Supplementary Material

Emissions from the Combustion of Torrefied and Raw Biomass Fuels in a Domestic Heating Stove. D. Maxwell, B.A. Gudka, J.M. Jones and A. Williams.

School of Chemical and Process Engineering, University of Leeds, Leeds, LS2 9JT, UK

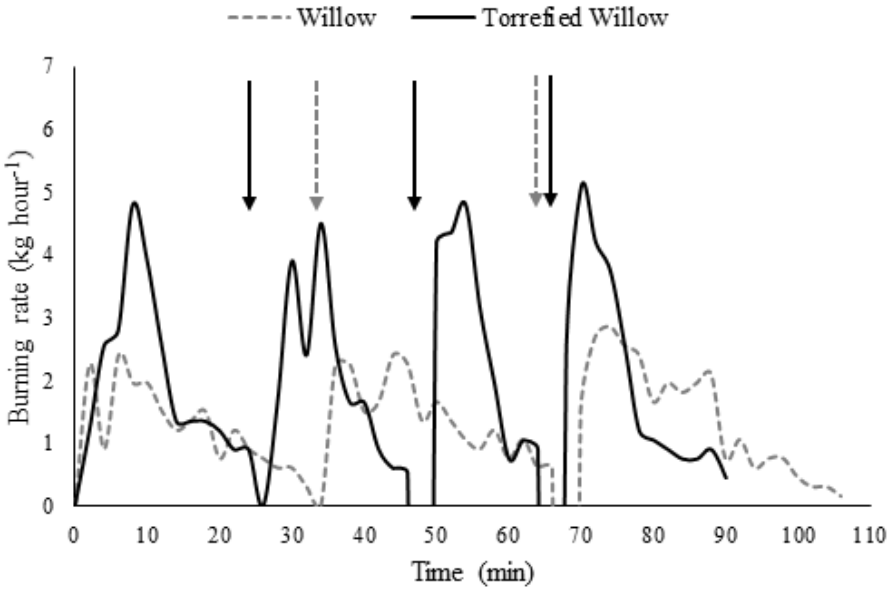

Fig S.1. Comparison of the burning rate for the willow (dashed line) and the torrefied willow (solid line) fuels. The points of fuel reloading are shown by vertical arrows.

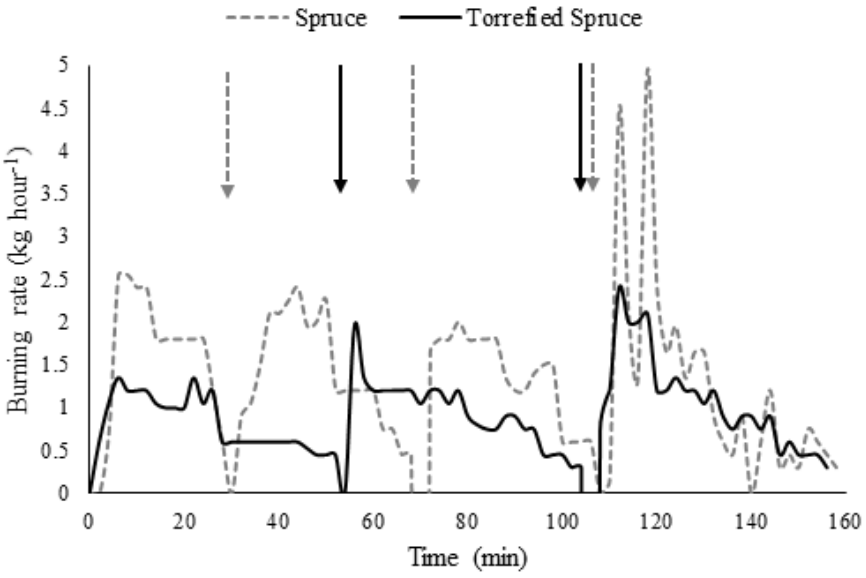

Fig. S.2. Comparison of the burning rate for the spruce (dashed line) and the torrefied spruce (solid line) fuels. The points of fuel reloading are shown by vertical arrows.

Figs S1 and S2 display a sharp peak in burning rates during reloading points (shown by the arrows) for the non-torrefied materials (particularly the briquettes), and broader peaks in burning rates for the torrefied fuels.

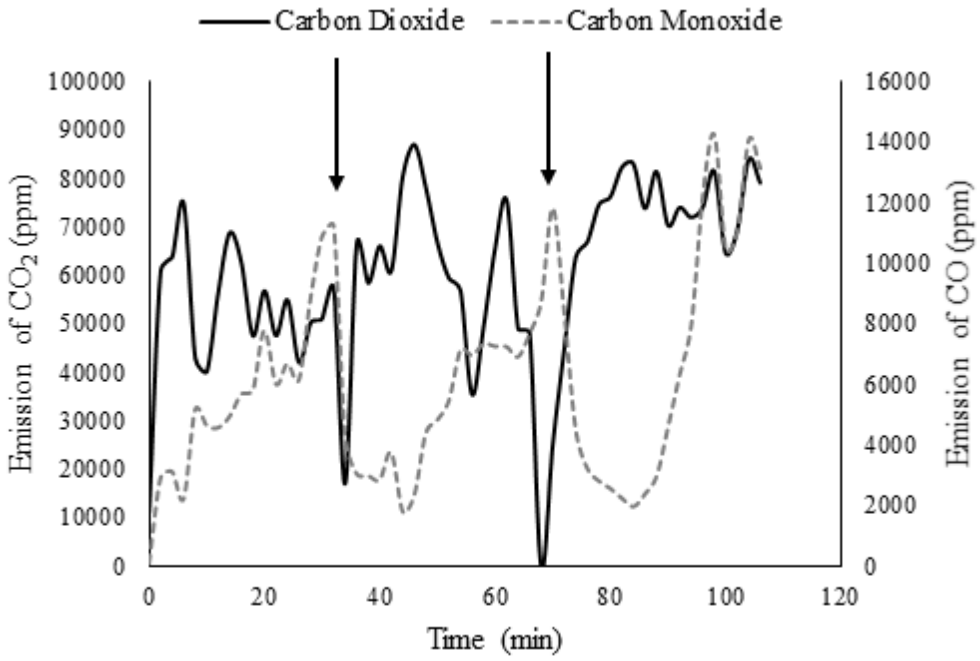

Fig. S.3. Emissions of CO_2 (solid line) and CO (dashed line) over the combustion period for willow. The arrow indicates the point of fuel reloading.

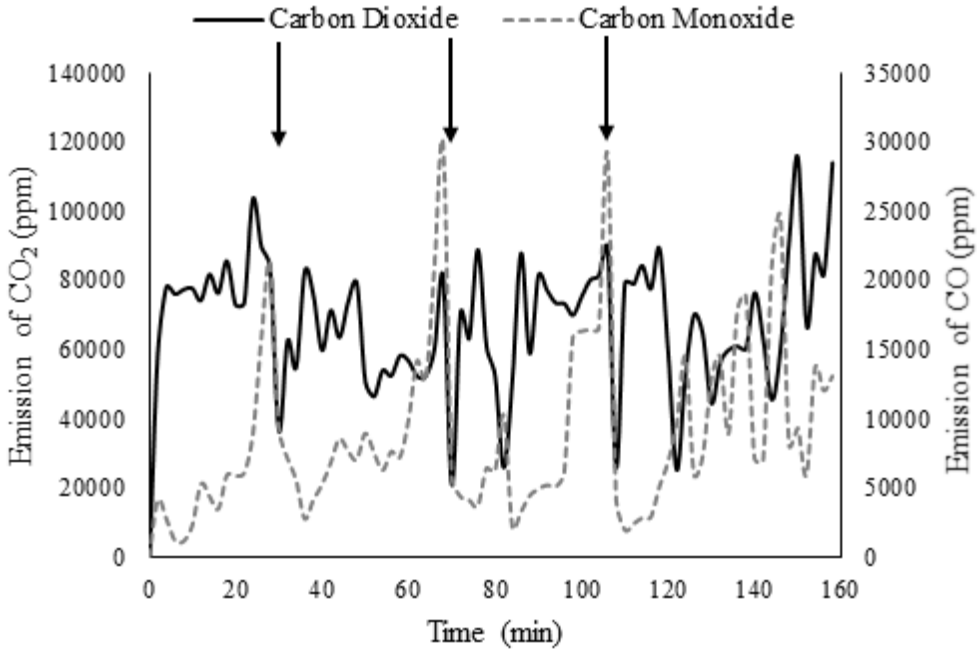

Fig. S.4. Emissions of CO_2 (solid line) and CO (dashed line) over the combustion period for spruce. The arrow indicates the point of fuel reloading.

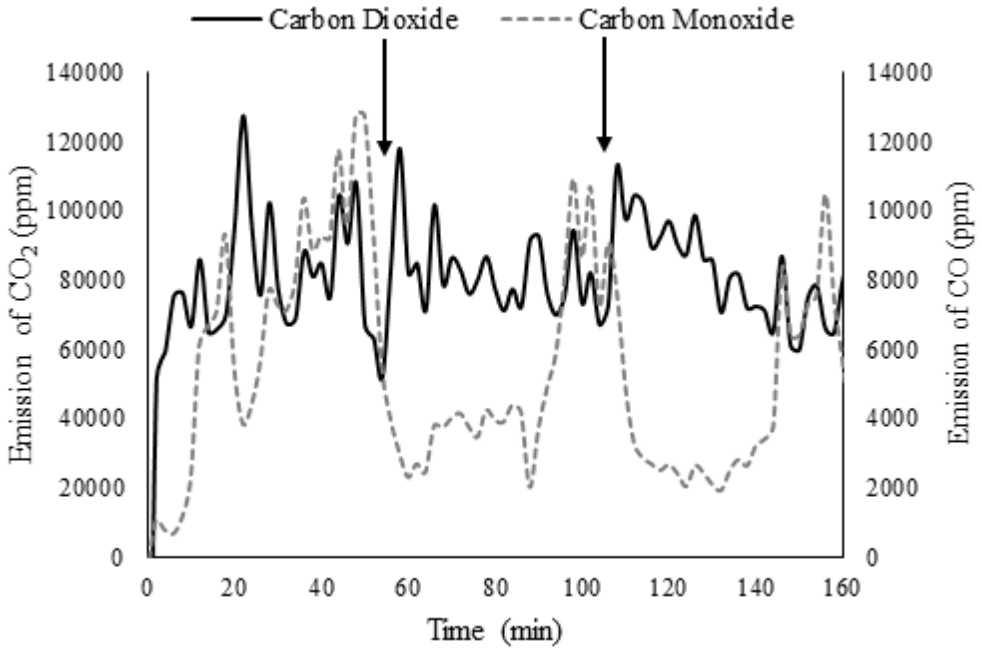

Fig. S.5. Emissions of CO_2 (solid line) and CO (dashed line) over the combustion period for torrefied spruce. The arrow indicates the point of fuel reloading.

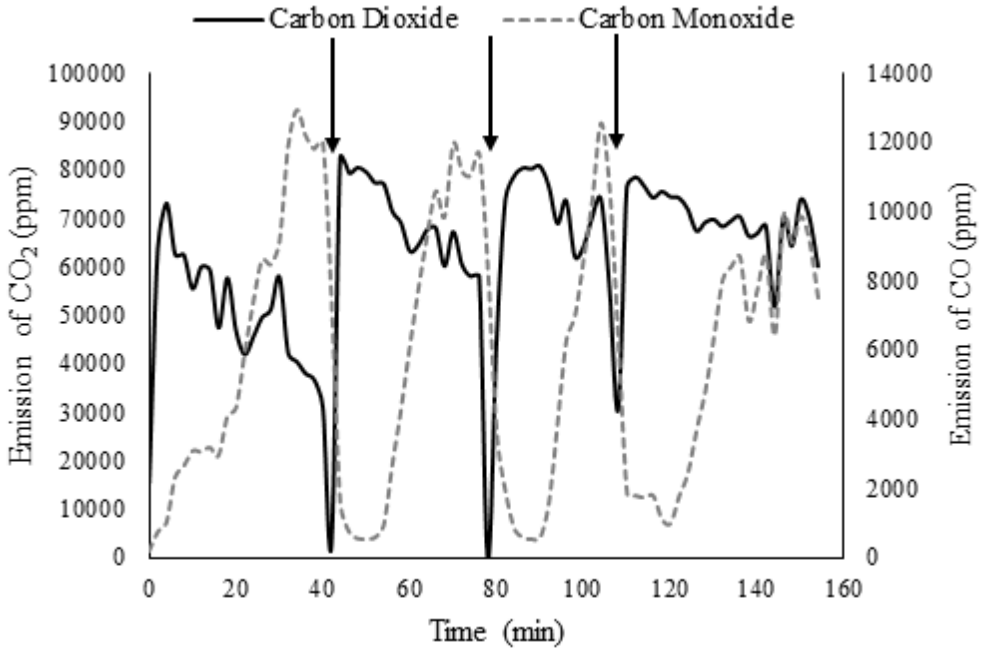

Fig. S.6: Emissions of CO_2 (solid line) and CO (dashed line) over the combustion period for olive. The arrow indicates the point of fuel reloading.

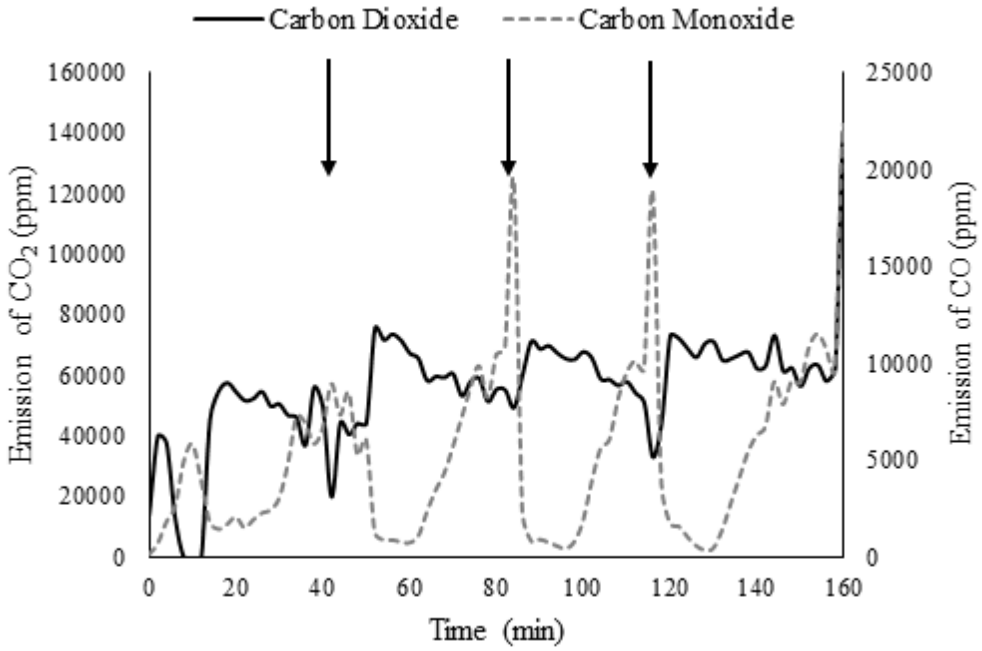

Fig. S.7. Emissions of CO_2 (solid line) and CO (dashed line) over the combustion period for torrefied olive. The arrow indicates the point of fuel reloading.

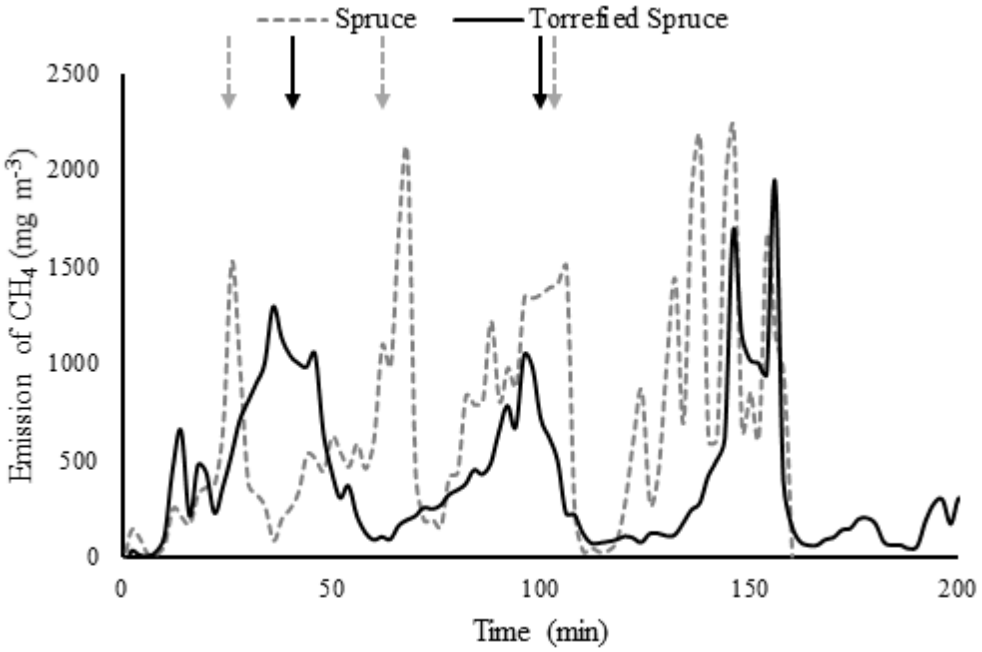

Fig. S.8. Comparison of methane emissions from combustion of the spruce (dashed line) and the torrefied spruce (solid line).

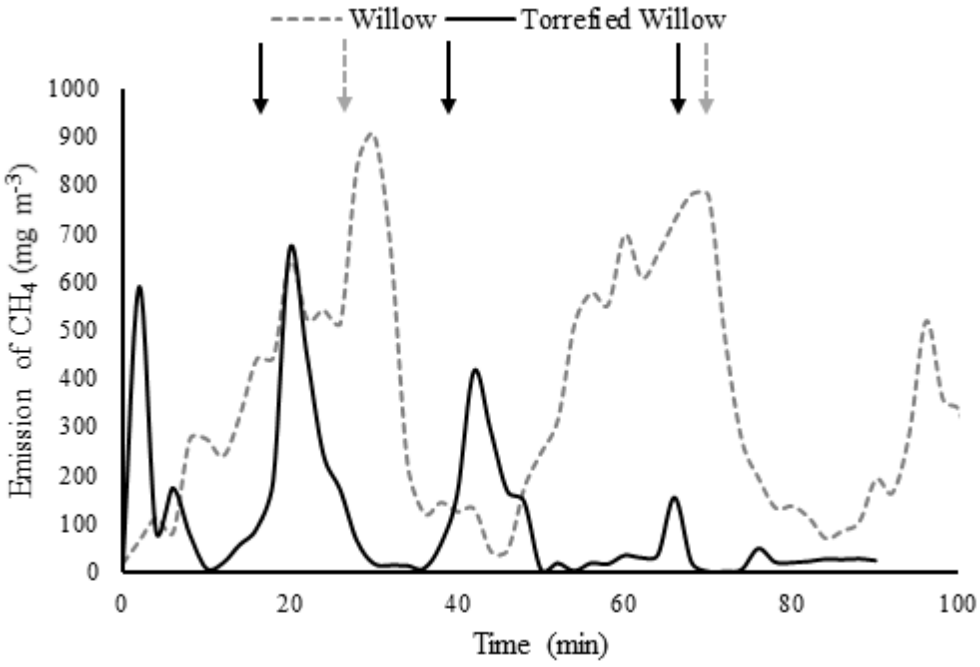

Fig. S.9. Comparison of methane emissions from combustion of the willow (dashed line) and the torrefied willow (solid line).

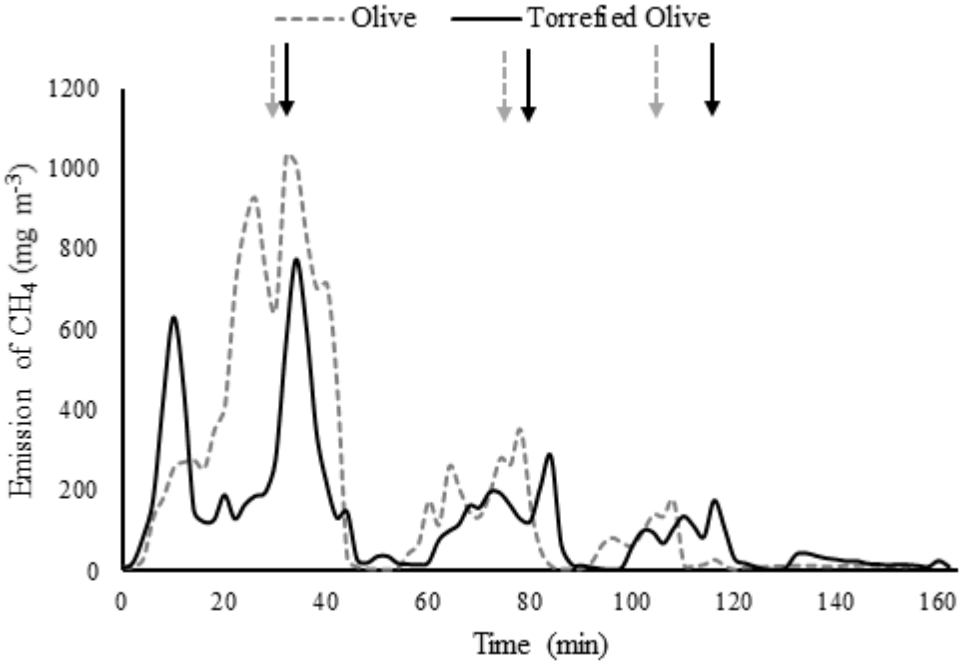

Fig. S.10. Comparison of methane emissions from combustion of the olive (dashed line) and the torrefied olive (solid line).

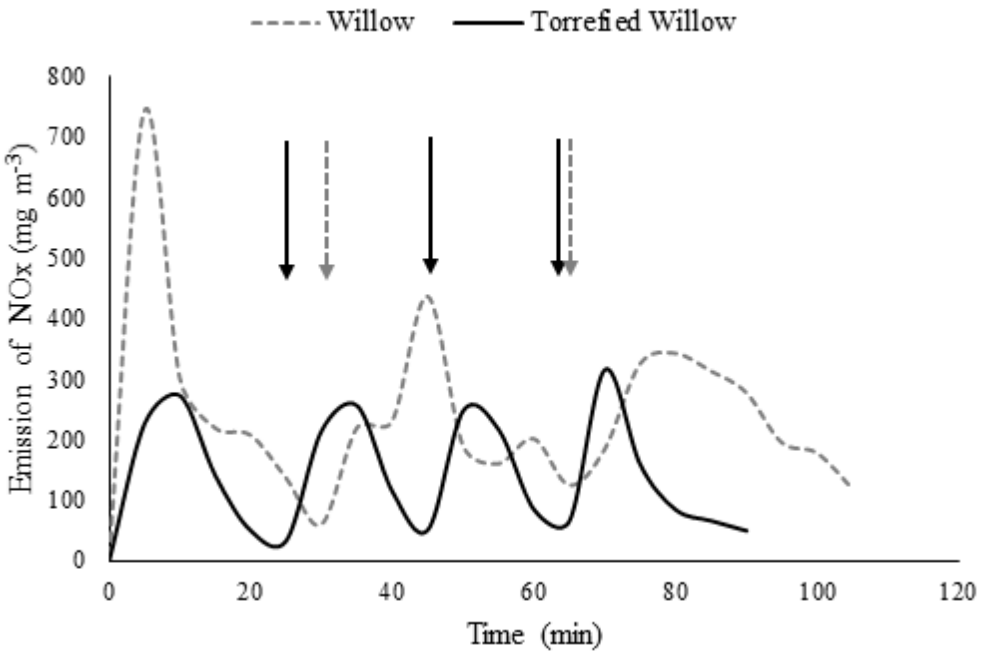

Fig. S.11. Comparison of NOx emissions from the willow (dashed line) and torrefied willow (solid line).

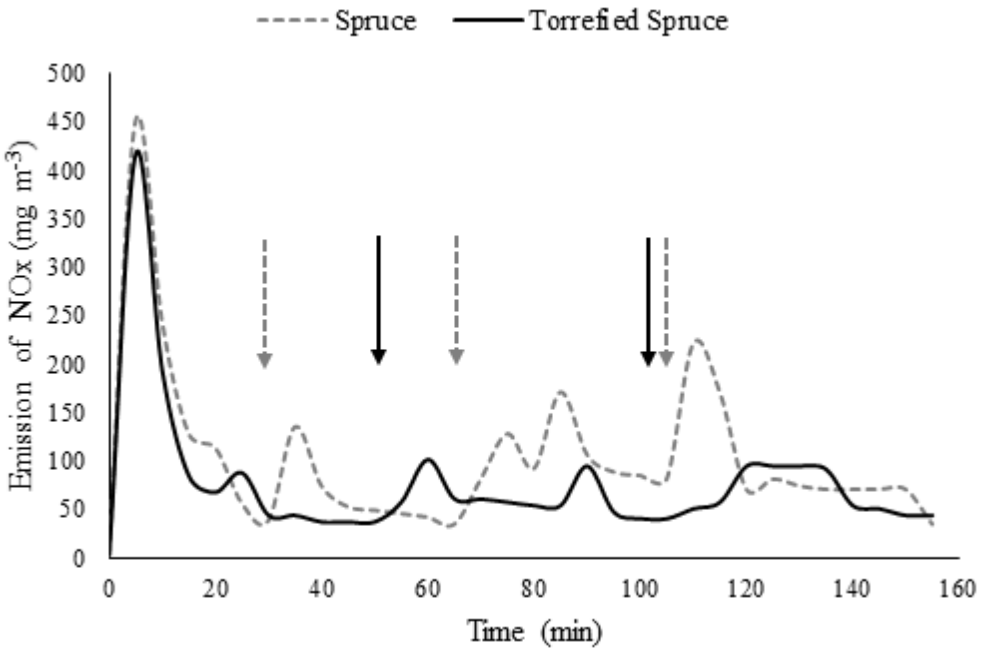

Fig. S.12. Comparison of NOx emissions from the spruce (dashed line) and torrefied spruce (solid line).

Figures S11 and S12 show that NOx emissions from torrefied fuels persist longer into the smouldering phase.

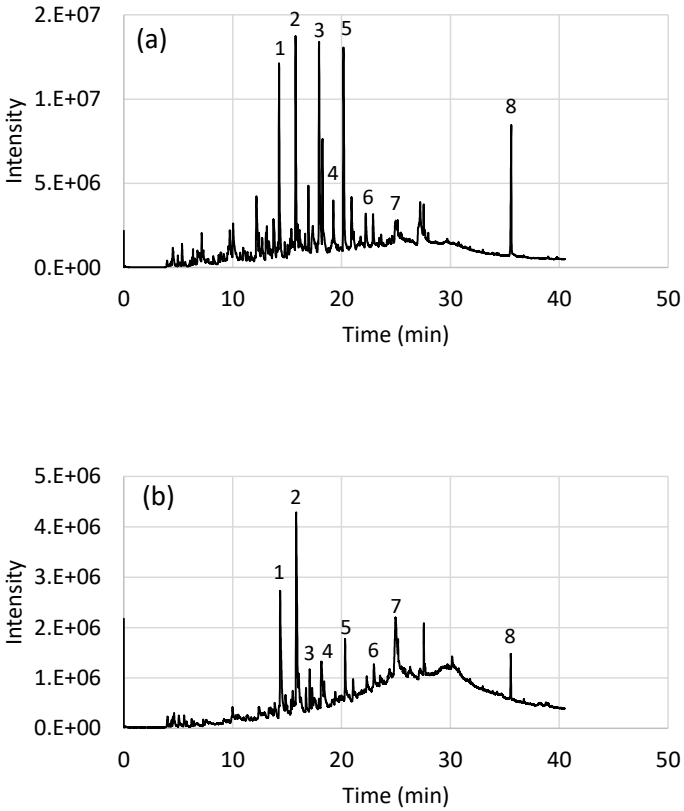

Fig. S13. Py GC-MS Chromatograms of (a) Raw and (b) torrefied Spruce. Probable peak identification is as follows: 1. Guaiacol 2. Cresol; 3. Methoxyacetophenones; 4. Methoxy propenyl phenols; 5. Eugenol; 6. acetovanillone; 7. Homovanillic acid or levoglucosan; 8. Squalene. Species to peak no 1 represent cellulose pyrolysis products; from peak 2 they represent lignin pyrolysis products.

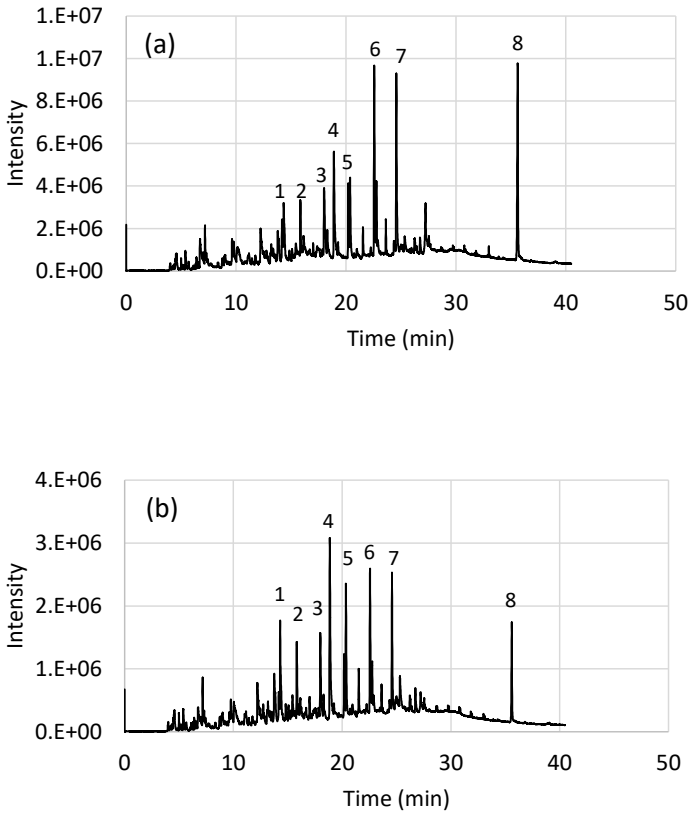

Fig. S14. Py GC-MS Chromatograms of (a) raw and (b) torrefied Willow. Probable peak identification is as follows: 1. Guaiacol 2. Cresol; 3. Methoxyacetophenones; 4. Dimethoxyphenols; 5. Eugenol; 6. dimethoxyacetophenones; 7. Propenyldimethoxyphenols; 8. Squalene. Species to peak no 1 represent cellulose pyrolysis products; from peak 2 they represent lignin pyrolysis products.

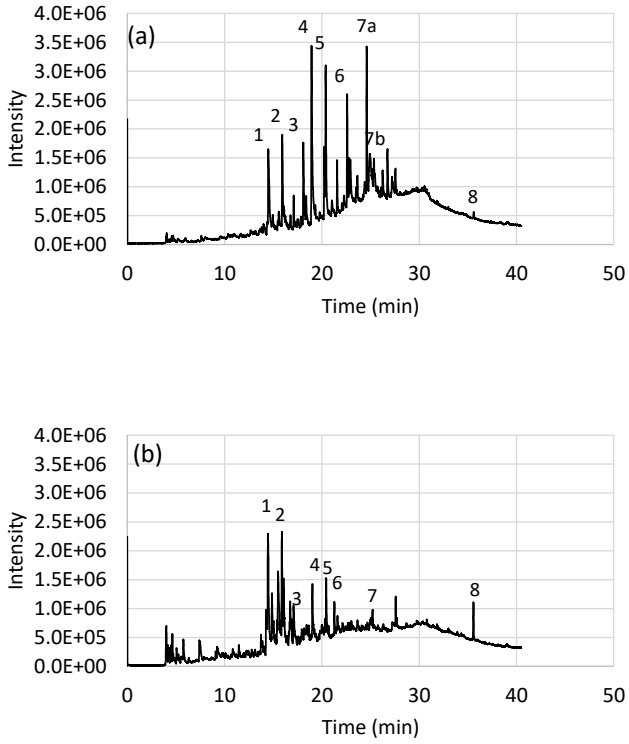

Fig. S15. Py GC-MS Chromatograms of (a) raw and (b) torrefied Olive. Probable peak identification is as follows: 1. Guaiacol 2. Cresol; 3. Methoxyacetophenones; 4. Dimethoxyphenols/syringol; 5. Eugenol; 6. dimethoxyacetophenones; 7a. Propenyldimethoxyphenols; 7b levoglucosan; 8. Squalene. (Many fats and fatty acids between 20-35 min retention time). Species to peak no 1 represent cellulose pyrolysis products; from peak 2 they represent lignin pyrolysis products.