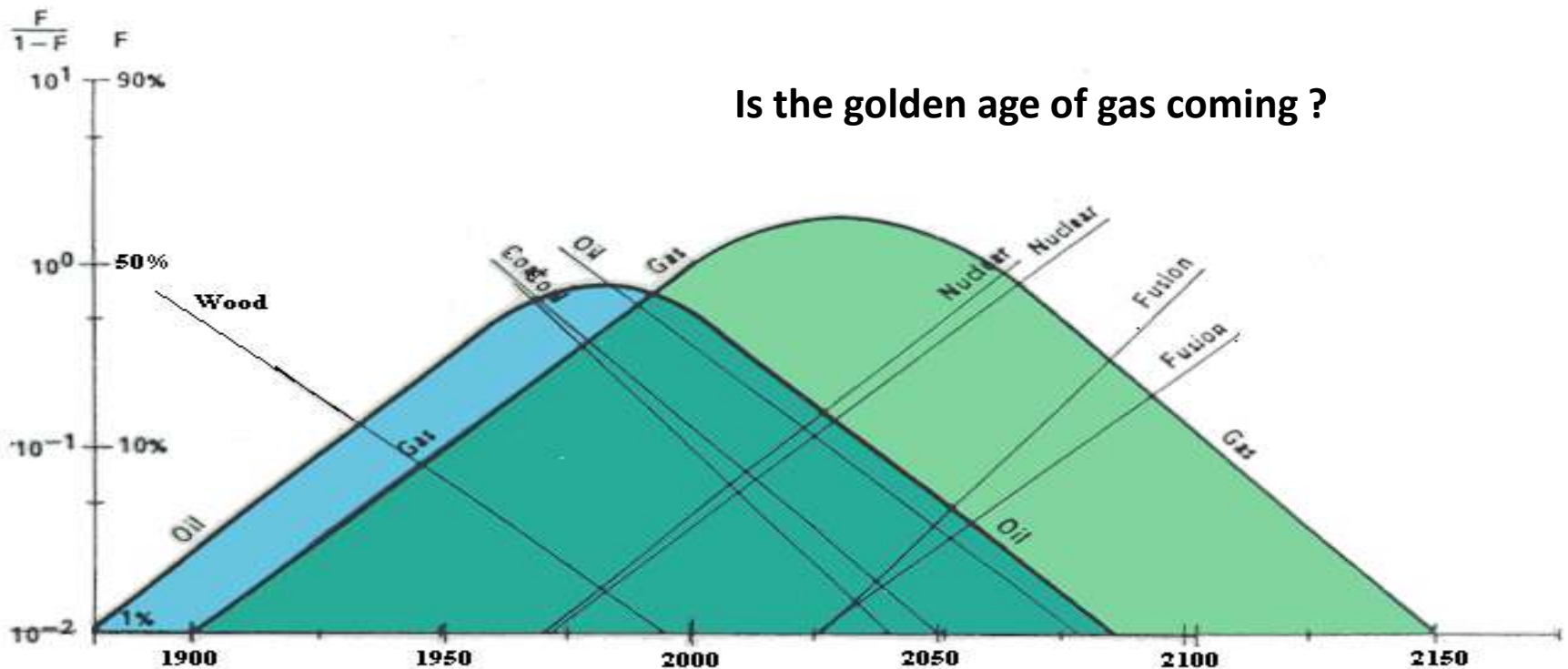


Chemicals and Fuels from (Natural) Gas

Alfred Ecker

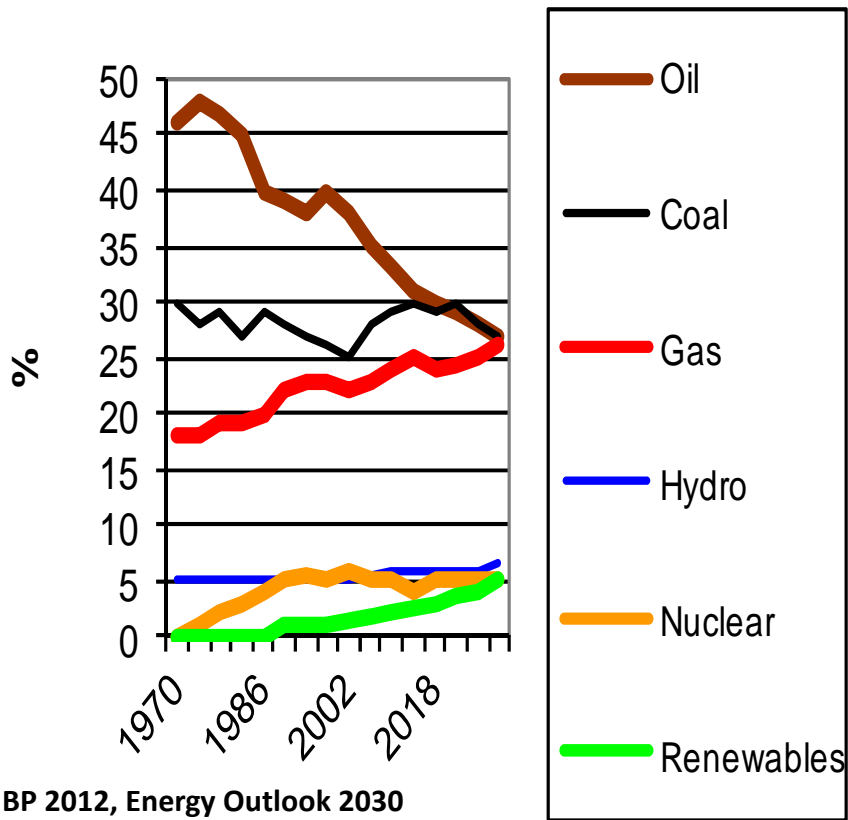
Life cycles of oil and gas

■ World Oil Life Cycle
■ World Gas Life Cycle

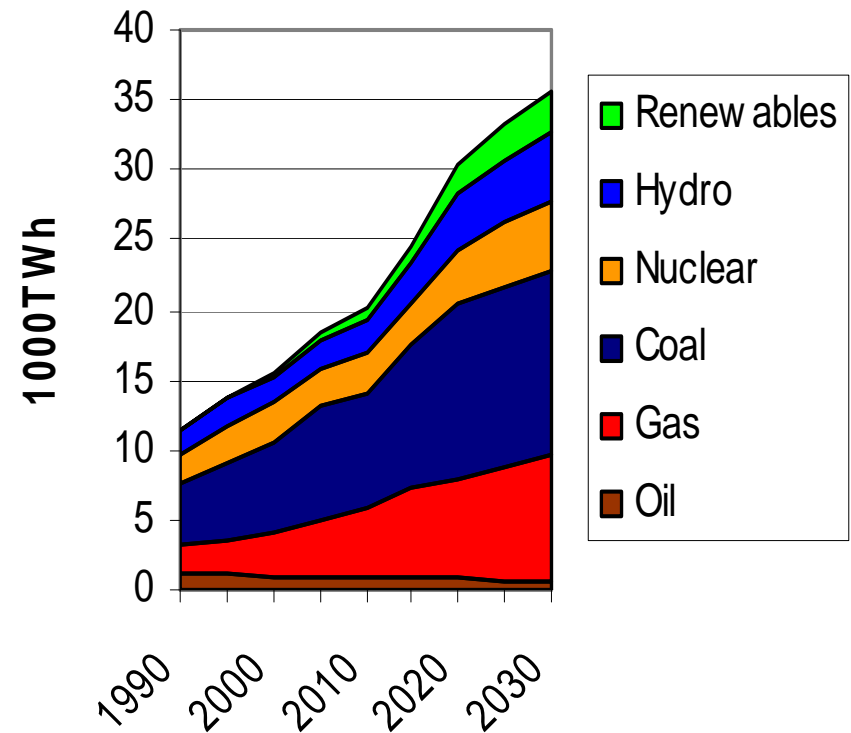


- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Shares of world primary energy

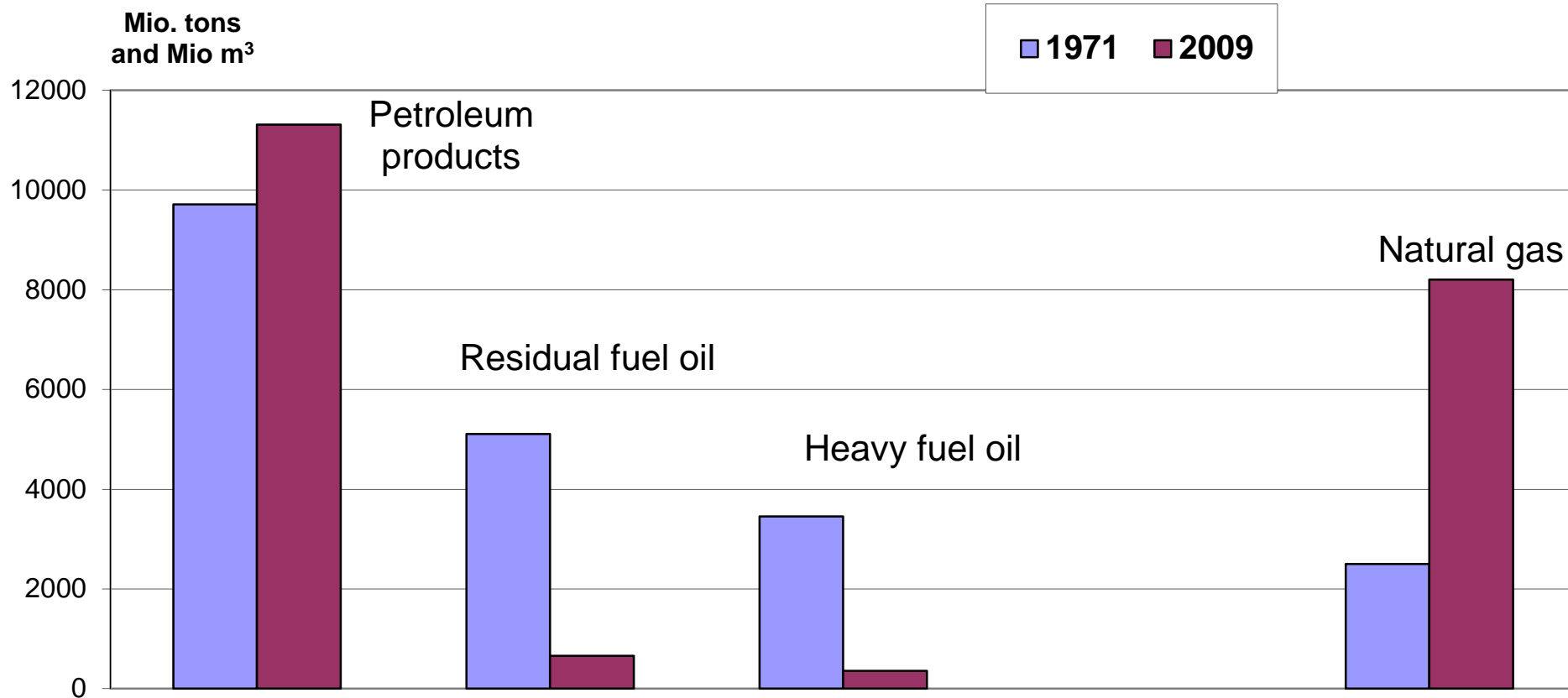


World power generation



- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Petroleum products and natural gas consumption in Austria



- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Advantages and disadvantages of gas

Advantages

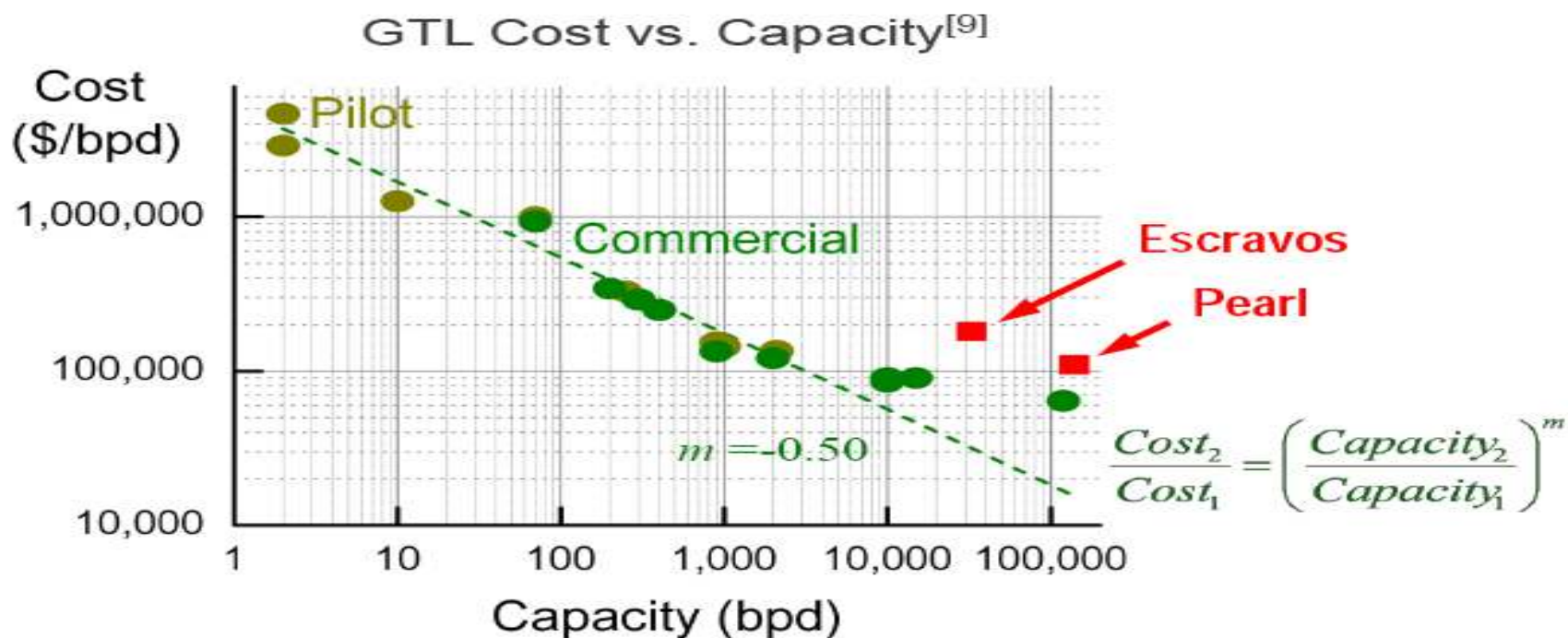
- Minimum C and CO₂
- Maximum H
- Cleaner than coal and oil
- Easily to convert
- Scale up possible
- Huge Resources

Disadvantages

- Gaseous, low energy density (transport, storage)
- Expensive building and operating a distribution system
- Volatile- Green house gas (CO₂ X 20)
- No commercial direct route to liquid fuels
- Not renewable

- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

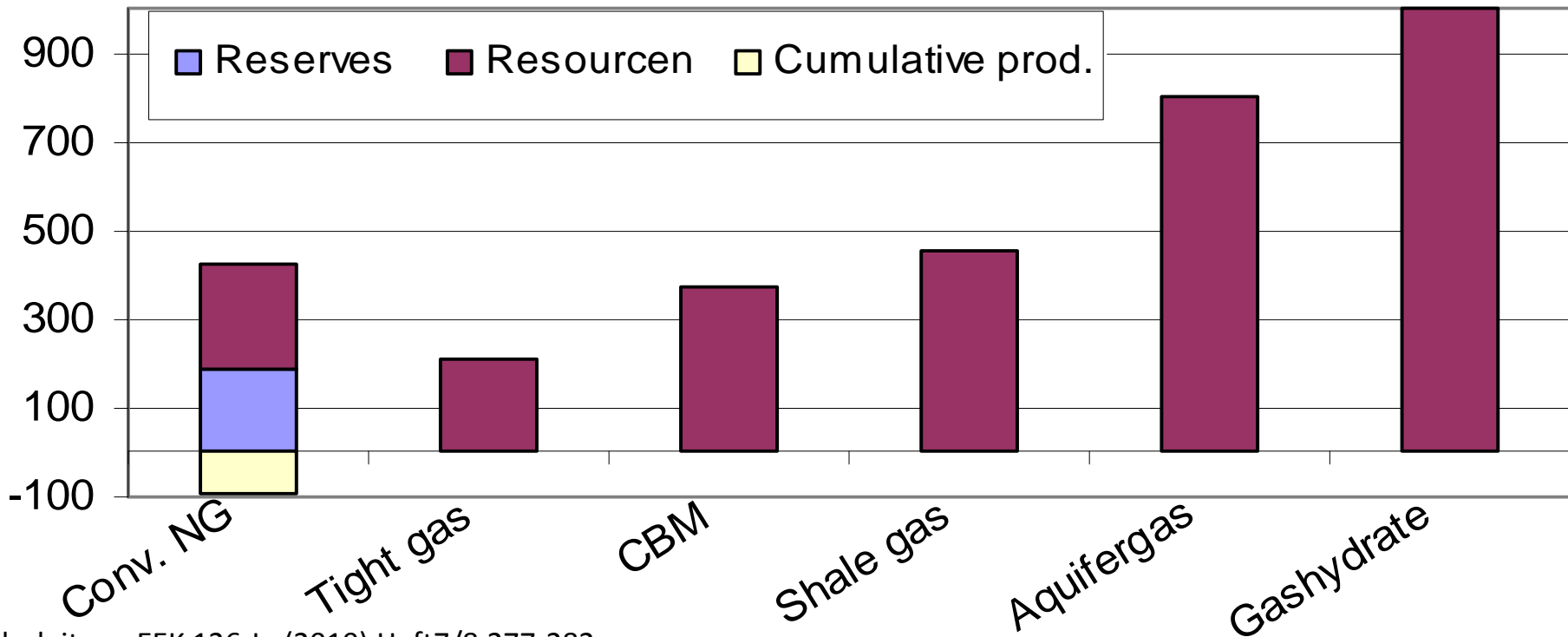
ECONOMIES OF SCALE



[9] PJA Tijm. *Gas to liquids, Fischer-Tropsch, advanced energy technology, future's pathway*. Feb 2010.

- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Natural gas Reserves and Resources in Tera (10^{12}) m^3

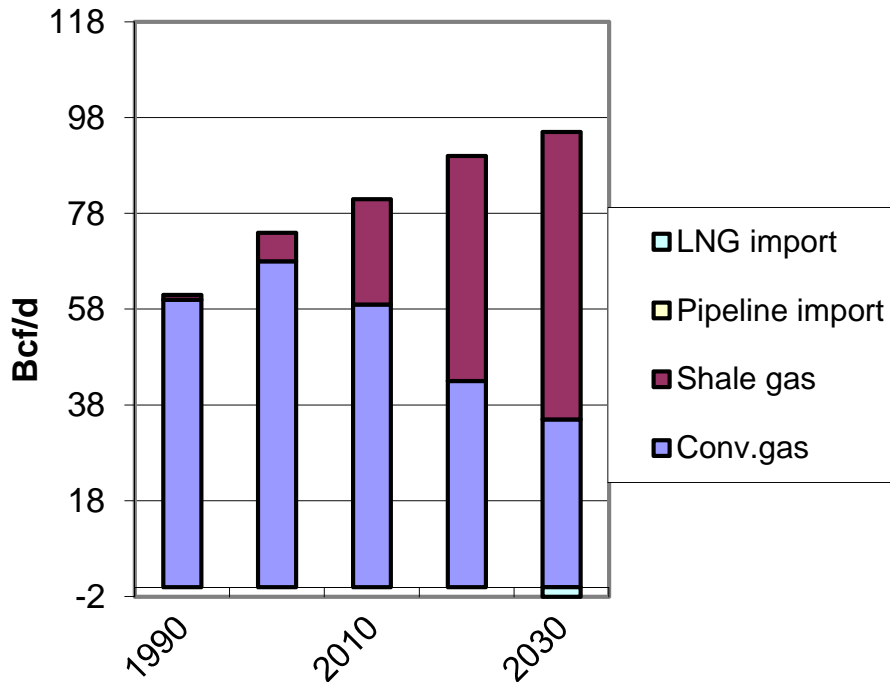


Andrleit a.o;EEK 126.Jg.(2010),Heft7/8,277-282

- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Sources of gas supply North America versus Europe

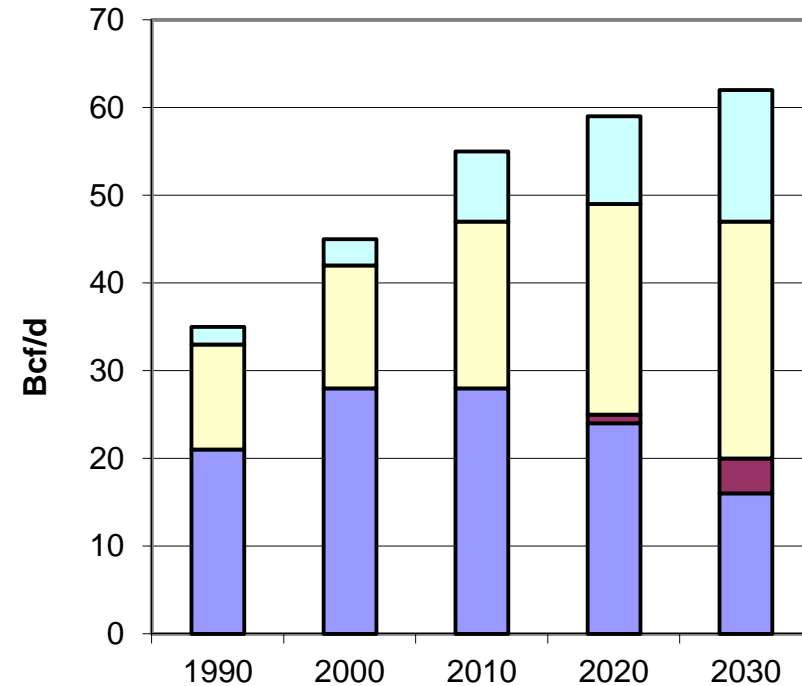
North America



BP 2012, Energy Outlook 2030

- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Europe



Leoben, 2012-09-21
 A.Ecker

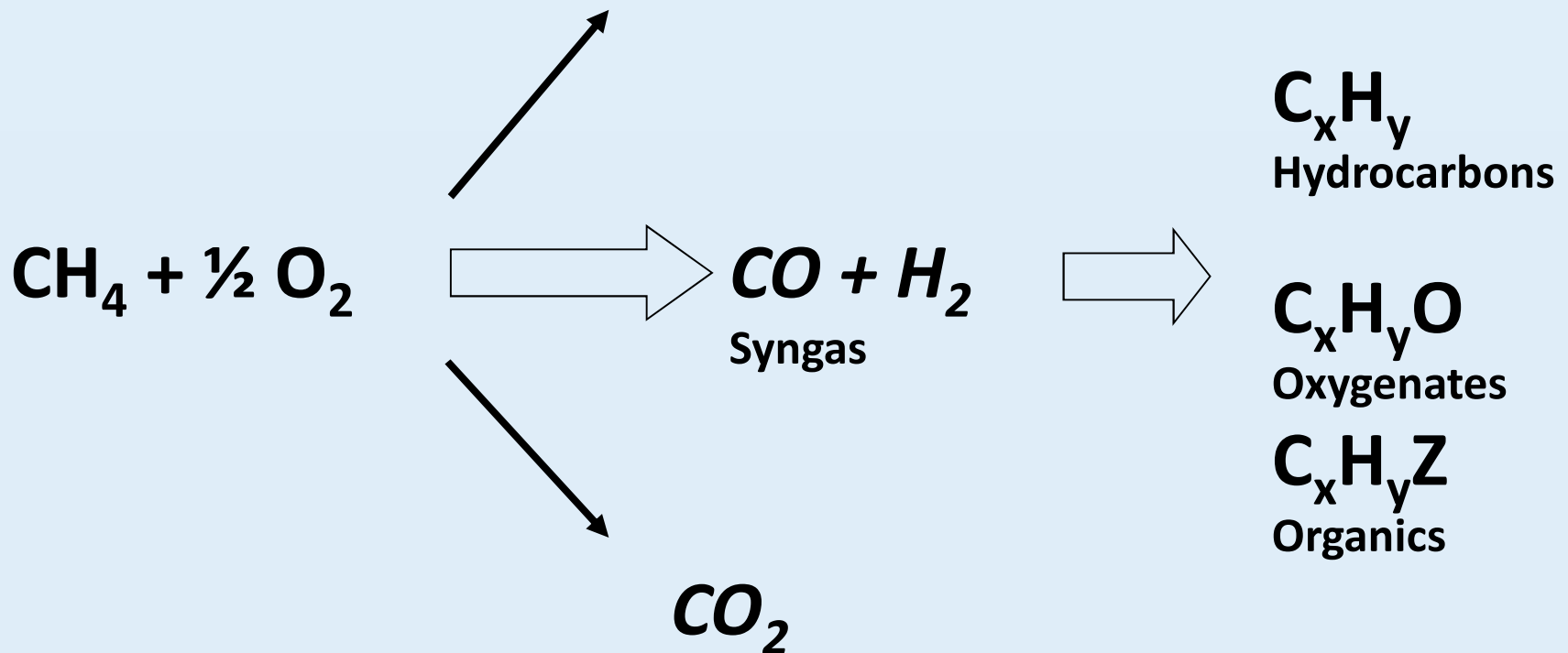
Natural Gas (Henry Hub) Chart in Dollar



- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

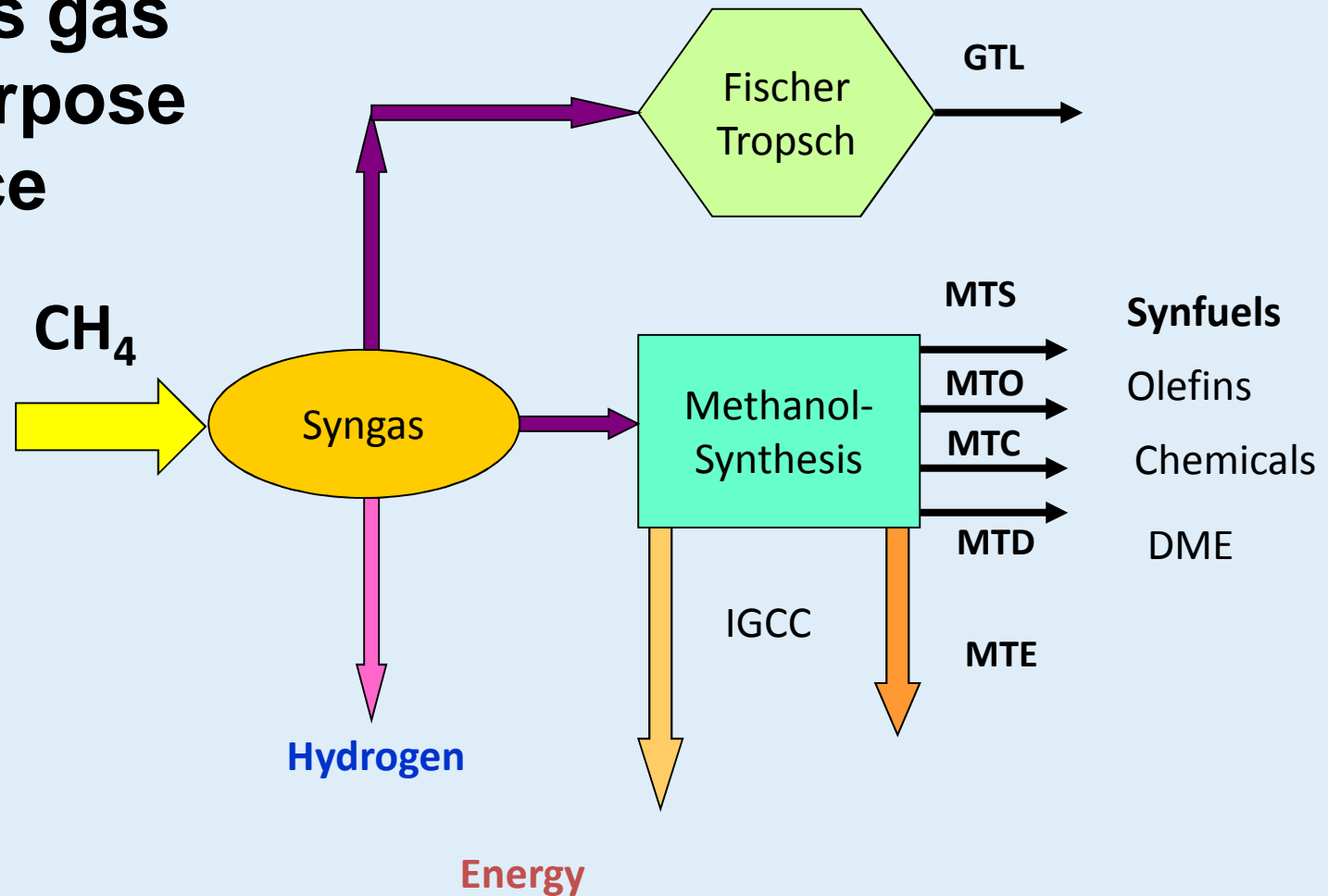
Direct reactions of methane have no selectivity !!

CH₄O, CH₂O, CH₂O₂, CO, CO₂ ?



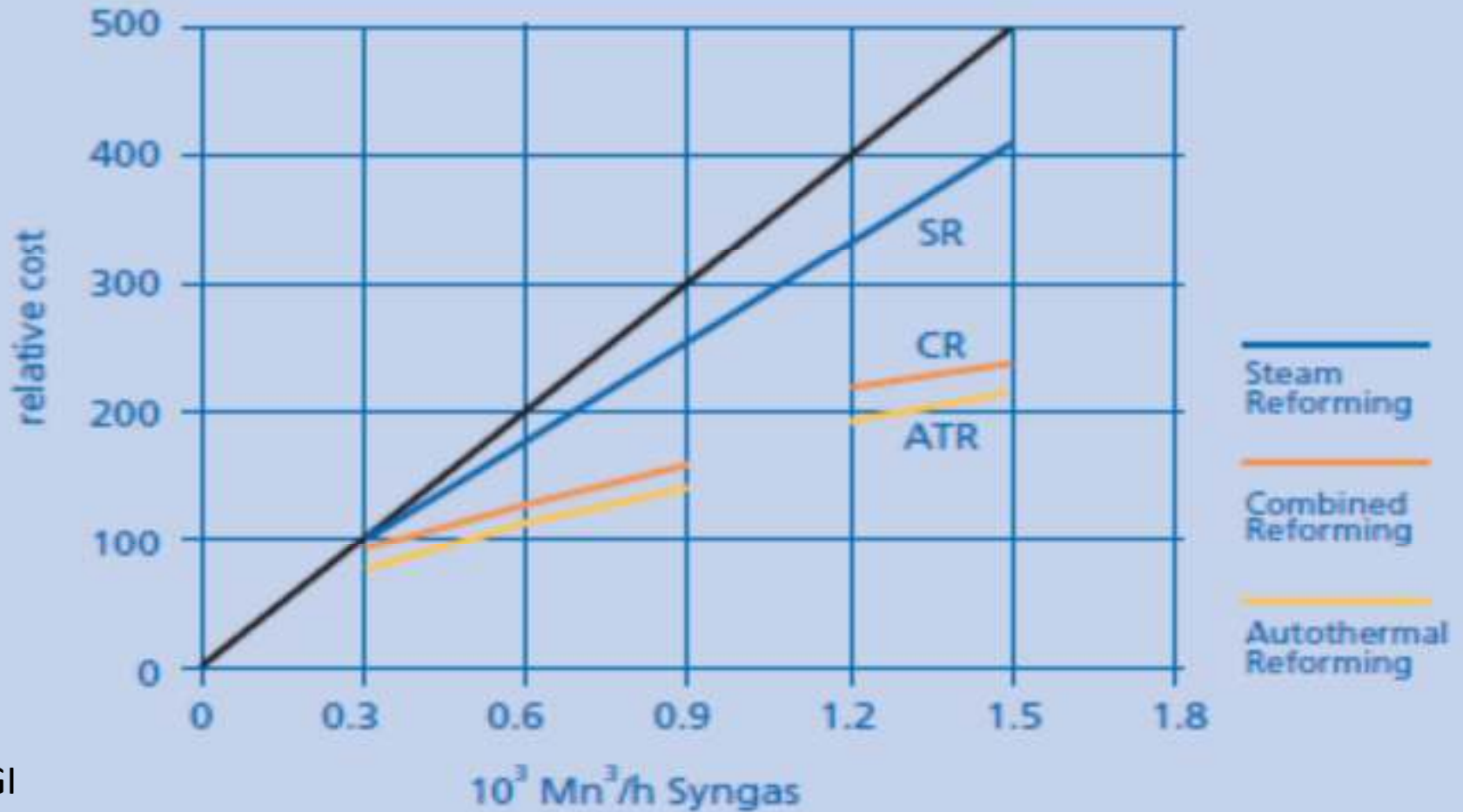
- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Synthesis gas a multipurpose source



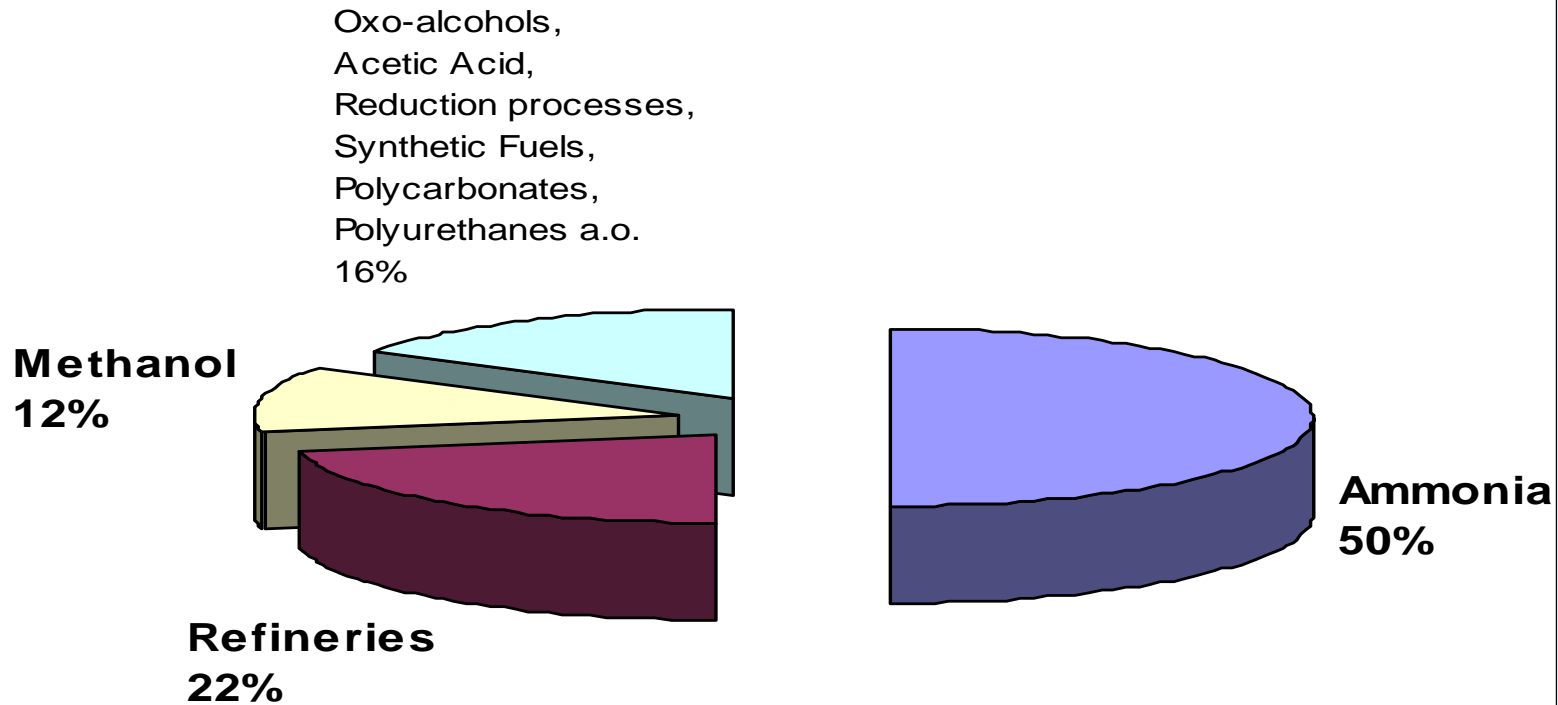
- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Reforming processes



LURGI

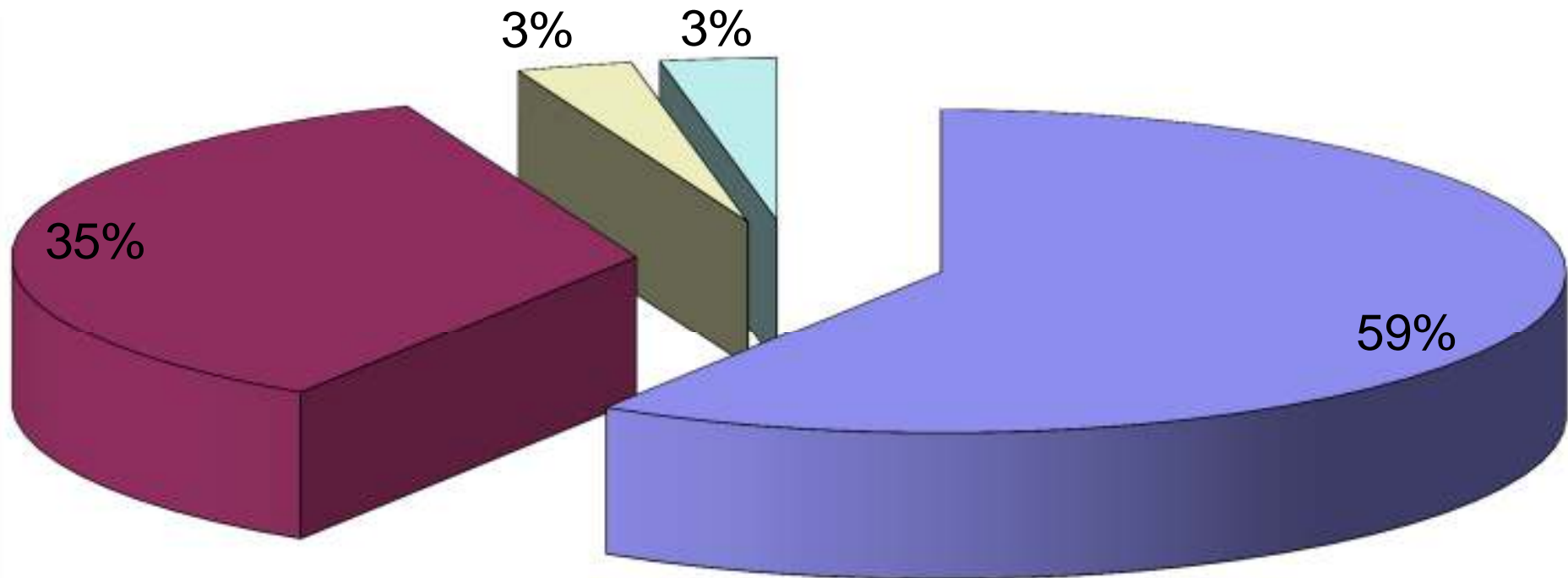
- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas



World consumption of Syngas

- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Hydrogen production in refineries



■ Steam Reforming

■ Partial Oxidation

■ Gas Purification

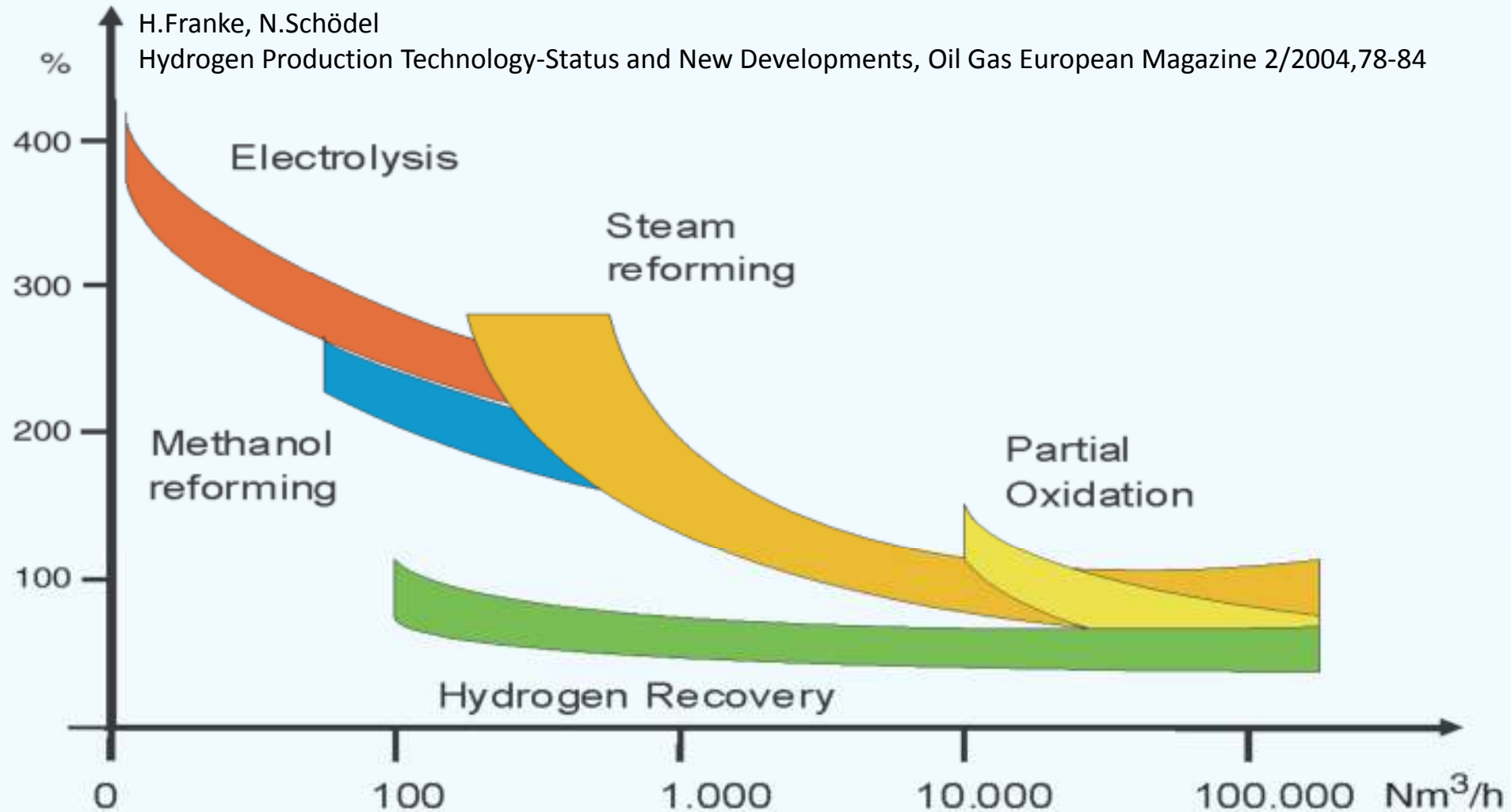
■ Others

- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Hydrogen production costs

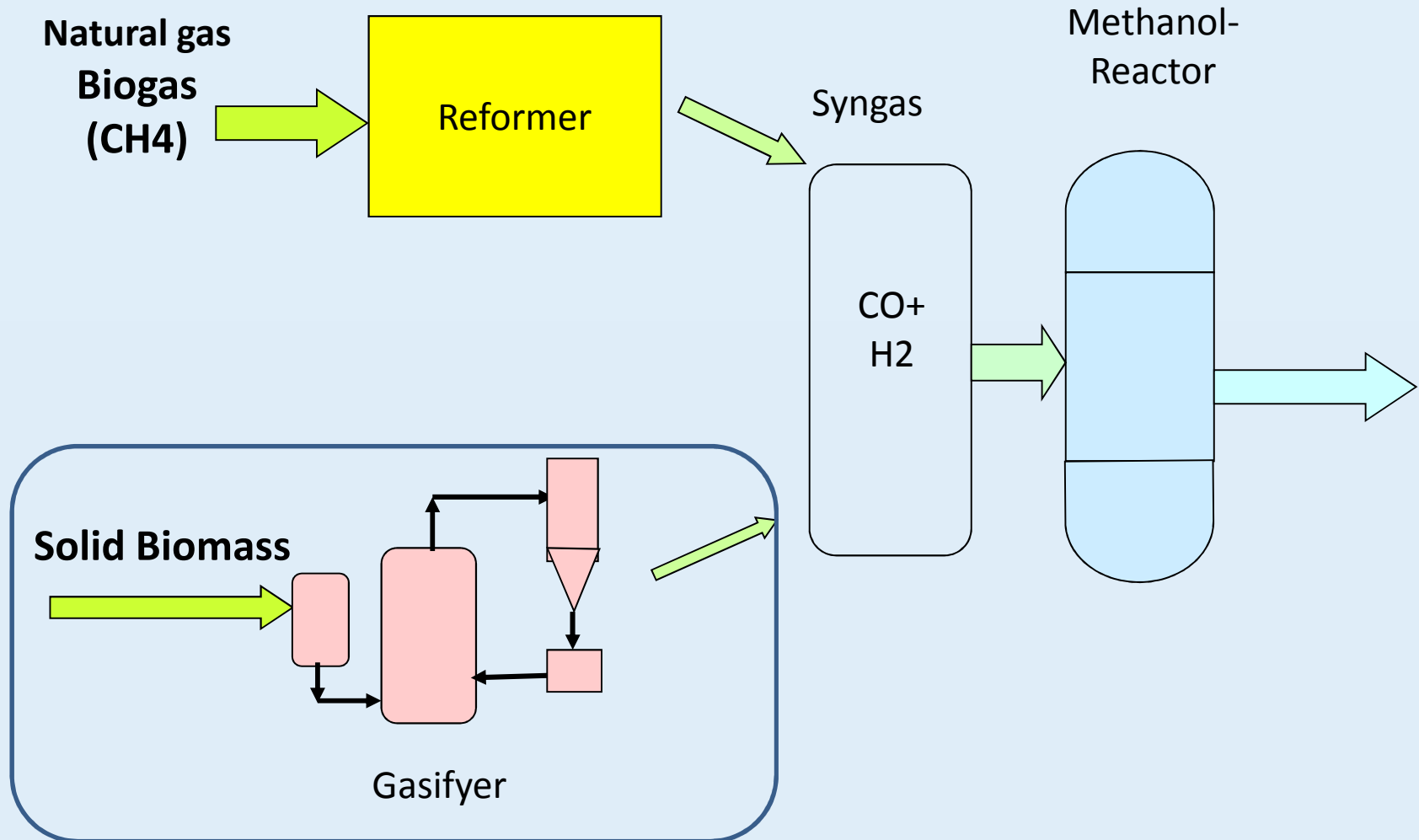
H.Franke, N.Schödel

Hydrogen Production Technology-Status and New Developments, Oil Gas European Magazine 2/2004,78-84



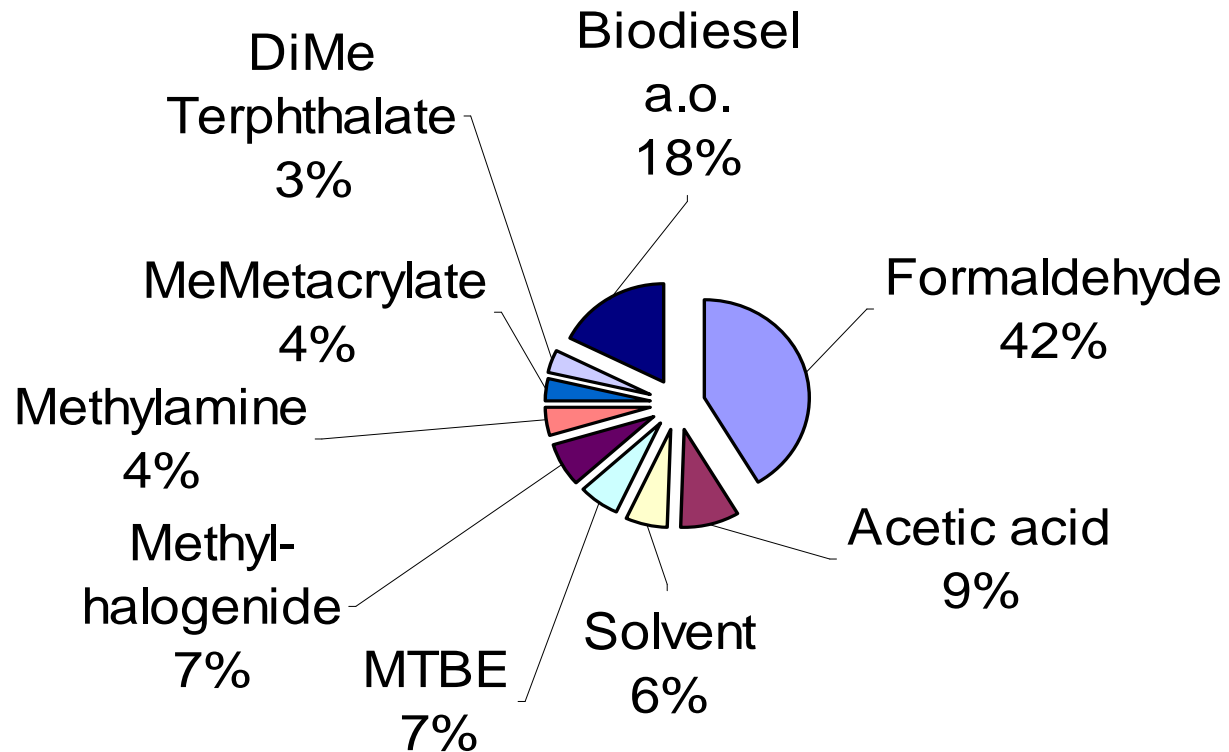
- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Methanol synthesis



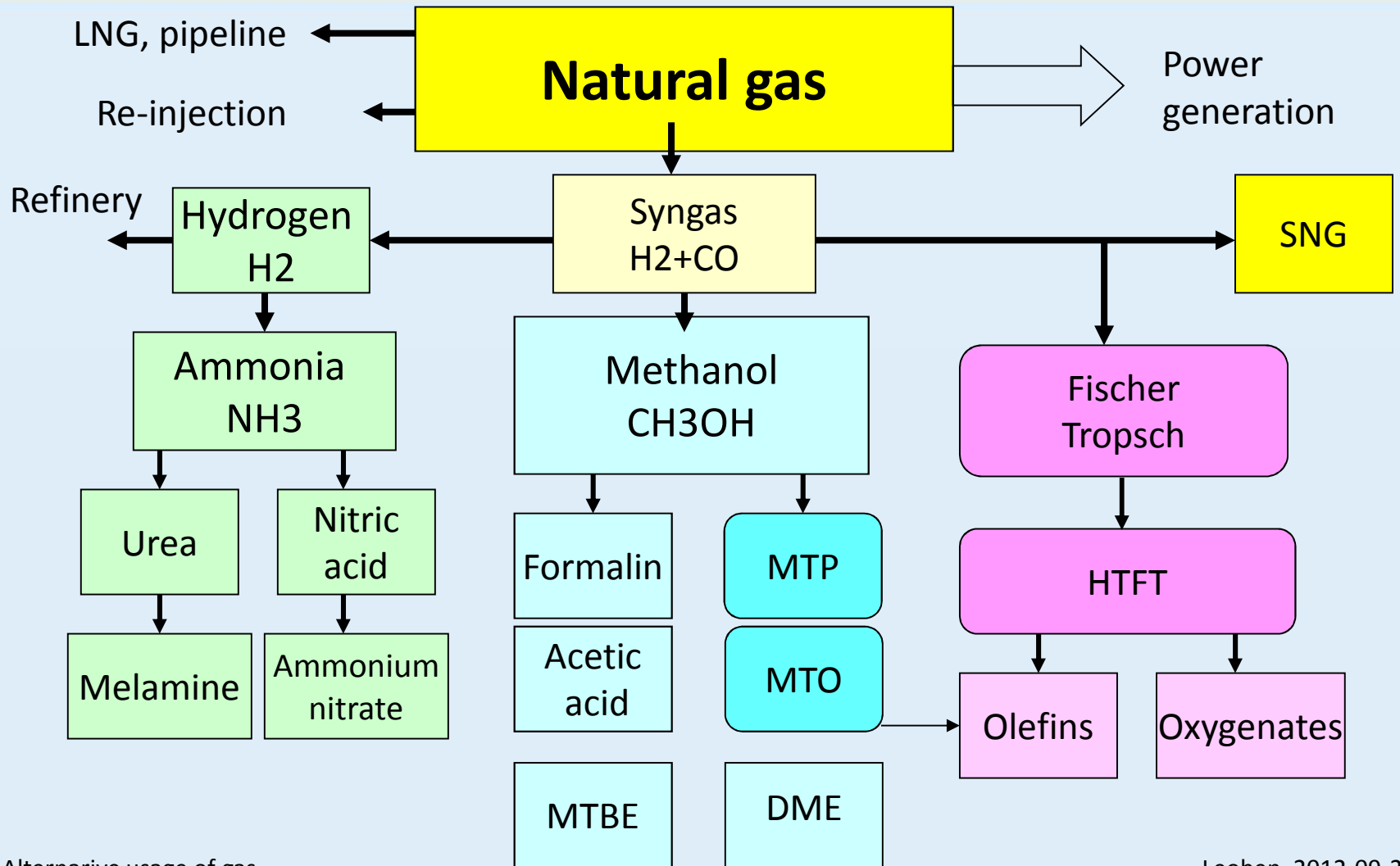
- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Chemical usage of Methanol



- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Chemical usage



- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Syntheses routes to olefins and fuels

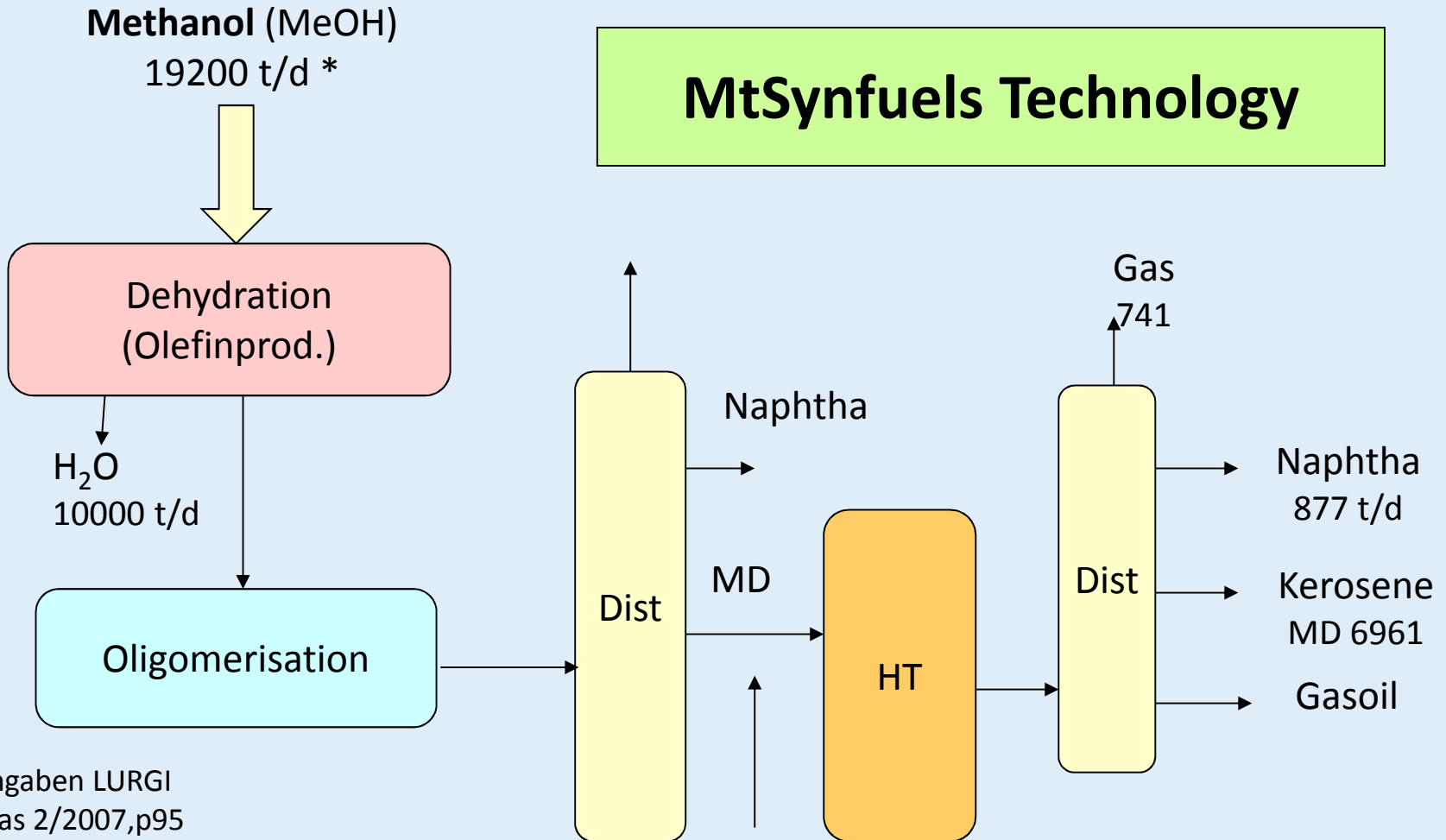
Feed: Syngas and Methanol

MTD	250	15-30	Al ₂ O ₃ /Zeolite	Uhde, Lurgi, Haldor Topsoe, Toyo Eng.
MTO, MTP	400-450		Zeolite	UOP/Hydro, Lurgi
MTG	300-450	15-25		ExxonMobil, Uhde
MOGD, MTSyn	300-400		Zeolite	ExxonMobil, Lurgi
STD	250-280	30-70	Cu/Al ₂ O ₃ /Zeolite	HaldorTopdoe, AirProducts
STG (TIGAS)	240-420	40-60	Bifunct/Zeolite	HaldorTopsoe
FTTO	300-350			(BASF)
ATF, ATD, ATJ	400/280	1, 60	Al ₂ O ₃ /Zeolite	

TIGAS=Topsoe Integrated Gasoline Synthesis

- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Methanol to Synfuels

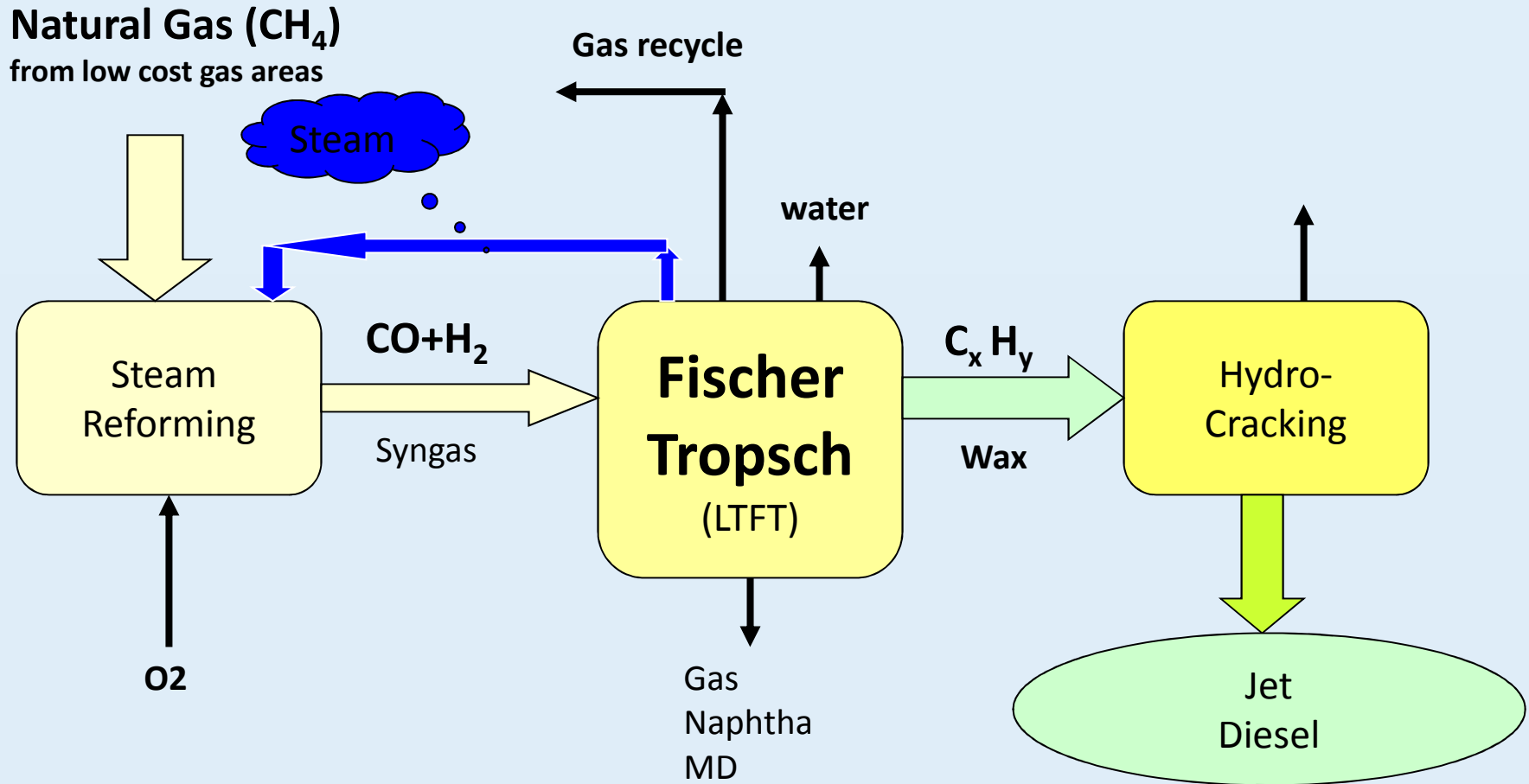


MtSynfuels Technology

*Angaben LURGI
OilGas 2/2007,p95

- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Fischer Tropsch process



- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Commercial FT-processes

Process	Catalyst	Reactor		Syncrude composition, %M			
				Olefin(a-OI)	Paraffin	Aromatic	Oxygenate
HTFT							
SAS, Secunda	Fused Fe	Fluid.bed	Naphtha	70 (49)	13	5	12
(Sasol advanced Synthol)			Distillate	60 (34)	15	15	10
Synthol, PetroSA	Fused Fe	Fluid.bed					
LTFT							
SSBP, Sasolburg	Precip.Fe	Slurry bed	Naphtha	64 (61)	29	0	7
(Sasol slurry bed process)			Distillate	50 (47)	44	0	6
ARGE, Sasolburg	Precip.Fe	Fixed bed	Naphtha	32 (30)	60	0	8
(ARGE Ruhrchemie-Lurgi)			Distillate	26 (24)	66	0	11
SSBP, Qatar	Co-Al2O3	Slurry bed	Naphtha	35 (32)	54	0	11
			Distillate	15 (14)	80	0	5
SMDS, Bintulu	Co-SiO2	Fixed bed					

- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

GTL (CTL) capacities



Conventional FT Reactors among the largest in the world

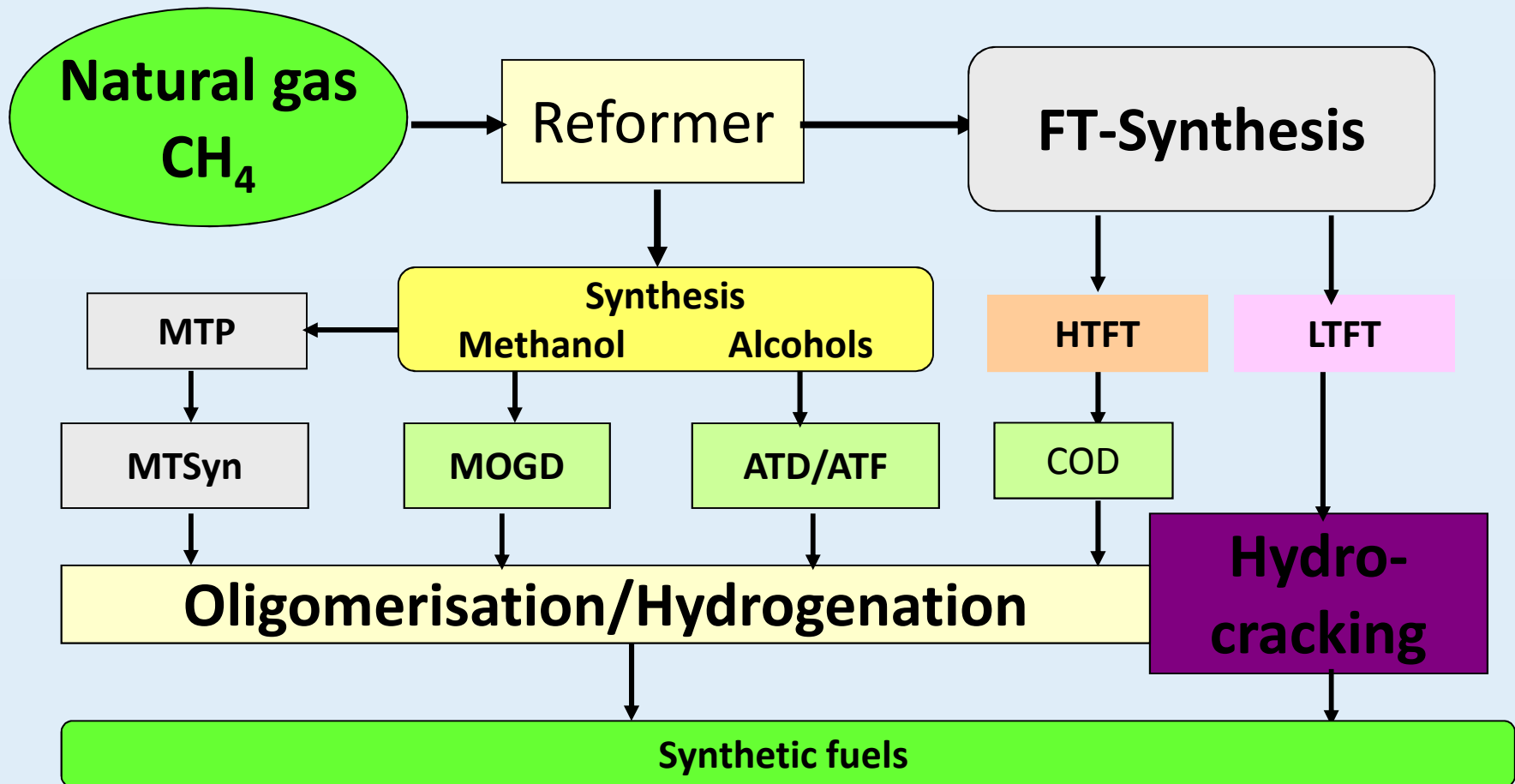
Source: Sasol Web Site, Oryx reactor

18

- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Leoben, 2012-09-21
A.Ecker

Transportation fuels synthesis routes



- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Synthetic diesel fuels

	Diesel (So)	FAME	NExBTL	GTL/FT	GTL/COD
Dichte/15°C	830-840	885	775...785	770...780	810
Flammpunkt	55...65	>100	>55...80	60...70	95
Viskosität/40°C	3...4	4...5	3...3,5	2,5...4	2,8
Cloudpoint	0...-5	0...-15	5 ...- 30	5...-30	<45
Cetanzahl	52	51	>80	80	55
Destillation 10% Vol	230	350	200	210	235
50% Vol	270	350	290	270	250
90% Vol	330	350	300	300	330

- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Why engage in advanced Jet fuels?

Alternative jet fuels must be produced (drop in fuels) to curtail future CO2 emission growth

**Electric power, fuel cells, Hydrogen, alcohols, plant oils
are no practical solutions for propulsion**

**Future Jet fuels from gas and Biomass
are a *must* to meet aeronautical expectations**

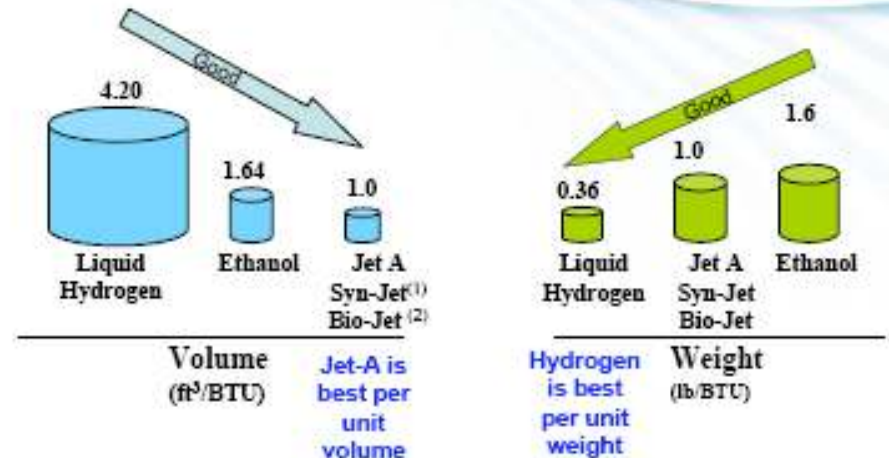
- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Hydrogen, Ethanol Aviation fuels ???

BOEING Ethanol fuelled airplane will require much larger wings & engines; reducing its fuel efficiency



BOEING Aircraft fuel needs to have a high energy content per unit volume and weight



- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Synthetic Aviation turbine fuels

	Specifications						
	FT/HC	FT/IPK	FT/COD	Bio-SPK	Oligo-Jet	JP7	JP8
Density/15°C, kg/m ³	756	760	779	753	781	779-806	775-840
Heating value, MJ/kg	44,1	43-44	>43	44	43,7	43,5	42,8
Hydrogen, %M	15	>14,5	>14,5	15	14,8	>14,4	>13,4
Paraffins (N+Iso), %M	100	100	>90	99	>90		
Aromatics, %M	<1	<1	3 bis 8	<1	3	>5	<25
Sulfur, ppm	<1	<1	<1	<1	<1	<1000	<3000
Flash Point, °C	45	42-57	69	42	74	>60	>38
Freezing Point, °C	-51	<-60	<-60	-63	-78	-43,3	<-47

- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas

Summary

The demand for more hydrogen, chemicals and fuels increases NG consumption

Hydrogenated petroleum products and synthetic fuels result less emissions

The dominant players in the oil and gas industry want to monetize natural gas (transport or conversion)

The current oil price and a low gas price are the greatest chance to building up a GTC- and GTF -industry

- Alternative usage of gas
- Chemicals and Fuels from (Natural)gas