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Project Rainbow Bee Eater

Proposed Kalannie Biochar Demonstration Node

ALUMINA LIMITED

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Summary: Proposed Kalannie Biochar Demonstration Node

The biochar process takes crop & plantation waste, that would otherwise decompose and release CO2 to the atmosphere within months or years, and converts it to a special form of charcoal called 'biochar' which is ~80% inorganic carbon using a process called 'pyrolysis'. Renewable energy is also captured by this process. Inorganic carbon is inert and therefore stable for very long periods (centuries).

The biochar is returned to suitable farm soil with benefits to soil health and crop yield. Fertiliser use and soil emissions are reduced. Regional employment increases.

In this way, atmospheric CO2 is effectively permanently removed and stored in the soil as inorganic carbon. It is "clean carbon capture and very long term storage" with environmental and social benefits in regional Australia and no known risks.

Pekabu Pty Ltd (Peter Burgess, Ian Stanley and Syd Shea) propose to build and operate a 1/10th scale biochar node at Kalannie as a demonstration facility. Once successfully demonstrated, multiple, full scale (100,000 dry tonnes a year) nodes are planned in locations distributed across the Western Australian wheat belt.

A summary of Node 1 is shown below. Project Rainbow Bee Eater is described in more detail in the attached Q&A document.

Location:
Kalannie farm site. Exact site yet to be chosen.

Inputs:
About 10,000 dry tonnes per year of local wheat straw and mallee harvested from on farm plantation mallee.

Outputs:

1. Biochar: ~3,500 tonnes per year for further field trials as soil amendment and permanent carbon storage. Biochar is a charcoal manufactured with modern pyrolysis equipment. Analysis: 80% fixed carbon, 10% ash, 10% water & organic carbon.

2. Biooil: ~3,500 tonnes per year for sale as heating oil or 8000MWh of electricity. We have several technology choices. Each technology has different characteristics with respect to the amount and properties of the bioil & suitability for onsite production of electricity.

3. Biogas: ~2,500 tonnes per year which will be trialled for additional electricity production, stripping eucalyptus oil from mallee. The biogas is relatively weak gas containing mainly methane, carbon monoxide and carbon dioxide. If unusable for other productive purposes it will be scrubbed and flared within EPA standards.

4. Water: ~1,000 tonnes per year of water for farm use. This is a resource. Some minor water treatment may be required.

5. Carbon Footprint: The node (including logistics) will be ~15,000 tonnes per year CO2e *carbon negative* (a net permanent removal of CO2e from the atmosphere).

Monitoring:

1. Pyrolysis Operation: monitored on an ongoing basis by Crucible Carbon Pty Ltd.

2. Biochar Field Trials: monitored on an ongoing basis by the WA Department of Agriculture & Food.

Sponsorship: Alumina Limited.

Questions: please direct any questions to Peter Burgess
Contacts: pekabu@telstra.com, 0407 368 231

Project Rainbow Bee Eater: Q & A

What is Biochar?
A charcoal product made from high temperature heating (400 - 500C) without air (or 'pyrolysis') of biomass such as farm or wood waste. Biochar is added to soils with several beneficial properties to soil health. It is an ancient concept with origins in Japan and the 'terra pretas' in Brazil. [1] Modern pyrolysis technologies also recover significant amounts of oil and gas as a byproduct of the biochar production process.

biochar produced
from rice husk (Japan)

Is Biochar like organic carbon?
No. Biochar is very different to organic carbon. Biochar is predominantly inorganic carbon which does not decompose like organic carbonaceous materials.

Organic carbon is a combination of carbon, hydrogen and other elements. Compost and lawn clippings are examples of organic carbon.

Biochar is about 80% inorganic carbon. The remainder is ash and a small amount of organic carbon and water from the original biomass. Charcoal, graphite and diamond are examples of inorganic carbon.

How much carbon is captured & stored?
For each tonne of biomass, carbon equivalent to ~ 1.0 tonne CO2e is captured and stored by the biochar. Another ~ 0.7 tonne reduction in CO2e emissions results from the use of the renewable biogas and biooil that is produced by modern pyrolysis and which replaces fossil fuels in the production of electricity or transport & heating fuels.[2]

The biochar process takes crop & plantation waste, that would otherwise decompose and release CO2 to the atmosphere within months or years, and converts it to a special form of charcoal called 'biochar' which is ~80% inorganic carbon using a process called 'pyrolysis'. Renewable energy is also captured by this process. Inorganic carbon is inert and therefore stable for very long periods (centuries).

[1] http://www.css.cornell.edu/faculty/lehmann/publ/Nature 447, 143-144, 2007 Lehmann.pdf

[2] unpublished Crucible Carbon report for Project Rainbow Bee Eater Aug 2008

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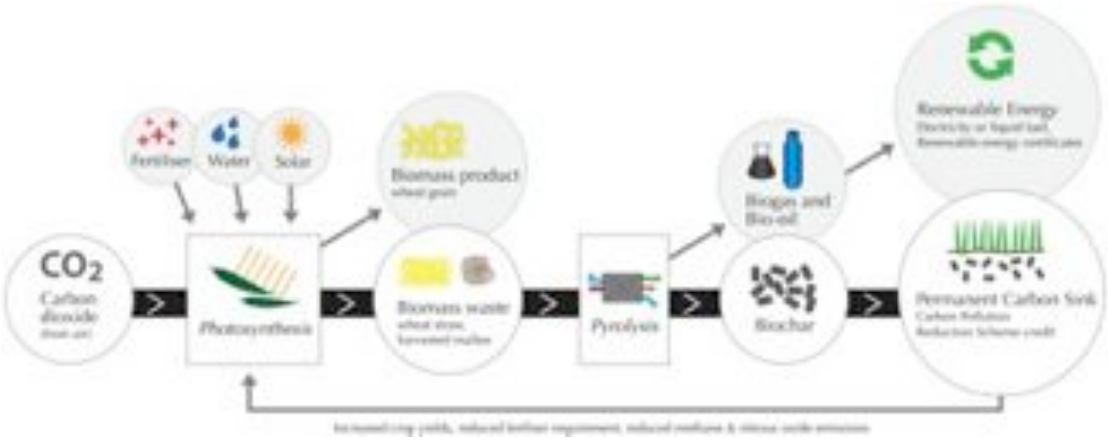
In this way, atmospheric CO2 is effectively permanently removed and stored in the soil as inorganic carbon. It is "clean carbon capture and very long term storage" with environmental and social benefits in regional Australia and no known risks.

Is the storage permanent?
This form of carbon degrades very slowly and is believed to remain in soils for thousands of years [3].

What is Pyrolysis?
Pyrolysis is the chemical decomposition of organic materials by heating in the absence of oxygen. Pyrolysis has been used for centuries to produce charcoal from wood. In more recent times, pyrolysis has been used on a major scale to turn coal into coke for steelmaking.

How does this capture & store carbon?



Where does biomass come from?
In the case of Rainbow Bee Eater, from harvested mallee, wheat straw and other local sources.

Does it compete with food production?
The biochar process does not compete with food production. It is expected that soil fertility will steadily increase over several seasons as biochar is added. As a result, crop yields are expected to increase. Crop yield increases of more than 100%[4] have been reported in some tropical soils. Our base case assumes a 30% increase in wheat yield. Fertiliser consumption is expected to permanently reduce.

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[3] http://www.biochar-international.org/images/Lehmann__2006_char_review.pdf

[4] Glaser, B., Lehmann, J. and Zech, W.: 2002, 'Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal - a review', Biology and Fertility of Soils 35 , 219-230.

How is solar energy utilized?
Plants utilize solar energy, water and CO2 in their leaves in the process called photosynthesis to produce energy rich molecules which enables them to grow. Oxygen is released in the process. In this way, each year Nature produces several tonnes of new biomass from each hectare.

Are there other regional benefits?
Yes. Project Rainbow Bee Eater is regional and we propose that it will be distributed across dozens of biochar nodes in Western Australia.

The existence of these multiple regional biochar nodes we believe will encourage increased and more sustainable plantings of mallee and other woody crops. This reverses salinity, erosion, habitat and job loss and creates additional above and below ground carbon sequestration which is not included in the project at this stage. [5]

What does biochar do to the soil?
As a soil amendment, biochar significantly increases the efficiency of and reduces the need for traditional chemical fertilisers, while enhancing crop yields. Biochar increases the ability of soils to retain moisture & nutrients.

Biochar provides a habitat for soil organisms which are beneficial to plant growth, but is not itself consumed by them to any significant extent. Most of the applied biochar can remain in the soil for several hundreds to thousands of years[6],[7] (see also *Terra Preta soils*). When used as a soil amendment along with organic and inorganic fertilisers, biochar significantly improves soil texture & structure, productivity (above that caused by fertiliser application), and nutrient retention and availability to plants.[8]

Char-amended soils have shown 50 - 80 percent reductions in nitrous oxide emissions and reduced runoff of phosphorus into surface waters and leaching of nitrogen into groundwater. [9]

How is the bio oil & bio gas used?
The bio oil, biogas and even the biochar can be used to make renewable electricity. Depending on the technology we choose, it may be possible to use the bio oil as feedstock for higher value uses such as liquid fuels.

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[5] http://www.oilmallee.com.au/pdf/SydShea_paper_milan_2003.pdf

[6] Pessenda, L.C.R., Gouveia, S.E.M., and Aravena, R., 2001, Radiocarbon dating of total soil organic matter and humin fraction and its comparison with ^{14}C ages of fossil charcoal, ***Radiocarbon***, 43: 595-601.

[7] Schmidt, M.W.I., Skjemstad, J.O., and Jager, C., 2002, Carbon isotope geochemistry and nanomorphology of soil black carbon: Black chernozemic soils in central Europe originate from ancient biomass burning. ***Global Biogeochemical Cycles***, 16: 1123.

[8] Glaser, B., Lehmann, J. and Zech, W., 2002, Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal --- a review, ***Biology and Fertility of Soils***, 35: 219-230.

[9] http://www.css.cornell.edu/faculty/lehmann/publ/FrontiersEcolEnv 5, 381-387, 2007 Lehmann.pdf

How much CO2e does the biochar process release?
This is an important question. These calculations are called Life Cycle Analyses and are fundamental to accurate assessment of any CO2 mitigation projects.

A small amount of CO2 is released to the atmosphere as a result of collecting the biomass, the pyrolysis process and delivering the biochar, bio oil & bio gas. That amount is much smaller than the CO2 that is captured.

Our best estimate at present is that for every tonne of biomass used for the biochar process, ~1.0 tonne of CO2e is captured and stored as biochar and another ~0.7 tonne reduction in CO2e emissions results from the use of the renewable bio oil and bio gas which displaces fossil fuels. We estimate that the amount of CO2e released as a result of the overall biomass to biochar process including logistics is less than 0.2 tonnes CO2e. So the overall carbon abatement of the pyrolysis process is expected to be at least 1.5 tonnes CO2e per tonne of biomass.

The initial Life Cycle Analysis will be updated once the first biochar 'node' is operating.

Are any harmful chemicals created?
The pyrolysis process will produce bio-oils and chars, which (like equivalent fossil derived materials) can have hazardous properties. The operation will ensure that such substances will be handled and stored in safe ways, in line with common practices in the petrochemical sector. The pyrolysis process will also produce a weak biogas which will be scrubbed and combusted so that any exhaust gasses are well within EPA standards. The process operates below the formation temperature of dioxin precursors, so these will not form.

How efficient is the process?
The preferred technology is designed for very high efficiencies and indeed has been selected because it is significantly more energy efficient than available alternatives.

The pyrolysis process is self sufficient in energy, using about a quarter of the energy in the bio-gas generated to provide the process heat. This is only a few percent of the total energy contained in the biomass, which is contained primarily in the oil and char product streams.

Is it dangerous?
Like coal fines, pure biochar can spontaneously combust, and therefore the product handling systems will be managed to avoid this. The most likely situation is that the biochar (leaving the reactor below 500^{o}C) will be mixed with water generated in the process removing any risk of spontaneous combustion.

The operation is at modest temperatures (up to around 500^{o}C). The gas composition will be below explosive limits and in any case will leave the reactor at low

temperatures (less than 100^{o}C). No hazards or safety issues have been identified that cannot be readily managed.

Does it use water?
No. The process actually collects water released from the moisture in the biomass.

Does it use fossil fuels?
Yes. Diesel will be used for collecting the biomass and delivering the biochar. A small amount of diesel or gas is used each time we start the pyrolysis process. We estimate that total use of fossil fuel is less than 10% of the CO2 that is captured & stored. It may be possible to replace all fossil fuel use with the biofuels produced.

Why isn't someone doing this already?
Japan, which imports most of its fossil fuels, has commercial operations using modern pyrolysis technology to convert rice husks and wood chips to electricity or to char and process heating that have operated for over 30 years. Such operations have not been economic in Australia and other countries where fossil fuel has been inexpensive.

Japan: Bags of Commercial Biochar produced from Rice Husk

How quickly can Australia do this?
The potential time scale for large scale implementation is relatively short. We believe that a feasible time frame to implement Rainbow Bee Eater to a scale of 5 million t/y CO2e or more, is 10 years or less. This is much shorter than other known large scale Greenhouse Gas countermeasures such as CO2 Carbon Capture and Storage or nuclear that are 15 years plus.

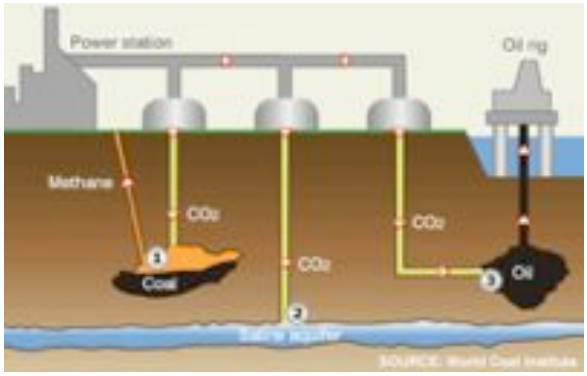
Is this another form of Carbon Capture and Storage?
Yes. CO2 is permanently removed from the atmosphere and stored as carbon in the ground. There are no known risks to that permanence.

This Char Carbon Capture and Storage can be taken to a very large scale within a few years. There are significant associated benefits already described above.

Consistent with the Australian Government's preferred position described in the Green Paper, CO2 captured and permanently stored as biochar could be netted out from the gross emissions of an organization that owned or owned rights to Project

Rainbow Bee Eater.

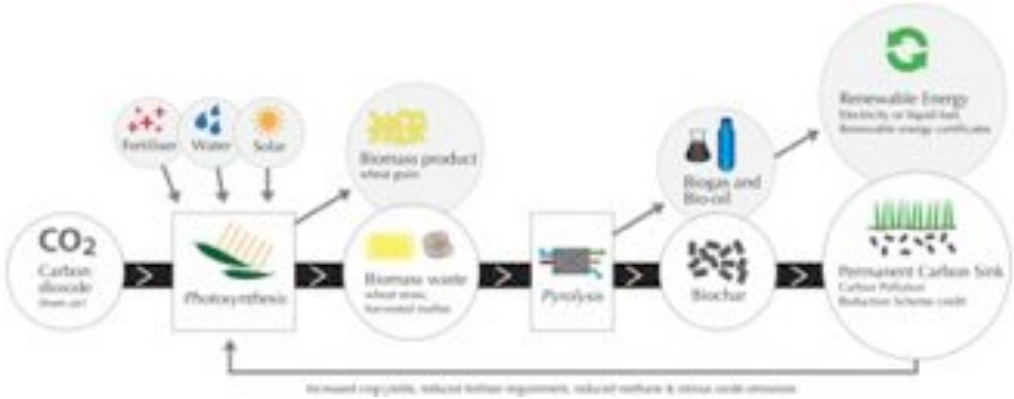
There are Two Carbon Capture and Storage Options
Option 1. Carbon Capture and Storage Concept endorsed in Green Paper



Green Paper page 107

2.4.6 Carbon capture and storage
Carbon capture and storage (CCS) is a developing technology to capture, transport and store emissions from gas production, electricity generation and other emissions intensive industrial processes, such as ammonia production and cement manufacture. These emissions would be transported by pipeline or other methods and stored underground; for example, in existing geological structures that have an impermeable seal. CCS facilities can be operated by the owner of the manufacturing plant or power station (the 'originating entity'); alternatively, the facilities can be owned by a third party offering CCS services. Another alternative is for the carbon capture facility to be operated by the originating entity and the storage component to be operated by a third party offering CCS services.

Option 2. Char Carbon Capture and Storage Concept proposed here



The biochar process captures CO2 as inorganic carbon, which is permanently stored in the soil[10].

[10] Gaunt, J and Lehmann, J, 2008, Energy Balance and Emissions Associated with Biochar Sequestration and Pyrolysis Bioenergy Production, manuscript accepted by Environmental Science & Technology.

Advantages of Char Carbon Capture and Storage
•Ready to implement within five years on a large scale
•Long term storage of carbon dioxide (thousands of years) safely
•Potential of 100 million tonnes of CO2 per year
•Major regional employment and environmental benefits
•Relatively low cost

How big could this be?
We believe that Australia has the potential to reduce its net GHG emissions by ~ 100 mmt/y CO2e based on conservative estimates of residues from cereal crops and plantation forests and Mallee Eucalypt plantings.[11]

Waste wheat straw and mallee biomass from the Western Australian wheat belt region alone would make & sequester enough biochar to offset 25 million t/y CO2e. The wheat belts in NSW, SA and Victoria also have opportunities of similar scale.[12]

We are aware that other organizations including NSW Department of Primary Industries, BEST, Crucible Carbon and EPRIDA are working on separate biochar developments in Australia using smaller scale waste streams such as poultry litter and paper sludge with potential to increase this scale further.

Is the Carbon Accounting difficult?
Carbon accounting is simple, measurable and auditable. Biochar contains 75 to 80% inert 'fixed' carbon, a few % 'volatiles' or organic carbon, a few % mineral matter or 'ash' and a few % moisture. For Char Carbon Capture and Storage we are interested in the inert 'fixed' carbon fraction of biochar. This is inorganic carbon that will not react and decompose in the ground. The organic and mineral matter and moisture components would not be counted in the carbon accounting.

The biochar will be sampled and a 'proximate analysis' conducted. This analysis which is very common in the coal industry tells us the moisture content, the mineral matter, the volatiles and the 'fixed' carbon in the biochar.

The biochar sample is dried at 100C. The weight loss is the moisture content. The sample is then heated to 925 degrees C in the absence of air and the volatiles are driven off. The fixed carbon and the mineral matter remain. The sample is then heated in air which burns off the carbon leaving the mineral matter. In this way % moisture, % volatiles, % mineral matter or 'ash' and % fixed carbon is measured. This gives a scientifically defensible fixed carbon % to be used for carbon accounting.

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[11] Biofuels in Australia - issues and prospects, A report for the Rural Industries Research and Development Corporation by Deborah O'Connell, David Batten, Michael O'Connor et al

[12] 'Availability of Biomass in Western Australia' John Bartle, Department Environment & Conservation, Biochar Workshop 20/6/07

The weight of biochar added to the soil would also be measured using an internationally recognised weighing process that was regularly calibrated and audited.

The CO2 permanently removed from the atmosphere is calculated by the formula,
CO2 removal = weight char (tonnes) x fixed carbon (%) x 44/12 (for CO2 equivalent)

What is Project Rainbow Bee Eater?
Multiple 'biochar nodes' will be developed in several locations in the Western Australian wheat belt. This will minimise logistics costs both for the biomass and the biochar. Our target is to rapidly expand to at least 5 million tonnes/year by 2018.

With the Western Australian Department of Agriculture and Food, we are conducting two field trials with several hundred plots in them in the wheat belt during the 2008 growing season. We plan to build the first biochar node in 2009.

We will purchase biomass, in this case wheat straw and harvested mallee from local farmers and produce biochar and biooil or renewable electricity for sale to the grid. The biochar will be sold on a 'delivered to farmers soil' basis to ensure the integrity of this critical part of the process including the carbon accounting.

Our preferred pyrolysis technology is Australian, newly designed, and potentially a significant breakthrough with respect to cost and efficiency. As we further test this and other technologies with wheat straw and harvested mallee, we will choose whether to produce a biooil or renewable electricity.

Rainbow Bee Eater is sponsored by Alumina Ltd, Alcoa's partner in three alumina refineries in Western Australia and two aluminium smelters in Victoria.

Why 'Rainbow Bee Eater'?
The Rainbow Bee Eater is a beautiful bird that survives in some of the harshest environments in Australia. Its habitat overlaps most of the area which could provide carbon capture opportunities in Australia.

The photo of this bird exploding from its nest is also a metaphor of the rapidity which carbon capture using biochar could make a major contribution to reducing carbon emissions while at the same time causing the reversal of environmental, social and economic decline of regional Australia.

Peter Burgess, Dr Syd Shea, Ian Stanley and Dr Joe Herbertson
for Project Rainbow Bee Eater

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