

**CHEMREC**

# **Black Liquor Gasification Technology**

**Presentation at**

**Workshop on Liquid Biofuels from Black Liquor  
Gasification**

**IEA Bioenergy ExCo Meeting**

**Ottawa, Canada October 6, 2004**

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Chemrec AB  
www.chemrec.se**

# **CHEMREC SCOPE OF BUSINESS**

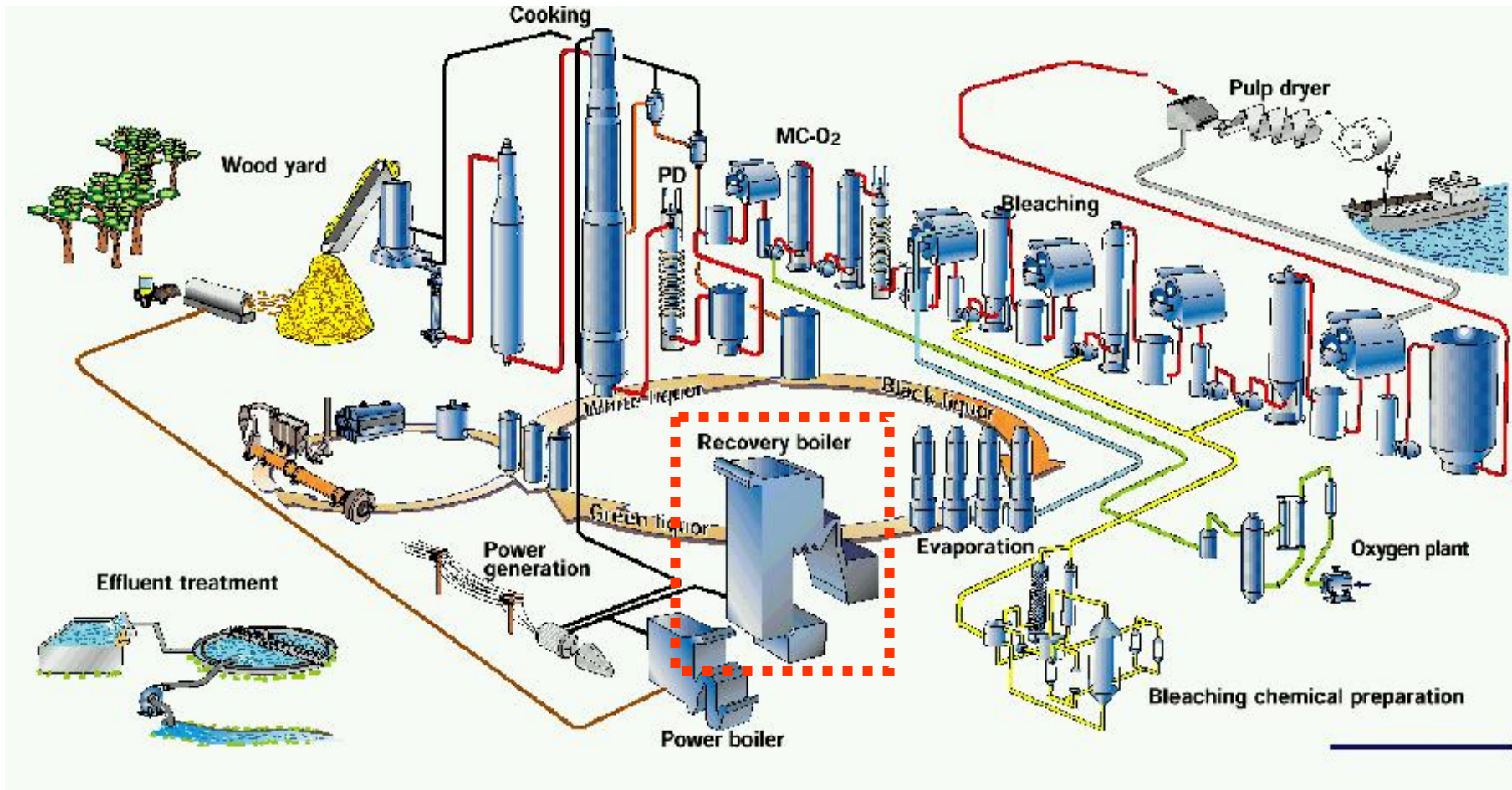
**The Scope of Business of Chemrec AB shall be:**

**“Technical Development and Commercialisation of energy and chemical recovery systems based on black liquor gasification”.**

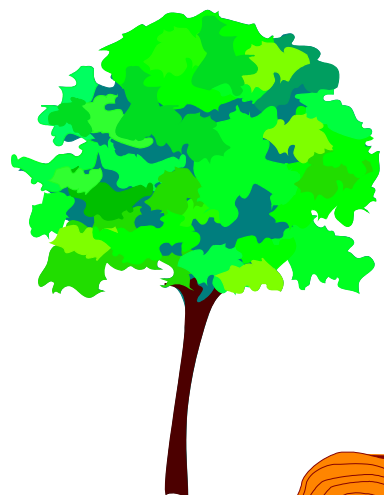
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2. **Why new technology? Some reasons.**
3. **The Chemrec BLGMF concept**
4. **Impact of introducing the BLGMF concept**
  - **Sweden**
  - **Canada and the US**
5. **BLGMF economics**
6. **Development status**
7. **Funding requirement and structure**

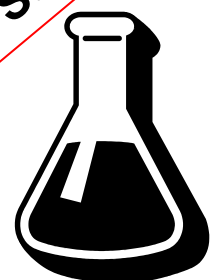
# The Pulp Mill



# Composition of Wood and Black Liquor



A Biomass Feedstock in Liquid State

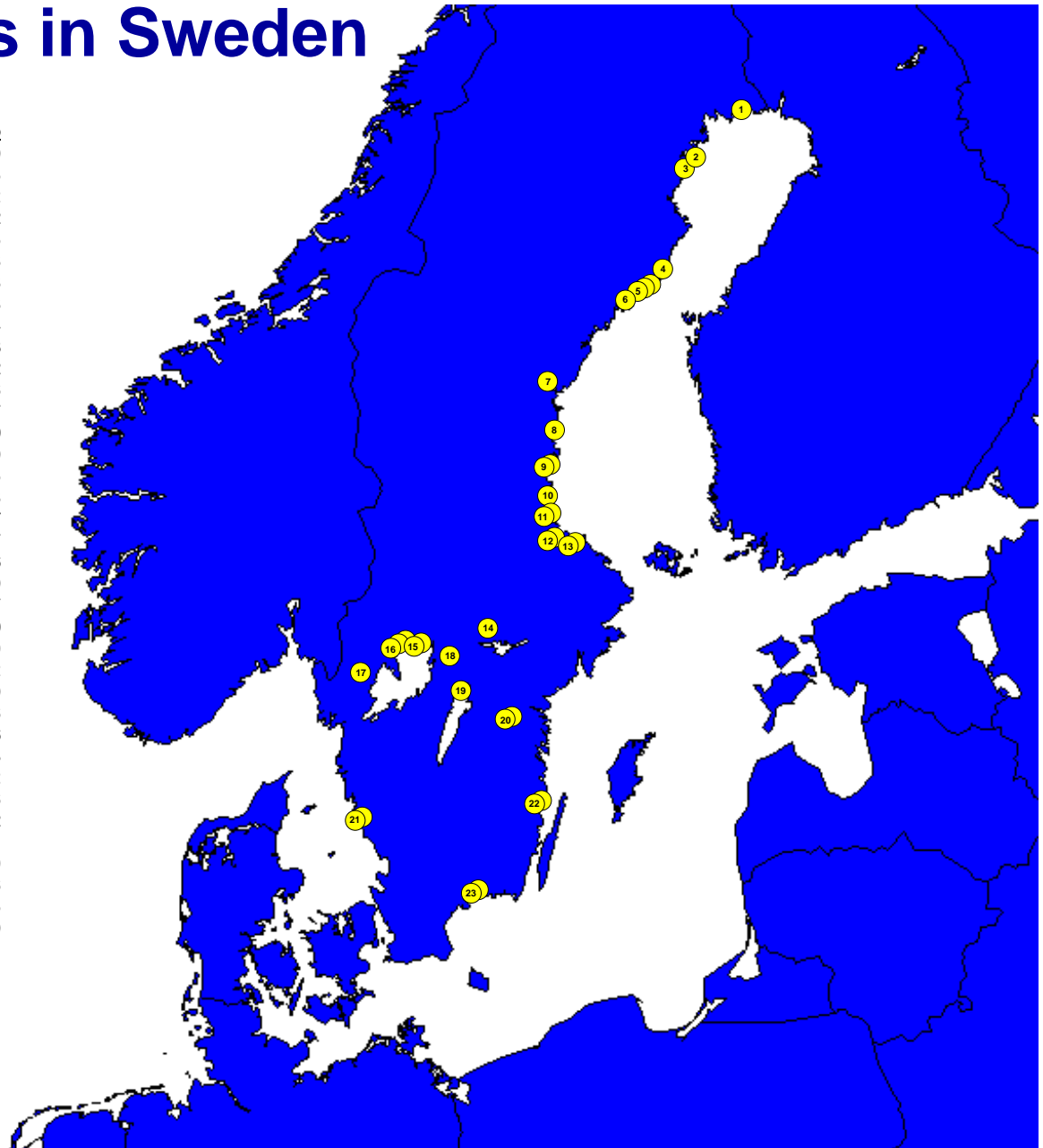


Wood Type	Cellulose	Hemi-cellulose	Lignine	Extractives + others
Spruce	42%	28%	27%	3%
Fir	41%	28%	27%	4%
Birch	41%	34%	21%	4%

Black Liquor Composition		
Component	% Mass	
C	34.55	
H	3.59	
S	4.35	
O	34.70	
Na	18.45	
K	2.96	
Cl	1.40	
N	-	
<b>Total (%):</b>	<b>100.0</b>	
Combustible Characteristics		
BL, Dry Solids	% Mass	80%
HHV	MJ/kg, DS	14.2
NHV	MJ/kg, DS	12.0

# Recovery Boilers in Sweden

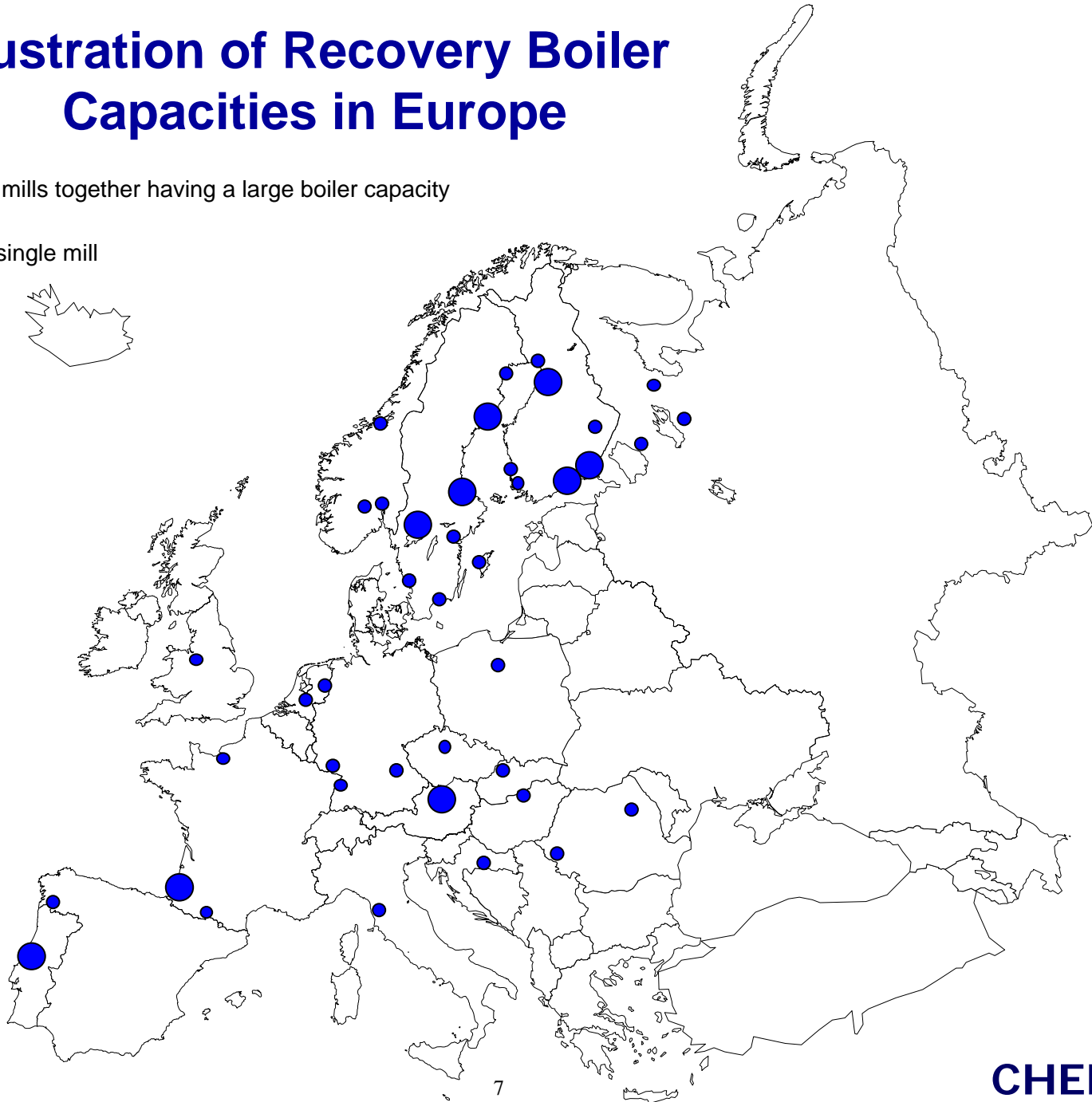
Site Nr.	Mill - Owner	Capacity tDS/24h	Start-up
1	Karlsborg - Billerud	1250	1980
2	Munksund - SCA	600	1965
3	Kraftliner Piteå - Kappa	1450	1972
4	Obbola - SCA	850	1962
5	Husum - M-Real	750	1965
	Husum - M-Real	700	1978
	Husum - M-Real	1100	1988
6	Domsjö -	375	1958
	Domsjö -	375	1964
7	Dynäs - Frantschach	915	1978
8	Östrand - SCA	1500	1982
9	Iggesund - Holmen	520	1966
	Iggesund - Holmen	520	1967
10	Vallvik - Rottneros	1000	1999
11	Norrsundet - Stora	540	1970
	Norrsundet - Stora	460	1965
12	Korsnäs - Kinnevik	865	1968
	Korsnäs - Kinnevik	1550	1987
13	Skutskär - STORA	585	1967
	Skutskär - STORA	1900	1976
14	Frövi - ASSI Domän	520	1970
15	Skoghall - STORA	300	1957
	Skoghall - STORA	910	1969
16	Gruvön - Billerud	500	1959
	Gruvön - Billerud	760	1972
	Gruvön - Billerud	2500	2000
17	Billingsfors - Munksjö	230	1976
18	Bäckhammar -	570	1976
19	Aspa - Munksjö	510	1973
20	Skärblacka - Billerud	600	1962
	Skärblacka - Billerud	1250	1976
21	Värö - Södra	1400	1972
	Värö - Södra	Under construction	
22	Mönsterås - Södra	1600	1979
	Mönsterås - Södra	4000	1996
23	Mörum - Södra	2000	1995
	Mörum - Södra	740	1970
Total No. of boilers		37	
Total capacity		36195 tDS/24h	



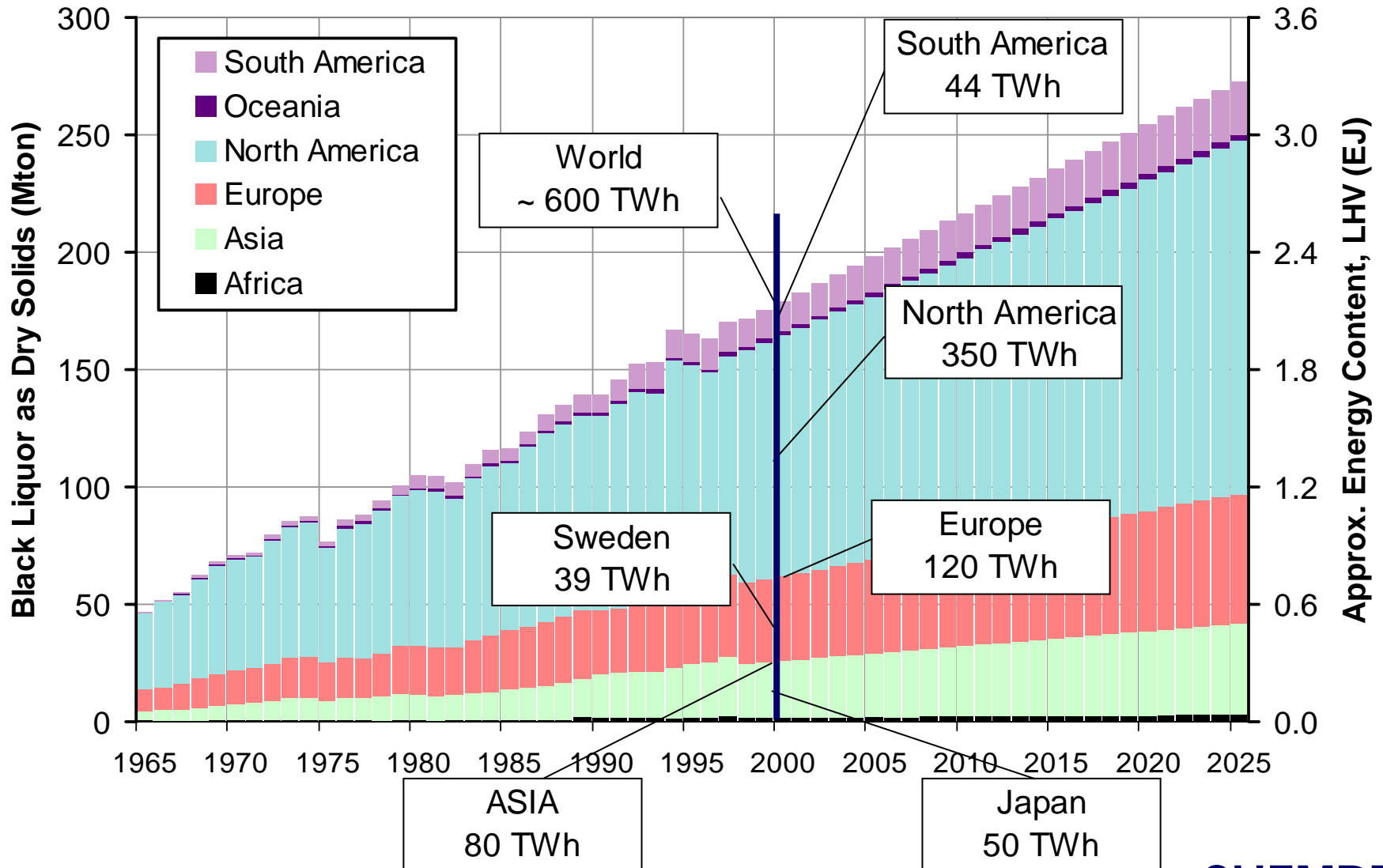
**39 TWh (LHV) Year 2000**

# Illustration of Recovery Boiler Capacities in Europe

- = clusters of mills together having a large boiler capacity
- = important single mill



# Estimated Black Liquor Production (World)





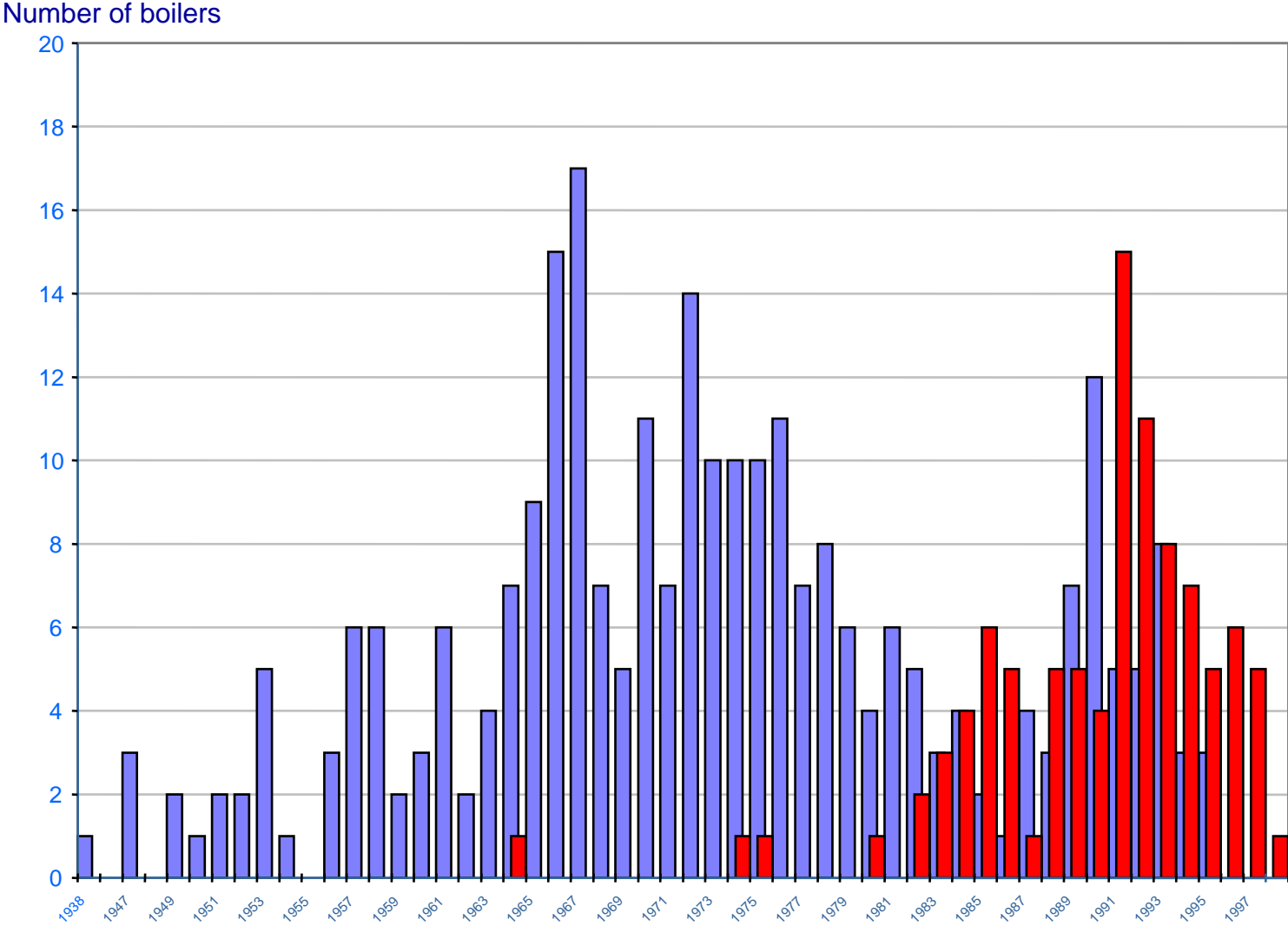
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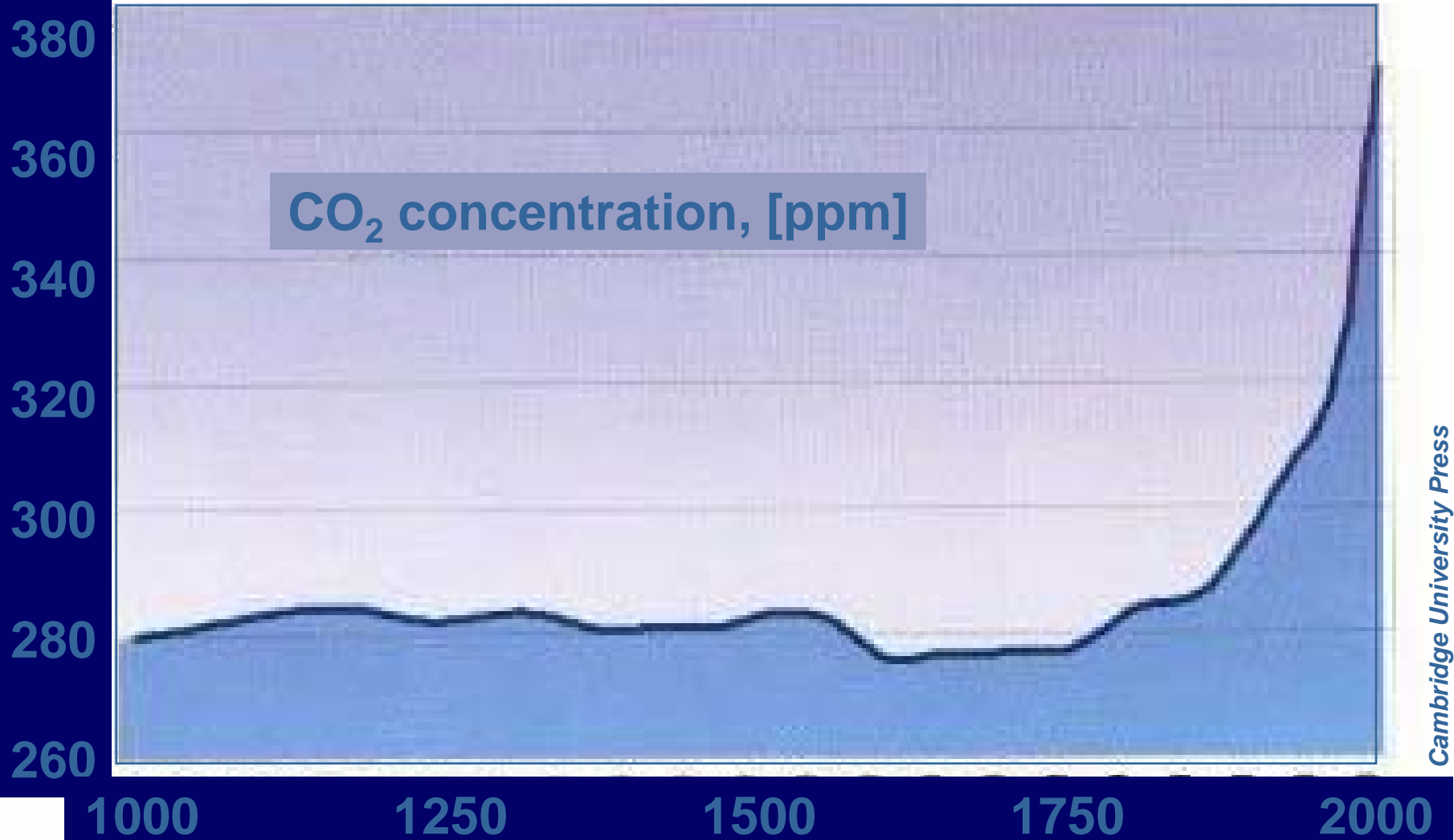
# Drivers for Technology Change

Possible Achievements with Gasification	Atmospheric Booster	Pressurized BLGCC/MF
Develop Technology for Incremental Capacity	X	(X)
Improved Cooking Methods ( <b>More pulp</b> per ton of wood)		X
Improved Energy Recovery ( <b>Power</b> or <b>Automotive Fuels</b> )		X
<b>Improved Safety</b>	X	X

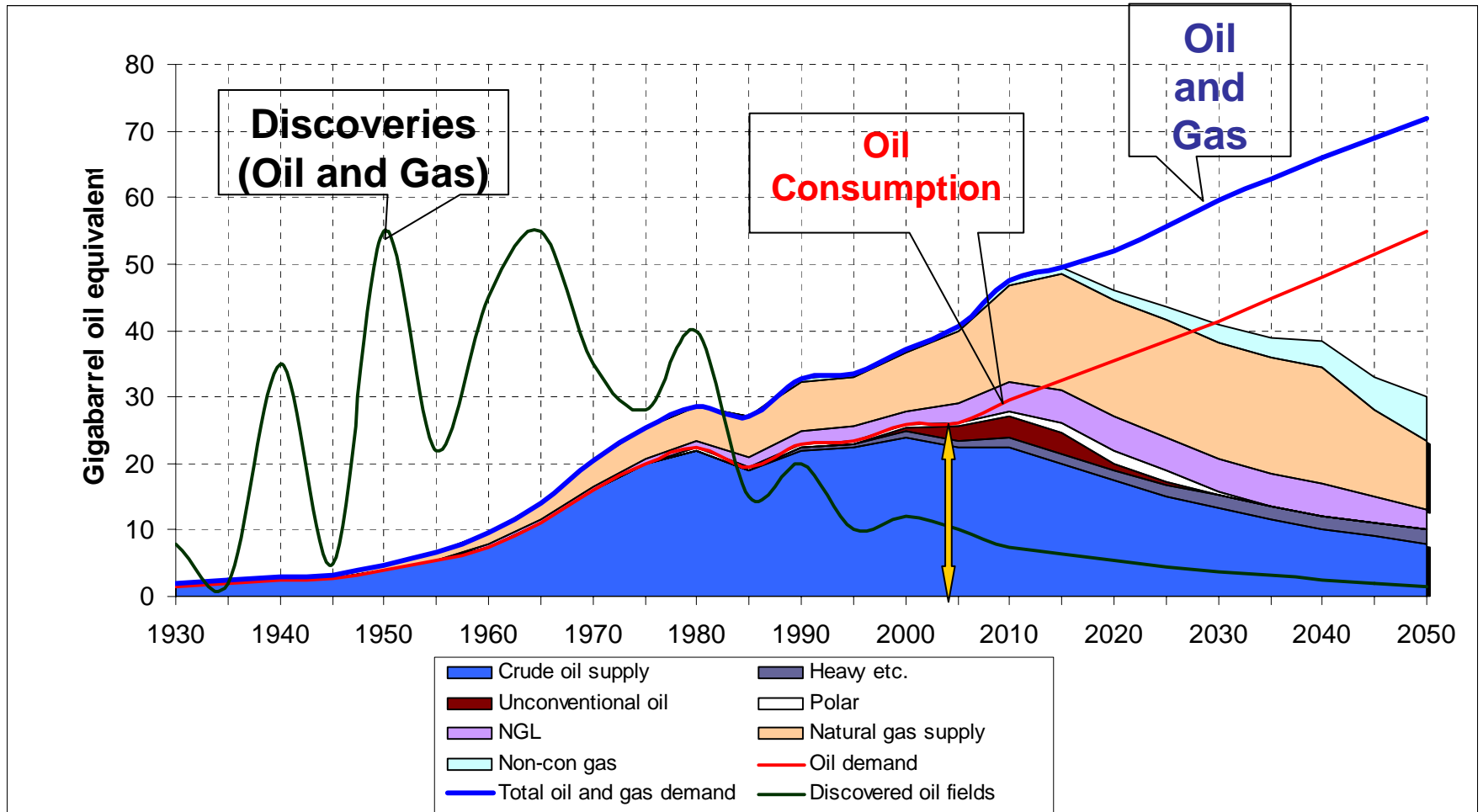
# Years of Start-up and Re-build of North American Recovery Boilers



# 1000 Years of Global CO<sub>2</sub> Change



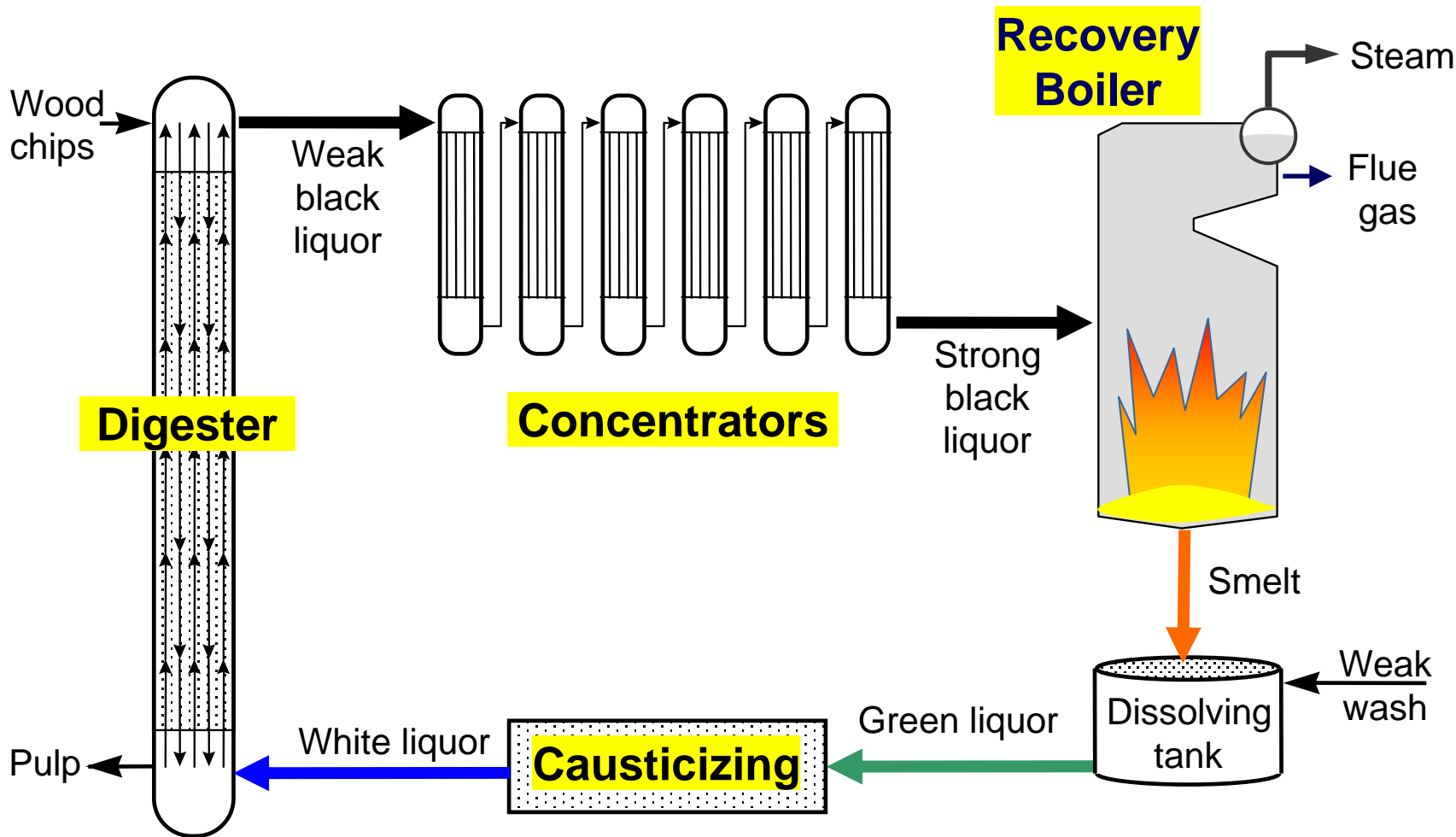
# Oil- and Natural Gas Consumption History and Prognoses



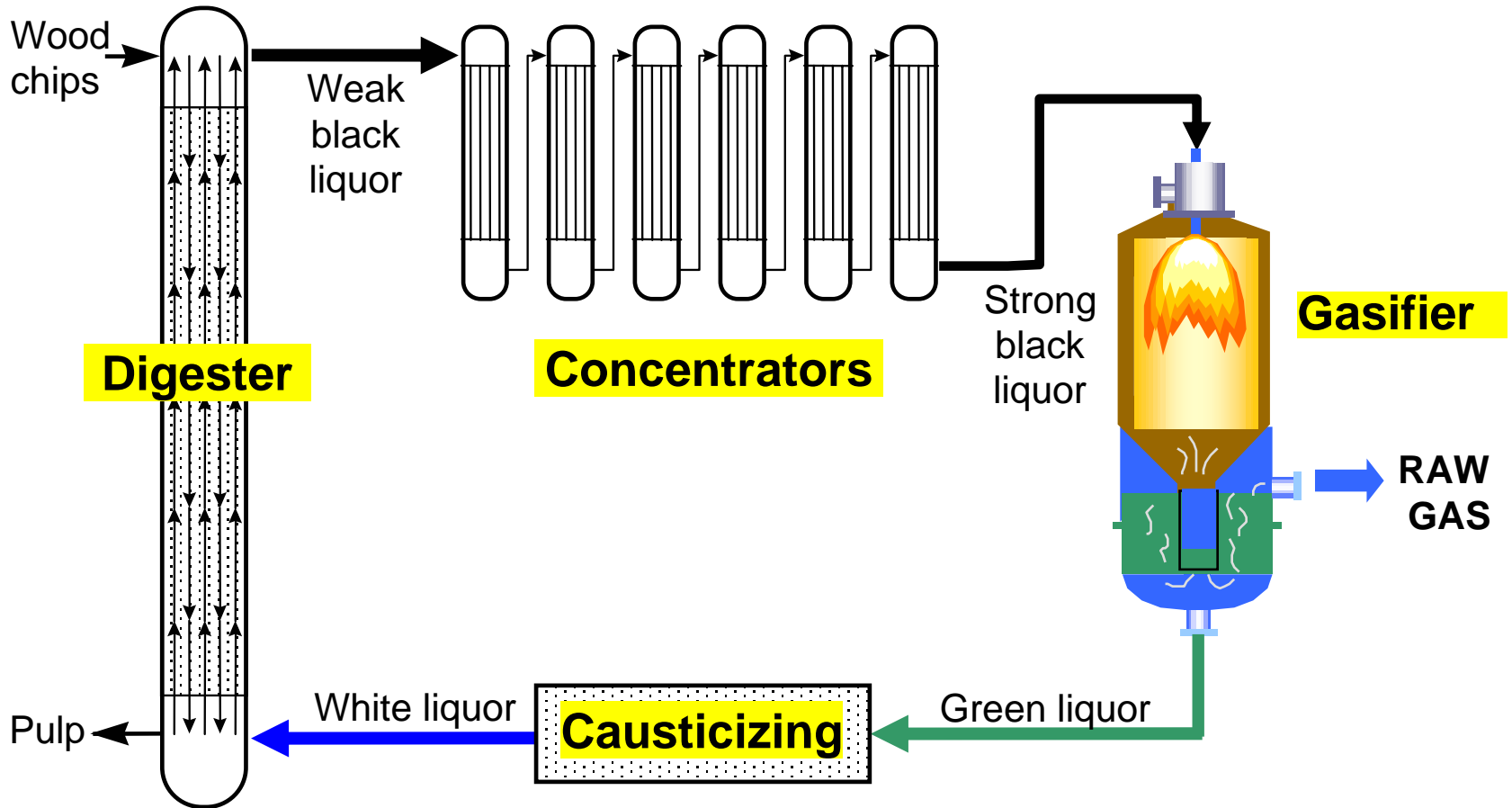
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# Technology of today for the Recovery of Cooking Chemicals

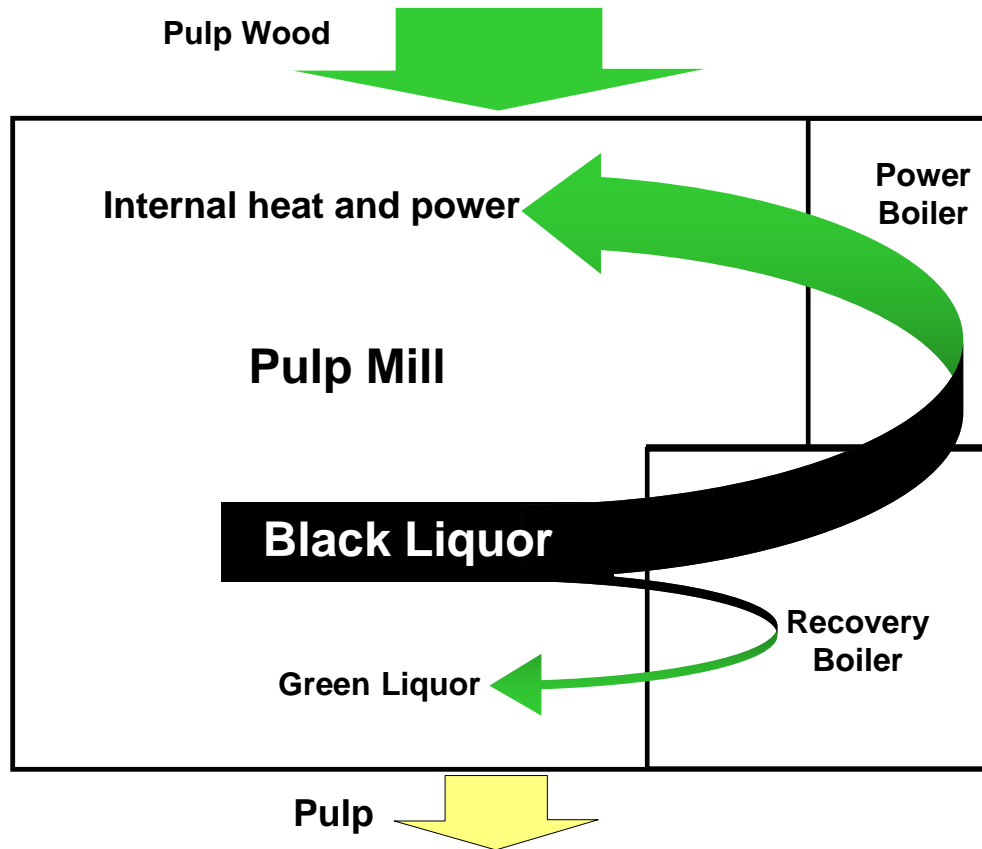


# Gasification Technology for the Recovery of Cooking Chemicals

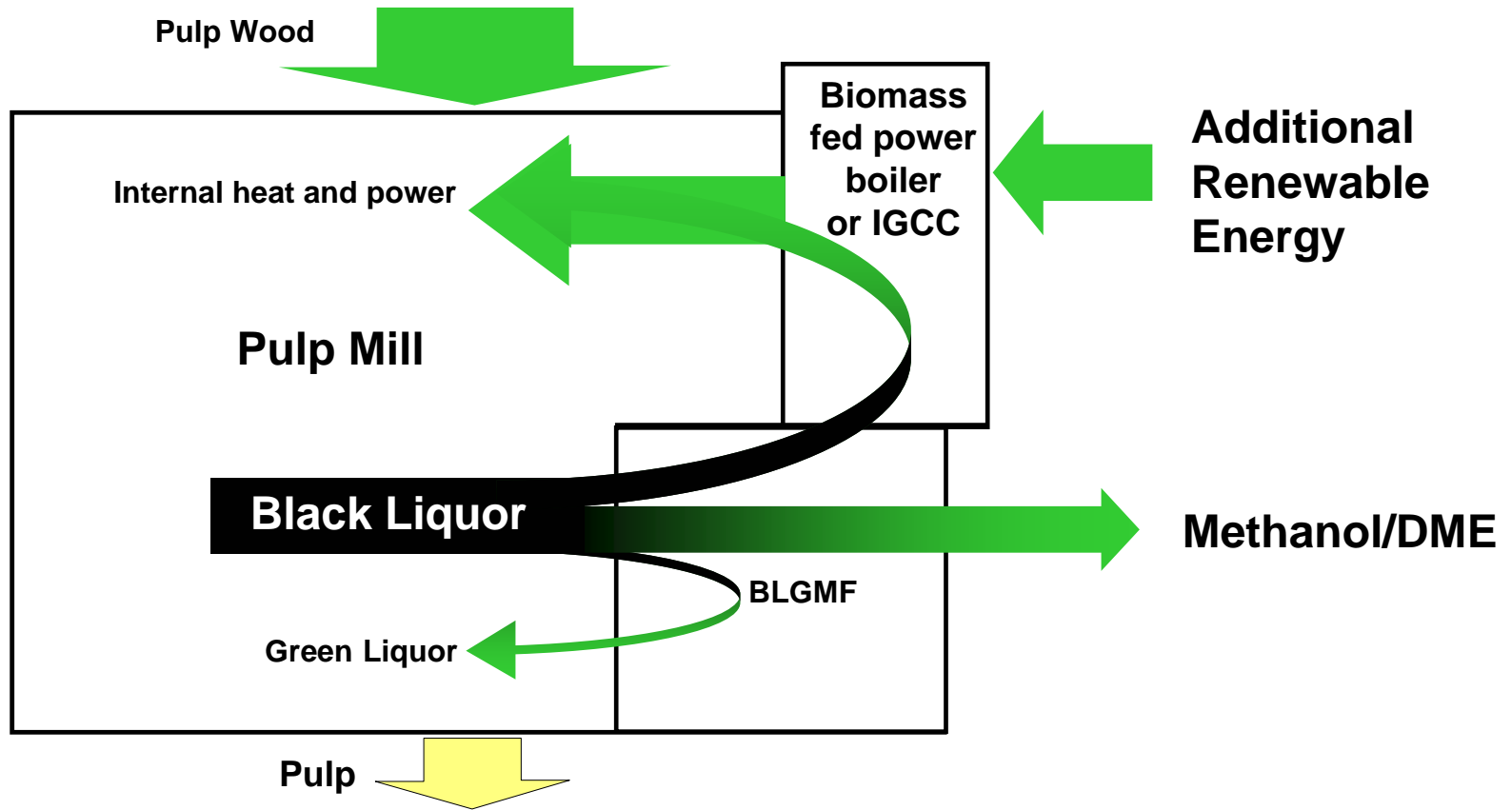




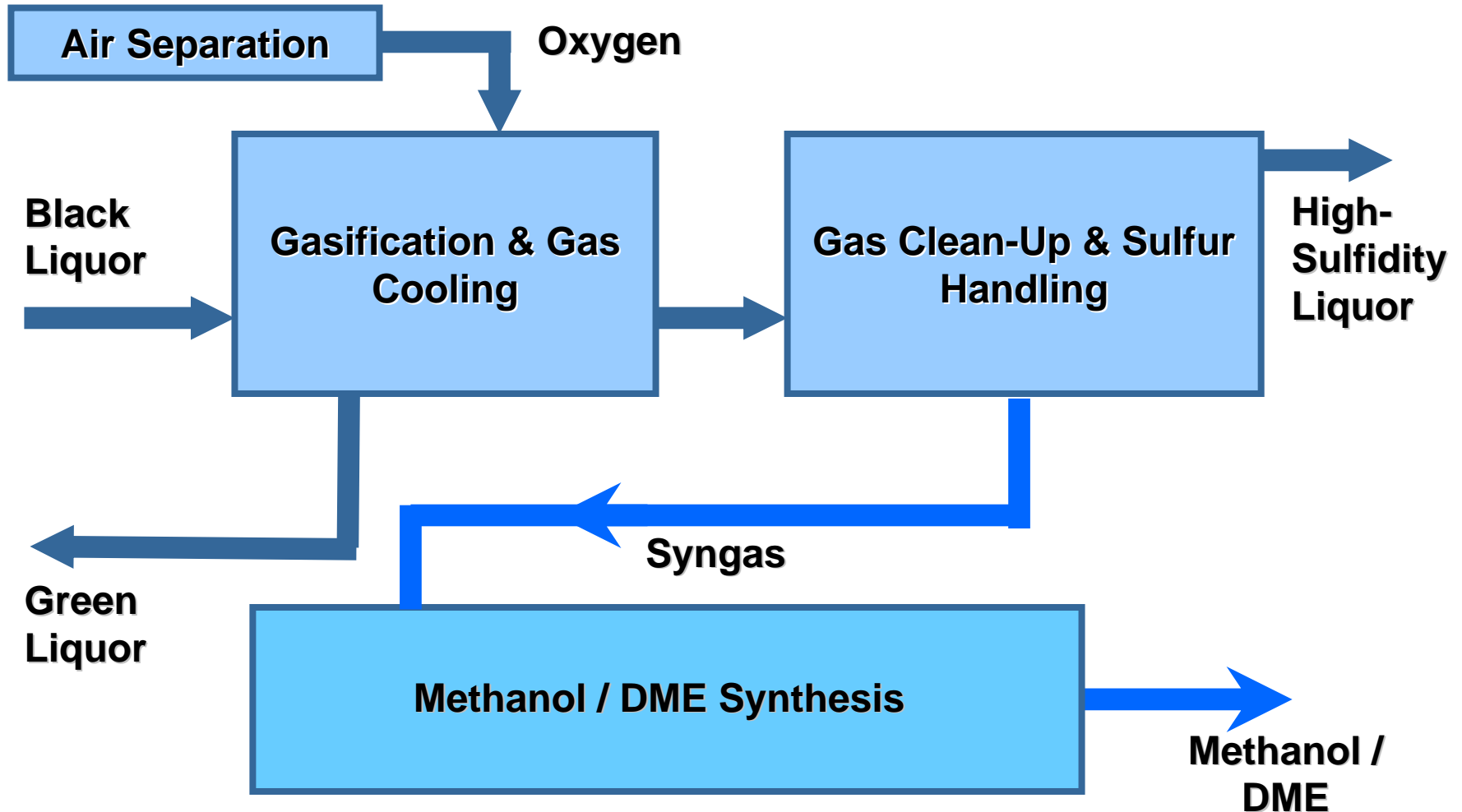
# Main Blocks in a Pulp & Paper Mill



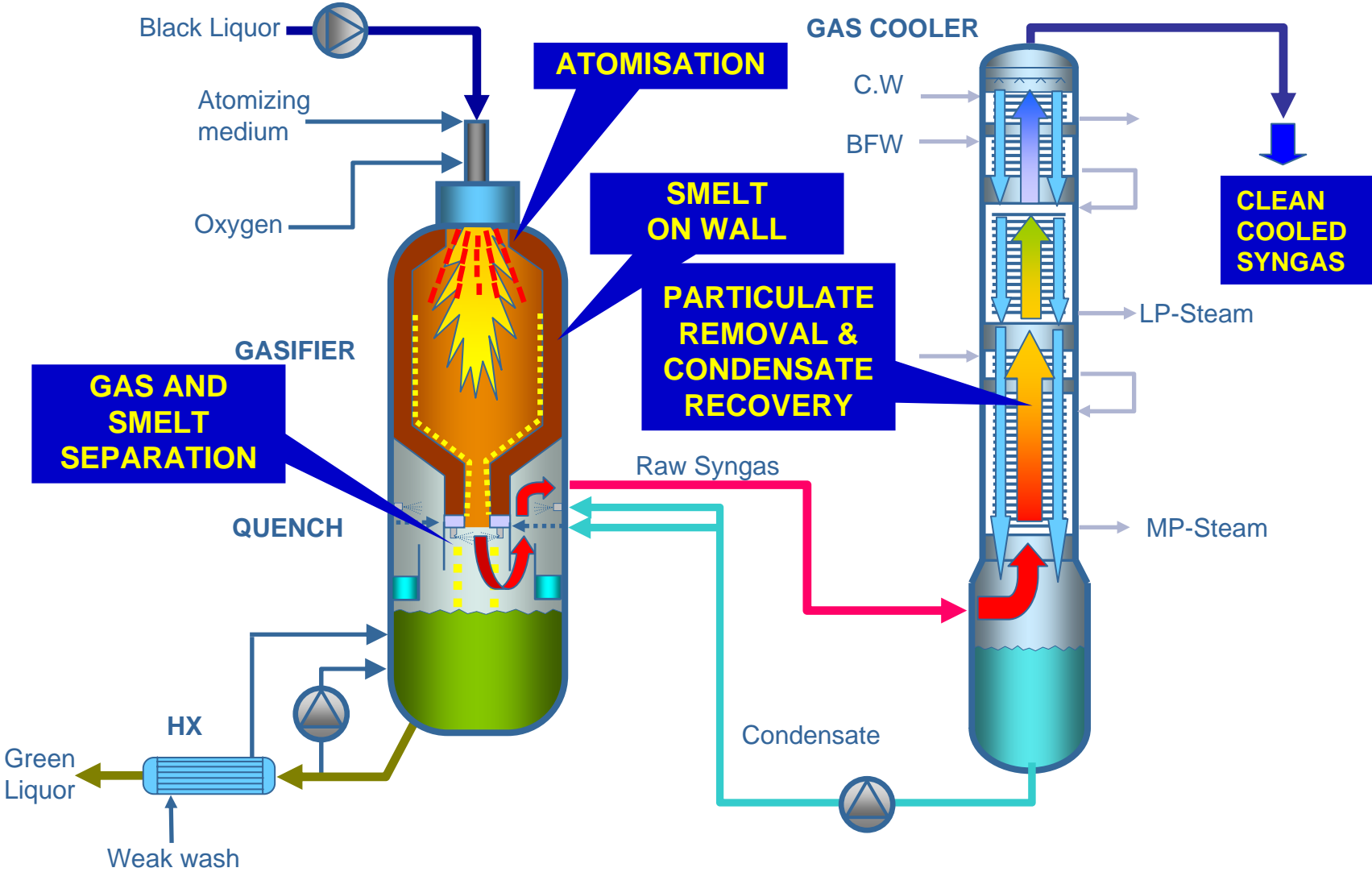
# P&P Mill with Motor Fuel Production and Heat/Power Unit



# Black Liquor Gasification with Motor Fuels Production (BLGMF)

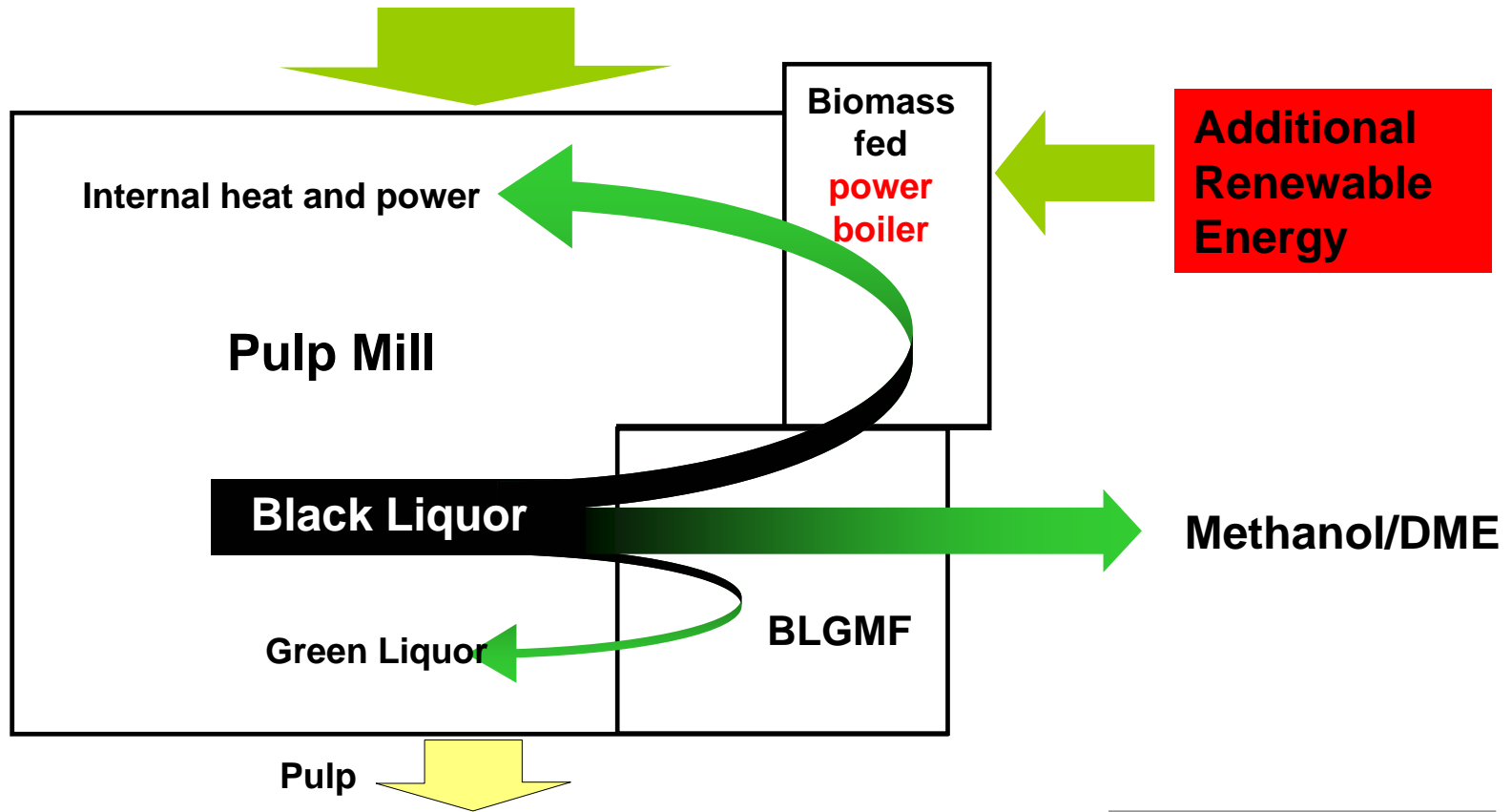


# Gasification Technology Principles



# BLGMF Process: Biomass-to-fuel Efficiency

## Case: Power Boiler

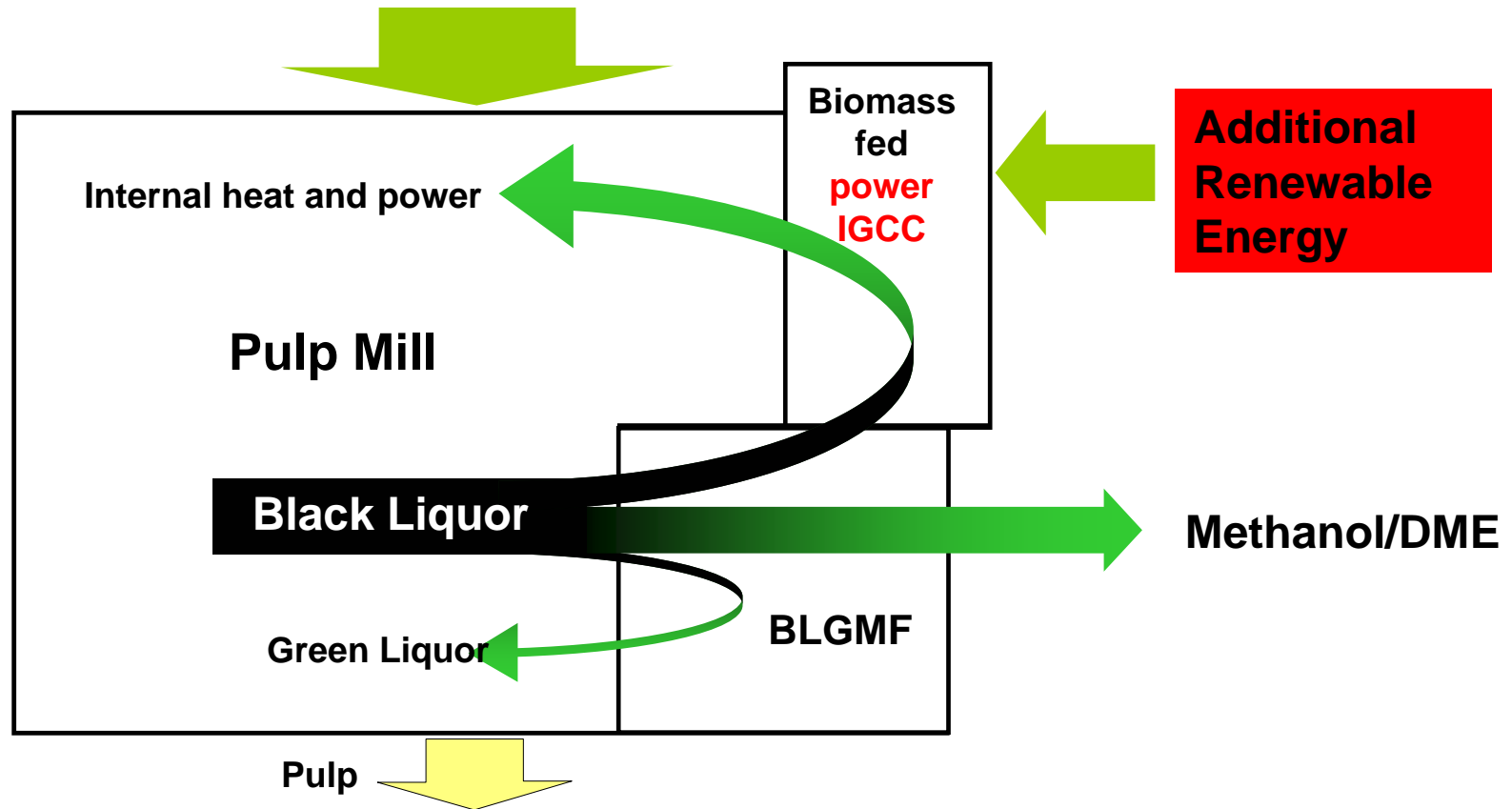


$$\text{Production Efficiency} = \frac{\text{Methanol/ DME}}{\text{Additional Renewable Energy}} = 65-70 \%$$

Same Power Need with  
RB or BL Gasification.

# BLGMF Process: Biomass-to-fuel Efficiency

## Case: Power IGCC



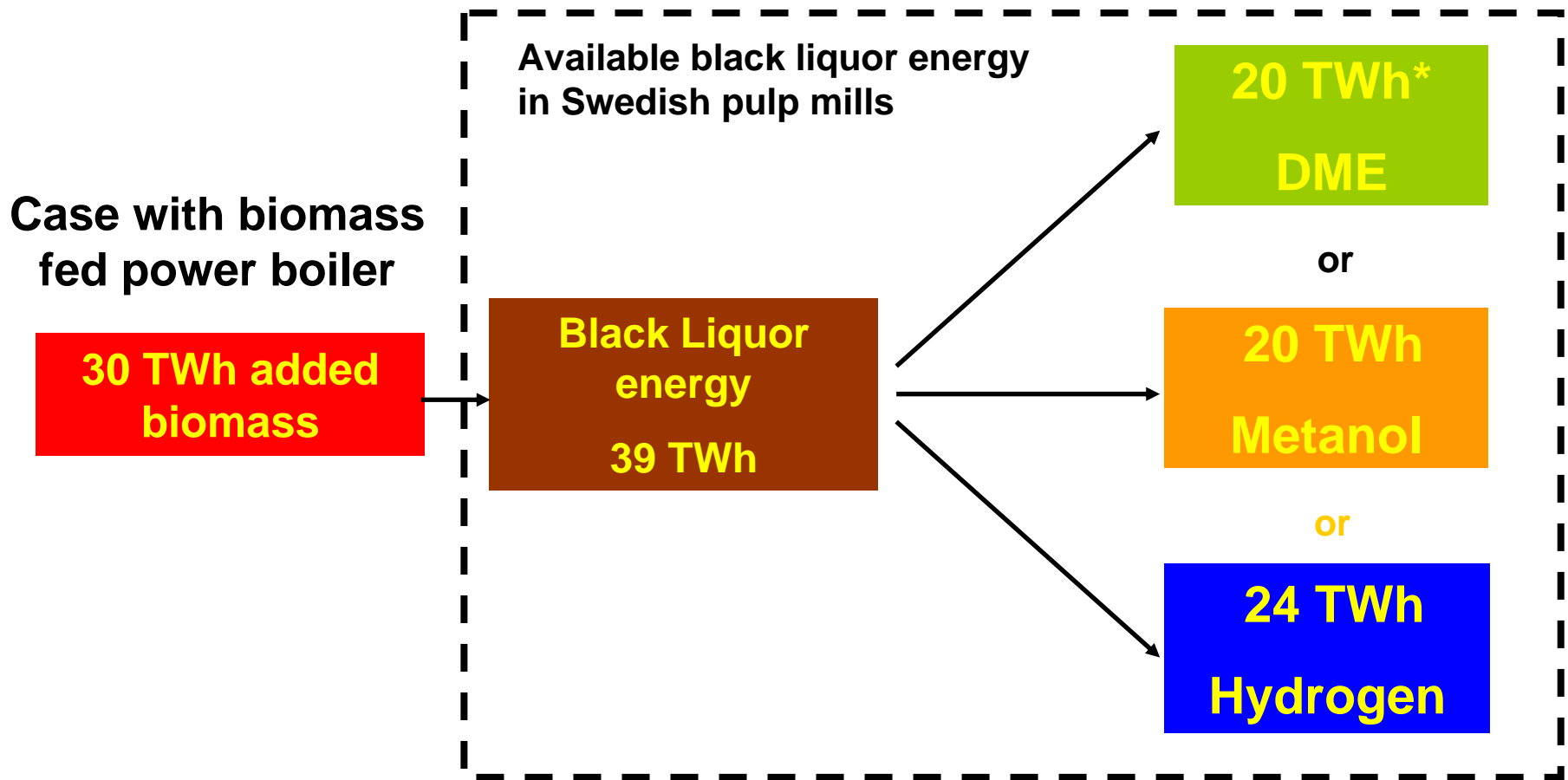
$$\text{Production Efficiency} = \frac{\text{Methanol/ DME}}{\text{Additional Renewable Energy}} = 80-90 \%$$

Same Power Need with RB or BL Gasification.

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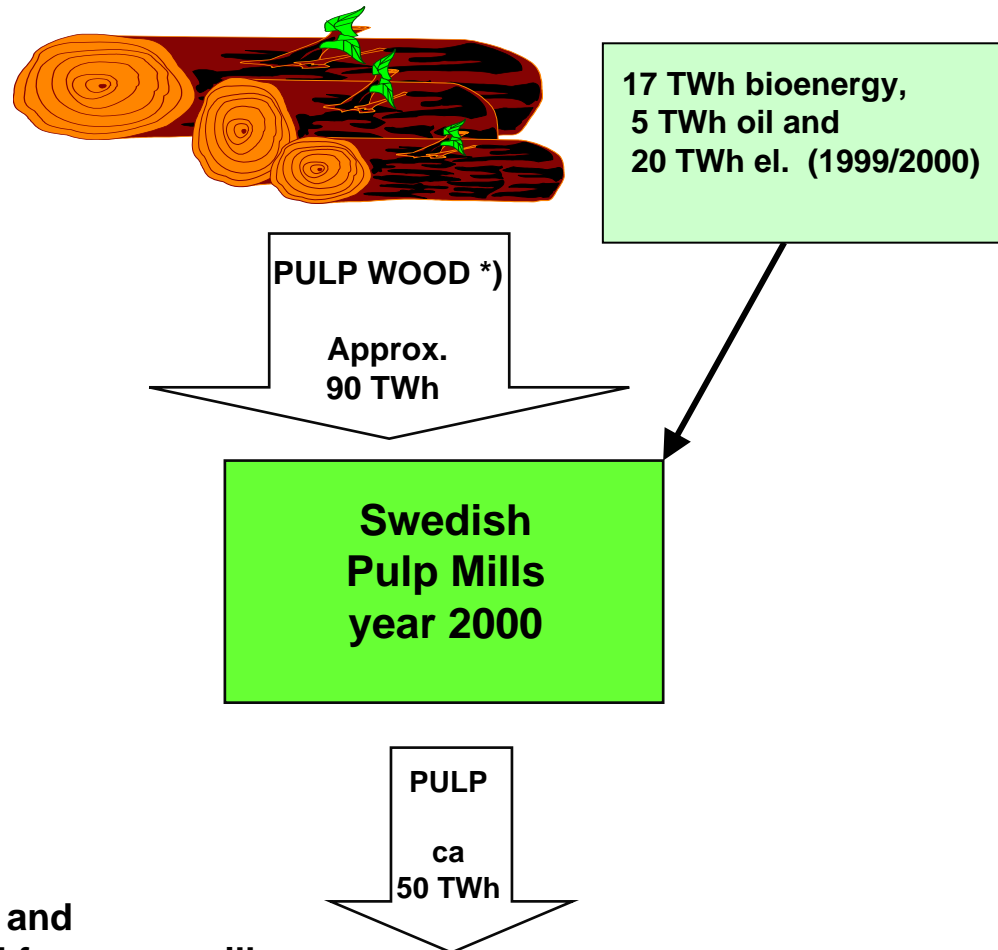
# Production potential in Sweden



\* Corresponds to approx. 30% of Swedish consumption of gasoline and diesel year 2000

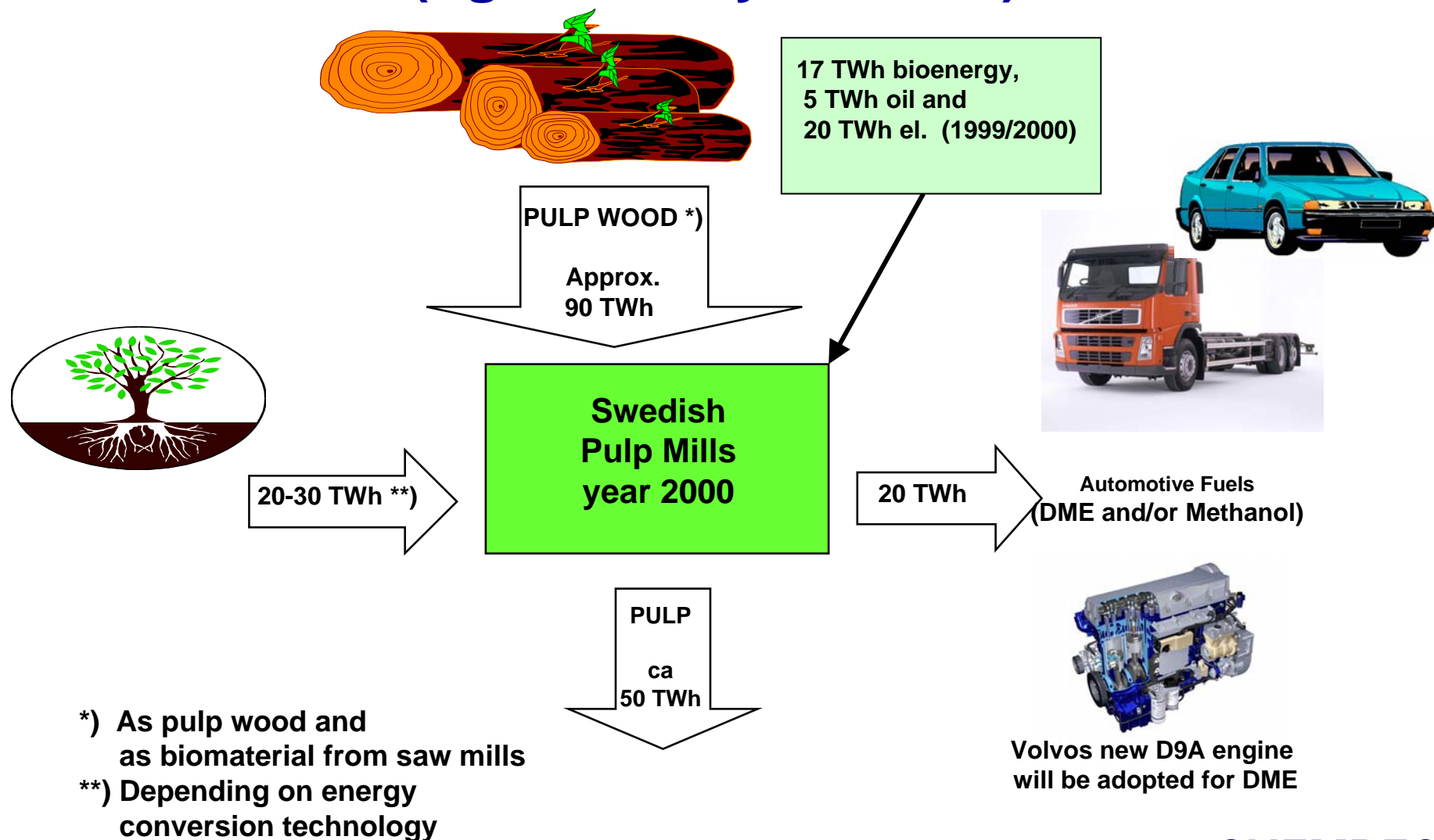


# Overall energy balance for all Swedish pulp Mills (figures for year 2000)



\*) As pulp wood and as biomaterial from saw mills

# Overall energy balance – Fuel generation at all Swedish pulp Mills using the BLGMF process (figures for year 2000)



\*) As pulp wood and as biomaterial from saw mills

\*\*) Depending on energy conversion technology

# Recovery Boilers in Canada

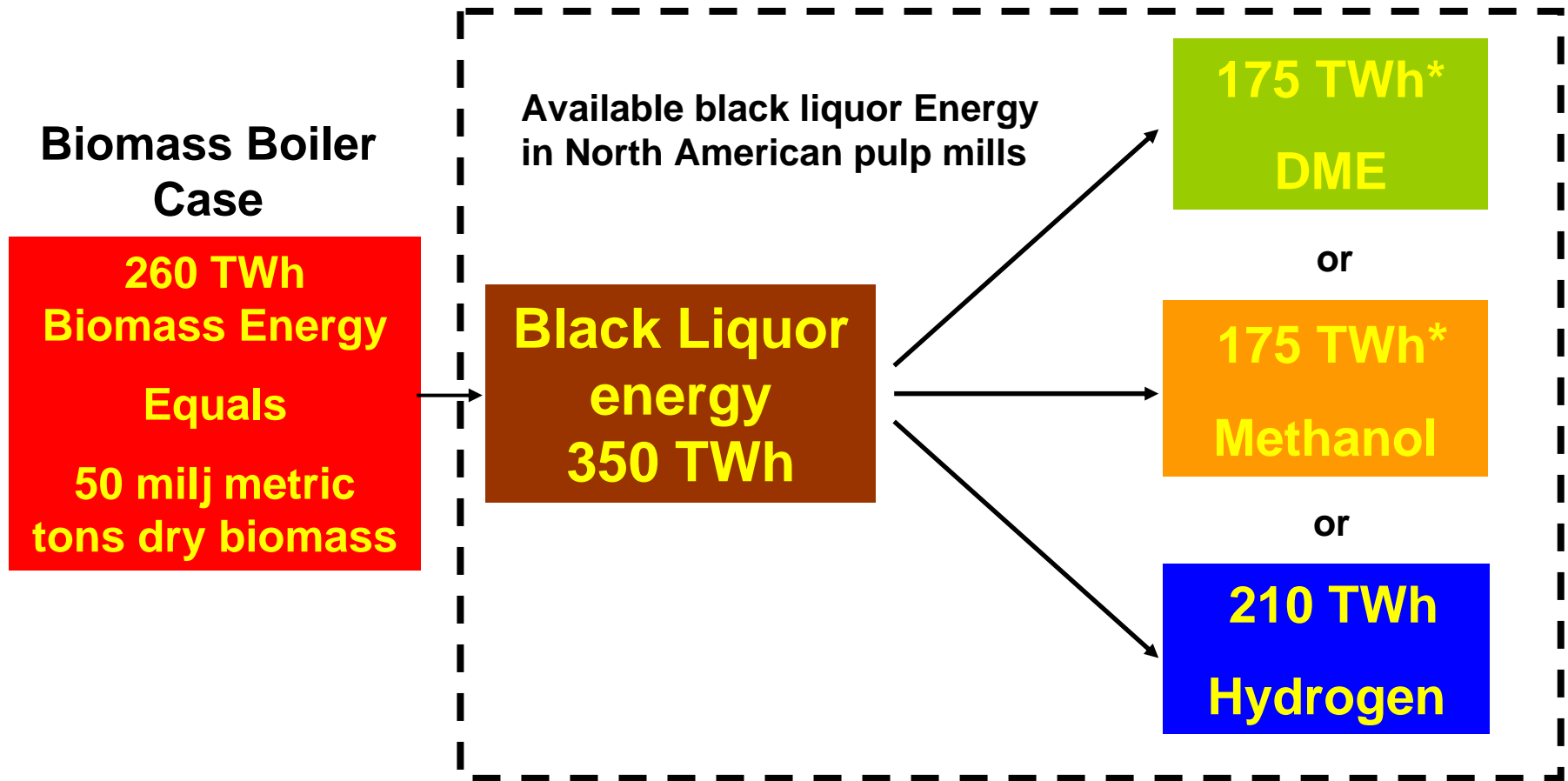
COUNTRY	COMPANY	GROUP	MILL	TOTAL PULP CAPACITY	CHEMICAL PULP CAPACITY	RECOVERY BOILERS	REC. BOILER CAPACITY (TDS/DAY)	REC. BOILER STARTUP YEAR	MOST RECENT REC. BOILER REBUILD	OTHER REC. BOILER REBUILDS
Canada	ABITIBI-CONSOLIDATED INC.	ABITIBI-CONSOLIDATED INC.	FORT FRANCES, ON	340	190	1	950	1971	1985	
Canada	ABITIBI-CONSOLIDATED INC.		TROIS RIVERES, QU	195	95	1	365	1947	1989	
Canada	ALBERTA-PACIFIC FOREST INDUSTRIES INC.		BOYLE, AL	505	505	1	2640	1993		
Canada	AV CELL INC.		ATHOLVILLE, NB	110	110	1	545	1983	1998	1995
Canada	AVENOR INC.	BOWATER CORPORATION	DRYDEN, ON	300	300	1	1160	1966		
Canada	AVENOR INC.		THUNDER BAY, ON	770	430	1	910	1966	1988	
Canada						1	1360	1976		
Canada	CANADIAN FOREST PRODUCTS LTD.	CANFOR CORPORATION	PRINCE GEORGE, BC (INTERCONTINENTAL PULP MILL)	255	255	1	1440	1968	1993	
Canada	CANADIAN FOREST PRODUCTS LTD.		PRINCE GEORGE, BC (PRINCE GEORGE PULP AND PAPER)	270	270	1	500	1983		
Canada						1	1090	1966	1966	
Canada	CARIBOO PULP & PAPER CO.		QUESNEL, BC	310	310	1	1810	1972	1994	1989
Canada	CASCADES EAST ANGUS INC.	CASCADES CORPORATION	EAST ANGUS, QU	60	60	1	295	1938		
Canada	CELGAR PULP CO.	STONE CONTAINER CORPORATION	CASTLEGAR, BC	420	420	1	2610	1993		
Canada	CRESTBROOK FOREST INDUSTRIES LTD.		SKOOKUMCHUCK, BC	215	215	1	1575	1993		
Canada	DAISHOWA MARUBENI INTERNATIONAL LTD.	DAISHOWA GROUP	PEACE RIVER, AL	390	390	1	1700	1990		
Canada	DOMTAR PAPERS	DOMTAR INC.	CORNWALL, ON	270	190	1	600	1959		
Canada	DOMTAR PAPERS		WINDSOR, QU	340	340	1	1480	1987		
Canada	DONOHUE INC.	DONOHUE INC.	ST. FELICIEU, QU	320	320	1	1360	1978		
Canada	E.B. EDDY FOREST PRODUCTS LTD.	E.B. EDDY CORPORATION	ESPANALDA, ON	342	342	1	1905	1983	1997	1991
Canada	EUROCAN PULP & PAPER CO.	WEST FRASIER TIMBER CO.	KITIMAT, BC	440	335	1	1540	1970	1989	1982
Canada	FLETCHER CHALLENGE CANADA LTD.	FLETCHER CHALLENGE CORPORATION	CAMPBELL RIVER, BC	770	340	1	710	1959		
Canada						1	1485	1963	1990	
Canada	FLETCHER CHALLENGE CANADA LTD.		CROFTON, BC	780	395	1	1080	1976	1992	
Canada						1	1800	1991		
Canada	FLETCHER CHALLENGE CANADA LTD.		MACKENZIE, BC	200	200	1	1280	1972	1985	
Canada	HARMAC PACIFIC INC.		NANAIMO, BC	380	380	1	1090	1963	1983	
Canada						1	540	1963	1997	1988
Canada						1	350	1951	1994	
Canada	HOWE SOUND PULP AND PAPER LTD.	CANFOR CORPORATION	PORT MELLON, BC	495	315	1	2990	1990		
Canada	INDUSTRIES JAMES MACLAREN INC.	NORANDA FOREST INC.	THURSO, QU	235	235	1	410	1990		
Canada						1	585	1984	1990	
Canada	IRVING PULP & PAPER LTD.	IRVING PULP & PAPER LTD.	SAINT JOHN, NB	285	285	1	1425	1970	1994	
Canada	JAMES RIVER - MARATHON LTD.	FORT JAMES CORPORATION	MARATHON, ON	170	170	1	990	1979	1989	1991
Canada	KIMBERLY-CLARK FOREST PRODUCTS INC.	KIMBERLY-CLARK CORPORATION	TERRACE BAY, ON	480	460	1	1090	1973	1997	
Canada						1	1090	1979	1996	
Canada	KIMBERLY-CLARK NOVA SCOTIA INC.		ABERCHROMBIE POINT, NS	245	245	1	1300	1967	1984	1981
Canada	MALETTE KRAFT PULP & POWER	TEMBEC CORPORATION	SMOOTH ROCK FALLS, ON	170	170	1	555	1965		
Canada						1	500	1982		
Canada	NORAMPAC INC.		RED ROCK, ON (CONTAINERBOARD MILL)	385	385	1	1090	1982		
Canada						1	1200	1997		
Canada	NORKRAFT QUEVILLON INC.	DOMTAR INC.	LEBEL-SUR-QUEVILLON, QU	280	280	1	1346	1997		
Canada	NORTHWOOD PULP AND TIMBER LTD.		PRINCE GEORGE, BC	515	515	1	1250	1966	1977	
Canada						1	1500	1982		
Canada	PACIFICA PAPERS INC.		POWELL RIVER, BC (POWELL RIVER DIVISION)	660	190	1	1090	1967	1985	
Canada	REPAP NEW BRUNSWICK INC.	REPAP ENTERPRISES INC.	NEWCASTLE, NB	235	235	1	1215	1967	1991	
Canada	SKEENA CELLULOSE INC.		PRINCE RUPERT, BC	450	450	1	1170			
Canada						1	1575			
Canada	ST. ANNE-NACKAWIC PULP COMPANY LTD.	PARSON & WHITTEMORE CORPORATION	NACKAWIC, NB	240	240	1	910			
Canada	ST. LAURENT PAPERBOARD INC.	ST. LAURENT PAPERBOARD INC.	LATUQUE, QU	445	445	1	1575			
Canada						1	585			
Canada						1	450			
Canada	STONE CONTAINER (CANADA) INC.	STONE CONTAINER CORPORATION	NEW RICHMOND, QU	200	200	1	750			
Canada	STONE CONTAINER (CANADA) INC.		PORTAGE DU FORT, QU			1	915			
Canada	TOLKO MANITOBA		THE PAS, MA	125	125	1	635			
Canada	WELDWOOD OF CANADA LIMITED	CHAMPION INTERNATIONAL CORP.	HINTON, AL	385	385	1	1090			
Canada						1	1215			
Canada	WESTERN PULP LIMITED PARTNERSHIP		SQUAMISH, BC	240	240	1	1755			
Canada	WEYERHAEUSER CANADA LTD.	WEYERHAEUSER CORPORATION	GRANDE PRAIRIE, AL	320	320	1	1550			
Canada	WEYERHAEUSER CANADA LTD.		KAMILOOPS, BC	440	440	1	410			
Canada						1	2040			
Canada	WEYERHAEUSER CANADA LTD.		PRINCE ALBERT, SA (PRINCE ALBERT PULP & PAPER MILL)	340	340	1	1040	1968	2000	
Canada						1	585	1977		
SUM CANADA				15322	13062		72026	1974		

72026 tpd  
 <=>  
 95 TWh/yr

# Pulp and Paper Mills in Canada



# Production Potential – North America



\* Corresponds to 7% of Canadian plus 2% of US automotive fuels consumption

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# The “BLGMF” Study

## Supported by the EU Altener II Program and the Swedish National Energy Administration

- **Duration:** Feb 2002 - Nov 2003
- **Total cost:** €400,000
- **Contents:**
  - Process design
  - Mill integration
  - Energy balances
  - Cost estimate
  - Market barriers

# BLGMF Study Project Partners



Process engineering consultant



Research centre for pulp and papermaking



National gasoline and oil distributor



Automotive fuel and engine consultant



Gasification technology supplier



World's largest methanol producer and distributor

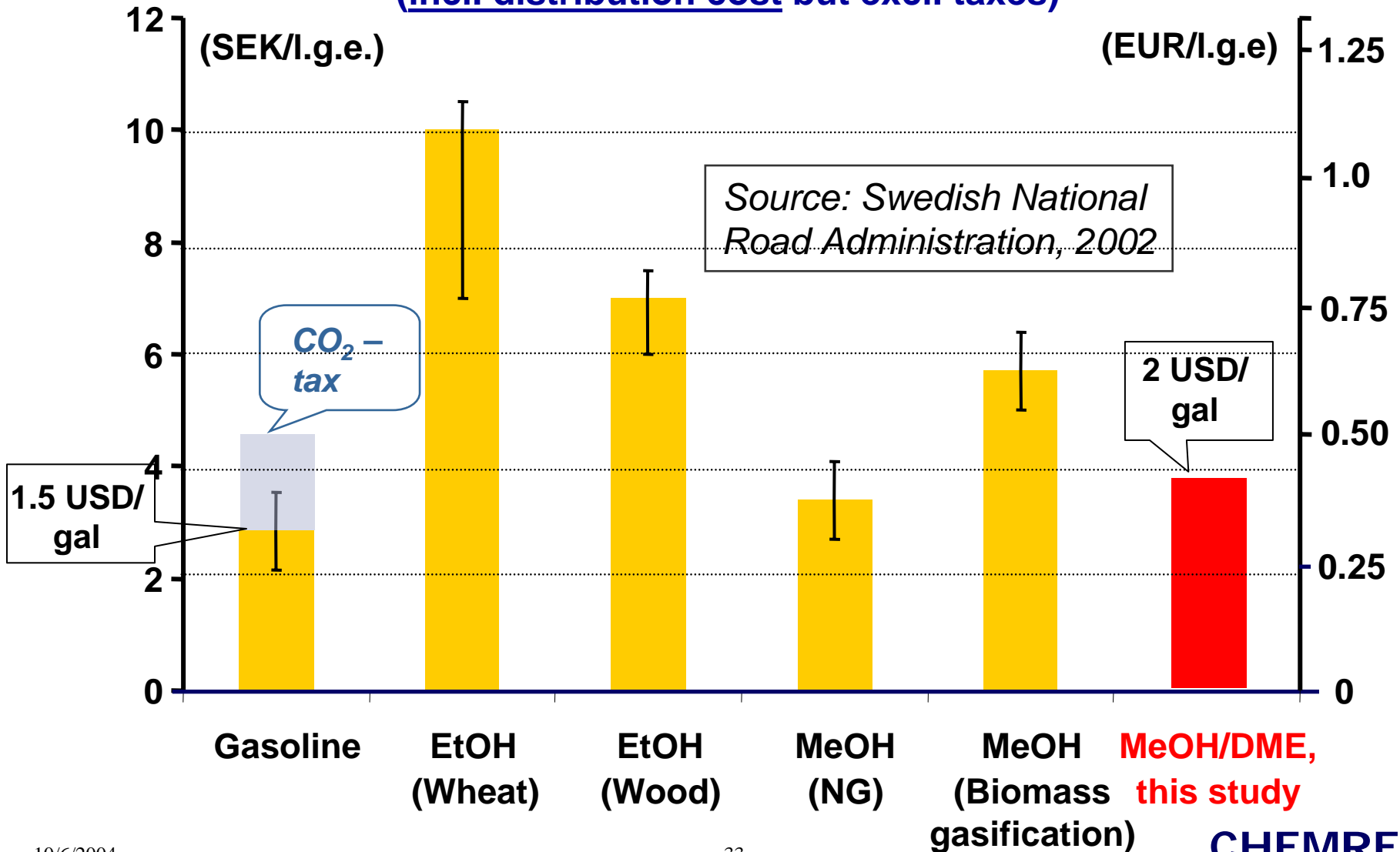


World-known automotive and engine developer

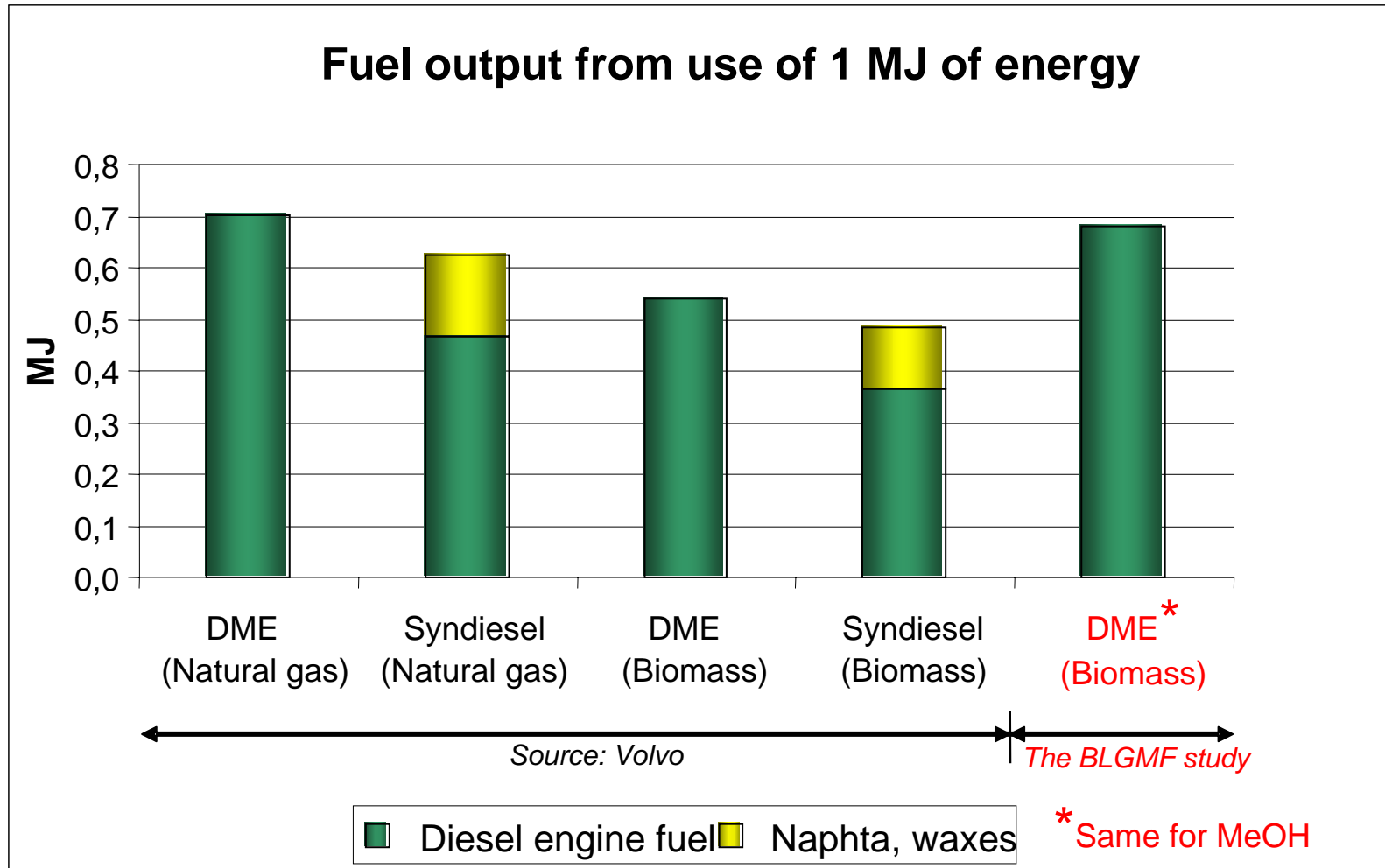


# Cost of fuel at pump, EUR or SEK per liter gasoline equivalent

(incl. distribution cost but excl. taxes)



# Fuel output from use of 1 MJ of energy

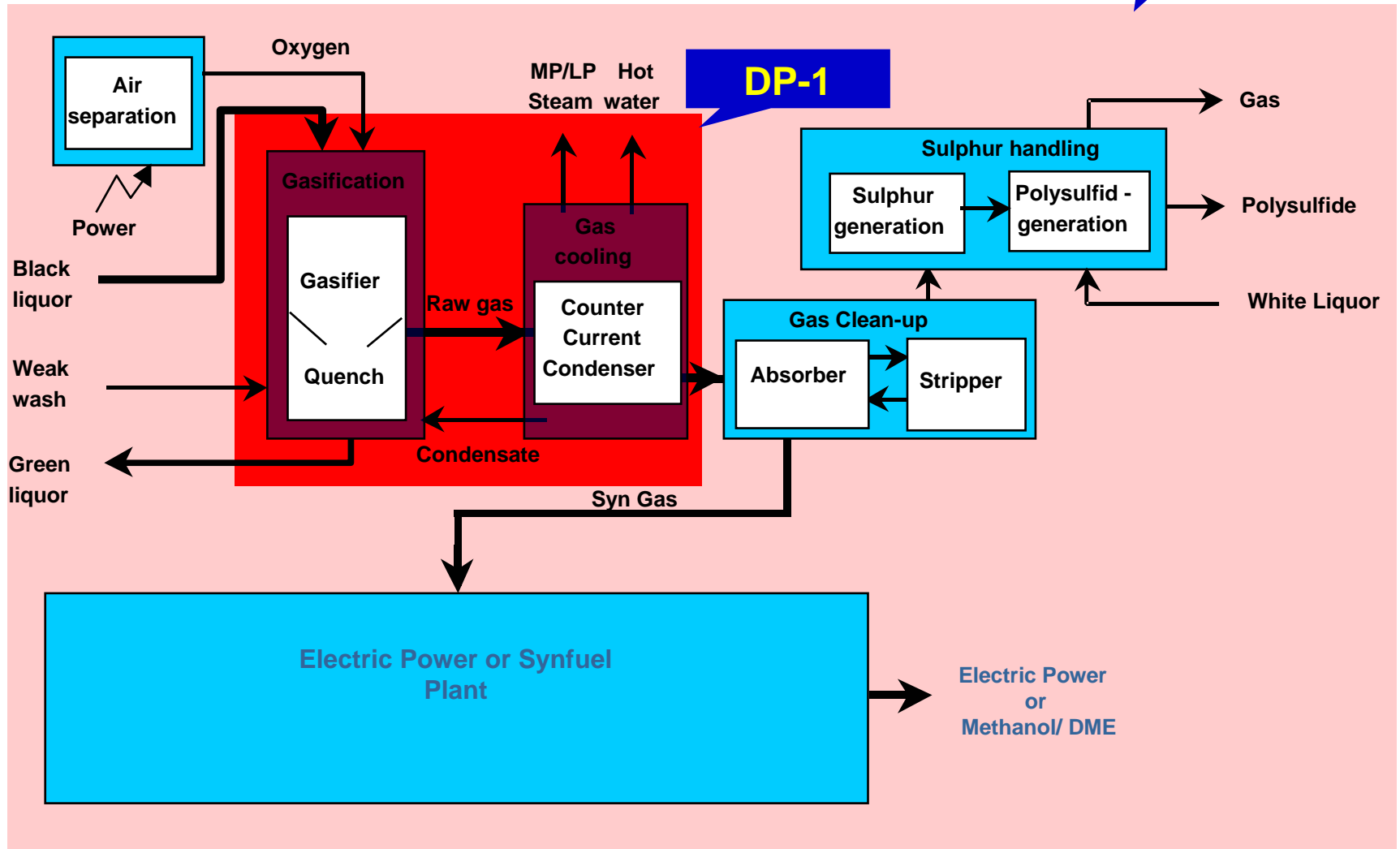


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# Pressurised BLG Development

DP-2



# CHEMREC DEVELOPMENT PLANTS

## DP-1 & DP-2

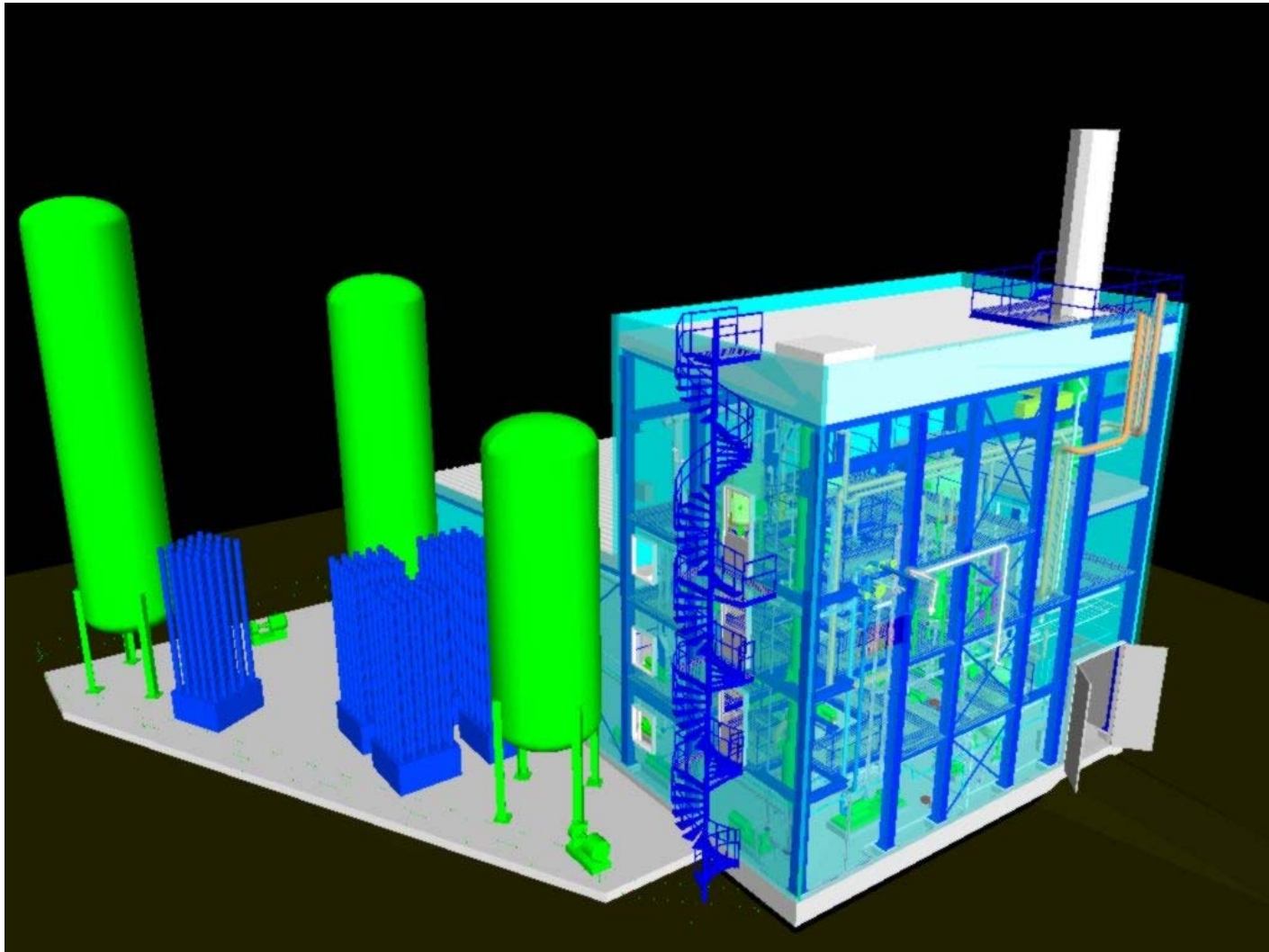
Plant	Location	Process Units	Capacity tDS per d / MW <sub>t</sub>	Pressure (bar)	Purpose
DP1*)	Piteå, North Sweden	<ul style="list-style-type: none"> <li>- Gasification</li> <li>- Gas Cooling</li> <li>- Gas Cleaning</li> </ul>	20 / 3	32	<ul style="list-style-type: none"> <li>- Verify Plant technical features.</li> <li>- Secure performance for DP-2</li> </ul>
DP2*)	Kappa Kraftliner Piteå	<ul style="list-style-type: none"> <li>- Full BLGCC concept</li> </ul>	~300 / 45	32	<ul style="list-style-type: none"> <li>- Fully develop the BLGCC concept.</li> <li>- Net product approx .10 MW<sub>e</sub> and 35 t/h of steam.</li> </ul>

\*) Plant Investments Supported by a Grant  
from the Swedish Government of 238 MSEK, approx 25 Mill €

# CHEMREC'S DP-1 PLANT AT PITEÅ



# DP1 Piping Model – From the mill side



# Time Schedule Pressurized BLG Development

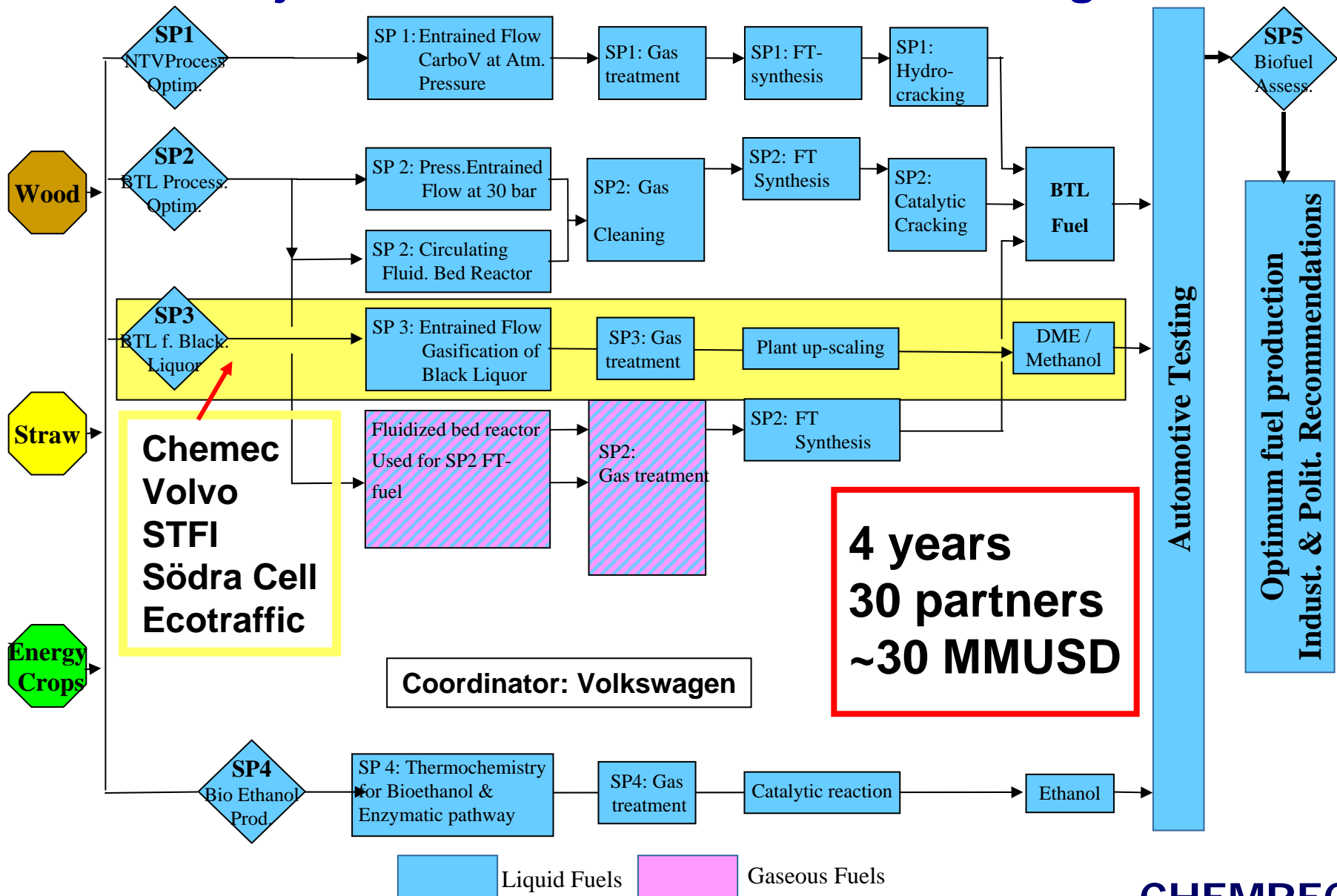
Activity	Quarter	2004				2005				2006				2007				2008				
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
<b>DP-1, Piteå, Sweden</b>																						
• EPC		█																				
• Operation						█																
<b>Demos in Sweden</b>																						
• DP-2 BLGCC, Piteå						█	█	█	█										█			
• DP-3 BLGMF, Mörrum							█	█	█	█										█		
<b>CD, USA *</b>										█	█	█	█									
<b>Commercialisation</b>														█	█	█						

\*) A US CD-plant project is planned to start after evaluation of Swedish DP-1 operating results

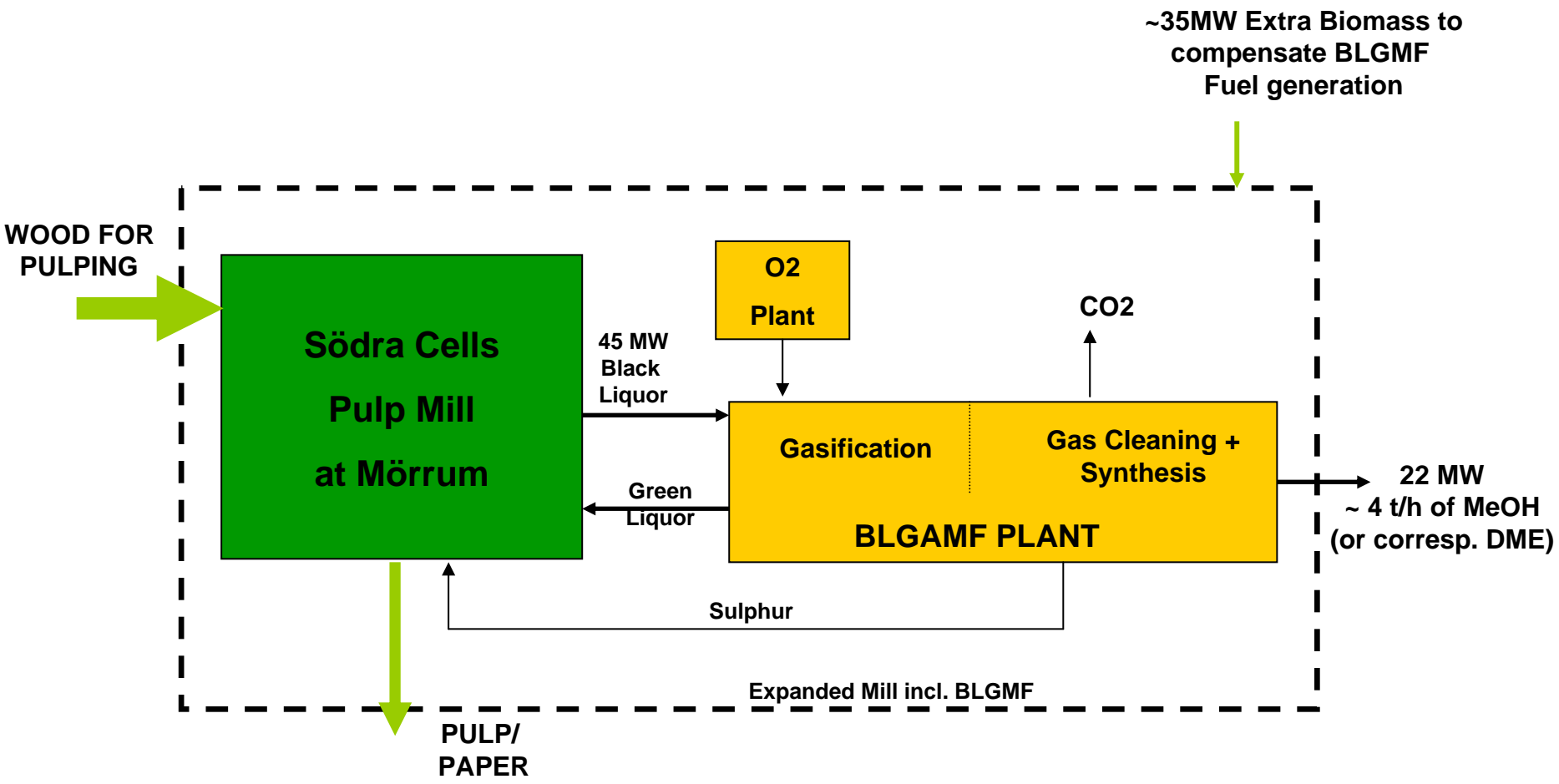


# The RENEW Project: Biomass to Liquid Fuels

## A Project within EU's 6th Framework Program



# Overall Concept for the SP3 BLGMF Plant



# Renew SP3

**SP3 will determine technical and commercial impact of locating a small BLGMF plant at a pulp mill**

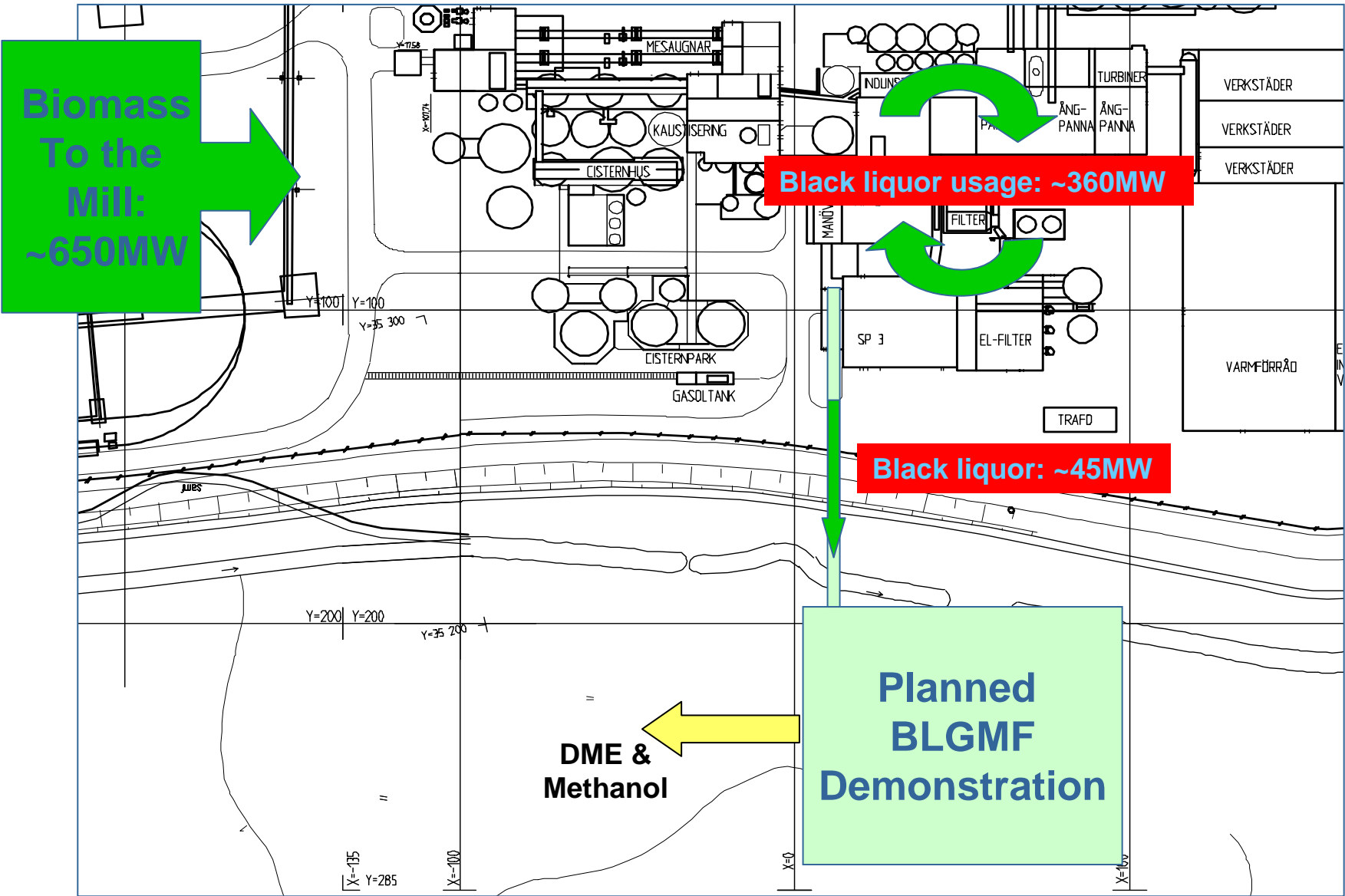
**Key input from work at four locations:**

- 1. Chemrec's Development Plant under construction in Piteå, north Sweden – Start-up 4th quarter 2004**
- 2. Södra Cell's pulp Mill in Mörrum, South Sweden**
- 3. STFI laboratories in Stockholm**
- 4. VOLVO Engine Development Laboratories in Gothenburg**

# Södra Cell Mörrum Mill



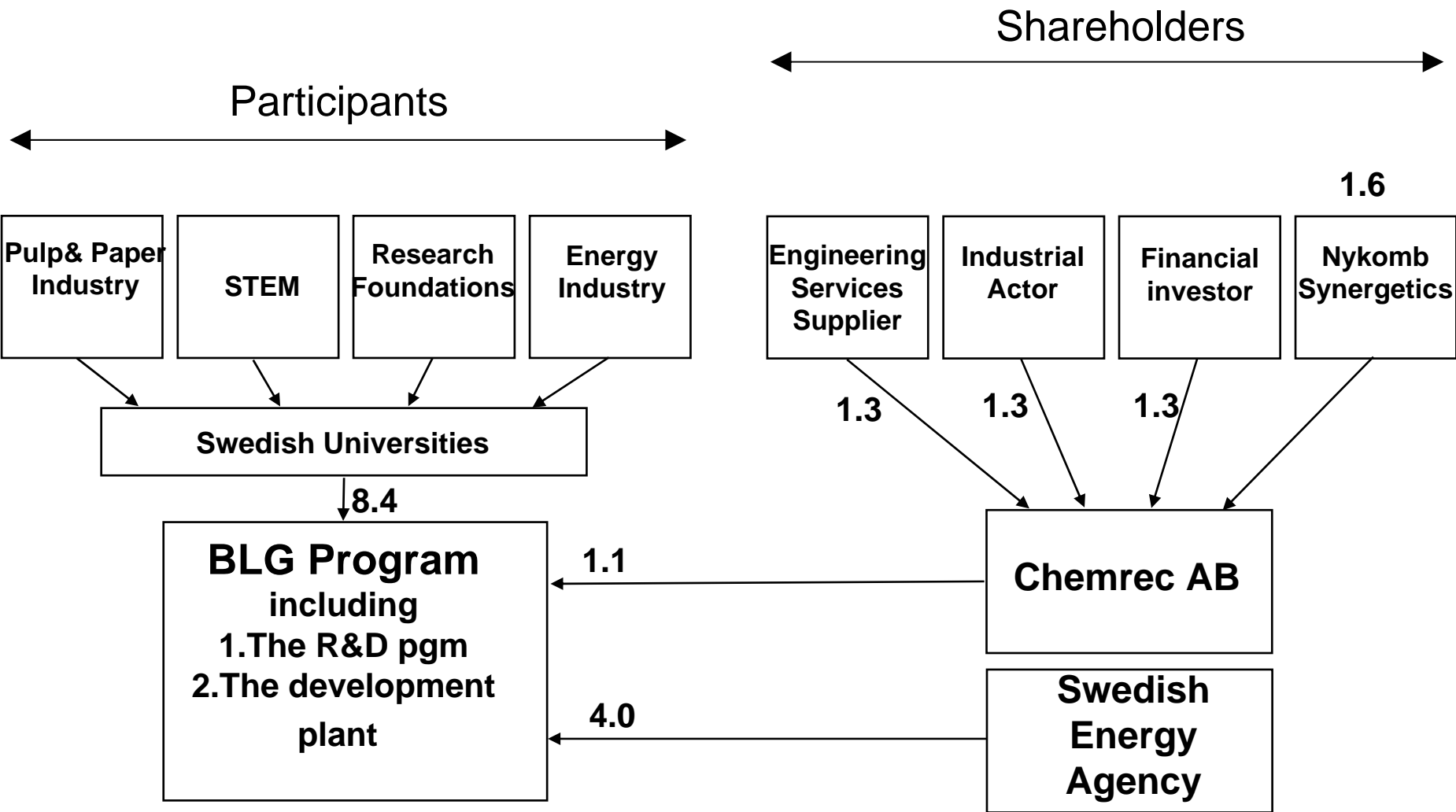
# Södra Cell Mörrum Mill with Planned BLGMF Plant



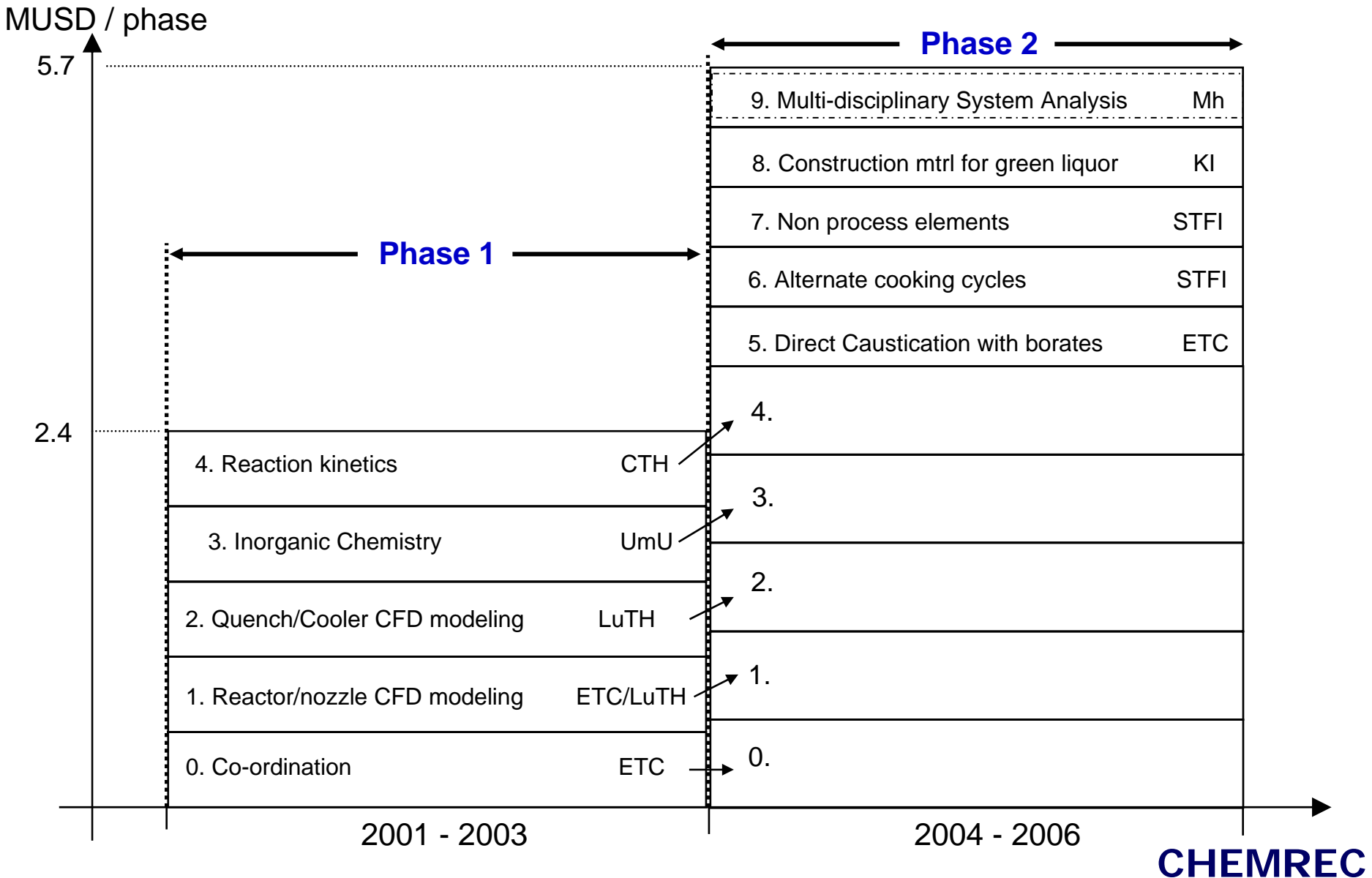
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# Chemrec New Financial Structure (Capital Requirement, MUSD)



# Two Phases in the BLG R&D Program

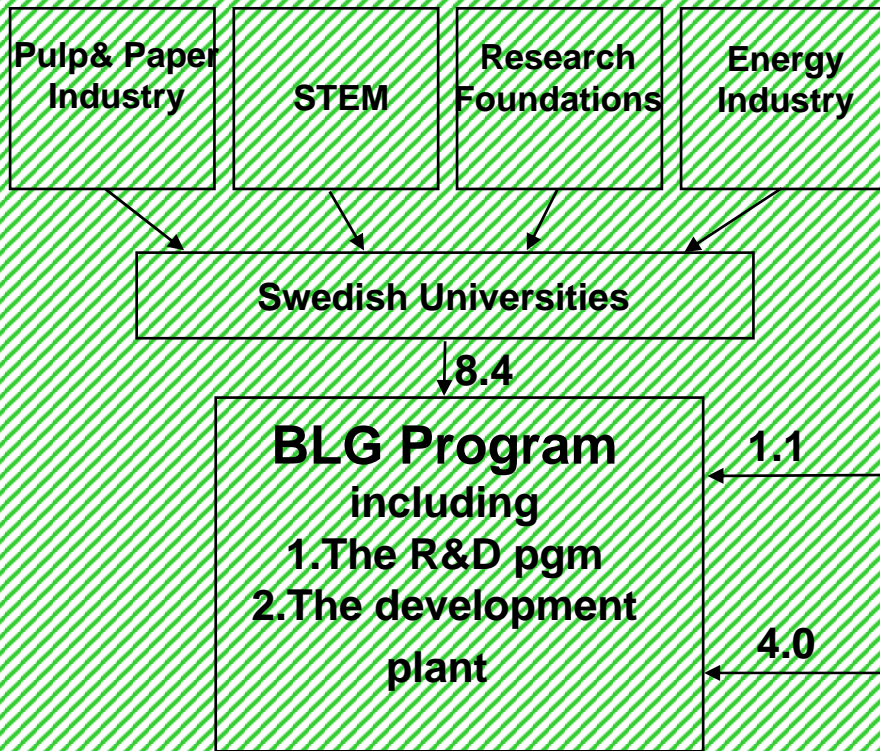




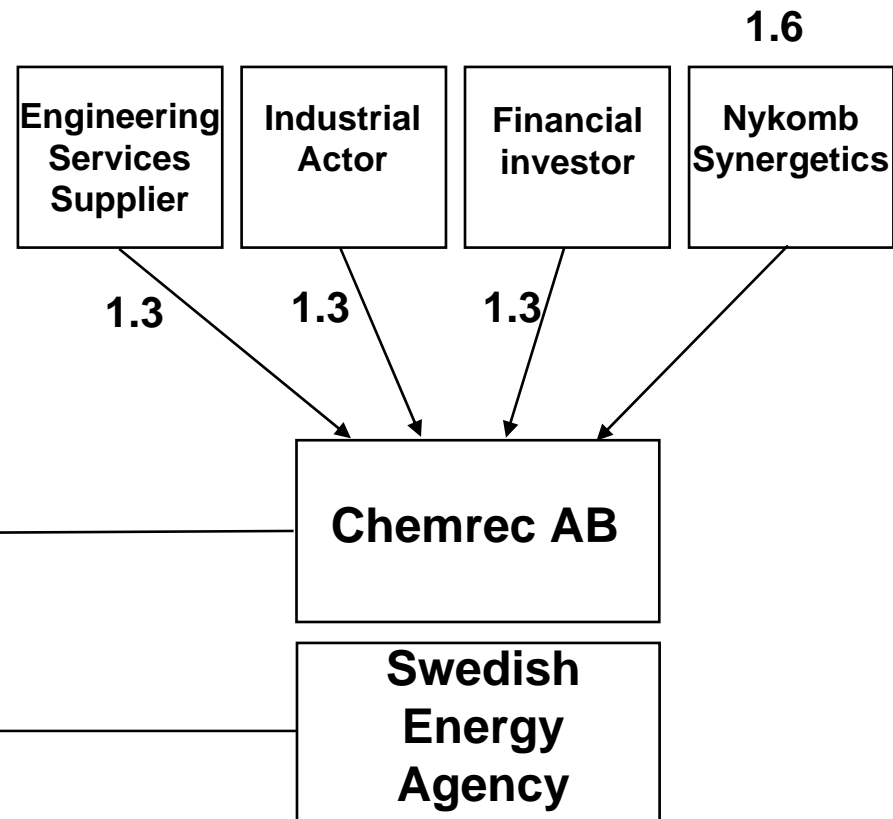
# Chemrec New Financial Structure (Capital Requirement, MUSD)

## Financing in Place

### Participants



## Shareholders



# Chemrec Pitea BLG User Group

## Nordic Companies:

- **Kappa Kraftliner**
- **SCA**
- **SVEASKOG**
- **Södra Cell**
- **Vattenfall**

## Status re. User Group participation

Provides land for DP-1 and favourable media supply

Committed to contribute cash and in kind

Committed to contribute cash

Committed to contribute cash and participates with Chemrec in Renew EUproject

Committed to contribute cash

# Chemrec Pitea BLG User Group

## North American Companies:

- Weyerhaeuser
- International Paper
- Georgia Pacific
- StoraEnso NA
- Mead Westvaco

## Status re. User Group participation

Since several years these companies work together with the DOE in the area of biomass and black liquor gasification. Meetings have been held in June and July, 2004 for definition of a novel "US Biorefinery concept"

**Objective:** The above companies discuss to formalize a USBLG consortium in a legal entity owned jointly by the companies and partly funded by the DOE. Chemrec AB hope that the consortium during the second half 2004 will negotiate participation in Chemrec's DP-1 effort in Piteå.

# One solution! Questions?

