CORKY'S CARBON CONSULTANCY

Deploying Base Load Renewable Power Technology

Corky's Background

- Drafting
  - Vessel design
  - Process flow diagrams
  - Conceptual P&IDs
  - 3D modelling [Inventor]
- Design
  - Coke Oven repairs / process improvements
  - Waste incinerator
  - Thermal desalination
  - Process plant design
  - Solar thermal processes
  - Process optimisation
  - Manufacturing supervision

Started

- 2002
  - Design MSW & Biomass Power Plants for India / Fiji

Feedlot Waste to Power

Sept 2006

A NSW feedlot operator wants a feasibility study to see if feed lot waste can be used to generate electricity. He hears this is done overseas.

Technically possible but the cost is not competitive with coal powered electricity. The possible technologies to use manure have a degree of technical risk or low energy yield.

Benefit: Very greenhouse gas positive but without a subsidy, or carbon tax, we continue to rely on coal. **Corky's decide this must be worked on!**

Common enquiry

Timber Mill: **Can we use sawdust to generate energy?**

Cotton Gin: **" " " cotton trash " "**

R and D pathway

1. Benchmark current and past waste to energy practices (Sep 2006 to present)
2. Talk with many potential customer to understand their needs (Sep 2006 to present)
   - return on capital needs
   - technical support needs
   - size of plant needs
   - constraints
3. Measurement of raw data use in design eg tar rate and reactivity (Jun 2007 to Dec 2008) Refine conceptual design.
4. Trial build and test Gasifier and associated equipment. (May to Aug 2009)
5. Measure dioxin emissions (Sep 2009)
6. Trail build plant for longer tests and heat recovery (Oct 2009 to May 2010)
7. Measure emission and power output for a wides range of materials (May to Aug 2009).

At the end of May 2010 we are at point 6 moving to point 7.

Current Biomass Technology

Typically:

- **Large scale: 10 to 50 MW plants**
- **Transport costs are increasingly prohibitive**
- **Can be seasonal** [eg. sugar cane bagasse]
- **Open Cycle** [raise steam and turbine converts to electricity]
- **Limited flexibility with respect to feedstock**
- **Utilise steam turbines:**
  - require specialised maintenance services
  - not efficient at small plant sizes

Power Generation

Past era technology

- Gasification / Biofuels:
  - common in WW2
  - superseded by cheaper coal & oil (energy was very cheap)
- Single feed / single product
- Mindset: unlimited resources
- Centralised generation of energy with long distance transmission:
  - energy potential wasted
  - high water consumption
  - capacity installed for peak supply

INNOVATION

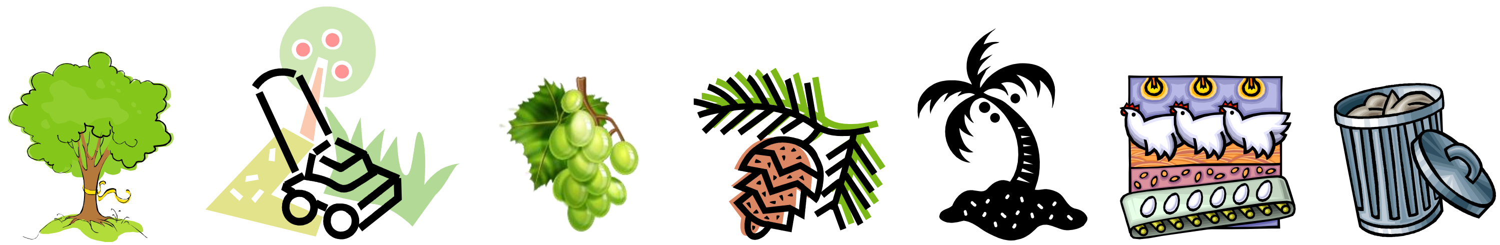
1 2 3

Future era standards

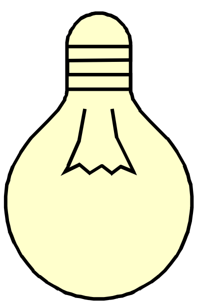
- CO_2 neutral (renewable)
- Water neutral
- Utilise waste as a feedstock
- Improved emission control
- Life cycle costs improved
- Local economy focus
- Sustainable
  - maximise recycling
  - reduce waste miles
  - use waste heat as a product

Unique BIOMASS Micro Power Plant

WASTE feed stocks



Moisture Dryer → Pre-Heater → Pyrolyser → Char Gasifier → Gas Engine



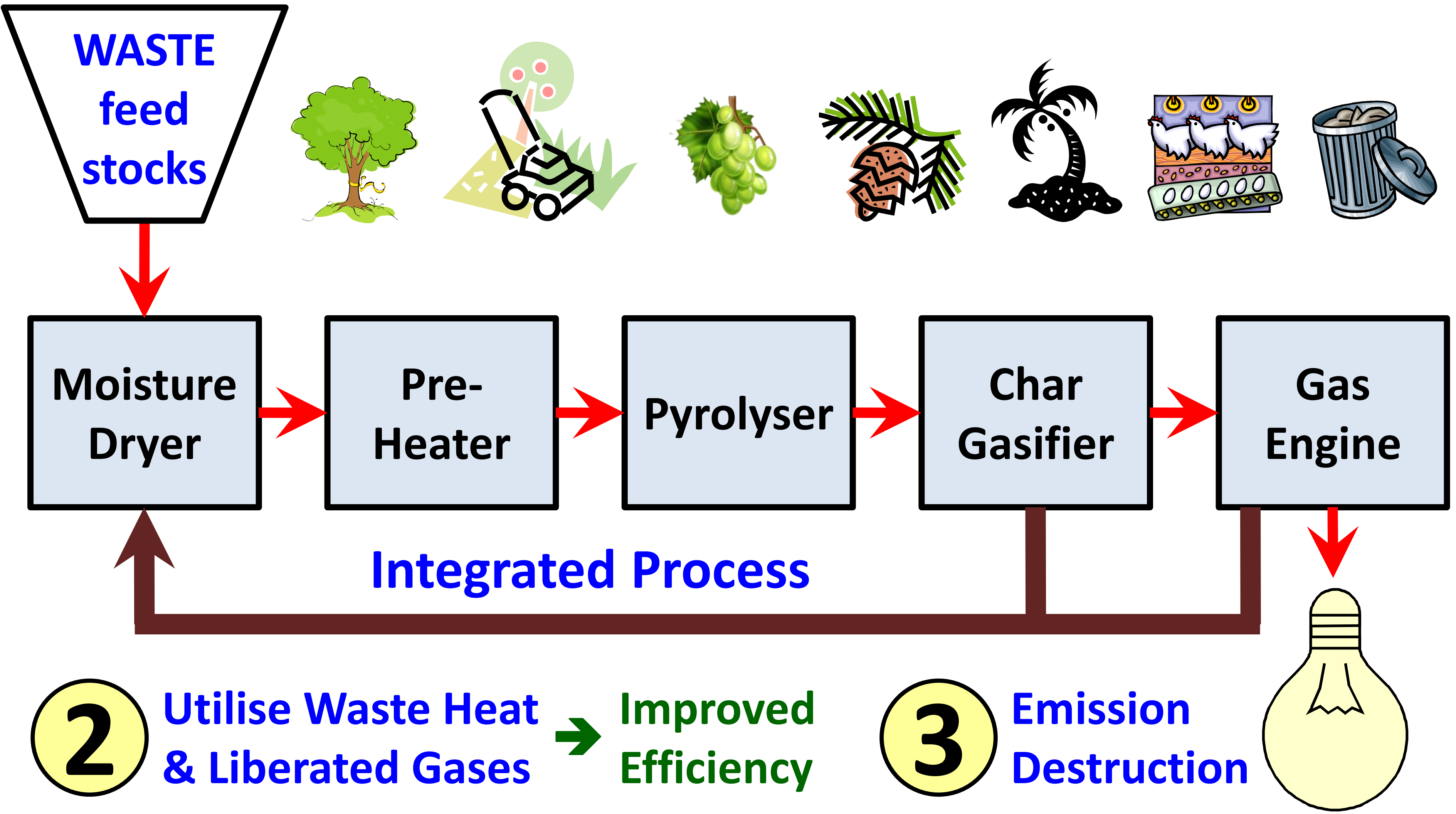
1 Multi Step →

Feedstock flexibility

Integrate with other processes

Separation of gases

Unique **BIOMASS** Micro Power Plant



Corky's R&D Program

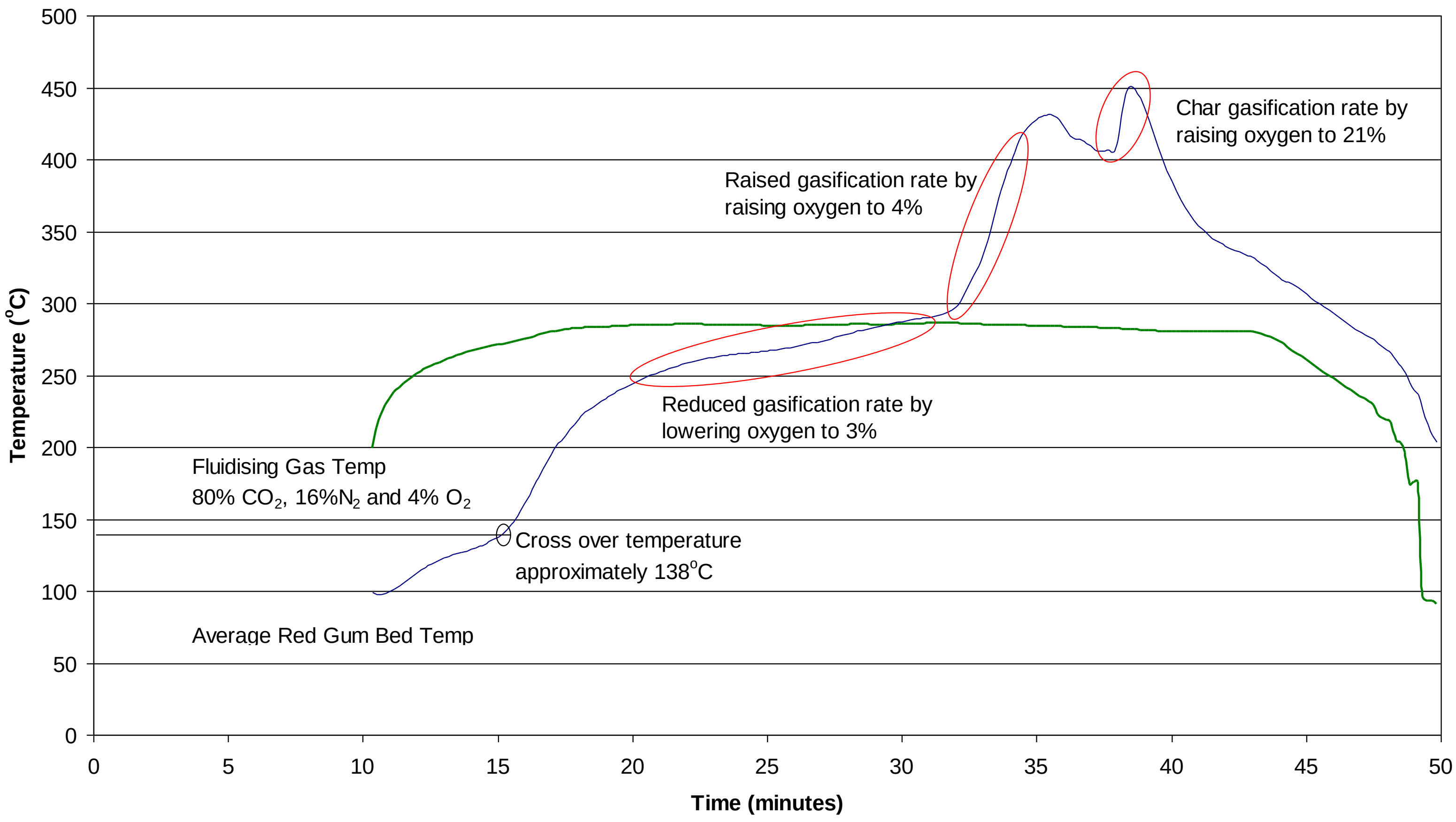
Gathering base data

Mortar Tube Furnace Test Rig

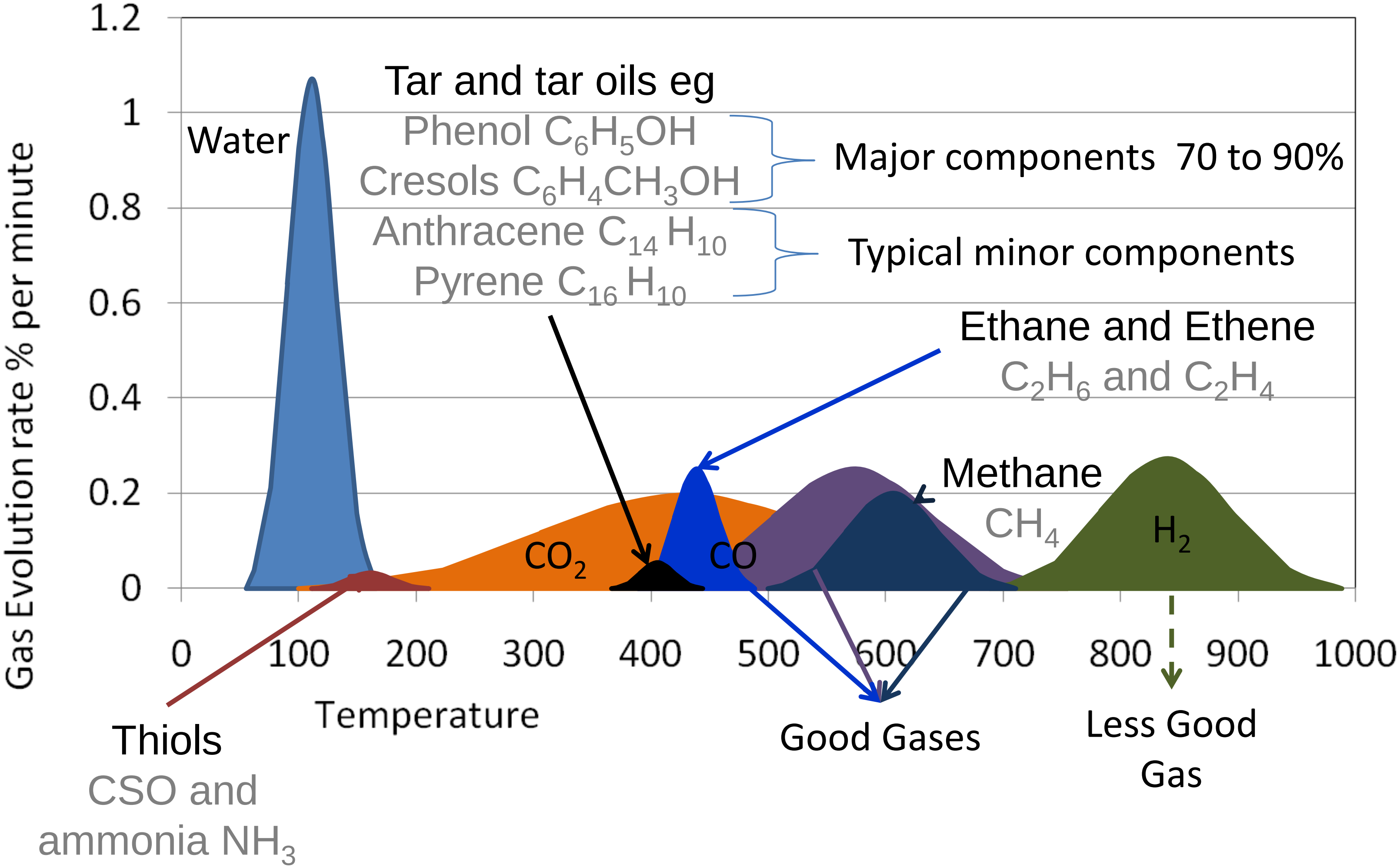
➔ Gas Evolution Curves

15 Kg Gasifier for Trial Plant

Mortar Tube Furnace Data: Australian Red Gum Wood



Typical Low Rank Coal and Biomass Gasification



Gasification Emission Reduction Test Plant

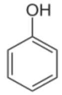
Tarry Emission Reduction - Test Objectives

Target: to produce a syn-gas
with resultant tar levels at less than 10 mg/Nm^3

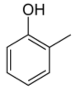
Historically, with the technology available, tarry compounds have been difficult to remove from the gas stream produced during low temperature combustion of biomass or similar feedstock. The presence of tar has been a barrier to using gas engines fuelled by high moisture feedstock.

Experimental results from Corky's test plant near Newcastle, NSW, have shown that tarry compounds are no longer difficult to remove.

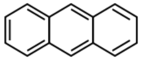
Typically tarry compound:



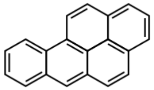
82%
Phenol



11%
Cresols



trace
Anthracene



micro trace
Benzo[a]pyrene

Tarry Emission Reduction - Test Results

Result: a clean syn-gas has been produced
with resultant tar levels at ***less than*** 5 mg/Nm^3

At 400°C, phenol and cresol use to predict tar load:

	mg/m^3				
no scrubber	3975 [1]	calculated			
80% through scrubber	795	measured	=	20.0%	
100% through scrubber	244	measured	=	6.1%	
O_2 injection at scrubber	101	measured	=	2.5%	at 8.6 l/min oxygen

At 800°C, as phenol and cresol levels were too small to be measured, propane and butane were recorded as a measure of VOC.

	ppm				
no scrubber	8250	calculated			
80% through scrubber	1650	measured	=	20.0%	
100% through scrubber	1250	measured	=	5.2%	
O_2 injection at scrubber	600	measured	=	7.3%	at 8.6 l/min oxygen

Note 1: typical and consistent with technical literature.

Test Plant – Summary of Results / Benefits

- Corkys' have produced a syn-gas that has a very, very low concentration of the tarry, corrosive compounds phenol and cresols (undetectable at 800^{o}C).
- Corky's have demonstrated that the water recovered from drying is contaminated by phenol and cresol. Nevertheless this water can be simply treated. The result is that creek life can flourish in this treated water. This means that the process can made be water neutral, or even slightly water positive, which is very import for inland Australia or other places that suffer extended dry seasons.
- Corky's have demonstrated the efficacy of the hot scrubber, particularly when there is a low oxygen flow to this scrubber. It was particularly pleasing to see that the there was very little efficiency loss with the scrubber at temperatures as low as 400^{o}C. This has very good ramification to the environment when we apply this technology to potentially contaminated wastes like municipal solid waste.

Test Plant – Summary of Results / Benefits

- Corky's have demonstrated the low ignition temperature of reactive feedstock which has ramifications for the efficient drying of wet, granular, materials; the most industrially significant being brown coal.

- This syn-gas can be produced from renewable feed stocks like timber mill waste, feed lot waste, energy crops like "enercane" which can be irrigated with salty ground water on non-arable land and other wastes like municipal solid waste.

Investigation into the use of biomass as a feedstock for low emission energy generation is not new . However, what is new, is the existence of a technology that allows the scale of a project to be "micro" (by comparison to centralised power generation) such that it is economically viable at a small scale.

Project Economics

The commercial viability of a *Renewable Energy* project is based on 10 factors:

i) **Power generating capacity (MW) & associated revenue**

ii) **Installed capital cost**

iii) **Capability for generation (supply) to meet consumption (demand)**

iv) **Operating utilisation** [factors: availability & operability, ie. consistency of source energy]

v) **Operating cost amortised over the commercial life of the plant**
[factors: design life, maintenance and equipment replacement costs]

vi) **Future cost of current electricity supply**

vii) **Future availability of current electricity supply**

viii) **Revenue from carbon credits and waste heat products**

ix) **Revenue from co-products** [in addition to electricity]

x) **Benefit to local economy**

Project Economics

The immediate target market is to supply customers who rely on generators for temporary "peak supply" and currently pay 3 to 4 times the average cost of being connected to the grid.

Model C
Micro Power Plant:

INDICATIVE

- → 33% cost of solar PV
- → 50% of solar thermal
- → 1 to 2.5 year Payback: compared to power from a diesel generator

Not renewable / Peaking supply

Diesel Generators

EXPENSIVE

2nd Test Plant – Summary of Results / Benefits

Total equivalent Dioxin 0.013 ng/Nm^3 when fired on supermarket waste standard is < 0.1 ng/Nm^3 in NSW for irregular fuel

3rd Test Plant – Aim to test wider range of materials – they all performed differently

Plant Range

Model	Type	Heat recovery Integration	Thermal Efficiency	Ease of operation	Typical Biomass requirement (tpa)	Average power output (kWe nett) wet wood
AA	Open cycle	No	Inefficient but cost effective	Simple	9,000	200
A	Combine cycle	Yes	Efficient	Complex	18,000	1,000
B	Two A plants with shared infrastructure	Yes	Efficient	Complex	36,000	2,100
C	Two B plants with shared infrastructure	Yes	Most efficient	More complex	72,000	4,400

Pricing:

- ➔ Installed cost depends on local site conditions
- ➔ Typically 10% extra cost for MSW due to extra emission verification and waste storage. However, this depends on local regulatory issues
- ➔ Price on par with wind generated power after taking wind availability into account
- ➔ Revenue from surplus energy and carbon credits and dump fees
- ➔ Base load and demand supply capability, but demand power costs 1% more for an upswing capacity of 1%
- ➔ A Feasibility Study is the recommended first step, to establish a project budget.

Waste to Energy (MICRO POWER) Plants

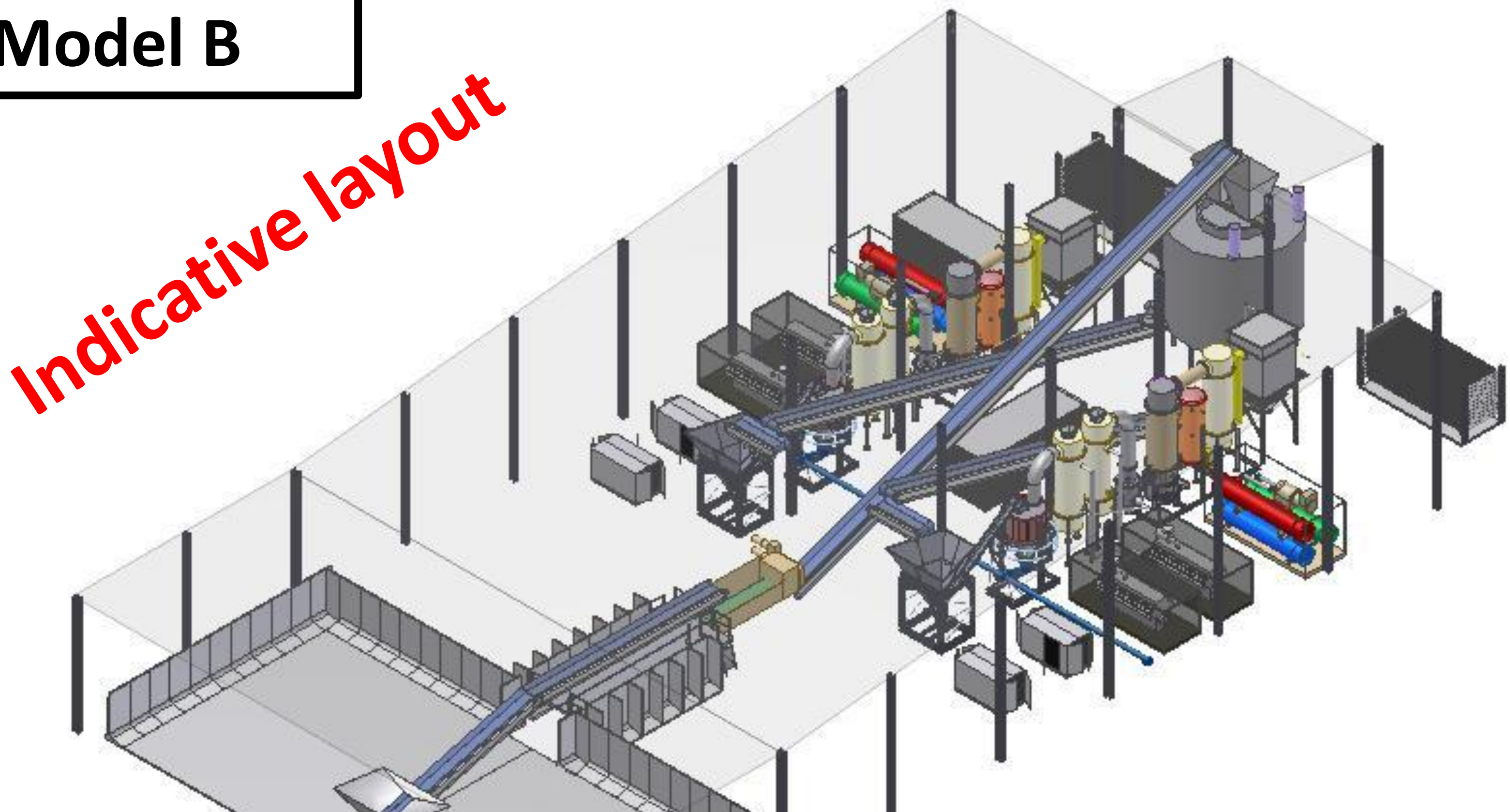
Model A

Indicative layout

A small house block

Waste to Energy (MICRO POWER) Plants

Model B



65mx 40m

Project Pathway

1) Concept: Waste to Energy conversion accepted as a viable alternative
2) Opportunity: Quantify waste streams and current disposal costs
3) **Feasibility**: Analyse waste and prepare cost-benefit analysis
   Preliminary conceptual design and approvals
4) Proposal: Site layout
5) Project Approval: Funding / Contracts (project and material supply)
6) Project Delivery: Design / Supply / Construct / Commission
7) Operate: Maintain / Monitor / Service

Corky's technology: a different paradigm

- **Range of plant sizes** [A~1 MW, B~2.1 MW, C~4.4 MW]
- **Modular units:** combine to increase generation capacity
- **Staged process with pre-drying**
- **Waste heat utilisation:** similar to combined cycle concepts by treating waste heat as a resource to optimise plant performance. Cycle Efficiency 28-30% even at this mini scale.
- **Wide range of feedstock types and sizes can be used**
- **Capacity for multiple product generation** (maximise value)
- **Unlock resources:** use waste or currently uneconomical resources
- **Decentralised power generation:**
  - internal combustion engine technology can generally be supported locally
  - technology can be integrated with existing industry to reduce costs
  - economic benefit moves to local community.

Biomass Opportunity

Australia produces about 50 million tonnes of biomass residue annually, much of which is burned, stockpiled or placed in landfill.

Sustainably harvested biomass for electricity generation is granted a ‘zero’ greenhouse gas status. Biomass can decay and produce methane [22 times more damaging than CO_2].

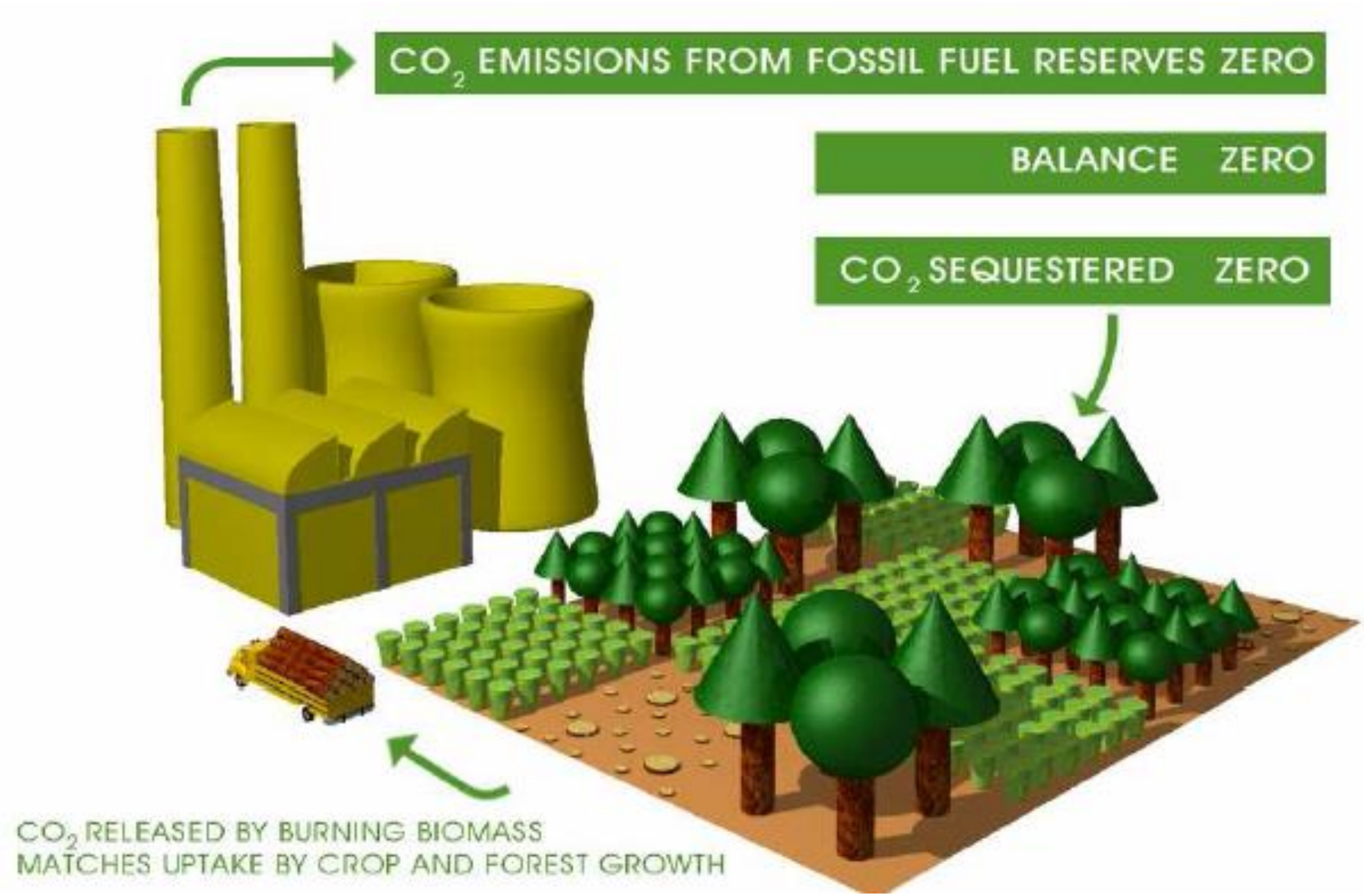
The Liddell trial involved integrating sawdust and wood shavings (maximum blend 5%) into the traditional coal fuel stream.

50,000 megawatt hours of biomass-powered electricity can supply 5,680 households (population 15,300) and save 50,000 tonnes of than CO_2 per annum.

Source: Macquarie Generation website – Liddell Power Station trial July 1999

CCC are setting up to deliver the same benefits via **distributed, localised power generation** solution using **biomass**.

Carbon Cycle



NEXT STEPS

- Corky's
  - Establish Test Plant in Hunter Region [Done Dec 2008]
  - Capital Raising to fund Business Plan / Commercialise
- Customer Initiate assessment of project viability by **providing** …
  - Plant location / number of plants
  - Any local taxes and or requirement for local manufacture
  - Biomass type / moisture levels / assay
  - Tonnage availability, distance and seasonality
  - Internal power requirements
  - Preferred Product Partition: [Gas, Char, hot water, Electricity %mix]
  - Potential for Govt Grants: [Establish Renewable Energy]
- Corky's
  - Prepare DRAFT Project Overview
  - Analyse project details / **Feasibility Report** [$100-$200k]
    [Cost Benefit Analysis / Optimise Product Partition & ROI]
  - Proposal ➔ Project contract