Pathways for conversion to energy

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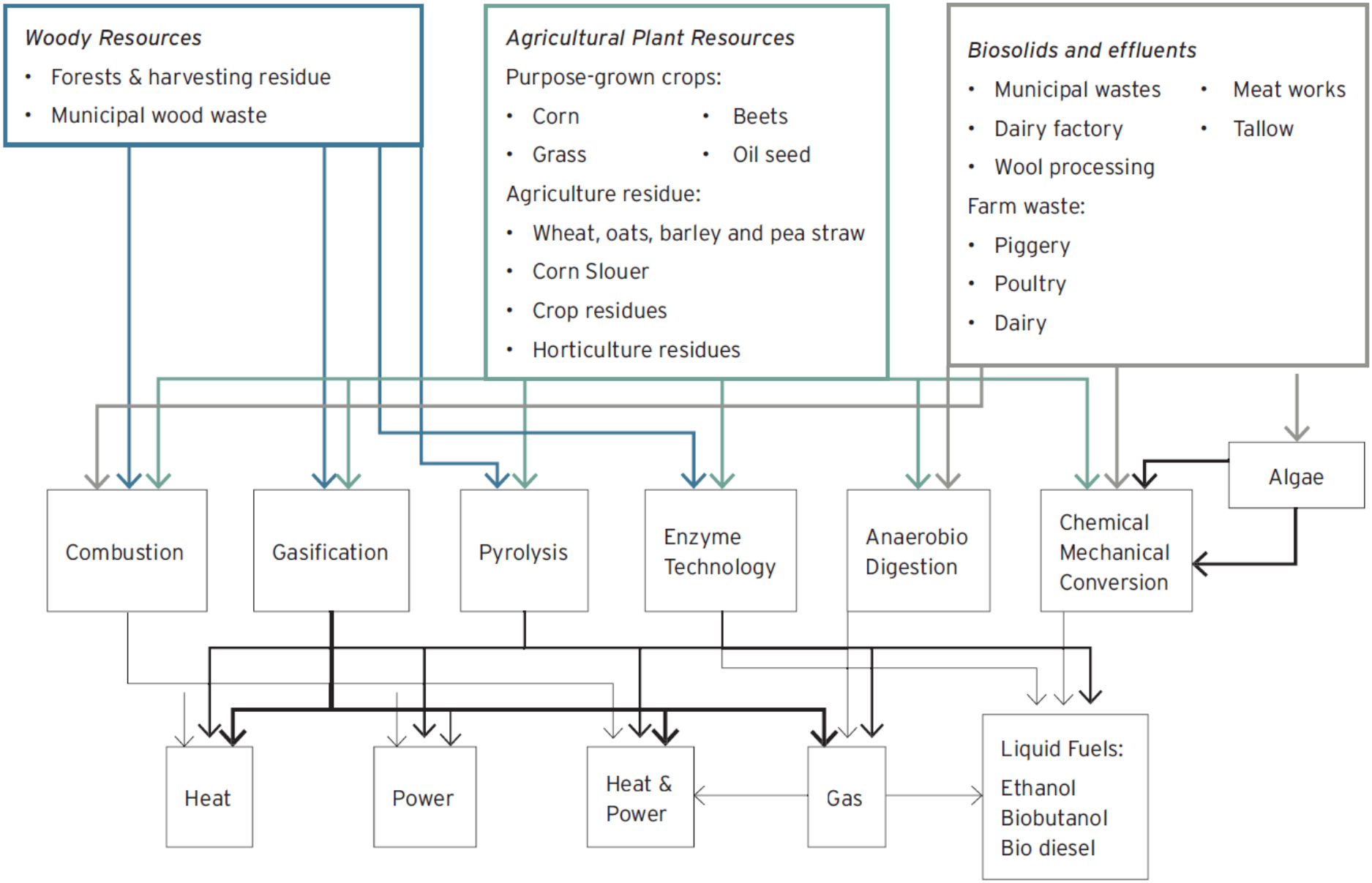
Biomass for heat, power and transport fuels



Pathways analysis

Criteria:

- Size of resource (regional vs. national)
- Environmental sustainability of pathway
- Economic viability
- Technological maturity

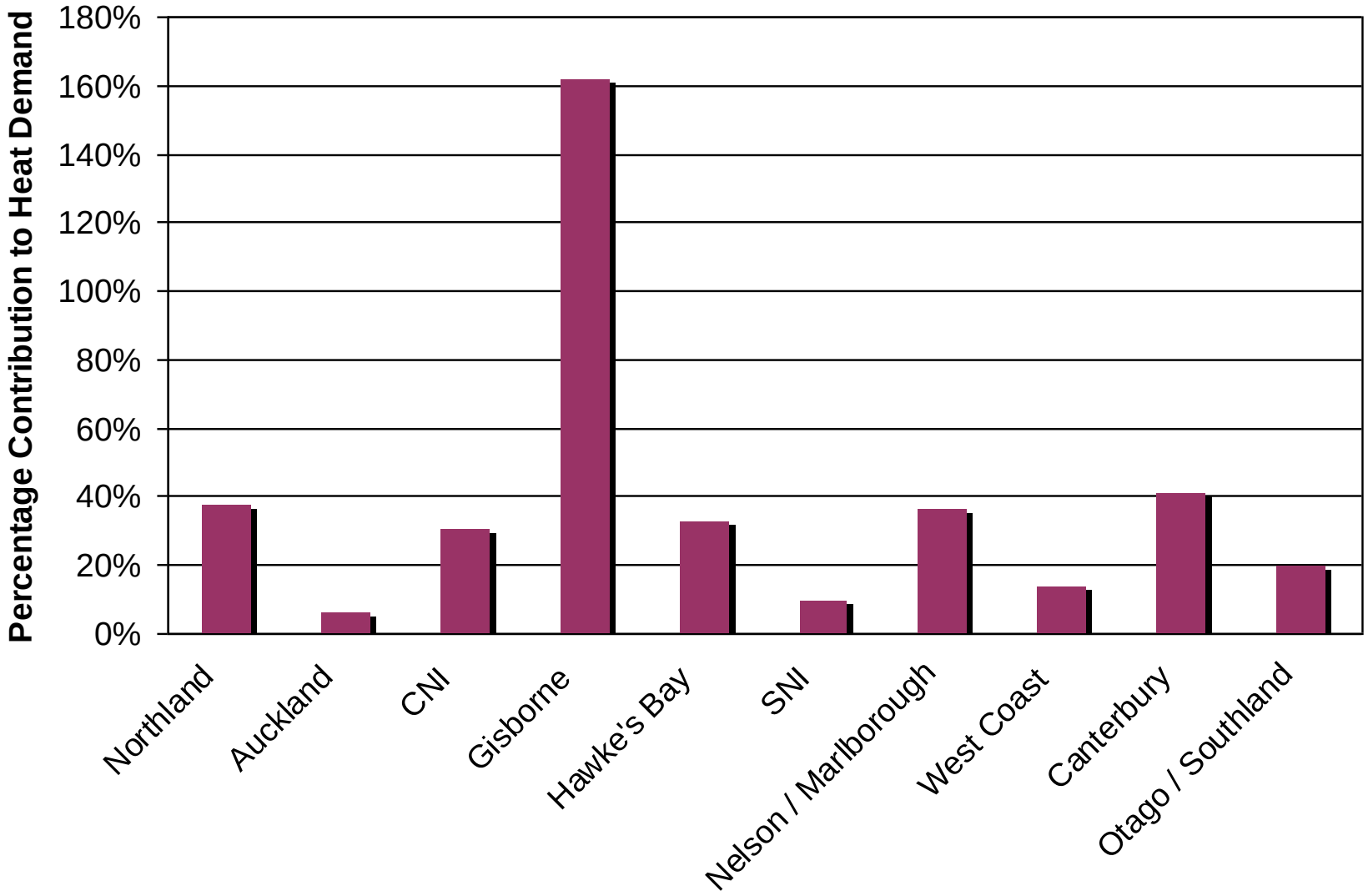
Pathway Analysis:

–1 summary report

–8 contributing reports

Landcare Research
Manaaki Whenua
SCION
Next generation biomaterials
Waste Solutions
Biotechnology Group
NIWA
Taihoro Nukurangi
CRL
CRL Energy Ltd

Residual resources and regional demand



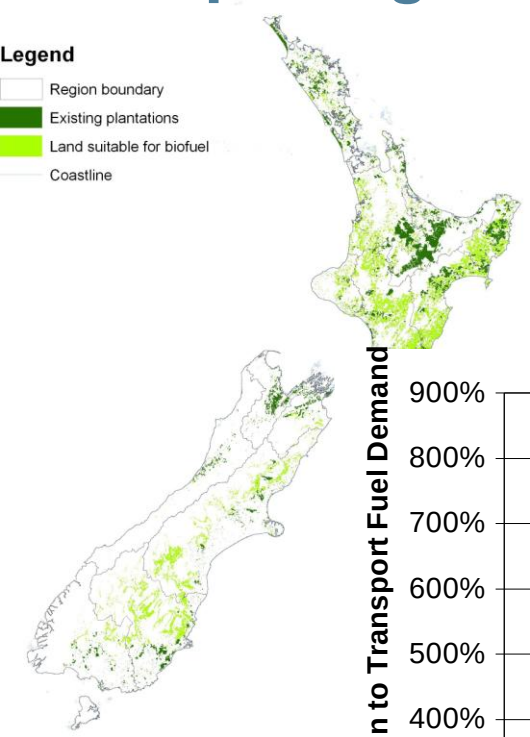
Includes all major biomass residuals: from forestry, agriculture, municipal, meat and dairy industry

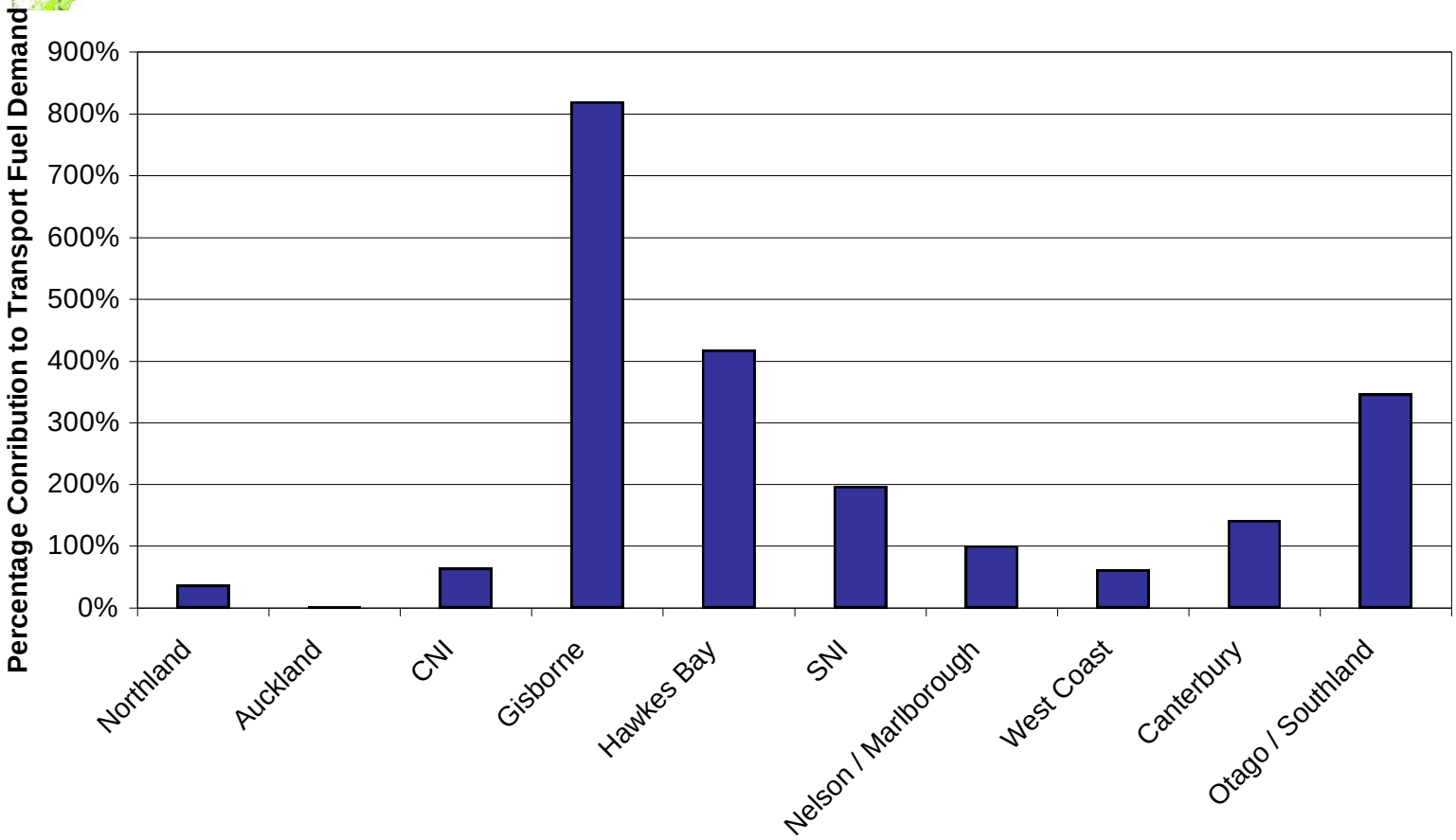
National energy demand

	Demand (consumer)	Fossil fuels	Biomass residuals (potential)
Liquid Fuels	245 PJ/y	100%	6%
Electricity	135 PJ/y	27%	12%
Heat	140 PJ/y	41%	30%

→ Purpose-grown biomass

Purpose grown forest and national demand





Life-cycle assessment of bioenergy pathways

- Life-cycle assessments of 16 pathways
- Identify environmental and economic “hotspots”
- Results sensitive to system boundary and allocation method

LCA – Woody residues to consumer energy

- Potentially 26 PJ p.a. of primary energy, rising to 46 PJ p.a. by 2030.

	Combustion Heat	Combustion CHP	Ethanol	Gasification Heat	Gasification CHP	Gasification Biodiesel
EROE I	**7.5:1**	**4.9:1**	**3.5:1**	**5.6:1**	**4.0:1**	**3.9:1**
GHG reductions*	**92%**	**94%**	**75%**	**90%**	**83%**	**83%**
Cost ($/GJ)	**$15.60**	**$27.60**	**$59.40**	**$31.20**	**$42.00**	**$34.50**
Technology status	**Mature**	**Mature**	**Developing**	**Developing**	**Developing**	**Developing**

* compared to heat from coal, electricity from the grid and fossil transport fuels

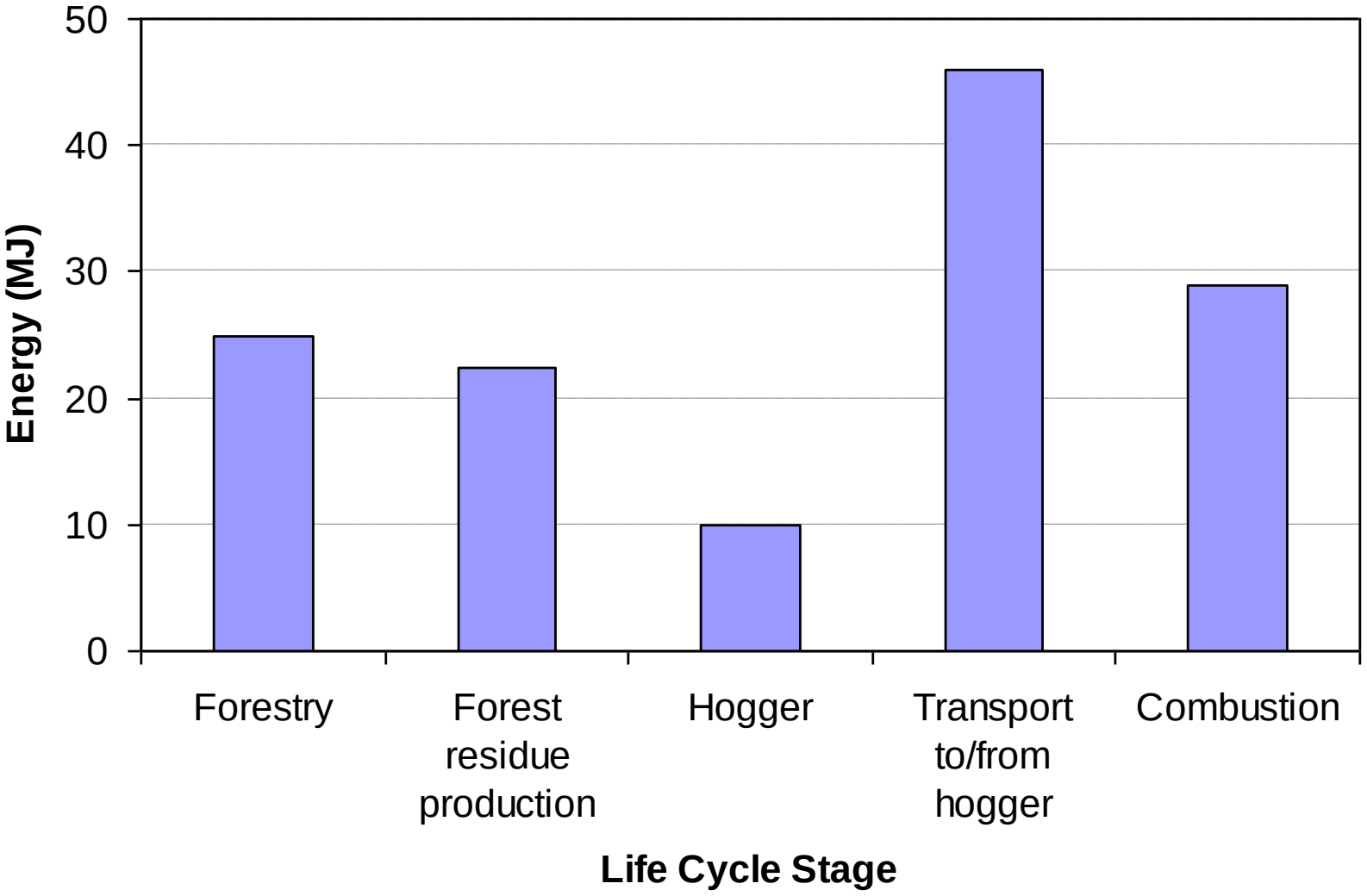
LCA - Purpose-grown forest to consumer energy

• Potential scale: up to 3.372 million ha of forest producing up to 600 PJ pa of primary energy.

	Combustion Heat	Combustion CHP	Ethanol	Gasification Heat	CHP	Gasification Biodiesel
EROEI	**10.9:1**	**6.9:1**	**4.5:1**	**7.7:1**	**5.5:1**	**5.4:1**
GHG reductions*	**95%**	**91%**	**80%**	**93%**	**89%**	**89%**
Cost ($/GJ)	**$34.50**	**$54.80**	**$86.60**	**$53.20**	**$72.60**	**$65.40**
Technology status	**Mature**	**Mature**	**Developing**	**Developing**	**Developing**	**Developing**

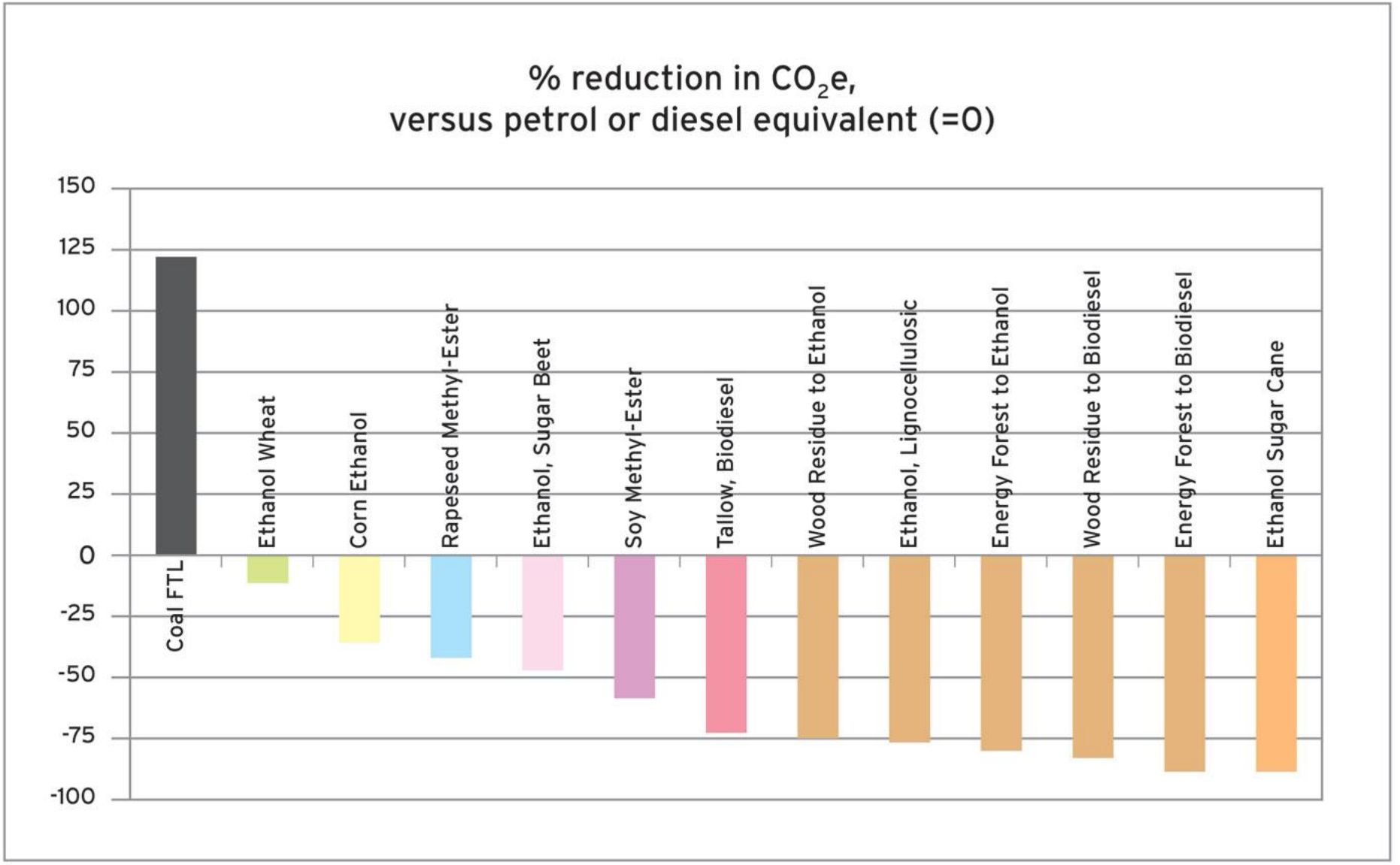
* compared to heat from coal, electricity from the grid and fossil transport fuels

Combustion of forest residue: Hotspots



Economics of liquid fuels from woody biomass

- Ethanol from purpose-grown forests competitive with petrol when ~$3/litre at the pump (US$165 to $210 a barrel depending on the exchange rate and carbon price).
- Given current trends likely to occur before 2020
- Carbon taxes: small effect
- Plenty of room for improvement in:
  - forest yield and harvesting and transport efficiency
  - conversion technology (intense international research)
  - cost reductions through co-products



References – Scion Bioenergy Options for New Zealand Pathways Analysis
– Larson, E. Princeton Environmental Institute, Princeton University, presented at Energy Week, World Bank, March 2006

Summary: Qualitative comparison of pathways

Energy Pathway	Potential Scale[1]	Environmental Sustainability[2]	Economic Viability[3]	Technological Maturity[4]
Forest residues to heat	✓ ✓	✓ ✓ ✓	✓ ✓	✓ ✓ ✓
Forest residues to ethanol	✓	✓ ✓	✓	✓ ✓
Purpose grown forest to ethanol	✓ ✓ ✓	✓ ✓	✗	✓ ✓
Pond algae on effluent to biodiesel	✓	✓	✗	✓
Purpose grown algae to biodiesel	✓ ✓ ✓	?	✗ ✗ ✗	✓
Straw to combined heat and power (CHP)	✓ ✓	✓ ✓ ✓	✗	✓ ✓ ✓
Canola crops to Biodiesel	✓ ✓	✓	✓	✓ ✓ ✓
Industrial effluent to CHP via anaerobic digestion	✓	✓ ✓ ✓ ✓	✓	✓ ✓ ✓

1. One tick: small scale, two ticks: regional scale, three ticks: national scale resource.
2. Based on greenhouse gas emissions and energy return on energy invested.
3. Ticks represent economically viable, crosses not viable at present.
4. One tick: proven at lab-scale, two ticks: demonstration, three ticks: commercial.

Questions ?