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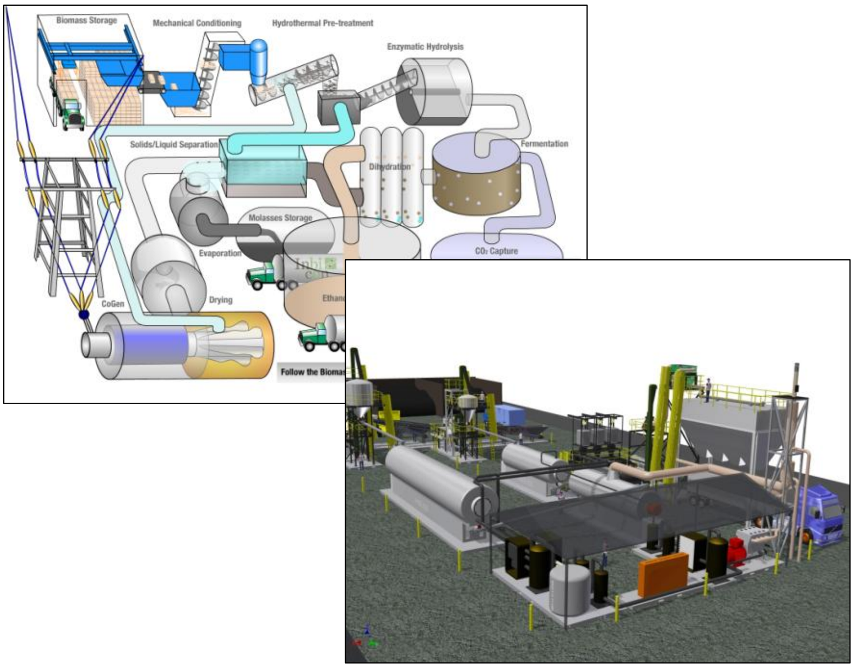
RC/BH/09

BioHubs

A Summary of the Concept



A Market Pulled Approach

Renewed Carbon is developing a national network of Regional Biomass Processing Centres, to be known as BioHubs (attached A, B and C), which focus on processing sustainably yielded biomass resources from:

1) **Urban waste streams** (MSW, C&I, C&D, biosolids etc.);
2) **Industrial sources** (forestry and agricultural sources and their respective downstream processing sectors);
3) **Land management residues** - "Caring for Country", Landcare, woody weed management; and
4) **Special purpose plantings** or new (dedicated) biomass production and focused agroforestry production

to manufacture and supply quality assured biobased products, such as animal feeds, various fermentation/digestion products, **charcoal** (for industry), **biochar** (for horticulture and agriculture), (biooil) and **synthesis gases** (bioenergy or as petrochemical precursors) all produced for existing individual customers, sectors and a growing list of new markets.

BioHubs are proposed to be located as a network of appropriately sized facilities, close to the sources of biomass, meeting the demand for new non fossil fuel resources as a national network, rather than as individual facilities alone.

1. Drivers for Change – Fundamentals Supporting the Opportunity

The Global Climate Change agenda is encouraging the community to replace or supplement fossil fuel use and/or reduce their net carbon footprint and to improve material use efficiency generally.

Recently (<100 years) generated biomass has the potential to provide the carbon based materials and energy sources previously provided by fossil resources if sourced and utilised sustainably and efficiently

The tangible market drivers that underpin this situation manifest in a number of forms:

i) **Regulated "push"**: legislated carbon taxes or trading arrangements;

ii) **Supply "pull"**: customers preferring or requesting "carbon lite" products or services; and

iii) **"Good governance"**: Risk/liability mitigation within companies or industry sectors.

In all cases, tangible, monetised benefits can accrue to enterprises responding proactively to these drivers for change. At Renewed Carbon we see BioHubs as an essential enabling initiative and empowering infrastructure platform that could be to the emerging biomass processing sector what the ubiquitous rail head grain silos are to the cropping sector.

2. Essential Elements of this Market Opportunity

The top carbon emitters in Australia are:

- The power stations;
- The metal manufacturers;
- The mining sector;
- The waste sector;
- The cement industry; and
- The agriculture sector.

These sectors have all been established using fossil fuels/resources; their respective reasons for wishing to replace and/or supplement those fossil resources are one or all of the reasons given above.

However, as the "food vs. fuel" debate has highlighted, just using biomass as a feedstock will not necessarily deliver net carbon benefits (see "Biomass ain't biomass" attached E as background).

To use biomass to reduce liability requires strict adherence to transparent standards, protocols and methodologies.

To achieve any or all of these goals just using biomass won't ensure success; the devil is in the detail:

- ➢ To participate in carbon trading arrangements, a range of complying hurdles and methodologies have been established, that must be adhered to, to the letter.

- ➢ To achieve market pull, the detailed "carbon lite" credentials will need to be proven by LCA or other methodology required by the customer or a third party accreditation body.

- ➢ To achieve tangible liability mitigation, the entire supply/value chain will need to have been evaluated and the carbon intensity of final products confirmed and certified.

3. Is Biomass Too Valuable to Just Burn?

Table 1 highlights that biomass has unique properties over all other non-fossil forms of energy production, and for that reason, Renewed Carbon looks to optimise the yield of specific carbon products first, with any surplus bioenergy presented as a major by-product from any BioHub proposal.

Table 1: Comparison of benefits and properties of non fossil sources

Low carbon energy sources	Features/Properties								
	Renewable	On demand supply	Heat	Power	Gas	Oil	Char	PetroChem industry manufacturing precursors	Potential to be Carbon negative
Fossil fuels with sequestration		✓	✓	✓					
Hydro	✓	✓		✓					
Wind	✓			✓					
Solar – thermal	✓		✓	✓					
Solar – PV	✓			✓					
Geothermal	✓	✓	✓	✓					
Wave/Tidal	✓			✓					
Nuclear		✓	✓	✓					
Biomass	✓	✓	✓	✓	✓	✓	✓	✓	✓

Source: Eco Waste Analysis (2011)

4. Factors for success include:

- Ensuring the sustainable yield of any biomass resources being considered as feedstocks;
- Ensuring that selected feedstocks have no alternative higher value application (food, fibre, pulp and paper, construction, manufacturing and ecosystem services etc.);
- Manufacturing quality charcoals, biochars, biooils and synthesis gases as the primary products, and managing surplus heat or gas only for energy production as a "by-product optimisation" strategy.

5. This approach focuses on:

- Utilizing wastes and residues where possible (reducing the waste sector liability);
- Optimising lignocellulosic feedstocks for second generation transport fuels where appropriate;
- Manufacturing charcoals (from low ash inputs) and related products for the metals manufacturing sector (Iron and Steel making; lead, zinc and copper smelting etc.);
- Manufacturing biochars (from higher ash inputs) for the horticulture and agricultural sectors (contributing to the reduction of carbon liabilities in this sector); and
- Supplying bioenergy products, (as by-products of the main pyrolysis processes) to the sectors with alternative fuel needs.

6. Success in this sector depends on:

- Ensuring sustainability of the feedstock yields;
- Best Available Technologies (BAT) and efficient supply/value chains;
- Manufacturing the highest net value products from secured materials; and
- Processing close to the biomass sources to minimise transport and logistics costs.

All of which are the key features of the Renewed Carbon BioHub business model and approach.

7. Problems Solved and Solutions delivered by the BioHub Networks

- Provides a secure supply of highest quality products to contracted customers, to their exact specifications, at lowest cost and greatest level of "supply" reliability.
- Provides "cascading", next best product options for the full range of available biomass resources when Highest Net Resource Value (HNRV) options are saturated or unavailable – to avoid the binary outcome of the materials being wasted if not utilised.
- Allows seasonal, occasional and disparate biomass supplies to be best matched with fixed customer demands.
- Uses the "network" approach to supply and support customers' needs, wherever they occur, from the vast array of available biomass sources wherever and whenever they arise.
- Establishes a trading platform in each location for residual biomass materials to be presented for fair value and subsequently converted with like materials from other sources into the highest value (HNRV) products for which the network has secured actual market demand.
- Provides a vital support structure for the full range of possible "agroforestry" initiatives. Whether the primary driver for a particular agroforestry program is erosion control, windbreaks, salt management, biodiversity, riparian repair and stabilisation, woody weed management, farm income/profit, land care objectives or any combination of the above, the presence of a local biomass receival and processing facility, that differentiates biomass types and offers fair market value for all materials received, will be of great economic benefit to any region so serviced.
- Provides a suite of existing/operational technology "agnostic" facilities that can offer all **technology vendors and developers** an operational platform to fast track the proving and testing of their particular offerings, where site, approvals, feedstocks and off takes are already established.
- Provides for diverse facility ownership and operational models for each BioHub. Whilst Renewed Carbon would manage the network "Brand" and provide each facility with secure and emerging market opportunities and provide the most suitable technologies for each facility, a "champion" or major local biomass producer(s) would be invited to own and operate individual facilities in the network to a common operational standard and protocol.

Renewed Carbon is keen to collaborate or JV with appropriate parties in a range of different locations such that respective BioHubs are established with the local partner securing a suitable site and providing a sustaining supply of biomass, and Renewed Carbon contributing the diverse markets for the value added products, including whole of value chain product certification, and the suite of process technologies to optimise the performance of each new BioHub project. Site operations to be allocated on the needs and merits of each situation.

Attached C and D – map and schedule of BIOHUB projects currently in various stages of development.

Contact Mark Glover – (mark@renewedcarbon.com.au) or Mob: 0417 224 919 (Attachment D).

Attachment A

BioHubs – Summary of Functional Specifications

Operational Capability

Basic functions

- A national network/multiple sites located “close to source”. (Biomass should be at least partially processed to value add BEFORE transport rather than being transported FOR processing).

- To receive suitable (pre-determined) biomass resources as-and-when they are available or presenting as spent/surplus/waste in need of a non disposal/destructive fate (a receiver of last resort).

- To proactively collect contracted biomass supplies from the individual facility catchment area (a platform for a systematic agro-forestry industry), including offering vegetation management services operating out of each BioHub.

- To sort, screen, select and stockpile (with or without certain pretreatment) all received materials.

- Process such materials (size reduction, blending, drying, fermenting, digesting, torrefying, pyrolysing, pelletising etc.) to exactly meet contracted customer needs and specifications.

- Manage:

  - Market risk;
  - Inventory risk;
  - Seasonal/campaign availability opportunities; and
  - Underwrite the QA/QC for the entire supply/value chain so that end customers receive fully certified final products.

In more detail:

Location

- Generally each facility needs to be centred within a 50-100 km catchment radius to limit transport/initial aggregation costs;
- Some facilities will be located so as to focus on urban waste streams, others on agricultural residues and others on forestry residues and arisings, and others located specifically to support special purpose plantings, agroforestry initiatives and energy/carbon crops; and finally
- Most will cater for a broad mix of such available inputs.

Sustainable Biomass Yields

To be applying biomass in lieu of fossil fuels is **only viable** where the “sustainability’ benefits are required, valued and certified, so detailed attention to these issues are a crucial requirement and a competitive advantage of the BioHub network.

Carbon based products (digestates, chars, charcoals, bio-oils etc.) will be the primary products, with heat and power being optimised “by-products” to be applied for full value. BioHubs will give particular attention to checking and verifying the “sustainable yield” characteristics of any biomass materials gathered, or offered to BioHub facilities embedded in the community – such that subsequent products will be presented with fully verifiable assurance as the basis for customers’ own carbon footprint claims and product credentials.

Products and Services Provided

As a receiver of a wide range of locally sourced biomass materials, the BioHubs will be able to provide a wide range of related services and products.

Services

- Aggregation point for contracted biomass supplies from growers or occasional generators;
- Distributor/supplier of certain compost or mulch ingredients to local operations;
- Receiver of last resort for any biomass “waste” streams to a published “gate fee”/reward price list and by negotiation and as appropriate.

Products

Whilst not every BioHub facility would manufacture every possible product, the BioHub network would have various capabilities at different sites to support the “network’s” complete product offerings, including:

- Fermentation/digestion products;
- Chip and mulch materials;
- Dried/pelletised products;
- Torrefied products (processed up to approx. 300°C);
- Pyrolysed products –
    - Chars, charcoal (industrial)
    - Biochars (high ash) agriculture
    - Biooils/tars for future bio-refinery sector;
- Heat/power as by-product of various processing stages;
- (Biooils – at a later stage when, and in support of, the emerging bio-refinery sector).

Attachment D

Renewed Carbon (www.renewedcarbon.com.au) – Specialist Project Developer

Background

Since 2002 Renewed Carbon has been developing specific biomass-to-biochar and bioenergy opportunities including sponsoring the development of tailor made paddle pyrolysis technologies and supporting pot, plot and broad acre growth trials of the resultant biochars to underpin all subsequent product marketing activities with hard science.

Since 2010 Renewed Carbon has also been working with the metal manufacturing sector to develop specific charcoal products, and their preferred supply, value add pathways for full commercialisation.

Renewed Carbon is also very active on standard committees and/or industry association working groups to develop the necessary sustainability protocols and final product performance criteria.

In 2012 the University of NSW was awarded a $500,000 ARC Linkage, Collaborative Research Agreement, "Development of the next generation of organo-mineral fertilisers utilising domestic and commercial waste products" with Renewed Carbon as the commercialisation project partner.

The 10 years of detailed R&D development work to date positions RC to now fully commercialise the opportunity, going into each and every project development opportunity with:

i) Secured off take arrangements and customers for a full range of charcoal, (industry) biochar (agriculture and horticulture) and bioenergy (various);

ii) Best available technologies for each application selected from a continuously updated inventory of local and international vendors;

iii) Detailed knowledge of all available/suitable sources of biomass in the various regions of Australia; and

iv) Core skills in the area of delivering and commissioning complex process technology projects.

The result is a project development strategy that features the development of a national network of BioHubs serving as regionally located biomass processing centres.

Although the demonstrated demand for biomass based products is now some 5 MT/yr and growing, the development of this sector must develop by value adding materials **before** transport and logistics costs are incurred due to its low energy density and moisture content. These issues have greatly informed the Renewed Carbon approach of creating the network of multiple BioHub facilities, close to source, so that defined end customers, and market demand generally, are **supplied from the growing network of diverse individual facilities rather than from any one project**.

Attachment E

To achieve a genuinely sustainable outcome, it is crucial to fully understand how to base the current project on sustainably sourced, procured, processed and delivered biomass supplies.

VEGETATIVE BIOMASS AS A RENEWABLE RESOURCE

The attraction of vegetative biomass as a renewable resource stems from the fact that currently grown vegetative biomass uses sunlight (solar energy) to drive photosynthesis, whereby atmospheric CO_2 is combined with water and soil nutrients to produce the lignocellulosic structures that present as the root, stem and branch and woody biomass materials that are the primary focus of the emerging BioHub network.

The carbon “near-neutral” potential for using such materials to replace/supplement fossil resources and as a source of energy comes from the carbon cycle, whereby the CO_2 absorbed by plant life during growth is released through combustion back to atmosphere in a short, no-net-CO_2-increase cycle, whereas the combustion of fossil resources is a net increase of CO_2 to the atmosphere.

Since achieving a genuinely sustainable outcome is a crucial outcome of this initiative, it is worth ensuring that the relationship between currently (< 100 years) produced vegetative biomass, as a source of carbon based energy and the fossil alternatives is completely understood.

Biomass was the source of the fossil resources (coal, oil, gas) that we use today. The original biomass deposits were “pyrolysed” by geological processes (heat, compression in the absence of oxygen) during the last 300-350 million years, and in so doing, substantially decarbonised the prevailing atmosphere, setting the platform for the more “friendly” climatic conditions we enjoy today. In effect, keeping most of the sequestered carbon from re-entering the earth’s atmosphere is the essence of limiting climate change as it presents today.

However, using currently produced vegetative biomass operates on a net carbon neutral cycle; and where any portion of that carbon can be sequestered into long life products (or soils), net atmospheric CO_2 can even be reduced, whilst still providing essential services.

Table 1 clearly shows that whilst biomass has demonstrable net GHG benefits over other “renewable” energy sources, it is also the only one that could result in carbon negative outcomes rather than carbon “reduced” or carbon neutral outcomes.

Table Error! No text of specified style in document.**2: Comparison of benefits and properties of non fossil sources**

Low carbon energy sources	Features/Properties								
	Renewable	On demand supply	Heat	Power	Gas	Oil	Char	PetroChem industry manufacturing precursors	Potential to be Carbon negative
Fossil fuels with sequestration		✓	✓	✓					
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Wind	✓			✓					
Solar – thermal	✓		✓	✓					
Solar – PV	✓			✓					
Geothermal	✓	✓	✓	✓					
Wave/Tidal	✓			✓					
Nuclear		✓	✓	✓					
Biomass	✓	✓	✓	✓	✓	✓	✓	✓	✓

Source: Eco Waste Analysis (2011)

The obvious versatility of biomass as a basic source of carbon-based products presents the collateral problem that in a carbon constrained economy, the demand and competitive pressures for the full range of biomass supplies will be intense. With this in mind, it will be essential that the vegetative biomass sources selected for any particular use are absolutely appropriate for that purpose and are produced sustainably and delivered entirely fit-for-purpose. In this paradigm, the available vegetative biomass sources should be applied to the end use that demonstrates the Highest Net Resource Value (HNRV) wherever possible.

To achieve this level of assurance, not only the precise characteristics of the various biomass sources need to be understood, but their net impact as a land use issue, their ability to provide collateral ecosystem services, and the socio-economic factors surrounding their selected generation and end use.

Bio-molecular Profile of Vegetative Biomass

Focusing on plant matter, biomass presents in three major forms:

i) The lignocellulosic structural portion; stems, branches, roots etc. (the water **insoluble** carbohydrate material);

ii) The water soluble carbohydrates, sugars, starches and proteins; and

iii) The lipids, oils and fats.

Hydrocarbons contain only carbon and hydrogen, have a high energy density[1] and are used for energy storage by biological organisms where weight and volume are critical. Carbohydrates also contain carbon and hydrogen, but have approximately one atom of oxygen for each atom of carbon in the structure. Oxygen reduces the energy density of carbohydrates compared to hydrocarbons, but has other valuable biological outcomes such as making the molecule water soluble (proteins, sugars and starch) so that it can be easily

[1] The long carbon chains in fat and oils are similar in structure to the hydrocarbons in diesel fuel and can be easily converted to biodiesel via transesterification.

transported within the organism, or aiding in the formation of polymers for structural roles (lignocellulose).

Humans are only able to successfully digest soluble carbohydrates and lipids; hence lignocellulose is not a direct human food. Animals are able to maintain the structural integrity of amino acids during digestion and hence use food protein for their own growth and development. This means that if protein can be separated from other biomass components, it can often have more value as an animal (including human) feed where the nitrogen and sulphur are an asset rather than a pollutant.

The energy density and physical properties of the biomass are critical factors for bioenergy feedstock considerations and need to be understood in order to match a feedstock to its most efficient processing technology.

The net result is that it is usually the lipids and water soluble carbohydrates that achieve their highest order use as sources of food (human and animal) and have provided the basis for first generation biofuels and the like, whilst the majority of biomass by weight and volume is the water insoluble lignocellulosic fraction.

It is this "dry", lignocellulosic or "woody" material that is likely to be the most appropriate and cost effective to apply to industrial and agricultural uses as it does not compete with food.

It is also worth noting that it is usually the reproductive parts of plants that provide the high value lipids and sugars, starches and proteins, whilst the foliage has high moisture and is more nitrogenous, and the bark on woody parts is often the higher ash containing fraction. All these factors influence not only which biomass is optimum for fossil resource replacement, but which parts of which plants.

To reinforce the point, the following table, reproduced from the Rural Industries Research and Development Corporation's *Sustainability Guide for Bioenergy* (RIRDC Publication # 05/190)[2] demonstrates that just using biomass isn't enough, it's which biomass and how applied.

[2] O'Connell, D., Keating, B., Glover, M., (2005), *Sustainability Guide for Bioenergy: A scoping study*, RIRDC Publications, https://rirdc.infoservices.com.au/items/05-190

Table 3: Balancing benefits and disbenefits of bioenergy

Biomass production/ recovery for Bioenergy can:	Which can present as a benefit…	Or as a disbenefit…
i) Provide a level of security of supply from the sun rather than fossil sources that are finite	If generated and recovered sustainably	If too much fertile land is quarantined or degraded in the process
ii) Provide more localised supply of heat and power	By reducing transport (fuel) and transmission (power) costs and impacts	Where smaller plant is less efficient in the conversion of the biomass – lack of efficiency equals waste of initial resource value
iii) Deliver substantial greenhouse benefits with short cycle carbon release and sequestration	Because fossil carbon is contained or not released	Where more essential land uses are denied
iv) Improve overall air quality	By provision of ecosystem services when growing and, if converted via sensitively designed and operated plant, when harvested as compared with traditional fossil fuel conversion	If the conversion pathway is inefficient, such inefficiency can squander much of the potential net benefit
v) Provide economic opportunities for rural and regional Australia	Where biomass energy sources provide a major new product range from the traditional food and fibre sectors or the stimulus for land remediation programs	Where the biomass is harvested unsustainably, the land has a finite capacity to sustain yields for offsite application and biomass harvesting could exacerbate soil degradation if conducted insensitively
vi) Impact soil quality, fertility, erosion and production	If the activity is conducted to improve soil quality, fertility, retention and production	If the activity is conducted so as to deliver negative soil impacts (over harvesting, insensitive monocultures etc.)
vii) Facilitate the remediation of degraded lands	Where the production of biomass yields is from land quite unsuitable for food production	If conducted inappropriately
viii) Provide local, catchment and global water cycle and management outcomes	If conducted sensitively and with due regard to the prevailing water cycle issues	Where inappropriate planting and over harvesting etc. deliver any or all of the outcomes as disbenefits
ix) Deliver net biodiversity outcomes in the soil and above ground	Where such issues are duly considered in the selection of plantings and the conduct of the specific management plan relevant for each locale	Where insensitive planting (mono cultures) and harvesting deliver negative biodiversity outcomes
x) Provide an intensive bioremediation opportunity for certain urban and industrial waste materials	Where the plantings and nutrient cycles are managed proactively	Where inappropriate wastes are put to land and managed inappropriately
xi) Deliver social / aesthetic outcomes / impacts	Over and above the economic benefits (v)	If inappropriate methodologies or management practices are adopted

Source: O'Connell, D., Keating, B., Glover, M., (2005), Sustainability Guide for Bioenergy: A scoping study, RIRDC Publications, https://rirdc.infoservices.com.au/items/05-190

Biomass as a Competing Land Use Issue

The RIRDC's *Sustainability Guide for Bioenergy* project (RIRDC Publication # 05/190) synthesizes the issues very succinctly:

– *Biomass is generated (for the purposes of this report) from the earth's productive soils which are finite.*

– *These same productive soils must sustain the production of biomass for a wide range of essential purposes, including but not limited to:*

  - *Food and fibre production (for a current target of > 9 Billion people);*
  - *Construction, engineering, pulp and paper and other industrial purposes;*
  - *Social, recreational, aesthetic and passive purposes; and*
  - *The provision of essential ecosystem services such as:-*
    - *Water, nutrient and mineral cycles*
    - *Soil stabilization*
    - *Biodiversity support*
    - *Air quality maintenance*

The potential to systematically utilize biomass as a solar energy converter in convenient biomass form, for commercial purposes, places another demand on the same individual plants – plants that already are required to deliver the above suite of products, services and outcomes. The RIRDC Sustainability Guide then goes on to propose a very high level and generic decision making framework based on a founding philosophy that in managing all land use outcomes the result should always be to "maintain or improve" soil quality and productivity. This means that when soil quality or productivity is devalued for some other essential (but temporary) function, such as mining or similar industrial development, offsetting, mitigation or remedial plans should be designed and implemented in parallel.

This is certainly more and more the case in OECD countries, where the effects of land degradation are progressively seen as unacceptable, to the point that remediation is now often an essential condition of original consent for the degrading activity.

Further, the obligation to remediate, for example, extractive industry voids, or even lands degraded by over exploitation or neglect, often presents as a significant financial liability to the original applicant.

As such, the opportunity to offset remediation liabilities with some sustainable income producing activity, by planting trees for biomass harvesting, could be commercially or socially attractive whilst producing a positive sustainability / environmental outcome as a collateral benefit.

Summary and Preferred Profile for Biomass Sourced for Fossil Fuel Replacement/Supplementation

In sourcing the most appropriate, assured and cost effective sources of biomass for fossil resource replacement/supplementation, the previous discussion on sustainability issues has defined some useful scoping criteria that could affect and influence any finally selected strategy and these are discussed below:

i) To seek to optimise biomass use is to be in the **sustainability business**. It is not because fossil resources are about to run out, although it is likely to increase in cost as governments introduce a suitably high price on carbon. To be in the sustainability sector means doing it properly to achieve the full suite of potential benefits for taking this initiative. The Food vs. Fuel outcomes in the liquid transport fuel sector as noted earlier provide clear indicators of what happens if genuine sustainability principles are not adopted. Table 2 demonstrates how the same action can produce quite different outcomes if the detail is not observed.

ii) A program to optimise the use of biomass to replace fossil resources will be challenged to present as a net cost cutting exercise (because of the convenience and energy concentration of existing fossil resources), see Table 1 above. However, by addressing the issue systematically, the cost increase is likely to be no more than is absolutely essential or unavoidable to achieve the primary sustainability goals. Having adopted the most cost effective biomass sources and supply chains, a sustainable competitive advantage should be created over competitors. The various sectors who have not adopted comprehensive biomass strategies have stayed with fossil resources after the introduction of carbon pricing, and cannot meet an emerging demand for ‘carbon lite’ products.

iii) Much the same rationale that is motivating industry to explore optimising vegetative biomass use will drive many other industry sectors to secure biomass raw materials and thus create strong competitive pressures for these resources. To respond to this situation, each sector should focus on biomass sources that are ideally suited to their particular needs, rather than on sources suitable for only heat/energy generation, such as in the cement making or power generating sector. This focus should be on securing the most appropriate parts of the plants identified setting aside lipid or starch or sugars or the moist nitrogenous foliage, or stem material that has a demonstrable higher order use as construction, agriculture, pulp and paper or furniture and the like.

> *Note: Vegetative biomass applied to higher order initial uses will eventually present at the end of its planned productive life as an urban waste and might then be ideal as a sustainable input to “next best” industrial applications, subject to quality issues.*

iv) Ideally, the vegetative biomass sourced for industrial purposes would have been grown on marginal or degraded land, such that the final net sustainability credentials are fully optimised by supporting the “maintain or improve” criteria for land use and application.