Bio-energy opportunities and technologies for the Limestone Coast region

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Overview

- The current landscape
- Logistical issues
- Technology options
- Typical case studies
- Opportunities

The current landscape

- Considerable investment in bio-energy plants worldwide including
  - Combustion of waste crop material (eg straw, forestry trimmings)
  - Combustion of purpose grown crop material (eg coppiced wood)
  - Combustion of municipal and commercial wastes
  - Digestion of wastes to produce bio-gas
  - Conversion of biomass to produce bio-fuels
  - Capture of gas from decomposing wastes (landfill gas)
- In Australia, capture of gas from decomposing wastes and combustion of waste crop material are the more typical applications

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Bio-energy plants in SA

- Bio-energy plants have been installed at
  - SA Water – various wastewater treatment plants anaerobic digestion for power generation and heat
  - Landfill gas – various small scale electricity generation facilities
  - Thomas Food International - Murray Bridge anaerobic digestion
  - Tarac Technologies – Nuriootpa anaerobic digestion
  - AR Fuels at Largs Bay – tallow and cooking oil to bio-diesel
  - Forestry processing - Mt Gambier heat and power generation
  - Swimming pool heating - Mt Gambier
  - Sita-Resource Co. – Wingfield process engineered fuel facility

Bio-energy sources

- Numerous potential supply and demand opportunities, mostly revolving around localised waste materials availability and local heat demands
- Opportunity to grow alternative vegetative crops
  - could provide a good use of non-productive cleared landscapes

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Logistical factors

- Biomass has logistical challenges
  - low energy value per tonne
  - low density
  - few economies of scale
  - the need for purpose built vehicles
- Economics of waste haulage suggests a range of up to 40-50 km
- Potentially up to 100 km if the feedstock is readily transportable / has higher value

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Potential bio-energy projects

- Indicative project definitions have been identified for:
  - Council green waste (garden and park waste)
  - Municipal solid waste
  - Forestry waste and sawmill residues
  - High moisture content organic wastes (pig slurries, chicken litter, dairy shed effluent, feedlot waste)
  - Straw feedstocks
  - Small scale biomass heating
  - Bio-gas upgrading to bio-methane (as an alternate to bio-gas use in gas engines)
  - Algae production and refining for liquid bio-fuels

Green waste or sorted MSW facility

- Combustion vs. AD for power and/or heat.
- Combustion offers the following advantages:
  - Higher diversion of waste from landfill (>90%)
  - Less residues i.e. only ash which may be 25 % or less
  - Lower CAPEX per tonne waste diverted
  - More useful energy generated as power and heat.
  - Can readily combust all non-inert waste, whereas AD cannot readily destroy dense solid feedstocks e.g. wood.
- Anaerobic digestion may be preferred if:
  - High moisture content feedstocks e.g. >60% moisture
  - Leaf and grass, manures or food waste components that can be readily source or mechanically separated from balance of non-digestible waste
  - Digestate can potentially be sold

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Anaerobic digestion of high moisture content organic feedstock

- Livestock animal manures, food wastes, garden wastes and similar feedstocks with moisture contents in excess of 55 to 60% by weight
- Digestion residence time = day or two or up to two months
- Batch or continuous process
- Gas often needs to be cleaned of contaminants, which can be damaging to downstream equipment.
- The methane content of bio-gas is typically 55 to 75%
- Uses of biogas:
  - Boiler - if there is sufficient local heat demand
  - Spark ignition gas engines or gas turbine generator(s) - power generation and heat recovery
  - Fuel cells for power and potentially also some heat
  - Upgrade to bio-methane

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Comparison of end use technology options

- Bio-gas use in spark ignition engines offers the following advantages:
  - Produces power at high efficiency – though fuel cells may be more efficient
  - Lower capital costs than fuel cells
  - Most well proven and commercialised conversion technology option
  - Readily scalable for a wide range of capacities
- Heat only boilers may be preferred if:
  - There is a considerable demand for heat
  - No readily available electricity grid connection exists
  - Low capital cost is important
- Gas turbines may be preferred if:
  - High electrical conversion efficiency is not the priority.
  - Significant demand for process steam exists

Anaerobic digestor

Forestry and sawmill residues

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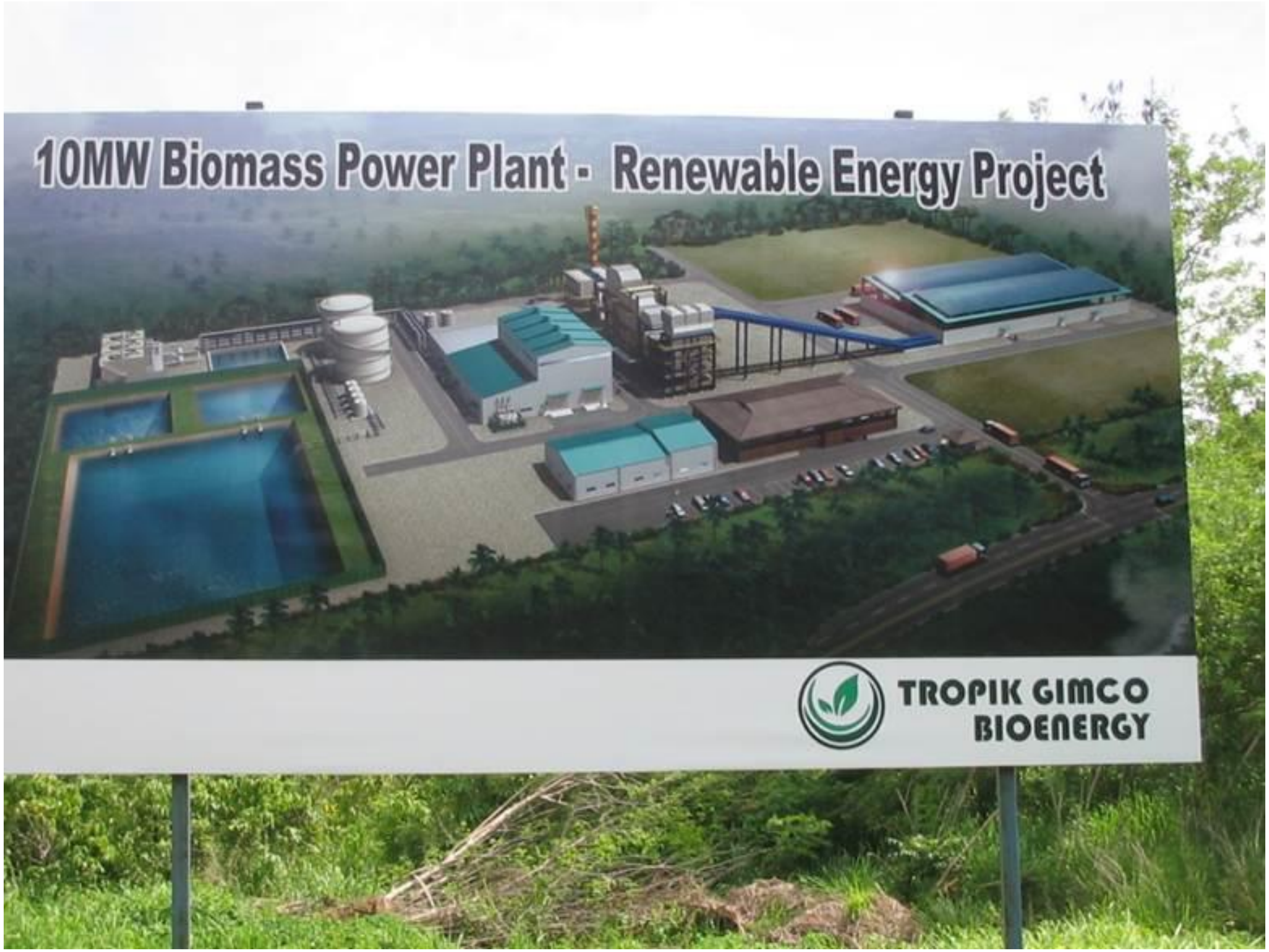
Forestry and sawmill residues

- Wood residues derived from saw mills or residues left in the forest after harvesting can potentially be combined to form the feedstock
- Two established and commercialised technologies:
  - Combustion with a steam turbine to generate power and heat on a medium to large scale of > 1 MW
  - Combustion coupled with an organic Rankine cycle (ORC) for smaller scale projects up to around 2 MW
- Both can operate as a combined heat and power (CHP) plant

Typical 10 MW CHP facility



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Upgrading bio-gas to bio-methane

Photo from EU Civitas Programme

Upgrading bio-gas to bio-methane

- Two options for bio-methane use are:
  - Upgrading to natural gas standards for grid injection
  - For vehicle fuel use either as compressed or liquefied natural gas.
- Grid injection offers the following advantages:
  - Less complex supply chain for end users e.g. CNG and LNG distribution and sales
  - Less infrastructure costs for vehicle refuelling stations.
- Vehicle fuel use may be preferred if:
  - The organisation generating the bio-methane has a considerable demand for vehicle fuels e.g. waste management, council fleet etc.
  - No readily available gas grid connection exists.

Conclusions

- There is considerable up-take of bio-energy worldwide and, to a lesser extent, in Australia. However uptake in SA is presently low
- There are many well established conversion technologies and so technology risk is not a major deterrent to developing projects in SA
- Industries in the Limestone Coast region that could benefit or expand from the opportunity include
  - Horticulture – heating
  - Intensive industries (e.g. chickens and pigs) – process heating and electricity generation
  - Processing plants – heating and power generation
  - Processing hubs – heating
  - Forestry processing – heating and power generation

100 ktpa green waste combustion facility

Indicative Parameter	Assumption	Comment
Mass of green waste for facility	100,000 tpa	Assuming this can be source segregated within reasonable economic transport distance from a single facility.
Moisture content of green waste	35% by weight	Assumes some natural drying from green moisture content (circa 50%) at source or at transfer stations.
Net calorific value	11 MJ / kg	Assumes 2 % ash content
Boiler energy output – heat only	33 MWth	Maximum potential for energy production in the form of heat for steam production or other industrial energy heat forms
Boiler efficiency – heat only	86%	LHV basis
Net power output - power only	9 MWe	Net power output if high temperature steam is generated and all fed to a steam turbine.
Electric efficiency – power only	23%	LHV basis and net of power plant parasitic load
Max overall efficiency – CHP plant	75%	LHV basis and net of power plant parasitic load – Assumes large process heat demand exists near facility.
CAPEX for power and CHP options	~$5-6 million / MWe	EPC cost for power plant or CHP options excluding owners development and site specific costs (e.g. land purchase, grid connection etc.)

Anaerobic digestion facility with engine generator

Indicative Parameter	Assumption	Comment
Mass of AD plant feedstock	30,000 tpa	Assuming this can be sourced cost effectively within a economic transport distance from a single facility.
Moisture content manure feedstocks	80% by weight	Assumes mixed feedstock 2:1 ratio of pig slurry and chicken litter.
Bio-gas yield per tonne	65 Nm^3 / tonne	Assumes medium yields from combined waste at 65% methane content.
Bio-gas produced	1.95 Million Nm^3/annum	At 65% methane content.
Equivalent gas energy value	47,000 GJ / annum	LHV basis assuming 24 MJ/Nm^3
Power generation capacity	620 kW	Assumes a 38% engine efficiency on a lower heating value basis
AD plant including engine CAPEX	~$10 -14 M / MWe	Construction cost excluding owner's development and site specific costs (e.g. land purchase, grid connection etc.)

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100 ktpa forestry and sawmill CHP facility

Indicative Parameter	Assumption	Comment
Mass of woody residues	100,000 tpa	Assuming this can be sourced within a reasonable distance from a single facility.
Moisture content of wood waste	50% by weight	Assumes green wood is used without natural drying prior to use.
Net calorific value	7.9 MJ / kg	Assumes 0.5% ash content
Boiler energy output – heat only	28 MWth	Heat for steam production or other industrial energy heat forms
Boiler efficiency – heat only	84%	LHV basis
Net power output - power only	6 MWe	Net power output if high temperature steam is generated and all fed to a steam turbine.
Electric efficiency – power only	22 %	LHV basis and net of power plant parasitic load
Max overall efficiency – CHP plant	74%	LHV basis and net of power plant parasitic load – Assumes large process heat demand exists near facility.
CAPEX for power and CHP options	~$5-6 M / MWe	EPC cost for power plant or CHP options excluding owners development and site specific costs (e.g. land purchase, grid connection etc).

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