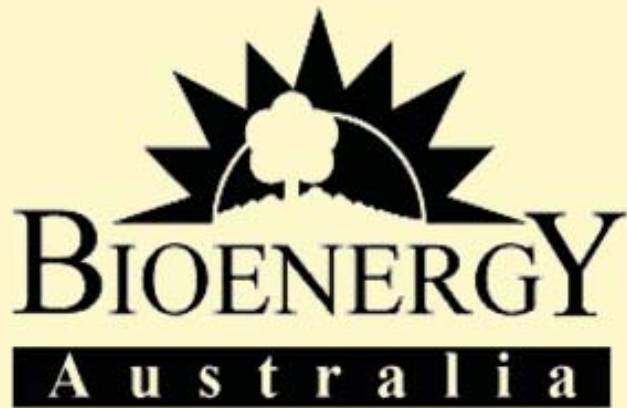


# Overview of Bioenergy Products and Opportunities

Timber Queensland Forum  
1 July, The Pavilion, Brisbane



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# Examples of Biomass

- Sawmill wastes, logging residues
- Agricultural residues (e.g. bagasse, straw)
- Portion of urban wastes
- Purpose grown woody and herbaceous energy crops
- Woody weeds (e.g. *Camphor laurel*)
- Processing wastes (e.g. black liquor)

*Solidified solar energy – via photosynthesis*



Tree Stumps ■

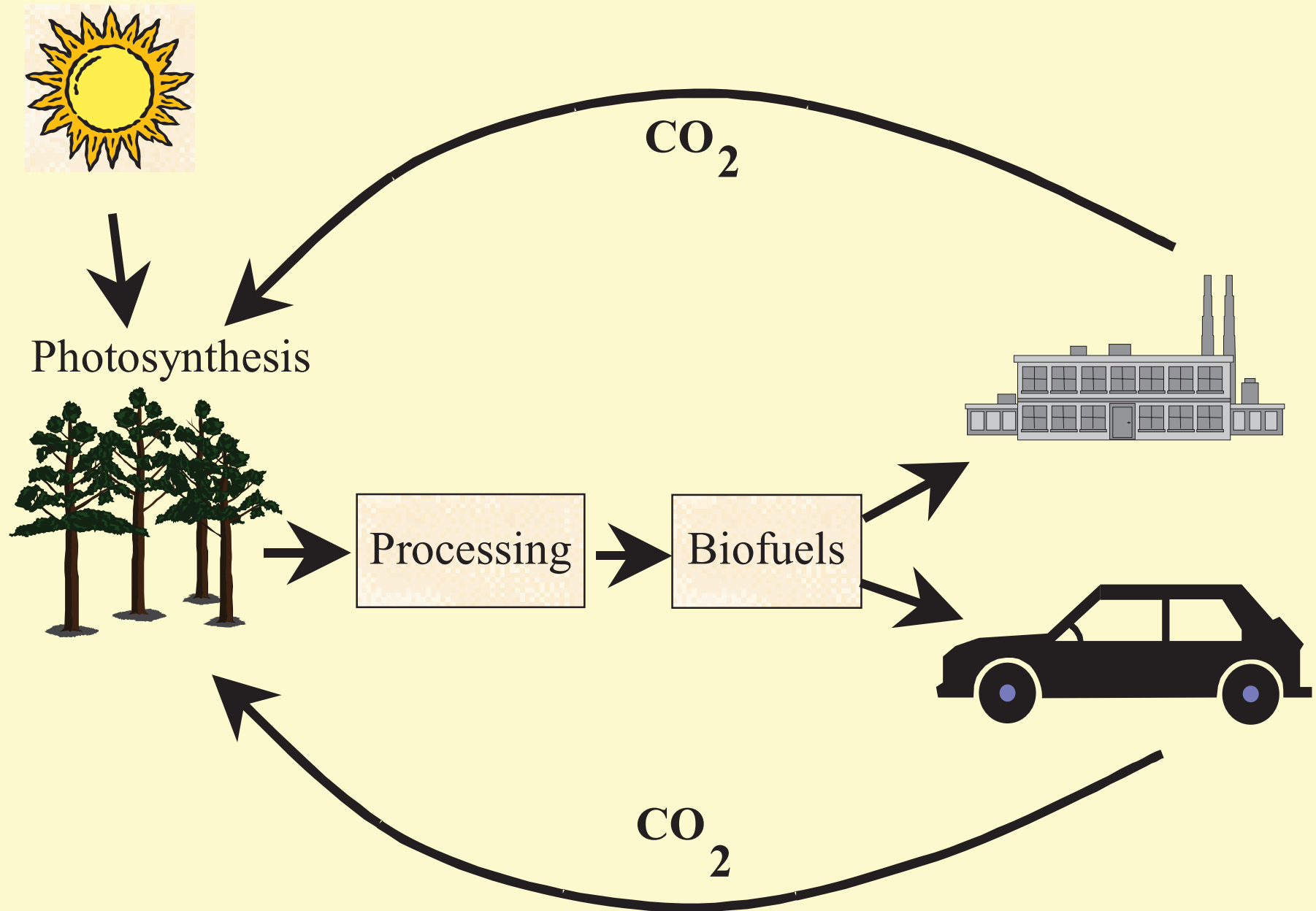
■ Sawdust and bark



Urban Wood Wastes ■

■ Straw



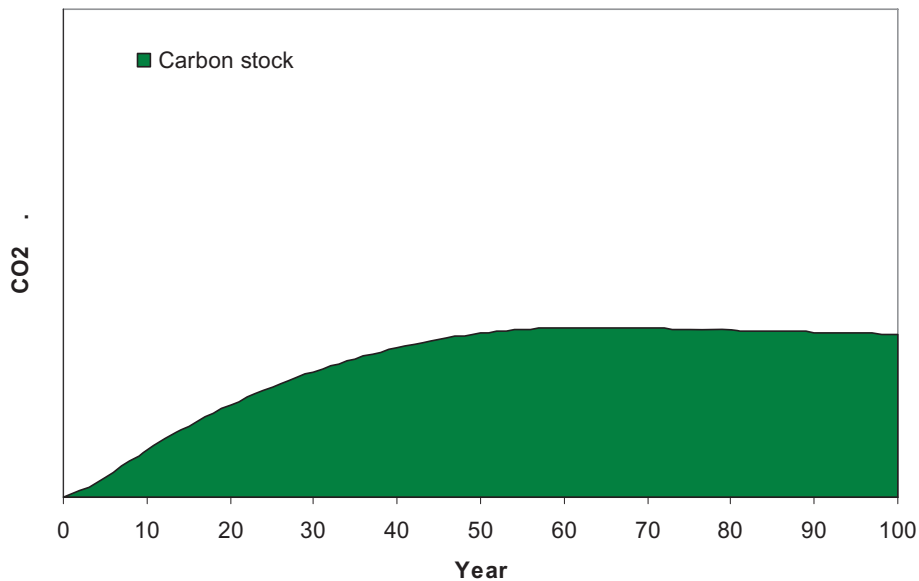


# Life Cycle Emissions of Various Technologies

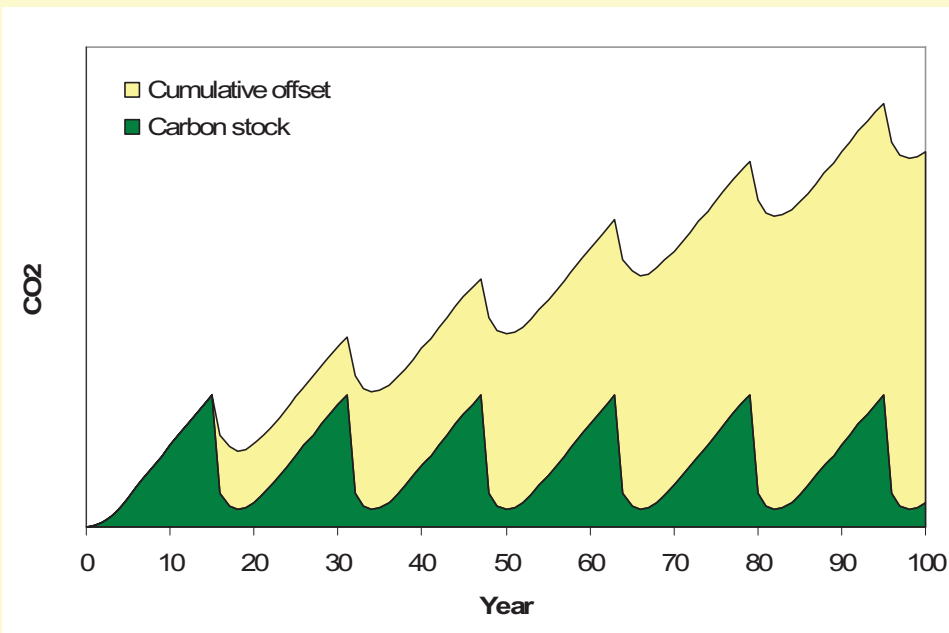
	g/kWh	CO <sub>2</sub>
• Black Coal		955
• Gas CCGT		446
<b>Bioenergy</b>		
• Straw - steam cycle		13
• Forestry residues – steam cycle		29
• Forestry residues – gasification		24
• Poultry litter – gasification		8
• Animal slurries – anaerobic digestion		31
• Landfill gas		49
• Sewage gas		4
• MSW incineration		364
<b>Other renewables</b>		
• Decentralised PV –new homes		178
• Wind – on shore		9
• Hydro – existing large		32

Source: IEA/DTI

# Permanent Plantings vs Energy Crops



- Permanent plantings
  - carbon stock plateaus
  - no revenue once max carbon stock reached



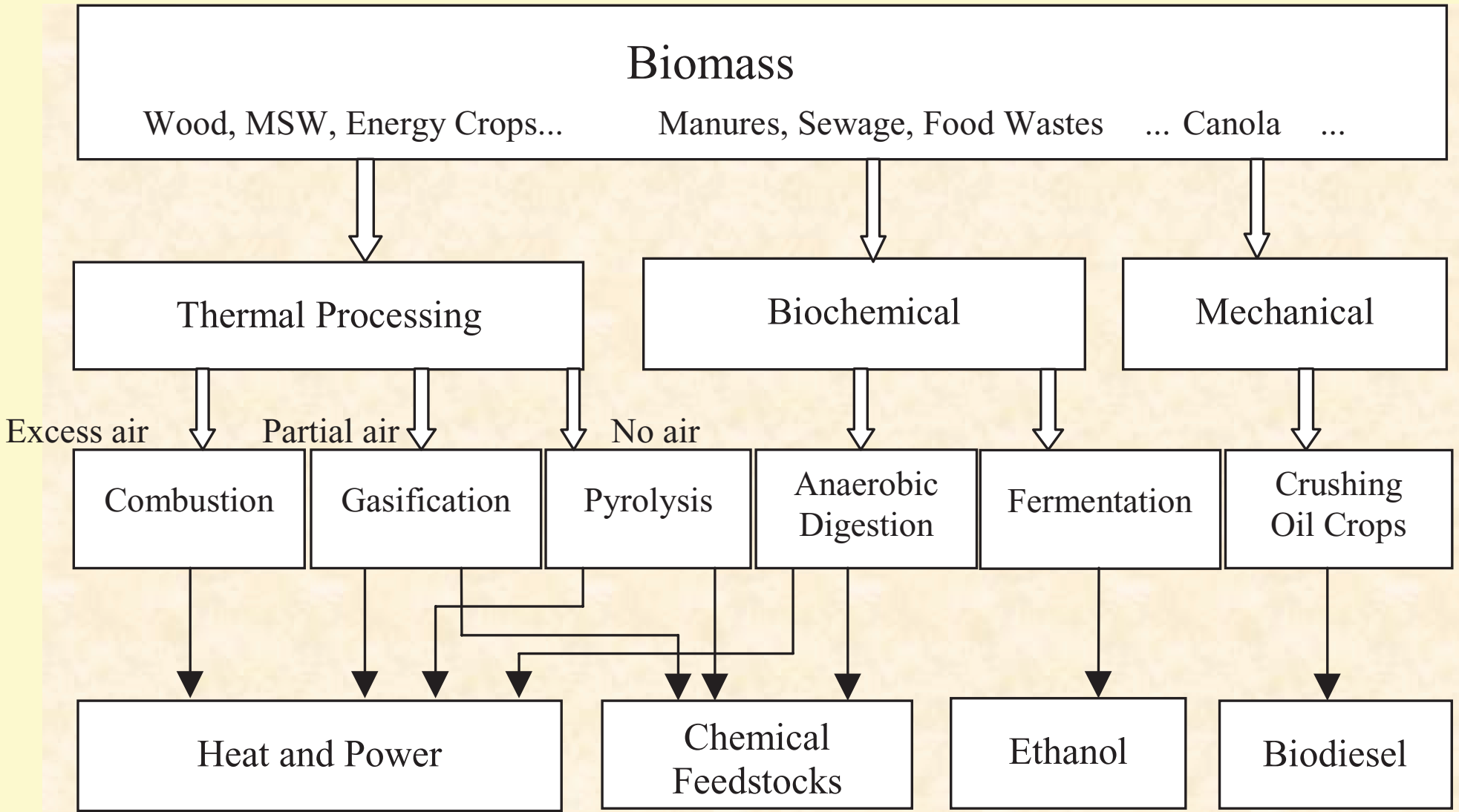
- Rotational crops
  - benefit from offset of fossil fuel use
  - ongoing revenue to fund management

# Co-Products

- Renewable Energy Certificates & GreenPower
- Other environmental instruments (carbon and salinity)
- Cogeneration opportunities
- Saleable ash
- Biofertilisers (e.g. Camellia anaerobic digester)
- Methanol and ethanol
- Pyrolysis oil products
- Charcoal and activated carbon
- Plant breeding and biotechnology

# Co-values of Bioenergy

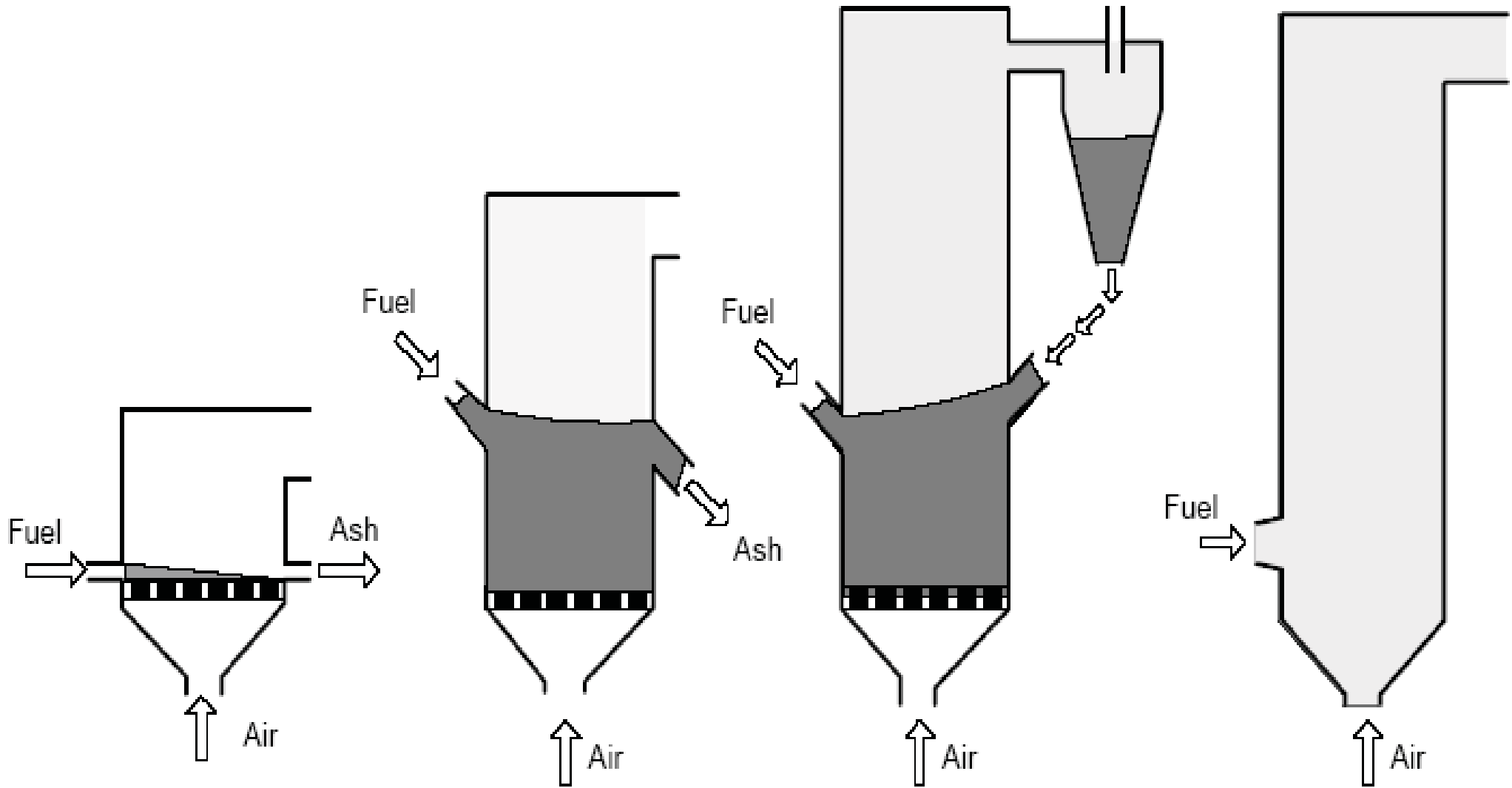
- Greenhouse gas reduction
- Dispatchable base load power – unlike wind and solar
- Regional development and employment
- Salinity mitigation and land repair
- Security of supply – indigenous resource
- Weed control
- Fire hazard reduction
- Biodiversity and animal habitat
- Waste management



# Biomass Conversion Technologies

- Combustion (full oxidation)
  - 90% of bioenergy plants
- Gasification (partial oxidation)
  - combustible gas of CO, H<sub>2</sub>, CH<sub>4</sub>, ...
  - gas engines, gas turbines, BIGCC, fuel cells
  - chemical feedstock for methanol, ethanol
- Pyrolysis (starved oxygen)
  - bio-oils, gaseous products and char
- Anaerobic digestion
  - landfill, covered ponds, plug flow reactors for combustible gas of methane and CO<sub>2</sub>
- First and second generation biofuels

# Combustion Technologies



Fixed bed furnace  
(grate furnace)

bubbling fluidised  
bed furnace

circulating fluidised  
bed furnace

dust firing

# Wood Pellets



District heating plant



Les Awirs – converted  
from coal to pellets

# Wood Chip Boilers for Heat



# Biomass Boiler at Milk Products Processing Plant - Switzerland



Chipped wood fuel is delivered through a grill from the street



# Macadamia Nut Shell Project – Gympie Qld

## 1.5 MW pinhole grate unit



Source: Ergon Energy



Bioenergy Australia



Semi-trailer unloading fuel at  
Tracy Biomass Plant

21 MW Tracy Biomass Plant, California

# Cuijk 24 MWe FBC plant in The Netherlands



Source: Essent Energie

**Bioenergy Australia**



## Cuijk Aircooled Bioenergy Plant





Rocky Point Sugar Mill – Qld -30 MW

## Australian Examples of Grate Boilers



Condong Sugar Mill – NSW - 30 MW



Grayling- Michigan, USA, 36 MW

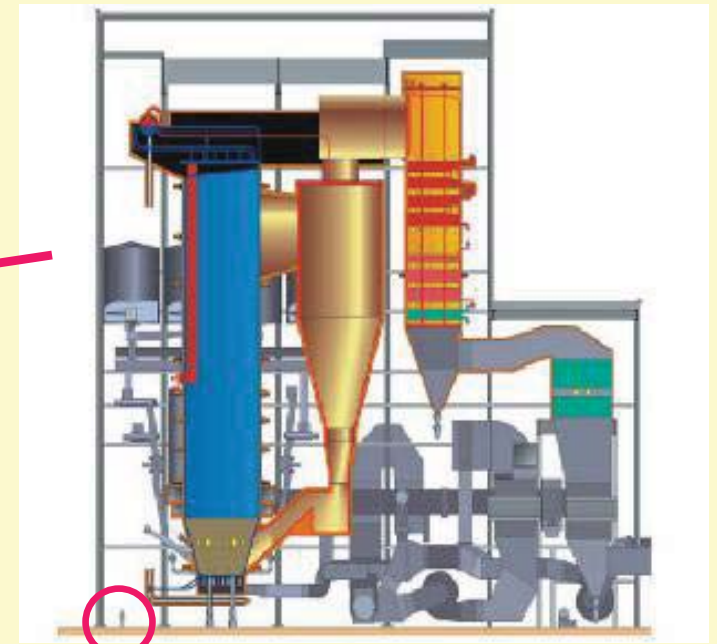


Kettle Falls (47 MW)– Washington State



Shastra Anderson Plant (50 MW) – California

# Alhomens Kraft 550 MW<sub>th</sub>, 240 MW<sub>e</sub> CFBC plant

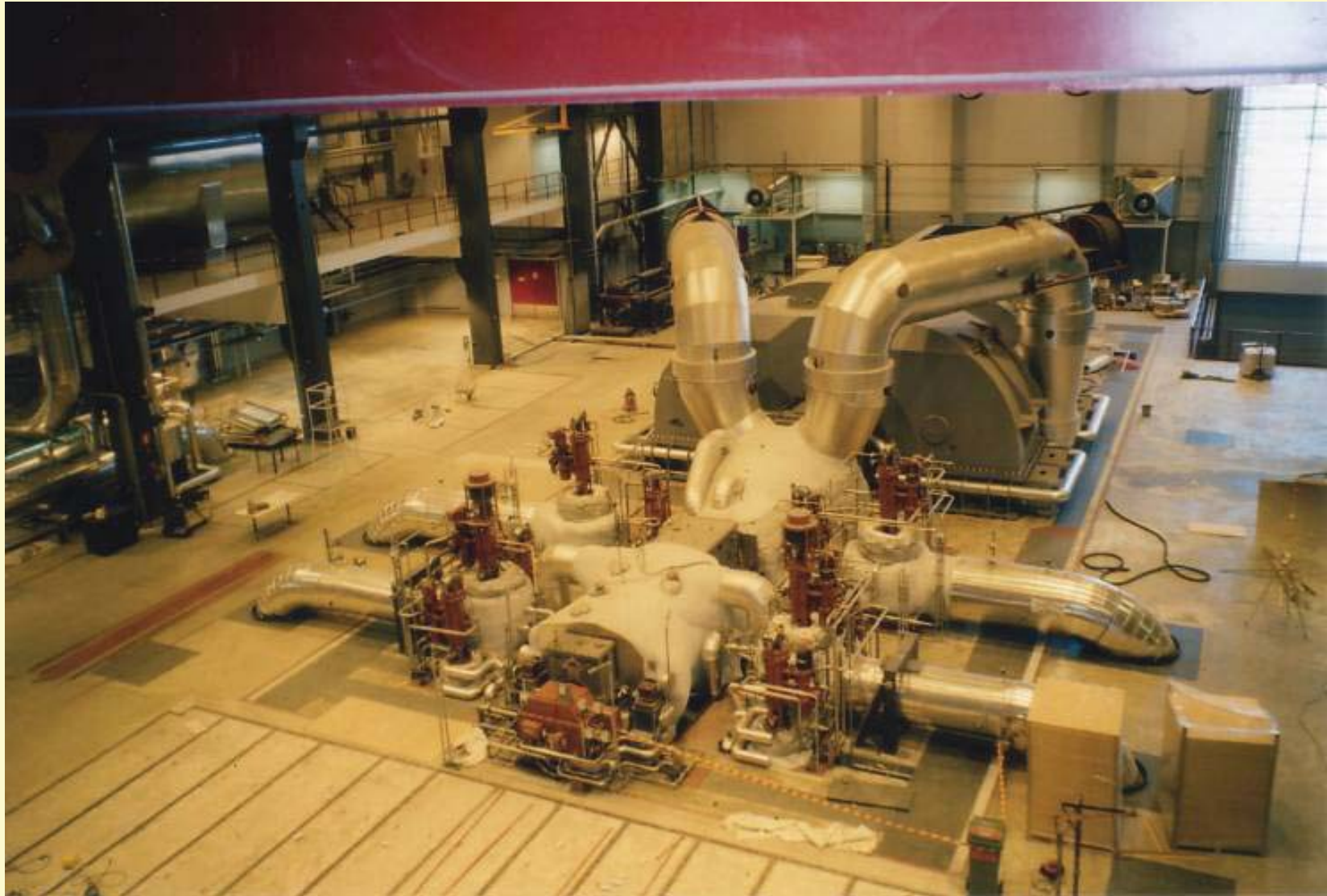


Slash bundles – part of fuel supply

source: Timberjack

**Bioenergy Australia**

# Alholmens Turbine Hall – 240 MW electrical



# Multi-fuel Unit

## AVEDØRE 2 CHP Plant

- 10 km south of Copenhagen
- Opened 2002; 505 MW<sub>e</sub> and 565 MW<sub>th</sub> – USC boiler 310 bar
- Multifuel capability: straw, wood pellets, natural gas, oil and coal
- Separate straw boiler – 40 MW<sub>e</sub> and 50 MW<sub>th</sub>. Straw 200,000 t/a
- 300,000 tonnes/a wood pellets. Pellet factory at nearby Køge.  
Also pellet supply from Sweden
- Efficiency up to 94%



# Co-Firing Biomass with Coal

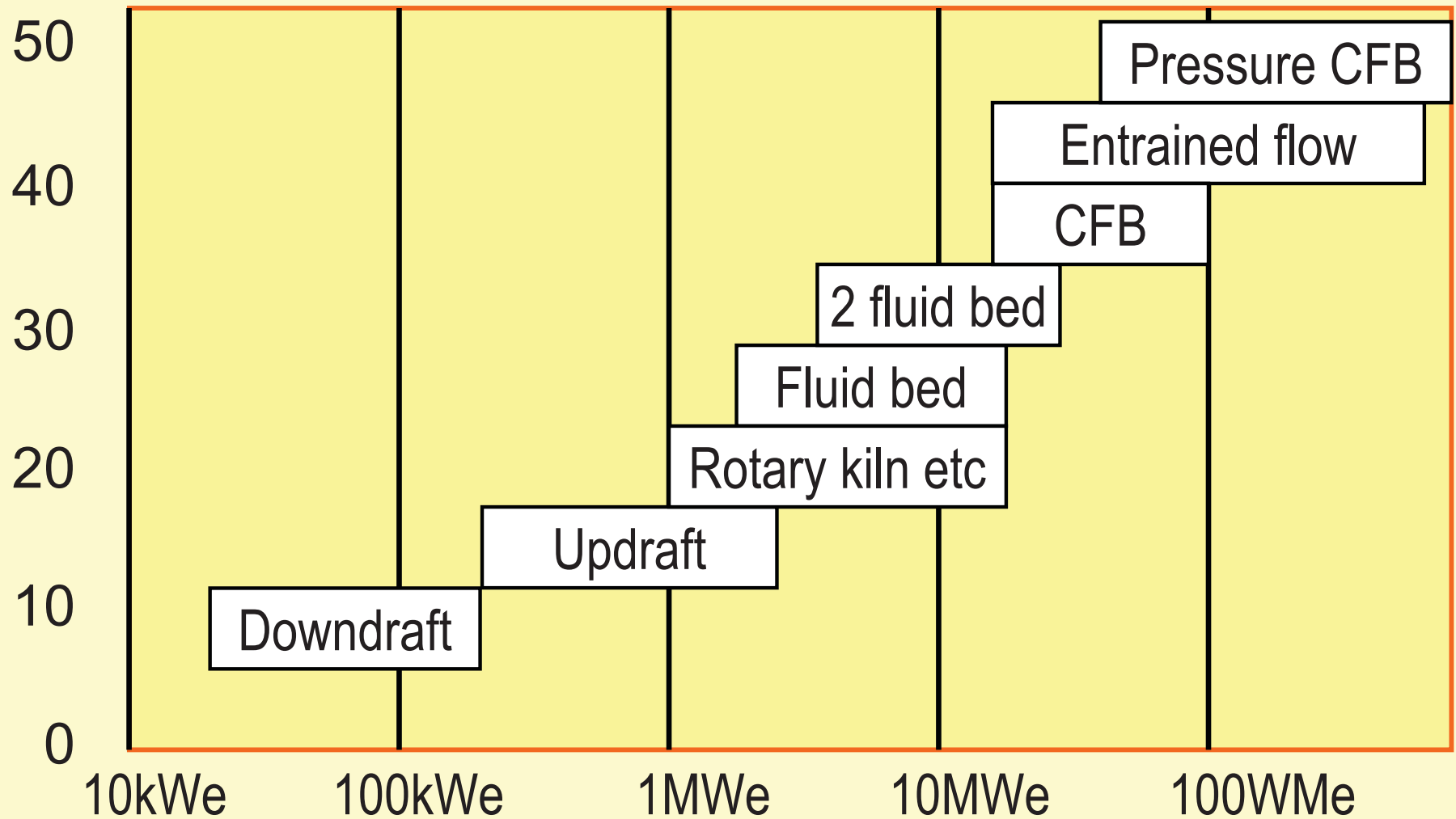


Biogas at Swanbank Power Station, Queensland

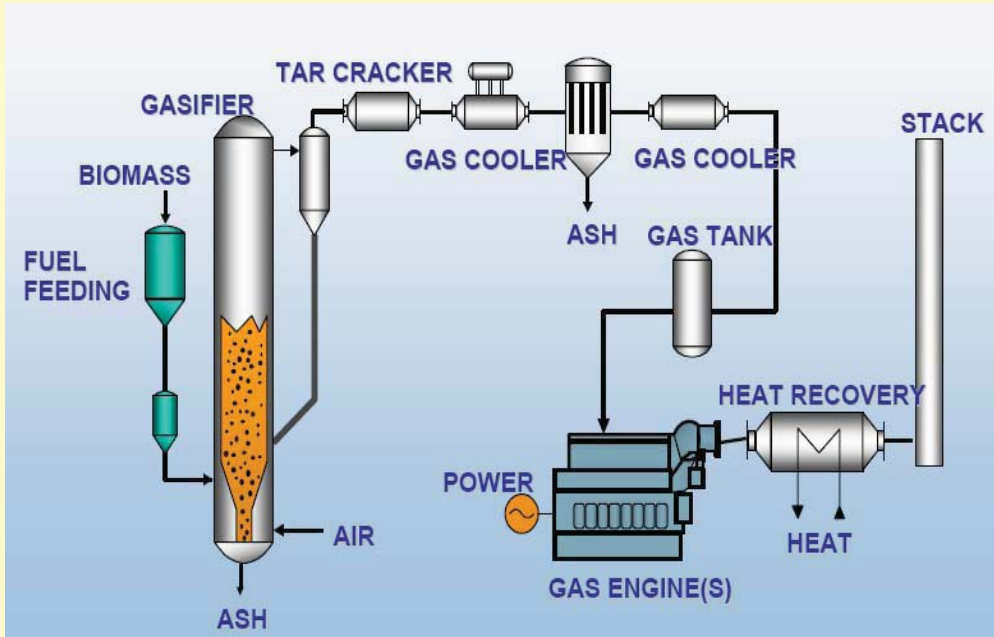
Wood waste/sawdust – Wallerawang Power Station, NSW

# Gasifier types, sizes & efficiencies

Efficiency to electricity (%)



# Gasification - small scale downdraft gasifiers for distributed electricity market



Real Power Solutions

Huon Valley, Tasmania



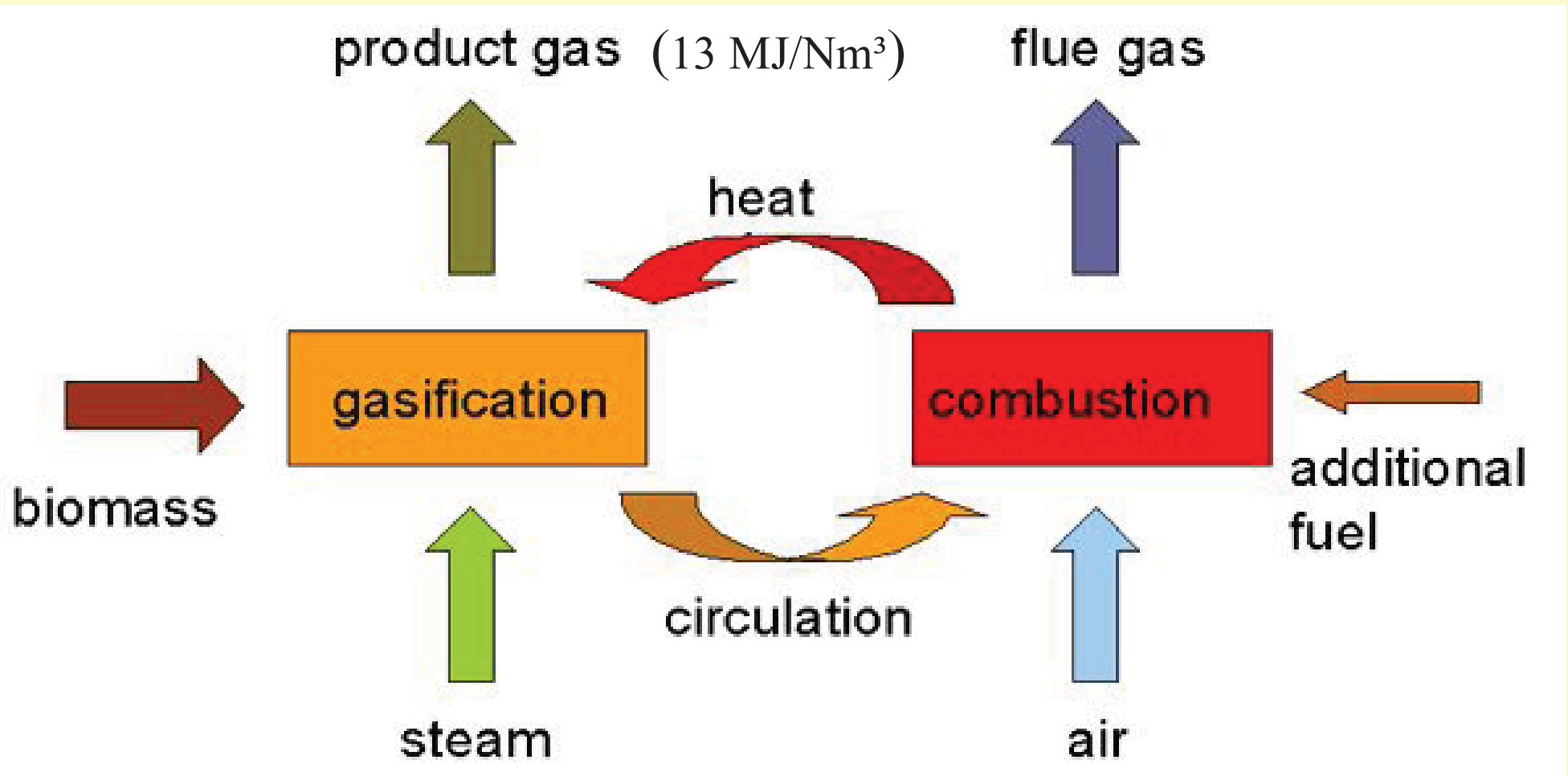
Varnamo BIGCC plant  
Sweden

- World's first BIGCC 1996
- 6 MW<sub>e</sub> and 9 MW<sub>th</sub>
- Sydkraft AB and Foster Wheeler
- 8500 hours gasifier operation
- 3600 hours BIGCC operation
- Air blown pressurised system
- Hot gas clean up

# Güssing - Austria CHP gasification plant



# Güssing Gasification Process



# Güssing - Austria CHP gasification plant



- Cogeneration Unit
- $2 \text{ MW}_e$
- $4.5 \text{ MW}_{th}$
- Electrical efficiency 25%
- Overall efficiency 81.3%





AMER Centraal  
gasifier - adjacent to  
900 MW coal fired unit

Co-firing wood  
gas: 83 MW<sub>th</sub>  
fuel input

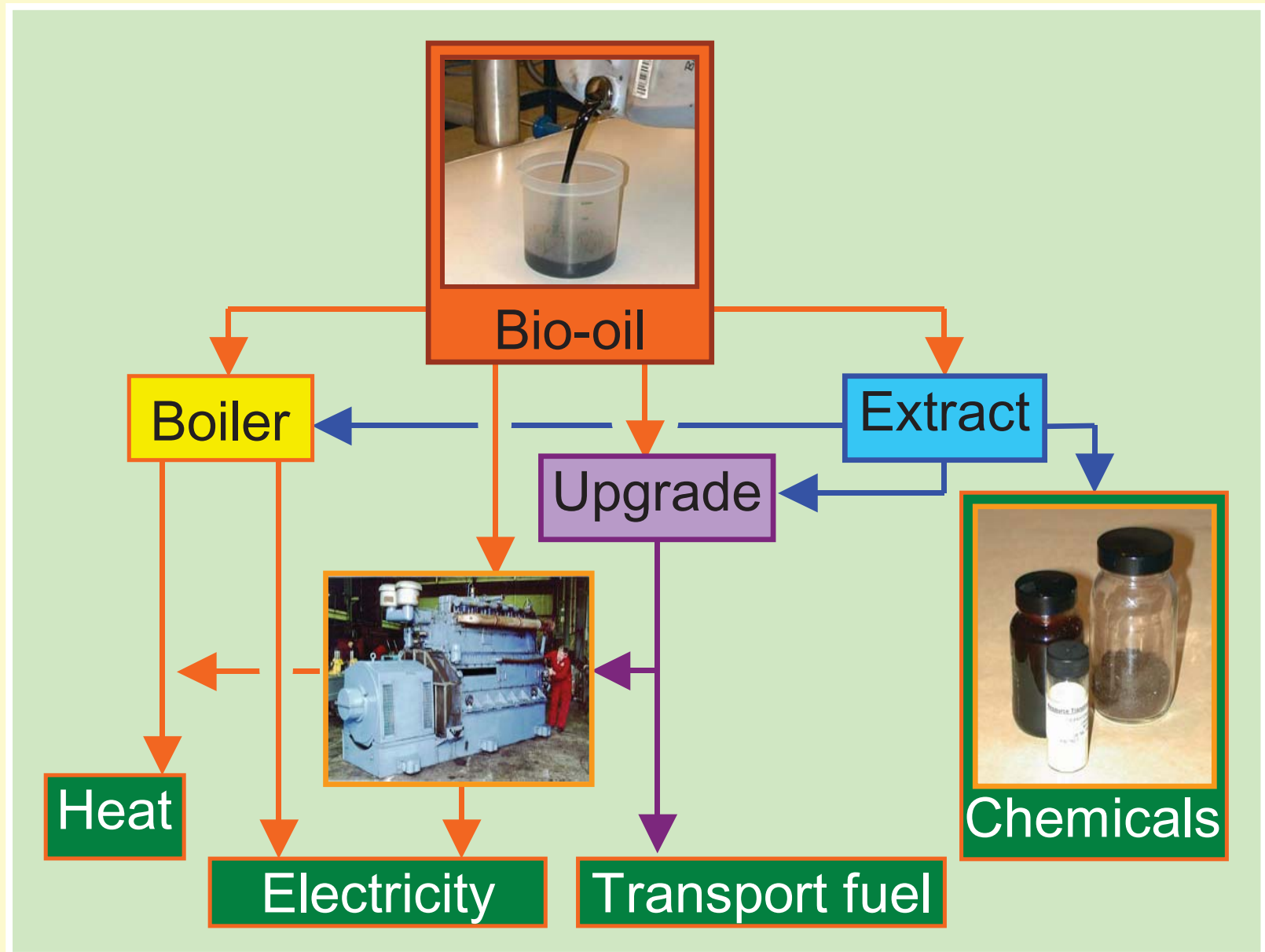


# Pyrolysis Bio-oil

- Dark brown mobile liquid
- Combustible
- Not miscible with hydrocarbons
- Heating value  $\sim 17$  MJ/kg (60%v diesel)
- Density  $\sim 1.2$  kg/l
- Acidic, pH  $\sim 2.5$
- Pungent odour
- Unstable - viscosity increases with time



# Bio-oil applications



# Power Production with Bio-oil



Ormskirk Dual Fuel Diesel

2.5 MW<sub>e</sub> Gas turbine -  
Dynamotive - Canada



Bioenergy Australia

# Progression of Dynamotive's Technology Development



**1. Pilot scale  
2 TPD**



**2. Demo. Scale  
15 TPD**



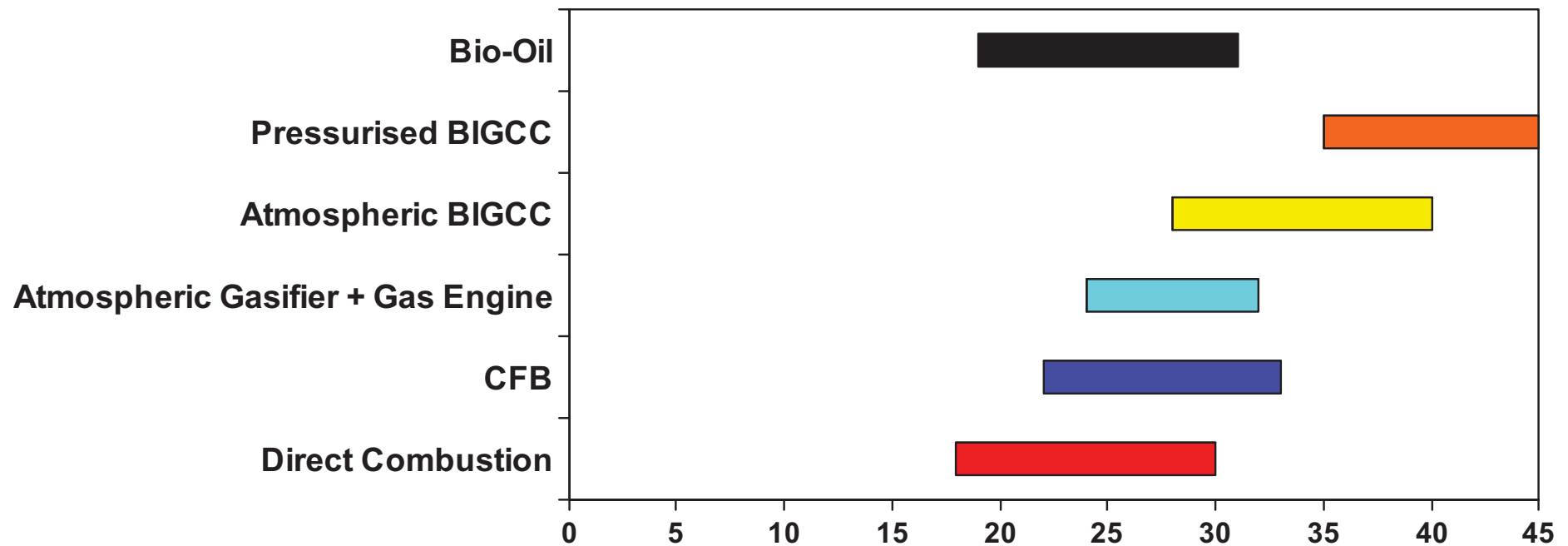
**3. Full scale  
130 TPD**



**4. Full scale  
200 TPD**

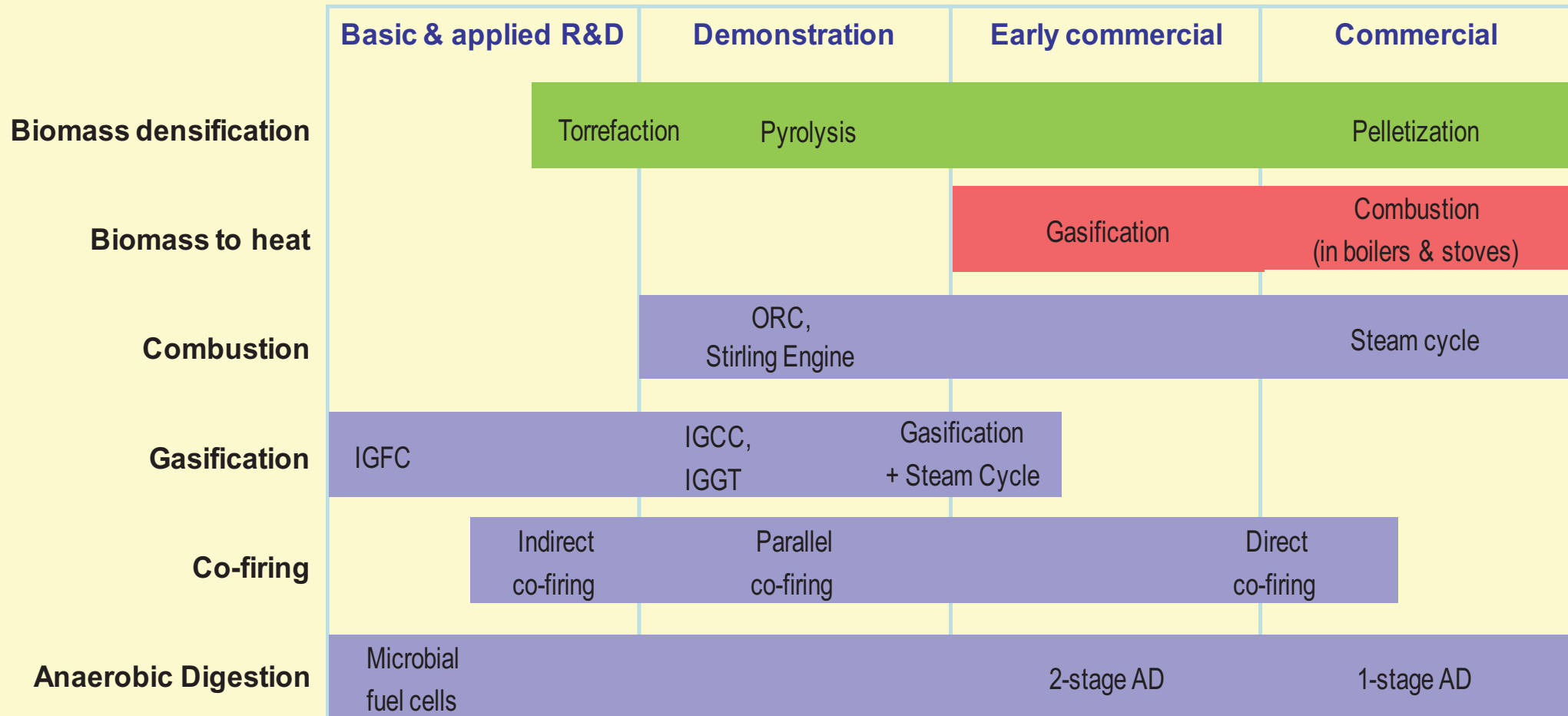


# Comparison of Various Bioenergy Thermal Conversion Paths

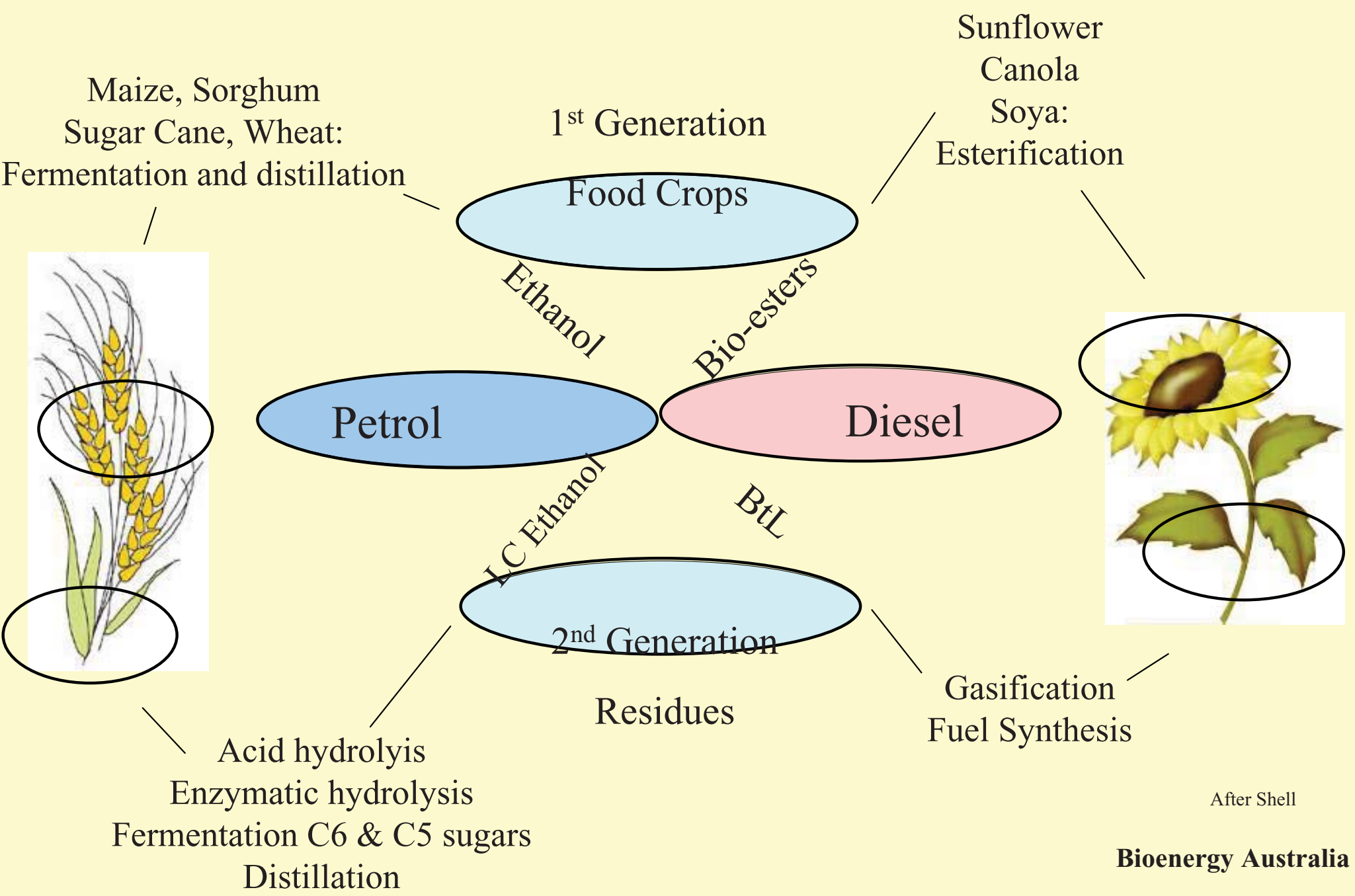


Net Efficiency Comparison of sub- 40 MW Plant

# Development of Stationary Bioenergy Technologies



# First and Second Generation Biofuels



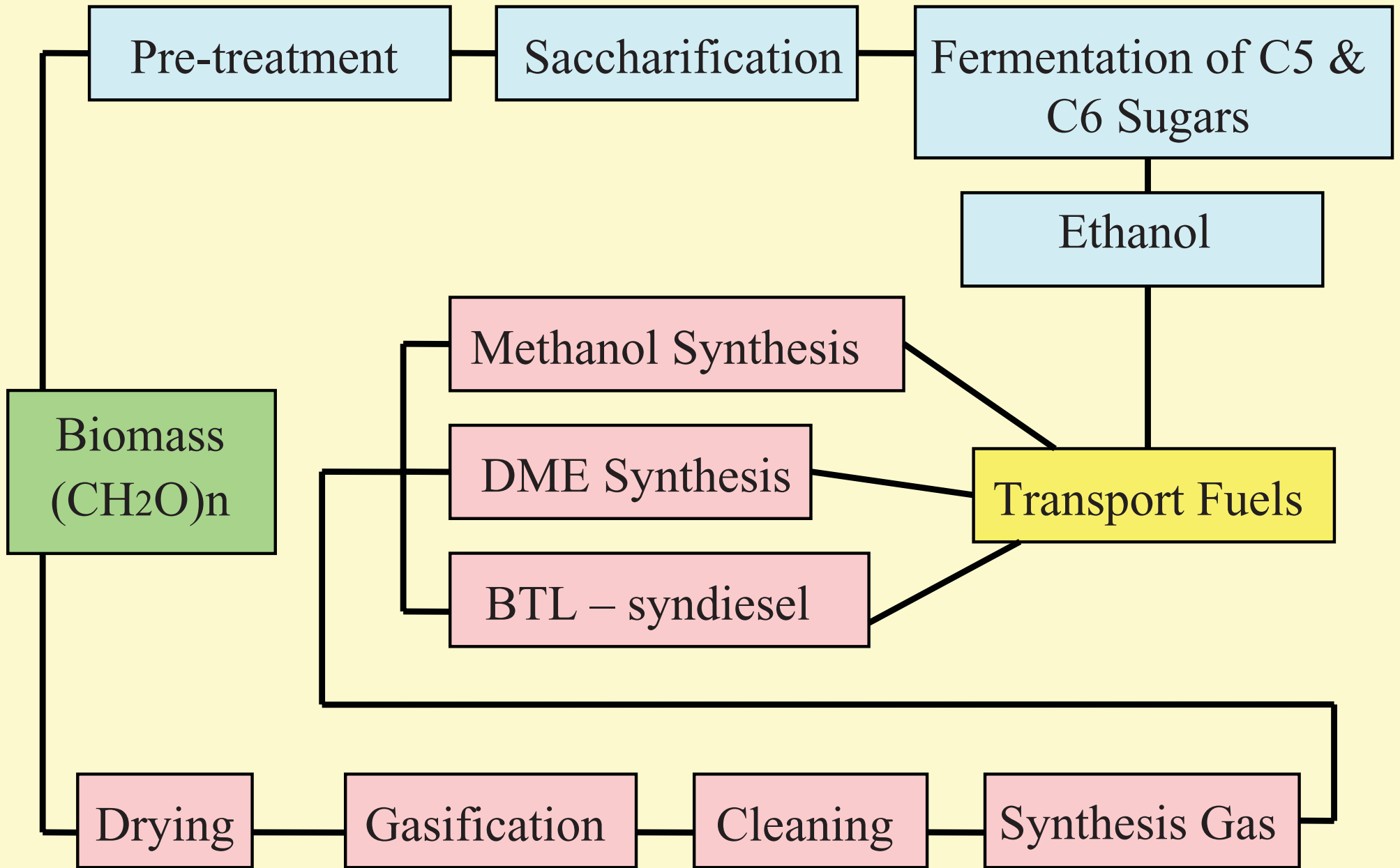
# First Generation Biofuels

**Biodiesel** – from vegetable oils and animal fats

– commercialised in Europe in early 1990's

**Ethanol** – from sugar cane, molasses, maize, sugar beet

– commercially produced since 1970's in USA and Brazil



## Second Generation Biofuels

# Second Generation Biofuels

## Two Main Technology Platforms

- **Biochemical:** conversion of cellulose and hemicellulose to sugars and fermentation to alcohol fuels
- **Thermochemical:** gasification to syngas and synthesis to fuels.

*Second generation biofuels aim to reduce costs, broaden range of feedstocks and hence allow increase in scale.*

# CHOREN Pilot Plant at Freiberg Germany Produces renewable synthetic diesel - *SunDiesel*



Source: CHOREN

**Today**

**Ethanol** – as a blending agent from grain, sugar or cellulosic material from Ag and/or Forestry industry

**Biodiesel** – transesterified vegetable oils blended with diesel

**Green Diesel** – fats, algal oils, waste oils, or virgin oils converted to low-sulfur diesel in petroleum refineries

**Higher Alcohols** – examples include: butanol, mixed alcohols, higher carbon alcohols (C5- and higher)

**Fischer Tropsch Liquids** – and other products from syngas including methanol, dimethyl ether (DME)

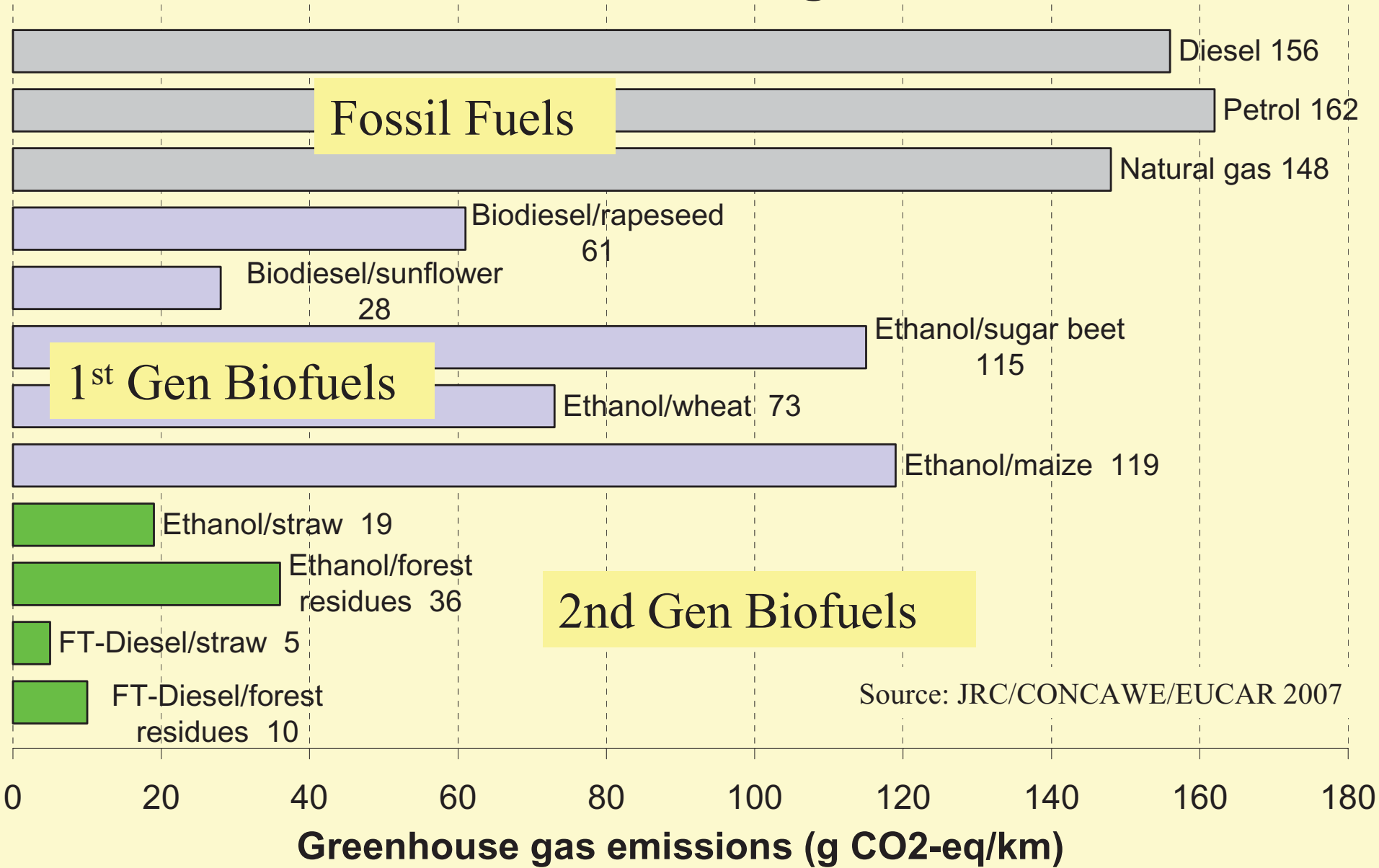
**Pyrolysis Liquids** – alternative feedstock to petroleum refinery or gasification facility

**Methanol derived fuels** – methanol to petrol technology and other products

**Other fuels** – Liquid transportation fuels from sugars/oils refinery not yet envisioned.

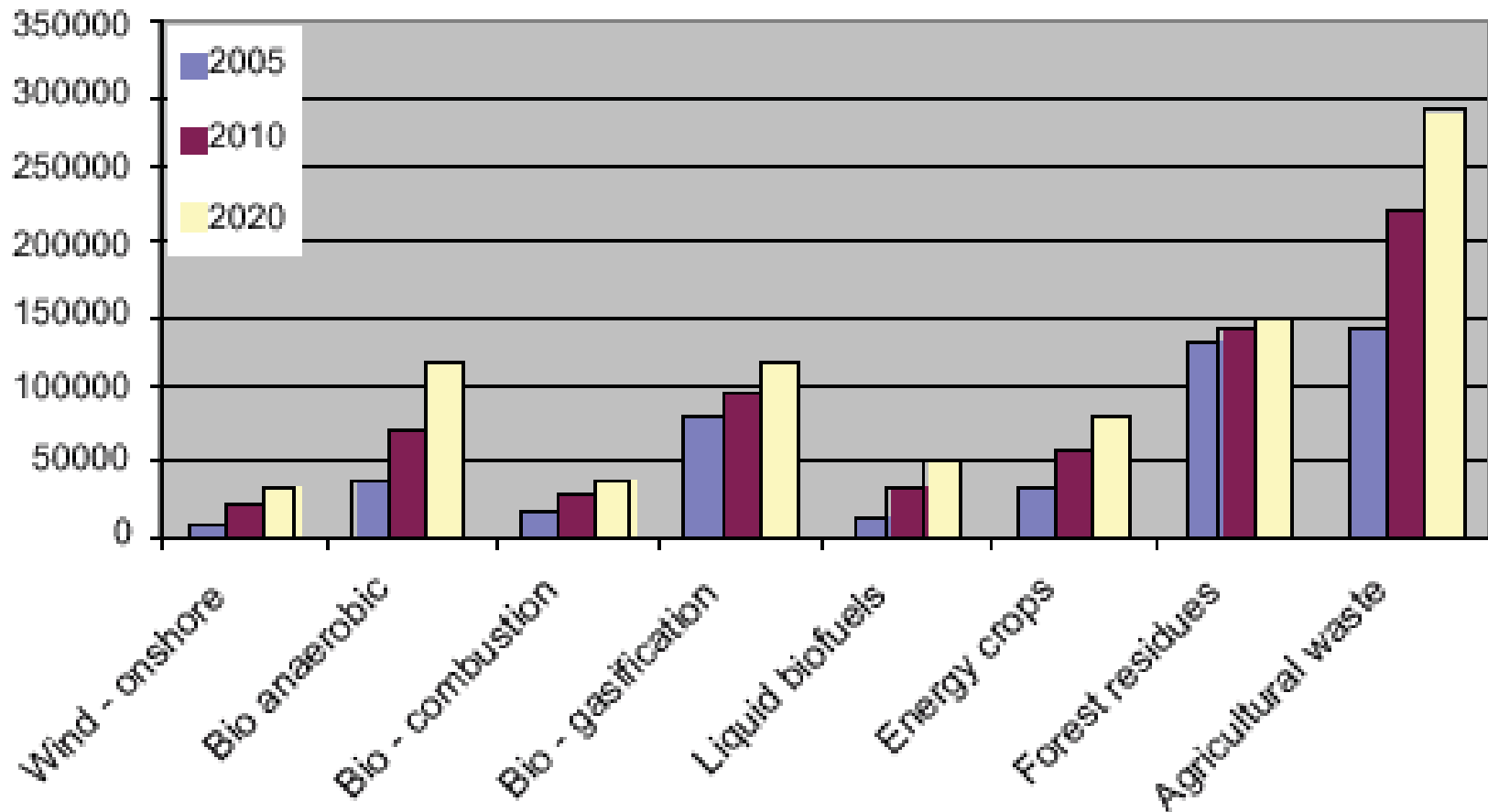
**Future**

# GHG Emissions Technologies 2010-2020



Source: JRC/CONCAWE/EUCAR 2007

# Large Rural Development/Job Numbers from Bioenergy



Projected employment in the EU for biomass technologies. Wind is included for comparison.  
Source: EU Altener Report: Impact of RES on Employment, 2000.

# Implementing Bioenergy in Australia

- Key Drivers for bioelectricity are the Renewable Energy Target (45,000 GWh/a by 2020), and in the longer term the Carbon Pollution Reduction Scheme.
- Bioenergy has provided about a quarter of all Renewable Energy Certificates surrendered under the MRET to date.
- ‘Clean Energy Future for Australia’ report led by WWF found that for a deep carbon cut scenario by 2040 bioenergy could provide 29 percent of the generation mix.
- Clean Energy Council stationary bioenergy roadmap indicates a four fold expansion of bioenergy by 2020.
- Biofuels has soft target of 350 ML/a by 2010. NSW has provided a biofuels mandate.

# Some Barriers to Implementation

- Low cost of fossil fuel (coals for electricity, oil for transport)
- Awareness and understanding of bioenergy by policy makers and shapers
- Concerns about using native forests for fuel. In most states logging residues are not permitted.
- Broader sustainability issues – e.g. food vs. fuel and water
- Economics of fuel procurement.
- Need long term regulatory stability for projects with a life greater than 25 years.



Queensland Wholesale Price of Electricity over  
Past Year (c/kWh)

# Conclusions



- World-wide 52,000 MW bioelectricity
- Australia has some 867 MW of all forms of bioelectricity capacity
- Globally large requirement for renewable fuels
- Large, unrealised potential – especially in Australia
- To learn more engage with Bioenergy Australia
- [www.bioenergyaustralia.org](http://www.bioenergyaustralia.org)