

Trees to engine fuel

(The lignocellulose to liquid energy conversion options)

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For Bioenergy Strategy for New Zealand

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- **Scene setting**
- **National scale bio-options**
- **Energy pathways**
- **What engines eat**
- **Basic chemistry**
- **2nd generation options**
- **Conclusions**

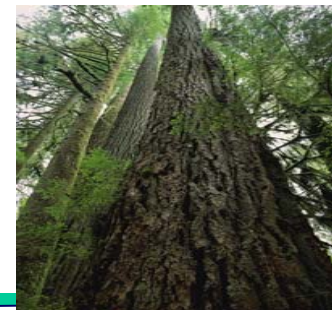
Scene setting

- **Global warming concerns**
 - currently a very strong driver. In 20 years time?
- **How long will we have cheap oil for?**
 - NZ economy at risk
 - Energy security
 - Climate change a deterrent
- **New Zealand has many indigenous, renewable options for electricity generation:**
 - should be OK.
- **New Zealand has many indigenous, including renewable, options for heat generation**
 - should be OK.
- **Difficult to provide the same for our transport sector ...**
 - difficult.

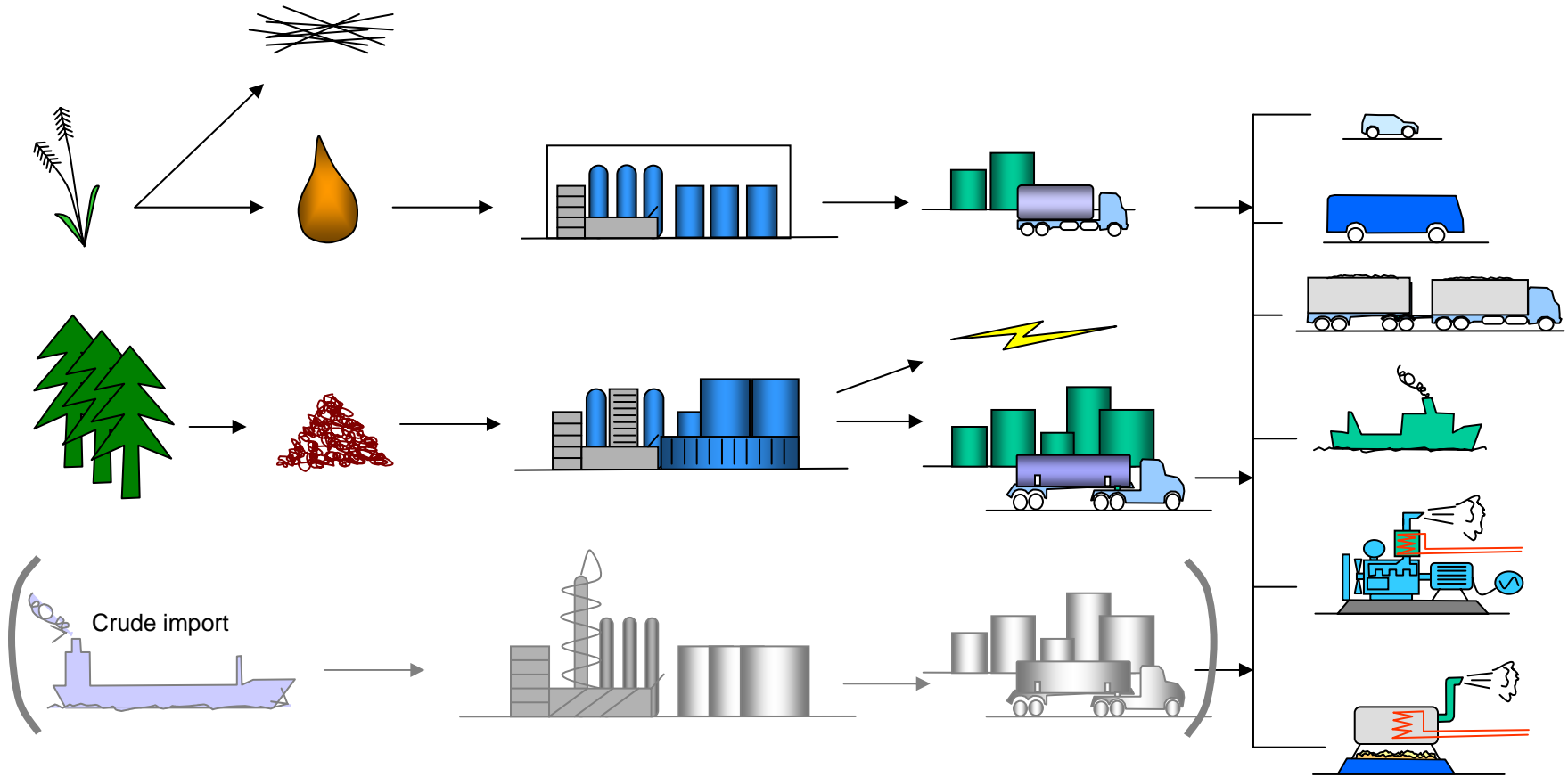
Not much energy from waste. What if we grow it?

Options:

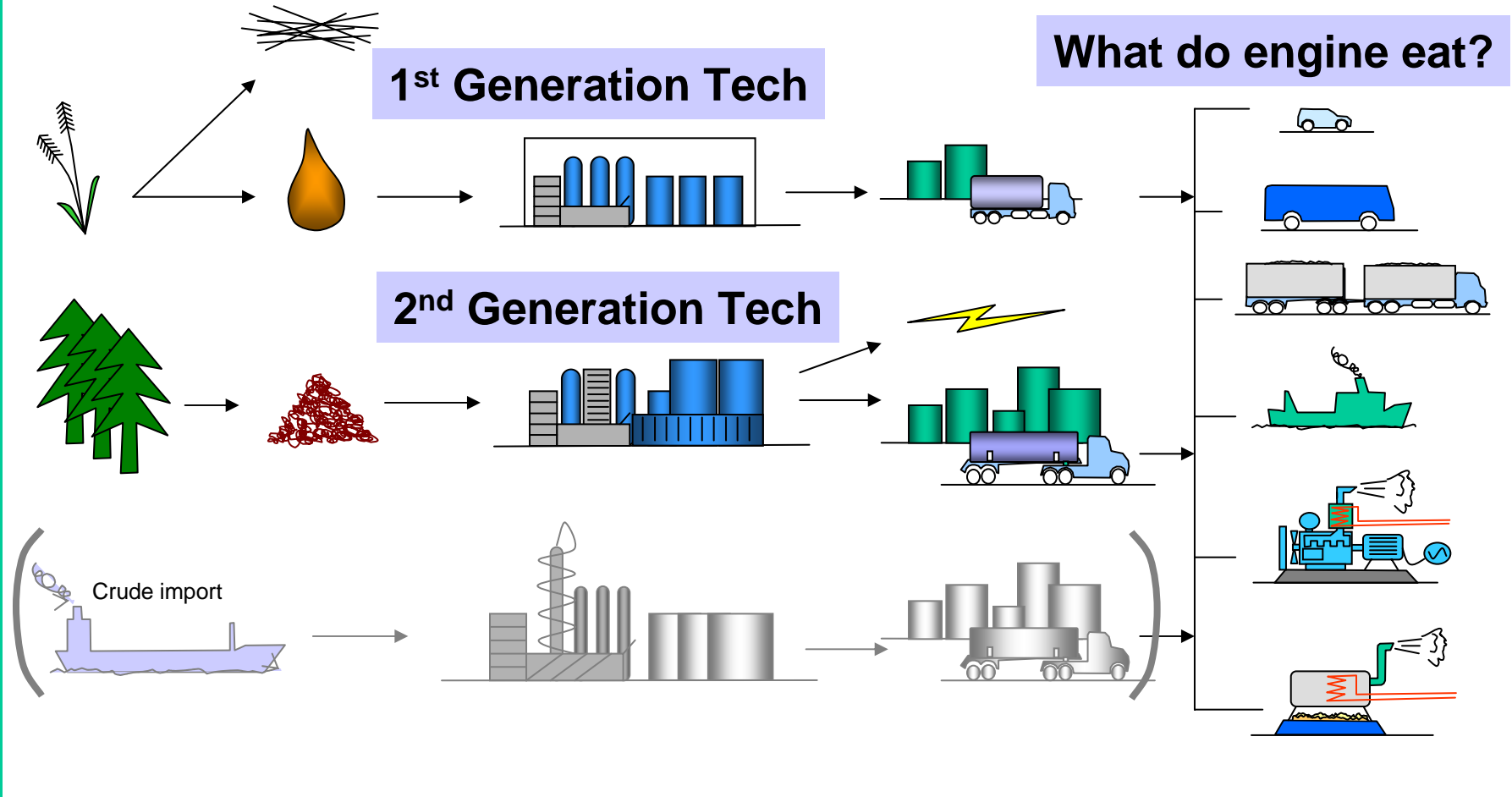
- Oilseed rape (canola)
 - Small % on national scale (as break crop).
- Perennial grasses
 - Potential fast track but appropriate land availability?
- Woody biomass
 - Purpose grown forest on appropriate marginal land
- ~~Sugar cane~~
- ~~Beets~~



Bio-Energy Pathway Options - Transport Fuel



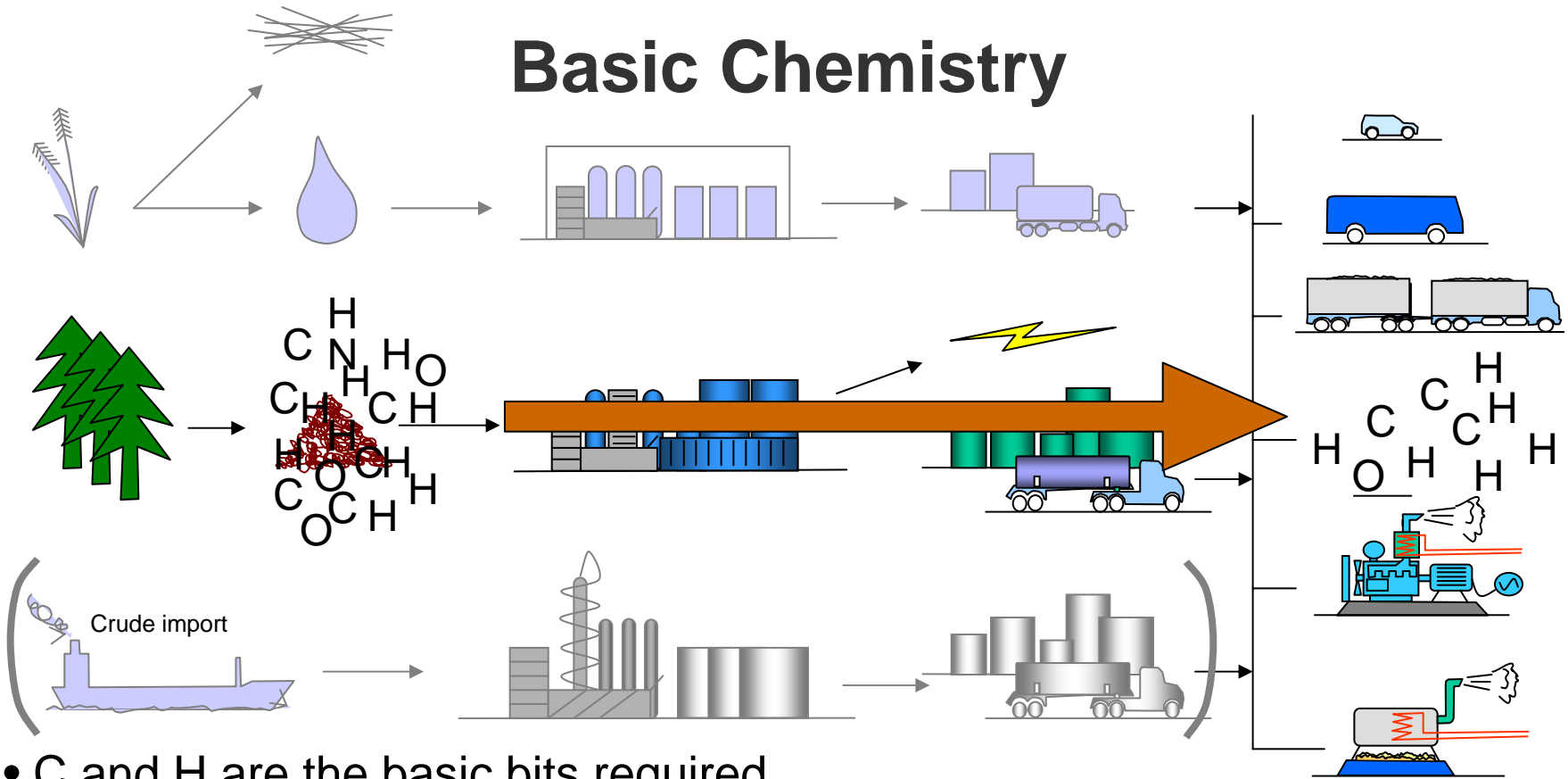
Bio-Energy Pathway Options - Transport Fuel



What do engines eat?

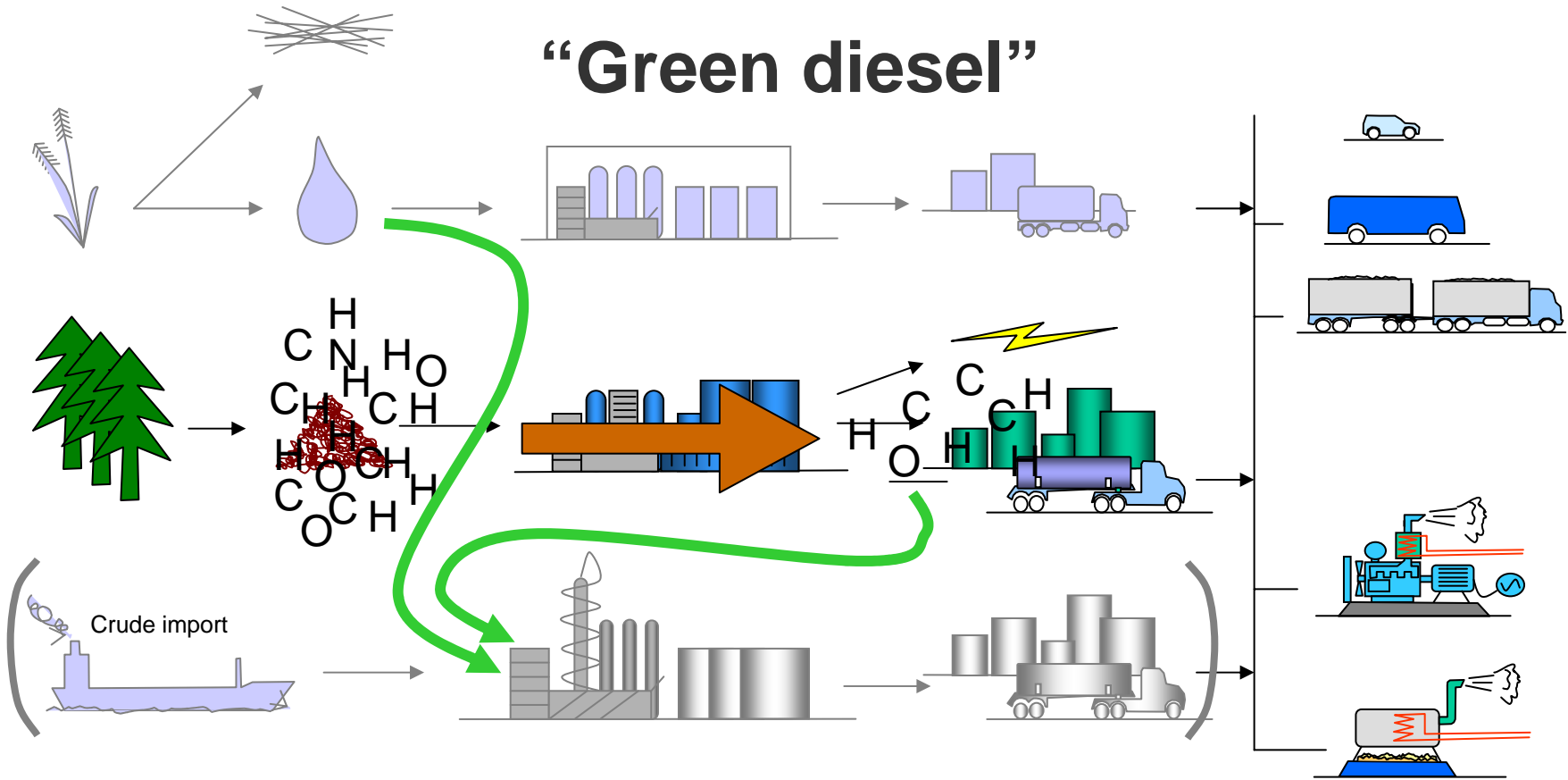
- Liquids for convenience
- Spark ignition engines:
 - Tend to be light engines
 - Fuels tend to have poor auto-ignition properties (simple gases, lighter-weight hydrocarbons, etc.)
 - History of petrol use. Current fleet does not support other alternatives in any scale unless they look like petrol to the engine manufacturer, or owner takes the risk.
 - Could take ~15-20 years to get a national-scale change → start now?
- Diesel ignition engines:
 - For the commercial sector, and now for light vehicles.
 - Fuels have good auto-ignition properties (heavier-weight hydrocarbons)
 - History of diesel use. Current fleet does not support other alternatives in any scale unless they look like diesel to the engine manufacturer, or owner takes the risk.
 - Could take ~15-20 years to get a national-scale change → start now?
- HCCI and others ... far from mainstream

Basic Chemistry



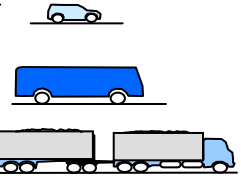
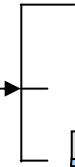
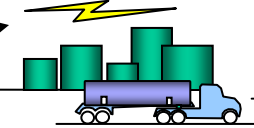
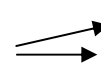
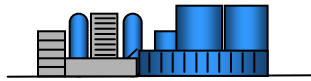
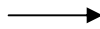
- C and H are the basic bits required.
- Many combinations provide the basic handling, storage and engine-use properties required.
- Few combinations meet exactly what the engine manufacturers currently want ... (not true “drop-in” solutions, if considering warranty also).

“Green diesel”



- Makes “looks like, smells like, must be diesel”.
- Additional process steps = \$\$\$
- In general, additional process steps including any added finishing costs \$

Energy Pathway Performance



→ more complex “2nd generation” processes.

3 main options, still in development:

- **Enzymic hydrolysis**

- Ethanol

- Butanol

- Diesel-like HCs

Large scale and expensive → OS collaboration

- **Gasification + Fischer Troupe**

- Syngas → liquids (like diesel and petrol to OEMs)

- Electricity

V. large scale and expensive – OS collaboration.

- **Pyrolysis** (stronger than “torrefaction”, more mild than “carbonisation”)

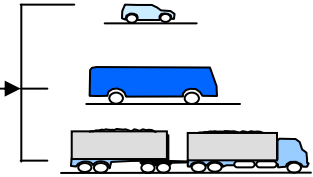
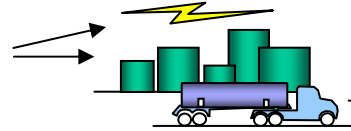
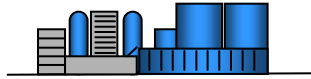
- Bio-oil → hydrotreating/refine into useful liquids.

- Biochar

Can be small scale, and at the forest

(increasing energy density of feedstock).

Energy Pathway Performance



→ more complex “2nd generation” processes.

3 main options, still in development:

- **Enzymic hydrolysis**

- Ethanol
- Butanol
- Diesel-like HCs
- Large scale and expensive

$\mu_e \sim 40\%$
 Competing with fossil at ~\$50-65/bbl
 Tech maturing ~ 2030
 Requires specific NZ research
 Requires fleet change

- **Gasification + Fischer Tropsch**

- Syngas → liquids (diesel)
- Electricity
- V. large scale and expensive

$\mu_e \sim 50\%$
 Competing with fossil at ~\$70-80/bbl
 Tech maturing ~ now to 2020
 Current fleet OK

- **Pyrolysis** (stronger than “torrefaction”, more fluid than carbonisation)

- Bio-oil → hydrotreated
- Biochar
- Can be small scale, and less expensive

$\mu_e \sim 55\%$
 Competing with fossil at ~\$70-75/bbl
 Tech maturing ~ 2020
 Requires fleet change

(increasing energy cost)

Conclusions

- **Still a place for waste and oilseed rape to liquid fuels, but national scale will require 2nd generation solutions.**
- **Expected options are enzymic hydrolysis, gasification and FT, pyrolysis and hydrotreating:**
 - All in development stage
 - Currently no clear winner
- **May need fleet change. We are dependent on overseas for this, and time (~15 years).**
- **Require collaboration with overseas groups to develop 2nd generation methods.**