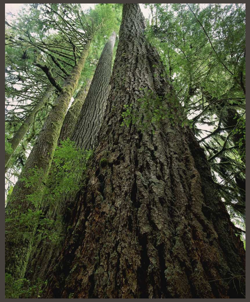
2000 2005 2030 2050

Bioenergy Options

Pathways analysis

Next generation biomaterials



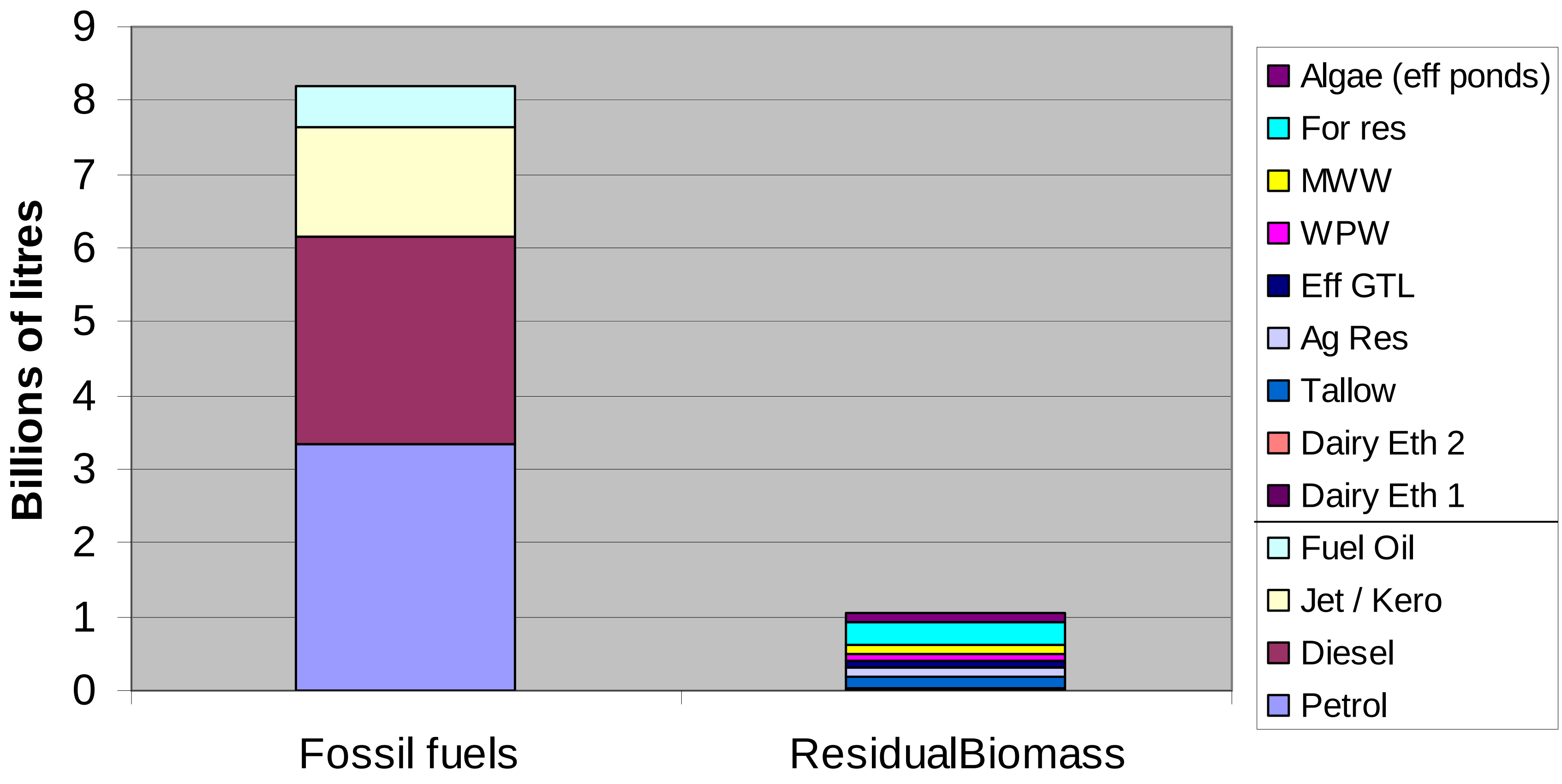
New Zealand’s EnergyScape

Situation Analysis - PJ/year Resource Availability

Type / source	**2005**	**2030**	**2050**
Forest Residues	**4.6**	**34.4**	**29.5**
Wood Process Residues	**7.0**	**9.1**	**18.4**
Municipal wood waste	**3.5**	**2.2**	**2.9**
Horticultural wood residues	**0.3**	**0.3**	**0.3**
Straw	**7.3**	**7.3**	**7.3**
Stover	**3.0**	**3.0**	**3.1**
Fruit and Vegetable Culls	1.2	1.2	1.2
Municipal Biosolids	0.6	0.7	0.7
Municipal solid waste , landfill gas	**1.9**	**2.0**	**2.0**
Farm Dairy	1.2	1.2	1.3
Farm Piggery	0.1	0.1	0.1
Farm Poultry	0.0	0.0	0.0
Dairy Industry	0.4	0.4	0.5
Meat Industry (effluent only)	0.5	0.5	0.6
Waste oil	0.2	0.2	0.2
Tallow	**3.6**	**3.6**	**3.6**
Total	**45.9**	**66.5**	**72.0**
Residual biomass as % of consumer energy	8.5%	9.2%	8.1%
Residual biomass as % of primary energy	6.6%	7.5%	6.6%

Liquid Fuels demand vs Residues

2000 2005 2030 2050



Liquid fossil fuels demand vs potential residual biomass supply

Pathways

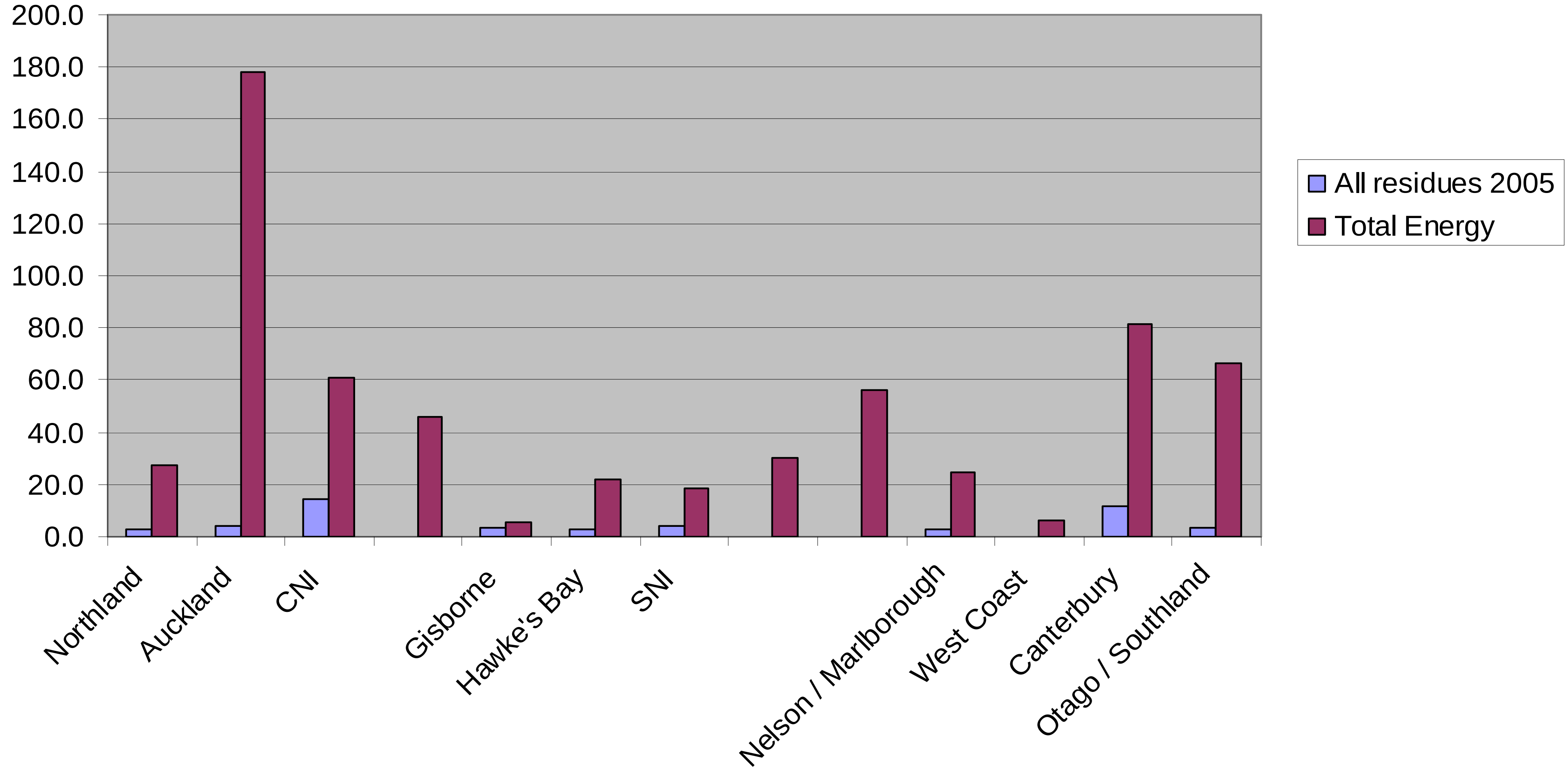
Feedstock	Conversion Technology	Energy Product
Wood Residues	Combustion	Heat Combined heat and power
	Enzymes	Ethanol Biobutanol
	Gasification	Combined heat and power
	Gasification + Fischer Tropsch	Biodiesel
	Pyrolysis / Oil	Combined heat and power
Effluents, Industrial, Farm waste effluent Municipal Biosolids	Anaerobic Digestion / Gas	Combined heat and power Gas for transport Liquid Fuels
	+ Algae Anaerobic Digestion / gas	Combined heat and power
	+ Algae Chemical Mechanical	Biodiesel
	+ Algae / supercritical water	Liquid fuels
Agricultural Residues (straws)	Combustion	Heat Combined heat and power
	Gasification + Fischer Tropsch	Biodiesel
Horticulture Residues (fruit wastes)	Anaerobic Digestion / Gas	Combined heat and power
	Enzymes	Ethanol
Agricultural Crops (canola)	Chemical Mechanical	Biodiesel
Waste Oil	Chemical Mechanical	Biodiesel
Landfill Gas	Capture	Heat and Power
Tallow	Chemical Mechanical Direct Fire	Biodiesel Heat and Power

Bioenergy Options

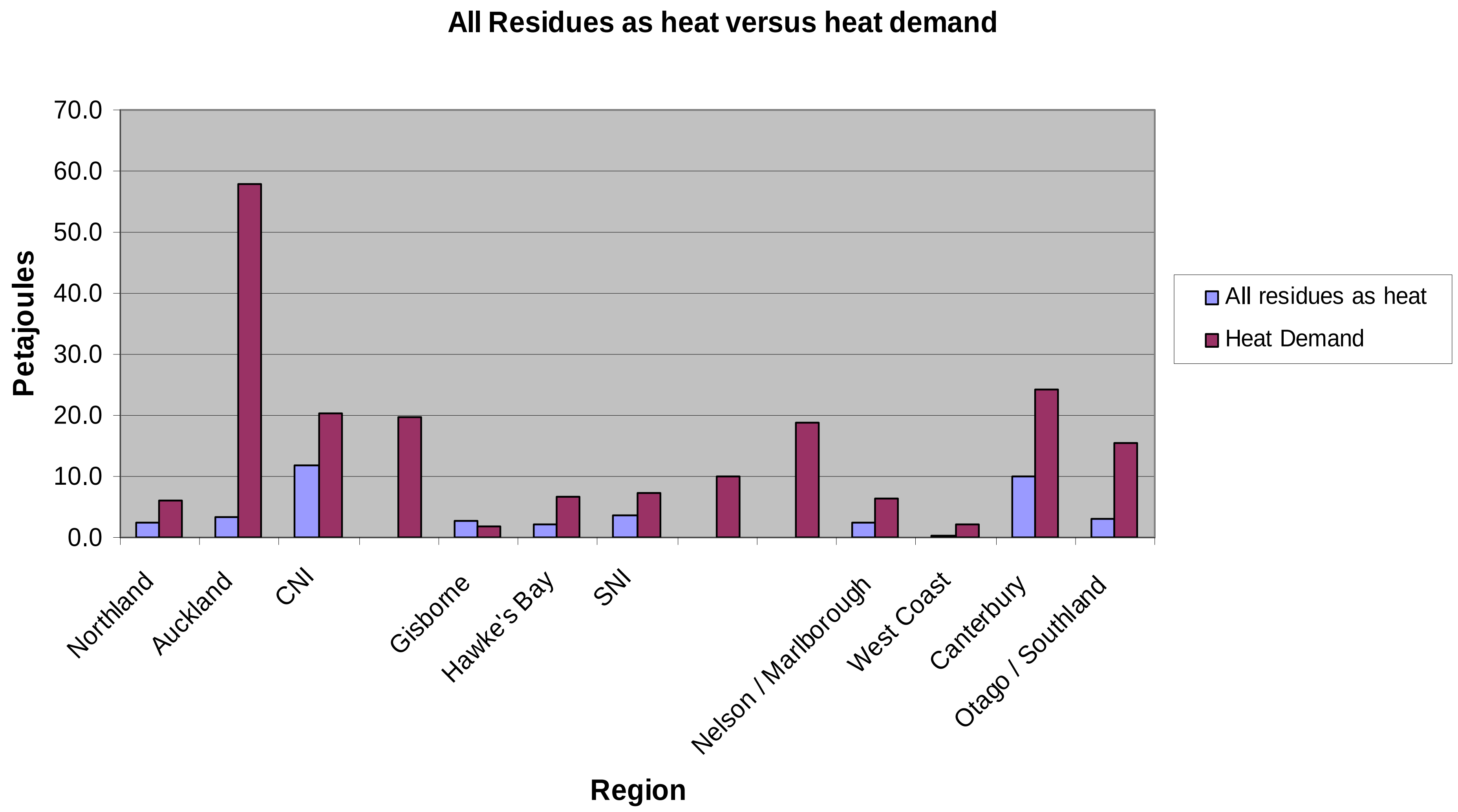
Pathways Analysis

Regional demand

All residues vs Total energy demand



Regional demand vs residues to heat


All Residues as heat versus heat demand

LCA – Anaerobic Digestion, Effluent

Key Points:

- Technology is mature.
- Economics marginal today.
- GHG benefits.
- Other environmental benefits (less waste, less toxic)
- With both meat and dairy sectors together this technology could supply 1 PJ of methane biofuel.
- à sufficient to replace 2% of the current national power production from natural gas (630,000 MWh/annum).

LCA Combustion of Straw

Key Points:

- Technology is mature.
- Similar primary energy requirements as for coal to heat and coal to electricity.
- Carbon neutral.
- Potential of 2 PJ/yr.
- Nor currently cost competative
- Highly regionalised – Canterbury, Waikato.
- Niche opportunities – e.g., food processing plant that needs heat.

LCA Oil Rapeseed Crop to Biodiesel

Key Points:

- Technology is mature.
- Economic at current prices c.f., fossil diesel.
- Reduction in GHG emissions of 50%-65%.
- Energy balance (energy out : energy in) of 2.2:1.
- Soil benefits and fits within a farming cycle.
- Also dependent upon the pressed seed cake – a valuable stock feed that also represents 90% of the displaced grazing taken up by the oil rapeseed crop

LCA Anaerobic Digestion of Kiwifruit Rejects

Key Points:

- Gas used for CHP.
- Technology is reasonably mature.
- Currently marginal/unattractive economics.
- 90% reduction in GHG emissions compared with grid electricity.
- 96% reduction in GHG emissions compared with heat from NG boiler.
- Potential of 0.2 PJ/yr
- Competing use for reject fruit as stock food

LCAs' of Wood

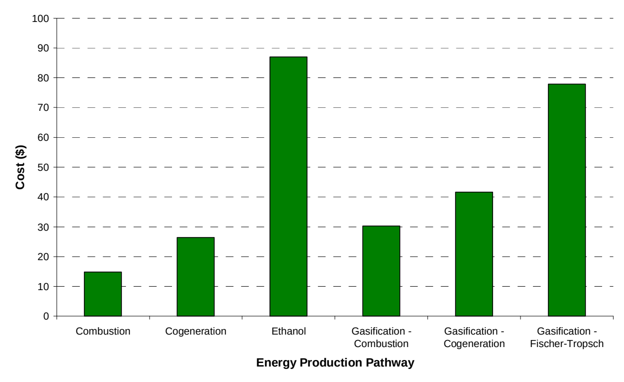
Pathway Name	Conversion Technology	User Energy
Combustion	Boiler Combustion	Heat
CHP	Combustion and CHP	Heat and electricity
Enzymic Ethanol	Enzymes	Liquid fuels
Gasification & Combustion	Gasification and combustion	Heat
Gasification - cogeneration	Gasification & CHP	Heat and electricity
Gasification + FT	Gasification + Fischer-Tropsch	Liquid fuels
Pyrolysis + refining	Pyrolysis, hydrotreating and finishing	Liquid fuels

LCAs’ of Wood

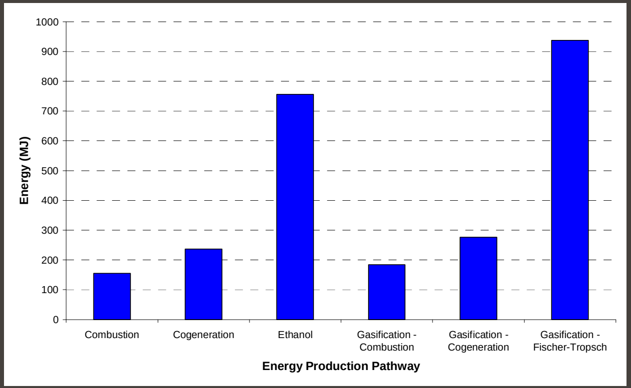
Pathway Name	Energy Efficiency	Cost vs Value/GJ in
Combustion	67%	$3.00 vs $3.75
CHP	46%	$3.90 vs $4.50
Enzymic Ethanol	41%	$6.90 vs $12.40
Gasification & Combustion	57%	$12.80 vs $2.50
Gasification - cogeneration	47%	$12.60 vs $6.70
Gasification + FT	52%	$11.10 vs $14.00
Pyrolysis + refining	56%	$5.80 vs $6.80

LCA wood to user energy

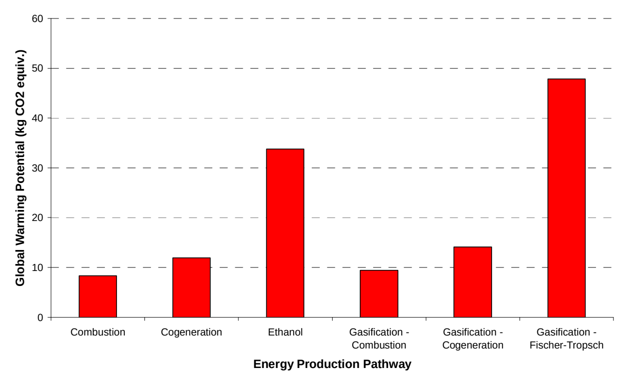
$



ENERGY

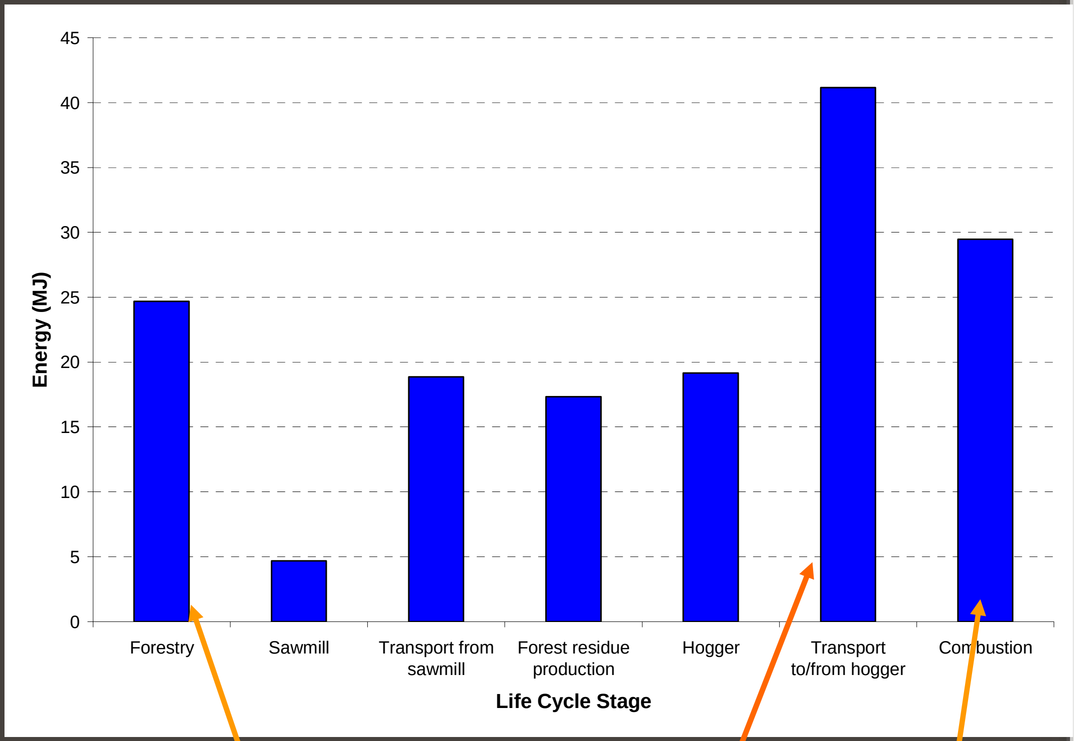


GWP



2000 2005 2030 2050

Embodied Energy



Resource

Transport

Combustion

Pathways evaluation

Wood feedstock	Efficiency	t/co2 GJ in	Cost per GJ out
Combustion	67	0.0027	$14.80
CHP	46	0.0027	$26.42
Ethanol	41	0.0035	$45.19
Gas + FT	52	0.0027	$30.25*
Pyrolysis +Ref	26	0.0027	$35.94*
Waste Veg Oil	84	0.0062	$29.40
Canola Biodiesel	69	0.0219	$37.00

*** Estimated from OS data, not proven**

Diesel is $46.0 per GJ
Coal heat $9.30 per GJ

Economics of liquid fuels from Biomass

Price of Oil US$ Barrel where liquid fuels from biomass is viable

		Foreign Exchange Rate NZ to US dollars		
Carbon Price	Resource Origin	0.8	0.7	0.6
C $20 tCO2 eq	Residual	$145	$127	$109
C $20 tCO2 eq	Purpose grown	$211	$185	$158
C $30 tCO2 eq	Residual	$143	$125	$107
C $30 tCO2 eq	Purpose grown	$208	$183	$157

Oil Price June 2008 = US$120 - $139

Oil - Up or down?

Conclusions

Key Points:

- We “can do” electricity and heat, the problem is liquid fuels.
- Many, many options and opportunities – including many new emerging technologies.
- Need robust comparisons of options (including efficiencies of conversion).
- Residues will only provide a few % (~ 5) of liquid fuels demand, plus difficult at small scale.
- à Must look at a large-sized energy crop to make a significant difference.
- à Purpose-Grown Forests appear most appropriate energy crop option for New Zealand.

For bioenergy research to be warranted:

- Must be an opportunity for scale
- Must be practical, a reasonable expectation that it will be viable.

Research Strategy – in progress

Key Points:

- Use Residues first
- Anaerobic digestion = environmental benefits, near economic, need an assessment of opportunities / sites
- Straws to heat/CHP – niche opportunities

Reinforced the PGEF concept (scale) – need a detailed implementation plan, including species, regimes, productivity, land use, land area, productivity, Carbon, water, erosion, etc. Multiple product forest – now and future

Wood – supply chain, harvesting, transport, comminution and logistics. Also applicable to other biomass resources

Ligno-cellulosic to biofuels conversion (some NZ but also O/S partnerships & adoption. (Enzymes, Gasification + FT, Pyrolysis and refine). No clear winner at this stage

Economic impacts of large scale biomass / bioenergy / forestry

Research Strategy, continued

2000 2005 2030 2050

Algae – needs thorough independent review of potential, costs, energy balance, LCA

Keep up with new developments (NZ + O/Seas)

- super critical water
- enzymes to diesel
- biobutanol
- CO to ethanol
- ?? others

Algae

If all NZ municipal effluents + dairy farm + pig/poultry farm effluents went into HRAP ponds (9,150 ha of ponds)

= 230 million litres pa of biodiesel (current production)

= 460 million litres pa (if yields double)

If we want to make all our Liquid Fuel needs from algae

= 306,000 ha of ponds (current algal yield)

= 153,000 ha of ponds (if yields double)

We need to know more about the process to do an LCA

Solution for liquid fuels?

Efficiency }
Conservation } Cap consumption growth (1 to 1.6 % pa)

Residues, effluents, wastes (~5%)

Canola (~5%)

Algae (~5%)

Electric Vehicles (~15-20%)

Other? (~2- 5%)

5.3 billion litres from forests? = 2.2 million ha

Energy Storage – is it important?

2000 2005 2030 2050

Fossil fuels are a mine-able energy store, we can take more or less at will.

How significant is this ability?

What will replace this?

Questions ?

Comments

Discussion

What is this ?

2000 2005 2030 2050

What is this ?

2000 2005 2030 2050

30 years of

Stored

solar energy

Canola crops

To meet NZ liquid fuel demand;
= 5,400,000 ha of canola

(we have 2.3 million ha of arable land).

Forests

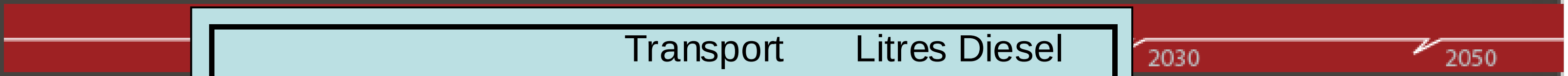
Need 3,750,000 ha to grow all current LF from forests

We have up to 5.1 million ha of steep hill country that is low to moderate productivity grazing.

Total liquid fuel, litres of diesel equivalent which could be generated, using the forest residues, export logs, 50% of industrial wood and PGEF at varying %'s

PGEF Hectares	% to energy	2010	2030	2050
1.0 million	25	1,316,140,000	3,791,620,000	3,172,260,000
	50	-	4,379,620,000	4,338,460,000
	100	-	5,555,620,000	5,514,460,000
2.0 million	25	-	-	4,338,460,000
	50	-	-	5,514,460,000
	100	-	-	7,856,660,000
3.0 million	25	-	-	4,926,460,000
	50	-	-	6,680,660,000
	100	-	-	10,198,860,000

Our Transport Fuels Future …



	Transport PJ/year	Litres Diesel Equiv (millions)
Total	**300**	6,667
Conservation	80	1,778
Residues and wastes	15	333
Oil Rapeseed	10	222
Algae	10	222
EVs at 30%	80	1,778
Remainder	**105**	2,333

Options:	PJ/y	$millions	Energy Security	GHG	Feedstock security	Level of Service	Acceptibility
Imports	105	2,333	x	x	x	√	x
Coal to liquids	105	2,480	√/x	x	√/x	√	x
PGF Ezymic ethanol	105	5,936	√	√	√	√	√/x
PGF Pyrolysis	105	4,352	√	√	√	√	√/x
PGF FT	105	5,530	√	√	√	√	√/x
EVs (less convenient)		vehicle ?				x	√/x
	105	resource ?	√	√	√		√/x

à **How much are we willing to pay:**

- **For energy security?**
- **To reduce GHG?**
- **For level of service?**