Transforming Pulp Mills to Biorefineries

Biomass to motor fuels over the black liquor route.

Status and requirements for demonstration

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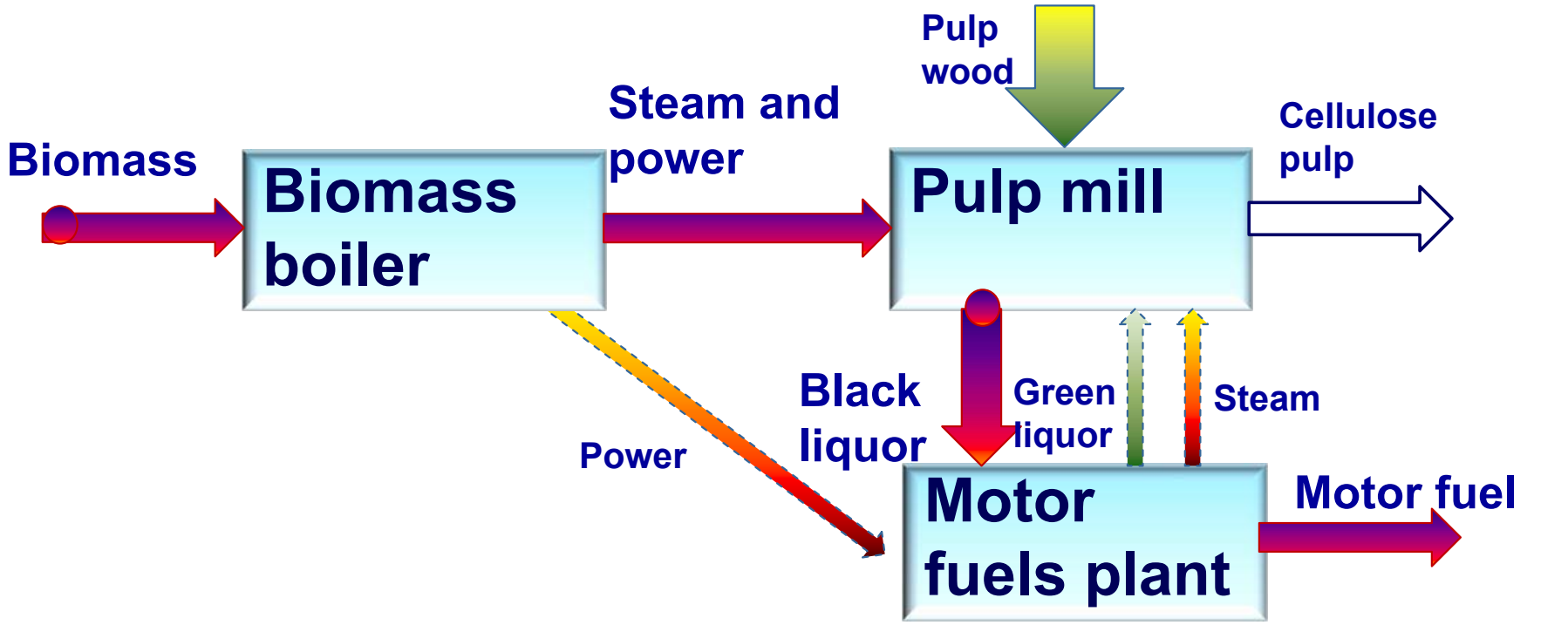
Pulp mill integrated process with biomass feedstock swap

- Existing plant-internal liquid biomass stream (black liquor) is used as motor fuels plant gasification feedstock
- Steam generation from biomass is used to make up energy content of produced biofuel



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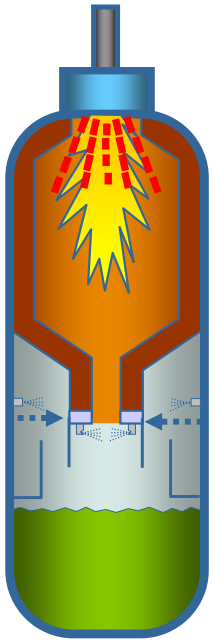
Black liquor is liquid biomass with properties uniquely suitable for gasification

- **It is a liquid**
  - *Easy to feed to a pressurized gasifier*
  - *Can be atomized to fine droplets for rapid gasification rates*

- **It is highly reactive due to high Na/K content**

⇨ **Gasification in an entrained flow high-temperature mode can then give**

  - *Full carbon conversion*
  - *No tar formation*
  - *Low methane formation*
  - *Small reactor volume (~25 m^3/1000 t BLS/d)*
  - *Simple gas clean-up*



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Feedstock swap gives full biomass feedstock flexibility

- **Any biomass that can be beneficially burned in conventional high-performance steam generating boilers can be used**
  - Forest logging residues (bark, tops, branches)
  - Saw mill, board mill and other wood waste
  - Agricultural residues (straw, corn stower, bagasse etc)
  - Mixed solid waste

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Typical value chain

Activity	Characteristics
Forestry	Well-established, low non-renewable resource use
Biomass extraction	By-product from extraction of saw logs and pulp wood
Feed stock preparation	Pulping to produce black liquor. Shredding /chipping of biomass for stream generation in conventional HP boiler
Gasification	High-temperature entrained-flow gasifier, very short retention time. Novel technology.
Raw gas post-treatment	Only condensing cooling/steam generation, ~5 ppm tar, low methane content
AGR and sulphur handling	Well-established technologies
Synthesis and product distillation	Well-established technologies (MeOH and DME)
Product	High flexibility - MeOH and DME preferred due to high conversion and vehicle efficiency, very good environmental performance, moderate investment cost.

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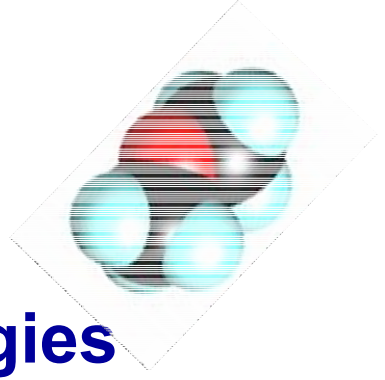
Critical technologies



- **Emphasis on using established technologies wherever possible:**
  - ASU, AGR, sulphur recovery, synthesis and product distillation
- **Scale-up of oxygen-blown, pressurized gasifier key challenge, in particular**
  - Burner nozzle (atomizing efficiency, flame shape, flow patterns)
  - Quench (flow patterns, mechanical design)
  - Gas cooler steam generator (mechanical design)
- **Special challenge from pulp mill integrated design:**
  - Even higher demand for availability

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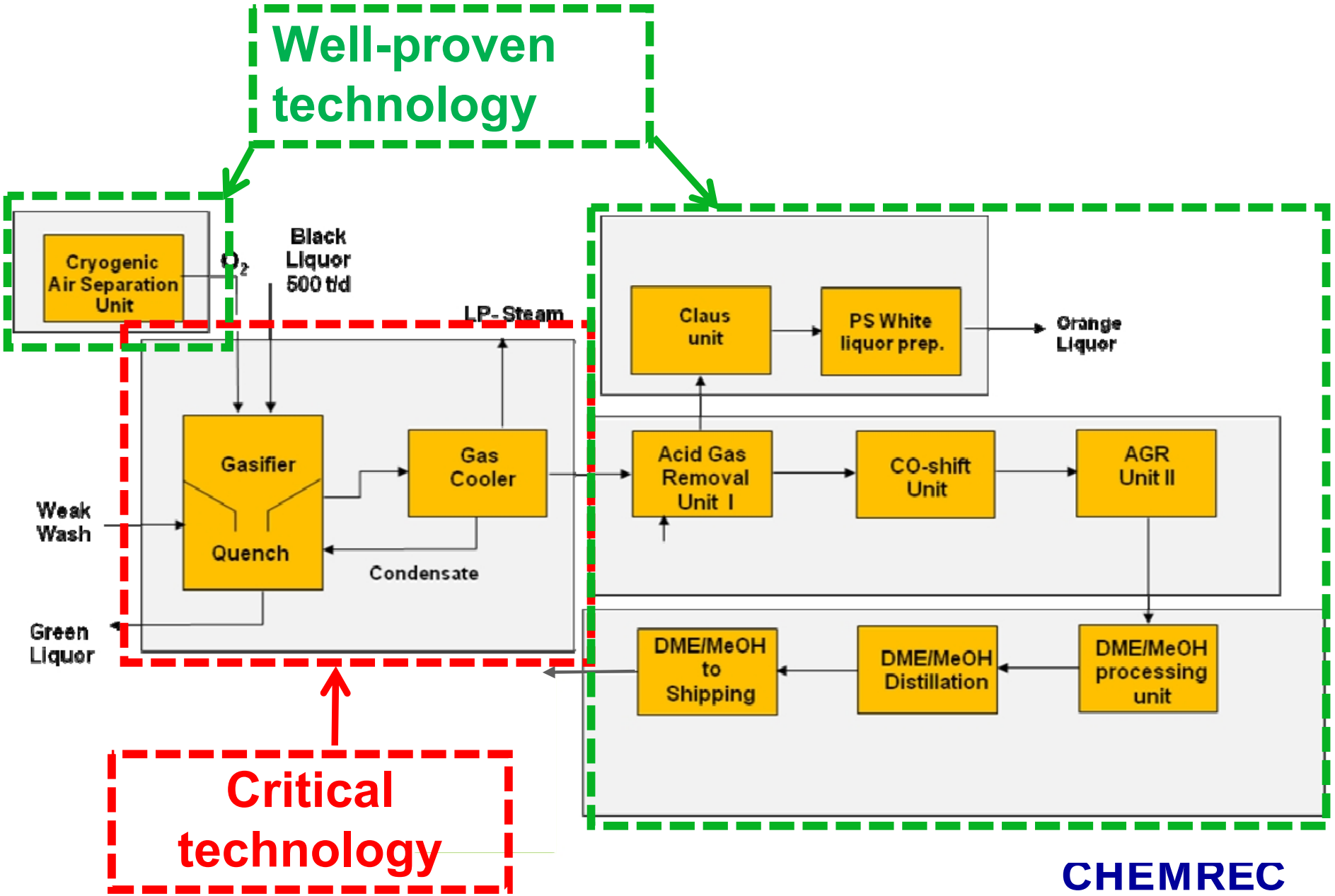
The motor fuels plant – MeOH/DME case



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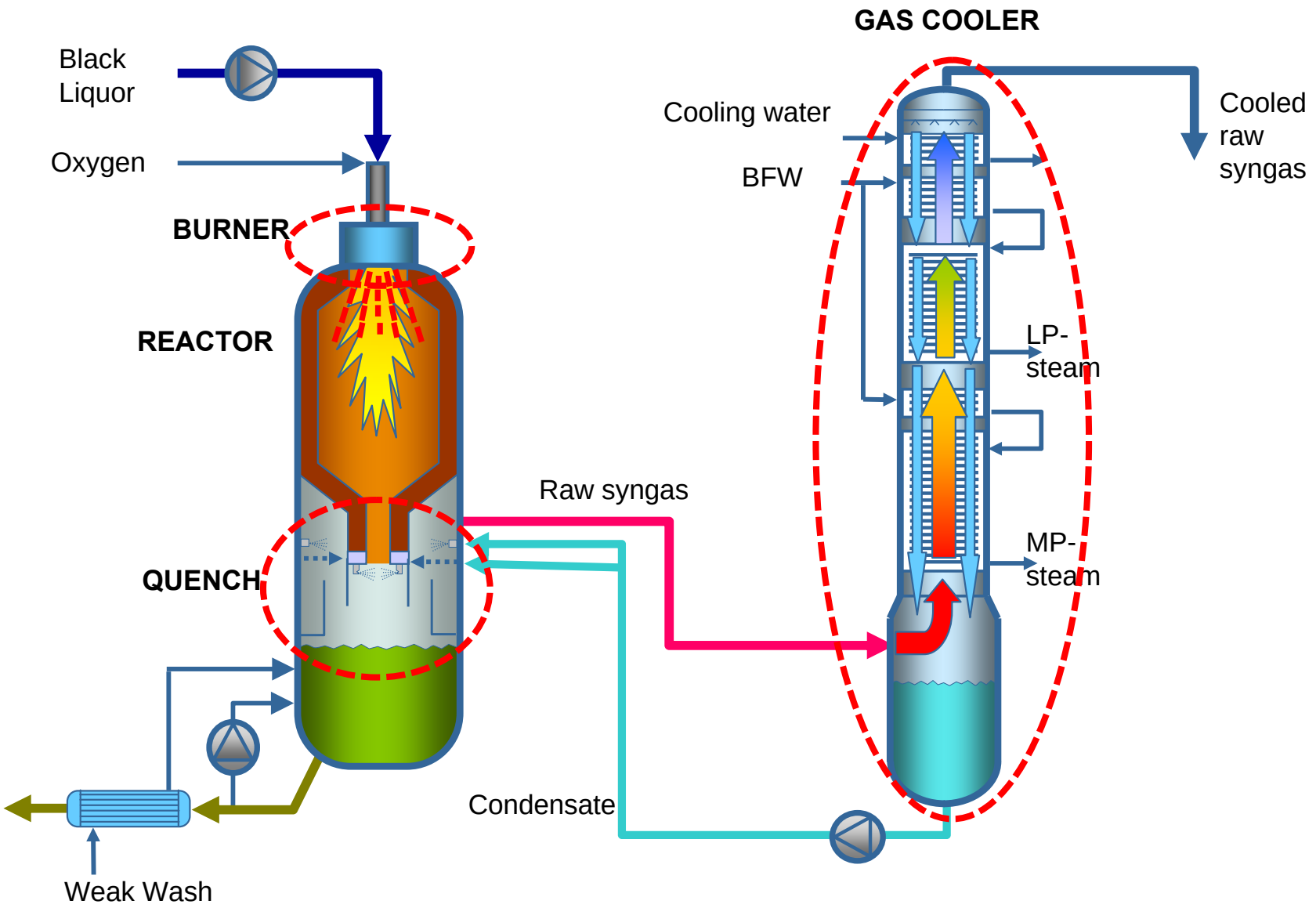
The Gasifier - Core technology risk areas



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Critical performance / cost areas

- Low risk in technology except for scale-up related risks for gasifier and gas cooler
- Low risk in investment cost estimates; high percentage of cost from established technologies
- Low risk in conversion / consumption related costs; high confidence in conversion efficiency
- Higher risk in project execution; can be mitigated by extensive pre-engineering and selection of contractors and contracting form. Can be in conflict with time-to-market goals.
- Start-up curve and final availability critical to overall project financial performance; first plants pose higher risk

First generation technology, > 55 000 h of full-scale operation

- Commercial atmospheric, air-blown gasifier to boost recovery capacity
- Capacity 300 t BLS/d, about 15% of total mill recovery capacity
- Installed in 1996, now operated more than 55 000 h
- Of great importance for development of refractory system and other components
- Has now reached 95% annual availability and 2 years refractory life

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Existing pilot plant

- Chemrec already runs the world's only plant for oxygen-blown, pressurized gasification of black liquor to raw syngas
- Capacity 20t solids/d, 3 MWth
- Oxygen-blown, 30 bar operating pressure
- In continuous 24/7 operation with 15 operators
- 8000+ hours of operation

Chemrec's plant and ETC's research facility


Ground floor of gasification plant

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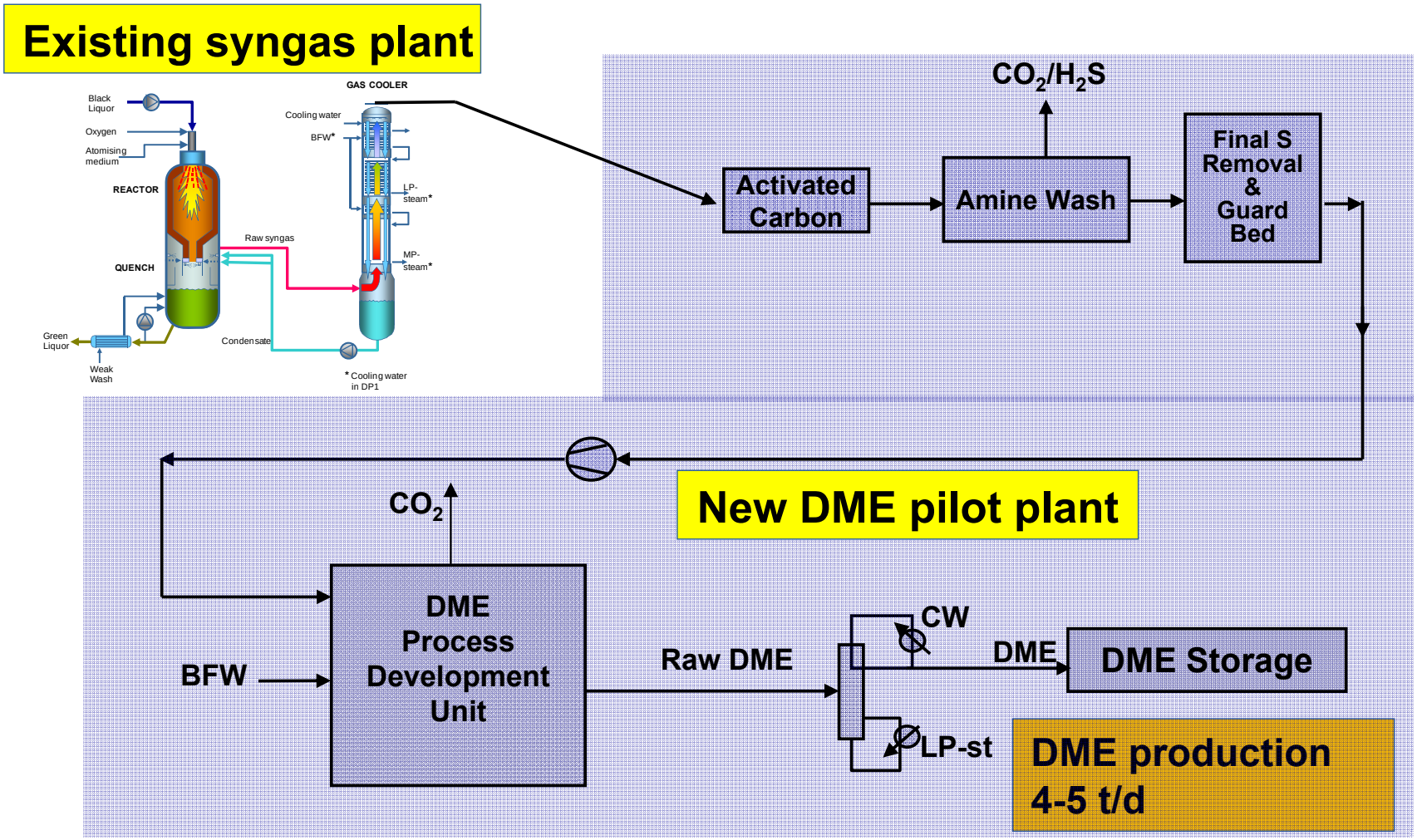
BioDME plant to be operational H1 2010



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BioDME Consortium

VOLVO

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preem

TOTAL

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Demonstration plant next step

- **Goals of demonstration plant**
  - Show successful operation of near-commercial size plant including scaled-up oxygen-blown gasifier
  - Demonstrate successful integration within motor fuels plant
  - Demonstrate successful integration with pulp mill
- **Minimum plant size 500 t BLS/d or about 32 000 m3 gasoline equivalents/year**
- **Total investment cost €150 million of which 50% grant funding or equivalent required**
- **Pre-projects for two demonstration plants on-going**

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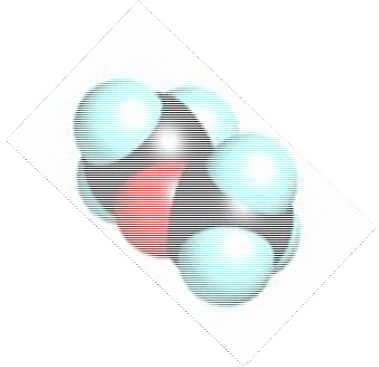
Demonstration plant partners needed



- Host pulp mill
- Motor fuels plant investors / operator
- Technology suppliers
- Product off-taker / Fuel distributor
- (Vehicle manufacturer)
- (Transportation buyers)

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Sustainability

DME via black liquor scores high on main criteria

- **Key environmental and economic sustainability issues for Chemrec black liquor gasification extensively evaluated within**
  - EUCAR / Concawe / JRC WtW project
  - Renew project
- **Very good scores for key variables including**
  - WtW and conversion efficiencies
  - GHG emission reduction
  - Land use efficiency
  - Product cost

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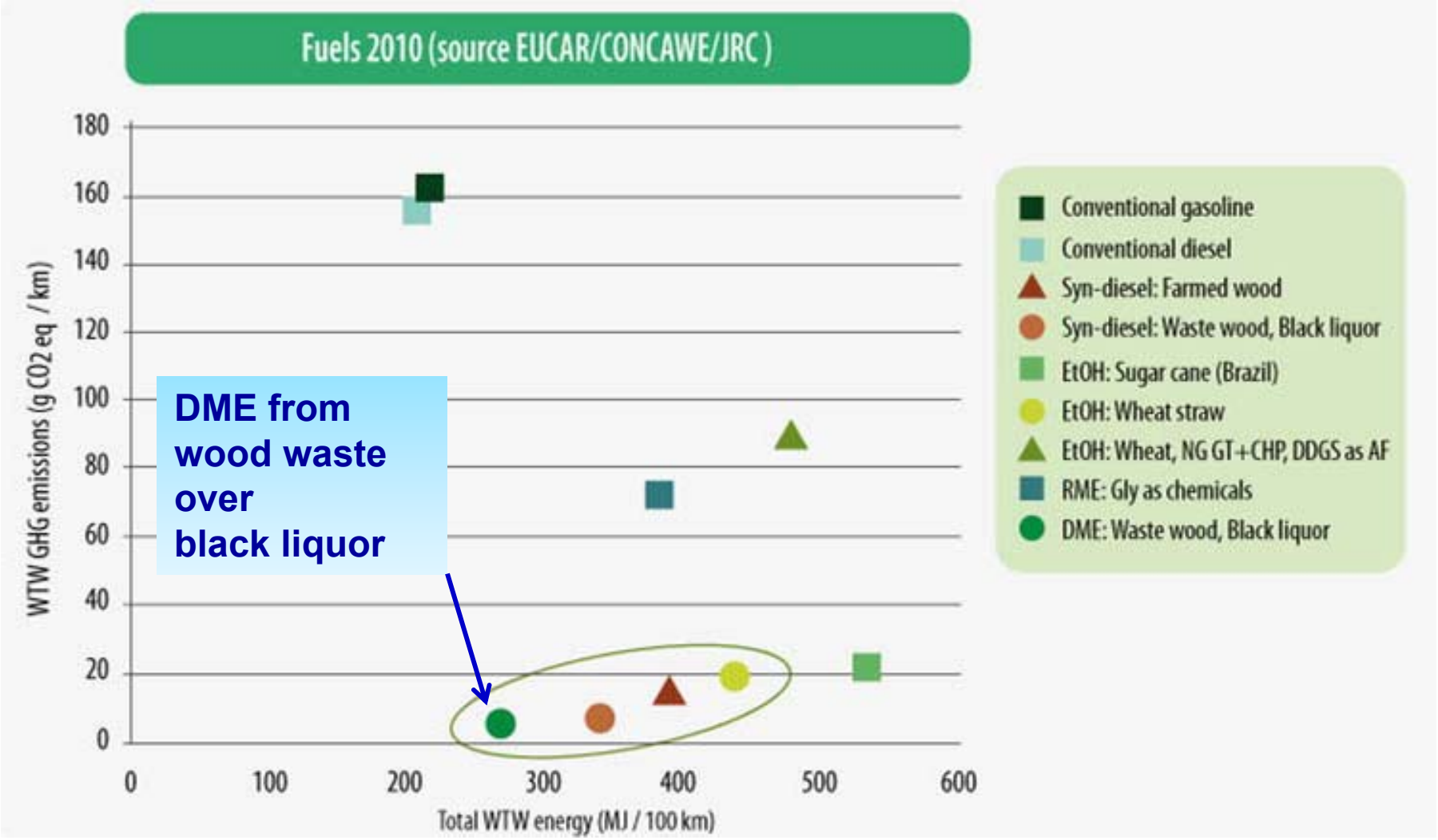
BioDME from Wood Waste over Black Liquor – Highest Efficiency, Lowest Emissions



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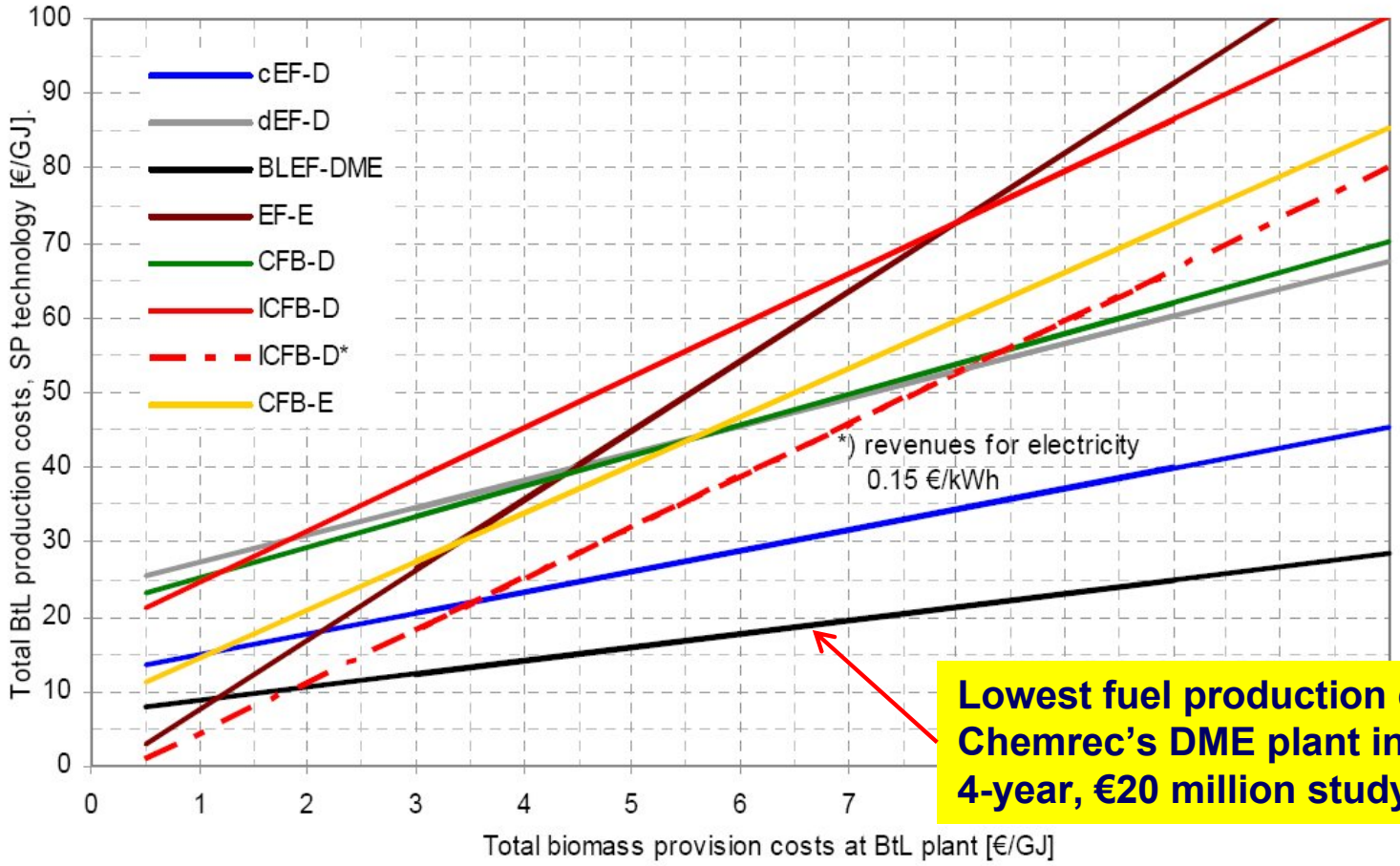
High efficiency, simple system and plant integration synergies gives low product cost



Lowest fuel production cost for Chemrec's DME plant in RENEW's 4-year, €20 million study

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Thank you !

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