, which achieve a certain standard of environmental quality. Air quality Standards are formulated on the basis of an assessment of the effects of the pollutant on public health and ecosystems(1).

In general terms, air quality standards have been framed in two categories, limit values and guideline values. Limit values are concentrations that cannot be exceeded and are based on WHO and EC guidelines for the protection of human health. Guideline values have been established for long-term precautionary measures for the protection of human health and the environment. European legislation is also considered standard for the protection of vegetation and ecosystems(1).

In response to general concern about pollution damaging human health, this paper will show with supporting data how Biomass Plants are one of the safest forms of energy source. This paper will not discuss other forms of energy sources in detail as their effects on human health are already well documented.

To support the fact that Biomass plant emissions are not health damaging this report will compare the figures given in the predictions from the Biomass CHP dispersion model to the ones set as Limit values for protecting Human Health in the Air Quality Standards Regulation of SI 271 of 2002 and also to the ones in the WHO Air Quality Guidelines (AQG) in 2005.

The quantity of the different pollutants which are predicted to be emitted in the worst case working situations of the biomass plant, will be compared to the figures given as being below any human risks.

This report will demonstrate for each pollutant that we are concerned about, how none of these different chemical compounds, not even in the worst case plant working situation, will be at a level capable of damaging health. This is also supported in the Biomass CHP Dispersion Model Report which states “The proposed straw and woodchip fired Biomass CHP plant will not result in any significant impact on air quality in the surrounding area with all ground level concentrations of pollutants well within their respective ground level concentration limit values”(1).

3. **Biomass CHP and Emissions**

Biomass is considered to be a renewable energy because its energetic content comes from the solar energy used by plants during photosynthesis. This energy is released as CO_2 and water during the process of combustion. The emissions level of CO_2 is considered neutral, as the quantity of CO_2 emitted is the same quantity previously used by plants during their growing process. Therefore, there is no increase of this gas in the atmosphere, when the complete cycle is taken into account.

Most biomass is composed of roughly 50% carbon by weight, 40% oxygen and 5% hydrogen. Under ideal combustion conditions these are completely converted to carbon dioxide (CO_2) and water vapour (H_2O). In addition there can be about 0.3% nitrogen, 0.1% sulphur, 0.1% chlorine, and trace quantities of various minerals such as calcium, potassium, silicon, phosphorus and sodium which were part of the plants. The small percentage of nitrogen is released as Nitrogen Oxides, which will be converted in the atmosphere to NO_2. The small percentage of sulphur is released as Sulfur dioxide SO_2. The very small quantity of chlorine is released as hydrochloric acid (HCl). The rest of the minerals, that are absorbed into growing biomass if present in the soil, water or atmosphere, contribute to the ash in the form of various salts.

During the combustion cycle, larger particles fall through the grate as bottom ash, while smaller particles can be carried up with the flue gases, together with any particulate unburned carbon, as fly ash and dust (particle matter). A high percentage of these stay in the filter as ashes, which can be used later as fertilizer in agricultural or forestry uses.

It is well known that emissions such as NOx, SOx and volatile organic compounds from Biomass plant burning equipment are, in general, very low in comparison to other forms of combustion heating, (this is because of the low quantity of those components in biomass to begin with), making this one of the less-polluting heating options available.

For example, the low levels of sulphur in most biomass leads to emissions of SO_2, at typically 20mg/MJ, which is considerably lower than those of oil (140mg/MJ) or coal (900mg/MJ), which are used for example in regular heating, fires at home and car engines, and considerably lower than the levels we are exposed to during our daily life due to the proximity to these everyday uses of these energy sources.

4. Pollutants

The principal concerns about emissions and the impact of combustion systems on air quality are in relation to:

- Carbon dioxide (CO_2)
- Carbon monoxide (CO)
- Oxides of Nitrogen (NO_x)
- Sulphur dioxide (SO_2)
- Particulate Matter (PM_{10})

Carbon dioxide (CO_2)

CO_2 is a greenhouse gas and an inevitable consequence of burning any organic (carbon containing) material.

CO_2 emissions from burning biomass are actually relatively high, calculated per kWh of energy, compared to most fossil fuels. However, the carbon released by burning biomass was taken out of the atmosphere recently, and is part of the current carbon cycle. Therefore, if the fuel is obtained from a sustainably managed source, will be absorbed by subsequent growth. This is why biomass is frequently described as "carbon neutral".

Carbon monoxide (CO)

In a well designed combustion system, which allows sufficient time and turbulence within the combustion chamber for complete combustion, levels of CO within the flue gases can be kept to a minimum.

Carbon Monoxide (CO) is a colorless, odorless gas. It forms when carbon in fuel is not burned completely because of insufficient oxygen supply, or incomplete combustion.

Vehicle exhaust makes up 85 – 90% of all CO emissions in every city and is one of the most dominant pollutants in cities. Higher levels of CO generally occur in areas with heavy traffic congestion. Other sources of CO emissions include industrial processes, residential wood burning, and natural sources such as forest fires. Woodstoves, gas stoves, cigarette smoke, and unvented gas and kerosene space heaters are sources of CO indoors.(2)

The highest carbon monoxide levels tend to occur when the weather is very cold or at high elevations where there is less oxygen in the air to burn the fuel. Cold weather can also cause temperature inversions which trap pollutants low to the ground.

Luckily, CO is quickly removed from the atmosphere by microorganisms in the soil.

Oxides of Nitrogen (NO_x)

This is a group of highly reactive gases that contain nitrogen and oxygen in varying amounts. Many of the nitrogen oxides are colorless and odorless. Nitrogen oxides are formed when the oxygen and nitrogen in the air react with each other during combustion. The formation of nitrogen oxides is favored by high temperatures and excess oxygen (more than is needed to burn the fuel). In addition this gas contributes to the formation of ground-level ozone, and fine particle pollution. The common pollutant nitrogen dioxide (NO_2) can often be seen combined with particles in the air as a reddish-brown layer over many urban areas.

Most atmospheric NO_2 is emitted as NO, which is rapidly oxidized by ozone to Nitrogen dioxide, NO_2, in the presence of hydrocarbons and ultraviolet light. It is the main source of tropospheric ozone which is formed when NO_x and volatile organic compounds react in the presence of heat and sunlight, and of nitrate aerosols, which form an important fraction of the ambient air mass (particulate matter, $PM_{2.5}$). NO_x react with ammonia, moisture, and other compounds to form small particles.(2)

The primary sources of nitrogen oxides are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels.

Sulphur Dioxide (SO_2)

Sulfur dioxide (SO_2) is one of a group of highly reactive gasses known as “oxides of sulfur.” The largest sources of SO_2 emissions are from fossil fuel combustion at power plants (66%) and other industrial facilities (29%). Smaller sources of SO_2 emissions include industrial processes such as extracting metal from ore, and the burning of high sulfur containing fuels by locomotives, large ships, and non-road equipment.(2)

Particle Matter (PM)

Tiny particles or liquid droplets suspended in the air can contain a variety of chemical components. Larger particles are visible as smoke or dust and settle out relatively rapidly. The tiniest particles can be suspended in the air for long periods of time and are the most harmful to human health because they can penetrate deep into the lungs.

Particle pollution, also known as "particulate matter" (PM), in the air includes a mixture of solids and liquid droplets. Some particles are emitted directly; others are formed in the atmosphere when other pollutants react. Particles come in a wide range of sizes.

PM_{10} and $PM_{2.5}$ refer to particles smaller than 10 microns and 2.5 microns respectively. In biomass burning, total particle emissions are predominantly $PM_{2.5}$, or "fine" particles. These particles are so small they can be detected only with an electron microscope. Other sources of fine particles include all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes.

Particles between 2.5 and 10 micrometers in diameter are referred to as "**coarse** dust particles." Sources of coarse particles include crushing or grinding operations, and dust stirred up by vehicles travelling on roads.(2)

5. Effects of Pollutants on Health

The following summarises the adverse effects that each compound can have on human health, which are well reported and based on studies all around the world. It is important to pay attention to the concentrations of each pollutant that causes each effect (which can vary from very slight to severe depending on the concentration of the pollutant).

Carbon Monoxide (CO)

This colourless, odourless gas can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues. CO enters the bloodstream when you inhale air. It is capable of binding to the haemoglobin in your blood (blood pigment), which carries oxygen from your lungs throughout your body. CO binds more effectively than oxygen and also stays bound to the haemoglobin for far longer than oxygen does. The effect is that the blood is starved of oxygen, which then affects the rest of the body, which does not receive any oxygen from the bloodstream. This results in different damage to the different organs depending on how much they need the oxygen to keep alive. The brain and the heart are extremely sensitive to the lack of oxygen, and this is why they are the first ones to be adversely affected.

The ability of CO to bind so strongly to the haemoglobin means that even when CO is in low concentrations it can rapidly build up in the blood. Initial symptoms of mild poisoning include headaches and dizziness due to lack of oxygen in the brain.

Cardiovascular Effects.

The health threat from lower levels of CO is most serious for those who suffer from heart disease, like angina, clogged arteries, or congestive heart failure. For a person with heart disease, a single exposure to CO at low levels may cause chest pain and reduce that person's ability to exercise; repeated exposures may contribute to other cardiovascular effects. This is because they already have a lower supply of oxygen to their heart, which is reduced even more with the exposure to CO. When exercising this effect is enhanced as the need for oxygen is increased.

Central Nervous System Effects.

Even healthy people can be affected by high levels of CO. People who breathe high levels of CO can develop vision problems, reduced ability to work or learn, reduced manual dexterity, and difficulty performing complex tasks. At extremely high levels, CO is poisonous and can cause death. People with marginal or compromised cardiovascular and respiratory symptoms, women that are pregnant or small children, are most at risk from CO pollution.[3]

In table 1 below, we can see the relationship between CO concentration and its impact on health. These effects range from very slight to severe.

Table 1. The health effects of CO at different levels in air, in ppm

CO Level	Health Effect
1-4ppm	Normal levels in human tissues produced by body.
5-6ppm	Significant risk of low birth rate if exposed during last trimester (Ritz & Yu-1999)
9ppm	ASHRAE standard for allowable spillage from vented appliances, indoors, for 8 hours exposure daily. EPA standard for outdoors for 8 hours and a maximum 3 times per year. (Clean Air Act)
10ppm	Outdoor level of CO found associated with a significant increase in heart disease deaths and hospital admissions for congestive heart failure. (JAMA, Penny) lst ambient level occupants should be notified-NCI Protocol
15-20ppm	First level World Health Organization lists as causing impaired performance, decrease in exercise time and vigilance 1st Alarm level for NSI 3000 Low Level CO Monitor-5 minutes
25ppm	Maximum allowable in a Parking Garage (International Mechanical Code)
27ppm	21% increase in cardio respiratory complaints (Kurt-1978)
30ppm	Earliest onset of exercise induced angina (World Health Organization) 1st visual display on UL2034 approved CO Alarm-Must not alarm before 30 days
50ppm	US OSHA recommended 8 hour maximum workplace exposure Maximum NCI level for Unvented appliances
70ppm	1st Alarm level of UL2034 approved CO Alarms- 2-4 hours 3rd Alarm level for NSI 3000 - 30 seconds NSI 3000 Low Level Monitor cannot be silenced by reset button
200ppm	First listed level(established in 1930) healthy adults will have symptoms- headaches, nausea NIOSH & OSHA recommend evacuation of workplace Maximum “Air Free” CO for vented water heater and unvented heaters (ANSI Z21) UL approved alarms must sound between 30 – 60 minutes(NSI 3000 – 30 seconds)
400ppm	Healthy adults will have headaches within 1-2 hours. Life threatening after 3 hours Maximum “Air Free” CO in all vented heating appliances (ANSI Z21) Maximum EPA levels for industrial flue exhaust UL Alarms must alarm within 15 minutes (NSI 3000 – 30 seconds) Maximum recommended light-off CO for all appliances – NCI (except oil)
800ppm	Healthy adults will have nausea, dizziness, convulsions within 45 minutes. Unconscious within 2 hours then Death(established in 1930) Maximum “Air Free” CO for unvented gas ovens (ANSI Z21) 800ppm+ Death in less than one hour

Sulphur Dioxide (SO_2)

SO_2 causes a wide variety of health and environmental impacts because of the way it reacts with other substances in the air. Particularly sensitive groups include people with asthma, children, the elderly, and people with heart or lung disease. Peak levels of SO_2 in the air (gaseous SO_2) can cause temporary breathing difficulty for people with asthma. Longer-term exposures to high levels of SO_2 gas and particles cause respiratory illness and aggravate existing heart disease.

SO_2 reacts with other chemicals in the air to form tiny sulphate particles. When these are inhaled, they gather in the lungs and are associated with increased respiratory symptoms and disease, difficulty in breathing, and premature death.

Short - term exposures

Controlled studies involving exercising asthmatics indicate that a proportion experience changes in pulmonary function and respiratory symptoms after periods of exposure to SO_2 as short as 10 minutes. Based on this evidence, it is recommended that a SO_2 concentration of 500µg/m^3 should not be exceeded over averaging periods of 10 minutes duration.

Because short-term SO_2 exposure depends very much on the nature of local sources and the prevailing meteorological conditions, it is not possible to apply a simple factor to this value in order to estimate corresponding guideline values over longer time periods, such as one hour.

Long-term exposures (over 24-hours)

Early estimates of day-to-day changes in mortality, morbidity or lung function in relation to 24 -hour average concentrations of SO_2 were necessarily based on epidemiological studies in which people are typically exposed to a mixture of pollutants. There is still considerable uncertainty as to whether SO_2 is the pollutant responsible for the observed adverse effects or whether it is a surrogate for ultrafine particles or some other correlated substance. The 24 hour guideline in Ireland and the EU is 125µg/m^3, however the WHO has adopted a more precautionary approach and has a guideline value of 20µg/m^3.

An annual guideline for SO_2 is not needed, since compliance with the 24-hour level will assure low annual average levels. (3)

Oxides of Nitrogen (NO_x)

Short-term exposures

Current scientific evidence links short-term NO_2 exposures, ranging from 30 minutes to 24 hours, with adverse respiratory effects including airway inflammation in healthy people and increased respiratory symptoms in people with asthma.

A number of short-term experimental human toxicology studies have reported acute health effects following exposure to 1 hour NO_2 concentrations in excess of 500µg/m^3. Although the lowest level of NO_2 exposure to show a direct effect on pulmonary function in asthmatics in more than one laboratory is 560µg/m^3, studies of bronchial responsiveness among asthmatics suggest an increase in responsiveness at levels upwards from 200µg/m^3.

Long-term exposures

There is still no robust basis for setting an annual average guideline value for NO_2 through any direct toxic effect. Evidence has emerged, however, that increases the concern over health effects associated with outdoor air pollution mixtures that include NO_2. For instance, epidemiological studies have shown that bronchitic symptoms of asthmatic children increase in association with annual NO_2 concentration, and that reduced lung function growth in children is linked to elevated NO_2 concentrations within communities already at current North American and European urban ambient air levels. A number of recently published studies have demonstrated that NO_2 can have a higher spatial variation than other traffic-related air pollutants, for example, particle mass. These studies also found adverse effects on the health of children living in metropolitan areas characterized by higher levels of NO_2 even in cases where the overall city-wide NO_2 level was fairly low.

Recent indoor studies have provided evidence of effects on respiratory symptoms among infants at NO_2 concentrations below 40μg/m^3. [(3)]

Ozone is formed when NO_x and volatile organic compounds react in the presence of heat and sunlight. Children, the elderly, people with lung diseases such as asthma, and people who work or exercise outside are also at risk from adverse effects from ozone. Therefore, reducing the limits for NOx also help reduce the formation of ozone.

Particle Matter (PM)

The evidence on airborne particulate matter (PM) and its public health impact is consistent in showing adverse health effects at exposures that are currently experienced by urban populations. The epidemiological evidence shows adverse effects of PM following both short-term and long-term exposures.

Particles less than 10 micrometers in diameter (PM_{10}) are so small that they can get into the lungs, potentially causing serious health problems. The ranges of health effects are broad, but are predominantly to the respiratory and cardiovascular systems. All population is affected, but susceptibility to the pollution may vary with health or age.

At present, most routine air quality monitoring systems generate data based on the measurement of PM_{10} as opposed to other particulate matter sizes. Consequently, the majority of epidemiological studies use PM_{10} as the exposure indicator. PM_{10} represents the particle mass that enters the respiratory tract and, moreover, it includes both the coarse (particle size between 2.5 and 10 μm) and fine particles (measuring less than 2.5 μm, $PM_{2.5}$) that are considered to contribute to the health effects observed in urban environments.

6. Effects of Predicted Biomass Emissions on Health

The following section compares the predicted levels of emissions from the Dispersion Modelling Assessment performed by Odour Monitoring Ireland for the proposed biomass plant in Newbridge, Co. Kildare to the Irish Guideline / Limit values as set out in SI No. 271/2002 – Air Quality Standards and the WHO Air Quality Guidelines for particulate matter, ozone, nitrogen and sulphur dioxide, Global Update 2005 (see Table 2 below). These emission levels are also evaluated for their impact on human health. It should be noted that the Irish Guideline / Limit values as set out in SI No. 271/2002 – Air Quality Standards are equivalent to the EU Limit values as laid out in the EU daughter Directive on Air Quality 99/33/EC.

Table 2. Comparison of the emission levels predicted in the Biomass CHP Dispersion Model to the guidelines in the* Air Quality Standards Regulation of 2002 *and the Air Quality Guidelines given by WHO for protection of human health.

Emission	**Maximum Predicted Ground Level Concentration (GLC) (μg/m^3)**	**Baseline and Maximum Predicted GLC (μg/m^3)**	**Irish Air Quality Standards Regulation SI.271/2002 (μg/m^3)**	**WHO Air Quality Guidelines (μg/m^3)**
Carbon monoxide - 8 hr maximum GLC	55.77	1,095.77	10,000	N/A
Oxides of nitrogen - Max Annual average	4.7	25.7	40	40
Sulphur dioxide - 24 hr Max 100th percentile	26.32	38.32	125	20
Sulphur dioxide – Max annual average	3.23	9.23	20	N/A
Total particulates - 24 hr Max 100th percentile	0.56	46.56	50	50
Total Particulates - Max annual average	0.080	23.08	40	20

Carbon monoxide

The Air Quality Standards Regulation SI.271/2002 for CO gives a limit value for the protection of human health for an averaging period of 8 hours as 10,000µg/m^3.

As we can see in table 2, the predicted Maximum Ground Level Concentration for CO is only 55.77µg/m^3, and the predicted plus the baseline for this gas is 1,095.77µg/m^3. These figures are well below the limit value of 10,000µg/m^3 set out by the Irish and EU Regulations that could cause any risk to health.

Converting the above predicted emission values from µg/m^3 to ppm, we can also directly compare these values to the health effects of different CO air concentrations given in Table 1.

The 8 hr maximum Ground Level Concentration of CO is 55.77µg/m^3 which is equivalent to 0.0487ppm. The 8 hr maximum Ground Level Concentration of CO plus the baseline concentration is 1095.77µg/m^3 and is equivalent to 0.9566ppm. These CO levels are below the normal levels in human tissues produced by body (1 to 4 ppm).

The quantities of CO that will be emitted from the biomass plant are so low that that will not have any ill effect on health.

Sulphur dioxide

For SO_2 the maximum annual average predicted Ground Level Concentration of biomass emissions would be 3.23µg/m^3 and 9.23µg/m^3 when added to the baseline concentration in the atmosphere. There is no annual average guideline given in the WHO AQG, but comparing these figures to the limit of 20µg/m^3 set in the Air Quality Standards Regulation of SI 271 of 2002, the emissions from the biomass plant will be well below the limits set for the protection of human health.

For SO_2 the maximum 24 hour average predicted Ground Level Concentration of biomass emissions would be 26.32 µg/m^3 and 38.32 µg/m^3 when added to the baseline concentration in the atmosphere. The Limit value for the protection of human health set by the Air Quality Standards Regulation of SI 271 of 2002 for SO_2 is 125µg/m^3 for daily emissions and again is well below the limit set for the protection of human health.

As said before, there is still considerable uncertainty as to whether SO_2 is the pollutant responsible for the observed adverse effects or whether it is a surrogate for ultrafine particles or some other correlated substance. Although the WHO has adopted a more precautionary approach and has a guideline value of 20µg/m^3 per 24 hour mean, it is recognised that it will be difficult for countries to achieve the revised guideline in the short term and therefore a stepped approach using interim goals is recommended coupled with monitoring of public health and SO_2 levels for health effect gains.

The interim targets for SO_2 24 hour average are:

1) Interim Target 1 - 125µg/m^3 (Current Irish and EU limit)
2) Interim Target 2 - 50µg/m^3
3) Air Quality Guideline - 20µg/m^3

Predicted emissions from the Biomass plant are still below the Interim Target 2 of 50µg/m^3. As the reduction in the limits are to be coupled with monitoring of public health and SO_2 levels for health effect gains, the limit will be reduced to 20µg/m^3 only if results of the public health monitoring deem it necessary.

Total particulates

In the dispersion model, as in most studies, total particle refers to PM_{10}. For PM_{10} the maximum 24 hour average predicted Ground Level Concentration of biomass emissions is 0.56μg/m^3. When added to the baseline figure, the emission level is 46.56μg/m^3. This is below the limit of 50μg/m^3 set by the Irish and EU Regulations and WHO AQG that could cause any risk to health.

The maximum annual average Predicted Ground Level Concentration of biomass emissions is 0.080μg/m^3. When added to the baseline figure, the emission level is 23.08 μg/m^3 which is well below the annual mean limit of 40μg/m^3 set by the Irish and EU Air Quality Standards.

The EU and Irish Regulations specify Stage 1 and Stage 2 Limits for PM_{10}. The current limit is Stage 1 and is set at 40μg/m^3 for 2005 – 2010. The Stage 2 limit is set at 20μg/m^3 for 2010. The Clean Air for Europe (CAFÉ) Directive (EP and CEU, 2008) was published in 2008 and is due to be transposed into Irish law by 11 June 2010. There are no changes to existing limit values, however, the upper and lower assessment thresholds for PM_{10} have been increased. The Stage II limit value for PM_{10} of 20μg/m^3 set out in the first daughter Directive (CEC, 1999) is not included in the CAFÉ Directive and will no longer apply following transposition of the CAFÉ Directive. [(5).]

It should be noted that meeting the guideline values for the 24 hour limits protects against peaks of pollution that would otherwise lead to adverse health effects. The maximum annual average quantity of PM_{10} that will be emitted in worst case scenario is only 0.08μg/m^3 and will have little effect on the current atmospheric concentrations. In reality the daily emissions will be even lower and would not have any ill effect on human health.

Oxides of nitrogen

For NO_x the maximum annual average predicted Ground Level Concentration of biomass emissions would be 4.70μg/m^3 and when added to the baseline atmospheric concentration is 25.70μg/m^3, which again is well below the annual mean limit of 40μg/m^3 set in the AQG by the WHO and the Limits in the Air Quality Standards Regulation of SI 271 of 2002. The NOx maximum hourly mean predicted is 50.17μg/m^3 and 92.17μg/m^3 when added to the baseline atmospheric concentrations, which is again well below the limit of 200 μg/m^3 set out by the Irish and EU regulations and WHO guidelines.

Emissions of NOx from the proposed biomass plant will not have any ill effects on human health.

7. Conclusion

The principal concerns about emissions and the impact of combustion systems on air quality are in relation to Carbon dioxide (CO_2), Carbon monoxide (CO), Oxides of Nitrogen (NO_x), Sulphur dioxide (SO_2) and Particulate Matter (PM_{10}).

Biomass is frequently described as carbon neutral as the carbon released by burning biomass was taken out of the atmosphere recently, and is part of the current carbon cycle. Therefore, if the fuel is obtained from a sustainably managed source, it will be absorbed by subsequent growth.

It is well known that emissions such as NOx, SOx and volatile organic compounds from Biomass plant burning equipment are, in general, very low in comparison to other forms of combustion heating, (this is because of the low quantity of those components in biomass to begin with), making this one of the less-polluting heating options available.

For example, the low levels of sulphur in most biomass leads to emissions of SO_2, at typically 20mg/MJ, which is considerably lower than those of oil (140mg/MJ) or coal (900mg/MJ), which are used for example in regular heating, fires at home and car engines, and are considerably lower than the levels we are exposed to during our daily life due to the proximity to these everyday uses of these energy sources. According to Dr Ciaran O'Donnell, EPA Programme Manager, traffic and smoking fuels are the two main factors adversely affecting air quality in Ireland[(5)].

The predicted emissions of Carbon monoxide, Nitrogen oxides, sulphur dioxide and particulate matter from the proposed biomass plant when added to the current baseline atmospheric concentrations are all well below the Irish Guideline / Limit values as set out in SI No. 271/2002 – Air Quality Standards, EU Limit values as laid out in the EU daughter Directive on Air Quality 99/33/EC and the WHO Air Quality Guidelines for particulate matter, ozone, nitrogen and sulphur dioxide, Global Update 2005. It should also be noted that the predicted emissions are worst case concentrations and that the daily emission levels will be lower again.

The limits and guidelines have been set for the protection of human health. Therefore, the proposed Biomass plant at Newbridge, Co. Kildare will not have any adverse effects on human health as all predicted emissions are below these limits.

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