CHEMREC BLGMF Technology

System Impact on the Mill and the Biomass Usage at the Mill Site

Presentation at

Workshop on Liquid Biofuels from Black Liquor Gasification

IEA Bioenergy ExCo Meeting

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Ingvar Landälv
Ingvar.landalv@chemrec.se
Chemrec AB
www.chemrec.se

Contents

From VOLVO: “Fuels for the Future”
Vehicle fuels for the future – how do we evaluate the alternatives ?

- **Sustainable availability**
- **Well-to-wheel energy efficiency and CO2 emissions**
- **Well-to-wheel regulated and unregulated emissions**
- **Economy & infrastructure**
- **Other considerations**
  - energy density
  - safety and health (fuel handling)
  - specific issues/concerns related to the different driveline applications (trucks, buses, marine, stationary)
  - political environment
  - customer perceptions

Electric Power or Synfuels from Biomass and Black Liquor

PROCESS ISSUES	BIOMASS TO:		BLACK LIQUOR TO:	
	POWER	SYNGAS	POWER	SYNGAS
- Technology selection	Air-blown	Oxygen -blown	Oxygen-blown	Oxygen -blown
- Feeding of biomass with lock-hopper systems against high pressure		yes, pressurised	No (+)	No (+)
- Need of lock-hopper gas	N_2 or CO_2 not easy available	Must be CO_2 (-)	Not required	Not required
- O_2 plant required	No (+)	Yes	Yes	Yes
- CH_4 handling	No issue (+)	Needs conversion to syngas through reforming. (-)	No issue (+)	Only small amounts (+)
- Tar handling	No issue (+)	Removal is necessary. New developments. (-)	Handled by gas cooling and maybe additional equipment	Handled by gas cooling. (+)
- Alkali components	High-temperature filtration required. (-)	No issue if syngas is cooled.	No issue	No issue
- Sulphur components handling	No issue (+)	Removal is necessary New developments. (-)	Commercial processes available	Commercial processes available
- Sulphur emissions	No issue (+)	Sulphur emitted as SO_2 or captured as waste. (-)	Can be reduced to low numbers.	Zero-emission within process. (+)
- CO_2 handling	No issue (+)	CO_2 removal expensive but commercially available (-)	CO_2 removal to be minimised. Commercial processes available (+)	Commercial process available. Pure CO_2 produced. (+)
- Selective handling of H_2S/COS vs. CO_2	No issue (+)	Difficult/ New developments. (-)	Commercial processes available	Commercial processes available
- **Summary:**	**Can achieve high thermal and power production efficiencies**	**Achievable but requires a number of process development break throughs.**	**Achievable with almost 100% improved power efficiency compared to existing technology.**	**Commercial processes except for gasification step. Very similar to today´s production route from e.g. high sulphur coal or residual oil.**

Approximate energy conversion efficiencies (stand alone balances)

Fuel	Technology/Process	Key Product	Net energy efficiency of Key Product (%)
Black liq.	State of the art RB	Power	11-13
Black liq.	High efficiency RB	Power	15-16
Black liq. or Biomass	BLGCC (Chemrec type)	Power	21-23 (from BL) ~75 (from Biomass(*))
Black liq. or Biomass	BLGMF (Chemrec type)	MeOH/DME	56 (from BL) 65-90 (from Biomass(*))
Black liq.	BLGMF (Chemrec type)	FTD	~35 (from BL)
Biomass	Bio-IGCC	Power	Close to 50
Biomass	Pressurizes CFB base system	MeOH/DME	50-55
Biomass	Pressurizes CFB base system	FTD	~35

(*) Incremental added biomass

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3. Why use Black Liquor as vehicle for biomass derived liquid fuel generation?
   - Cost efficient
   - Attract industrial partners
   - Pulp mill synergies
   - New use of the P&P industry’s own forest resource
   - Good logistics
4. European activities in the field of liquid biofuels

Characteristics of the BLGMF Concept

- **Black liquor gasification makes a high quality synthesis gas ideal for further conversion into synthesised fuels or hydrogen.**

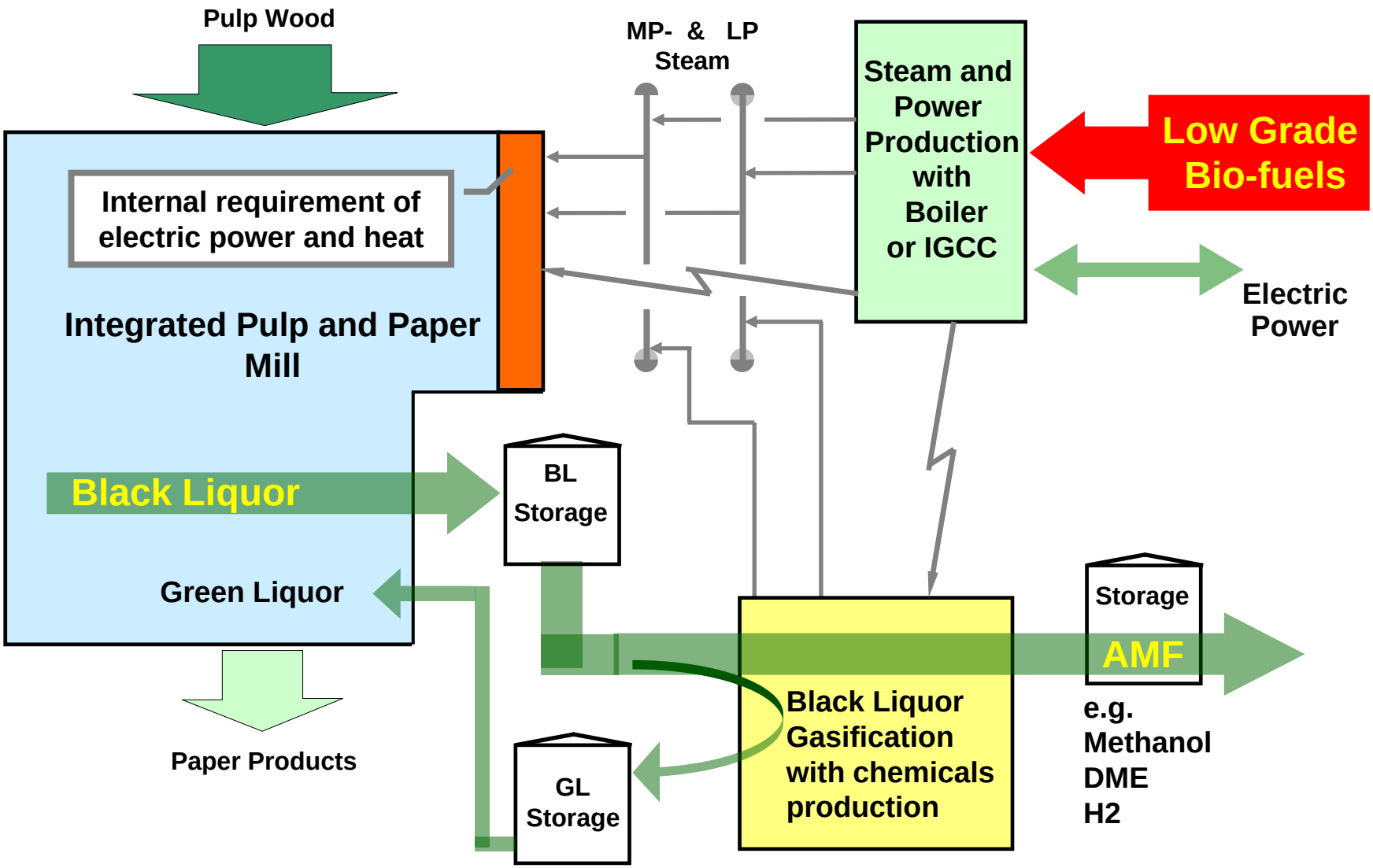
Rawgas composition from a Chemrec Gasifier

Gas component	*Unit*	*Value*
H_2	mole%	39.17
CO	mole%	38.08
CO_2	mole%	19.05
CH_4	mole%	1.34
N_2	mole%	0.24
H_2O	mole%	0.18
H_2S	mole%	1.88
COS	mole%	0.06
Total gas flow	Nm^3/h	141 938
Temperature	°C	31.5
Pressure	bar(a)	31

Characteristics of the BLGMF Concept

- **Black liquor gasification makes a high quality synthesis gas ideal for further conversion into synthesised fuels or hydrogen.**
- **When energy in shape of DME, methanol or hydrogen is withdrawn from the mill it results in a heat sink that must be filled with increased supply of primary energy; - like biomass.**

Ideal use of low grade biomass



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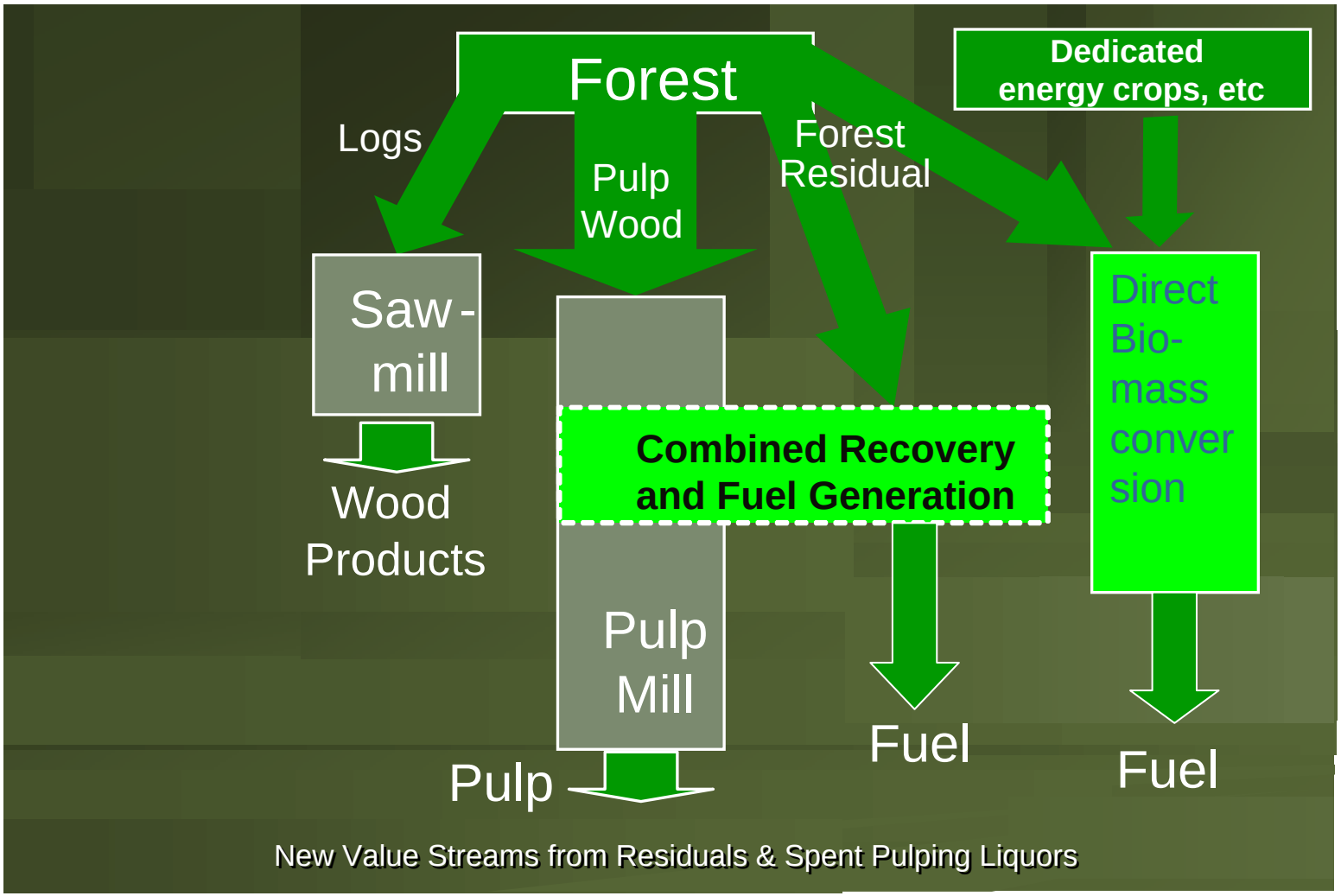
Biomass flow to the Biorefinery Concept



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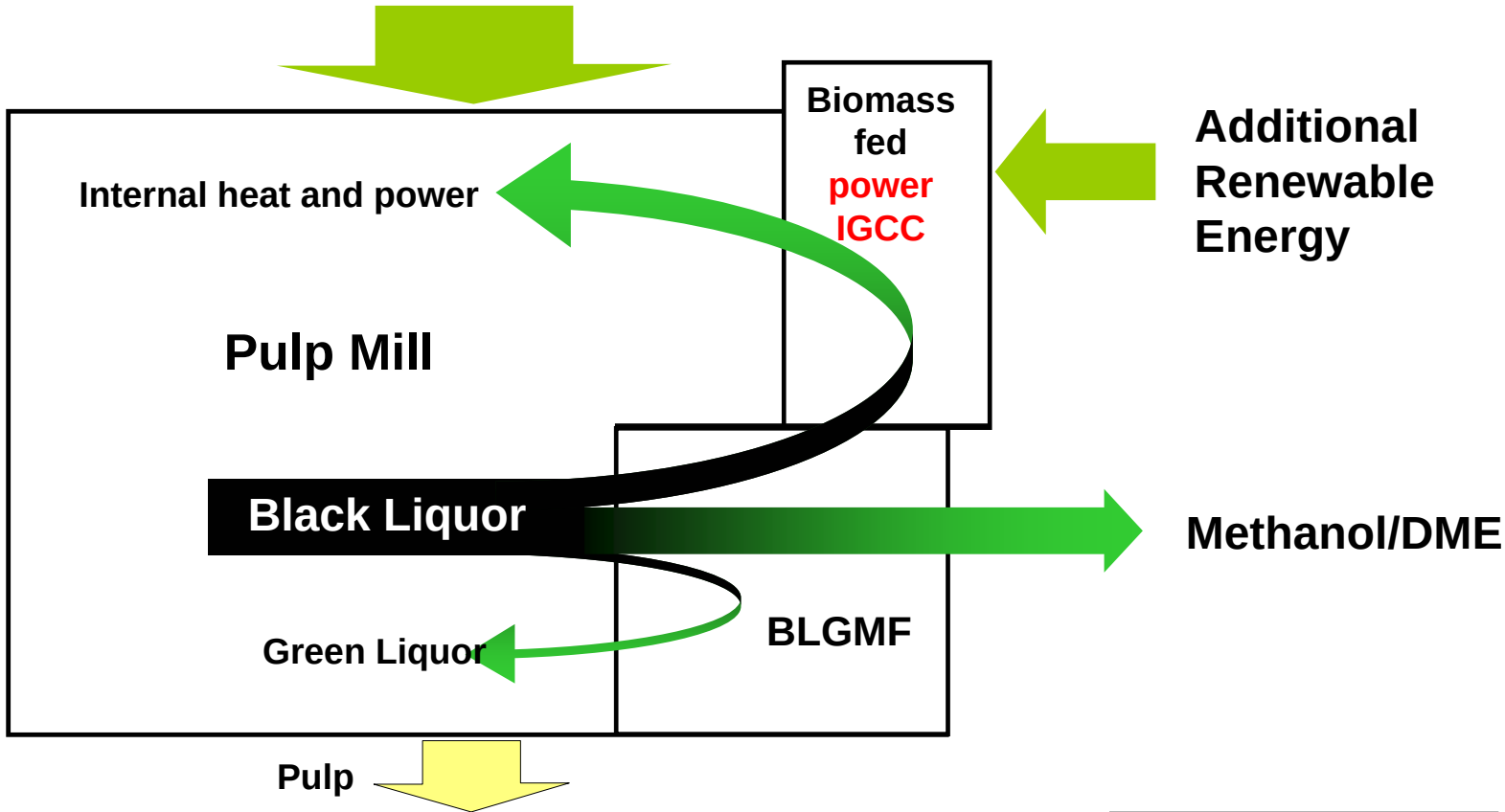
- **The pulp mill becomes an efficient user of surplus biomass. The mill is already an efficient user of large quantities of forest materials and has an optimum location for increased usage of biomass.**
- **The evolved heat sink is almost independent of seasonal changes (compare to district heating systems). Pulp mills operate all year round and constitutes an attractive location for efficient heat and power production via a boiler or an IGCC**

BLGMF Process: Biomass-to-fuel Efficiency
Case: Power IGCC



$$\text{Production Efficiency} = \frac{\text{Methanol/ DME}}{\text{Additional Renewable Energy}} = 80\text{-}90\ \%$$

Same Power Need with RB or BL Gasification.

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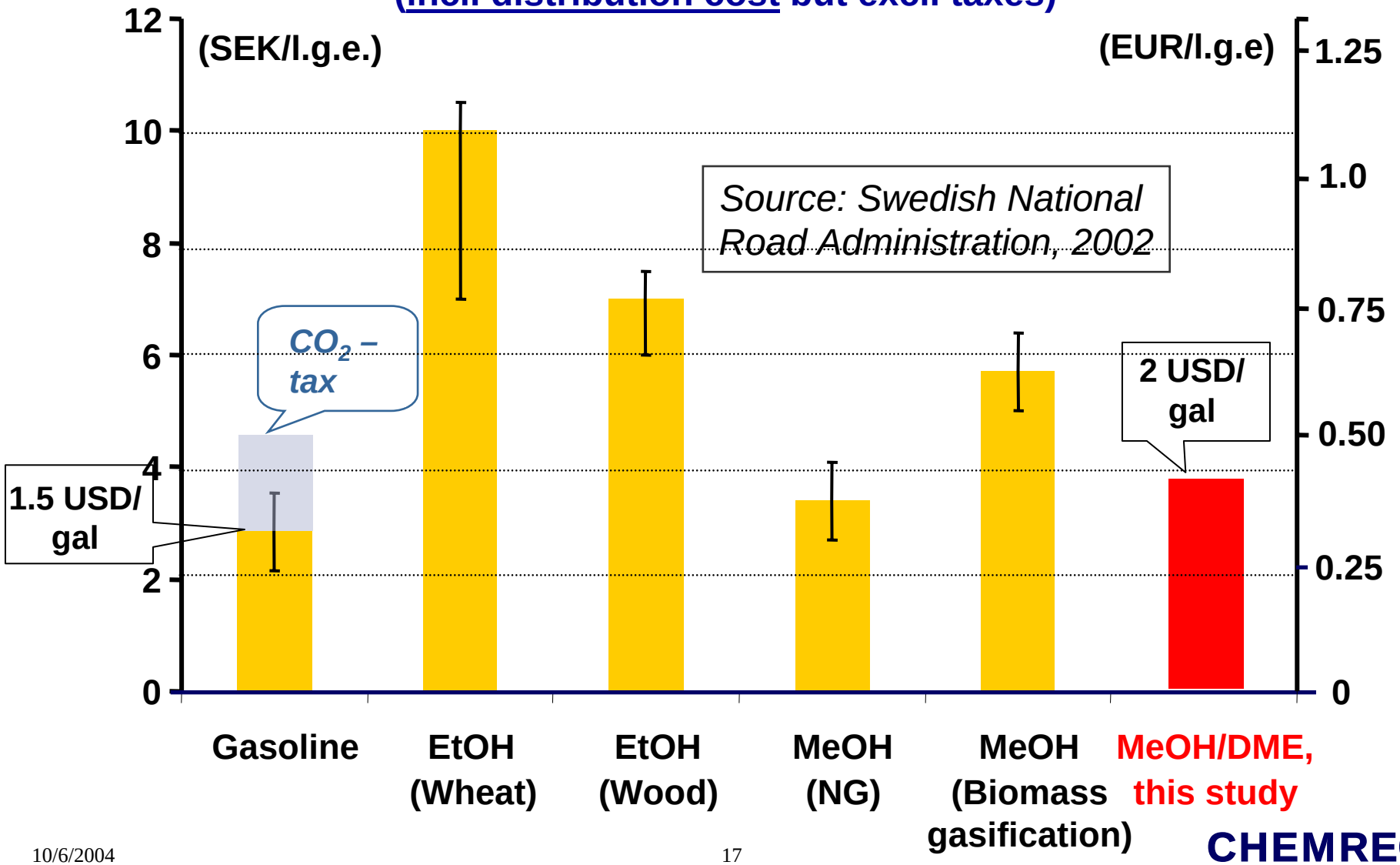
Why use Black Liquor as Vehicle for Biomass Derived AMF Generation?

- **Biomass derived AMF can be produced at a the same cost level as fossil based fuel alternatives without subsidy through reduced energy taxes.**

Cost of fuel at pump, EUR or SEK per liter gasoline equivalent

(incl. distribution cost but excl. taxes)



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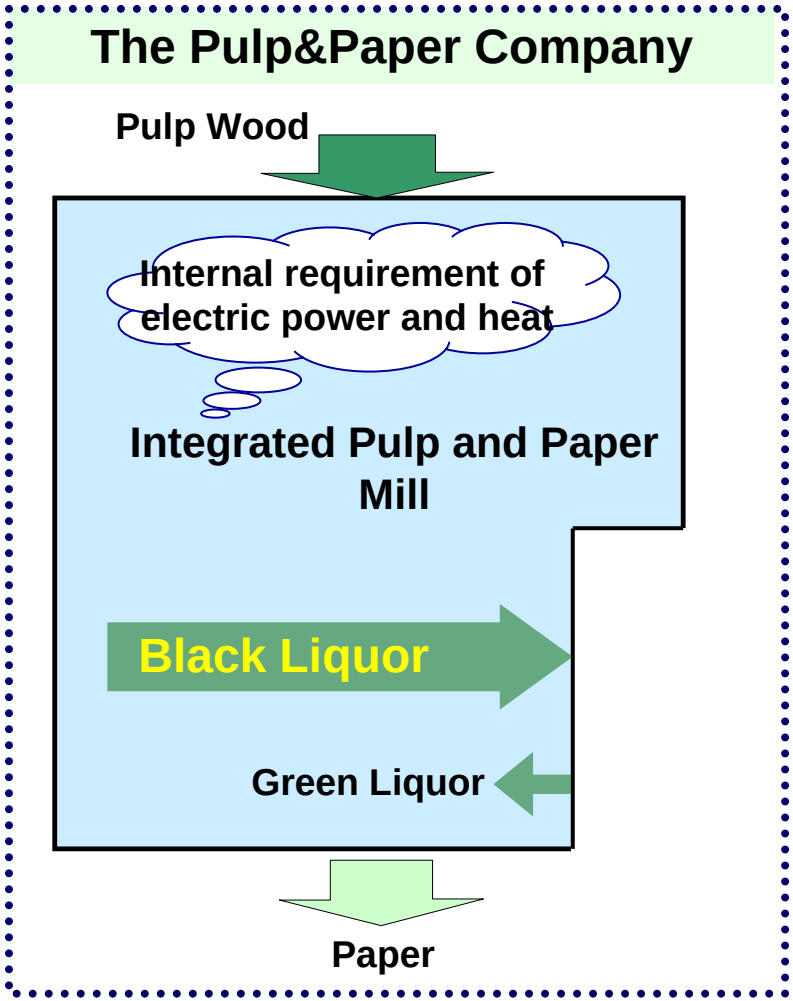
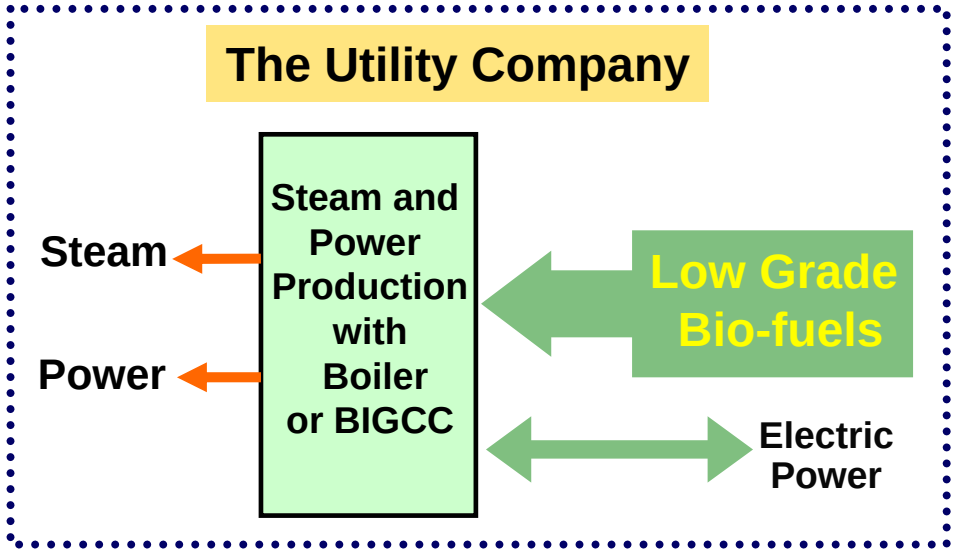
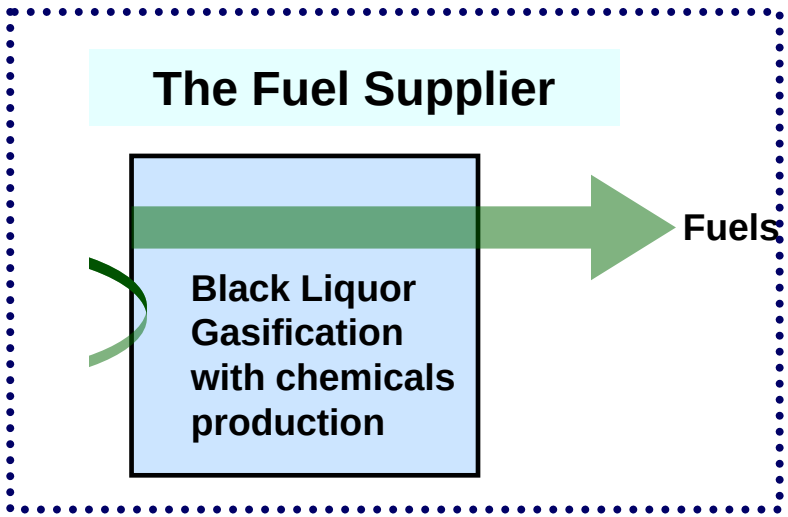
  - **Forest owners**
  - **Pulp and paper Industry**
  - **AMF suppliers**
  - **Air gas suppliers**
  - **Heat and electricity suppliers**
  - **Automotive industry**

Three Integrated but Independent Actors







Gas utilization together with CHEMREC® :s BLG process

- **Oxygen:**

  Ca 600 ton O_2 per 1000 ADt of pulp

- **Nitrogen, Argon and other rare gases:**

  N_2 as inert gas in the BLG process

- **Carbon dioxide:**

  Available at > 90% purity from the BLGMF process. Possible to produce also from BLGCC.

- **H_2 and CO:**

  As fuel gas for combined cycle, as feedstock for synthesis or for other use

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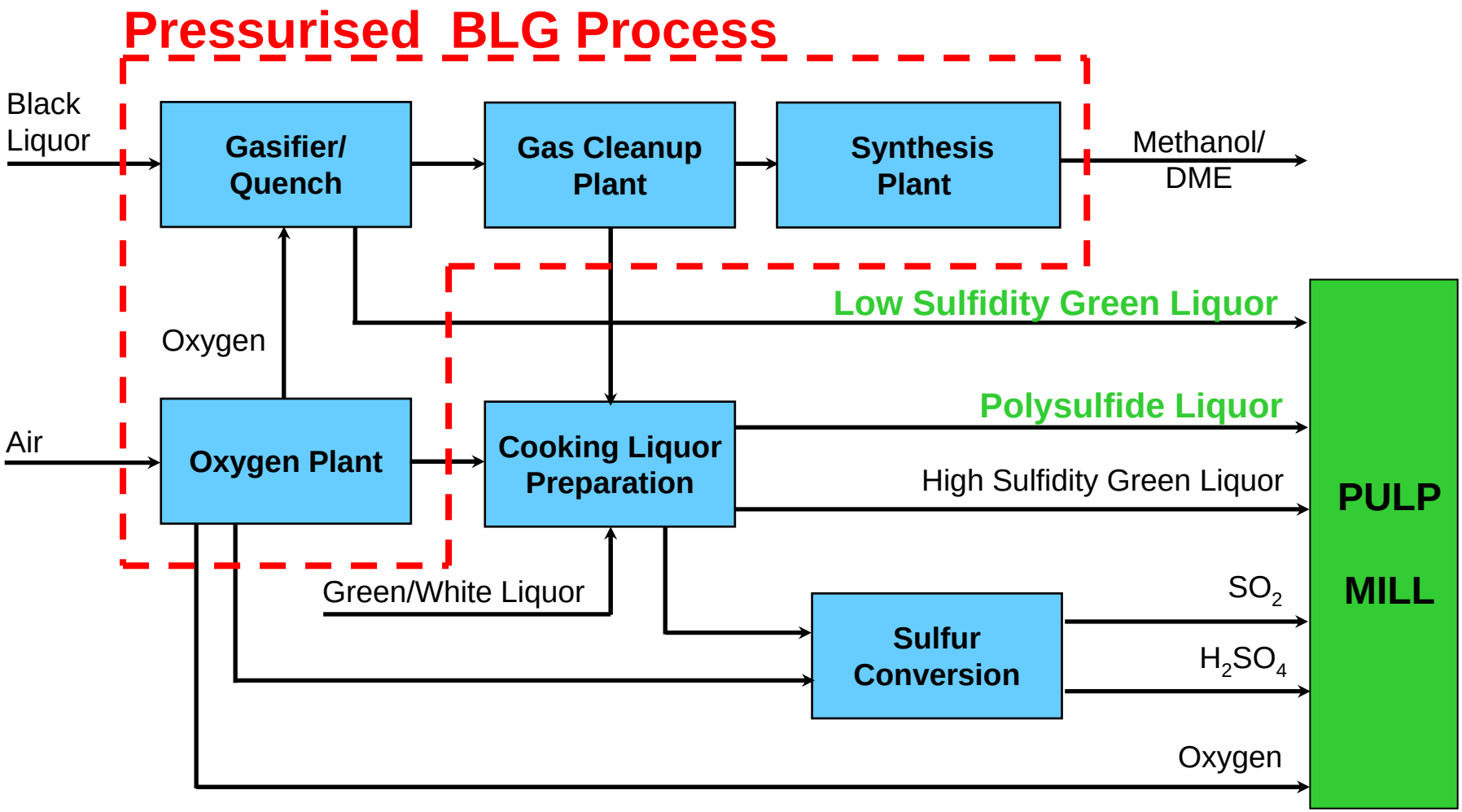
BLGMF – Pulp Mill Integration Flow Scheme



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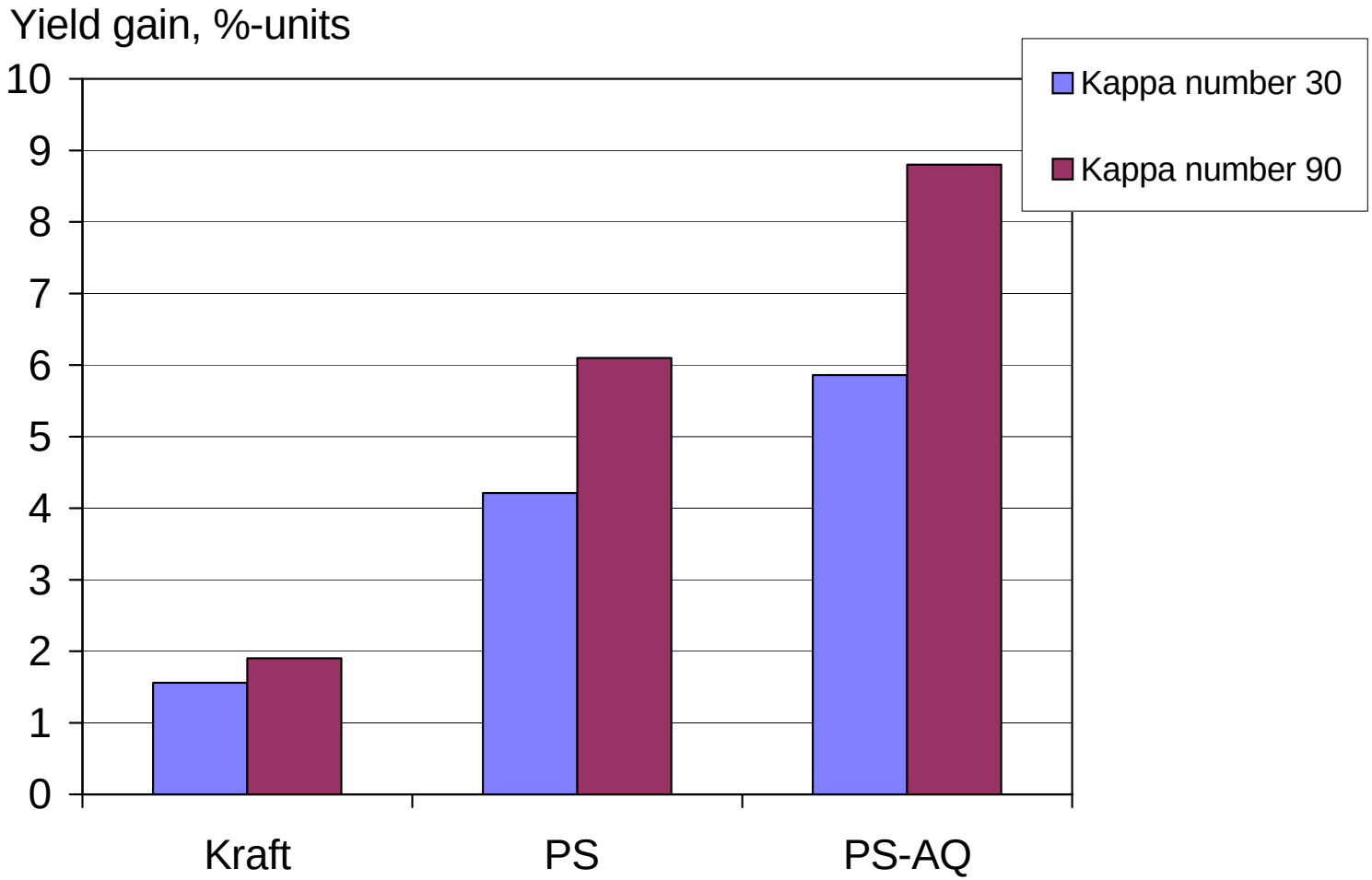
Potential for Increased Pulp Yield, like

ZAP - "*Zero Effective Alkali in the Pretreatment Stage*"



Source: STFI

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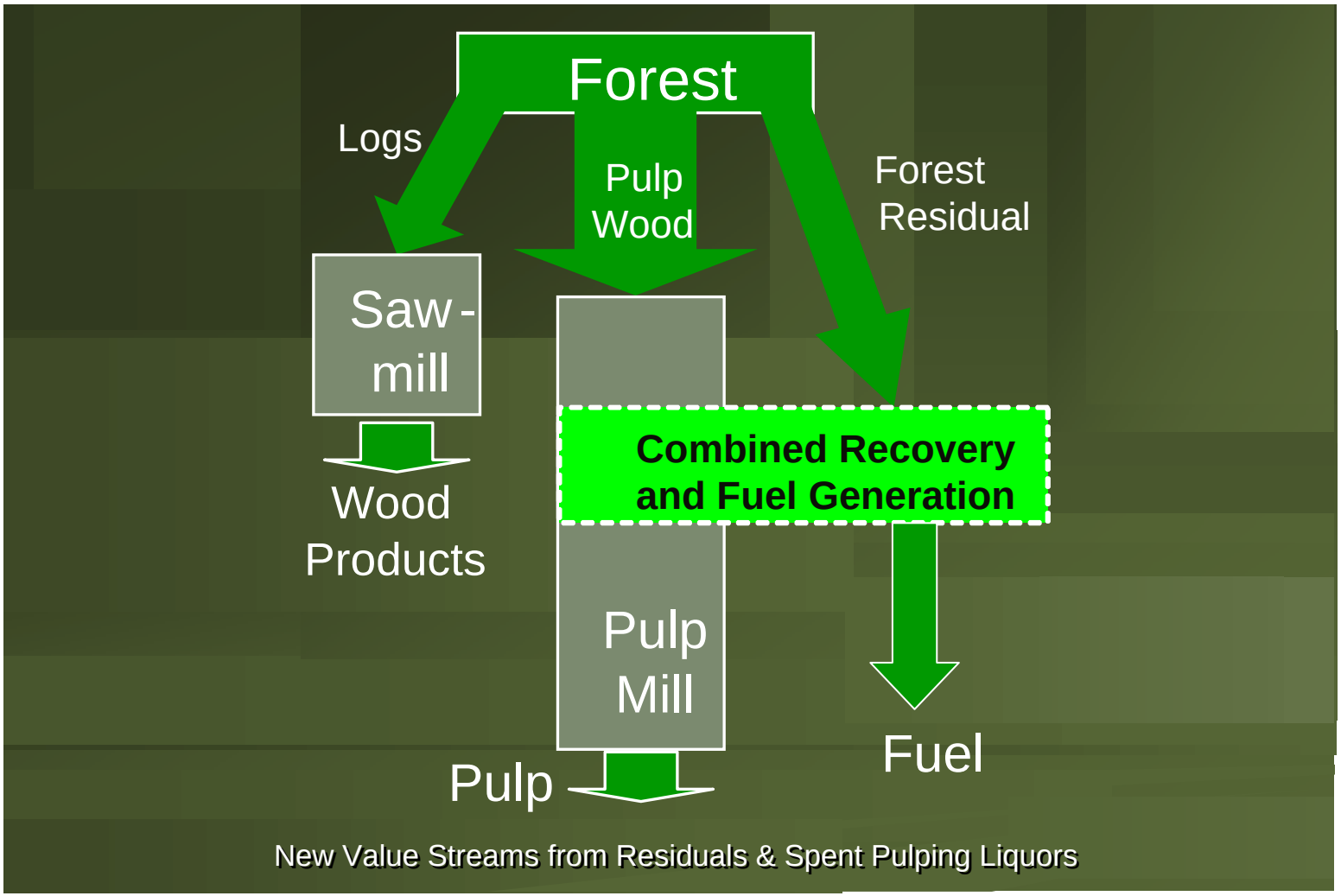
Key reason for the Biorefinery Concept



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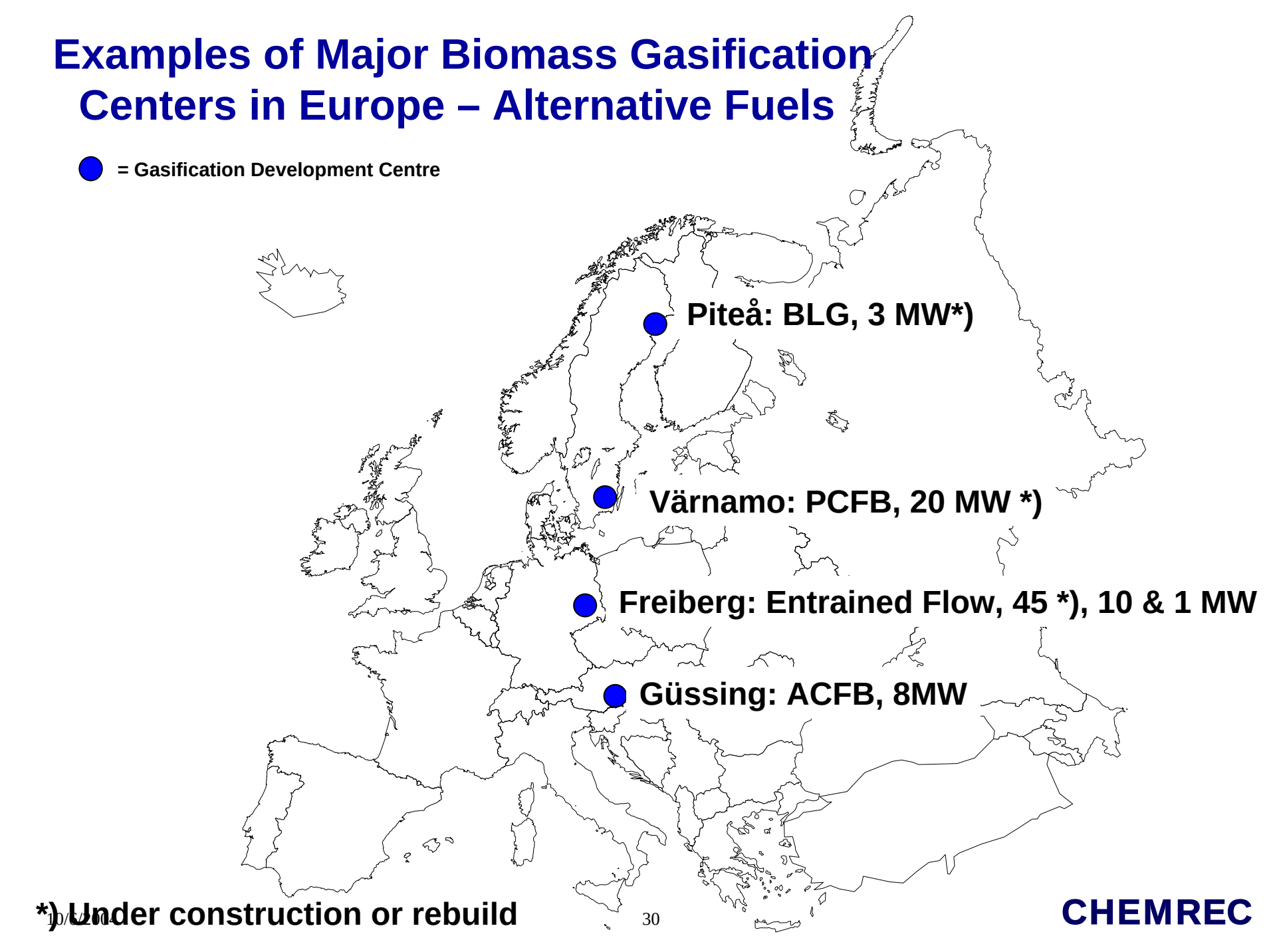
Examples of Major Biomass Gasification Centers in Europe – Alternative Fuels



*) Under construction or rebuild

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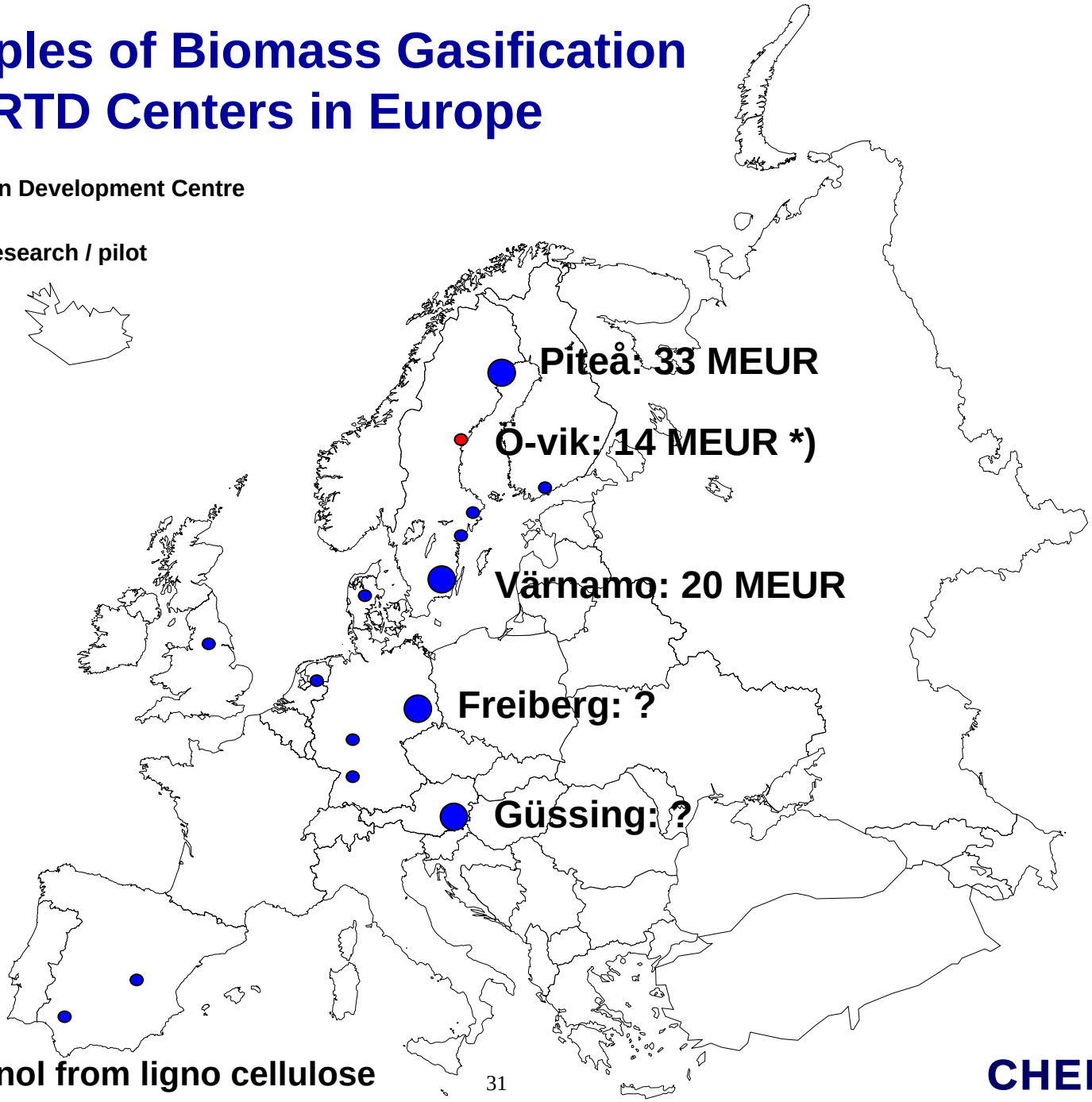
Examples of Biomass Gasification RTD Centers in Europe

= Gasification Development Centre

= important research / pilot



*) Ethanol from ligno cellulose