Biomasse Polygeneration - die Zukunft?

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Produktion von synthetischem Erdgas durch katalytische Methanierung von Holzgas

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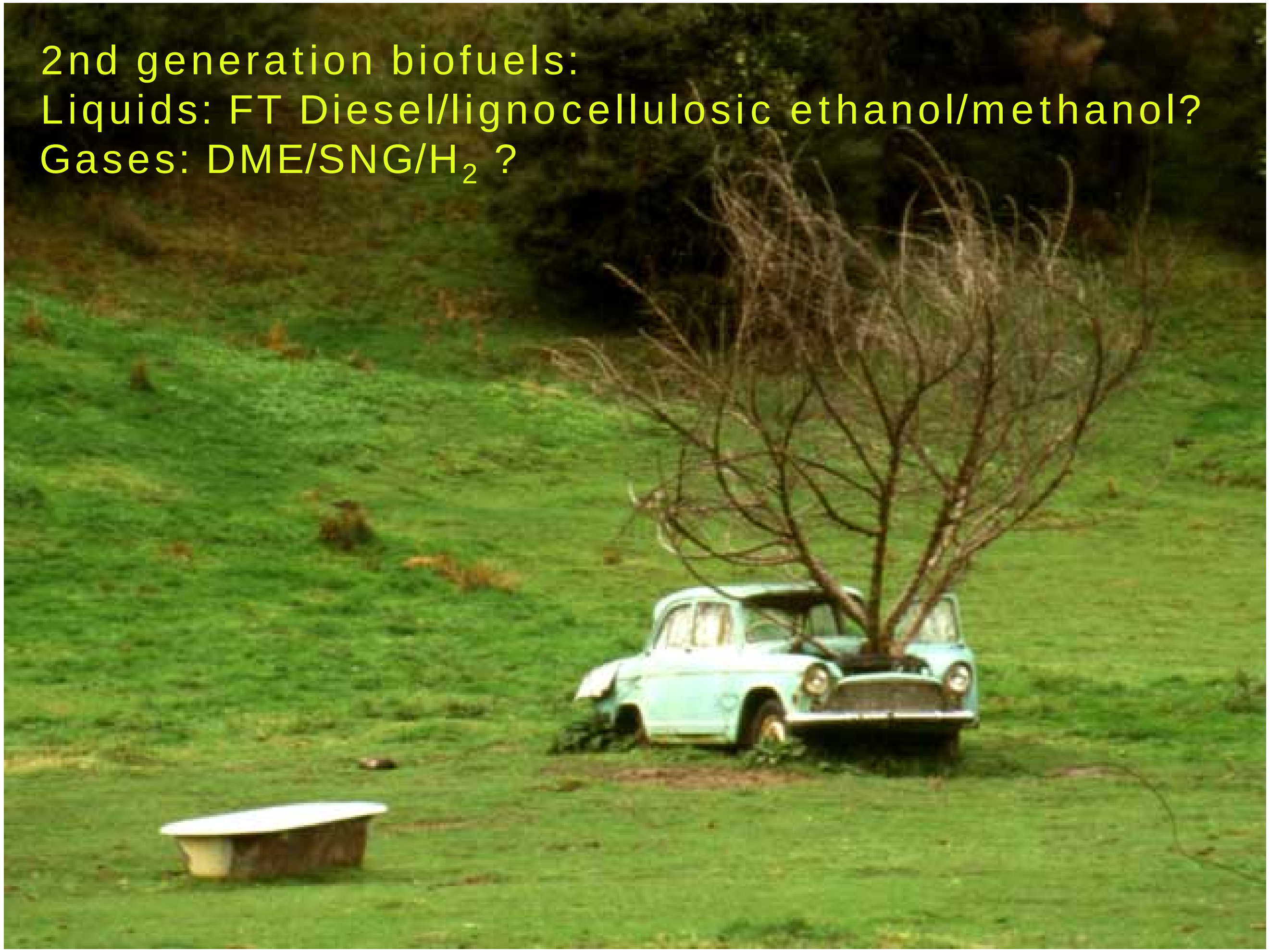
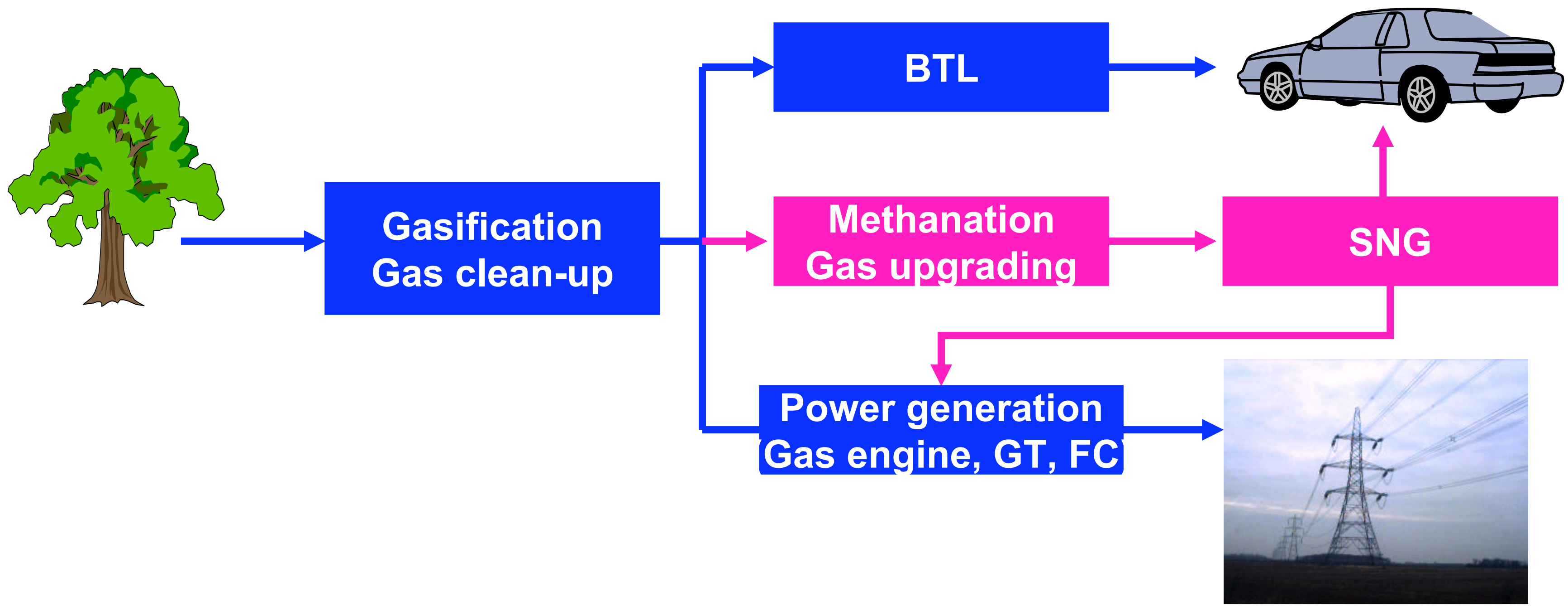
What is the best way of getting biomass into the car?

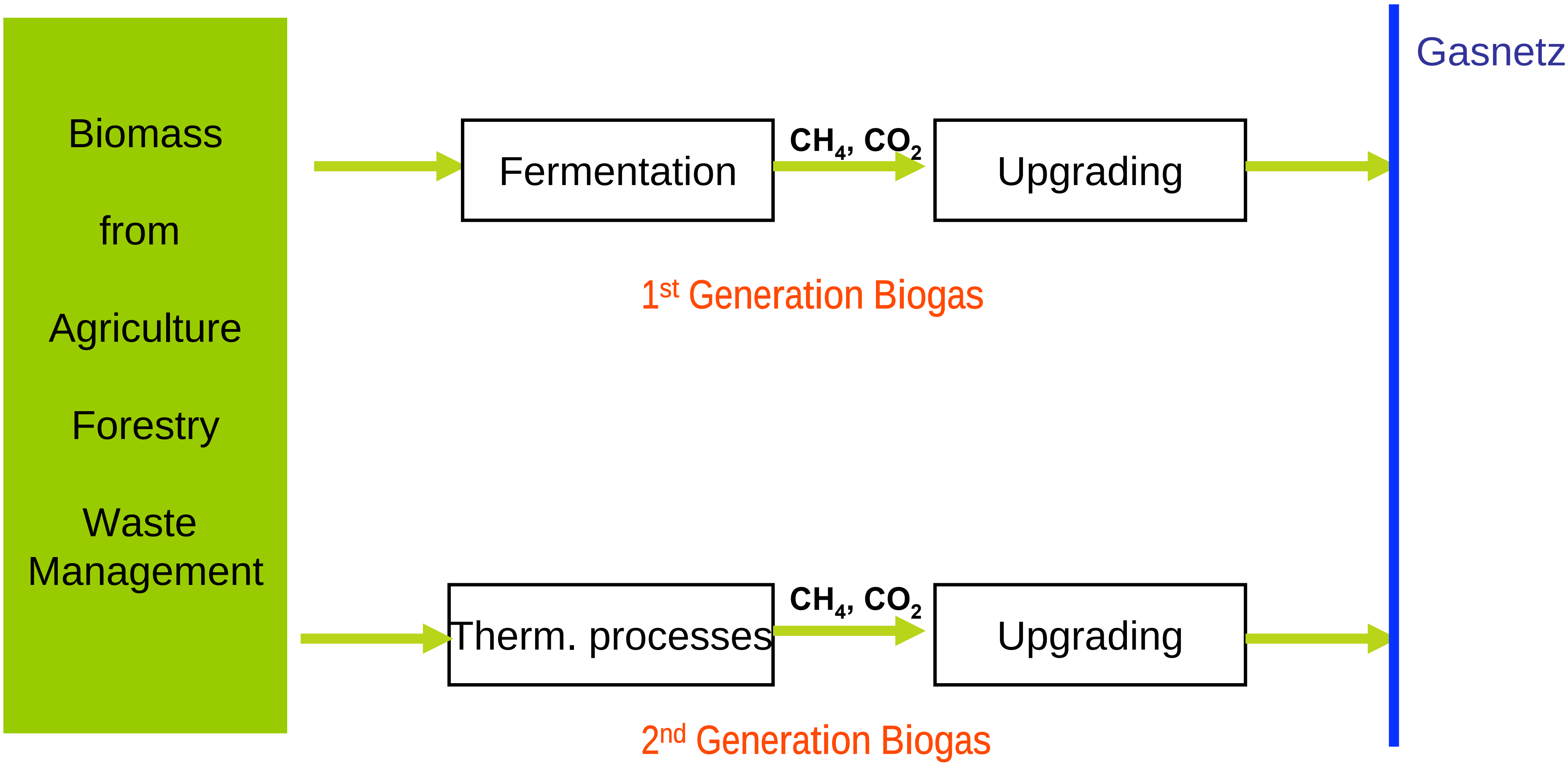


Dealing with a Finite Resource: Electricity or Transportation Fuel?



Gas leaves both options open

Biogenic Gases for Injection into the Gas Grid



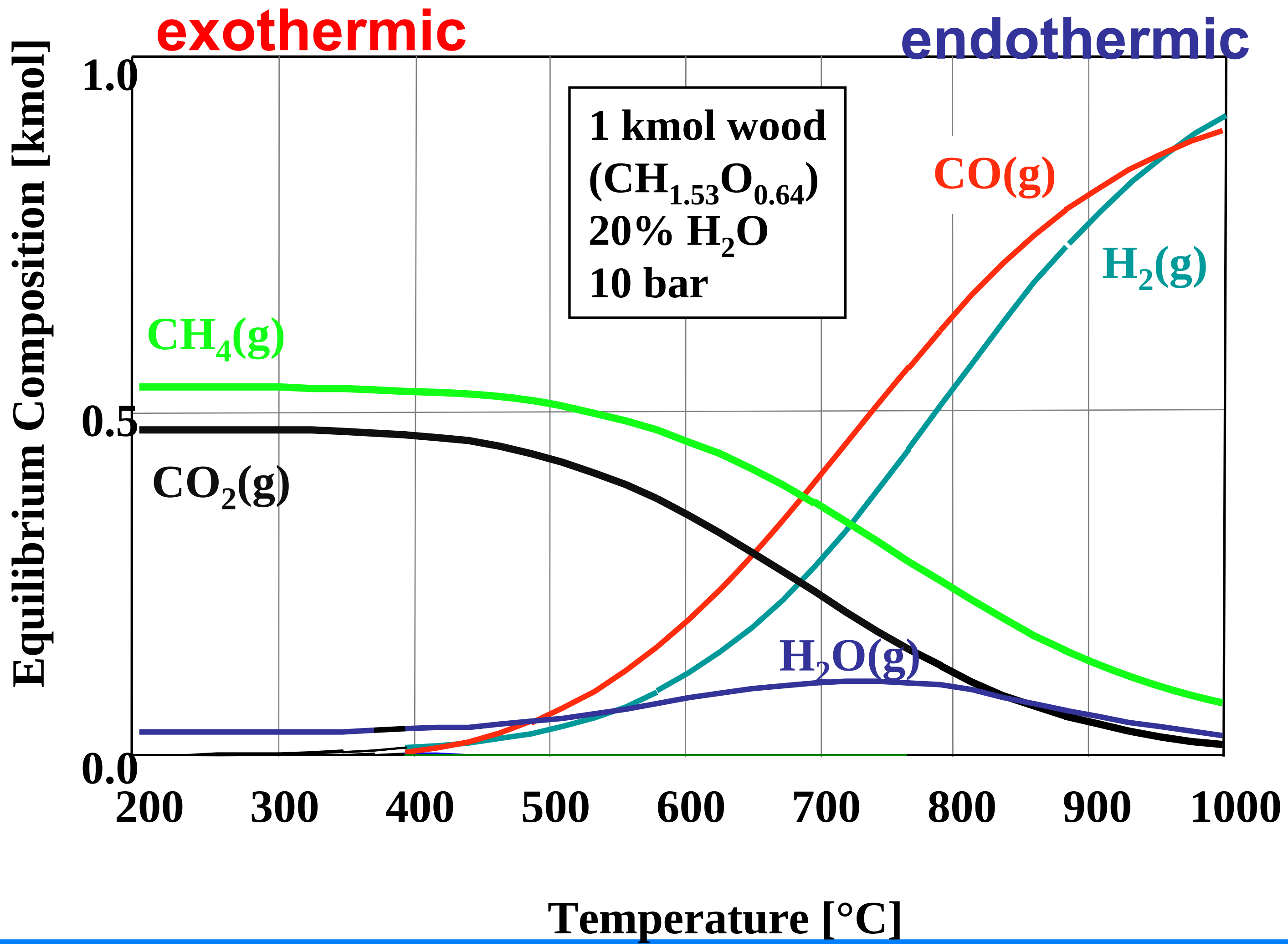
2nd vs. 1st Generation Biogas

Advantages of thermal processes:

- Complete conversion of biomass to methane and CO_2 by thermal process:
  potentially higher overall efficiency;
  minimized residues;
- Faster Conversion
- High fuel flexibility with suitable gasification systems
- Suitable for large scale plants
- Methane losses via CO_2 offgas easier to avoid

But: Thermodynamically, methane formation is favored by low temperature

Equilibrium of the System Biomass - Water



Methane Synthesis Routes from Biomass

Gasification
800-900°C

no catalyst

$CO + 1.08\ H_2$

Methanation
400°C

Ni catalyst

$\Delta_r H° = +100.8$ kJ/mol

$\Delta_r H° = -126.8$ kJ/mol

$CH_{1.49}O_{0.67}(s) + 0.33\ H_2O(g)$

$\Delta_r H° = -26$ kJ/mol

Direct process (?)

$0.52\ CH_4 + 0.48\ CO_2 + 0.04\ H_2O(g)$

$\Delta_v H^{100} = +41$ kJ/mol

$0.33\ H_2O(l)$

Gas Compositions of Suitable Biomass Gasifiers.

Vol. %	FICFB	Bioflow	GSP	Carbo-V
Hydrogen	41	26	29	40.15
Carbon monoxide	22	17	45	39.3
Nitrogen	5	4.8	9	0.11
Carbon dioxide	21	35	18	20.4
Methane	8.2	13	0.1	0.06
Ethene	3	2.6	n.a.	n.a.

Condition: Oxygen blown or indirect gasification

Chemical Reactions in the Synthesis of SNG

Main reactions

$CO + 3\ H_2$	$\longrightarrow$	$CH_4 + H_2O$	**Methanation**
$CO + H_2O$	$\longrightarrow$	$CO_2 + H_2$	**Shift**
$2\ CO$	$\longrightarrow$	$CO_2 + C$	**Boudouard**

Conversion of minority hydrocarbons

$C_2H_4 + 2\ H_2O$	$\longrightarrow$	$2\ CO + 4\ H_2$	**Steam Reforming**

Maximum Theoretical Efficiencies for the Production of SNG from Producer Gases

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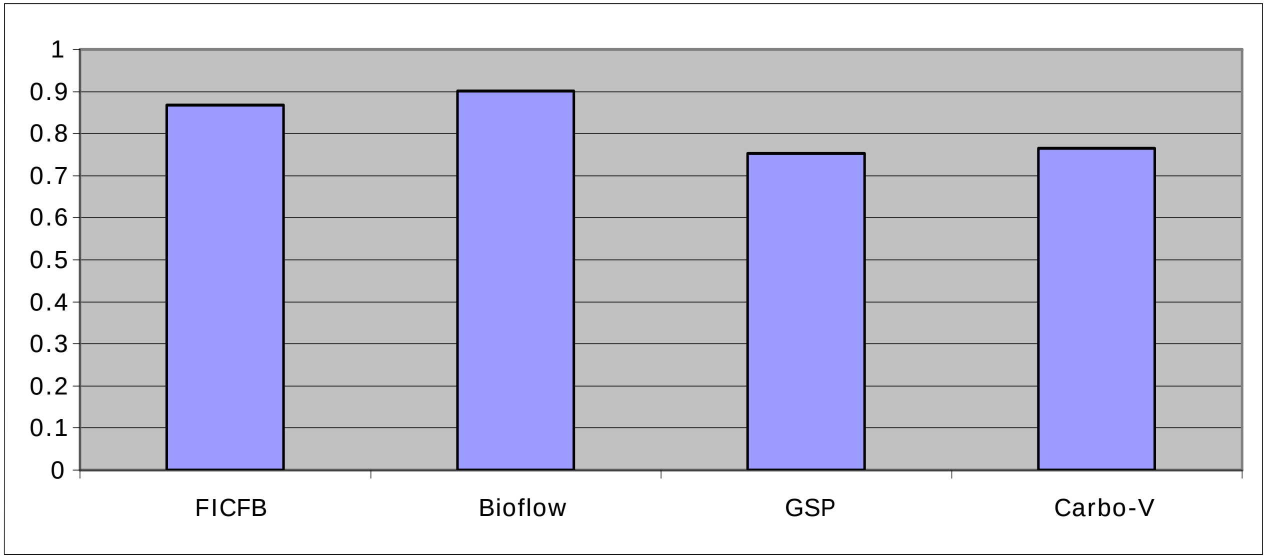

Energy Content of Producer Gases (MJ/Nm^3)

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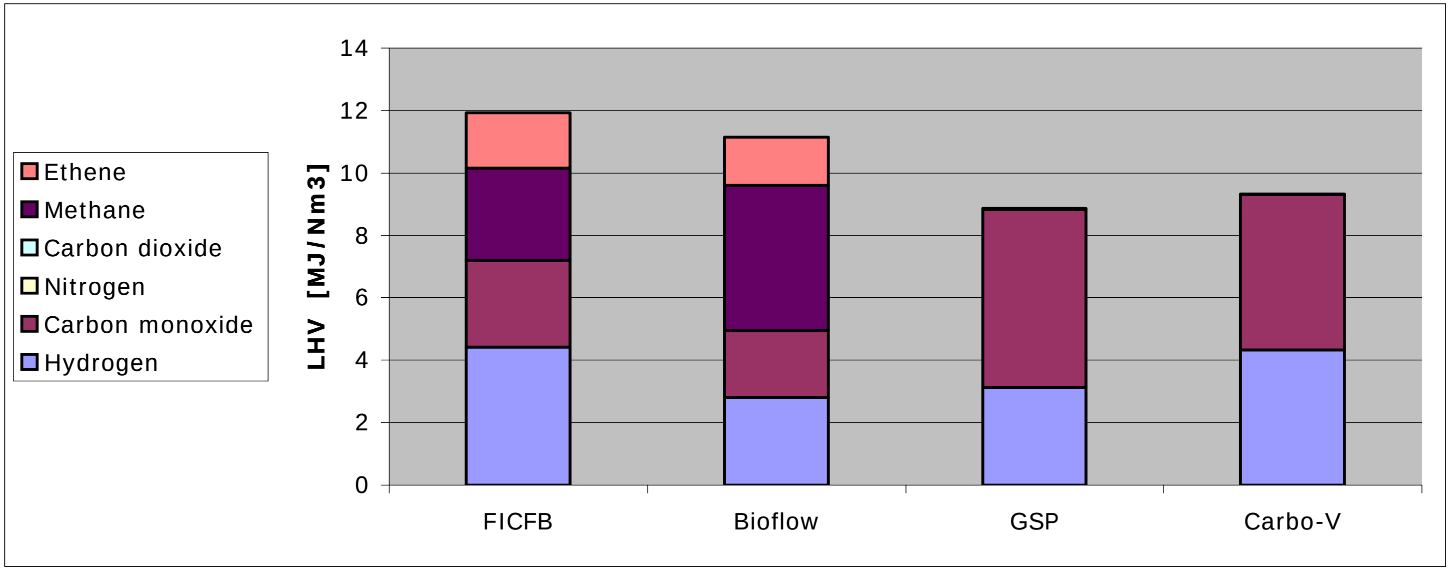
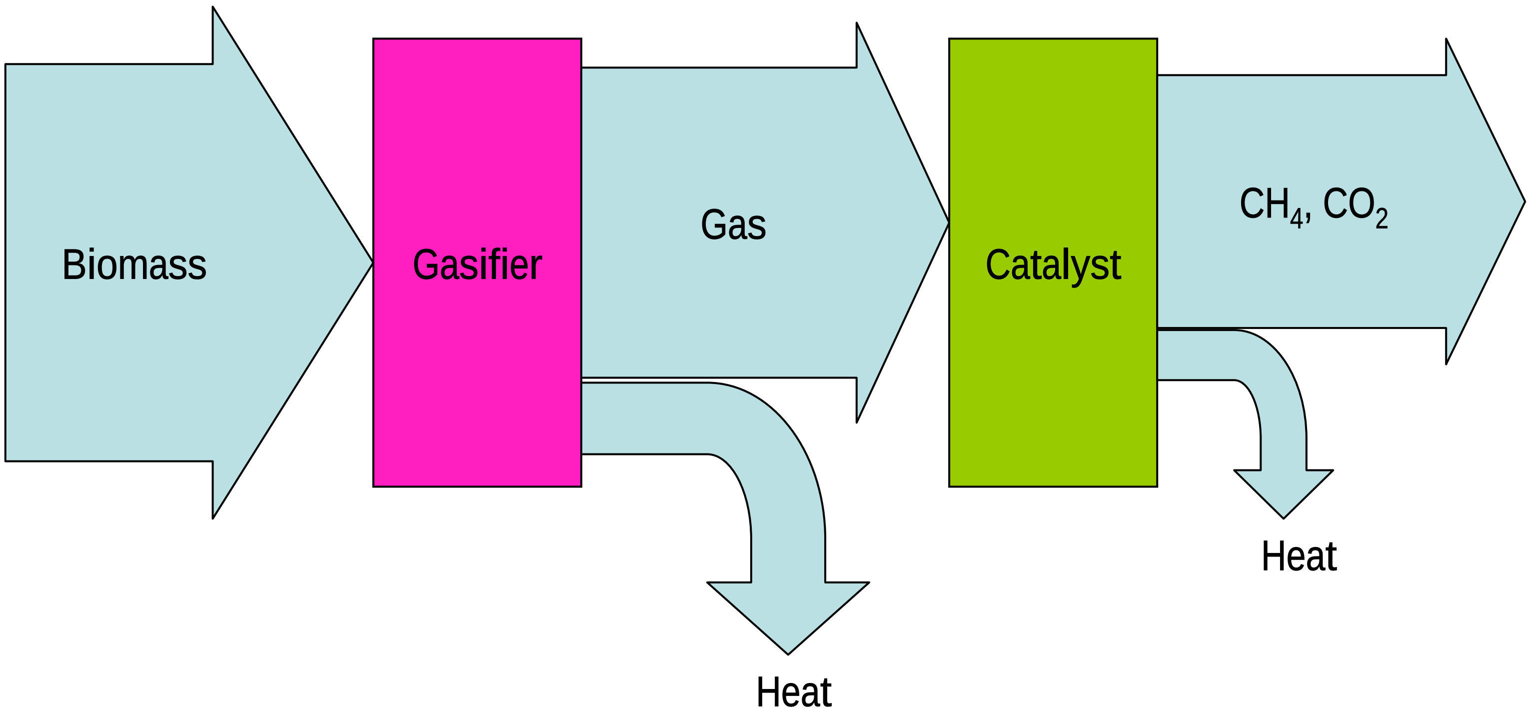


Efficiency of Process Chain



Autothermic gasification:
Losses given by exit temperature of gases, heat loss from reactor Walls, moisture of feed.

Exothermic methanation:
Losses given by selectivity and yield of catalyst, input composition

Optimization of Overall Efficiency

- High selectivity and yield for methane (catalyst activity, temperature, pressure)
- High methane content in primary gas (=> low gasification temperature)
- High cold gas efficiency in gasifier (low heat losses via surfaces, low exit temperature of product gases, biomass drying)
- Minimizing of auxiliary energies
  - Indirect atmospheric gasification: compression
  - Oxygen blown gasification: energy for air separation

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Conversion of minority hydrocarbons

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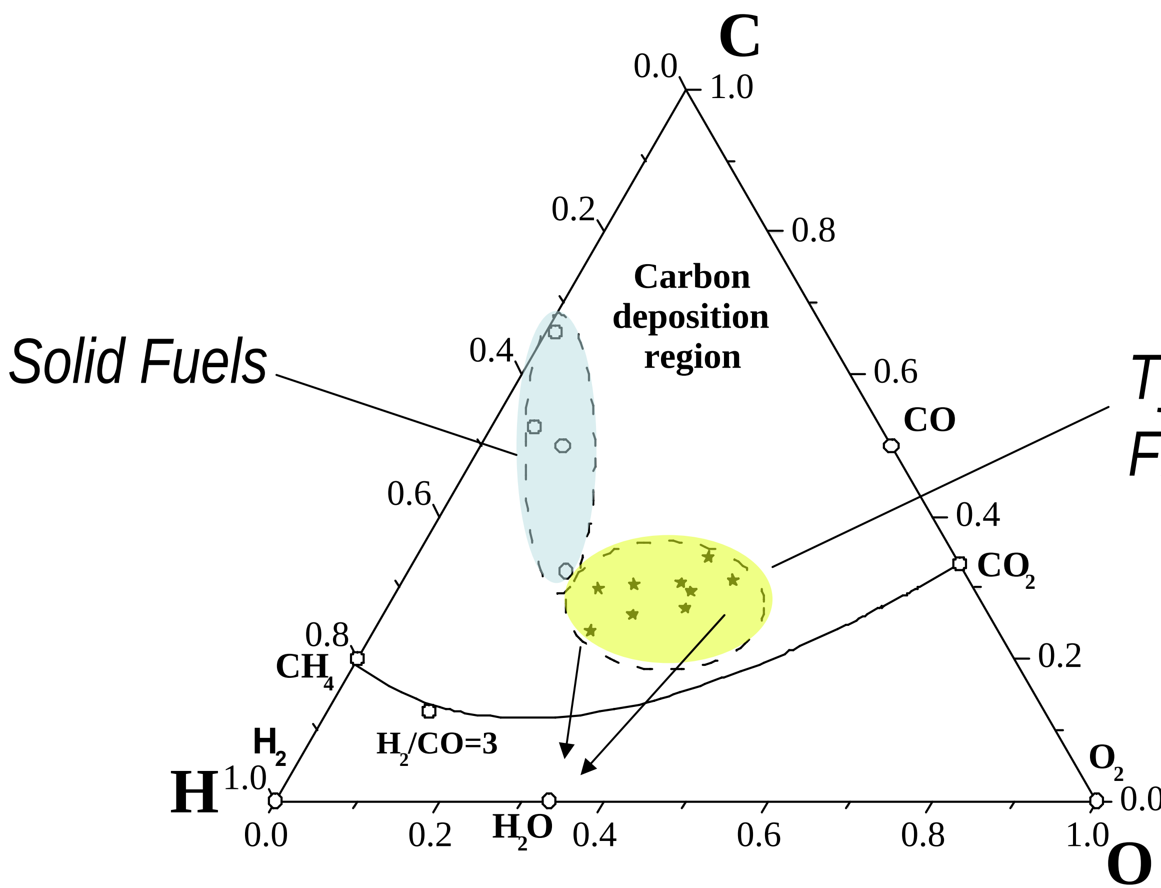
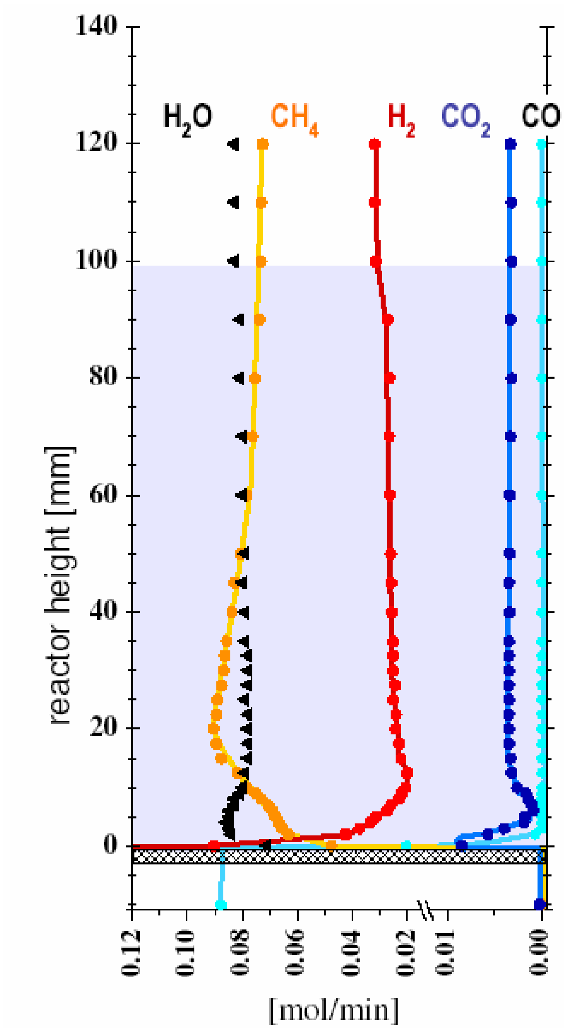
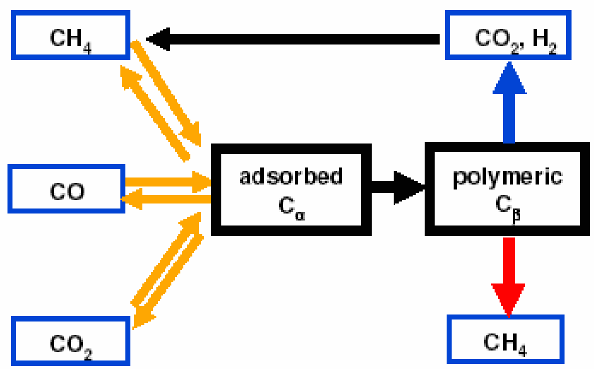
Converting Solid Fuels to SNG



Carbon management on catalyst: the key to stable operation



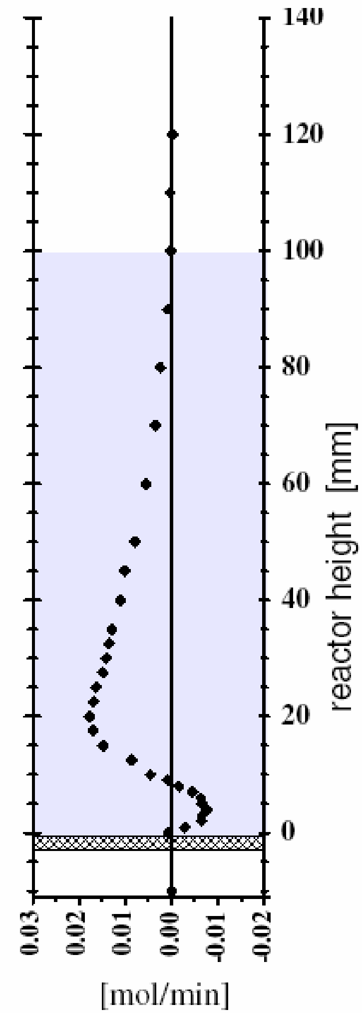


$CO \leftrightarrow C^* + O^*$

$CO + 3\,H_2 \leftrightarrow CH_4 + H_2O$

$CO + H_2O \leftrightarrow CO_2 + H_2$

$2CO \leftrightarrow CO_2 + C$

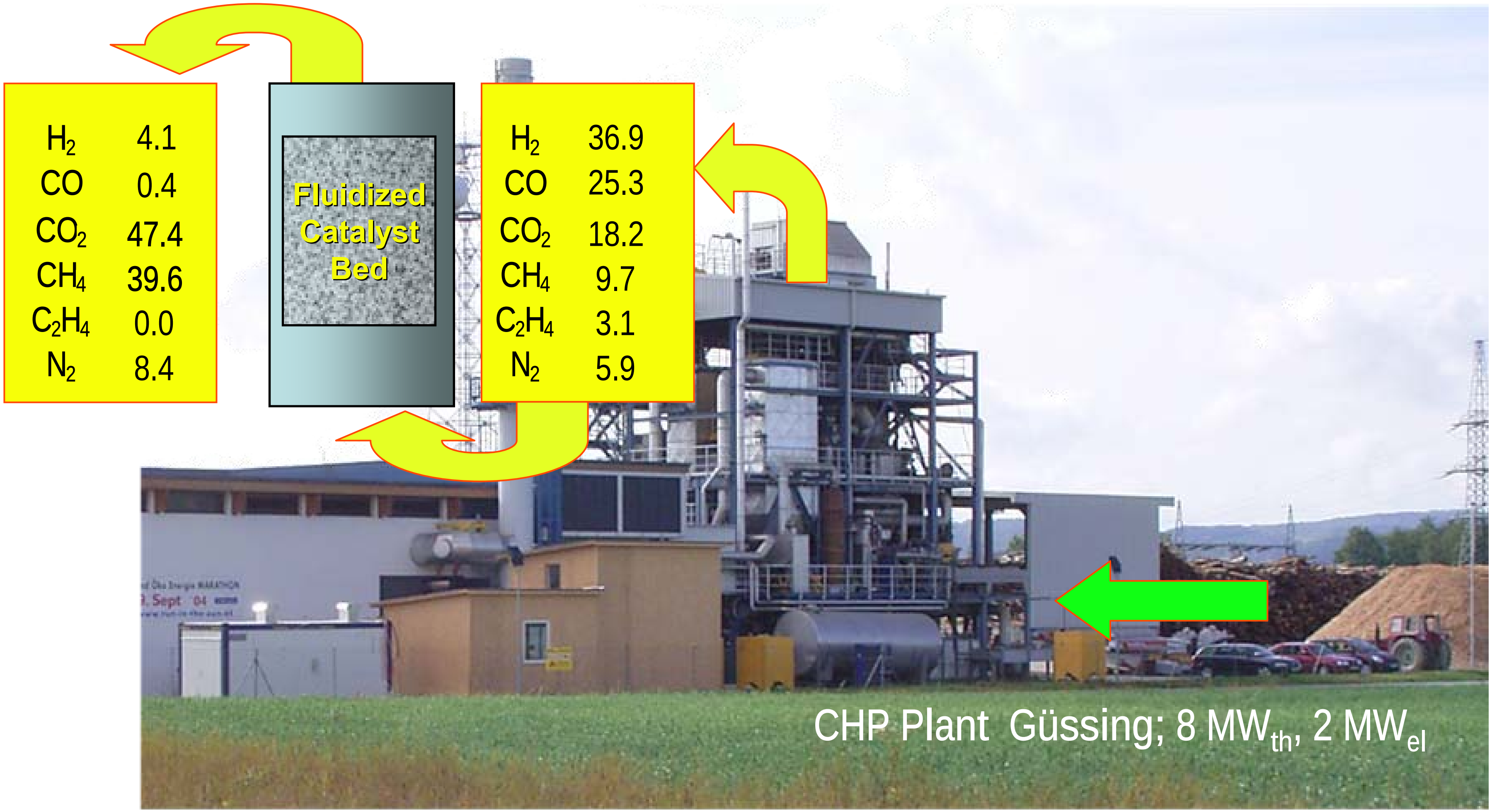


M.C. Seemann, T.J. Schildhauer, S.M.A. Biollaz, S. Stucki, A. Wokaun, Appl. Catalysis A: General 113 (2006) 14-21

Catalytic Conversion of Producer Gas

H_2	4.1
CO	0.4
CO_2	47.4
CH_4	39.6
C_2H_4	0.0
N_2	8.4

H_2	36.9
CO	25.3
CO_2	18.2
CH_4	9.7
C_2H_4	3.1
N_2	5.9



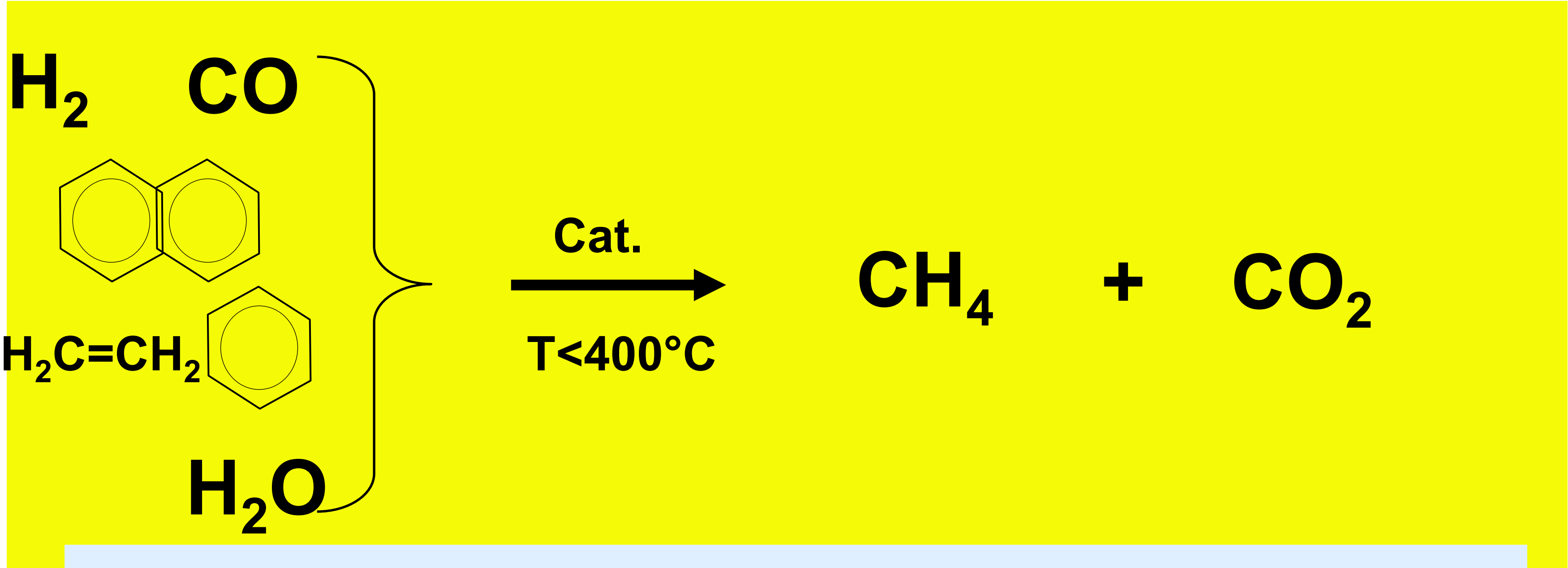
PSI's Methanation test plant in Güssing

10 kW power

Catalytc Methanation of producer gas from industrial biomass gasifier without stoichiometry adjustment with high selectivity and yield. Energy efficiency for the conversion of producer gas: 85%.

Wood to Methane: >60%

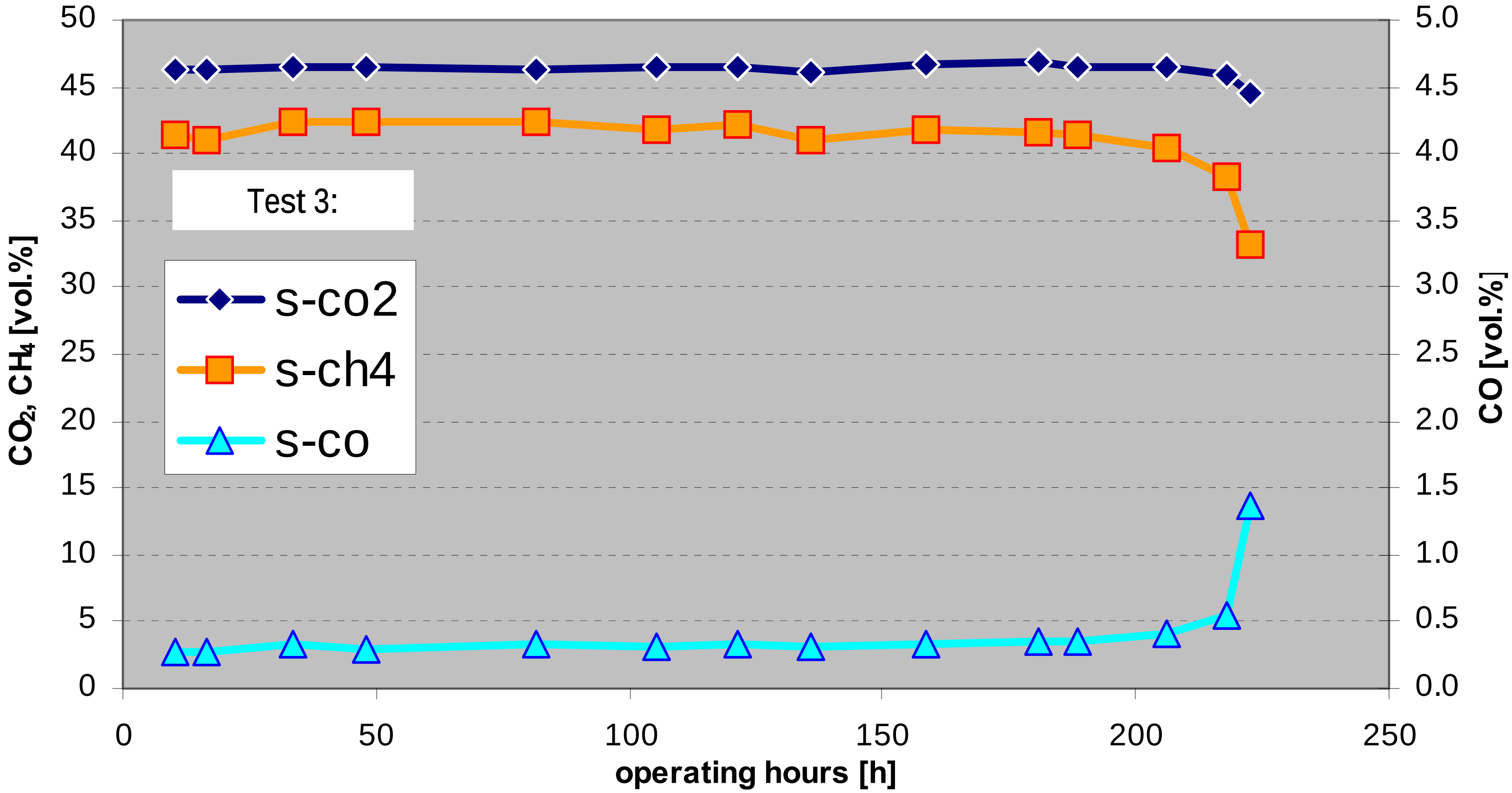
Robust Catalyst



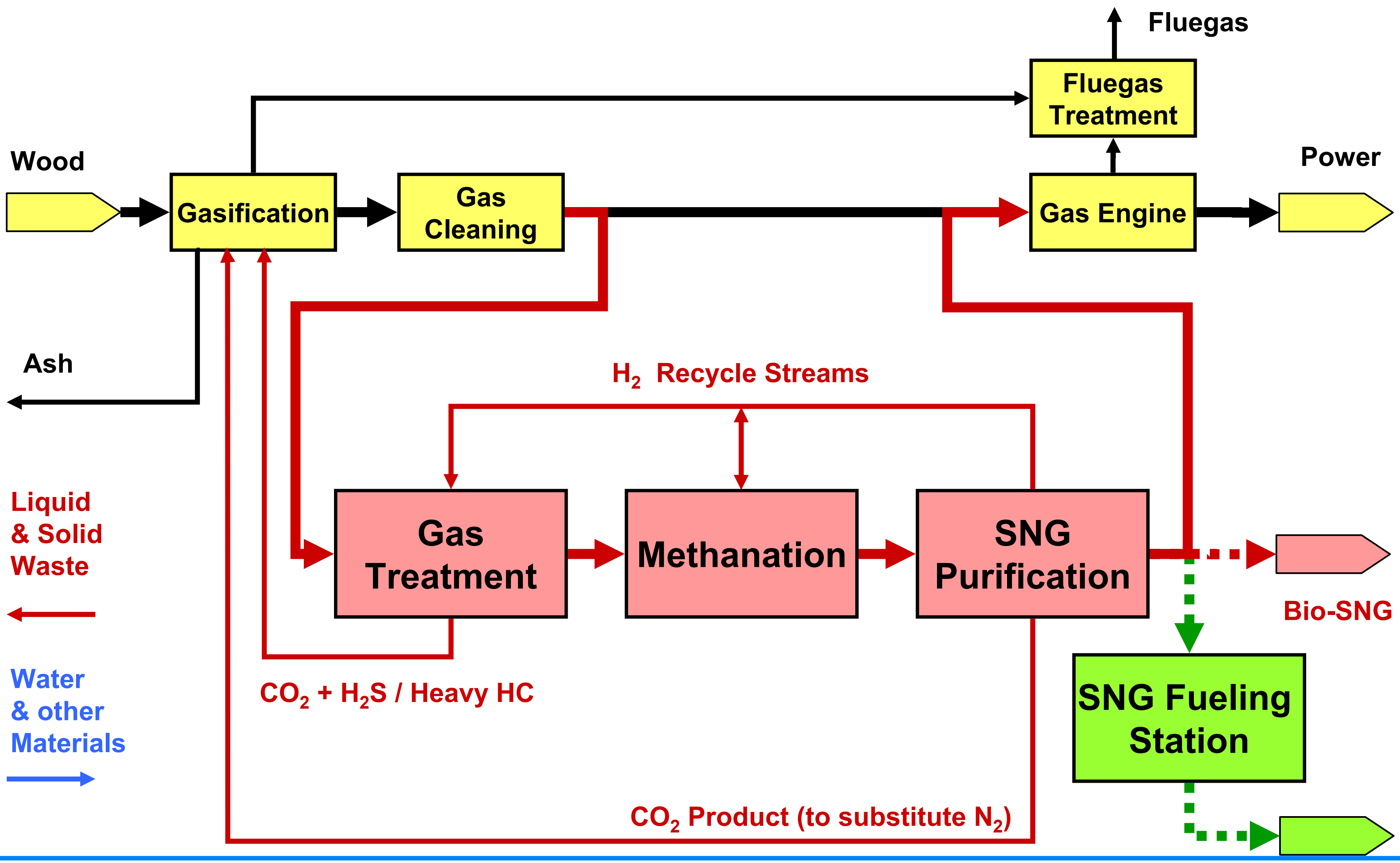
Simultaneous Reforming, Shift, Methanation

Sulfur Species Limiting Catalyst Life.

Gas cleaning must remove sulfur species



Principle Flow Diagram SNG from Wood



Project Phases

Phase 1: Research project

Fundamentals of methanation process and process integration

1998 bis 2004

Phase 2: P&D project

Demonstration of methanation with product gas from Güssing gasifier on the 1 MW scale

2006 to 2008; EU-Project Bio-SNG (DG-TREN);

Phase 3: First commercial plant

Scale: 20 MW Gas

2010+

P&D-Project Bio-SNG

Demonstration of the whole chain on a technically relevant scale (1 MW), from fuel wood to SNG (CNG) fuel, including filling station.

Erection at Güssing site (2007)

Technology base for scale-up to industrial size plants

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Bio-SNG Partners

- Institute for Energy and Environment GmbH (Germany), IE
- Vienna University of Technology (Austria), TUV
- PSI, Paul Scherrer Institut (Switzerland), PSI
- Biomasse Kraftwerk Güssing GmbH (Austria), BKG
- Repotec Umwelttechnik GmbH (Austria), Repotec
- Conzepte Technik Umwelt AG (Switzerland), CTU
- Institute of Chemical Process Fundamentals (Czech Republic), ICPF
- Verbundnetz Gas AG (Germany), VNG
- Electricite de France (France), EdF
- King's College London (United Kingdom), KCL

Technologiekonsortium
Methan aus Holz

PAUL SCHERRER INSTITUT PSI

Bio-SNG

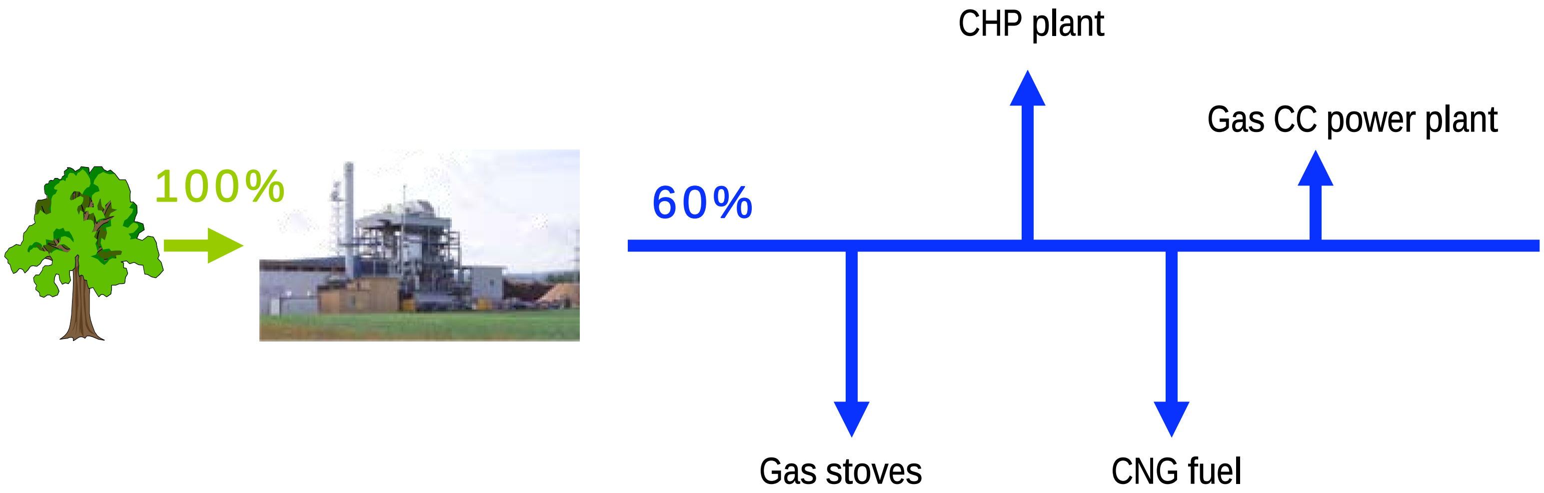
Technical Challenges

Proof of stable operation on technical scale;

Catalyst stability and regeneration;

Optimized gasifier operation for SNG production

Injection of Biogenic SNG Leaves all Options Open for Efficient End Use



- Efficient process chain from field to pipeline
- No risk for end-user
- Gas grid can be used as a buffer to some extent
- Plant size can be adjusted to local circumstances