RENEW

Results of the RENEW project

IP-502705

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Project supported by European Commission under FP6

Renewable Fuels

for Advanced Powertrains

Integrated Project, supported under FP6

- **budget: 20 Mio €, funding 10 Mio €**
- **duration 4 years, start: 01/2004**
- **coordinator: Volkswagen AG**
- **32 partners from 9 countries (Daimler, Renault, Volvo, BP, Total...)**

Objectives

- **advancement of conversion technologies**
- **evaluation of most efficient conversion technology - ecological (LCA) and economical**
- **investigations on substitution potential for biofuels**
- **draft of biofuel specifications for current and future ICEs**

RENEW Contractors

RENEW
32 contractors
18 enterprises
14 R&D institutions
9 countries

Automotiv Industry
VW
Daimler
REGIENOV
Volvo

Process Optimisation
R&D Institutes
and Universities
AICIA
CERTH
CRES
CUTEC
EEE
LU
FZK
IEE
INiG
ITN
PSI
TUV
ZSW

Fuel Distribution
BP
TOTAL

Plant Engineering
& Construction
Chemrec
Repotec
UET/Choren

Plant Operator
Abengoa
BKG
Södra Cell

Agriculture and
Forrestry Biomass
reserch
EC BREC/IPiEO
STFI
UCD

Services
BAUM
Ecotraffic
ESU-services
SYNCOM

Investors
EDF

RENEW structure

Renewable fuels for Advanced Powertrains RENEW

Coordinating Committee
chairman: coordinator IP
member: project leader SPs and industrial key partners

IP coordination
- administration
- daily management
- finances

SP 1

Product optimisation of BTL-production
- modified synthetic tailored
- early engine tests, fuel sepecification
- process optimisation with non woody biomass

SP 2

Process optimisation of BTL-production
- process comparison and optimisation
- mid term fuel production
- optimisation of FT-catalysts
- exergetic analysis

SP 3

Black Liquor to DME/methanol
- planning of a demo-plant (45 MW)
- process assessment
- cost assessment

SP 4

Optimisation of Bioethanol production
- data implementation for fermentation to ethanol
- catalytic conversion of syngas to ethanol

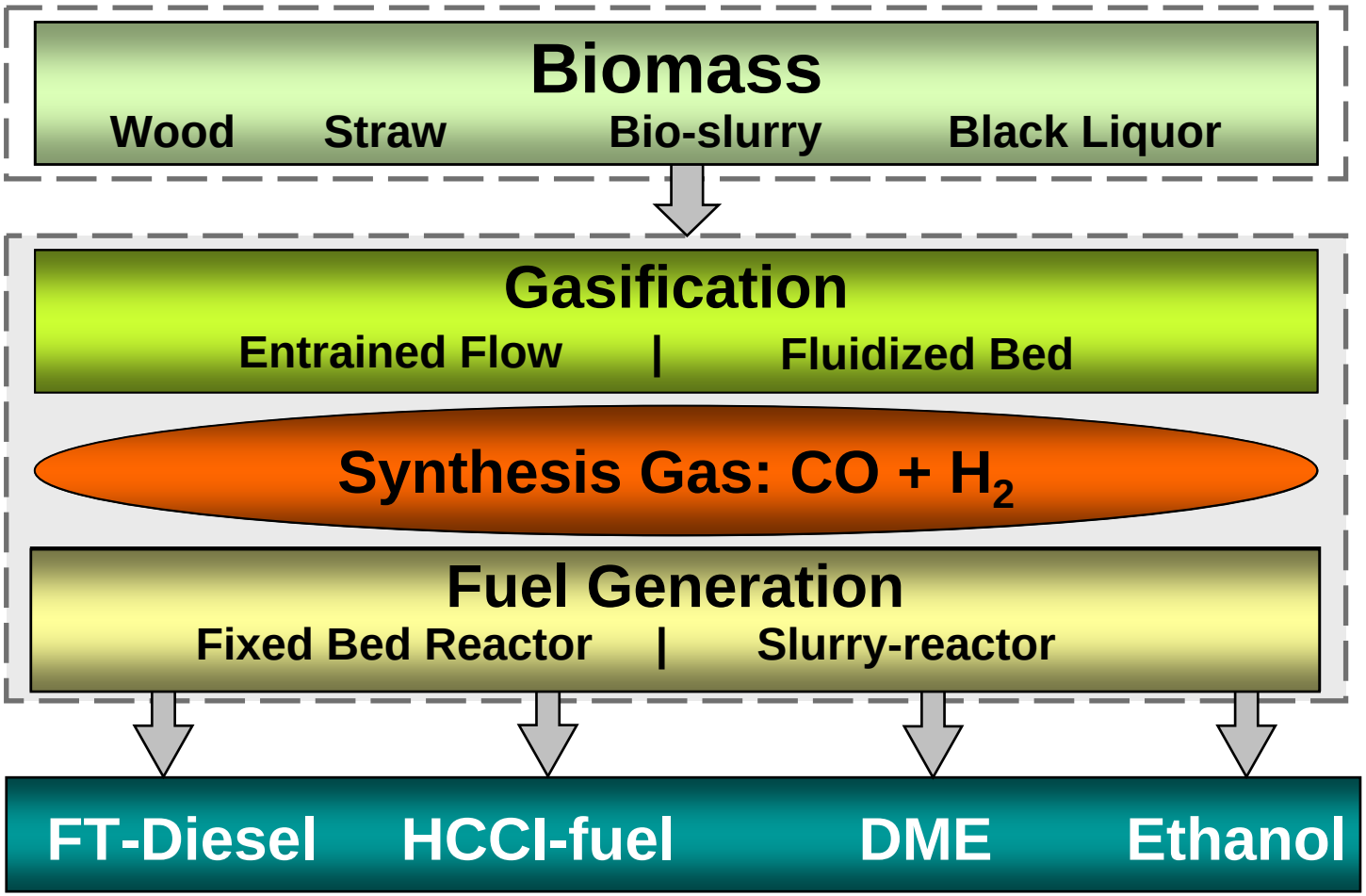
SP 5

Biofuel Assessment
- biomass potential
- live-cycle assessment
- socio economical impact
- suitability for IC engines
- comparative production assessment
- commonly agreed recommendations
- thermo chemical gaseous fuels production

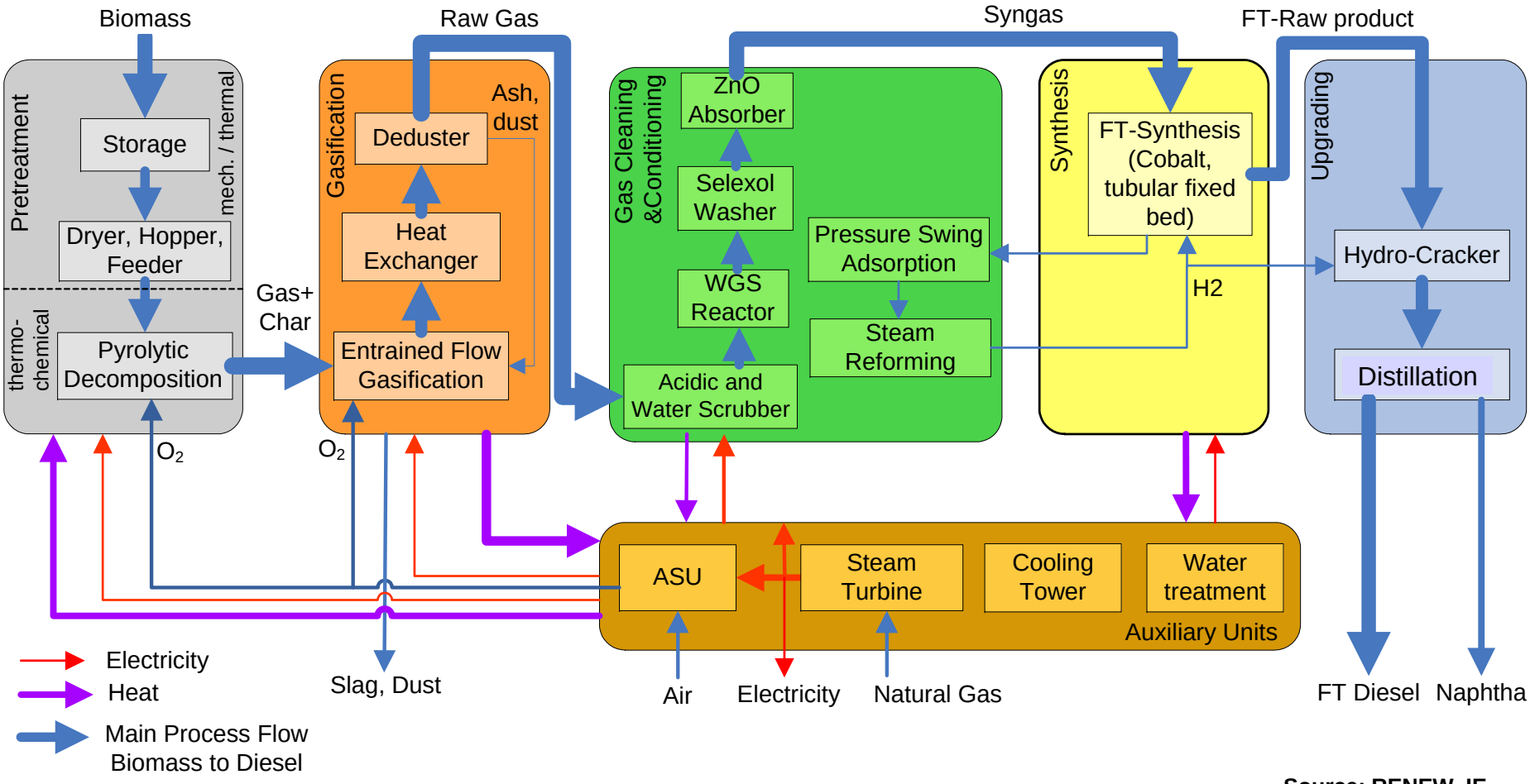
SP 6

Training
- 2 summer schools

Scope/Conversion Technologies



One Conversion Pathway



Source: RENEW, IE

Conversion Technologies

7 different conversion technologies were further developed & assessed

- **UET (Choren) with a large stand-alone entrained flow (EF) gasification of wood chips (500 MW) and FT-synthesis (200.000 t/a fuel output)**
- **FZK with remote plants for straw pyrolysis (each 100 MW) and a central very large EF gasification (>1 mio. t/a fuel output)**
- **Chemrec‘s Black Liquor EF-gasification for DME synthesis as part of a pulp mill (500 MW)**
- **Cutec‘s feedstock flexible circulating fluidised bed (CFB) gasification for FT-BtL (500 MW)**
- **TU Vienna ICFB for tri-generation of heat, power & fuel (10.000 t/a) from wood chips (50 MW)**
- **Abengoa EF and CFB concepts for ethanol production from synthesis gas (both 500 MW)**

Assessment & Scenarios

Assessement of:

- **ligno-cellulosic biomass feedstock potential that does not interfer with food production**
- **7 BtL production pathways; efficiency, costs …**
- **engine suitability of BtL-products FT-diesel and FT-naphtha, DME**

By analysis of:

- the life cycle (environment),

- the technical issues

- the economical properties

Assessment & Scenarios

Scenarios are

- **Starting point (SP) reflecting the situation of 2004/2005**
- **Scenario 1 with intensive agriculture in 2020 and possible renewable H_2 (e.g. from off-shore wind power)**
- **Scenario 2 (self sufficient) with a less intensive agriculture**

Biomass potential

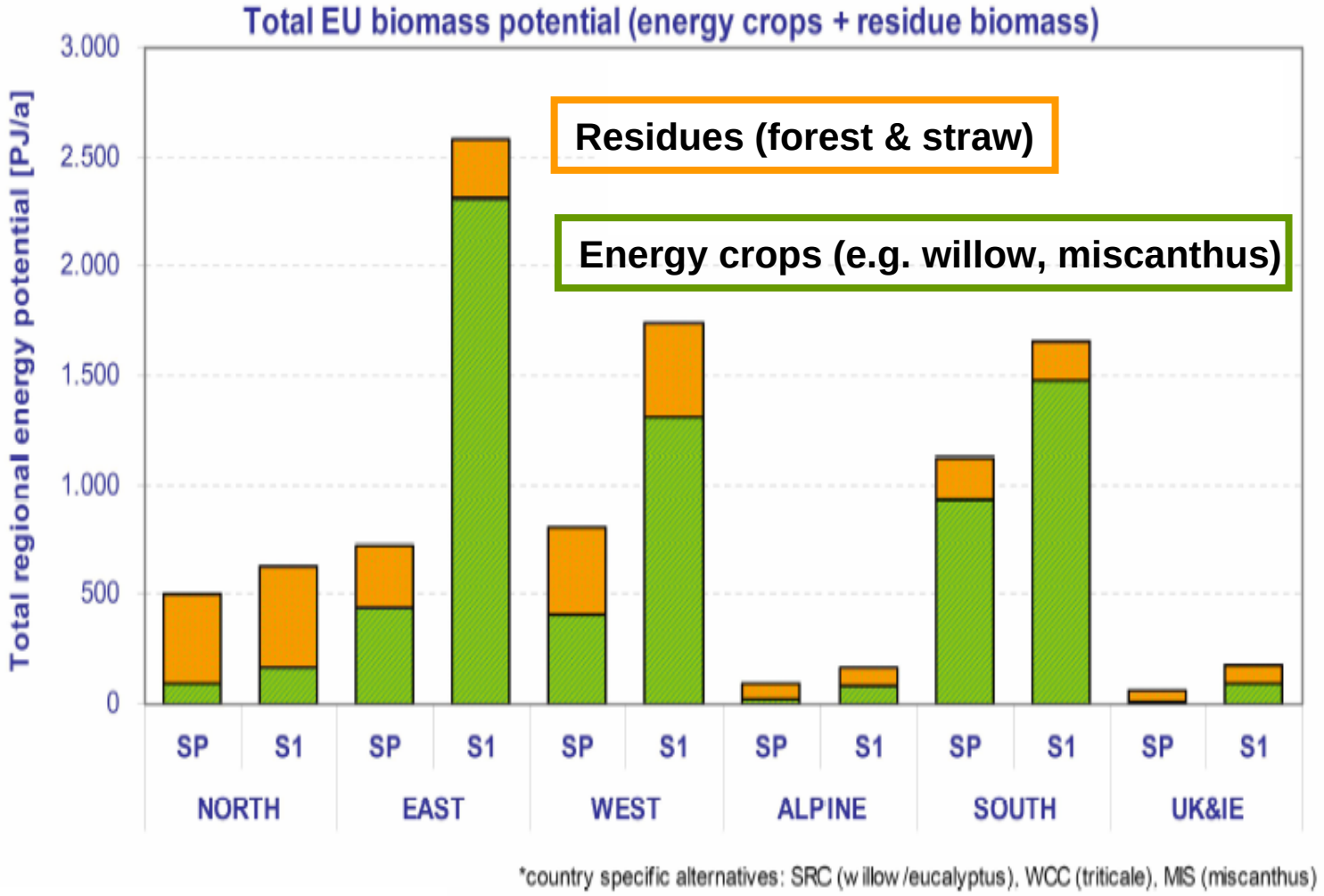
Assumptions are:

- **Production of food, animal fodder and fibre unaffected**
- **100% availability of land released by CAP reform (unused land) + current bioenergy plantations (all scenarios)**
- **On-going intensification of agriculture (S1, S2)**
- **30% reduction of meat and cereal exports (scenario 1)**
- **30% reduced energy crop yields due to less fertilisation (scenario 2)**

Biomasses are:

- **Residues – Thinning wood, logging residues and wood balance from forestry; cereal, maize and rape straw from agriculture**
- **Energy crops – Willow (salix), miscanthus and triticale and in the south eucalyptus and switchgrass**

Biomass potential

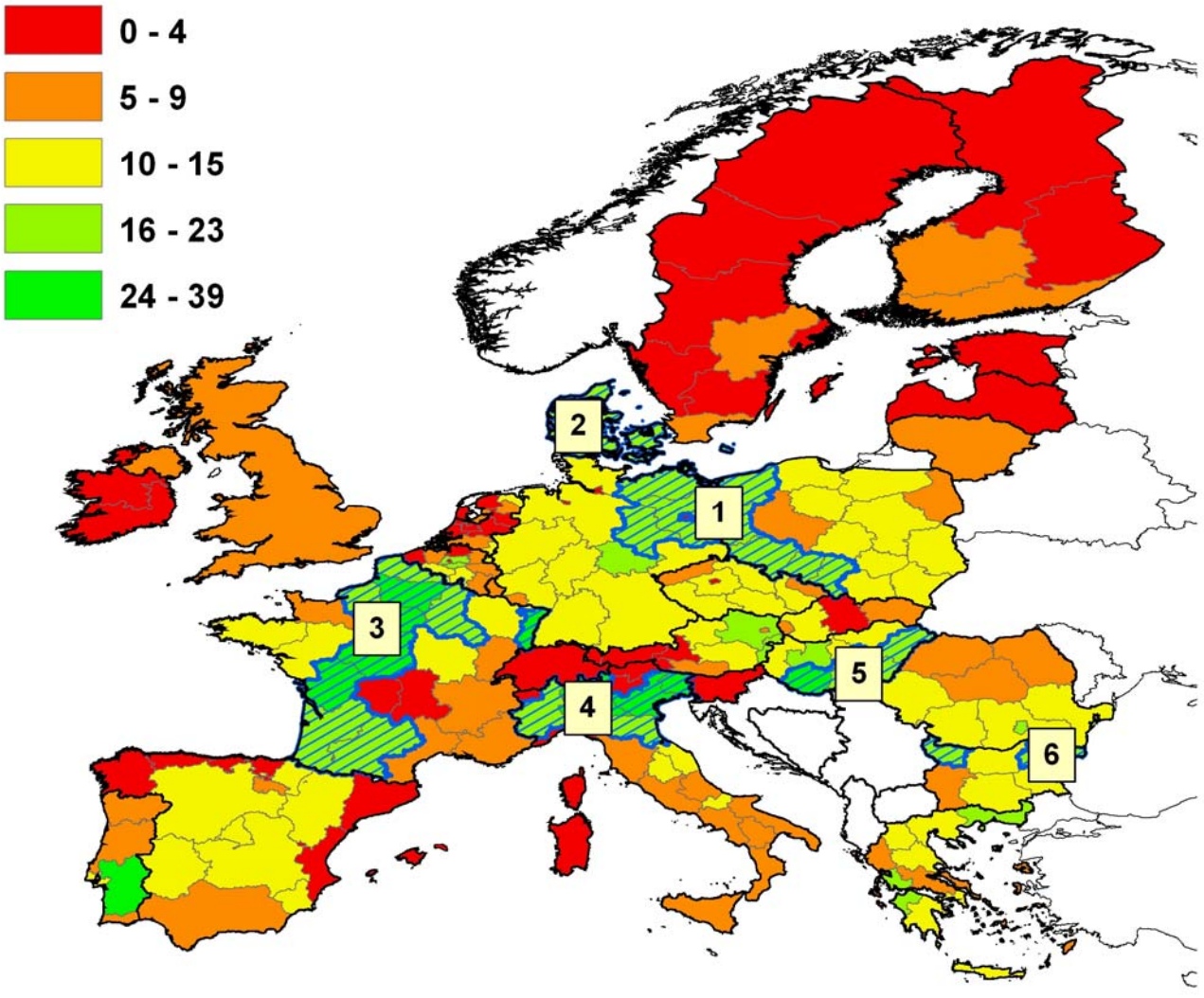


SP: starting point 2004

S1: intensive agriculture 2020

Source: ECBREC , IE

Suitable regions for BtL plants



Source: EC BREC

SP, cumulated additional potential of crop residues and energy crops per total land surface [GJ/ha]

Substitution potential

Total additional biomass EU from 95 to 172 Mio t oil equivalent

Assume 50% for BtL production available!

FT biomass potential EU from 48 to 86 Mio t oil equivalent

Assume 48% thermal efficiency, main fuel

FT fuel potential EU from 23 to 41 Mio t oil equivalent

or

14% to 24% of **present** diesel consumption (170 Mio t)

12%...21% of **expected** diesel consumption (2020, 200 Mio t)

Substitution potential

First generation biofuels on equivalent area:

9 … 16 Mio t oil equivalent

or

5% …9% of present oil consumption

4%…8% of expected oil consumption (2020)

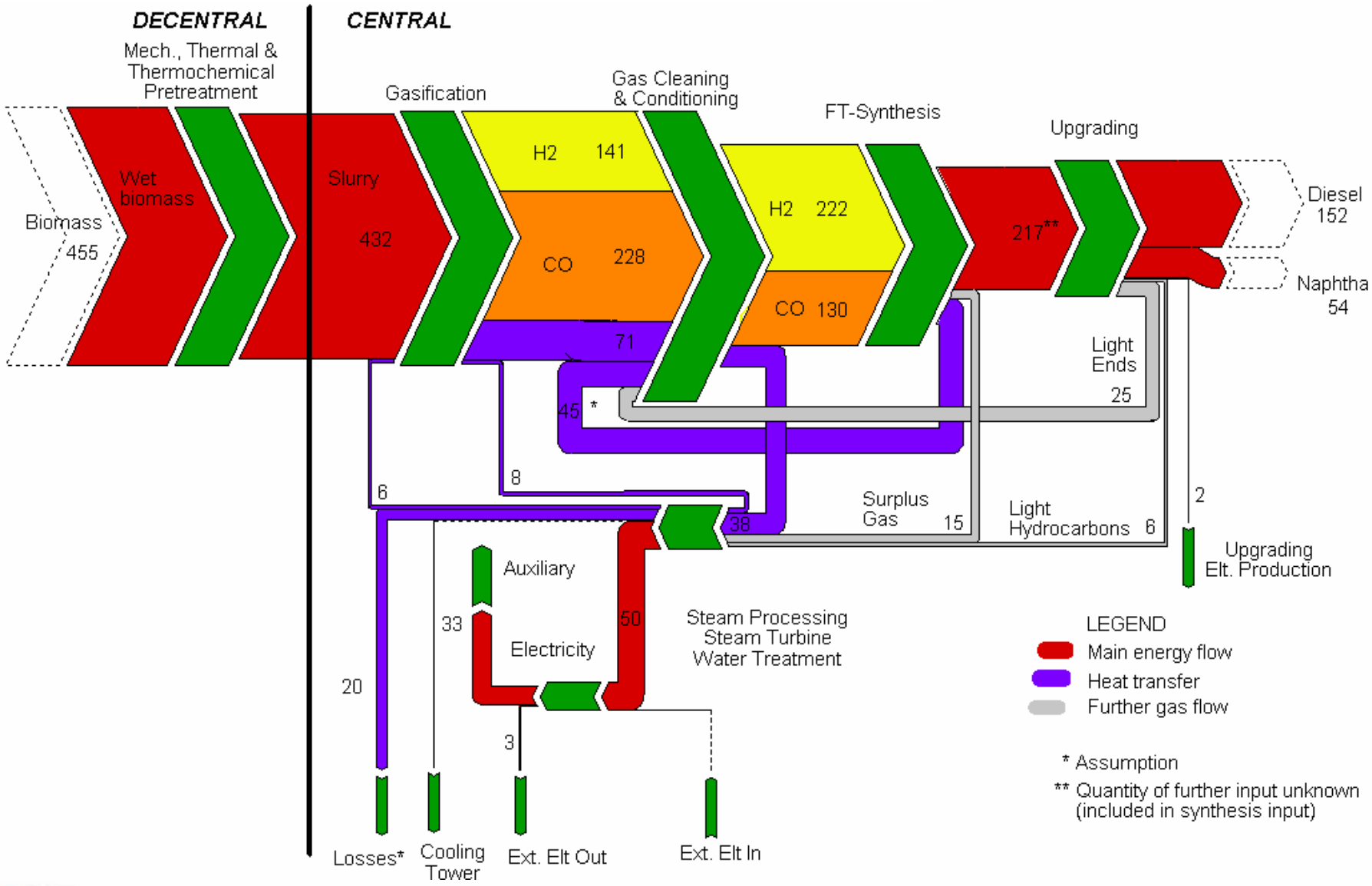
Substitution potential of BtL is 2.6 times higher than for first generation biofuels!

Technical assessment

Targets:

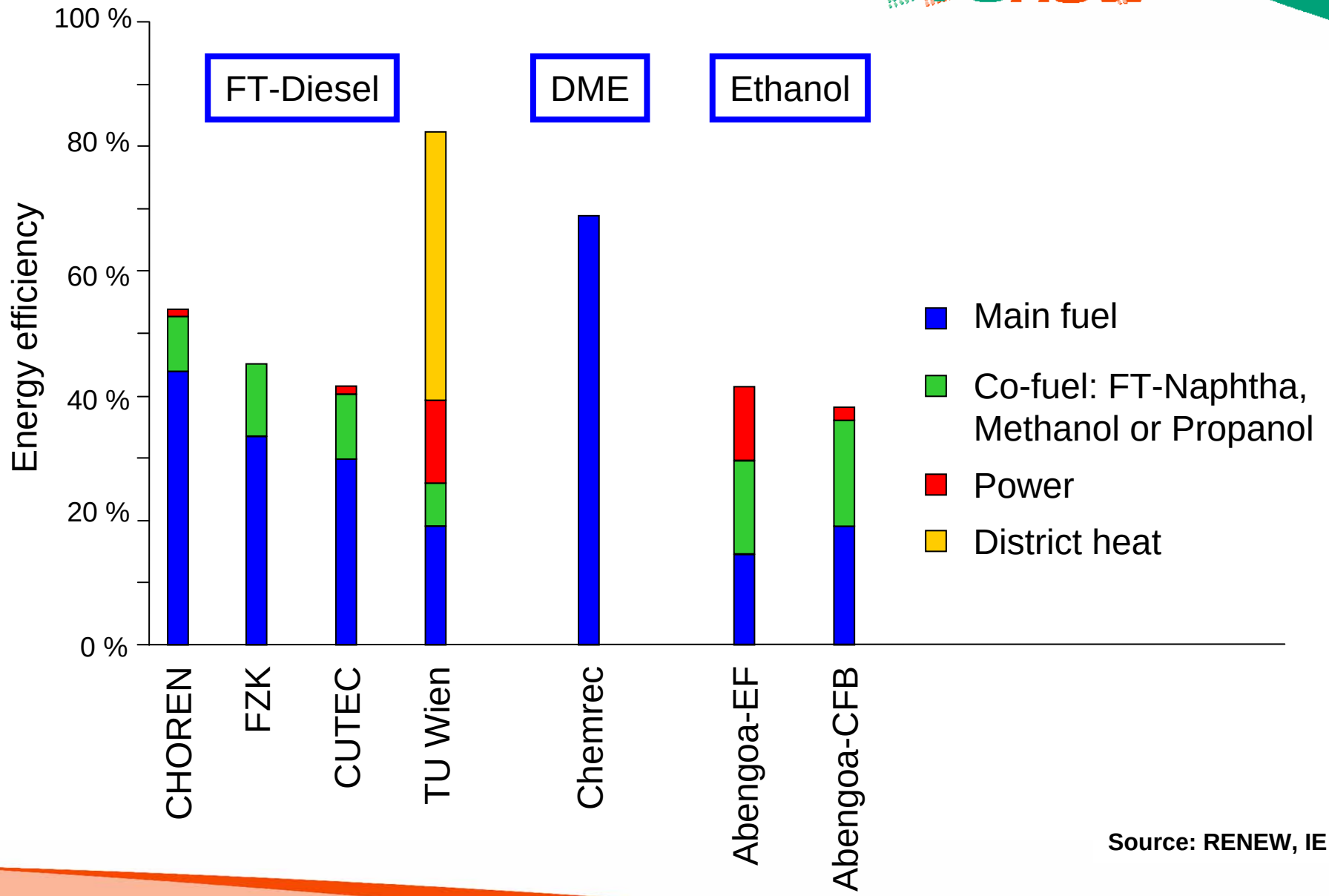
- **Consistent comparison of BtL concepts**
- **Detailed profiles and characteristics**
- **Analysis of technical performance of BtL production (in particular energy aspects)**
- **Technical challenges**
- **Comparison to coal (CtL) or gas (GtL) based plants**

Energy flux



Source: RENEW, IE

Overall efficiency



Source: RENEW, IE

Maturity

Concept	CHOREN	Chemrec	TU Wien	FZK	CUTEC	Abengoa EF	Abengoa CFB
Scale up steps	1	1	1	(1)	2	no gasifier	no gasifier
Mass balances (start / end run)	β: available Σ: progress	available	-	-	-	-	-
Catalyst provider available	1	3	(1)	-	-	-	-
CAPEX / OPEX	available	available	available	-	-	simulation level	simulation level
Plot plan	available	available	-	-	-	-	-
Water flow plan	β: available Σ: progress	available	-	-	-	-	-
Health safety executive	β: available Σ: progress	-	partly available	-	-	-	-
Modelling quality	test data + mass balances	(test data +) mass balances	test data + mass balances	mass balances	mass balances	mass balances	mass balances

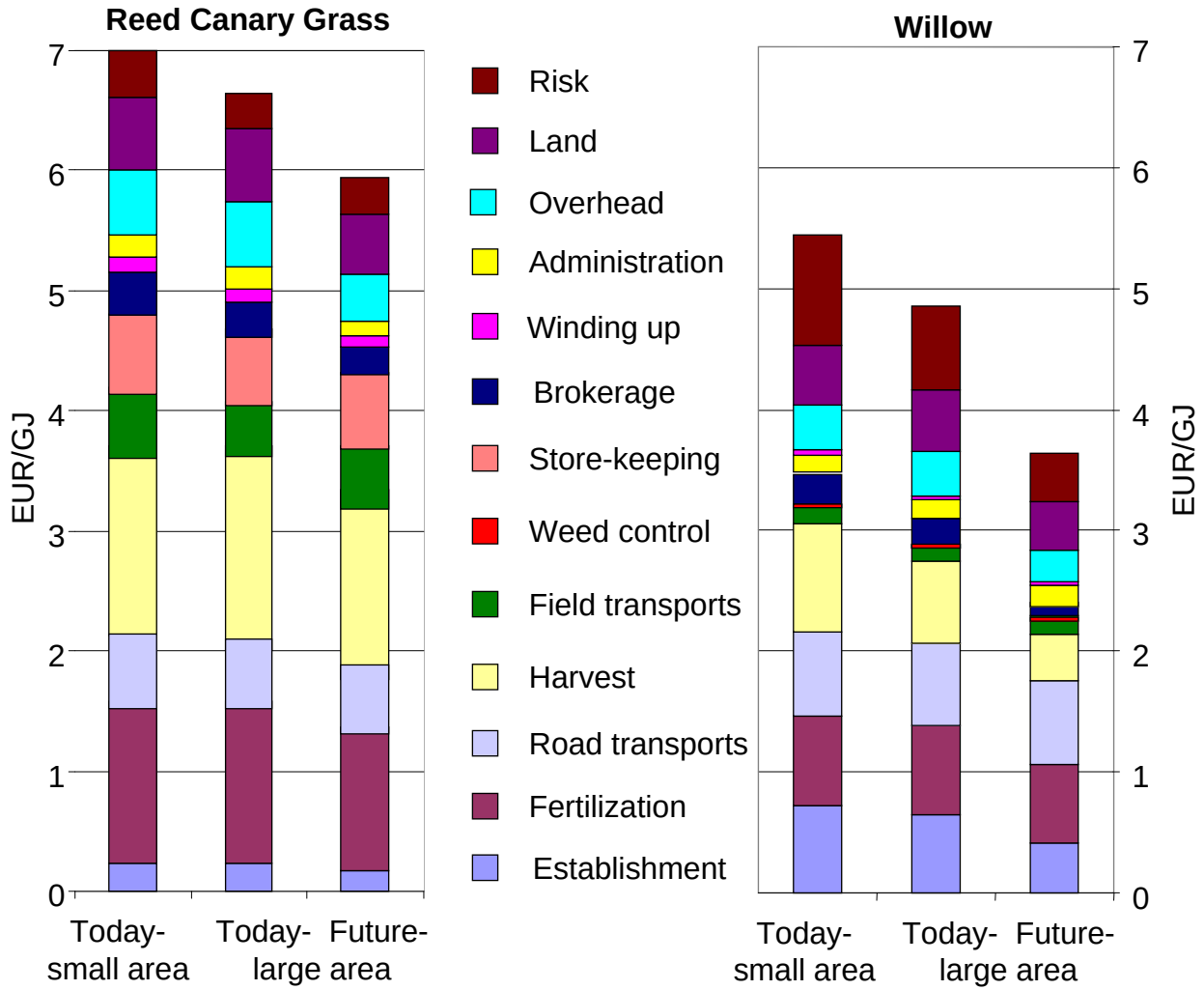
Concepts of CHOREN and CHEMREC ready for demonstration !

Economic assessment

Approach:

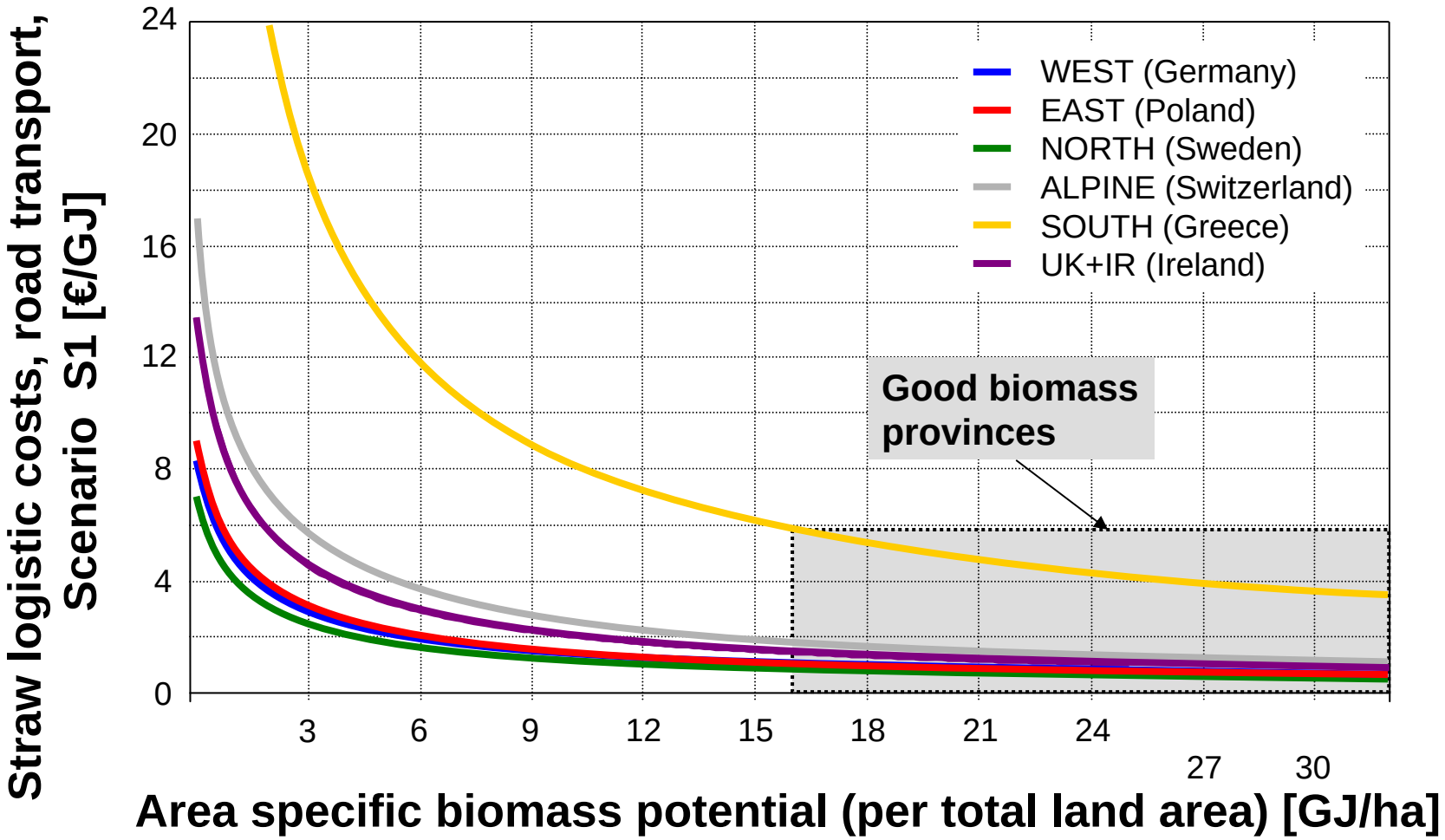
- **Biomass production costs for straw, logging residues, willow, eucalyptus, miscanthus and triticale**
- **Logistic costs for bales, wood chips and wood bundles**
- **BtL production costs for each concept**
- **Based on model countries Sweden, Poland, Germany, Ireland, Switzerland and Greece for north, east, west, UK-Ireland, alpine, south**

BtL costs: biomass production



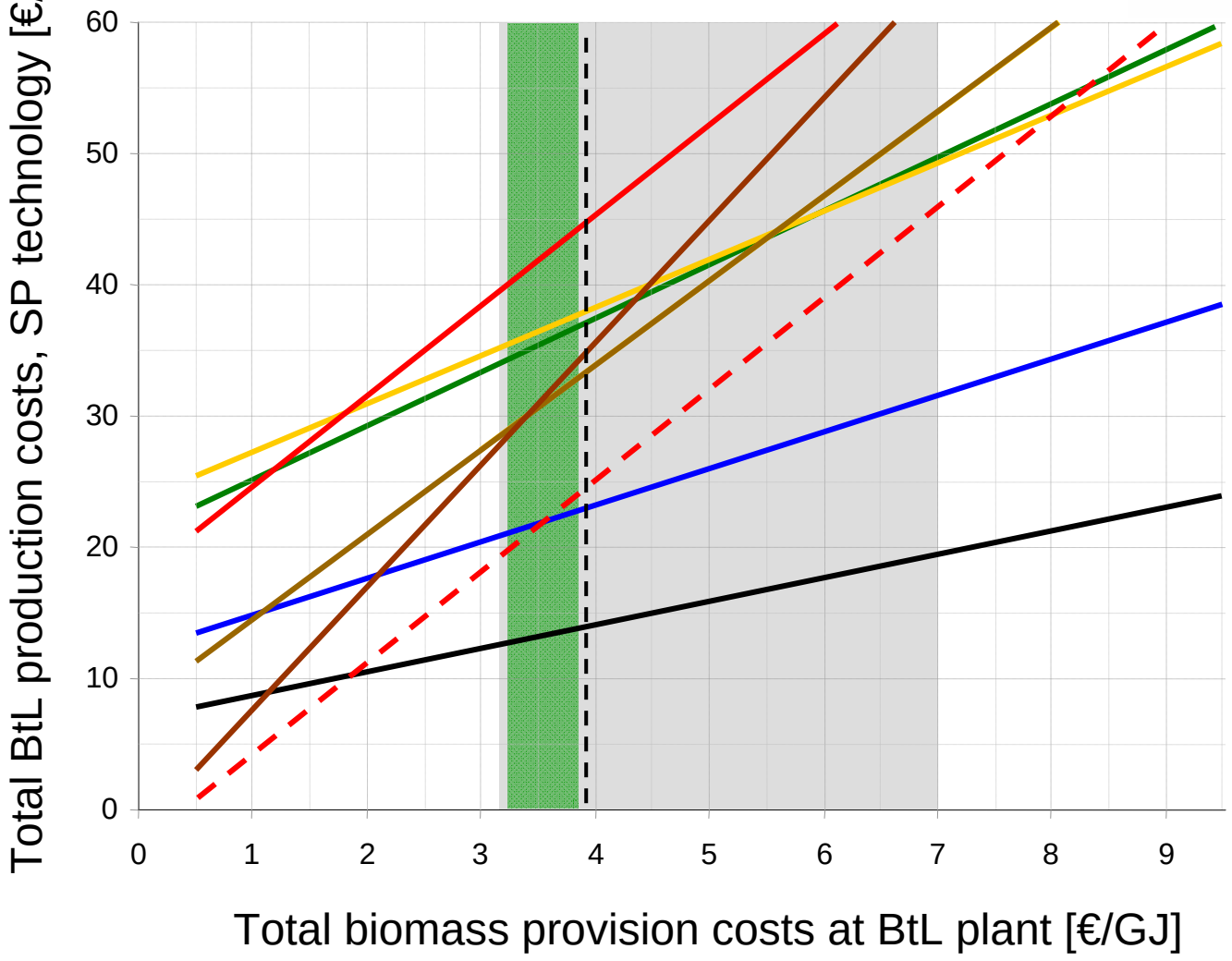
Source: Universitet Lund

BtL costs: biomass transport



Source: ECBREC, IE

BtL costs: total, starting point



BLEF-DME, Chemrec
cEF-D, UET/Choren
dEF-D, FZK
ICFB-D, TU Wien
CFB-E, Abengoa
EF-E, Abengoa
CFB-D, CUTEC

SP range of biomass costs in good provinces

S1 range of biomass costs in good provinces

129 SEK/MWh wood chips free plant gate, price acc. Swedish Energy Agency

Site specific issues: ICFB-D concept with current Austrian renewable power bonus

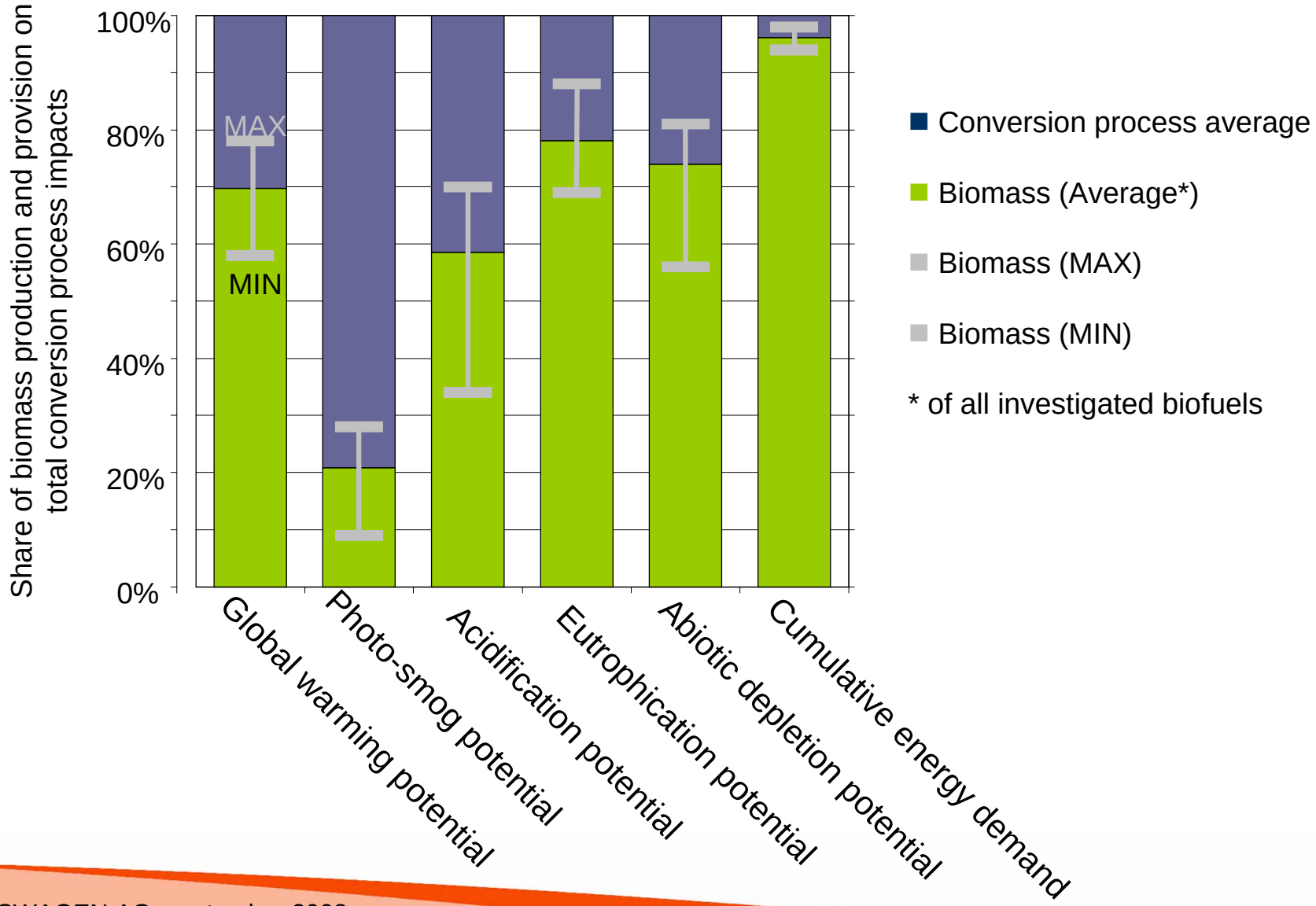
28 €/GJ = 1 €/l_{DE}, based on 2004 costs

Life cycle assessment

Approach:

- **study according to ISO 14040/44, including peer review**
- **Well-to-tank, i.e. chain from**
  - **biomass production (willow, miscanthus, wheat straw)**
  - **biomass logistics (tracktor, storage, truck)**
  - **BtL production (cEF-D, dEF-D, BLEF-DME, CFB-D, ICFB-D)**
  - **transport of FT-Diesel or DME to the filling station**

Life cycle assessment



BtL suitability

Targets:

- **Determination of fuel properties according to EN 590 (diesel norm)**
- **Study of**
  - **unmodified current diesel engines (FT-diesel)**
  - **software-adapted, current diesel engines (FT-diesel)**
  - **research single-cylinders HCCI (FT-naphtha)**
  - **modern truck-engine with modified fuel system (DME)**

BtL engine performance

FT diesel fuel offers high emission reduction potential for non-adapted engines. These benefits can be utilized in existing vehicle fleet.

w/o Engine Modifications

+

- **HC reduction potential 70%**
- **CO reduction potential 70%**
- **PM reduction potential 20%**
- **Slightly reduced CO2 5%**

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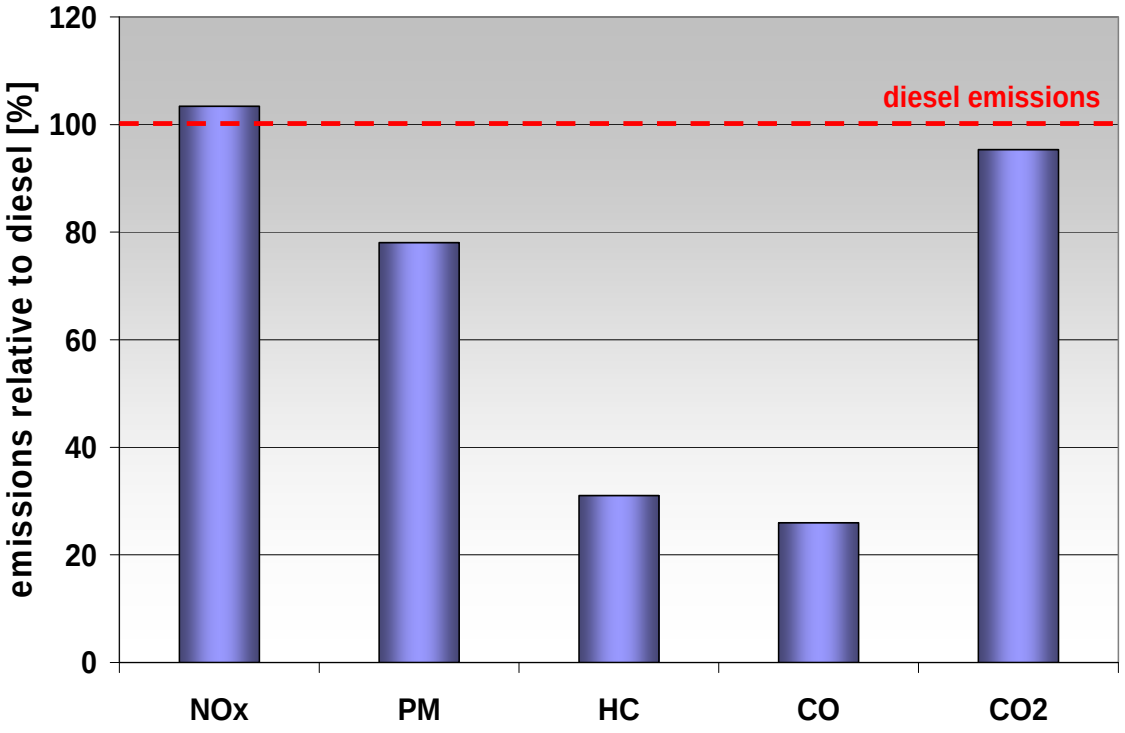
- **Limited NO_X-reduction**
- **Slightly reduced power**
- **Higher volumetric fuel consumption**



Vehicle: Golf V, unit injector, 103kw **Source: VW**

BtL engine performance

Software adaptation would facilitate NO_X-reduction of engines operated with BTL fuel.

Only Software Adaptation

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- **Simultaneous Particulate and NO_X-Reduction of up to 25% in NEDC**

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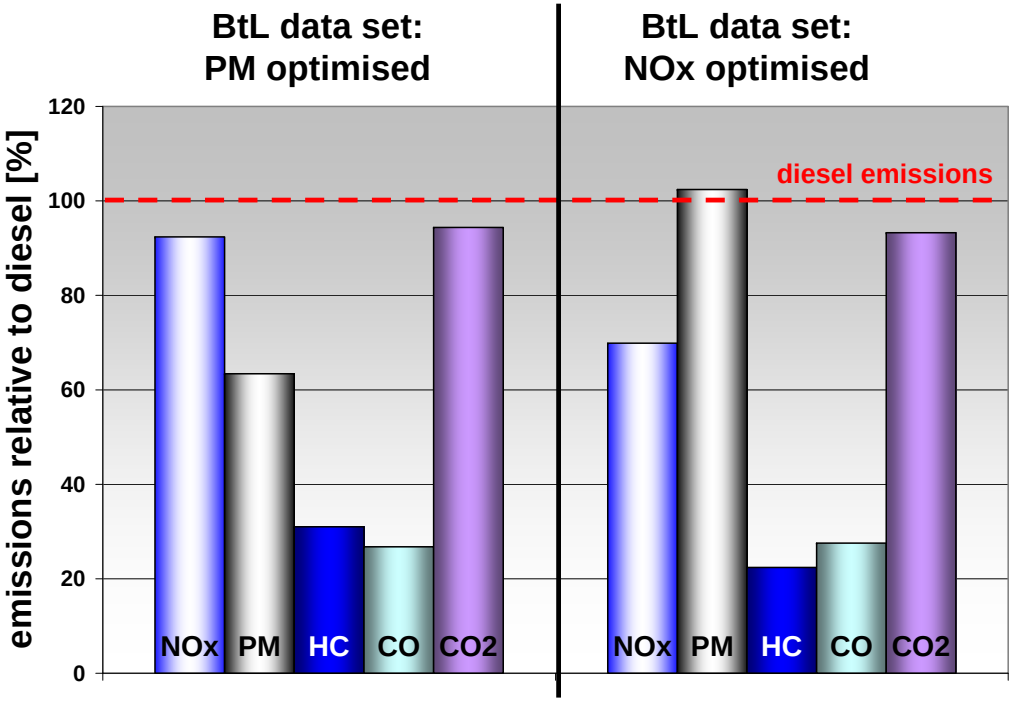
- **Emission limits still be fulfilled with fossil Diesel**
- **Higher volumetric Fuel Consumption**



Vehicle: Golf V, unit injector, 103kw

Source: VW

BtL properties & specification

BtL diesel

- meets most parameters of EN 590 (diesel norm)
- is suitable for all diesel engines
- Can be blended in any ratio to diesel
- has superior emission properties

			conventional engines (Diesel)		future powertrains (homogeneous combustion) [5]	
			BTL 100	BTL as 20% Blending component	future BTL 100	BTL naphta 100
Parameters						
	5% recovered at	°C	170	170	160	50
	95% recovered at	°C	320	350 [3]	250	160
	%-n-paraffin/iso-paraffin		cannot be derived form RENEW results			
	Olefine	mass %	< 1	< 1	< 1	< 1
	Aromatics	mass %	< 1	< 1	< 1	< 1
	Sulfur	ppm	< 5	< 5	< 5	< 5
	Oxygen content	mass %	cannot be derived form RENEW results			
Characteristics						
	Cetan no.		> 60	> 60	< 50 / >65 [1]	< 45
	CFPP	°C	< -22	< -17 [4]	< -22	< -23
	Flash point	°C	> 55	> 50	> 55	-
	Density	g/ml	0,76	> 0.76	0,74	0,70
	H/C	mol/mol	> 2	> 2	> 2	> 2
	Lower heating value	MJ/kg	44,8	44,8	44,6	44,3
	Lubricity	um	< 460 [2]	< 460 [2]	< 460 [2]	< 460 [2]
	Others		EN 590	EN 590	EN 590	-

www.renew-fuel.com

Thank you for your attention !