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ALTERNATIVE FUELS FOR AVIATION

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Context - The 'Three Hard Truths'

- **Surge in energy use**

Energy use will increase due to increasing population and prosperity. This will mean greater demand for oil and gas, as well as other energy sources

- **Supply will struggle to keep pace**

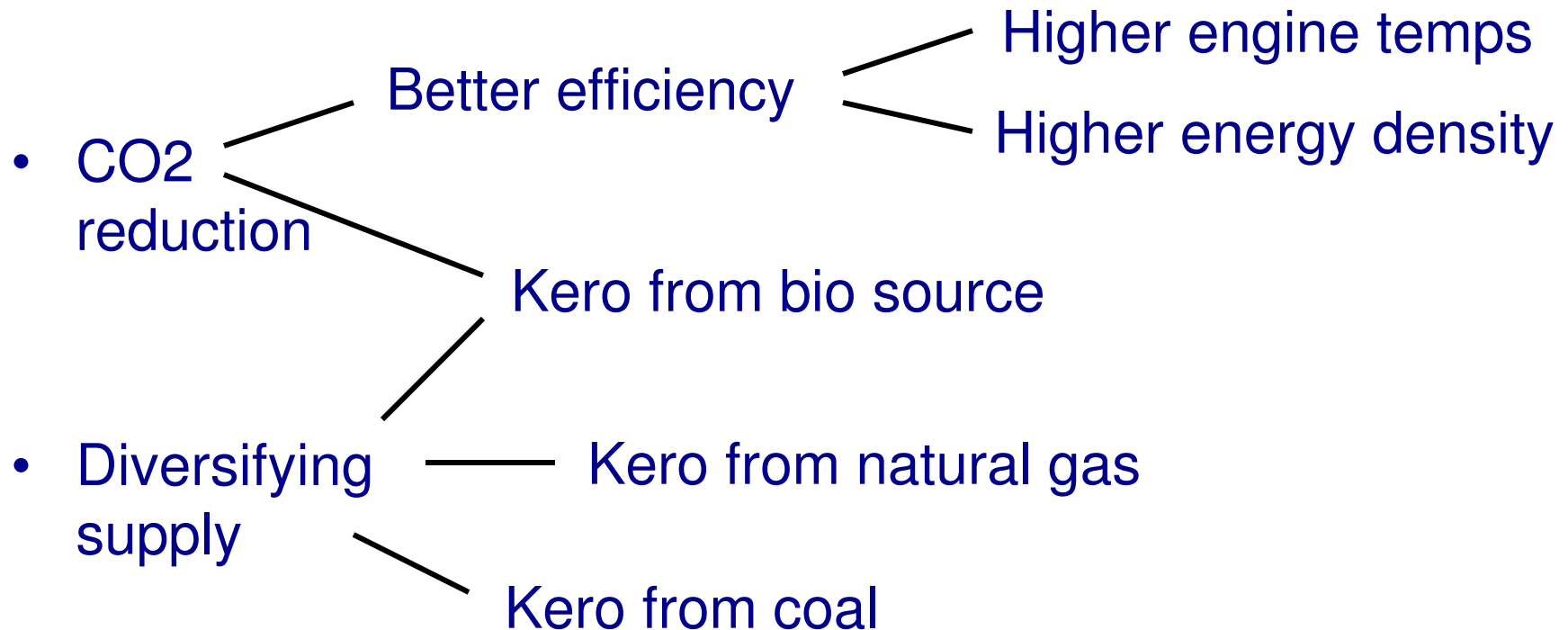
Conventional oil and gas, and indeed all energy sources together, cannot meet this unconstrained demand

- **Environmental stresses are increasing**

More energy means more CO₂ emitted at a time when climate change looms as a critical global issue.

By 2050, we need double the energy & half the CO₂

Going forward, aviation needs to produce less CO₂ and have access to more kerosene molecules



In Aviation fuel solutions are limited – not much scope for special fuels

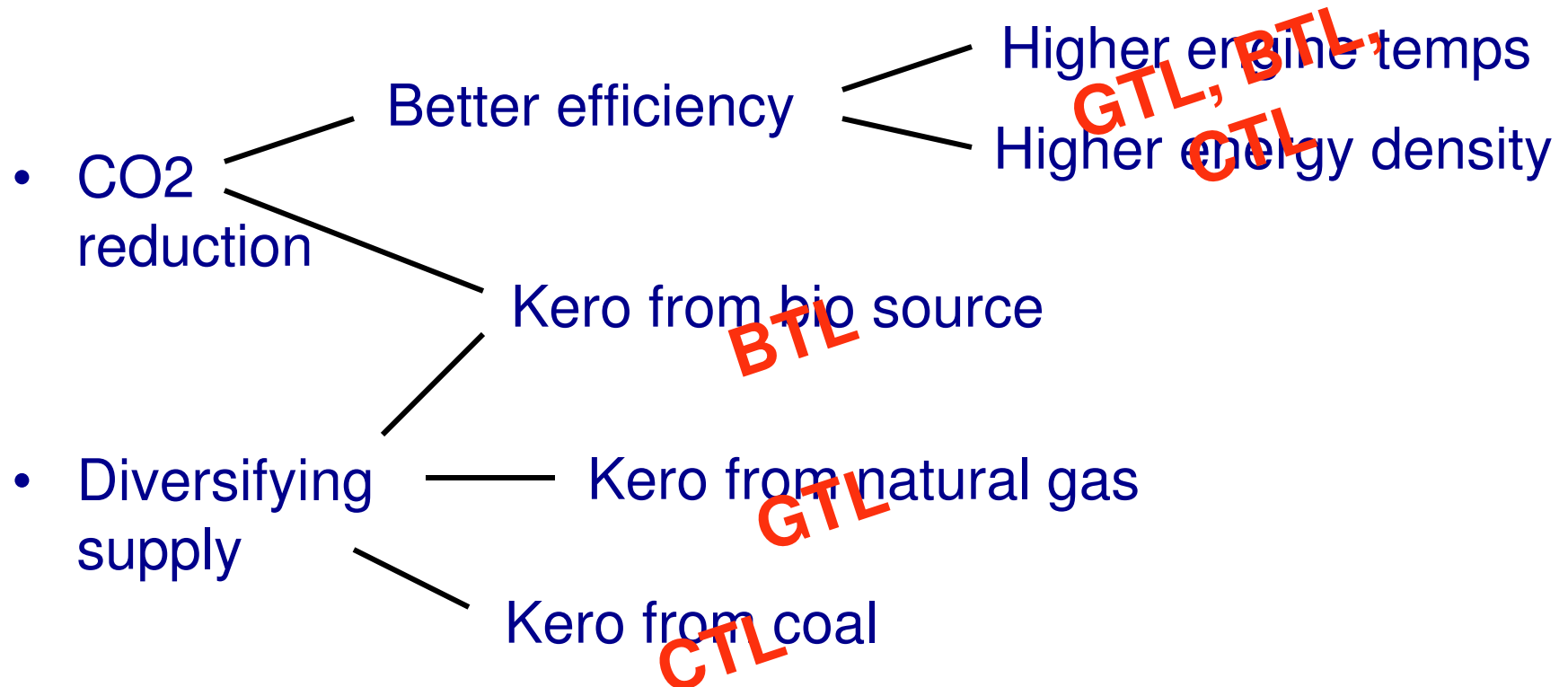
- Long lifetime and high capital cost of aircraft – kerosine is preferred jet fuel for next 30 years
- Focus on safety means lead times for fuel or additive development are long (~10 years)
- Airlines don't like aircraft that need special fuel
- Little incentive for OEMs to develop aircraft/engines running on a special high performance or alternative fuel
- Local alternative fuel solutions common in ground transportation fuels only applicable to General Aviation
- Hydrogen would need completely new aircraft and infrastructure

Aviation is a very special global industry – but not much scope for special fuels

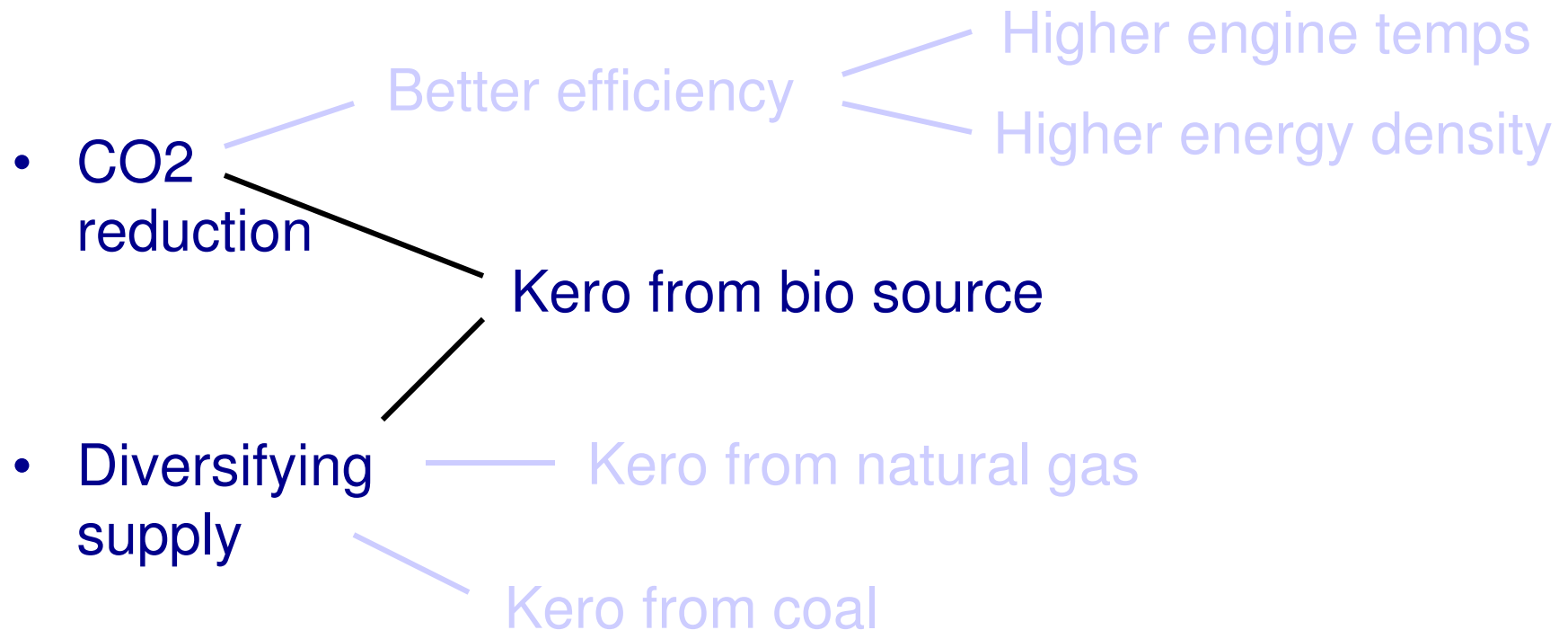
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**Any new or alternative aviation fuel
for the short to medium term
must be a drop-in replacement**

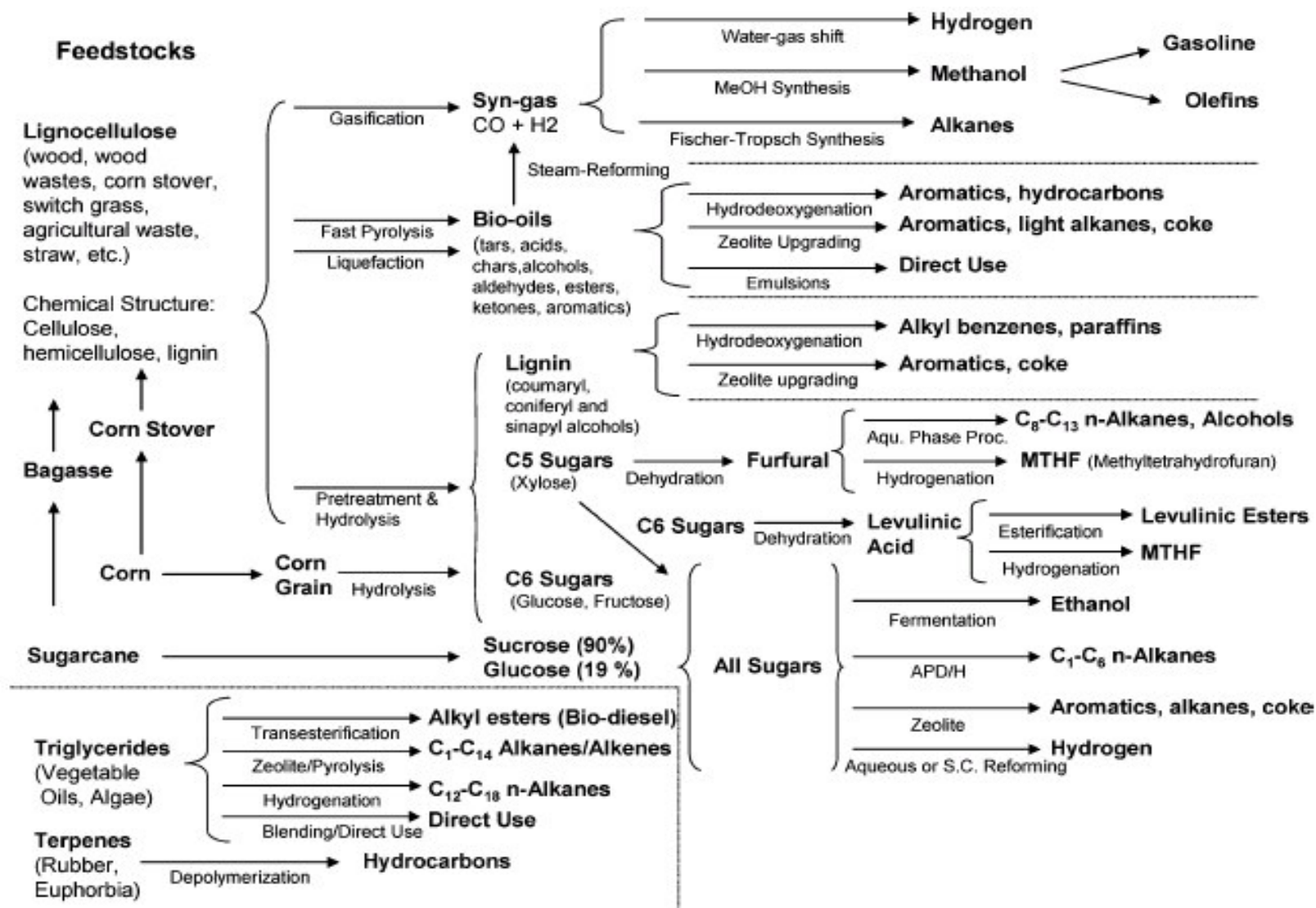
The Fischer-Tropsch process offers great opportunity for diversifying supply whilst producing a high performance kerosene



Producing jet fuel from renewable sources looks like a great solution, but is easier said than done...



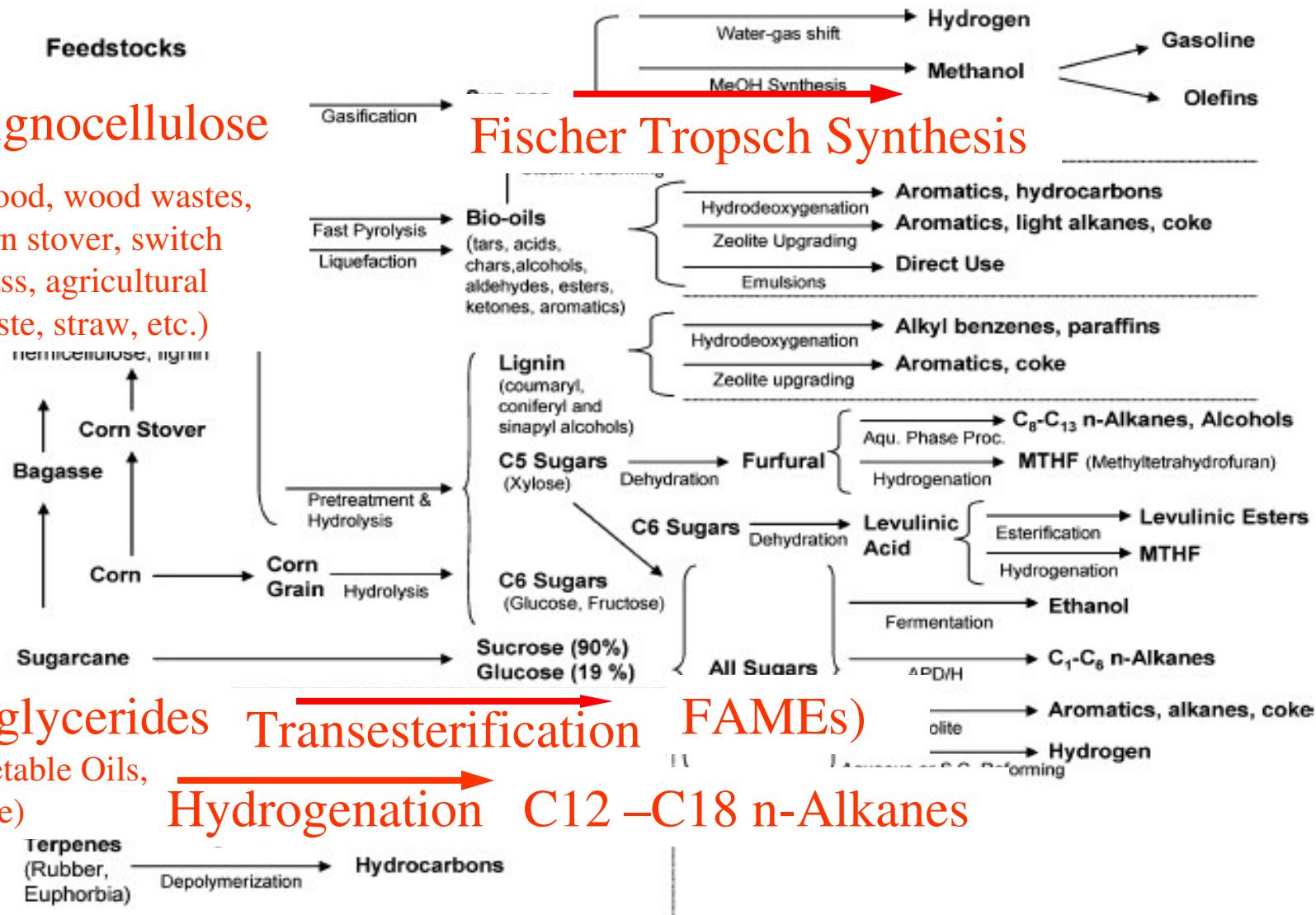
No shortage of options to produce biofuels ...



and there are a few front runners ...

Lignocellulose

(wood, wood wastes, corn stover, switch grass, agricultural waste, straw, etc.)



...but there is no silver bullet at the moment

	Feedstock	Process
FAME	Veg oils are expensive and bring land use & sustainability issues Algae could be long term solution	Cheap, low energy process but resultant product not suitable for aviation use. Not drop-in. OK for automotive use
BTL	Can use cheap waste material. Plus no obvious competition with food or land use issues	Produces great fuel, but currently looks very expensive route. Only in demo mode at present
HVO	Veg oils are expensive and bring land use & sustainability issues Algae could be long term solution	Relatively low energy, affordable technology, available now

Summary

- Very significant work conducted on alternative aviation fuels in last 3 years to meet challenges of reducing CO₂ and diversifying supply
 - Development, testing, approving and writing into fuel specifications has moved ahead quickly
 - Good cooperation between key stakeholders on demonstration and certification activities
- No clear winner in terms of feedstock and process
 - Spec will allow several routes provided big rules satisfied
- Economic case for producing, supplying or purchasing these new fuels not clear yet
- Will continue to need coordination and leadership eg ICAO, IATA, CAAFI