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Bundesministerium für Verkehr, Innovation und Technologie

Akteure
Workshop
Technologien
Publikationen
News
Biokraftstoff
Netzwerk
Experten
Österreich
Projekte
Biotreibstoffe
Energieversorgung
Aktivitäten
Forschung
Informationsaustausch
Ergebnisse
Wissen
Nachhaltigkeit
Vernetzung
Fragestellungen
Plattform
erneuerbare Energie

# Highlights der Bioenergieforschung

## Nationale und internationale Ergebnisse zu den IEA Schwerpunkten

**30. und 31. März 2011**

**Fachhochschule Wieselburg**

e2050

IEA FORSCHUNGS KOOPERATION

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e 2050
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## Highlights der Bioenergieforschung

# Nationale und internationale Ergebnisse zu den IEA Schwerpunkten

Die 20/20/20-Ziele der europäischen Kommission sind nicht nur eine energiepolitische Herausforderung, sondern vielmehr eine Chance für innovative Betriebe in Österreich. Im Bereich Biotreibstoffe, wie auch in verschiedenen anderen Bereichen der erneuerbaren Energietechnologien, konnte sich Österreich bereits europaweit und weltweit gut etablieren. Um in diesen Bereichen die Führungsrolle noch stärker auszubauen, sind wesentliche Anstrengungen in der Forschung und Technologieentwicklung, aber auch bei der Marktüberführung, z.B. mit Mitteln aus der Europäischen SET-Plan-Initiative, notwendig.

Bei den Biotreibstoffen spielen Innovationen, Investitionsmittel für die Errichtung von Anlagen im Industriemaßstab, die Integration in bestehende Strukturen, sowie die nachhaltige, umwelt- und sozialverträgliche Beschaffung der Rohstoffe eine wesentliche Rolle. Vor diesem Hintergrund steigt die Bedeutung internationaler Zusammenarbeit, sei es im Rahmen der IEA oder der Instrumente der EU. Vorteile wie internationale Trends und Entwicklungen zeitgerecht zu identifizieren oder an technologisch anspruchsvollen Fragestellungen gemeinsam arbeiten zu können sind für Österreich als kleines Land entscheidend.

Das bmvit hat den diesmaligen Veranstaltungsfokus auf den Schwerpunkt „Biotreibstoffe“ gesetzt. Kombiniert wird die bereits **5. Highlights der Bioenergieforschung** mit dem **Nationalen Task 39 Workshop** von IEA Bioenergy Task 39, bei dem alle drei Jahre die österreichischen Forschungsaktivitäten zu Biotreibstoffen kompakt dargestellt werden. Die Organisation der Veranstaltung erfolgt in Zusammenarbeit mit dem **Netzwerk Biotreibstoffe**, welches bei dieser Gelegenheit sein breites Informationsangebot darstellen wird. Dank der gemeinsamen Trägerschaft mit BIOENERGY 2020+ und unter Mithilfe der Fachhochschule Wieselburg, FJ-BLT und Joanneum Research wird die zweitägige Veranstaltung an der FH Wieselburg und im TZWL durchgeführt.

## Ort

**Fachhochschule Wieselburg**
**Zeiselgraben 4**
**3250 Wieselburg**

## Zeit

**30. und 31. März 2011**
**10:30 bis 21:30 Uhr**
**8:30 bis 17:30 Uhr**

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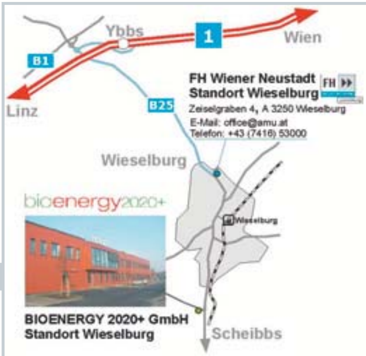
## ANREISE

**Öffentliche Anreise:**
**> von Wien:** Wien Westbahnhof – Abfahrt ÖBB Intercity 8:44, Umsteigen in St.Pölten Hbf – Abfahrt Regionalzug Richtung Scheibbs 9:37, Ausstieg Wieselburg/Erlauf Bahnhof – Ankunft 10:22, weitere 13 Minuten zu Fuß
**> von Linz:** Linz/Donau Hbf – Abfahrt ÖBB Intercity 8:31, Umsteigen in St.Pölten Hbf – Abfahrt Regionalzug Richtung Scheibbs 9:37, Ausstieg Wieselburg/Erlauf Bahnhof – Ankunft 10:22, weitere 13 Minuten zu Fuß
**> von Graz:** Graz Hbf – Abfahrt ÖBB Eurocity 5:39, Umsteigen Wien Meidling – Abfahrt S-Bahn Richtung Unterpurkersdorf 8:27, Umsteigen Wien Hütteldorf – Abfahrt ÖBB Intercity 8:52, Umsteigen in St.Pölten Hbf – Abfahrt Regionalzug Richtung Scheibbs 9:37, Ausstieg Wieselburg/Erlauf Bahnhof – Ankunft 10:22, weitere 13 Minuten zu Fuß

**Anreise mit dem Auto:**
Zur Tagung gelangen Sie über die Autobahn A1:
> von Wien oder Linz kommend / Abfahrt Ybbs/Wieselburg / B25 Richtung Wieselburg ca. 3 km / bei 1. Ampel an der Ortseinfahrt links / nach 30 m rechts auf den FH-Parkplatz




## NÄCHTIGUNGSINFORMATIONEN

Shuttle Service zwischen Veranstaltungsort und den Nächtigungsmöglichkeiten nach Bedarf.

**Hotel Steiner** Pöchlarnerstraße 26-30, 3251 Purgstall
Buchungscode: Highlightsveranstaltung Biotreibstoffe
Tel.: +43/(0)7489/70888; Email: info@hotelsteiner.at; www.hotelsteiner.at
Preis: EZ ab € 64,-- inkl. Frühstück

**Landgasthaus Bärenwirt** Ybbser Straße 3, 3252 Petzenkirchen
Buchungscode: Highlightsveranstaltung Biotreibstoffe
Tel.: +43/(0)7416/521530; Email: baerenwirt@aon.at; www.baerenwirt1.at
Preis: EZ ab € 50,-- inkl. Frühstück

**Gasthof zur Traube** Ybbser Straße 1, 3252 Petzenkirchen
Tel.: +43/(0)7416/52152; Email: office@gasthofzurtraube.at; www.gasthofzurtraube.at
Preis: EZ ab € 42,-- inkl. Frühstück

Detaillierte Informationen zur Anreise und weitere Nächtigungsmöglichkeiten entnehmen Sie den zusätzlichen Anreiseinformationen (www.nachhaltigwirtschaften.at/iea/veranstaltungen).
Wegen der begrenzten Nächtigungsmöglichkeiten in Wieselburg und Umgebung wird um rasche Anmeldung und Zimmerreservierung ersucht.

***www.nachhaltigwirtschaften.at/iea***

# Programm Tag 1: 30. März 2011

## Highlights der Bioenergieforschung

**10:30 Anmeldung und Information**

**11:00 Biokraftstoffe: Energie für den Transportsektor**
Moderation Martina Ammer, BMVIT, III/I 3

Begrüßung durch das BMVIT
▷ *Michael Paula, BMVIT, III/I 3*

Begrüßung durch die FH Wieselburg
▷ *Astin Malschinger, FH Wiener Neustadt, Standort Wieselburg*

Landwirtschaft und Biokraftstoffe
▷ *Johann Marihart, AGRANA Beteiligungs AG*

Biokraftstoffe aus industriellen Reststoffen
▷ *Edgar Ahn, BDI - BioEnergy International AG*

Equipment zur Produktion von Biokraftstoffen
▷ *Thomas Pschorn, Andritz*

Biokraftstoffe und Raffinerieprozesse
▷ *Walter Böhme, OMV AG*

Erneuerbare Energie im Individualverkehr der Zukunft
▷ *Max Lang, ÖAMTC*

**12:40 Mittagessen**

**14:00 Biokraftstoffe in Österreich und der EU**
Moderation Gerfried Jungmeier, Joanneum Research - Resources

Biokraftstoffproduktion in Österreich
▷ *Reinhard Thayer, ARGE Biokraft*

Rechtliche Basis in Österreich und der EU
▷ *Heinz Bach, BMLFUW, Abteilung V/5*

European Industrial Bioenergy Initiative – Chancen für die Industrie
▷ *Theodor Zillner, BMVIT, III/I 3*

$CO_2$-Minderung im Straßenverkehr
▷ *Werner Tober, TU Wien - IFA*

Netzwerk Biotreibstoffe
▷ *Dina Bacovsky, BIOENERGY 2020+*

**15:40 Kaffeepause**

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**16:15** **Das IEA Energy Technology Network**
Moderation Manfred Wörgetter, FJ-BLT

IEA Bioenergy
▷ *Josef Spitzer*

Task 33: Thermal Gasification of Biomass
▷ *Reinhard Rauch, TU Wien - VT*

Task 37: Energy from Biogas and Landfill Gas
▷ *Bernhard Drosg, BOKU - IFA Tulln*

Task 38: Greenhouse Gas Balances of Biomass and Bioenergy Systems
▷ *Neil Bird, Joanneum Research - Resources*

Task 39: Commercialising Liquid Biofuels from Biomass
▷ *Dina Bacovsky, BIOENERGY 2020+*

Task 40: Sustainable International Bioenergy Trade - Securing Supply and Demand
▷ *Lukas Kranzl, TU Wien - EEG*

Task 42: Biorefineries: Co-production of Fuels, Chemicals, Power and Materials from Biomass
▷ *Gerfried Jungmeier, Joanneum Research - Resources*

IEA Advanced Motor Fuels und IEA Hybrid and Electric Vehicles
▷ *Andreas Dorda, BMVIT, III/I 4*

Diskussion

**17:45** **Resumee des Tages**
▷ *Theodor Zillner, BMVIT, III/I 3*

**18:10** **Transfer ins Technologiezentrum Wieselburg-Land (TZWL)**

**18:30** **Kamingespräch im TZWL**
Moderation Manfred Wörgetter, FJ-BLT

Begrüßung
▷ Karl Gerstl, Bürgermeister der Gemeinde Wieselburg-Land
▷ Claus Zeppelzauer, ecoplus. Niederösterreichs Wirtschaftsagentur

**Verbrannt - Verstromt - Verfahren?**

vor dem Kamin:
▷ *Alexander Bachler, Landwirtschaftskammer Österreich*
▷ *Franz Kirchmeyr, ARGE Kompost&Biogas*
▷ *Ewald-Marco Münzer, Münzer Bioindustrie*
▷ *Reinhard Koch, Europäisches Zentrum für erneuerbare Energie*

**19:30** **Transfer und Abendessen**

# Programm Tag 2: 31. März 2011

## Transportation Biofuels Research in Austria 2011

**8:30** **Lignocellulosic Biomass and Biofuels**
Chair Manfred Wörgetter, FJ-BLT

Availability of forest biomass: regional energy concepts and consumer acceptance
▷ *Josef Walch, FH Wiener Neustadt, Standort Wieselburg*

Logistic chains for wood chips from short rotation forestry
▷ *Franz Handler, FJ-BLT*

Investigation of hydrolytic microorganisms and enzymes for depolymerisation of recalcitrant biomass
▷ *Georg Gübitz, Stefan Weiß, TU-Graz - Umweltbiotechnologie*

Is second generation bioethanol commercialized yet?
▷ *Markus Lehr, VOGELBUSCH Biocommodities*

Assessment of ligno-cellulosic bioethanol concepts in Austria – technical, economic and environmental aspects
▷ *Kurt Könighofer, Joanneum Research - Resources*

The current situation of lignocellulosic bioethanol – with regard to straw in Austria
▷ *Heike Kahr, Alexander Jäger, FH Oberösterreich, Campus Wels*

New avenues for fungal strain improvement towards enzymatic degradation of cellulosic biomass for biofuel production
▷ *Verena Seidl-Seiboth, Christian P. Kubicek, TU Wien - VT*

**10:15** **Coffee Break**

**10:45** **Innovative Technologies**
Chair Dina Bacovsky, BIOENERGY 2020+

Advanced biofuels by gasification - Status of R&D work in Güssing
▷ *Reinhard Rauch, TU Wien - VT; BIOENERGY 2020+*

New Ways to Aviation Biofuels
▷ *Alfred Ecker, JKU Linz, CEFL*

Direct use of biomass in FCC-plants
▷ *Alexander Reichhold, TU Wien - VT*

Status and prospects for microalgae as raw material for third generation biofuels
▷ *Martin Mohr, ecoduna*

Algae for energy – Identification of the most promising algal-based pathways in Austria
▷ *Maria Hingsamer, Joanneum Research - Resources*

HYVOLUTION – Biological production of hydrogen from biomasses: process balances and process integration
▷ *Walter Wukovits, Domenico Foglia, Anton Friedl, TU Wien - VT*

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**12:45 Lunch Break**

**13:45 Developments for Pure Plant Oil, Biodiesel and Biogas**
Chair Kurt Pollak, New Energies and Strategies

Status and prospects for pure plant oil as transport fuel
▷ *Josef Rathbauer, FJ-BLT*

Biomethane for CNG and Grid Injection using Membrane Processes: New Developments and Technology Rollout
▷ *Michael Harasek, TU Wien - VT*

Environmental assessment of biomethane injected into the gas grid
▷ *Johanna Pucker, Joanneum Research - Resources*

Emissions in the engine combustion of biofuels and fuel mixtures
▷ *Jürgen Blassnegger, TU Graz - VKMB*

Impact of oxygenates in diesel fuel blends on engine emissions and combustion properties
▷ *Philipp Teiner, TU Wien - IFA*

**15:30 Coffee Break**

**16:00 Biofuels and Sustainability**
Chair Kurt Könighofer, Joanneum Research - Resources

Experiences and lessons learned of applying the GHG-methodology of the European Directive to Austrian biofuel plants
▷ *Gerfried Jungmeier, Joanneum Research - Resources*

BioGrace – Harmonising calculations of biofuel GHG emissions
▷ *Nikolaus Ludwiczek, BIOENERGY 2020+*

Biofuel production in African countries – case studies
▷ *Katharina Zwiauer*

Developing countries – Programs and lessons learned
▷ *Hannes Bauer, Austrian Development Agency*

**17:20 Summary of Day**
▷ *Theodor Zillner, BMVIT, III/I 3*

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Titelfoto: ELEN, fotolia.com

**Information und Anmeldung:**

**JOANNEUM RESEARCH**
**Forschungsgesellschaft mbH**
**Kurt Könighofer**
**Email: kurt.koenighofer@joanneum.at**
**Tel.: +43 (0)316/876 1324**
**Fax: +43 (0)316/876 1320**

Die Teilnahme ist kostenfrei, eine Anmeldung ist bis spätestens 23.3.2011 erforderlich.

Beschränkte Teilnehmerzahl, bitte rechtzeitig anmelden!

**Mitveranstalter:**

bioenergy2020+ — Task 39 IEA Bioenergy — FH Wiener Neustadt Wieselburg — FJ BLT Wieselburg

*Forschungskooperation Internationale Energieagentur*

*Verantwortung:*
*Bundesministerium für Verkehr, Innovation und Technologie*
*Abteilung für Energie- und Umwelttechnologien*
*Leitung: DI Michael Paula*
*A-1010 Wien, Renngasse 5*

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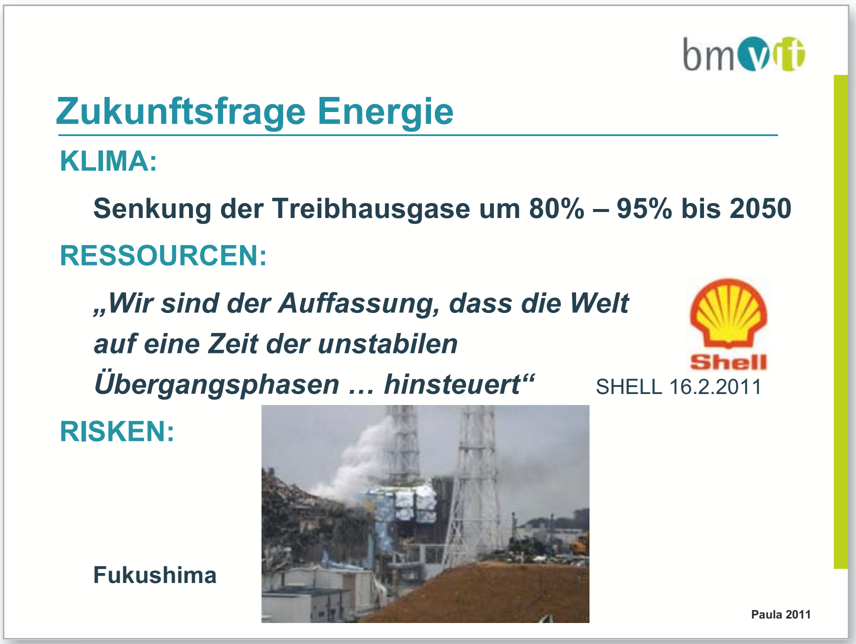
# Highlights der Bioenergieforschung

## Biokraftstoffe: Energie für den Transportsektor

***Moderation: Martina Ammer**, BMVIT, III/I 3*

### Begrüßung durch das BMVIT

***Michael Paula**, BMVIT, III/I 3*

## Begrüßung durch das BMVIT

*Michael Paula, BMVIT, III/I 3*

### Übergang zu einem postfossilen Wirtschafts- und Energiesystem

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- Rasante Veränderungen, Brüche(?)
- Globaler Wettlauf um zukünftige Technologiemärkte hat begonnen
- Besonders China, Indien, etc. beschleunigen rasant
- EU-SET-Plan,
- Clean Energy Ministerial, …

Fatih Birol (IEA) spricht
von einer *Energierevolution*

Paula 2011

### Was heißt das für Österreich?

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- Bei Technologien der Energie- und Ressourceneffizienz ist Österreich führend
- Wie lange noch?
- Andere Länder insbesondere in Asien holen stark auf
- In den nächste 5–7 Jahren muss eine neue Generation hocheffizienter und intelligenter Technologien für Globale Märkte etabliert werden.
- F&E hat Schlüsselrolle
- Heimmarkt für Marktüberleitung entscheidend

Paula 2011

# Landwirtschaft und Biokraftstoffe

Wieselburg, 30. März 2011

DI Johann Marihart, CEO AGRANA Beteiligungs-AG

SUGAR. STARCH. FRUIT.

März 2011|1

## AGRANA – Auf einen Blick

**AGRANA Produkte im täglichen Leben**


| ZUCKER. | STÄRKE. | FRUCHT. |
|---|---|---|
| • Zucker wird vertrieben<br>- an Endverbraucher über den Lebensmittelhandel (20 %) sowie<br>- an die weiterverarbeitende Industrie: z. B. Süßwarenindustrie, Fermentationsindustrie sowie sonstige Nahrungsmittel- und Getränkeindustrie (80 %). | • AGRANA produziert Stärke und Spezialstärkeprodukte.<br>• Stärke: komplexes, nicht wasserlösliches Kohlehydrat. Stärke wird in der Nahrungsmittelverarbeitung als Verdickungsmittel sowie für technische Anwendungen z.B. in der Papierverarbeitung eingesetzt.<br>• Bioethanol ist Teil unseres Stärke-Geschäftes. | • Fruchtsaftkonzentratkunden sind Fruchtsaftabfüller und die Getränkeindustrie.<br>• Fruchtzubereitungen sind kundenspezifische Produkte für<br>- die Molkereiindustrie,<br>- die Backwarenindustrie,<br>- die Eiscremeindustrie. |

März 2011|2

## AGRANA – Auf einen Blick

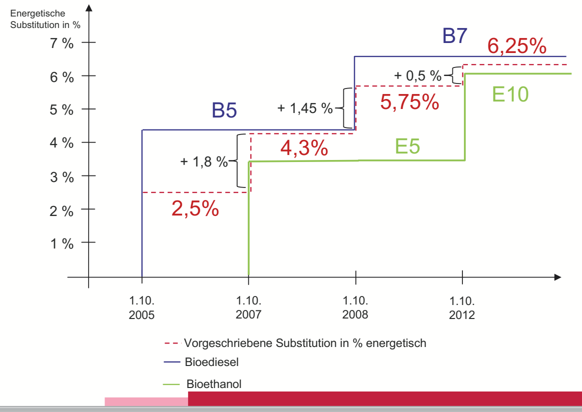
**AGRANA – der natürliche Mehrwert!**

- Konzernumsatz > 2 Mrd. €
- Ergebnis der Betriebstätigkeit > 100 Mio. €
- Eigenkapitalquote > 50 %
- Reduktion der Nettofinanzschulden
- Aufnahme in den österr. Nachhaltigkeitsindex VÖNIX
- Investitionen ~ 60 Mio. €
- Mitarbeiter ~ 8.000
- 52 Produktionsstandorte in 25 Ländern

März 2011|3

## Der Biokraftstoffpfad in Österreich

- Ab 1.10.2012 6,25 % Substitution (6,3 % in Diesel (B7), 6,1 % in Benzin (E10))




März 2011|4

## Ausblick Bioethanol

Einführung von E10 in Österreich 2012

- Notwendig zur Erhöhung des energetischen Substitutionsziels von 5,75 % auf 6,25 %
- AGRANA Bioethanolanlage in Pischelsdorf|NÖ exportiert aktuell 50% (ca. 100.000 m³)
- Es wird E5 (ca. 15 %) neben E10 (ca. 85 %) weiterhin für Altfahrzeuge geben
- Tankstelleninfrastruktur nach Auflassen von Normalbenzin verfügbar
- Normierung von E10 analog zu Deutschland
- Bioethanol in Österreich -> Pischelsdorf ausreichend für E10!

März 2011|5

## Warum Bioethanol aus Pischelsdorf?

- Technologie – State of the Art:
  - o Investition 125 Mio. €, 80 Arbeitsplätze
  - o Logistik: Bahn und Schiff!
  - o Energieversorgung: Verbund mit kalorischem Kraftwerk
- Verarbeitung lt. UVP von bis zu 620.000 Tonnen Getreide jährlich möglich
  => **Österreichs Getreide-Überschussmengen finden eine sinnvolle Verwertung!**
- Bioethanol-Kapazität von bis zu 240.000 m³ (= 200.000 Tonnen) jährlich
  => **kann 10 % des österr. Benzinbedarfs (=E10 Bedarf) substituieren!**
- „DDGS" (Eiweißfuttermittel ActiProt) von bis zu 190.000 Tonnen jährlich
  => **substituiert rund 1/3 der österr. Soja-Eiweißfuttermittelimporte!**
- Weitere geplante/in Bau befindliche Nebenproduktverwertung:
  - o $CO_2$ Rückgewinnungsanlage – biogenes $CO_2$ v.a. für Kohlensäure für Getränkeindustrie
  - o Weizenstärkeanlage – dem Bioethanolwerk vorgeschaltete Weizenverarbeitung – in der Weizenstärkenanlage ungenutzte Rohstoffbestandteile werden in Bioethanol- und Eiweißfuttermittelproduktion weiterverwertet

März 2011|6

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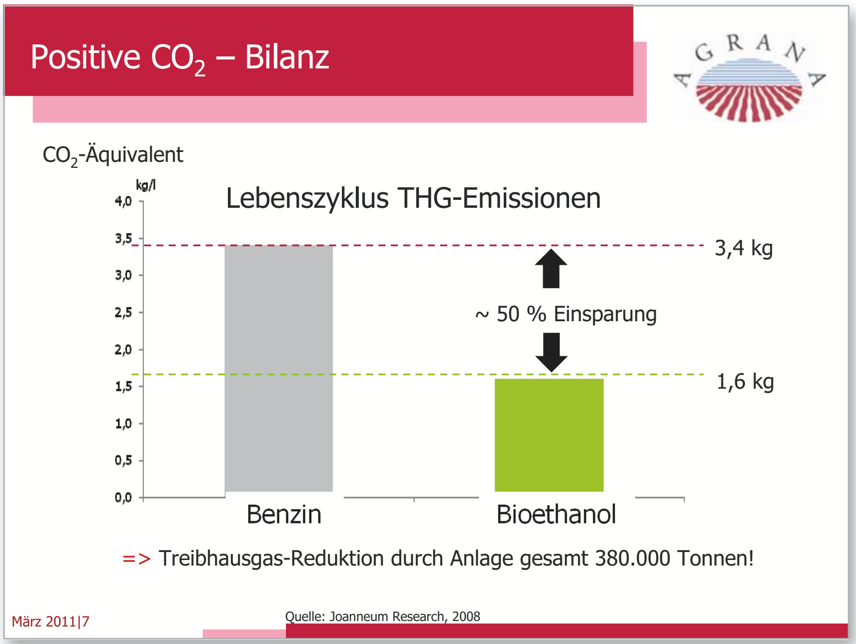


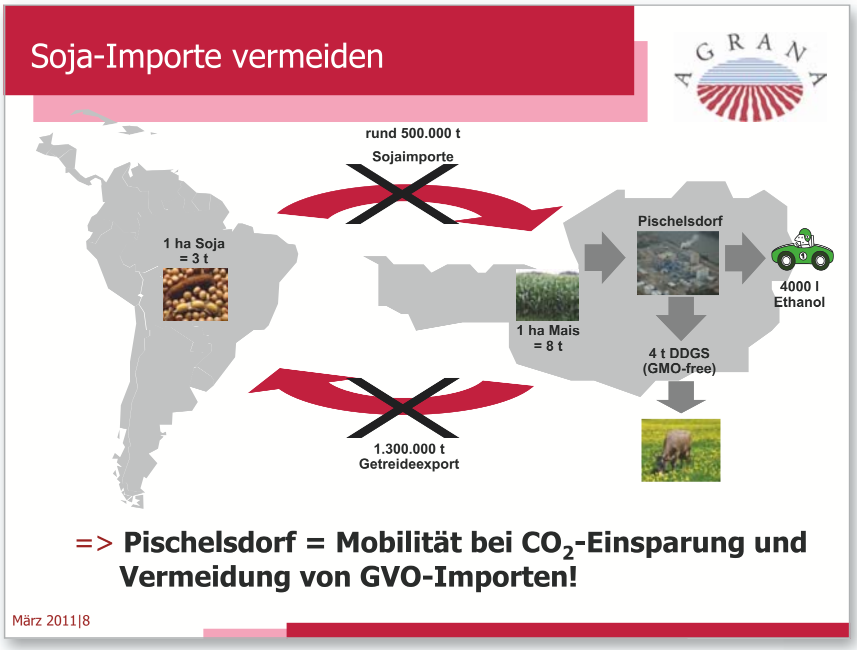


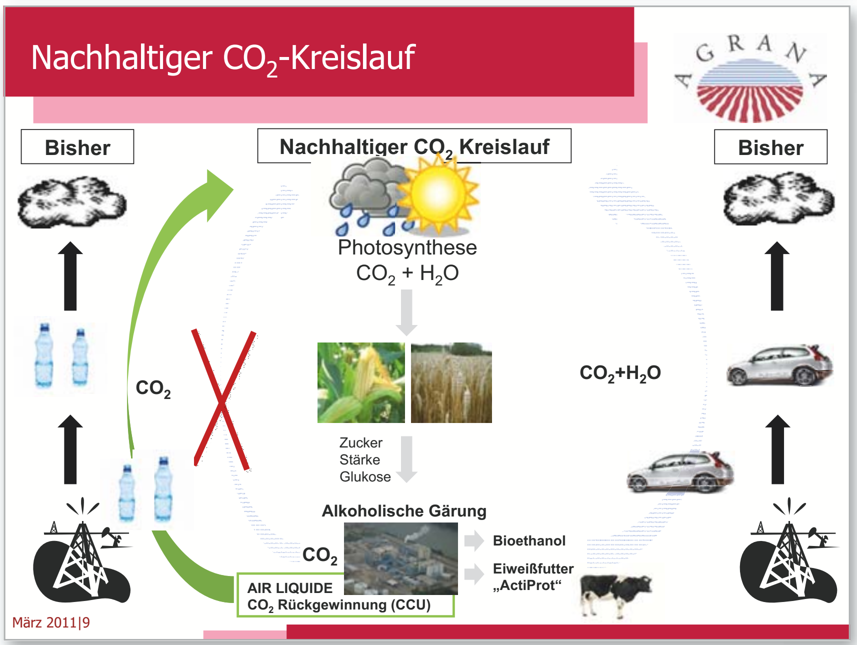


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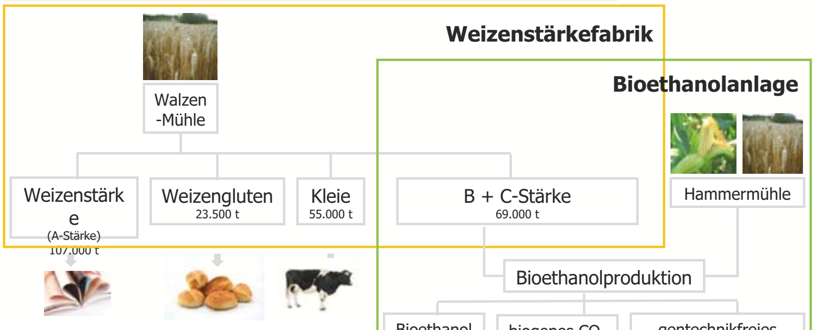
## Schema Weizenstärke-/Bioethanolfabrik integriert




**Treibhausgasbilanz von Bioethanol**
AGRANA Bioethanol spart über den gesamten Lebenszyklus 50% an Treibhausgasemissionen gegenüber Benzin!

März 2011|10

## Einflussfaktoren auf Rohstoffpreise

**Langfristig**

- Bevölkerungsentwicklung
  - o Weltbevölkerung steigt um ca. 80 Mio. Menschen pro Jahr (davon 95 % in Entwicklungsländern)
  - o Derzeit 6,5 Mrd. Menschen, 2050 über 9 Mrd.
- Wirtschaftswachstum -> wohlstandsbedingte Veränderung der Ernährungsgewohnheiten
  - o Welt-Fleischkonsum lt. USDA 2005-2010 +9 % auf 238 Mio. Tonnen
  - o Fleischproduktion erhöht Getreidebedarf:
    - -1 kg Geflügel -> ~ 4 kg Getreide
    - -1 kg Rind -> ~ 8 kg Getreide
  - o 2|3 des weltweiten Getreideaufkommens werden schon heute als Futtermittel eingesetzt
- Strukturschwächen/fehlende Investitionen in die Landwirtschaft in Entwicklungsländern
  - o 60 – 80 % der Bevölkerung arbeiten in der Landwirtschaft und können Bedarf nicht decken
  - o in entwickelten Ländern produzieren 2 % Landwirte Überschüsse
  - o verfehlte landwirtschaftliche Prioritäten

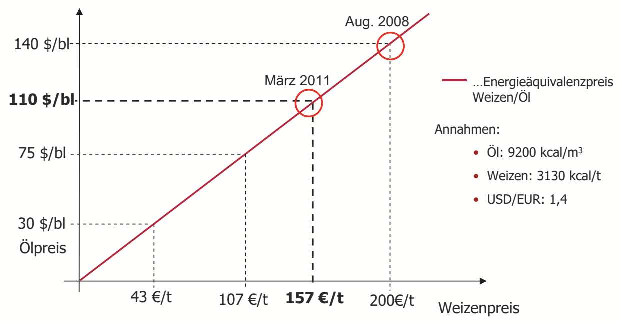
**Kurz- & Mittelfristig**

- Temporäre witterungsbedingte Angebotsengpässe
- Internationale Getreideproduktion & -Verbrauch
- Finanz-Spekulation

März 2011|11

## Fundamentale Einflussfaktoren Energieäquivalenzpreis

- Ölpreis ca. 110 USD/bl
- EUR/USD 1,40
- Weizen 253 €/t




=> Getreide wird derzeit unter Annahme eines Energieäquivalents überzahlt!

März 2011|12

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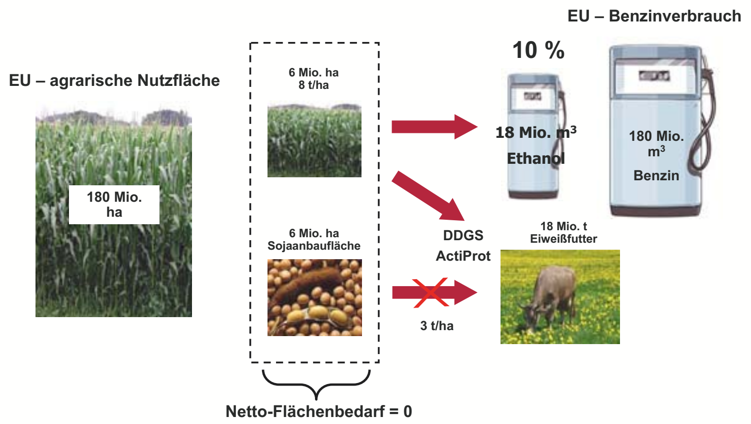
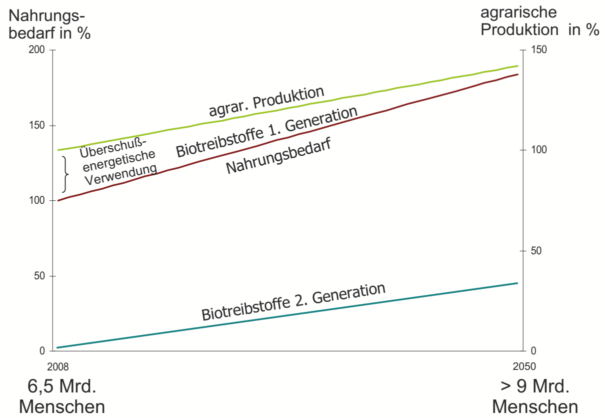
## Flächenverfügbarkeit 10% in der EU




März 2011|13

## Biotreibstoffpotential 1. vs. 2. Generation




März 2011|14

## Zusammenfassung

- Bioethanolproduktion in Österreich ist nachhaltig und macht Sinn
- Erfolgreiche 1. Generation ist Voraussetzung für 2. Generation
- Kapazität für E10 ist schon in Betrieb!
- Rohstoffversorgung ist gegeben

März 2011|15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März 2011|17

## Biokraftstoffe aus industriellen Reststoffen

Edgar AHN
Highlights der Bioenergieforschung,
FH Wieselburg

www.bdi-bioenergy.com

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## BDI Standort

**BDI - BioEnergy International AG**

**Parkring 18**
**A-8074 Grambach/Graz**
**Austria / Europe**
**www.bdi-bioenergy.com**

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## BDI Geschäfts Aktivitäten

**BDI ist Markt- und Technologieführer für den Bau von maßgeschneiderten schlüsselfertigen BioDiesel-Anlagen und auch BioGas-Anlagen.**

**Consulting**
**Forschung & Entwicklung**
**Engineering**
**Konstruktion**
**Inbetriebnahme**
**After Sales Service**

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## RES-EU Richtlinie: EC/28/2009, Annex V

A. *Typical and default values for biofuels if produced with no net carbon emissions from land-use change*

| Biofuel production pathway | Typical greenhouse gas emission saving | Default greenhouse gas emission saving |
|---|---|---|
| palm oil biodiesel (process not specified) | 36 % | 19 % |
| palm oil biodiesel (process with methane capture at oil mill) | 62 % | 56 % |
| waste vegetable or animal (*) oil biodiesel | 88 % | 83 % |
| hydrotreated vegetable oil from rape seed | 51 % | 47 % |
| hydrotreated vegetable oil from sunflower | 65 % | 62 % |
| hydrotreated vegetable oil from palm oil (process not specified) | 40 % | 26 % |
| hydrotreated vegetable oil from palm oil (process with methane capture at oil mill) | 68 % | 65 % |

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## Beispiel 1: Altspeiseöl (UCO) zu BioDiesel

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## Altspeiseöl zu BioDiesel

**1994 ECODRIVE-Projekt mit der Stadtverwaltung Graz**

ÖKODRIVE mit Ökodiesel

**Sammlung:**

- ✓ Abfallbehälter von Haushalten
- ✓ von Restaurants
- ✓ McDonalds Austria (~170 Restaurants)

**Produktion:**

- ✓ BDI-Anlage mit 16.000 t/a Kapazität
- ✓ SEEG – Agrargenossenschaft
- ✓ Kommunale Unabhängigkeit (+ Biogas Anlage & Holzverbrennungsanlage)

**Kunden:**

- ✓ Öffentliche Busse in Graz (140 Busse, B100)
- ✓ Speditionen
- ✓ Logistik von McDonalds Austria
- ✓ Öffentliche Tankstellen

UCO

BioDiesel

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## Ökodrive Graz: Altspeiseöl Sammlung

**Sammelbehälter**
125.000 kleine Eimer (3 – 5 Liter) zur Sammlung in Haushalten,
Verteilung in Graz und umliegenden Gemeinden
Speziell entworfene Container (500 – 1.000 Liter)
für Restaurants (ca. 250 in Graz)
Direkte Verladung auf Tank-LKW,
im Gegenzug Bestätigung der legalen Entsorgung

**Sammelmengen in Graz von Fa. Ökoservice**
aus Haushalten: ca. 70 t / Jahr
aus Restaurants: ca. 180 t / Jahr

**McDonalds Österreich** (ca.170 Restaurants): ca. 1.000 t / Jahr

**Gesamtmenge Österreich**: 30.000 – 50.000 t / Jahr

**Altspeiseöl Marktpreis**: ca. 820 € / t



## Beispiel 2: Tierfett zu BioDiesel

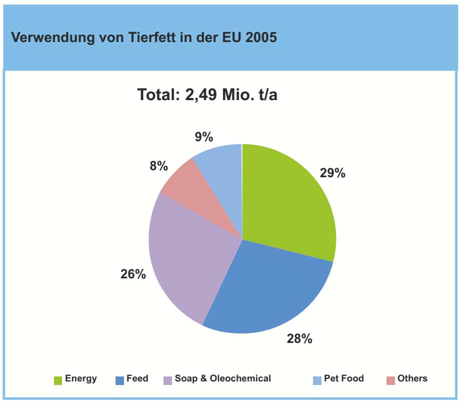


## Tierfett zu BioDiesel

**Menge Tierfett in Österreich**
rd. 40.000 t / Jahr (2008)

**Verwendung**
~ 60% energetische Verwertung
(Prozesswärme, BioDiesel)
~ 35% Export
~ 5% stoffliche Verwertung

**TKV Standorte Österreich**
Tulln (NÖ)
Regau (OÖ)
Ehrenhausen (Stmk)
Unterfrauenhaid (Bgld)




*Quelle: European Fat Processors and Renderers Association (EFPRA), 2004/05*

## Risikomaterial Tierische Fette (Kat.1)

**Verordnung (EG) Nr. 92/2005: Freigabe des BDI-Verfahrens zur Nutzung Kategorie 1 Tierfett für BioDiesel Herstellung**

**BDK BioDiesel Kärnten / A**
Line 1: 25,000 to/y

**Argent Energy / UK**
50,000 to/y

**DAKA / DK**
50,000 to/y

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## Beispiel 3: Fettabscheiderfette

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## Fettabscheiderfette zu BioDiesel

**2010 1ste BioDiesel Anlage weltweit für Fettabscheiderfette**

**Hongkong**

**Kapazität: 100.000 t/a**
**30 mio gal/y**

**Type: MF , Generalplanung, Lieferung inkl. Start-up**

**Besitzer: ASB BioDiesel**

**Rohstoff: Fettabscheiderfette, Altspeiseöl, Tierfett, Palm Fatty Acid Distillate (PFAD)**

**Nebenprodukte: Rohglycerin, Feststoffdünger**

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## Fettabscheiderfette zu BioDiesel

**2010 BioDiesel Amsterdam, Niederlande**

**BD Amsterdam**

**Kapazität:** 100.000 t/a
30 mio US gal/y
**Type:** MF , Generalplanung, Lieferung inkl. Start-up
**Besitzer:** BioDiesel Amsterdam
**Rohstoff:** Altspeiseöl, Tierfett, Palm Fatty Acid Distillate (PFAD)
**Nebenprodukte:** Glycerin (80%), Feststoffdünger



## Biogas aus Industrieabfall



## ®enbasys: ENBAFERM patentierte Neue Generation

**Höchst entwickelte wirtschaftliche Lösung**

**Komplexe organische Reststoffe -Multi Feedstock**

- Lebensmittelabfälle, Industrieabfälle
- Biomüll
- Reststoffe der Biotreibstoffproduktion
- …aber auch, wenn verfügbar
  - LW-Reststoffe und Produkte (Silage)



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## Industrie Abfälle

enbasys

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## Abfälle zu BioGas

enbasys

**Kommunaler und gewerblicher Biomüll – größte Anlage in Europa (Italien)**

**Technical details:**

Rohstoff: organic fraction of municipal solid waste (OFMSW), Abfälle der Lebensmittelindustrie, Schlachthausabfälle, Schlempen, Nebenprodukte der Biotreibstoffproduktion

Kapazität: 105.000 ton/a

Fermenter-System: 2 x 2900m$^3$, Beladungsrate 10 – 13 kg COD/m$^3$

Ertrag: Biogas: 1.450 Nm$^3$/h (59% $CH_4$)
Elektrizität: 3,4 $MW_{el}$ (27 GWh/y)
Gereinigtes Wasser: 43.827 m$^3$/y
Feststoffdünger : 47.173 m$^3$/y

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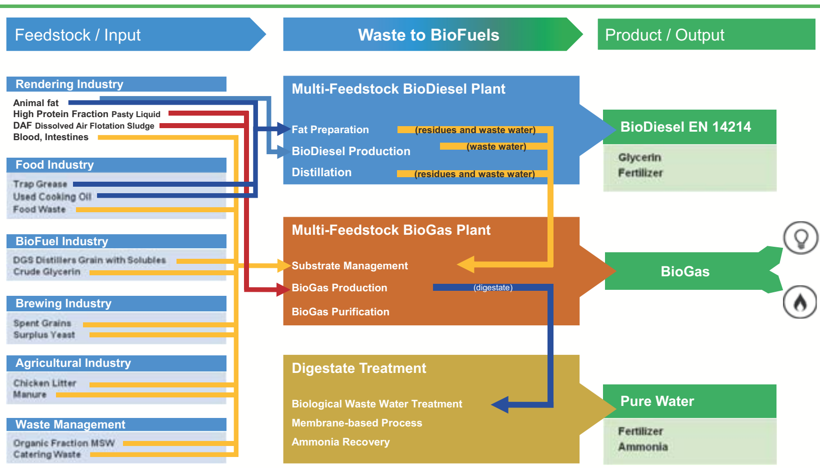
## BDI‘s integriertes Abfall-zu-BioTreibstoff Konzept

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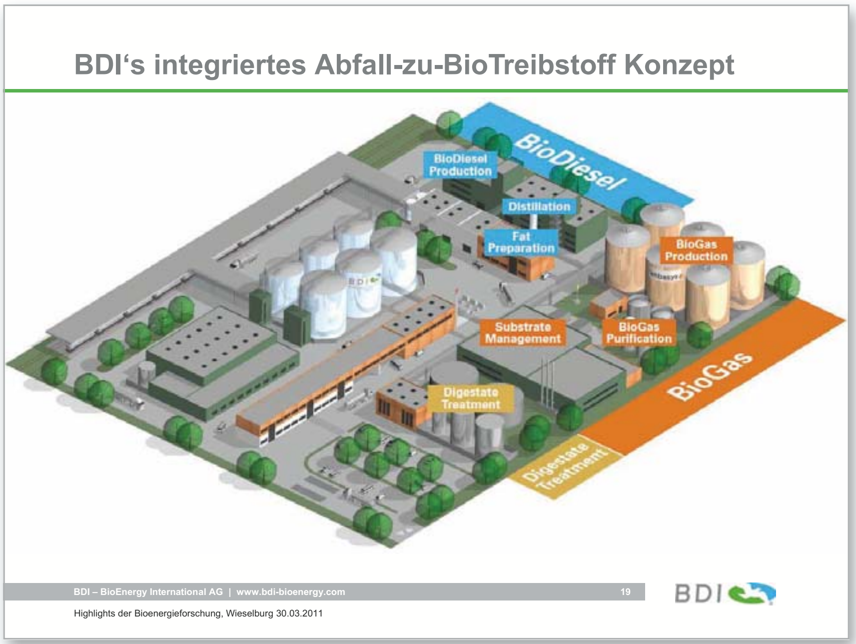
BDI's integriertes Abfall-zu-BioTreibstoff Konzept
BioDiesel
BioDiesel Production
Distillation
Fat Preparation
BioGas Production
Substrate Management
BioGas Purification
Digestate Treatment
BioGas
Digestate Treatment
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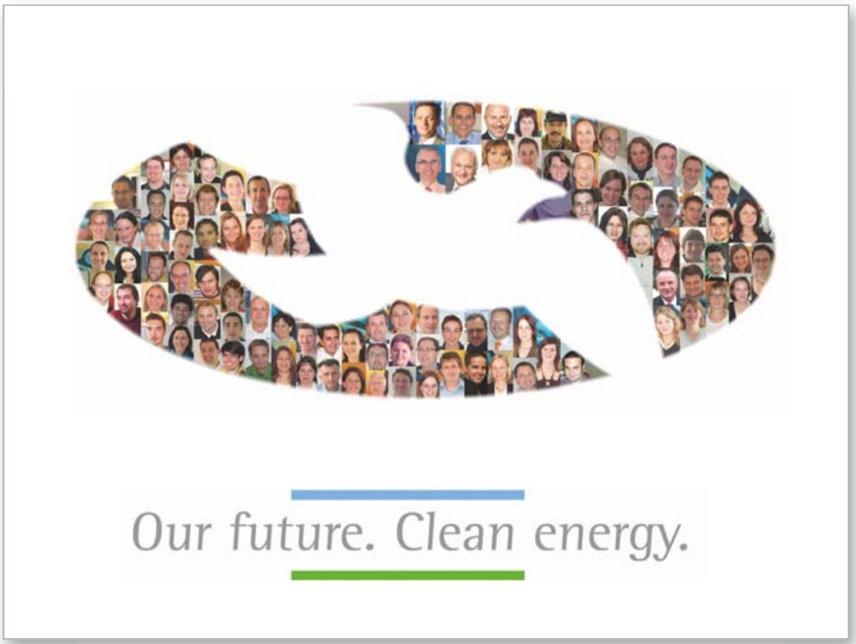
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# Biokraftstoffe aus industriellen Reststoffen

*Edgar Ahn, BDI – BioEnergy International AG*

ANDRITZ

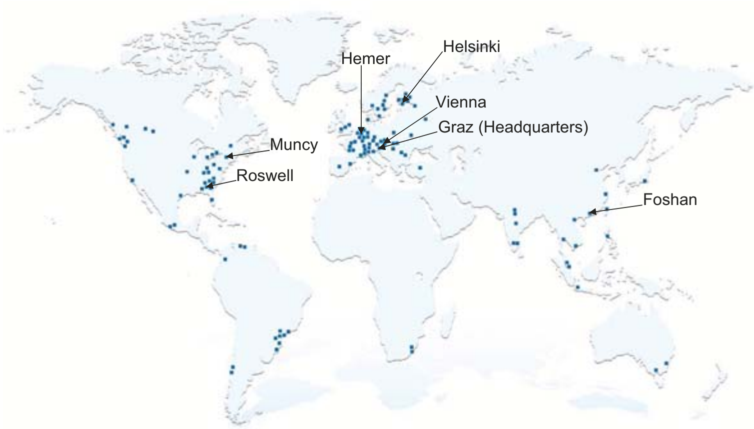
## Fiber and Chemical Division

Globaler Geschäftsbereich Biotreibstoffe

**Biotreibstoff-Ausrüstungen –** erprobtes Equipment aus der Zellstoff & Faserplattenindustrie wird mit geringfügigen Anpassungen für die **2. Generation von Biotreibstoffen und Biochemikalien** verwendet => einfacher Scale-Up

## ANDRITZ Globale Präsenz:

Über 13,000 Beschäftigte - weltweit 120 Service & Produktionsstätten

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ANDRITZ Pulp & Paper

## The ANDRITZ GRUPPE

**Weltweit führender Lieferant in vielen Geschäftsbereichen**

| ANDRITZ Pulp & Paper | ANDRITZ Environment & Process | ANDRITZ Feed & Biofuel | ANDRITZ Hydro | ANDRITZ Metals |
|---|---|---|---|---|
| ▪ Maschinen & Anlagen für die Produktion von Holz-und Zellstoff sowie einiger Papiersorten.<br>▪ Maschinen & Anlagen für bio-chemische & thermo-chemische Bioenergie, Biokraftstoffe & Biochemikalien | ▪ Maschinen & Anlagen für die mechanische & thermische Aufbereitung und Separierung diverser Schlämme – und Flüssigkeiten für Industrie – und Kommunalanwendungen | ▪ Maschinen & Anlagen für Pellets für den Energie- und Futtermittelmarkt | ▪ Elektromechanische Ausrüstungen für Wasserkraftanlagen und Pumpen | ▪ Systeme für die Produktion und Verarbeitung von Kohlenstoffbandstählen – und Edelstahlsbändern |

**Andritz Bio-Fuel Business**

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## Fokus auf Erneuerbare Energieträger

- Laugenrückgewinnungskessel erzeugen Energie von Biomasse
- Wärmerückgewinnungsanlagen
- Vergasungsanlagen
- Biomassekessel/boiler
- Pretreatment/Vorbehandlungsanlagen fur biochem. Biotreibstoffe

ANDRITZ Pulp & Paper

- Wasserturbinen & Generatoren

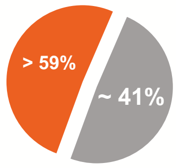
ANDRITZ Hydro

- Verarbeitung von Schlämmen in Granulat, dass als Ersatz von fossilen Treibstoffen verwendet wird

ANDRITZ Environment & Process

- Anlagen zur Erzeugung von Holz und Biomasse pellets

ANDRITZ Feed & Biofuel




Über 50% des **ANDRITZ Umsatzes** kommen von **Erneuerbaren Energie-Technologien**

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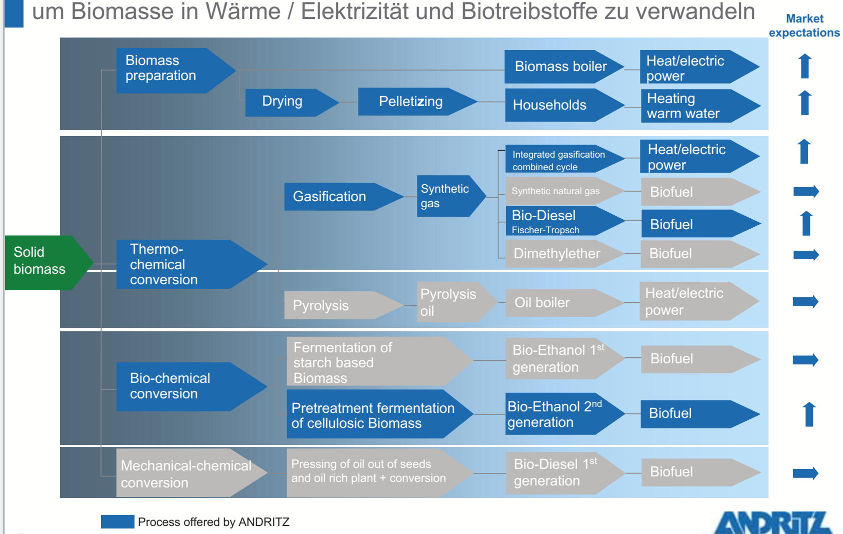
## ANDRITZ Technologien

um Biomasse in Wärme / Elektrizität und Biotreibstoffe zu verwandeln

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## Warum erneuerbare Biotreibstoffe ?

- **Die USA importiert täglich 8-9 Millionen barrels Öl (bei US$ 100/barrel = 800 Millionen). 90% davon wird für „Transport-Treibstoffe“ verwendet (Benzin, Diesel, Jet-fuel / Flug-kerosin) – nur 2% des Erdöls werden in den USA gefördert, aber ~ 25% des weltweiten Erdöls verbraucht.**
- **Lt. USDA (US Ministerium für Ackerbau) könnten theoretisch > 50% durch Biotreibstoffe ersetzt werden (1st Gen., 2nd Gen. & Advanced Biofuels), ohne die Nahrungsmittelkosten zu beeinträchtigen.**
- **In den USA wird Elektrische Energie zu ~52% durch Kohle, ~20% Nuklear, ~19% durch Erdgas – und nur 8.5% werden durch erneuerbare Energieträger (Wasserkraft, Solar, Wind, etc.) erzeugt. Elektrisch betriebene Fahrzeuge sind auch mittelfristig in den USA keine Ideallösung.** (Ralph J. Cicerone, President of the National Academy of Sciences)
- **Das Elektrische Netz in Teilen der USA (z.B. im bevölkerungsreichsten Staat = Kalifornien) ist zur Zeit am Kapazitätsmaximum, der erforderliche Ausbau findet statt – aber langsam. (dies trifft z.B auch für das UK zu)**

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## Anlagen für verschiedene Biomasse Varianten

- **Holzartige & Stauden**
  - Hackschnitzel von Hart-und Weichholzabfällen (Birke, Pappel, Eucalyptus,…)
  - Speziell entwickelte Hochertagshölzer (Hybrid-Pappeln, Staudenweiden,…)
- **Getreideabfälle**
  - Corn stover/ Maistroh & Maisspindeln
  - Weizen & Roggen Stroh
- **Zuckerpflanzenabfälle**
  - Zuckerrohr & energy cane Bagasse
  - Zucker/Süss-sorghum-reste
- **Gräser**
  - Switch grass (panicum virgatum) & andere Präriegräser
  - Alfalfa
  - Jose tall wheat grass, bermuda grass (cynodon dactylon), bahia grass (paspalum notatum), napier grass (pennisetum purpureum)
  - Miscanthus, arundo donax (giant reed) & andere Hochausbeutegräser

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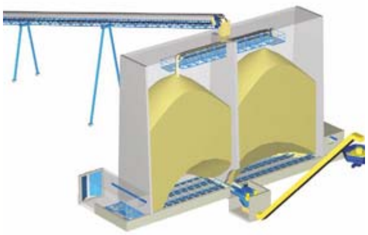
## Feed-Stock Handling

- Stoker Silo (Zugboden)



- Stapeln & Schichten (Stacking & Blending)

- Einbringung (Reclaiming)

- Portalkräne

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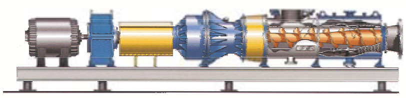
## Einspeisevorrichtungen in Druckreaktoren & Vergasungskesseln

**Stopfschnecken, MSD's & Drehventile**

- Drehventile / Zellradschleusen

- Stopfschnecke die mit einer Kapazität von über 1500 tato (atro) Holzhackschnitzel in Betrieb ist



- MSD Impressafiner, eine Hochkompressionsschnecke, die zur Beschickung verschiedenster Druckreaktoren verwendet wird

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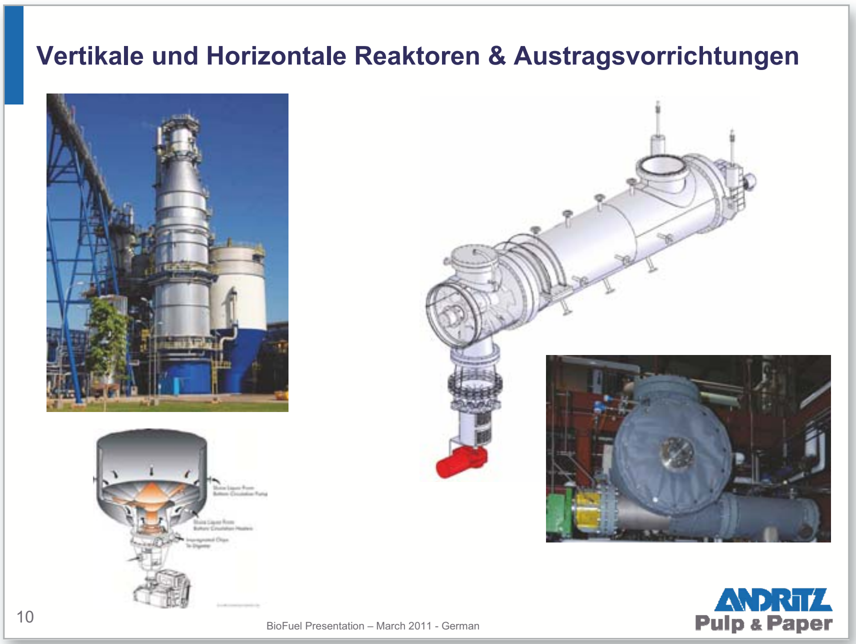



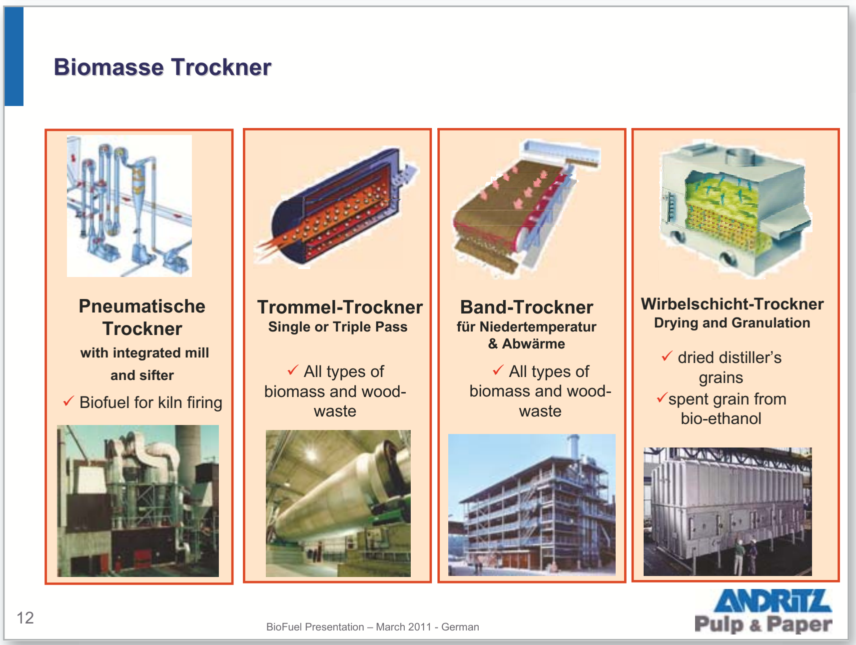


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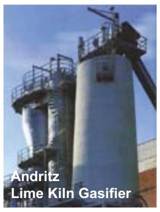
## Biomassekessel / boiler & Vergasungs Anlagen

**Wirbelschicht Druckvergasungsanlagen**

- zur direkten Stromerzeugung (Gasmotoren-Generatoren), Fernwärme
- Dampfkessel, Kilns, Gasturbinen
- BTL & Flüssigtreibstoffe via katalytischer Umwandlung, Erdgasersatz, etc.

**BioMasse Dampfkessel als Ersatz für Öl-und Gaskesselanlagen**

- in Papierfabriken (Ence Navia & Huelva, Portucel Cacia & Setubal, etc.)
- CHP / kombinierte Wärme & Stromerzeugung (Estonia, etc.)

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## Holz – und Biomasse Pelletieranlagen

- Weich- und Hartholz (Global > 440 Holzpelletieranlagen.)
- Stroh – und andere Agrarabfälle.

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ANDRITZ

**Pilot & Demonstrations Anlagen**
**Für 2nd Generation**
**Pre-Treatment Systems**


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## Pilot, Demonstrations – und Grossanlagen

- Seit 25 Jahren wurden ca. 100 kleinere Pilot- und Demonstrationsanlagen für die Zellstoff- und Faserplattenindustrie zur Verarbeitung von Holz und Nebenprodukten aus der Landwirtschaft und der Nahrungs- und Futtermittelindustrie wie Bagasse u.ä. geliefert.
- Viele dieser Einrichtungen sind in Forschungseinrichtungen der Industrie in Betrieb und werden teilweise als F&E Plattform zur Aufbereitung von Biomasse wie z.B. Miscanthus, Switch Grass, Maisspindeln, Corn Stover (Maisstroh) und Abfällen der Holzindustrie und der Landwirtschaft für die Erzeugung von Ethanol und Biochemikalien verwendet. Die Systeme werden zumeist vormontiert in Containern geliefert.
- Andritz hat umfangreiche Erfahrungen mit korrosionsbeständigen Materialien und fertigt Einrichtungen aus Materialien wie Duplex 2205, Hastelloy oder Zirkonium. Herkömmliche Zellstoffkocher können für die Vorbehandlung lignozelluloser Biomasse mit verdünnten Säuren und Enzymen verwendet werden.

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## Pilot & Demo Systems

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## ANDRITZ’ Erfahrung in 2nd Gen Biotreibstoffen

Das „Pulp&Paper“-Technologiezentrum von Andritz (in Glens Falls, NY) wurde zur Untersuchung von Vorbehandlungsmethoden wie SteamExplosion, fortgeschrittene SteamExplosion und Säurehydrolyse um ein Bio-Laboratorium und Reaktoren aus säurebeständigen Materialien erweitert. Es können im eigenen Haus auch Gärungs- und Hydrolyseversuche durchgeführt werden.

Teilbereiche, vor allem die Fest-Flüssigstoff Separierung & Entwässerungs Charakteristika werden im Andritz Forschungszentrum in Graz analysiert und entsprechende Versuche durchgeführt.

Forschung & Entwicklung wird in den hauseigenen Versuchsanlagen sowie in Zusammenarbeit mit Kunden und Fremdfirmen durchgeführt.


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## Glens Falls Pretreatment System ("Dampfexplosions-Kanone")

BioMass – BioChem. PreTreatment

- 27.5 bar / 400 PSI
- 8" dia x 6' tall
- Kompl. in Hastalloy
- BlowTank Austrag

- Pretreatment system (Auto- and Acid Hydrolysis) and Steam Explosion

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## Glens Falls Laboratory Capabilities

Biofuel Laboratory - Enzymatic Hydrolysis / Biofuel Analysis

Orbital & Rotary Incubators / Rotationsinkubatoren

Vergärungs- / Bioreaktoren

- Verzuckerung/Saccharification & Vergärung
- Zuckeranalysen
- Enzym-Behandlung / Enzymatic Hydrolysis
- Propagierung von div. Pilzen / fungi und Hefen
- Alkohol & Ethanol Analysen

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## Equipment zur Produktion von Biokraftstoffen

*Thomas Pschorn, Andritz*

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OMV Refining & Marketing

# Biokraftstoffe und Raffinerieprozesse

**Wieselburg, 30. März 2011**

Dr. Walter Böhme, OMV AG

Dr. Alexander Buchsbaum, OMV R&M

**Mehr bewegen.** OMV

## Biokraftstoffe und Raffinerieprozesse

- Allgemein verwendete Biokraftstoffe
  - FAME
  - Ethanol und ETBE
- Spezialprodukte
  - Hydriertes Pflanzenöl (HVO)
- In Entwicklung
  - Bestehende Anlagen:
    - Hydrieren von Pflanzenölen, Fetten, FAME als Coprocessing
    - Katalytisches Kracken von Pflanzenölen, Fetten, FAME (Alexander Mittelmayer OMV, Alexander Reichhold TU Wien)
  - Neue Anlagen:
    - Wasserstoff aus Biomasse (J. Lichtscheidl OMV, R. Rauch TU Wien)
    - Thermisches Cracken von Biomasse, Kunststoffen



## Allgemein verwendete Biokraftstoffe

- Diesel: Biokomponente = FAME
- Benzin: Biokomponente = Ethanol und/oder ETBE

- CEN Standard
  - für FAME: EN 14214
  - für DK mit 7%Vol. FAME: EN 590
    10% FAME in DK derzeit in Arbeit
    30% FAME in DK derzeit in Arbeit
  - für 5%Vol. Ethanol und ETBE in Ottokraftstoff: EN 228
    10% Ethanol in Ottokraftstoff in Arbeit (CEN EN 228)

- Gesamturteil:
  - Eingeführte Technologie und Produkte
  - Erhöhung des Anteils stoßen auf sowohl bei Benzin als auch bei Diesel auf Probleme und Widerstand seitens Automobilhersteller

## ETBE Herstellung

ETBE als Komponente in Ottokraftstoff:
- Herstellung in der Raffinerie aus Buten und Ethanol
- Sehr ähnlich dem MTBE Verfahren (Buten und Methanol)

- 10%v/v Ethanol kann erfüllt werden mit
  - 10%v/v Ethanol Direktblending
  - mit 5%v/v Ethanol und 11%v/v ETBE
  - oder 22%v/v ETBE
- Materialverträglichkeit der ETBE Mischungen besser als bei 10%v/v Ethanol Direktblending
  - Bestandssorte: max. 5%v/v Ethanol, max. 2,7%m/m Sauerstoff

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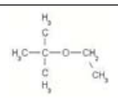
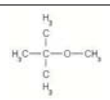
## ETBE im Vergleich zu MTBE

| | ETBE | MTBE |
|---|---|---|
| |  |  |
| Siedepunkt [°C] | 74 | 55 |
| Dichte [g/ml] | 0,75 | 0,74 |
| RON | 118 | 118 |
| MON | 102 | 101 |
| RVP [psi] | 4 | 8 |
| Lösliches H2O in Ether [M%] | 0,5 | 1,5 |

- ETBE Benefits
  - Geringere Flüchtigkeit
  - Geringere Löslichkeit in Wasser
  - Höhere Produktionskapazität: 15,9 % mehr Massenprodukt
- Nebenreaktionen (höherer Wassergehalt in EtOH): Bildung von TBA (Tertiärbutylalkohol).

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## FAME und Ethanol als Komponenten im Kraftstoff

- FAME und Alkohole ändern die chemischen Eigenschaften der Kraftstoffe
  - Materialverträglichkeit
  - Wassertoleranz (Ethanol in Ottokraftstoff)
  - Biologisch angreifbar
  - Düsentreibstoff muss FAME frei sein (Pipeline!).
  - Sauerstoffgehalt reduziert den Heizwert

| RED | Wert | Einheit | Wert | Einheit |
|---|---|---|---|---|
| Diesel | 43 | MJ/kg | 36 | MJ/l |
| Biodiesel | 37 | MJ/kg | 33 | MJ/l |
| Pflanzenöl | 37 | MJ/kg | 34 | MJ/l |
| HVO | 44 | MJ/kg | 34 | MJ/l |
| Benzin | 43 | MJ/kg | 32 | MJ/l |
| ETBE | 36 | MJ/kg | 27 | MJ/l |
| MTBE | 35 | MJ/kg | 26 | MJ/l |
| Ethanol | 27 | MJ/kg | 21 | MJ/l |

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## Synthetische Biokraftstoffe

- Biomasse: Pflanzenöle , Tierfett, gebrauchte Öle (UFO)
- Möglichkeiten der Erdölraffinerie
  - Katalytisches Kracken um die großen Fettmoleküle zu zerkleinern
  - Hydrieren um die Esterbindung zu spalten
- Die Endprodukte haben dann die Eigenschaften wie die fossilen Kraftstoffe
  - Kein Unterschied bei der Materialverträglichkeit
  - Stabil bei Lagerung, Verwendung

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## Hydrotreating of Vegetable Oils or FAME

$CH_3(CH_2)_{16}COO\ CH_2$
$CH_3(CH_2)_{16}COO\ CH$
$CH_3(CH_2)_{16}COO\ CH_2$

catalyst + $H_2$ → $nC_{18} + nC_{17} + C_3H_8 + H_20 + CO_2 + CO$

↓ CH3OH, catalyst

CH$_3$(CH$_2$)$_{16}$COO CH3

+ Glycerol

catalyst + H2 → $nC_{18} + nC_{17}$ + CH4 + H20+ CO2+CO

Reaction products, but not stoichiometrically correct!

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## Hydrieren von Pflanzenölen oder FAME

- Hydrierverfahren von Neste Oil und UOP
- Warum Coprocessing:
  - Hydrierverfahren der Raffinerie (HDS) sind dafür grundsätzlich geeignet.
  - Mögliche freie Kapazitäten in HDS Anlagen
- Warum FAME Coprocessing?
  In Pflanzenölen sind bis zu 5% freie Fettsäuren (FFA)
  - Korrosion der Hydrieranlagen (C-Stahl) durch FFA.
  - Reinigungsschritte benötigen zusätzlich neue Anlagen. FAME hat diese Reinigung schon hinter sich.
  - Es gibt kostengünstige FAME Mengen am Markt (schlechtes Kälteverhalten, borderline)

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## Coprocessing of Vegetable Oil vs. Gasoil(100%)

| | Gasoil (100%) | Gasoil + 25% Vegetable-oil (or FAME) |
|---|---|---|
| Corrosivity | 0 | it depends |
| | | |
| Heat of reaction | marginal | high |
| Operation window for reaction | not identical | |
| | | |
| Consumption of Hydrogen | 0,6%M | 4%M |
| Production of $H_2O$ | 0 | stoichiometric volume |
| CO | 0 | high (for typical HDS catalyst) |
| $CO_2$ | 0 | high (influences amine treating of off-gas) |
| Propane (or Methane) | low | stoichiometric volume (dilutes recycle gas) |

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## HVO by Coprocessing of FAME

Main targets of OMV test program:

- Hydrogen consumption
- Material balance
- Quality of hydrogenated products, especially detectable biofuels content

| | RME | FAME made from used frying oil and animal fat (UFO*) |
|---|---|---|
| Light Gasoil | 25% RME<br>75% Gasoil | |
| Kerosen | 25% RME<br>75% Kerosen | 25% UFO*<br>75% Kerosen |

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## Hydrieren von Pflanzenölen - Coprocessing

**Pilot Plant Test parameters:**

Standard catalysts and standard conditions like in commercial OMV plants

| | | Hydrotreating |
|---|---|---|
| WABT | °C | Appr. 350 |
| $ppH_{2\ inlet}$ | bar | Appr. 50 |
| LHSV | $h^{-1}$ | 1 |
| $H_2/oil_{\ inlet}$ | $Nm^3/m^3$ | 200 |

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## Data of Feed

| | | RME | UFO* | Gasoil | Kerosen |
|---|---|---|---|---|---|
| Density 15℃ | g/cm³ | 0,8833 | 0,8743 | 0,8479 | 0,7928 |
| Sulfur | mg/kg | <2 | 7 | 1512 | 457 |
| Nitrogen | mg/kg | 2 | 2 | 136 | <0,6 |
| Water | mg/kg | 200 | 266 | | |
| Cloudpoint | ℃ | -3 | 13 | -8 | <-48 |
| Pourpoint | ℃ | -9 | 15 | | |
| Iodine value | g/100g | 114 | 48 | | |
| FAME content | %M | 99,0 | 89,5 | | |

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## Co-Processing FAME zu PTU

### Recovery of products [%wt]

| | Gasoil/RME 3:1 | Gasoil | Kerosen/RME 3:1 | Kerosen/UFO* 3:1 | Kerosen |
|---|---|---|---|---|---|
| C1 | 1,5 | 0,1 | 1,7 | 1,6 | 0,2 |
| C2 | 0,1 | 0,1 | 0,1 | 0,1 | 0,0 |
| C3 | 0,2 | 0,2 | 0,6 | 0,4 | 0,3 |
| iC4 | 0,3 | 0,3 | 2,4 | 1,6 | 0,8 |
| nC4 | 0,3 | 0,2 | 0,7 | 0,5 | 0,3 |
| iC5 | 0,7 | 0,6 | 2,9 | 2,0 | 1,1 |
| nC5 | 0,2 | 0,1 | 0,3 | 0,2 | 0,1 |
| C6-SB Raffinat | 22,6 | 30,6 | 26,8 | 19,5 | 18,0 |
| Raffinat | 71,8 | 68,0 | 61,7 | 72,0 | 79,9 |
| H2O | 2,5 | 0,0 | 2,4 | 2,5 | 0,1 |
| CO | 0,0 | | | 0,1 | |
| CO2 | 0,4 | | | 0,5 | |

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## Co-processing of FAME

### Hydrogen consumption

| | LGO/RME 3:1 | LGO | Kerosen/RME 3:1 | Kerosen/UFO* 3:1 | Kerosen |
|---|---|---|---|---|---|
| g H2/kg feed | 18 | 12 | 18 | 16 | 9 |

- Based on this data: Hydrogen consumption for FAME (100%) is about 36 to 45 gH2/1000 g feed
- All recovered products free of FAME

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## Detection of Biogenic Parts of Products

- Detection by Liquid Scintillation Counter
- Analysis performed by the Laboratory of Austrian Tax Authorities

- Living organisms take carbon atoms in their body by food or photosynthesis. There are stable isotopes $^{12}C$ and $^{13}C$ and the radioactive $^{14}C$.
- $^{14}C$ in biocomponents show radioactive decomposition. These decompositions per minute are detected by Liquid Scintillation Counter.

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## Biogenic Parts of Products

| [%M] | feed |
|---|---|
| Gasoil | 75 |
| RME | 25 |

| Products | %M | Bio-component | Products of FAME found |
|---|---|---|---|
| Methane | 1,5 | 100 | 1,5 |
| C2 - C4 | 0,9 | 0 | 0,0 |
| C5 – 250℃ | 23,5 | 6* | 1,4 |
| Raffinat (250-345℃) | 71,8 | 28* | 20,1 |
| Water | 2,5 | 100 | 2,5 |
| CO2 | 0,4 | 100 | 0,4 |
| **Total** | 100,6 | | **25,9** |

*** by ($^{14}C$ Analysis)**

(Wasserstoff nicht bilanziert)

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## Facts for Economics Calculation

Hydrogenation (Coprocessing) of vegetable oil

- Vegetable oil or FAME gives a high quality component for automotive diesel if hydrotreated (Cetane number)
- Products are accepted as biofuels
- 100% FAME as feed gives only 80% liquid product, rest is $CO_2$, $H_2O$, methane or propane
- Hydrogen consumption between 36 and 45 g/1000g feed

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## FCC processing of Vegetable oils or FAME

- Processing options for liquid biomass in a mineral oil refinery
- Why FCC?
- **OMV Pilot Plant Tests**
  - Product yields
  - Oxygen Analyses
- Conclusions

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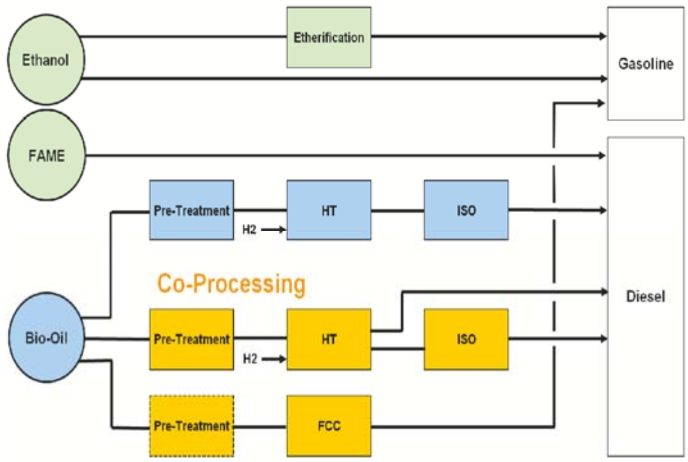
## Processing Options in a Conventional Refinery

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## Why FCC (Fluid Catalytic Cracking)? (1/2)

| **FCC co-processing** | **HT co-processing** |
|---|---|
| **Lower $SO_x$ and $NO_x$-Emissions** | **> 3 wt% Hydrogen consumption (based on feed rate)** |
| **no Hydrogen consumption** | **Additional $CO_2$-generation at Hydrogen plant** |
| **Pretreatment maybe not necessary** | |

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## Why FCC (Fluid Catalytic Cracking)? (2/2)

**Products**

- Bio FCC products are fully blend-able (pure hydrocarbons)
- The Bio-FCC produces bio-monomers and bio-fuels suitable for conventional engines
- No restrictions in blending rates

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## Is it economic?

- Bio-Oil co-processing reduces conversion compared to conventional feedstock
  - Propylene ↓
  - Butanes ↓
  - Light Cycle Oil and Slurry ↑
  - CO, $CO_2$, Water ↑

➡ **Co-processing would have to be accepted by EU-legislation as contribution to the bio-fuel contingent and/or to be granted tax concessions**

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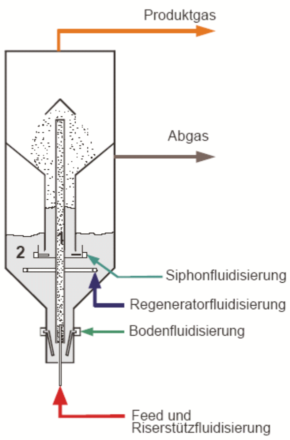
## FCC Pilot Unit




1 Reaktor
2 Regenerator

Forschungsprojekt
OMV & Technical University of Vienna
(Alexander Reichhold)

Very compact
Internal circulation
Good correlation to FCCU
at Schwechat refinery

Technical Data:

| | |
|---|---|
| Total height | 2500 mm |
| Diameter regen | 200 mm |
| Heigth of riser | 1977 mm |
| Catalyst | 9 kg |
| Feed rate | 2-5 kg/h |

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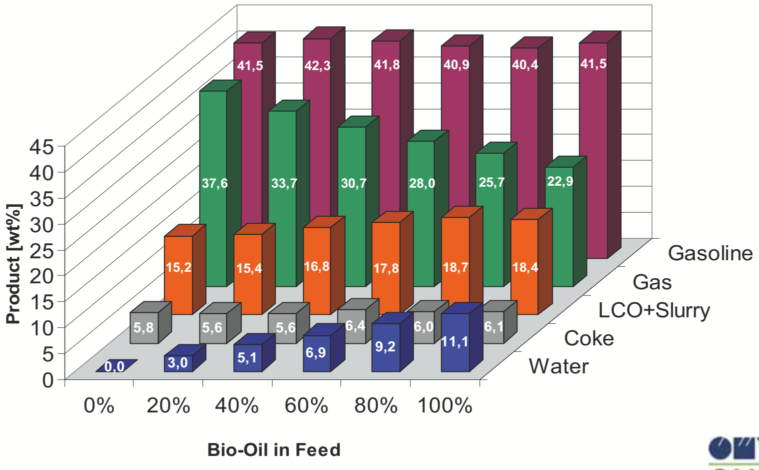
## Rapeseed Oil – 0% to 100% Blends

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## Bio FCC Pilot Plant Tests – Conclusions (1/2)

- Slightly modified product yields
  - Decrease in conversion is mainly caused by the Oxygen content of the feed
  - Obtained light hydrocarbons still contain a high percentage of Ethylene and Propylene
  - High Octane Gasoline fraction

→ **No significant influence on routine operation of the Fluid Catalytic Cracking-plant**

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## Bio FCC Pilot Plant Tests – Conclusions (2/2)

- Vegetable oils are practically free of chemical bound Nitrogen and Sulphur → $NO_x$-, $SO_x$-Emissions decrease

→ **The FCC process has the potential to produce bio-polymers and bio-fuels suitable for conventional engines**

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## Wasserstoff aus Biomasse

- 2 Bilder kommen von Sepp Lichtscheidl
  Projekt in Ausarbeitung (in Kontakt mit R. Rauch TU und Wörgetter)

Grundaussagen:

- Raffinerie braucht Wasserstoff
  - Früher war die Herstellung von Ottokraftstoff eine ausreichende Quelle (Platforming-prozess). Heute muss Wasserstoff aus Erdgas hergestellt werden (→ $CO_2$ Emission!)
  - Synthesegas aus Biomasse ist möglich
  - Wasserstoff aus Synthesegas ist durch optimiertem Shift maximierbar.
  - (Reinigung des Synthesegas für Fischer-Tropsch ist höchst aufwendig und teuer)

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## Vergasung von Biomasse

50 MW

Biomasse (Hackschnitzel) → 12 t/h trocken

→ **H2 (ca. 900 kg/h)**

→ **Wärme 5 MW**

→ CO2 (ca. 11 t/h) Option

Ca. 15 % Energie wird zur Spaltung benötigt

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## Zeitplan

| | |
|---|---|
| FFG Projekt: Engineering der Anlage bis 3. Qu. 2011 | |
| Einreichung in NER 300 Call der EU | jetzt |
| Entscheidung EU | Ende 2011 |
| Genehmigungen (Behörde, OMV) | bis Ende 2012 |
| Bauphase | 2013 - 2015 |
| Inbetriebnahme wäre möglich | Mitte 2015 |

Hafen Wien
Vorgesehene Baufläche

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# Elektromobilität

## Erneuerbare Energie im Individualverkehr der Zukunft

**Dr. Max Lang – ÖAMTC Technik**

30.03.2011 | **Dr. Max Lang** | Leiter Fahrzeugtechnik

## Der Charme des Elektrofahrzeugs

- ***Keine unmittelbaren gasförmigen Emissionen.***
- ***Fast wartungsfreier, unkomplizierter Antrieb***
- ***Sehr gute Energieausnutzung des Elektromotors***
- ***Sehr großer nutzbarer Drehzahlbereich (kein Schaltgetriebe erforderlich)***
- ***Leise.***

Seite 2 | 18.09.2010 | **FAHRZEUGTECHNIK**

## *Elektroauto: Klimaschutz ($CO_2$) und Nullemission?*

***Die Emissionen des Elektroautos werden ins Kraftwerk verlagert.***

- Elektrofahrzeuge sind bei heutigen Kraftwerksmix nicht grundsätzlich effizienter und verringern nicht generell den $CO_2$-Ausstoß
  bei 20 kWh/100 km: in Österreich ca. 44 g/km
  in Frankreich ca. 12 g/km
  in Deutschland ca. 120 g/km
  in China ca. 200 g/km
- Zur Reduzierung der $CO_2$-Emissionen ist der Einsatz zusätzlicher regenerativer Quellen zur Stromerzeugung erforderlich. Für Elektroautos sollten also auch neue Energieerzeuger zugebaut werden.

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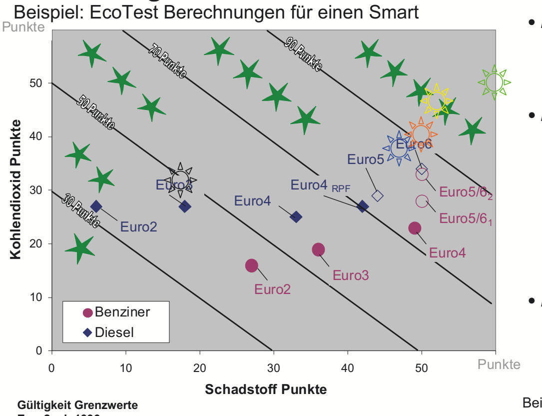
## Verbraucherschutzstandards für E-Fahrzeuge bei Sicherheit, Umwelt, Kosten

### *Entwicklung der Grenzwerte über die Zeit*

Beispiel: EcoTest Berechnungen für einen Smart




**Gültigkeit Grenzwerte**
**Euro2: ab 1996**
**Euro3: ab 2000**
**Euro4: ab 2005**
**Euro5: ab 2009**
**Euro6: ab 2014**

- ***Die Umweltbilanz des Elektroantriebes fällt und steht mit dem Kraftwerks-Mix und dem Fahrzeugverbrauch.***
- ***Der Fahrverbrauch hängt von unterschiedlichen Verlusten und von der Betriebsart ab:***
  - Betrieb, Standzeiten, Nebenaggregate
  - Ladeverhalten
  - Kurzstrecke, Fernstrecke, Tagesfahrleistung
- ***Ein verbrauchsarmes Elektro-Fahrzeug führt zu verbesserter Gesamt-Umweltbilanz.***

Beispiel: EcoTest des Smart

Steinkohle, Erdgas, Strommix A, Strommix D, Windkraft on-shore



## Was erwartet der Autofahrer vom Elektrofahrzeug?

### *Umfrage: Kaufbereitschaft Elektroautos*

***Überall ist derzeit vom Elektroauto zu hören und zu lesen. Kein Hersteller, der sich nicht mit Ankündigungen überschlägt. Aber es stellen sich noch viele Fragen:***

Wie sehen die Verbraucher, als Autofahrer dieses Thema?
Ist der Elektromotor für den Kunden der Antrieb der Zukunft?
Welche Wünsche und Erwartungen hat der Kunde an ein Elektrofahrzeug?

***Die Befragung richtete sich gezielt an Teilnehmer, die am Auto interessiert sind und neuen Antriebsformen gegenüber nicht abgeneigt sind.***

***Die Teilnehmer der Befragung (übe r 90% männlich, um 40-50 Jahre, hohes Bildungsniveau) sind am Auto und neuen Antriebsformen interessiert.***
***Sie passen sehr gut in die Zielgruppe für Elektromobilität!***

***Befragungszeitraum: Ende Mai bis Mitte September 2009***
***Teilnehmer:4.146 verwertbare Antworten***



## Was erwartet der Autofahrer vom Elektrofahrzeug?

***Vorraussetzungen für Elektromobilität***

- 90% der Neuwagenkäufer stehen dem Elektroantrieb positiv gegenüber.
- 80% und darüber haben einen privaten Stellplatz für ihren Pkw.
- 70% der Befragten besitzen einen Stromanschluss nahe dem privaten Stellplatz.
- 60% können am Arbeitsplatz Parkplätze des Unternehmens nutzen – i.d.R. ohne Steckdose.
- 60% der Befragten fahren nicht mehr als 30 km zur Arbeit.

***Nur: Die Erwartungen und das Angebot passen nicht zueinander.***

- 40% der Befragten würden für ein Elektroauto nicht mehr Geld ausgeben wollen, als für ein vergleichbares Fahrzeug mit herkömmlichen Antrieb.
- Die überwiegende Mehrheit ist nicht zu Kompromissen bereit, wenn es um Reichweite, Höchstgeschwindigkeit, Ladezeit und Raumangebot geht.
- Die Bereitschaft für neue Mobilitätsformen in Kombination mit dem Elektrofahrzeug (Mietwagen, Bahnfahrten) sind mit unter 30% gering. Ein ähnlicher Prozentsatz würde ggf. für lange Strecken auf Bahn oder Mietwagen umsteigen.



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## Was erwartet der Autofahrer vom Elektrofahrzeug?

***Die Menschen überschätzen die Technologie!***

- ***Reichweite mit einer Batterieladung:***
  ***Nur rund 10% würden sich mit einer Strecke bis 100 km zufrieden geben. Jeder Fünfte will immerhin schon 200 km weit kommen. Die meisten (31,6%) erwarten 500 km Fahrt ohne lästige Ladepause.***
- ***Höchstgeschwindigkeit:***
  ***69% wünschen sich eine Höchstgeschwindigkeit von min. 120 bzw. 150 km/h. Mit Tempo 100 würde sich nur jeder Zehnte zufrieden geben und nur 3% halten Tempo 80 für ausreichend.***
- ***Ladedauer der Batterie:***
  ***Mehr als ein Drittel der Befragten würden nur eine „Tankzeit" von bis zu 2 Stunden akzeptieren.***
  ***Dabei möchten 56% der potenziellen Elektromobilfahrer, dass die „Zapfsäule" nicht weiter als einen Kilometer, also fußläufig, von zu Hause entfernt ist.***
- ***Raumangebot:***
  ***Rund die Hälfte der Befragten möchte, dass das Elektroauto 4 Sitzplätze hat. Jeder vierte erwartet sogar ein deutlich größeres Raumangebot.***

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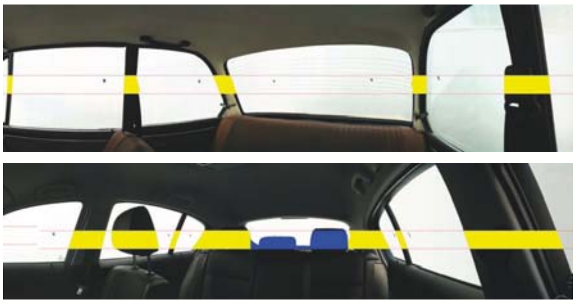
## Verbraucherschutzstandards für E-Fahrzeuge bei Sicherheit, Umwelt, Kosten

**Aktive Sicherheit**

**Objektive Messung der Rundumsicht**



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## Verbraucherschutzstandards für E-Fahrzeuge bei Sicherheit, Umwelt, Kosten

***Wie sicher sind Elektroautos?***

- **Hybridfahrzeuge** können sehr sicher konstruiert wie werden. Die geringe Masse der Batterie muss kein Nachteil sein. Crashenergie wird um die Batterie herum abgebaut.
- **Höheres Fahrzeuggewicht** im Vgl. zum Standardantrieb führt i.d.R. zu erhöhten Insassenbelastungen im Crash.
- **Leichtmobile, Leichtelektromobile** müssen hohe Anforderungen an Strukturstabilität erfüllen. Heutigen Leichtmobile erfüllen dies nicht.

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## Verbraucherschutzstandards für E-Fahrzeuge bei Sicherheit, Umwelt, Kosten


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## Crashtest – Heckcrash

Mitsubishi i-MiEV


Seite 11 | 18.09.2010 | **FAHRZEUGTECHNIK**

## Crashtest - Mitsubishi i-MiEV

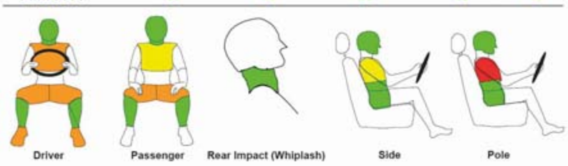
**Mitsubishi i-MiEV**

2011

| | Adult Occupant | Child Occupant | Pedestrian | Safety Assist | |
|---|---|---|---|---|---|
| Score | 26,266 | 38,000 | 17,177 | 6,000 | |
| Max Points available | 36 | 49 | 36 | 7 | |
| Normalised Score (%) | **73** | **78** | **48** | **86** | |
| Weighting (%) | 50 | 20 | 20 | 10 | TOTAL |
| Weighted Percentage S | 36,5 | 15,6 | 9,6 | 8,6 | **70** |

**Rating Requirements (2011)**

| | Normalised Score (%) | | | | TOTAL |
|---|---|---|---|---|---|
| ☆☆☆☆ | 65 | 60 | 25 | 40 | 60 |

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**Crashtest - Mitsubishi i-MiEV**


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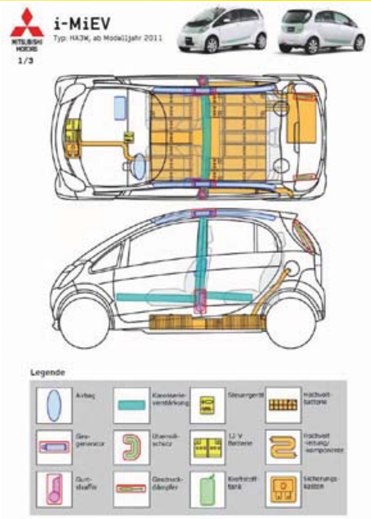
**Unfallforschung – Rettungskarte**

**Rettungskarte – Mitsubishi i-MiEV**




Seite 14 | 18.09.2010 | **FAHRZEUGTECHNIK**

**Danke für Ihre Aufmerksamkeit**

30.03.2011 | **Dr. Max Lang** | Leiter Fahrzeugtechnik

IEA FORSCHUNGS KOOPERATION

# Erneuerbare Energie im Individualverkehr der Zukunft

*Max Lang, ÖAMTC*

## Biokraftstoffe in Österreich und der EU

***Moderation: Gerfried Jungmeier**, Joanneum Research – Resources*

# Biokraftstoffproduktion in Österreich

***Reinhard Thayer**, ARGE Biokraft*

## *Biokraftstoffproduktion in Österreich*

**Highlights der Bioenergieforschung**
Fachhochschule Wieselburg
30. & 31. März 2011

Dr. Reinhard Thayer
FV chemische Industrie, FV Mineralölindustrie
Arbeitsgemeinschaft Flüssige Biokraftstoffe

ARGE Biokraft

## Überblick

1. Vorstellung der ARGE Biokraft
2. Biodiesel - Produktion und Absatz in Österreich
3. Bioethanol - Produktion und Absatz in Österreich
4. Substitutionsquoten für Österreich
5. Herausforderungen und Probleme

30. März 2011

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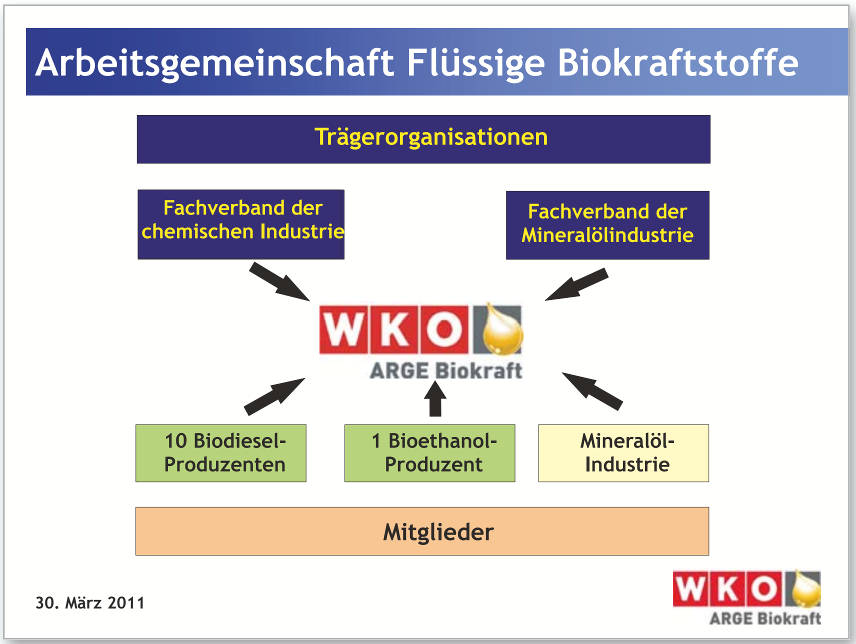




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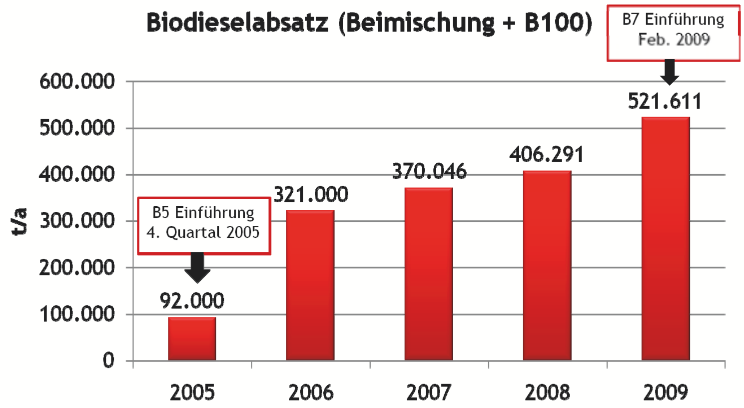
## Biodieselabsatz in Österreich




Quelle: Biokraftstoffberichte, Umweltbundesamt

30. März 2011

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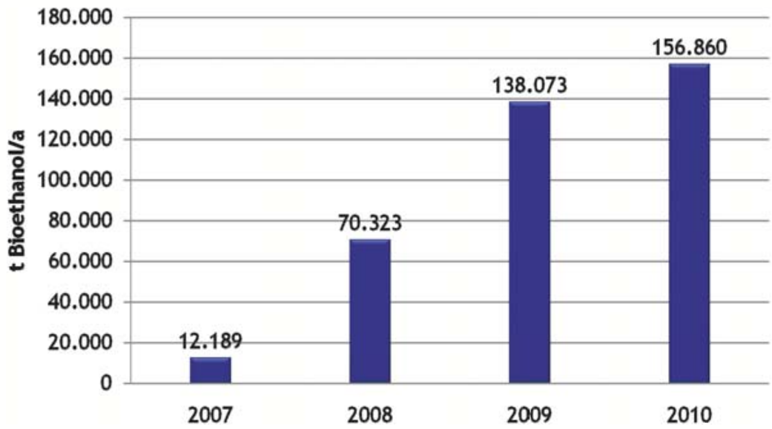
## Bioethanol - Produktionsdaten für Österreich




30. März 2011

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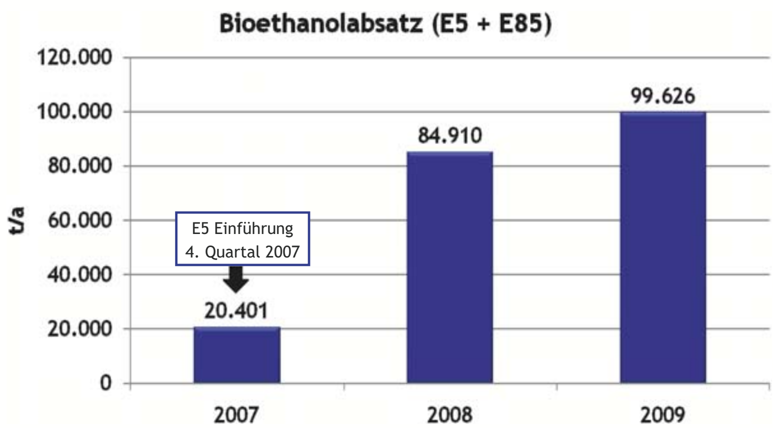
## Bioethanolabsatz in Österreich




Quelle: Biokraftstoffberichte, Umweltbundesamt

30. März 2011

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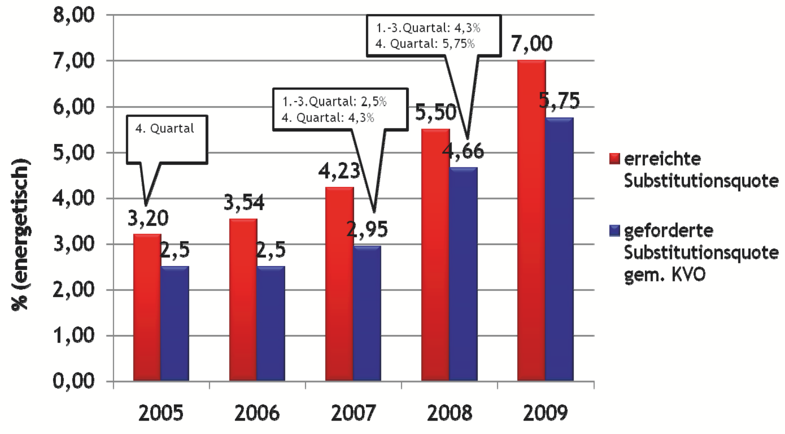
## Substitutionsquoten für Österreich




Quelle: Biokraftstoffberichte, Umweltbundesamt

30. März 2011

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## Herausforderungen und Probleme

- **Fehlende Nachhaltigkeitszertifizierungssysteme in Europa (1)**
  - **Hintergrund:**
    - Um die ökologische Verträglichkeit der Biokraftstoffe zu garantieren, gelten EU-weit verpflichtend vorgeschriebene Nachhaltigkeitskriterien
    - Umsetzung in der EU RL 2009/28/EG zur Förderung der erneuerbaren Energie (RED – Renewable Energy Directive) sowie die EU RL 2009/30/EG zur Kraftstoffqualität (FQD – Fuel Quality Directive)
    - Notwendigkeit von Kontroll- und Zertifizierungssystemen in den MS bzw. EU-weit gültige Systeme
    - Beide Richtlinien waren in den MS bis Dezember 2010 in nationales Recht umzusetzen.

30. März 2011

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## Herausforderungen und Probleme

- **Fehlende Nachhaltigkeitszertifizierungssysteme in Europa (2)**
  - **Problem:**
    - Entsprechende Zertifizierungssysteme sind gesamteuropäisch noch nicht ausreichend umgesetzt
    - Dadurch sind kaum zertifizierte Rohstoffe aus der Ernte 2010 für die Biokraftstoffproduktion verfügbar
    - Gilt vor allem hinsichtlich importierter Rohstoffe für die Biodieselproduktion, aber in geringerem Ausmaß auch für die Bioethanolproduktion
    - Problem pflanzt sich entlang der Zertifizierungskette auch auf die Mineralölunternehmen fort
    - Ist gesamteuropäisches Problem
    - Nebeneffekt: Deutlicher Preisanstieg bei zertifizierten Rohstoffen

    → **Forderung:** Übergangsregelungen für 2011

30. März 2011

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## Herausforderungen und Probleme

➢ **FQD - Verpflichtendes 6% THG-Einsparungsziel bis 2020 für Anbieter von Kraftstoffen (1)**

- **Hintergrund:**
  - Zukünftige Kraftstoffnormung wichtig (E10, B10, „7+3(x)“, B30)
  - Bei 10 % (v/v) Beimischung sind Biokraftstoffe mit >60% THG-Einsparung notwendig
  - Bei Verwendung von Standardwerten gemäß Anhang V der RED: Kaum Biokraftstoffe der „ersten Generation“ mit ausreichend hoher THG-Minderung (Bsp.: Ethanol aus Zuckerrohr → 71%, Biodiesel aus Abfallöl → 88%)
  - Zukünftig: Steigender Bedarf der Mineralölindustrie an THG-optimierten Biokraftstoffen (zur Erfüllung der 6% THG-Minderungsverpflichtung)

30. März 2011

WKO ARGE Biokraft

## Herausforderungen und Probleme

➢ **FQD - Verpflichtendes 6% THG-Einsparungsziel bis 2020 für Anbieter von Kraftstoffen (2)**

- **Lösungsmöglichkeiten:**
  - Erhöhung der Biokraftstoff-Beimischung (Frage: Entwicklung Kraftstoff-Normung bzw. technische Eignung der Fahrzeuge?)
  - Biokraftstoffe der 2. Generation (Verfügbarkeit?; marktfähige Preise?)
  - Optimierung der 1. Generation Biokraftstoffe und Berechnung von tatsächlichen Werten für die Minderung von THG-Emissionen
    - Optimierungspotential u.a. bei der landwirtschaftlichen Kultivierung und im Biokraftstoff-Produktionsprozess

30. März 2011

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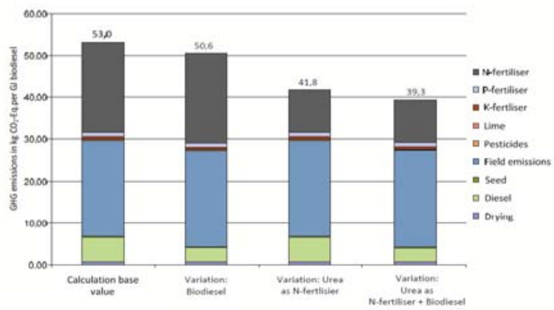
## Herausforderungen und Probleme

➢ **FQD - Verpflichtendes 6% THG-Einsparungsziel bis 2020 für Anbieter von Kraftstoffen (3)**

**Beispiel Biodiesel: THG-Reduktionsmöglichkeit beim Anbau (- 26%)**




Quelle: DBFZ, Präsentation im Rahmen der Konferenz „Biokraftstoffe der Zukunft 2011“, Berlin

30. März 2011

WKO ARGE Biokraft

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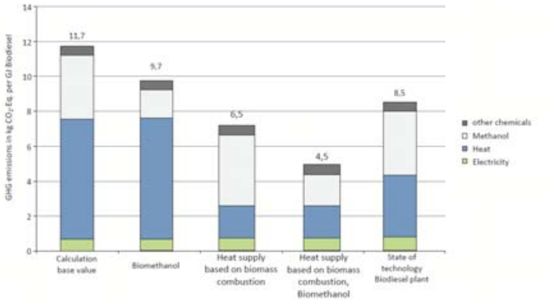
## Herausforderungen und Probleme

➢ **FQD - Verpflichtendes 6% THG-Einsparungsziel bis 2020 für Anbieter von Kraftstoffen (4)**

**Beispiel Biodiesel: THG-Reduktionsmöglichkeit im Produktionsprozess (-62 %)**




Quelle: DBFZ, Präsentation im Rahmen der Konferenz „Biokraftstoffe der Zukunft 2011“, Berlin

30. März 2011

WKO ARGE Biokraft

## Herausforderungen und Probleme

➢ **B100-Eignung von EURO 6 Motoren?**

EURO 6:

- Gesetzlich vorgeschrieben ab 1.1.2014
- Inverkehrbringung erster Fahrzeuge ab 2011

→ Wegfall des B100 Marktes?
→ Einfluss auf nationale Substitutionsziele?

➢ **Kostenbelastung durch das EU Chemikalienrecht REACH**

Beispiel Biodieselanlage (50.000 t/a):

- Anfallende Kosten für:
  - Registrierung (3 Stoffe)
  - Konsortium
  - interne Stunden/Ausbildung

} ca. € 100.000.-

30. März 2011

WKO ARGE Biokraft

Vielen Dank für Ihre Aufmerksamkeit.


www.biokraft-austria.at

30. März 2011

WKO ARGE Biokraft

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## Rechtliche Basis in Österreich und der EU

***Heinz Bach**, BMLFUW, Abteilung V/5*

***Vortrag verfügbar auf www.nachhaltigwirtschaften.at/iea***

## Rechtliche Basis in Österreich und der EU

*Heinz Bach, BMLFUW, Abteilung V/5*

Bundesministerium
für Verkehr,
Innovation und Technologie

## European Industrial Bioenergy Initiative – Chancen für die Industrie

**DI Theodor Zillner, bmvit**

Highlights der Bioenergieforschung
Wieselburg, 30. März 2011

## Inhalt

- **Strategic Energy Technology Plan der EU**
- **European Industrial Bioenergy Initiative**
- **Chancen für die Industrie**
- **Die österreichische Perspektive**

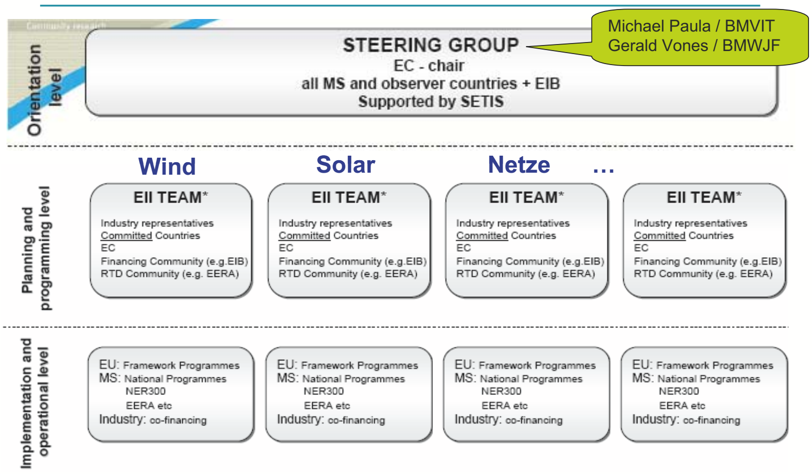
Seite 2

## SET-Plan Übersicht

- Investitionen: bis zu **70 Milliarden €** über insgesamt **10 Jahre**
- Kerninstrumente: **Industrieinitiativen** (EII) und **European Energy Research Alliance** (EERA)
- Finanzierung: **P**ublic-**P**ublic-**P**rivate (EU + Mitgliedsstaaten + Privater Sektor)
  **Joint Programming** in variabler Geometrie
  (Grenze zwischen RTD und Deployment ist dabei fließend)

Seite 3

## SET-Plan Übersicht




Seite 4

## European Industrial Bioenergy Initiative (EIBI)

- The purpose of the EIBI is to boost the **contribution of sustainable bioenergy to EU 2020 climate and energy objectives**, with a focused approach leveraging on **puplic-private partnership** to manage the risks and share the financing.
- The scope of the EIBI is focused on **innovative bioenergy value chains which are not yet commercially available** and which **could bring significant contribution to the bioenergy markets** by large scale deployment, whilst complying with the sustainability requirements of the RES Directive (2009/28/EC).
- The EIBI is proposing a **pragmatic approach** to select the most promising options, based on **transparent criteria** reflecting a set of **key economic, environmental and social performances**.

Seite 5

## Bioenergy Value Chains of the EIBI

| | **Thermochemical pathways** |
|---|---|
| 1 | Synthetic liquid fuels and/or hydrocarbons (e.g. gasoline, naphtha, kerosene or diesel fuels) and blending components |
| 2 | Bio-methane and other bio-synthetic gaseous fuels through gasification |
| 3 | High efficiency heat & power generation through thermochemical conversion (propose limit e.g. $\eta_{el}$ > 45%) |
| 4 | Intermediate bioenergy carriers through techniques such as pyrolysis and torrefaction |

Seite 6

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## Bioenergy Value Chains of the EIBI

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| | Biochemical pathways |
|---|---|
| 5 | Ethanol and higher alcohols from ligno-cellulosic feedstock through chemical and biological processes |
| 6 | Hydrocarbons (e.g. diesel and jet fuel) through biological and/or chemical synthesis from biomass containing carbohydrates |
| 7 | Bioenergy carriers produced by micro-organisms (algae, bateria) from $CO_2$ and sunlight |
| | **Complementary measures and activities** |
| 8 | Biomass feedstock for bioenergy |
| 9 | Set of activities on longer term R&D&D on emerging and innovative bioenergy value chains |

Seite 7

## Chancen für die Industrie

bmvit

- **70 Milliarden Euro** an Investitionen in Forschung und Technologieentwicklung im Rahmen des SET-Plan in den nächsten 10 Jahren
- SET wird **wichtiger Pfeiler der europäischen Technologiepolitik**
- Beteiligung eröffnet einschlägigen Unternehmen **große Chancen**
- beschert bei fehlendem Engagement einen **systematischen, langfristigen Nachteil**

Seite 8

## Die österreichische Perspektive

bmvit

| Industrie-Iinitiative | €- Bedarf F&E, Demo, frühe Markteinführung | Ziele | Quantifizierung |
|---|---|---|---|
| Windkraft | 6 Mrd. € | Kosten, Offshore, Netzintegration; 5-10 Prüfanlagen, 10 Demoprojekte, 5 Prototypen offshore Fundamente | 20% des EU Stromverbrauchs |
| Solarenergie (PV/CSP) | 16 Mrd € | PV: 5 Pilotanlagen f. automatisierte Massenfertigung, Demo zentral und dezentral; CSP: 10 Prototyp-Kraftwerke | 15% des EU Stromverbrauchs |
| Stromnetze | 2 Mrd. € | echter Binnenmarkt, Integration volatiler Erzeugung, Management Wechselbez. zw. Lieferanten. und Kunden; 20 Demoprojekte | 50% der Netze „Smart“ |
| Bioenergie | 9 Mrd. € | fortgeschrittene Biokraftstoffe, Biomasse KWK; 30 Demoanlagen | 14% des EU Energiemix |
| $CO_2$ – Sequ. | 13 Mrd. € | Demonstration der vollständigen CCS-Kette in industriellem Maßstab | Kosten 30-50 EUR/Tonne CO2 |
| Nuklear | 7 Mrd. € | Generation IV Reaktoren, erste KWK-Reaktoren | Erste Prototypen |
| Smart Cities | 11 Mrd. € | Ausgangspunkt für Einführung intelligenter Netze, Smart Energy Efficient Buildings, emissionsarmer Verkehrsmittel | 25-30 Demo- Städte |

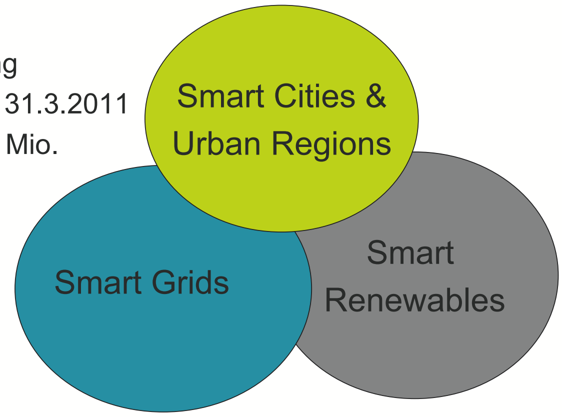
Quelle: "Investitionen in die Entwicklung von Technologien mit geringen CO2-Emissionen (SET-Plan)" KOM(2009) 519 endg.

Seite 9

## Die österreichische Perspektive

**Smart Energy Demo – fit4set**

1. Ausschreibung
Einreichschluss 31.3.2011
Fördermittel € 2 Mio.

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## DANKE!

- Kontakt EIBI im bmvit:
  Martina Ammer
  martina.ammer@bmvit.gv.at

- Kontakt SET-Plan im bmvit:
  Theodor Zillner
  theodor.zillner@bmvit.gv.at

Seite 11

Highlights der Bioenergieforschung - 30. März 2011
Biokraftstoffe in Österreich und der EU

# $CO_2$-Minderung im Straßenverkehr

IFA
Institut für Fahrzeugantriebe & Automobiltechnik

**Dipl. Ing. Werner Tober**

TU WIEN Technische Universität Wien – Vienna University of Technology
Institut für Fahrzeugantriebe & Automobiltechnik

## Motivation und Inhalt

- ☐ Der dauerhafte Schutz der Gesundheit des Menschen und des Tier- bzw. Pflanzenbestandes, sowie der Klimaschutz zählen zu den erklärten Zielen der Europäischen Union und ihrer Mitgliedsstaaten.
- ☐ Nur eine ganzheitliche Betrachtung
  - der gesetzlichen und politischen Rahmenbedingungen,
  - der Schadstoff- und $CO_2$-Emissionenentwicklung und
  - der Entwicklung der Luftqualität

  zeigt die im Sinne des Umwelt- und Klimaschutzes noch zu bearbeitenden Handlungsfelder des Straßenverkehrs auf.

**In dieser Präsentation:**

- ☐ Beitrag des Straßenverkehrs zur Erreichung der $CO_2$-Reduktionsziele durch
  - fahrzeugseitige Maßnahmen ($CO_2$-Reglementierung),
  - alternative Kraftstoffe und
  - Elektromobilität.



## Gliederung

- ☐ Motivation und Inhalt
- ☐ $CO_2$ Reglementierung der Europäischen Union für PKW und Leichte Nutzfahrzeuge
- ☐ $CO_2$-Emissionsprognose des österreichischen Straßenverkehrs
- ☐ $CO_2$-Emissionen vs. $CO_2$-Reduktionsziele
- ☐ Weitere Lösungsansätze der $CO_2$-Reduktion im Straßenverkehr
- ☐ $CO_2$-Reduktionspotential durch alternative Kraftstoffe
- ☐ $CO_2$-Reduktionspotential durch Elektromobilität
- ☐ Zusammenfassung

Quelle: W. Tober: Entwicklung der Schadstoff- und $CO_2$-Emissionen des Straßenverkehrs und Ableitung des zusätzlichen Handlungsbedarfs bis 2030. Wien: Institut für Fahrzeugantriebe und Automobiltechnik, 2011. Dissertation



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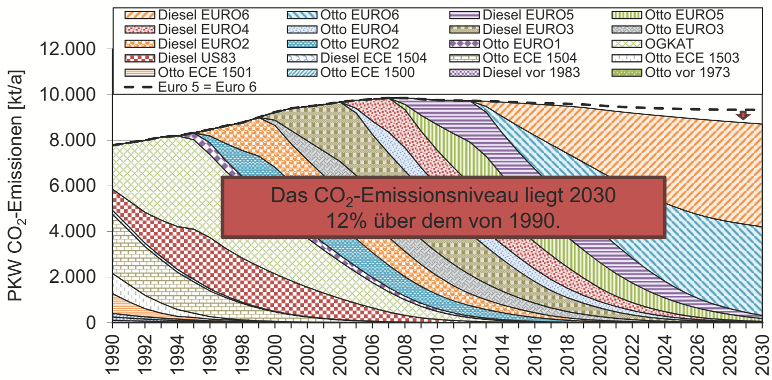
## $CO_2$ Reglementierung
### Personenkraftwagen und Leichte Nutzfahrzeuge

- Bereits im Jahr 1995 veröffentlichte die Europäische Kommission ihre Strategie zur Minderung der $CO_2$-Emissionen von Personenkraftwagen und zur Senkung des durchschnittlichen Kraftstoffverbrauchs.
  - Ziel: $CO_2$-Emission von 120 g/km im Jahr 2005 (spätestens 2010).
- Für Personenkraftwagen gilt nun ab dem Jahr 2012 eine durchschnittliche $CO_2$-Emission der Neuwagenflotte von 120 g/km.
  - 130 g/km durch Verbesserungen der Motorentechnik und innovative Technologien
  - Weitere 10 g/km durch zusätzliche Maßnahmen wie Optimierung von Reifen, Klimaanlage, Kraftstoff und Fahrverhalten.
  - Zielwert ab 2020: 95 g/km
- Für leichte Nutzfahrzeuge (Kategorie N1) liegt ein Verordnungsvorschlag vor, in welchem ab dem Jahr 2014 die durchschnittlichen $CO_2$-Emissionen der neu zugelassenen leichten Nutzfahrzeugflotte auf 175 g/km beschränkt werden.
  - Bis zu 7 g/km können durch zusätzliche Maßnahmen generiert werden.
  - Zielwert ab 2020: 135 g/km



## $CO_2$-Emissionsprognose PKW in Österreich
### Entwicklung ohne $CO_2$-Reglementierung

- Zwischen 2013 und 2030 erfolgt eine $CO_2$-Reduktion von 2,7% bzw. 4,6Mio.t.




Keine $CO_2$-Gutschrift zufolge Biokraftstoffe berücksichtigt.



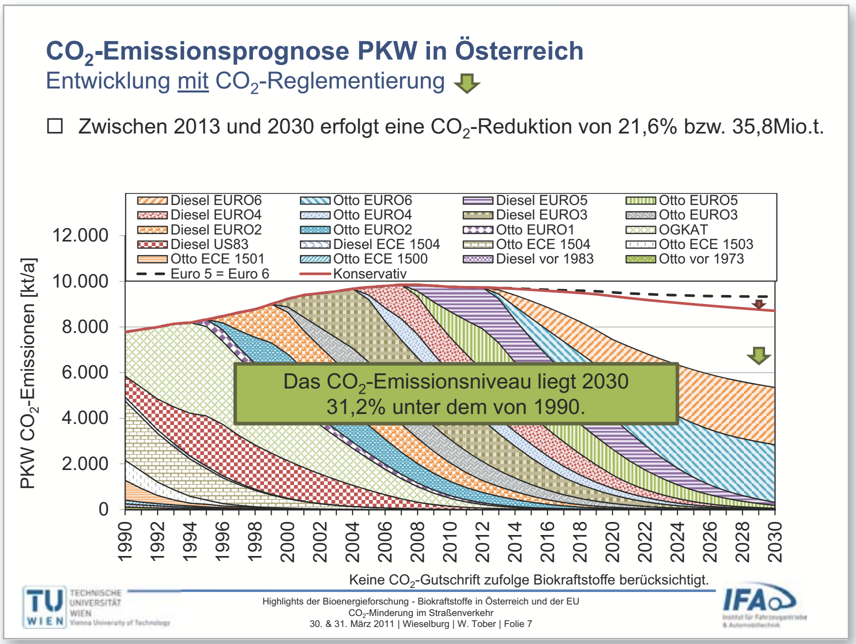
## $CO_2$-Emissionen der Flotte - Fahrzeugseitige Maßnahmen
### Annahmen zur Umsetzung der $CO_2$-Reglementierung

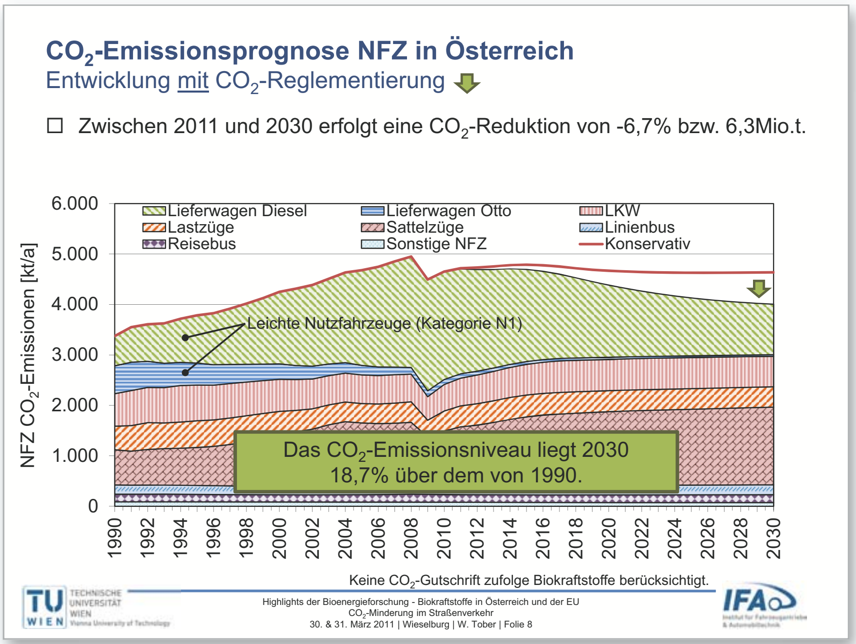
- Personenkraftwagen

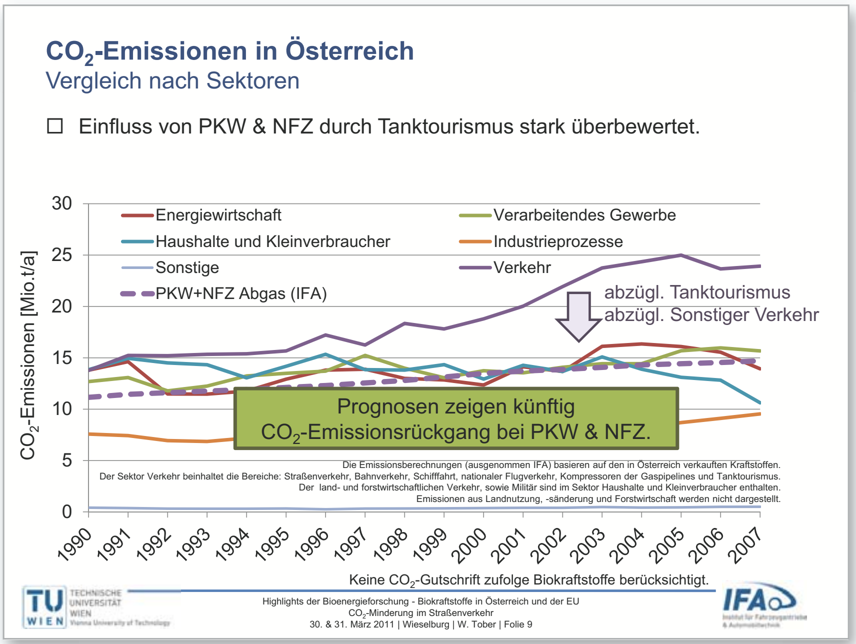
| Jahr | Otto $gCO_2/km$ | Diesel $gCO_2/km$ | Ziel |
|---|---|---|---|
| 2012 | 140 | 120 | 120 |
| 2020 | 105 | 85 | 95 |
| 2030 | 95 | 75 | - |

Leichte Nutzfahrzeuge (Kategorie N1)

| Jahr | Klasse | Otto $gCO_2/km$ | Diesel $gCO_2/km$ | Ziel |
|---|---|---|---|---|
| 2014 | I | 140 | 120 | 175 |
| | II | 157 | 159 | |
| | III | 238 | 200 | |
| 2020 | I | 105 | 85 | 135 |
| | II | 118 | 112 | |
| | III | 179 | 142 | |
| 2030 | I | 95 | 75 | - |
| | II | 107 | 99 | |
| | III | 162 | 125 | |

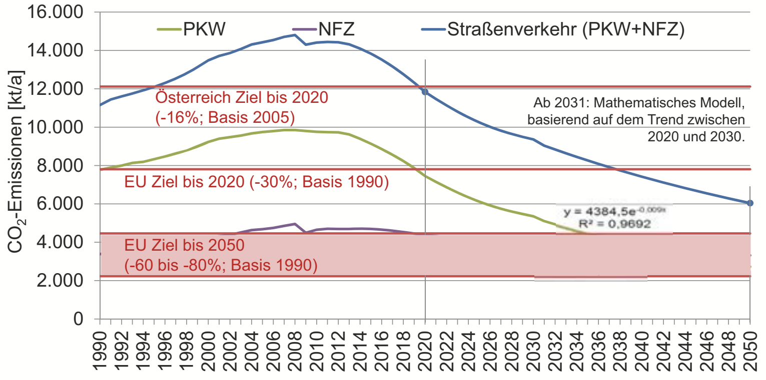

CO2-Emissionsprognose PKW in Österreich
Entwicklung mit CO2-Reglementierung
Zwischen 2013 und 2030 erfolgt eine CO2-Reduktion von 21,6% bzw. 35,8Mio.t.
Diesel EURO6
Diesel EURO4
Diesel EURO2
Diesel US83
Otto ECE 1501
Euro 5 = Euro 6
Otto EURO6
Otto EURO4
Otto EURO2
Diesel ECE 1504
Otto ECE 1500
Konservativ
Diesel EURO5
Diesel EURO3
Otto EURO1
Otto ECE 1504
Diesel vor 1983
Otto EURO5
Otto EURO3
OGKAT
Otto ECE 1503
Otto vor 1973
PKW CO2-Emissionen [kt/a]
0
2.000
4.000
6.000
8.000
10.000
12.000
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030
Das CO2-Emissionsniveau liegt 2030 31,2% unter dem von 1990.
Keine CO2-Gutschrift zufolge Biokraftstoffe berücksichtigt.
Highlights der Bioenergieforschung - Biokraftstoffe in Österreich und der EU
CO2-Minderung im Straßenverkehr
30. & 31. März 2011 | Wieselburg | W. Tober | Folie 7


CO2-Emissionsprognose NFZ in Österreich
Entwicklung mit CO2-Reglementierung
Zwischen 2011 und 2030 erfolgt eine CO2-Reduktion von -6,7% bzw. 6,3Mio.t.
Lieferwagen Diesel
Lastzüge
Reisebus
Lieferwagen Otto
Sattelzüge
Sonstige NFZ
LKW
Linienbus
Konservativ
NFZ CO2-Emissionen [kt/a]
0
1.000
2.000
3.000
4.000
5.000
6.000
Leichte Nutzfahrzeuge (Kategorie N1)
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030
Das CO2-Emissionsniveau liegt 2030 18,7% über dem von 1990.
Keine CO2-Gutschrift zufolge Biokraftstoffe berücksichtigt.
Highlights der Bioenergieforschung - Biokraftstoffe in Österreich und der EU
CO2-Minderung im Straßenverkehr
30. & 31. März 2011 | Wieselburg | W. Tober | Folie 8


CO2-Emissionen in Österreich
Vergleich nach Sektoren
Einfluss von PKW & NFZ durch Tanktourismus stark überbewertet.
Energiewirtschaft
Haushalte und Kleinverbraucher
Sonstige
PKW+NFZ Abgas (IFA)
Verarbeitendes Gewerbe
Industrieprozesse
Verkehr
abzügl. Tanktourismus
abzügl. Sonstiger Verkehr
CO2-Emissionen [Mio.t/a]
0
5
10
15
20
25
30
Prognosen zeigen künftig CO2-Emissionsrückgang bei PKW & NFZ.
Die Emissionsberechnungen (ausgenommen IFA) basieren auf den in Österreich verkauften Kraftstoffen.
Der Sektor Verkehr beinhaltet die Bereiche: Straßenverkehr, Bahnverkehr, Schifffahrt, nationaler Flugverkehr, Kompressoren der Gaspipelines und Tanktourismus.
Der land- und forstwirtschaftlichen Verkehr, sowie Militär sind im Sektor Haushalte und Kleinverbraucher enthalten.
Emissionen aus Landnutzung, -sänderung und Forstwirtschaft werden nicht dargestellt.
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
Keine CO2-Gutschrift zufolge Biokraftstoffe berücksichtigt.
Highlights der Bioenergieforschung - Biokraftstoffe in Österreich und der EU
CO2-Minderung im Straßenverkehr
30. & 31. März 2011 | Wieselburg | W. Tober | Folie 9

## $CO_2$-Emissionen des Straßenverkehrs in Österreich vs. $CO_2$-Reduktionsziele der EU und Österreichs bis 2050

- ☐ Trotz $CO_2$-Reglementierung für PKW und Leichte Nutzfahrzeuge werden die $CO_2$-Reduktionsziele der Europäischen Union <u>nicht</u> erreicht werden.




Keine $CO_2$-Gutschrift zufolge Biokraftstoffe berücksichtigt.

Highlights der Bioenergieforschung - Biokraftstoffe in Österreich und der EU
$CO_2$-Minderung im Straßenverkehr
30. & 31. März 2011 | Wieselburg | W. Tober | Folie 10

## Weitere Lösungsansätze der $CO_2$-Reduktion im Straßenverkehr

- ☐ Die Notwendigkeit weiterer $CO_2$-Reduktionen im Straßenverkehr, zur deutlichen Unterstützung der europäischen $CO_2$-Reduktionsziele ist in direkter Weise dargelegt.
- ☐ Insbesondere bei schweren Nutzfahrzeugen ist eine $CO_2$-Reglementierung (fahrzeugseitiger Maßnahmen) noch ausständig.

### Mögliche Lösungsansätze:

- ☐ Bereits heute im Einsatz sind alternative Kraftstoffe, welche die $CO_2$-Emissionen reduzieren <u>können</u>.
- ☐ Elektromobilität, als derzeit stark favorisierter Lösungsweg <u>kann</u> ebenfalls zu einer Senkung der verkehrsbedingten $CO_2$-Emissionen beitragen.

Highlights der Bioenergieforschung - Biokraftstoffe in Österreich und der EU
$CO_2$-Minderung im Straßenverkehr
30. & 31. März 2011 | Wieselburg | W. Tober | Folie 11

## $CO_2$-Reduktionspotential durch alternative Kraftstoffe
Vergleich mittels Ökobilanz

- ☐ Essentieller Vorteil dieser Maßnahme ist, dass der gesamte Straßenverkehr zur $CO_2$-Reduktion betragen kann, da das Potential nicht nur auf neu zum Verkehr zugelassene Fahrzeuge beschränkt ist.
- ☐ Bestimmung des Potentials zur Minderung der $CO_2$-Emissionen am Beispiel alternativer Dieselkraftstoffe, mittels Ökobilanz und Emissionsberechnung.

| $CO_2$e in g/km | Diesel | RME | HVO | BTL | GTL |
|---|---|---|---|---|---|
| Well to Tank | 21 | +228% | +251% | -49% | +121% |
| Tank to Wheels | 122 | +2% | -5% | -4% | -4% |
| Well to Wheels | 143 | +35% | +33% | -11% | +14% |
| $CO_2$-Gutschrift | 0 | Ja | Ja | Ja | Ja |
| Well to Wheels | 143 | -50% | -47% | -91% | +14% |

RME… Raps-Methyl-Ester | HVO… Hydriertes Pflanzenöl
BTL… Biomass to Liquid | GTL… Gas to Liquid

Highlights der Bioenergieforschung - Biokraftstoffe in Österreich und der EU
$CO_2$-Minderung im Straßenverkehr
30. & 31. März 2011 | Wieselburg | W. Tober | Folie 12

## Annahme der Kraftstoffzusammensetzung

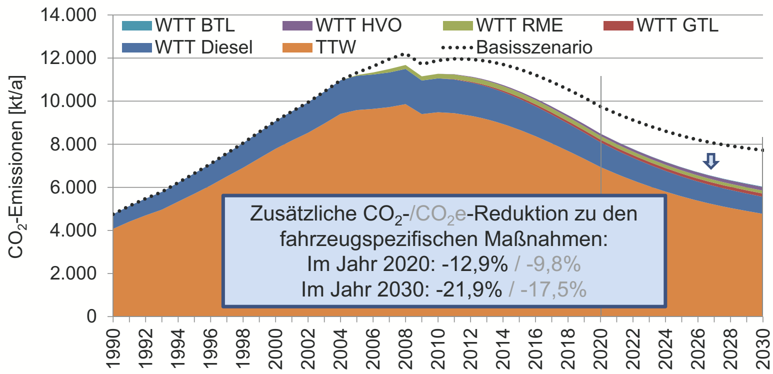
- Die getroffenen Annahmen beruhen auf einer optimistischen Einschätzung der Verfügbarkeiten der einzelnen Kraftstoffe.

| Energetischer Anteil in % am Dieselkraftstoffbedarf des Straßenverkehrs in Österreich | 2005 | 2007 | 2008 | 2010 | 2015 | 2020 | 2030 |
|---|---|---|---|---|---|---|---|
| Diesel | 98,7% | 94,8% | 94,1% | 93% | 88% | 83% | 72% |
| GTL | - | - | - | - | 3% | 5% | 8% |
| RME | 1,29% | 5,19% | 5,89% | 7% | 7% | 7% | 7% |
| HVO | - | - | - | - | 2% | 4% | 8% |
| BTL | - | - | - | - | - | 1% | 5% |



## $CO_2$-Reduktionspotential des dieselbetriebenen, österreichischen Straßenverkehrs

- Trotz opt. Beimischungsquoten werden die $CO_2$-EU-Ziele nicht erreicht.
- Alternative Kraftstoffe leisten dennoch einen wesentlichen Beitrag.

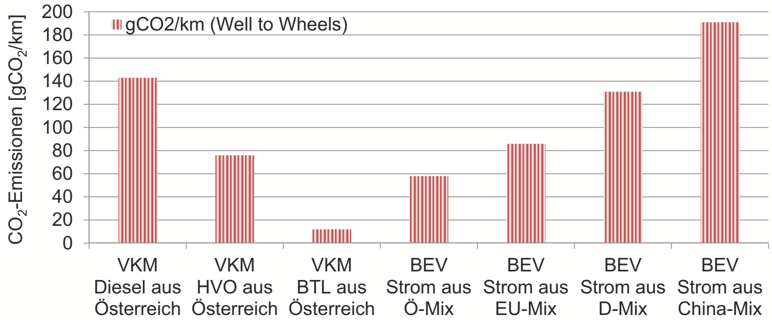



WTT... Well to Tank | TTW... Tank to Whells



## $CO_2$-Reduktionspotential durch Elektromobilität
Vergleich mittels Ökobilanz

- Biokraftstoffe der zweiten Generation sind „$CO_2$-konkurrenzfähig".
- Der Strommix ist entscheidend ob Elektrofahrzeuge einen $CO_2$-Vor- oder Nachteile generieren.




VKM... Verbrennungskraftmaschine | BEV... Batterieelektrisches Fahrzeug | HVO... Hydriertes Pflanzenöl | BTL... Biomass to Liquid
Ö-Mix... Österreichischer Strommix | D-Mix... Deutscher Strommix | EU-Mix... Europäischer Strommix
Betrachtung ohne Fahrzeugherstellung

## Zusammenfassung

- ☐ Der Vergleich der europäischen $CO_2$-Reduktionsziele mit den fahrzeugseitigen $CO_2$-Reduktionsvorgaben zeigt auf, dass **weitere Maßnahmen der $CO_2$-Emissionsreduktion erforderlich** sind.
- ☐ Eine Analyse des **$CO_2$-Reduktionspotentials von alternativen Kraftstoffen** im dieselbetriebenen österreichischen Straßenverkehr zeigt, dass im Jahr 2020 bzw. 2030 die $CO_2$e-Emissionen des dieselbetriebenen österreichischen Straßenverkehrs **um 9,8% bzw. 17,5% reduziert** können.
- ☐ Das **$CO_2$-Reduktionspotential von Elektrofahrzeugen** ist unmittelbar von der Zusammensetzung des Strom-Mix abhängig ist. Der darstellbare $CO_2$-Vorteil wird durch den Anteil an regenerativ erzeugtem Strom bestimmt. **Europaweit** sind die Potentiale als **gering** zu bewerten, kann aber nicht vernachlässigt werden.

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Highlights der Bioenergieforschung - Biokraftstoffe in Österreich und der EU
$CO_2$-Minderung im Straßenverkehr
30. & 31. März 2011 | Wieselburg | W. Tober | Folie 16

IFA Institut für Fahrzeugantriebe & Automobiltechnik

## Herzlichen Dank für Ihre Aufmerksamkeit!

IFA Institut für Fahrzeugantriebe & Automobiltechnik

Dipl. Ing. Werner Tober
werner.tober@ifa.tuwien.ac.at

TU WIEN Technische Universität Wien Vienna University of Technology

Institut für Fahrzeugantriebe & Automobiltechnik

## Literatur

W. Tober: Entwicklung der Schadstoff- und CO2-Emissionen des Straßenverkehrs und Ableitung des zusätzlichen Handlungsbedarfs bis 2030. Wien: Institut für Fahrzeugantriebe und Automobiltechnik, 2011. Dissertation

Sowie:

Folie 4

- ☐ Europäisches Parlament.: Verordnung (EG) Nr. 443/2009 des Europäischen Parlaments und des Rates vom 23. April 2009 zur Festsetzung von Emissionsnormen für neue Personenkraftwagen im Rahmen des Gesamtkonzepts der Gemeinschaft zur Verringerung der CO2-Emissionen von Personenkr... Amtsblatt der Europäischen Union. 5. Juni 2009, L140, S. 1-15.
- ☐ Europäische Kommission.: Vorschlag für eine Verordnung des Europäischen Parlaments und des Rates zur Festsetzung von Emissionsnormen für neue leichte Nutzfahrzeuge im Rahmen der Gesamtstrategie der Gemeinschaft zur Minderung der CO2-Emissionen von leichten Nutzfahrzeugen und PKW. Brüssel : Amt für amtliche Veröffentlichungen der Europäischen Gemeinschaften, 2009. KOM(2009) 0593.

Folie 9

- ☐ Fernandez, R. et al: Annual European Community greenhouse gas inventory 1990–2007, and inventory report 2009 (Version 27 May 2009). Copenhagen: European

Folie 15

- ☐ Helms, H, et al.: Electric vehicle and plug-in hybrid energy efficiency and life cycle emissions. 18th International Symposium Transport and Air Pollution. Dübendorf : EMPA, 2010.
- ☐ Demel, H.: Energiebedarf im gesamten Lebenszyklus für verschiedene Fahrzeugkonzepte. Tagungsband zum 30. Internationalen Wiener Motorensymposium. Düsseldorf : VDI-Verlag GmbH, 2009. VDI Fortschritt-Berichte Band 697.

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Highlights der Bioenergieforschung - Biokraftstoffe in Österreich und der EU
$CO_2$-Minderung im Straßenverkehr
30. & 31. März 2011 | Wieselburg | W. Tober | Folie 18

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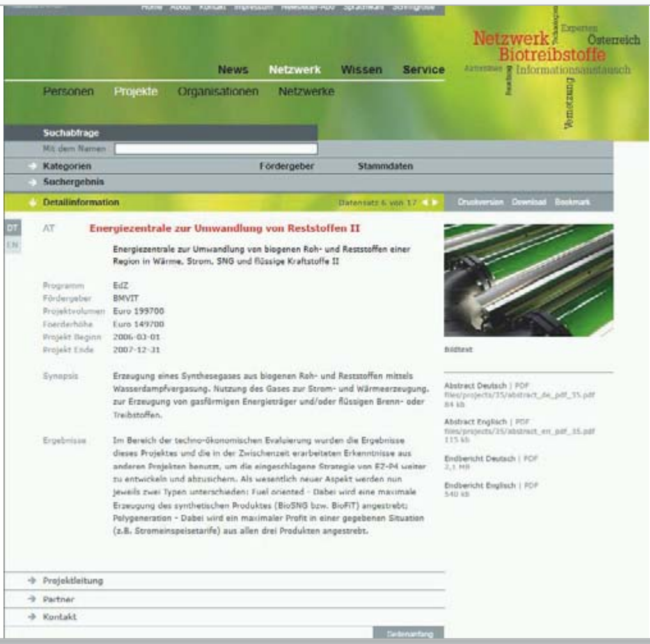
# Netzwerk Biotreibstoffe

Highlights der Bioenergieforschung V
30.+31.3.2011, Wieselburg


## Netzwerk Biotreibstoffe

*Dina Bacovsky, BIOENERGY 2020+*



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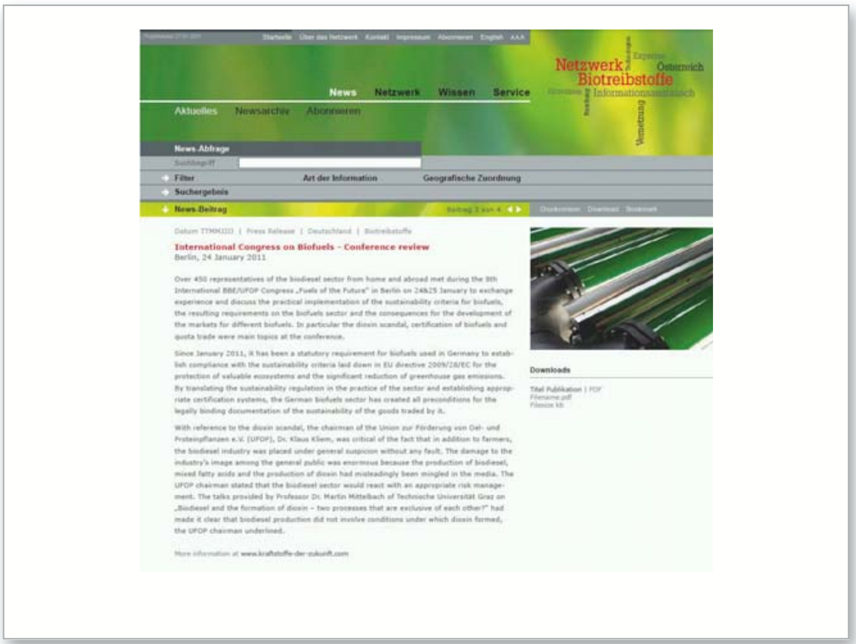




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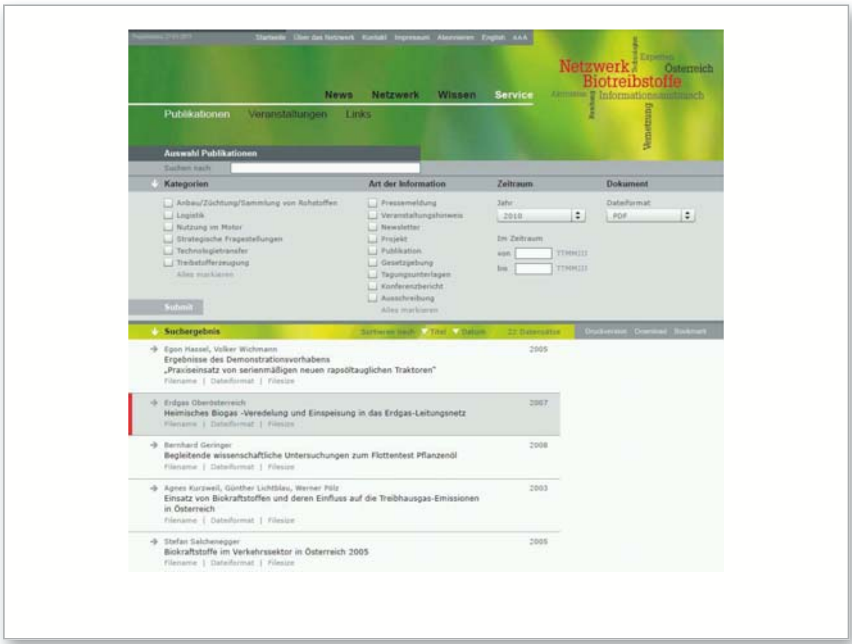
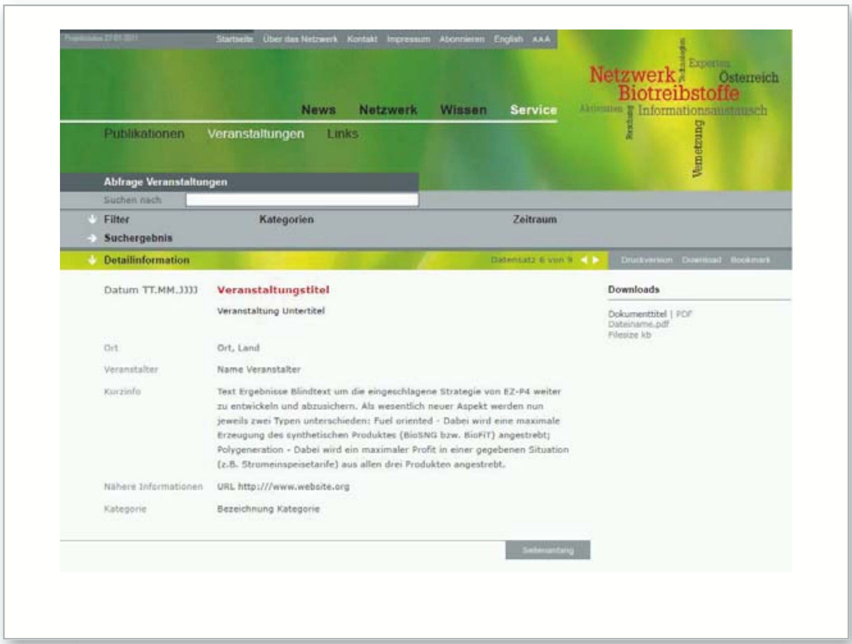
## Netzwerk Biotreibstoffe

*Dina Bacovsky, BIOENERGY 2020+*





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Netzwerk Biotreibstoffe
www.netzwerk-biotreibstoffe.at
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## Netzwerk Biotreibstoffe

*Dina Bacovsky, BIOENERGY 2020+*

## Das IEA Energy Technology Network
***Moderation: Manfred Wörgetter**, FJ-BLT*

### Das IEA Energy Technology Network
***Manfred Wörgetter**, FJ-BLT*



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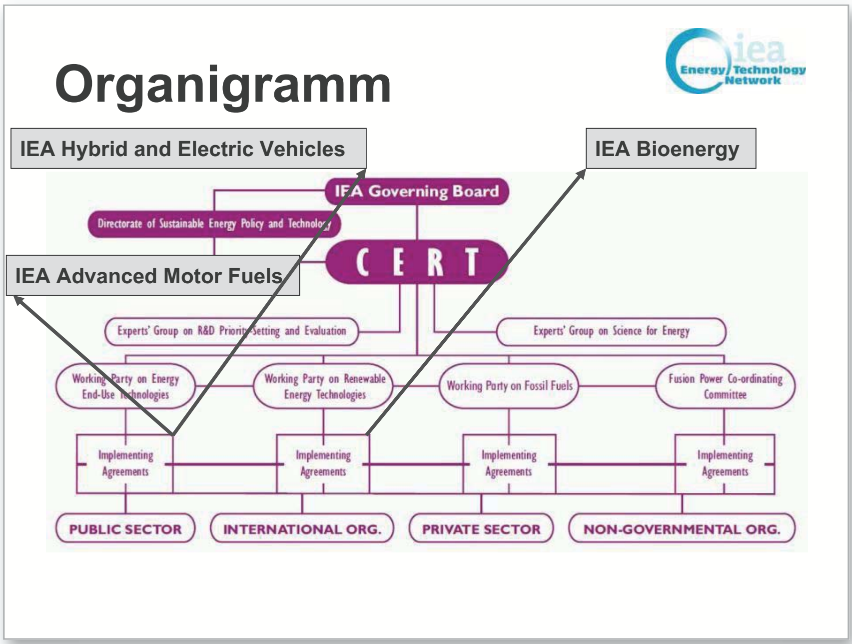


| Biofuels-related: | Auf der Couch: |
|---|---|
| IEA Bioenergy | Josef Spitzer |
| Task 33: Gasification | Reinhard Rauch |
| Task 37: Biogas | Bernhard Drosg |
| Task 38: GHG Balances | Neil Bird |
| Task 39: Liquid Biofuels | Dina Bacovsky |
| Task 40: Biomass Trade | Lukas Kranzl |
| Task 42: Biorefineries | Gerfried Jungmeier |
| IEA Hybrid and Electric Vehicles | Andreas Dorda |
| IEA Advanced Motor Fuels | Andreas Dorda |

# IEA Bioenergy

iea Energy Technology Network

***Facilitating commercialisation and market deployment of environmentally sound, sustainable and cost-competitive bioenergy technologies………***

**Josef Spitzer**

**Highlights der Bioenergieforschung**
**30. März 2011**

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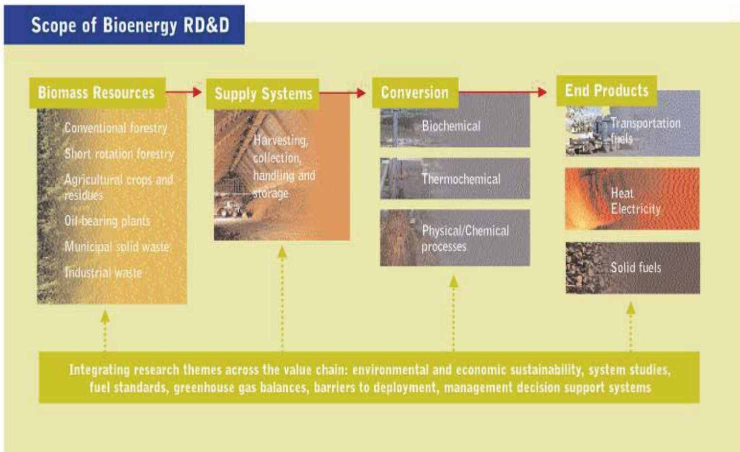
IEA Bioenergy

## Scope of IEA Bioenergy




**http://www.ieabioenergy.com**

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IEA Bioenergy

## Was bietet die Teilnahme an IEA Bioenergy?

- **Internationaler Wissensaustausch für die österreichische F&E**
- **Internationale Verbreitung der Ergebnisse der österreichischen F&E**
- **Anbahnung internationaler F&E-Projekte**
- **Aufbau von Kontakten österreichischer Unternehmen zu internationalen Firmen**

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## Welche Fragestellungen werden bearbeitet?

- **Rohstoffbasis: Mengen (regional, global), Ernte/Aufbereitung, internationale Logistik**
- **Umwandlung: Prozesse (1. & 2. Gen), Ko-Produkte („Bioraffinerie“)**
- **Treibhausgasemissionen: prozessbedingt, LUC-bedingt, Bilanzen mit LCA**
- **Politik: Marktkonkurrenz („FFF“), Energie- und Klimapolitik, Einführungsstrategien**

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## Wie werden die Ergebnisse verbreitet?

- **Publikationen**
  - **Strategic position papers**
  - **Annual Reports**
  - **Newsletters (halbjährlich)**
  - **ExCo Workshop Reports**
- **Veranstaltungen**
  - **Task Workshops**
  - **IEA Bioenergy Conference**


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Vienna University of Technology

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# IEA Bioenergy Task 33: Thermal Gasification of Biomass

Highlights der Bioenergieforschung 30. März 2011, Wieselburg

Dr. Reinhard Rauch

Vienna, University of Technology
Institute of Chemical Engineering

Participation in IEA Bioenergy is financed by bmvit

Institute of Chemical Engineering
Working Group Synthetic Biofuels

## Überblick

Operating Agent:
- The United States Department of Energy

Task Leader:
- Dr. Richard Bain, NREL, USA
- Dr. Reinhard Rauch, TU Vienna

1. Austria
2. Denmark
3. Finland
4. Germany
5. Italy
6. The Netherlands
7. New Zealand
8. Switzerland
9. United States
10. **Sweden (since 2011)**
11. **Japan**
12. **Norway**
13. **Turkey**

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Institute of Chemical Engineering
Working Group Synthetic Biofuels

## Arbeiten

Die Ziele von Task 33 sind
- Netzwerkaktivitäten
- Informationsaustausch
- Standardisierung

Die Arbeiten sind
- Erstellen Country Reports
- Abhalten von Meetings und Workshops
- Erstellen von Studien bzw. Standardisierungsaktivitäten

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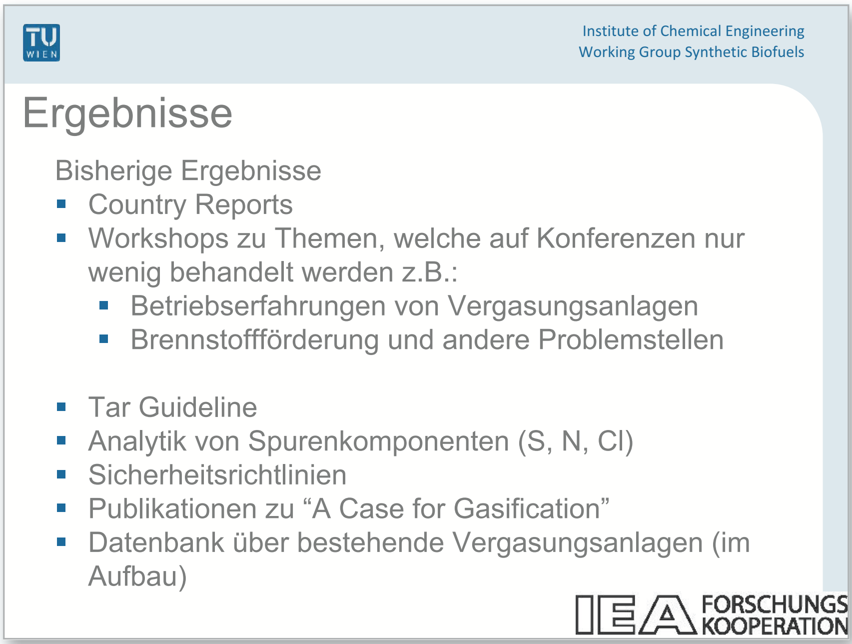
## Task 33: Thermal Gasification of Biomass

*Reinhard Rauch, TU Wien – VT*



IEA Bioenergy

# IEA Bioenergy Task 37 "Energy from Biogas"

Highlights der Bioenergieforschung V
30.+31.3.2011, Wieselburg

IEA Task 37 „Energy from Biogas"

IEA Bioenergy

## IEA Task 37 – "Energy from Biogas"

Schwerpunkte 2010–2012:

Topic 1 – Substrate für Biogaserzeugung

Topic 2 – Optimierung des Anaerobprozesses

**Topic 3 – Biogasaufreinigung und Netzeinspeisung**

Topic 4 – Gärrestaufbereitung und -qualität

**Topic 5 – Emissionen aus Biogasanlagen**

Topic 6 – Information und Ausbildung

IEA Task 37 „Energy from Biogas"

IEA Bioenergy

## Beiträge und Infos für Biotreibstoffe in Österreich

- Gute Datenbasis und Informationen über Nettoenergiebilanz in der Biogaserzeugung
- Details und internationale Erfahrungen zur Verwendung von Biogas als Treibstoff
- Vergleich und Gegenüberstellung unterschiedlicher Technologien zur Biogasaufreinigung
- Integration von Biogastechnologie in Biotreibstofffabriken – Energetische Nutzung der Reststoffe
- Zusammentragen von Daten über Emissionen in der Biogaserzeugung

IEA Task 37 „Energy from Biogas"


IEA Bioenergy
Informationsverbreitung
• Task-Homepage: http://www.iea-biogas.net/
• Task37 Newsletter
• IEA Broschüren, "Success stories", technische Berichte
• Workshops, Tagungsbeiträge, Konferenzen
www.adswec2011.org
ADSW&EC 2011 Vienna, Austria
• Kontakt – österreichische Vertreter:
DI Bernhard Drosg (bernhard.drosg@boku.ac.at)
DI Günther Bochmann (guenther.bochmann@boku.ac.at)
IEA Task 37 „Energy from Biogas"

IEA Bio

IEA FORSCHUNGS KOOPERATION

# Task 38

## Greenhouse Gas Balances of Biomass and Bioenergy Systems

**Highlights der Bioenergieforschung**
Nationale und internationale Ergebnisse
zu den IEA Schwerpunkten
30.–31. März 2011, Wieselburg

N. Bird
Task 38 – Task Leader
JOANNEUM RESEARCH Forschungsgesellschaft mbH, Graz, Austria

IEA Bio

Task 38 – Greenhouse Gas Balances of Biomass and Bioenergy Systems

## Welche Rolle spielen LUC und iLUC bei der Nachhaltigkeit und C-Neutralität von Biotreibstoffen?

- **Langfristig ist Bioenergie nachhaltig, nicht immer aber auch gleichzeitig C-neutral**
- **„Land-use change“ (LUC und iLUC) kann eine sehr große Rolle in der <u>kurzfristigen</u> Treibhausgasbilanz von Bioenergie spielen**
  - ➔ Direkt – wenn die Landbewirtschaftung geändert wird
    - Lebende und nicht lebende Biomasse (inkl. Boden)
  - ➔ Indirekt – durch die Rohstoffverfügbarkeit
    - wenn Bioenergie in Konkurrenz mit anderen Nutzungen steht („food, fibre or fuel“)

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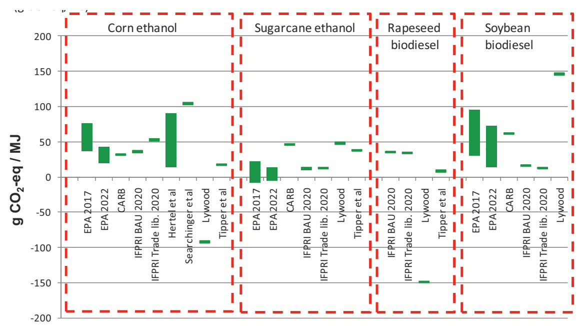
Task 38 – Greenhouse Gas Balances of Biomass and Bioenergy Systems

## Welche Rolle spielen LUC und iLUC bei der Nachhaltigkeit und C-Neutralität von Biotreibstoffen?




Von: Berndes G., Bird N., and Cowie A. 2010. Bioenergy, Land Use Change and Climate Change Mitigation. IEA Bioenergy Strategic Paper. IEA Bioenergy:ExCo:2010:03. Available at: http://www.ieabioenergy.com/LibItem.aspx?id=6770

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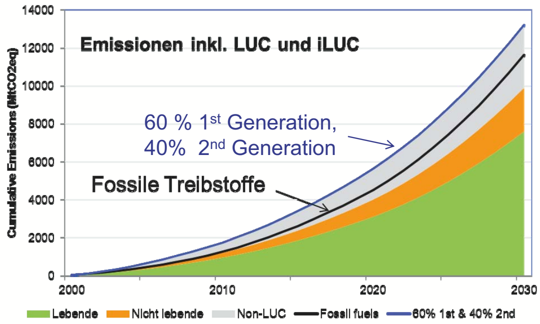
Task 38 – Greenhouse Gas Balances of Biomass and Bioenergy Systems

## Aufteilung der Gesamtemissionen von Biotreibstoffen im Vergleich zu fossilen Treibstoffen unter Berücksichtigung von LUC und iLUC




Unveröffentlichte Ergebnisse. Bitte nicht verwenden
Basierend auf ein Model von Havlík et al (IIASA)

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Task 38 – Greenhouse Gas Balances of Biomass and Bioenergy Systems

## Was bietet Task 38 den österreichischen Experten zu Biotreibstoffen? Welche Fragestellungen werden bearbeitet und wie werden die Ergebnisse verbreitet?

- **LCA von verschiedenen Energiesystemen inklusive dLUC (noch nicht iLUC)**
  - ➔ Paldau Biogas „Case Study“
  - ➔ Bioraffinerie „Case Study“, derzeit in Bearbeitung
- **ACRP Projekt – SMART FORESTS**
  - ➔ JR, BOKU, ÖBF und ÖBV arbeiten gemeinsam am Thema „Timing der Treibhausgasemission von Bioenergie aus Holz“ in Österreich, Fertigstellung 2012
- **Task-38 Website**
  - ➔ http://www.ieabioenergy-task38.org
- **Task-38 Workshops und Expert Meetings**
  - ➔ LUC Conference Brazil – September 2011
  - ➔ Expert Meeting, Graz – 1.Quartal 2012

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Commercializing Liquid Biofuels from Biomass

Task 39 IEA Bioenergy

# IEA Bioenergy Task 39:
## Commercializing Liquid Biofuels from Biomass

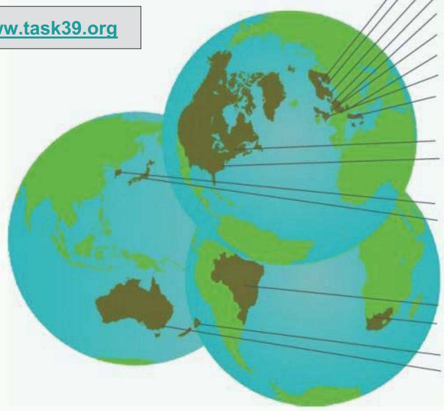
Highlights der Bioenergieforschung V
30.+31.3.2011, Wieselburg

Commercializing Liquid Biofuels from Biomass

Task 39 IEA Bioenergy

## Task Members 2009-11

www.task39.org




Commercializing Liquid Biofuels from Biomass

Task 39 IEA Bioenergy

## Studien und Berichte

- Biodiesel GHG Emissions: Past, Present and Future (2011)
- Current Status and Potential of Algal Biofuels (2010)
- Status of 2nd Gen Demonstration Facilities (2010)
- Backgrounder: Overview of sustainability criteria (2010)
- Update on implementation agendas: A review (2009)
- Examination of the Potential for Improving Carbon/Energy Balance of Bioethanol (2009)
- From 1st to 2nd Gen Biofuel Technologies (2008)
- …

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Commercializing
Liquid Biofuels from Biomass
Task 39
IEA Bioenergy
Informationsaustausch
Task 39:
• www.task39.org
• Taskmeetings
• Task Newsletter
• Konferenzen
Österreich:
• E-mail Aussendungen
• Nationaler Workshop: „Transport Biofuels Research in Austria"
Ansprechpartner:
–Manfred Wörgetter
–Dina Bacovsky
–Andrea Sonnleitner
IEA Bioenergy

# IEA Bioenergy Task 40
# Sustainable International Biomass Trade

**Lukas Kranzl**

**Highlights Bioenergieforschung**
**30. März 2011, Wieselburg**

Energy Economics Group | TECHNISCHE UNIVERSITÄT WIEN Vienna University of Technology | IEA FORSCHUNGSKOOPERATION

## „Was bietet die Teilnahme an Task 40 den österreichischen Experten zu Biotreibstoffen?“

- **Informationen zur Herkunft der Rohstoffe**
- **Analysen zu den Zusammenhängen auf den (internationalen) Biomassemärkten und –Transportrouten**
- **Auswirkungen der Nachhaltigkeitszertifizierung (gemäß Erneuerbare-RL EC 2009/28)**

- **Generell in Task 40 alle Bioenergieströme behandelt. Aufgrund der hohen Energiedichte für Kraftstoffe besonders relevant!**

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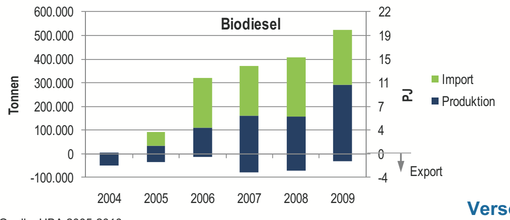
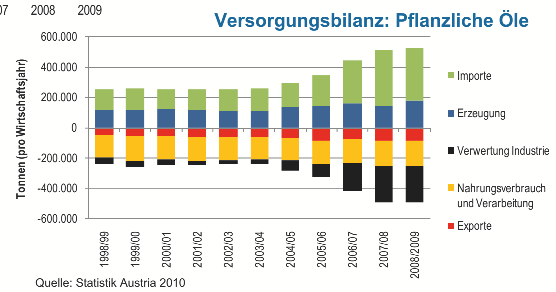
## Biodiesel

**Produktion, Import, Export**




Quelle: UBA 2005-2010

**Versorgungsbilanz: Pflanzliche Öle**




Quelle: Statistik Austria 2010

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## Nachhaltigkeitskriterien und -zertifizierung?

- Ca. 70 verschiedene Initiativen mit unterschiedlichen Standards, Aspekten und Zielsetzungen
- Die meisten davon zielen auf flüssige biogene Kraftstoffe ab.
- Fokus auf Umwelt-relevante Zielsetzungen.
- Aspekte der Nahrungsmittelsicherheit oder sozio-ökonomischer Auswirkungen meist nicht berücksichtigt (z.T. Arbeitnehmerschutz in freiwilligen Vereinbarungen)
- Große Bandbreite der Standards und Methoden => Risiko von Verwirrung, Missbrauch und „Ausverkauf" von Standards
- Trotz derzeitiger Beschränkungen hat Zertifizierung das Potenzial, direkte und lokale Wirkungen zu beeinflussen.
- => weitere Entwicklung und Stärkung von Standards und klaren, transparenten Methoden?!
- => indirekte Effekte?!

Source: Dam et al 2010

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## Weitere Informationen:

- Nationale und internationale Task-40 Workshops

- www.nachhaltigwirtschaften.at
- www.bioenergytrade.org
- www.eeg.tuwien.ac.at

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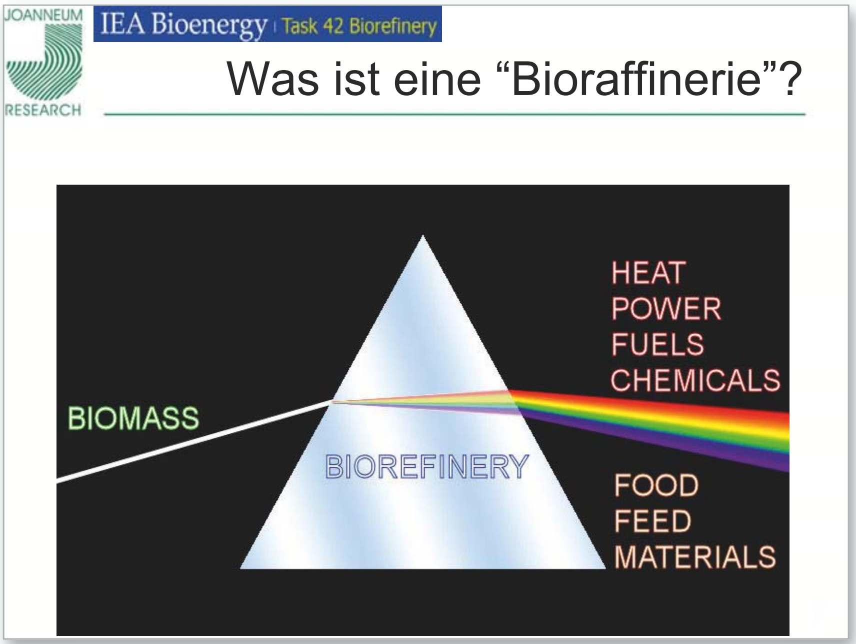
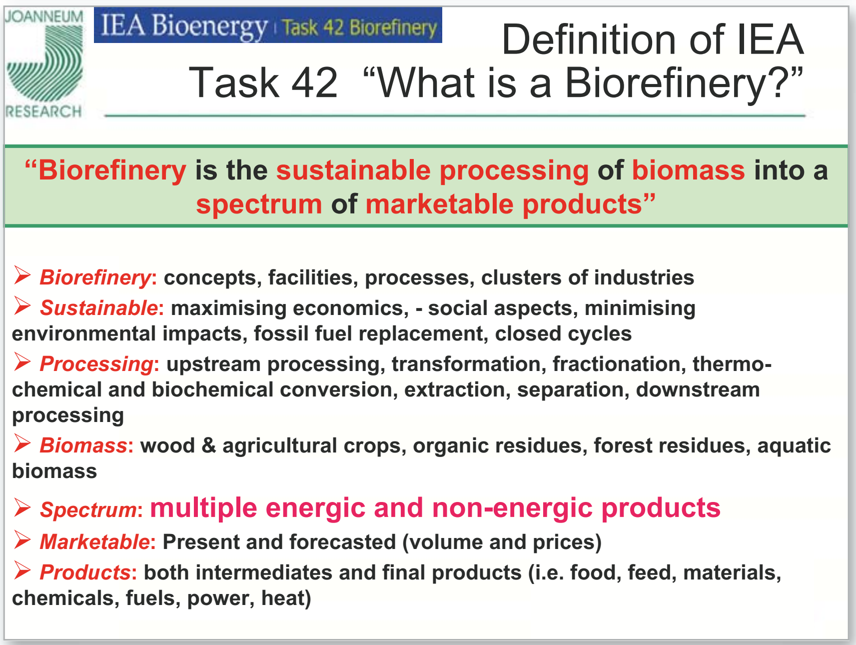
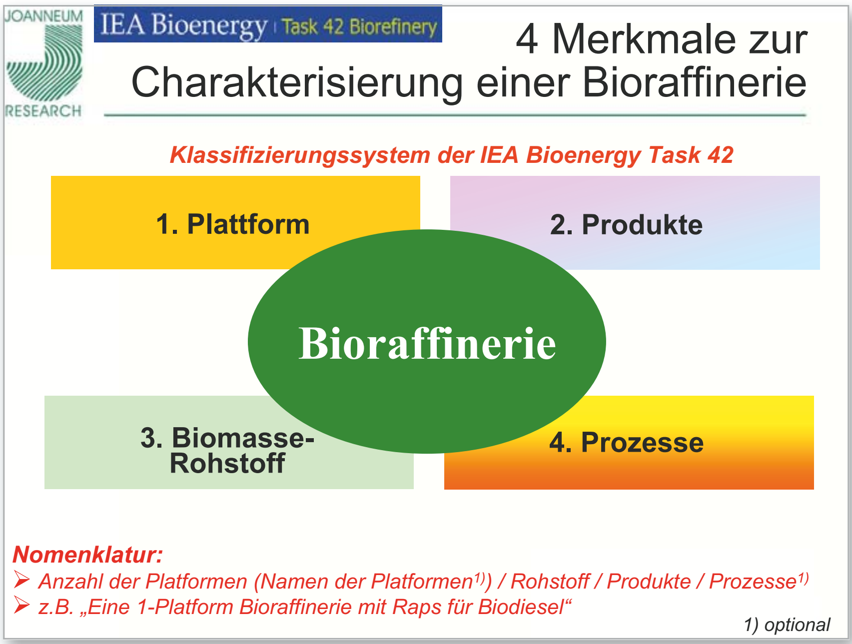
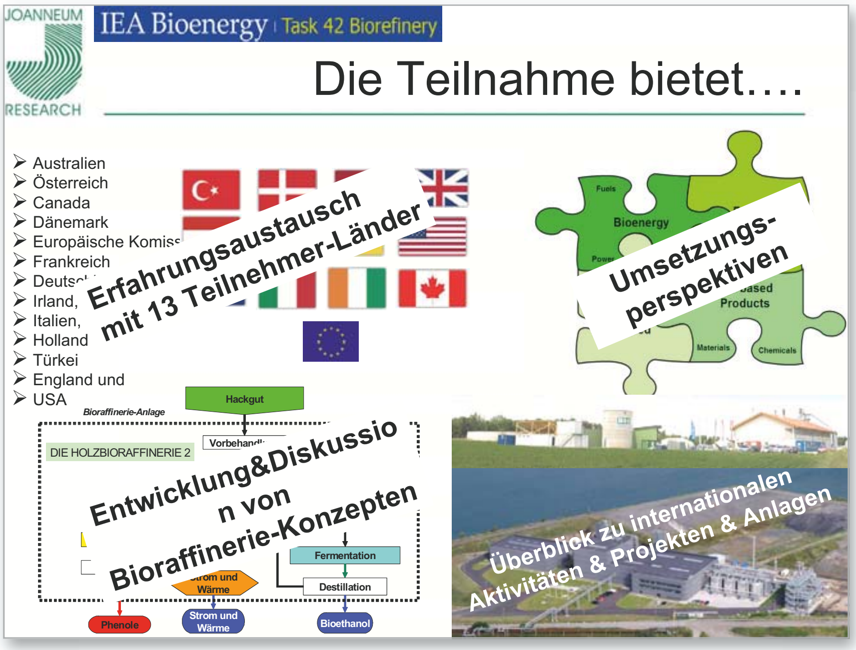
JOANNEUM RESEARCH
JOANNEUM RESEARCH
Forschungsgesellschaft mbH
IEA Bioenergy | Task 42 Biorefinery
Gerfried Jungmeier
Highlights der Bioenergieforschung
Das IEA Energy Technology Network
30 .– 31. März 2011, Wieselburg
IEA FORSCHUNGS KOOPERATION
bmvit
Die Teilnahme an den Tasks in IEA Bioenergy wird finanziert vom Bundesministerium für Verkehr, Innovation und Technologie / Abteilung für Energie- und Umwelttechnologien.
INNOVATION aus TRADITION

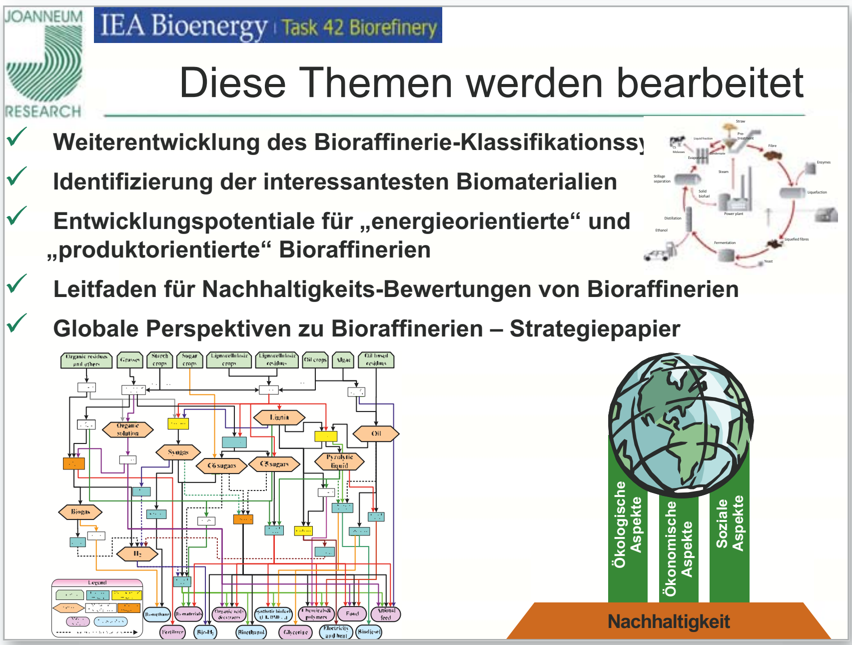

JOANNEUM RESEARCH
IEA Bioenergy | Task 42 Biorefinery
Was ist eine “Bioraffinerie”?
BIOMASS
BIOREFINERY
HEAT
POWER
FUELS
CHEMICALS
FOOD
FEED
MATERIALS


JOANNEUM RESEARCH
IEA Bioenergy | Task 42 Biorefinery
Definition of IEA Task 42 “What is a Biorefinery?”
“Biorefinery is the sustainable processing of biomass into a spectrum of marketable products”
Biorefinery: concepts, facilities, processes, clusters of industries
Sustainable: maximising economics, - social aspects, minimising environmental impacts, fossil fuel replacement, closed cycles
Processing: upstream processing, transformation, fractionation, thermo-chemical and biochemical conversion, extraction, separation, downstream processing
Biomass: wood & agricultural crops, organic residues, forest residues, aquatic biomass
Spectrum: multiple energic and non-energic products
Marketable: Present and forecasted (volume and prices)
Products: both intermediates and final products (i.e. food, feed, materials, chemicals, fuels, power, heat)

*Gerfried Jungmeier, Joanneum Research – Resources*



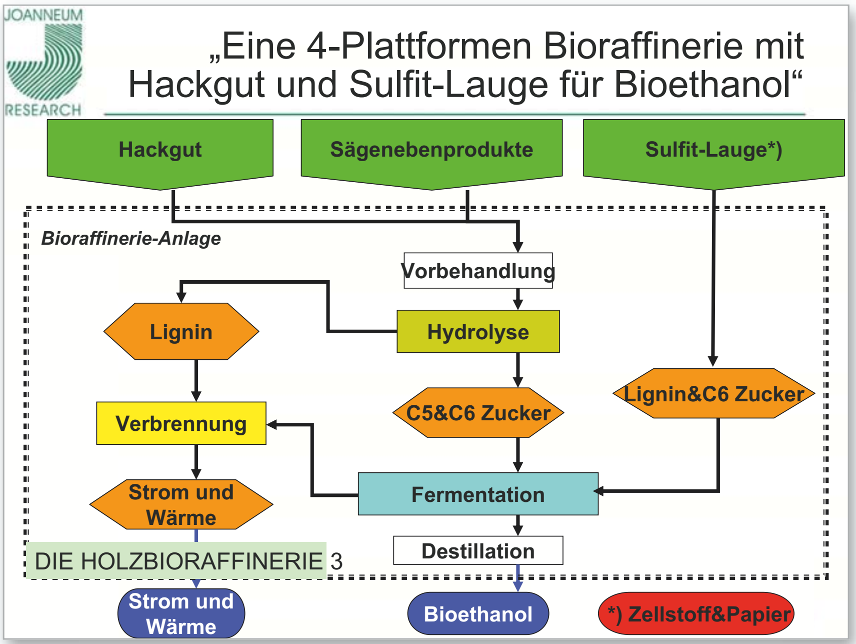



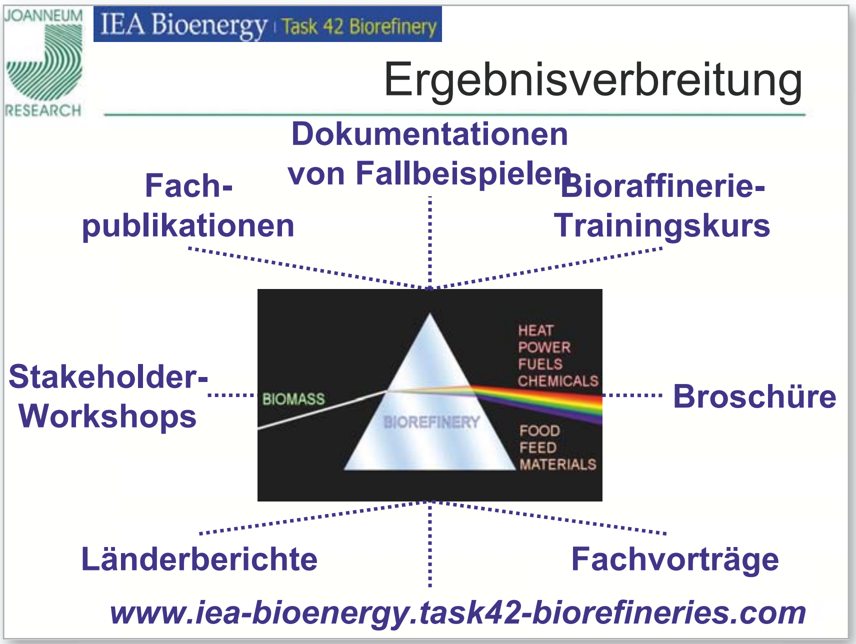
JOANNEUM RESEARCH | IEA Bioenergy | Task 42 Biorefinery

## Die interessantesten "Bioenergy-driven" Bioraffinerien 2020

**"Bioenergy-driven" Biorefinery concepts of Task 42 (Status of 5 Oct. 2010):**

1. "A 5-platform (biogas, biomethan, green pressate, fibres, electr.&heat) biorefinery with grasses for biomethan"
2. "A 1-platform (oil) biorefinery with oil crops for biodiesel"
3. "A 1-platform (oil) biorefinery with oil based residues&oil crops for biodiesel"
4. "A 1-platfrom (C6 sugar) biorefinery with sugar&starch crops for bioethanol"
5. "A 2-platform (electricity&heat, syngas) biorefinery with wood chips for FT-Biofuels"
6. "A 2-platform (C6&C5 sugar, electr.&heat, lignin) biorefinery with wood chips for bioethanol"
7. "A 2-platform (electr.&heat, biomethan) biorefinery with wood chips for biomethan (SNG)"
8. "A 4-platform (electr.&heat, hydrogen, biomethan, syngas) biorefinery with wood chips for biomethan (SNG)"
9. "A 3-platform (pulp, syngas, electricity&heat) biorefinery with wood chips for FT-Biofuels"
10. "A 4-platform (C6&C5 sugar, lignin&C6 sugar, electr.&heat) biorefinery with saw mill residues, wood chips and Sulfite liquor for bioethanol"
11. "A 4-platform (C6&C5 sugar, lignin, pulp) biorefinery with wood chips for bioethanol"
12. "A 5-platfrom (C6 sugars, C6&C5 sugar, lignin, syngas, electr.&heat) biorefinery with starch crops and straw for bioethanol"
13. "A 2-platform (electricity&heat, syngas) biorefinery with straw for FT-Biofuels"
14. "A 3-platform (C6&C5 sugar, electr.&heat, lignin) biorefinery with straw for bioethanol"
15. "A 4-platform (biogas, biomethan, oil, electr.&heat) biorefinery with algae for biodiesel"

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A3PS

# IEA Implementing Agreements

## Advanced Motor Fuels
## Hybrid & Electric Vehicles

**Austrian Agency for Alternative Propulsion Systems (A3PS)**

Wieselburg, 30/03/2011 *Highlights der Bioenergieforschung V*

## IA – Advanced Motor Fuels
### IA End-Use Technologies/Transport

- Österreich Mitglied seit 2007
- Themen:
  - Beitrag alternativer Treibstoffe zur Versorgungssicherheit
  - Energie-Effizienz
  - Umwelt- Sozial- und Wirtschaftauswirkungen
  - Unterstützung bei der Erstellung von Standards und gesetzlichen Rahmenbedingungen für alternative Treibstoffe.
- Der Fokus dieses IA liegt in der Anwendung der Treibstoffe (nicht in der Herstellung) und den jeweiligen Umweltauswirkungen.
- Berücksichtigt werden Treibstoffe für den Einsatz in allen Verkehrsmodi

A3PS 44

## IA – Advanced Motor Fuels
### IA End-Use Technologies/Transport

- Art der Kooperation: die meisten laufenden Annexe beinhalten umfangreiche Labor- und Testversuche, die zwischen unterschiedlichen Forschungseinrichtungen koordiniert werden. Das Arbeitsprogramm innerhalb der Annexe erfolgt auf Basis von „Cost-Sharing“ oder „Task-Sharing“ Systeme. Publikationen und gemeinsame Aktivitäten werden aus dem „Common Fund“ finanziert.
- Public domain: http://www.iea-amf.vtt.fi/

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## Laufende Annexe

- Information Service & AMF Website (AMFI) – **XXVIII**
- Algae as a Feedstock for Biofuels – **XXXIV-2**
- Particle Measurements: Ethanol and Butanol in DISI Engines – **XXXV-2**
- Fuel and Technology Alternatives for Buses (Cooperation: IA-HEV, IA- AMF, IA-Bioenergy) – **XXXVII**
- Environmental Impact of Biodiesel Vehicles – **XXXVIII**
- Enhanced Emission Performance and Fuel Efficiency for HD Methane Engines – **XXXIX**
- **Life Cycle Analysis of Transportation Fuel Pathways – XL**
- Alternative Fuels for Marine Applications – Future Marine Fuels Study – **XLI**
- Toxicity of Exhaust Gases and Particles from IC-Engines – International Activities Survey – **XLII**
- Performance Evaluation of Passenger Car, Fuel and Powerplant Options – **XLIII**

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## Beteiligte Organisationen

- Department of Energy/Argonne National Laboratory – **USA**
- Natural Resources Canada (CanmetENERGY)
- VTT – **Finnland**
- Swedish Road Administration/AVL – **Schweden**
- NEDO/LEVO/NTSEL – **Japan**
- CATARC – **China**
- ADEME – **Frankreich**
- Fachagentur Nachwachsende Rohstoffe – **Deutschland**
- Bundesamt für Energie/Berner Fachhochschule – **Schweiz**

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## Beteiligte Organisationen

- Danish Energy Agency/Danish Technical University – **Dänemark**
- IDAE – **Spanien**
- National Science and Technology Development Agency (NSTDA) – **Thailand**
- Department of the Environment, Water, Heritage and the Arts – **Australia**
- ENI S.p.A./Istituto Motori (IM) – **Italien**

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## Öffentliche Berichte

- **Annex XXXIX**: "Enhanced Emission Performance and Fuel Efficiency for HD Methane Engines"

*"Enhanced emission performance and fuel efficiency for HD methane engines"* May 2010.

- **Annex XXXVI**: Measurement Technologies for Hydrocarbons, Ethanol, and Aldehyde Emissions from Ethanol Powered Vehicles

*"Measurement technologies for emissions from ethanol fuelled vehicles"*
SAE Technical Paper 2010-01-1557, November 2009.

- **Annex XXXIV**: Biomass-Derived Diesel Fuels

Task 1: Analysis of Biodiesel Options. *"Biomass-Derived Diesel Fuels"* Final Report, May 2009.

- **Annex XXXV**: Ethanol as Fuel for Road Transportation

*"Ethanol as a Fuel for Road Transportation"* Final Report, May 2009.

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## IA – Hybrid and Electric Vehicles

### IA End-Use Technologies/Transport

Laufende Annexe:

- Information exchange – Annex I
- Electrochemical systems – Annex X
- Electric cycles – Annex XI
- Heavy-duty hybrid vehicles – Annex XII
- Fuel cell vehicles – Annex XIII
- Market deployment of hybrid and electric vehicles: lessons learned – Annex XIV

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## IA – Hybrid and Electric Vehicles

### IA End-Use Technologies/Transport

Laufende Annexe – II

- Plug-in hybrid electric vehicles – Annex XV
- Fuel and technology alternatives for buses – Annex XVI
- System integration and optimization of components for enhanced overall electric vehicle performance – Annex XVII
- EV readiness forum: Infrastructure policy and systems for the electrification of transport – Annex XVIII

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Diskussion – Resumee des Tages

*Theodor Zillner, BMVIT, III/I 3*

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www.bmvit.gv.at

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## Internetseiten

iea Energy Technology Network

| | |
|---|---|
| IEA Bioenergy | www.ieabioenergy.com |
| Task 33 | www.ieatask33.org |
| Task 37 | www.iea-biogas.net |
| Task 38 | www.ieabioenergy-task38.org |
| Task 39 | www.task39.org |
| Task 40 | www.bioenergytrade.org |
| IEA AMF | www.iea-amf.vtt.fi |
| IEA HEV | www.ieahev.org |
| IEA FORSCHUNGS KOOPERATION | www.nachhaltigwirtschaften.at/iea/index.html |

**Diskussion – Resumee des Tages**

***Theodor Zillner***, *BMVIT, III/I 3*

## Kamingespräch im TZWL

*Moderation: Manfred Wörgetter, FJ-BLT*

**Begrüßung**

***Karl Gerstl***, *Bürgermeister der Gemeinde Wieselburg-Land*

***Claus Zeppelzauer***, *ecoplus. Niederösterreichs Wirtschaftsagentur*

**Verbrannt – Verstromt – Verfahren?**
**vor dem Kamin:**

***Alexander Bachler***, *Landwirtschaftskammer Österreich*

***Franz Kirchmeyr***, *ARGE Kompost&Biogas*

***Ewald-Marco Münzer***, *Münzer Bioindustrie*

***Reinhard Koch***, *Europäisches Zentrum für erneuerbare Energie*

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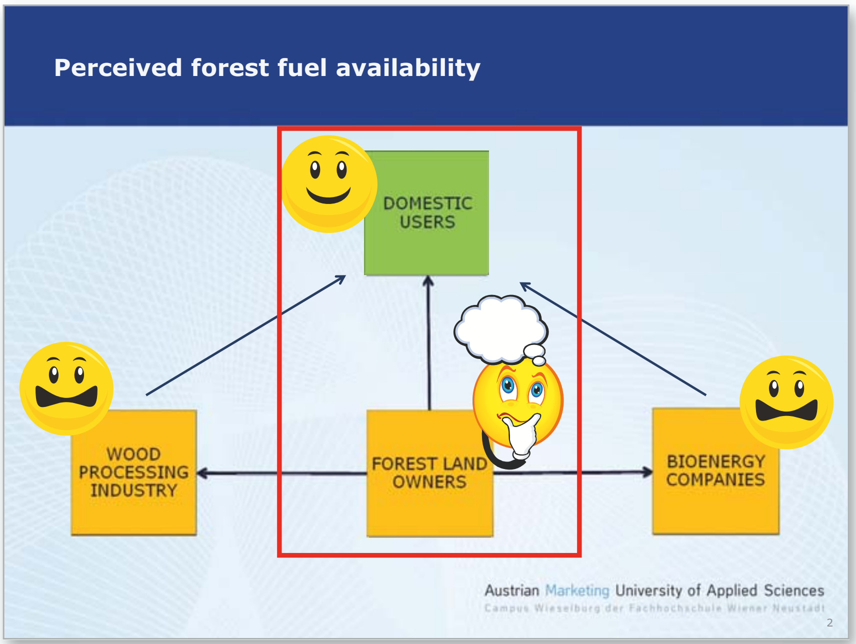
# Transportation Biofuels Research in Austria 2011

## Lignocellulosic Biomass and Biofuels
***Chair: Manfred Wörgetter**, FJ-BLT*

### Availability of forest biomass: regional energy concepts and consumer acceptance

***Josef Walch**, FH Wiener Neustadt, Standort Wieselburg*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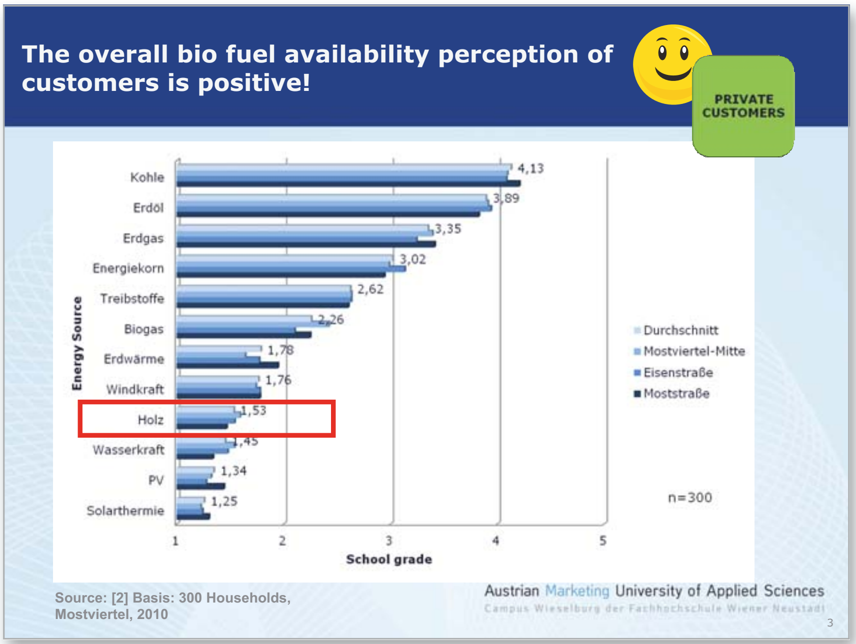
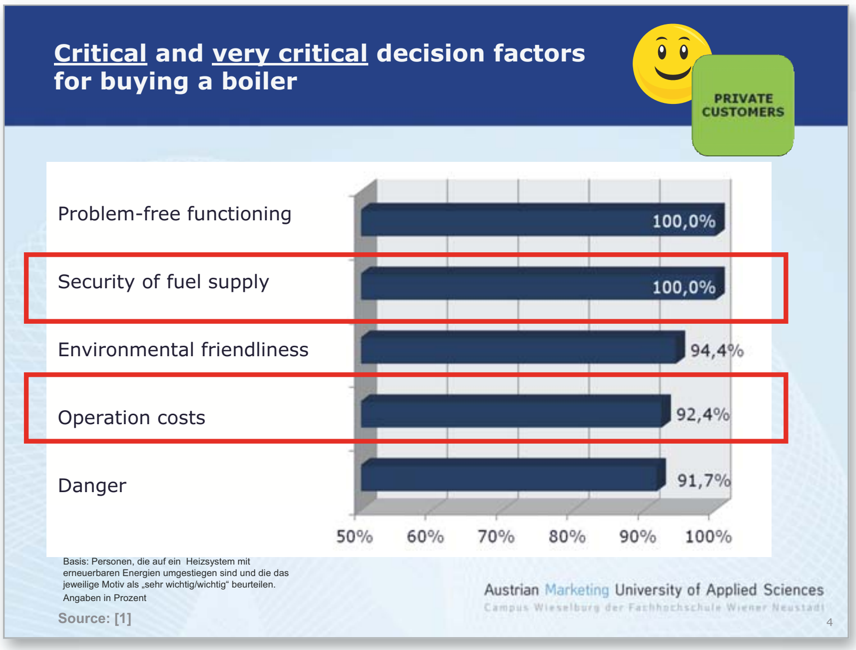
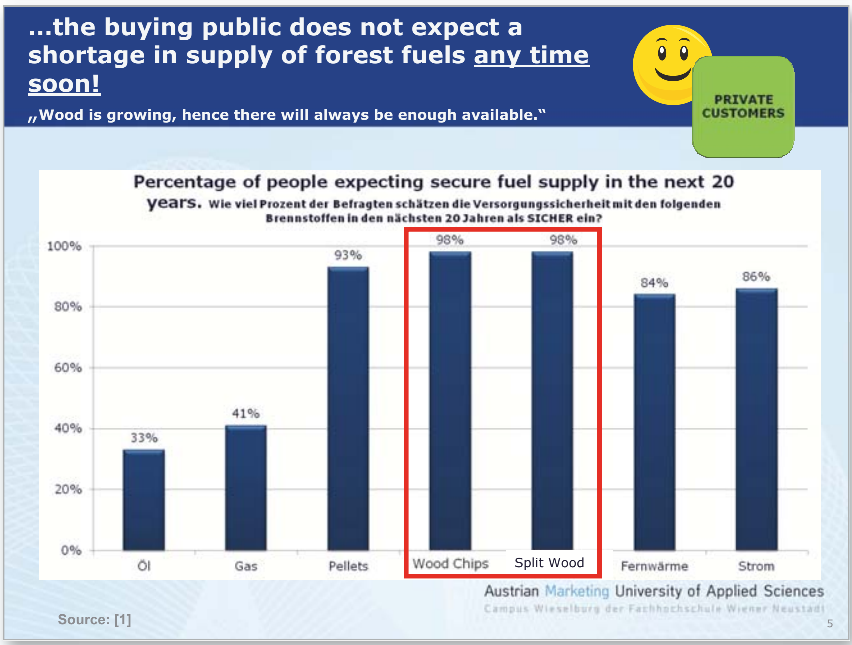
*Josef Walch, FH Wiener Neustadt, Standort Wieselburg*

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Forest land owners perspective:
Availability of forest fuels –
a question of price?
FOREST
LAND
OWNERS
Minneapolis Park & Recreation Board
FREE
WOODCHIPS
Austrian Marketing University of Applied Sciences
Campus Wieselburg der Fachhochschule Wiener Neustadt
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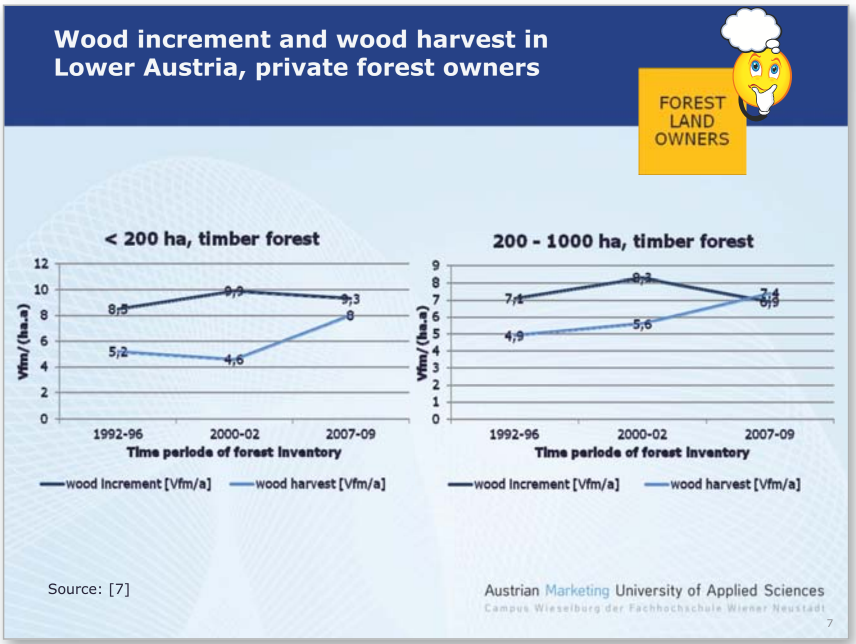
Wood increment and wood harvest in
Lower Austria, private forest owners
FOREST
LAND
OWNERS
< 200 ha, timber forest
200 - 1000 ha, timber forest
Vfm/(ha.a)
Time periode of forest inventory
1992-96
2000-02
2007-09
8,5
9,9
9,3
5,2
4,6
8
7,1
8,2
6,9
4,9
5,6
7,4
wood increment [Vfm/a]
wood harvest [Vfm/a]
Source: [7]
Austrian Marketing University of Applied Sciences
Campus Wieselburg der Fachhochschule Wiener Neustadt
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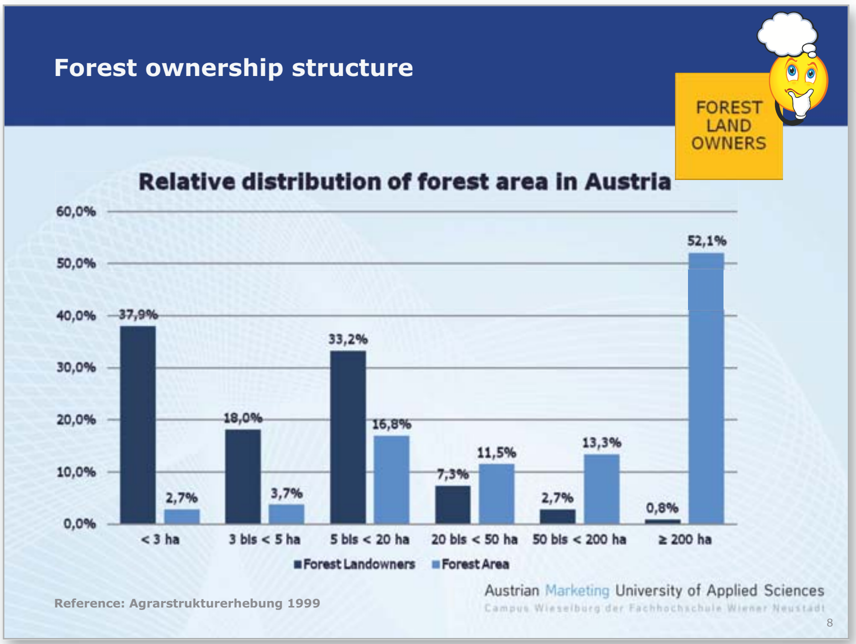
Forest ownership structure
FOREST
LAND
OWNERS
Relative distribution of forest area in Austria
37,9%
2,7%
18,0%
3,7%
33,2%
16,8%
7,3%
11,5%
2,7%
13,3%
0,8%
52,1%
< 3 ha
3 bis < 5 ha
5 bis < 20 ha
20 bis < 50 ha
50 bis < 200 ha
≥ 200 ha
Forest Landowners
Forest Area
Reference: Agrarstrukturerhebung 1999
Austrian Marketing University of Applied Sciences
Campus Wieselburg der Fachhochschule Wiener Neustadt
8

## Sustainable forest management value chain priorities

FOREST LAND OWNERS

1. High grade timber (ecology, outdoor leisure, investment …)
2. (Hunt)
3. Pulpwood
4. Biomass

Professional forest management increases the share of high grade timber account of pulpwood and biomass!

Picture: Forstbetriebsgemeinschaft Rothenburg

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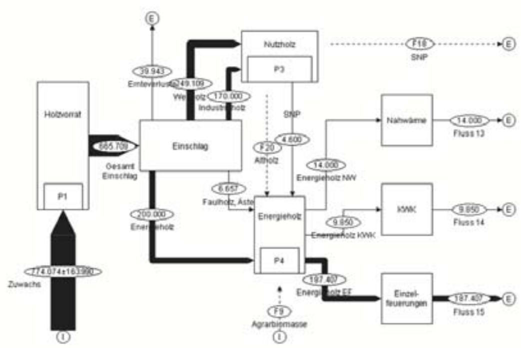
Campus Wieselburg der Fachhochschule Wiener Neustadt
9

## Biomass flow chart „Leader Region Eisenstraße"

FOREST LAND OWNERS




Created with STAN

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## Contribution of regional energy concepts to forest fuel availability

- Providing independent information on a regional level on forest biomass consumption, supply and the sustainable wood potential to ensure:
  - sustainable forest management
  - price stability
  - customer acceptance of woody bioenergy use
  - …

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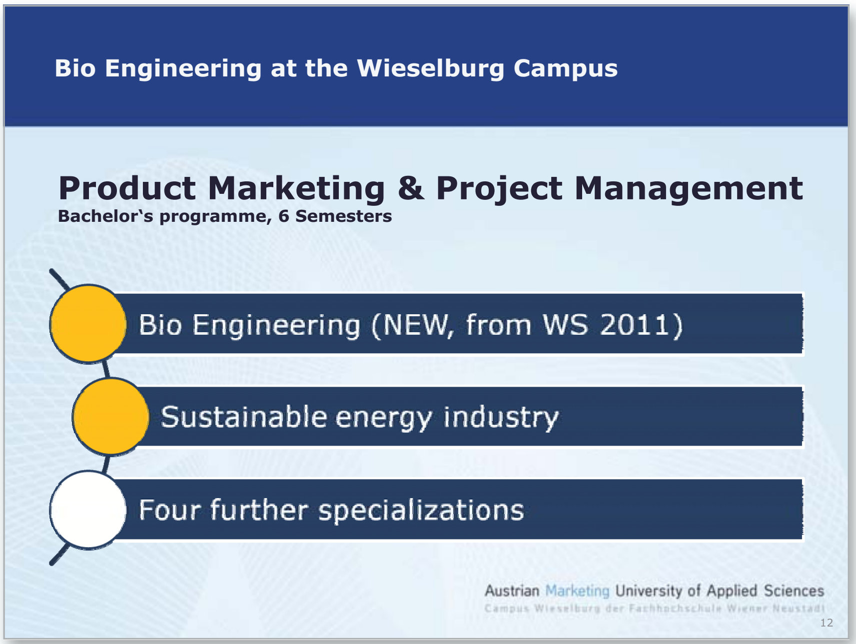
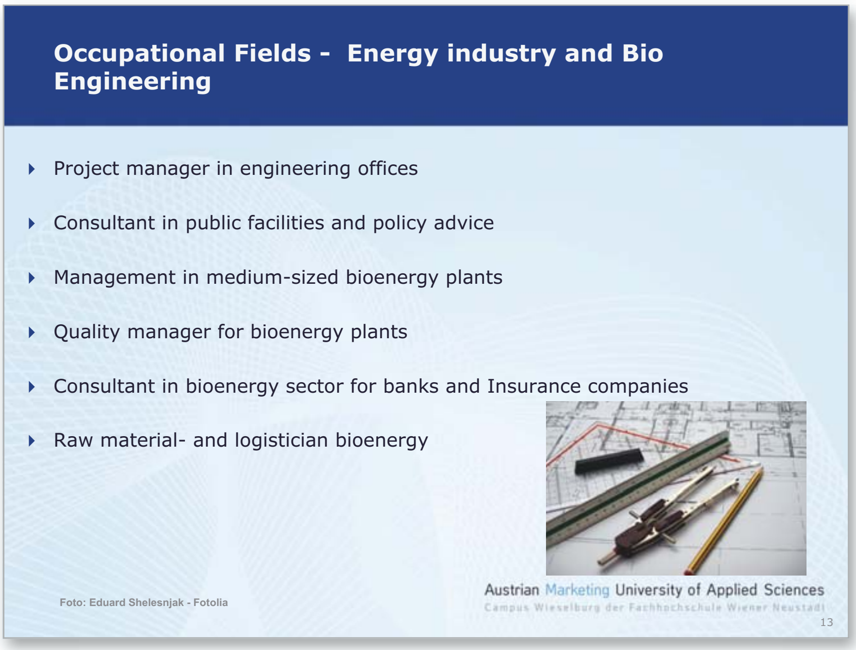

Bio Engineering at the Wieselburg Campus
Product Marketing & Project Management
Bachelor's programme, 6 Semesters
Bio Engineering (NEW, from WS 2011)
Sustainable energy industry
Four further specializations
Austrian Marketing University of Applied Sciences
12


Occupational Fields - Energy industry and Bio Engineering
Project manager in engineering offices
Consultant in public facilities and policy advice
Management in medium-sized bioenergy plants
Quality manager for bioenergy plants
Consultant in bioenergy sector for banks and Insurance companies
Raw material- and logistician bioenergy
Foto: Eduard Shelesnjak - Fotolia
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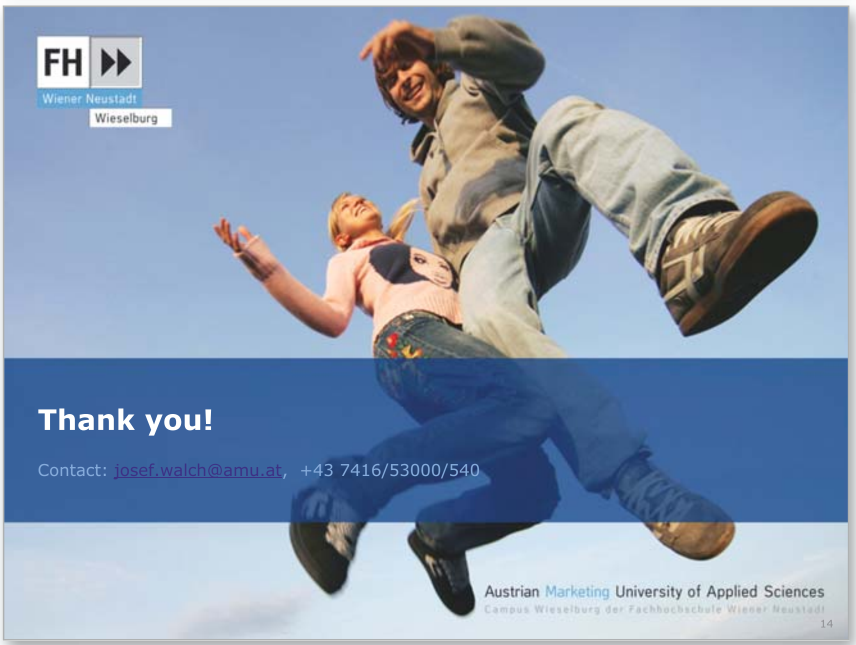
FH
Wiener Neustadt
Wieselburg
Thank you!
Contact: josef.walch@amu.at, +43 7416/53000/540
Austrian Marketing University of Applied Sciences
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References
[1] Klug S, Pernkopf T, Dörfelmayer D, Hofbauer V. Motivstudie Heizsysteme. 2008.
[2] Walch J, Brunmayr T, Gosch M, et al. Regionale Energiekonzepte der Leaderregionen Eisen-, Moststraße und Mostviertel Mitte. 2011.
[3] und Hogl K, Pregernig M, Weiß G. Wer sind Österreichs WaldeigentümerInnen? Einstellungen Verhalten traditioneller und „neuer" Waldeigentümergruppen im Vergleich. 2003.
[4] BLFUW. Grüner Bericht 2010. Bericht über die Situation der österreichischen Land- und Forstwirtschaft. 2010.
[5] Biermayr P, et. al.: Innovative Energietechnologien in Österreich Marktentwicklung 2009. Biomasse, Photovoltaik, Solarthermie und Wärmepumpen. 2010
[6] Redl F, et. al.: NÖ Energiebericht 2009. Bericht über die Lage der Energieversorgung in Niederösterreich. 2011
[7] Büchsenmeister, R. Federal Research and Training Centre for Forests, Natural Hazards and Landscape. 2011
Vortragender Titel Vorname Nachname
Austrian Marketing University of Applied Sciences
Campus Wieselburg der Fachhochschule Wiener Neustadt
15

# Logistic chains for wood chips from short rotation forestry

**Franz Handler und Emil Blumauer**

Highlights der Bioenergieforschung
Wieselburg, March 31st, 2011

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F | J BLT

1

## Harvesting

- Forage harvester (Claas Jaguar 890 - 370 kW) equipped with a special header (Biomasse Europa)
  - Theoretical cutting length: 34 mm
  - Maximum diameter of trunks: 13 cm
  - Working width: 120 cm

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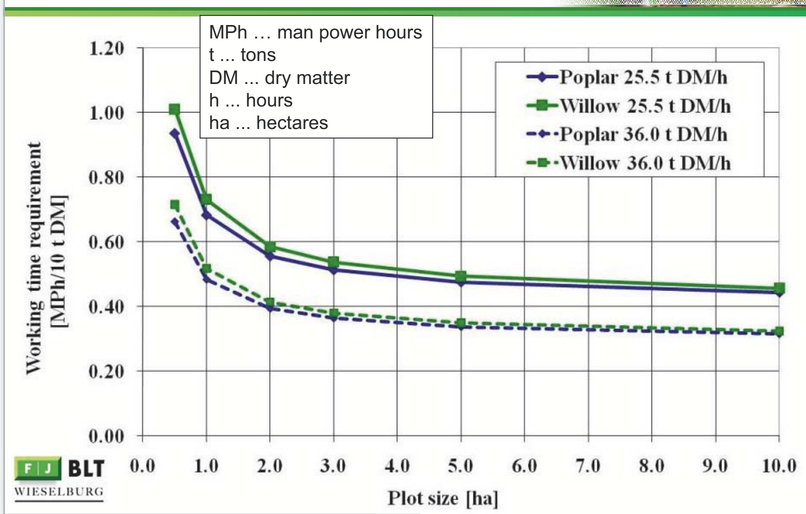
2

## Results - Working time requirement - Harvester




**Mass flow related to effective chopping time**

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## Transport

### Chain 1:

- Tractor-pulled trailers directly transport the wood chips from the field to the storage.
- Types of trailers:
  - 2- or 3-side tippers
  - Body tippers
  - Push-off trailers
  - Silage trailers
- Loading space: 19 – 40 m³

## Transport

### Chain 2:

- Tractor-pulled trailers transport the wood chips from the field to an interim storage near the field.
- The transport from the interim storage to the storage is carried out by articulated lorries or road trains.
- A wheel loader or telehandler loads the lorries.

## Transport

### Chain 3:

- Tractor-pulled **adapted** field transfer trailers transport the wood chips from the field to the articulated lorries or roadtrains.
- By means of an auger the field transfer trailers directly load the wood chips on the lorries.
- The lorries transport the wood chips to the storage

## Transport

### Chain 4:

- Tractor-pulled hook lift trailers transport the wood chips from the field to an interim storage for the containers near the field.
- At the interim storage two loaded containers are picked up by a hook lift lorry and are transported to the storage.

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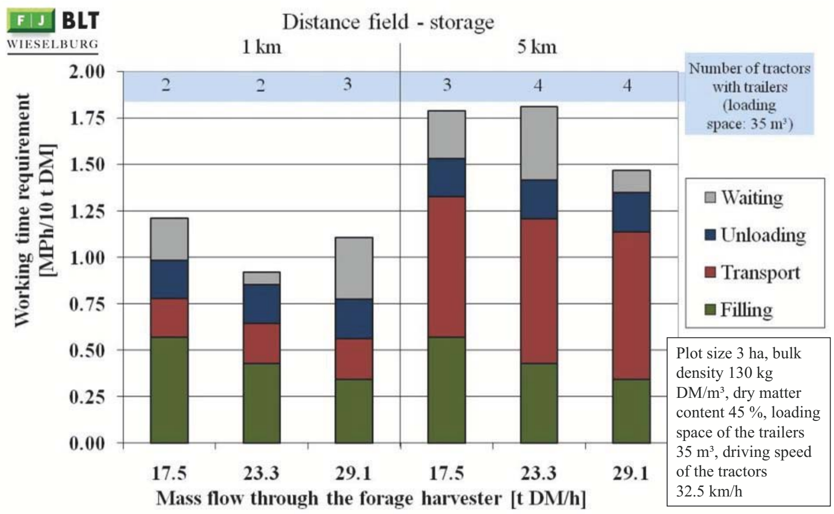
## Working time requirement for transport from field to storage

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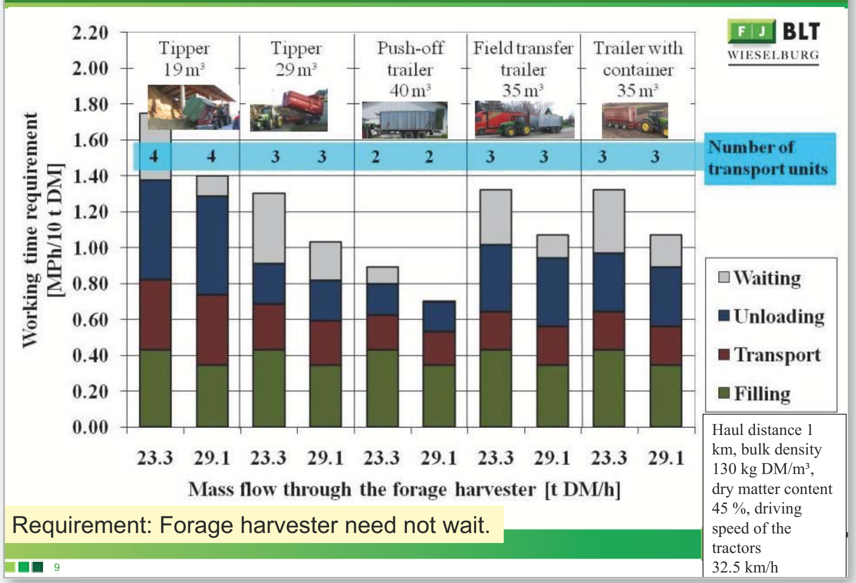
## Transport: Field – interim storage




Requirement: Forage harvester need not wait.

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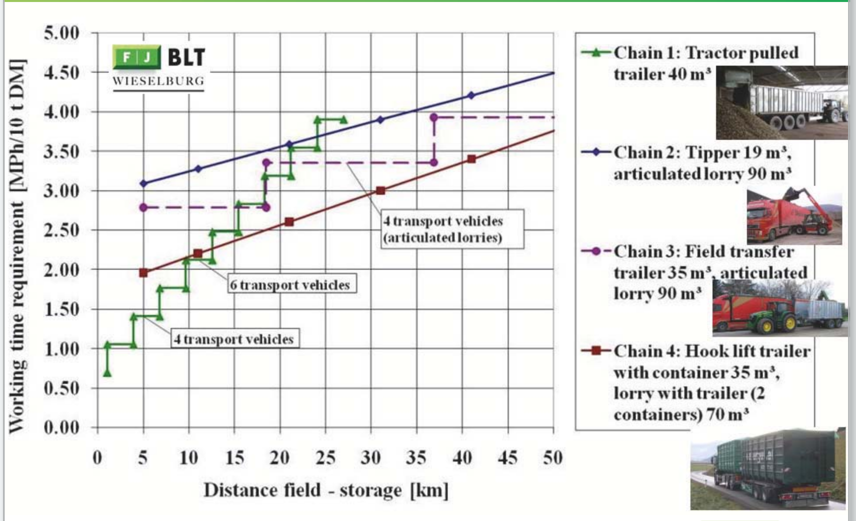
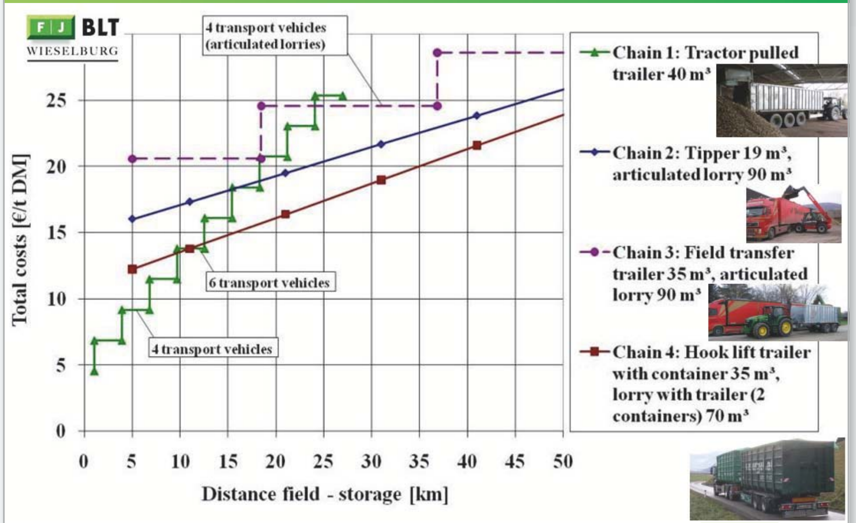
## Transport: Field – storage




10

## Transport: Field – storage

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## Conclusions

- A lower working time requirement for chopping causes a lower working time requirement for transport of wood chips
- The working time requirement for transport corresponds to the loading space of the trailers and to the transport distance.
- Because of the high costs idle time of the harvester should be avoided. This requirement causes idle time of the transport vehicles.
- The degree of utilization of the transport chain determines the idle time of the transport vehicles.

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## Conclusions

- The degree of utilization of the transport chains is mainly determined by
  - mass flow through the harvester
  - transport distance
  - speed and loading space of transport vehicles
- The direct transport from field to storage by a tractor with trailer is the most time and cost effective way to transport wood chips up to a distance of 10 to 15 km.
- For larger distances the use of containers is the most time and cost effective way. (containers act as buffer ➔ enough containers must be available)

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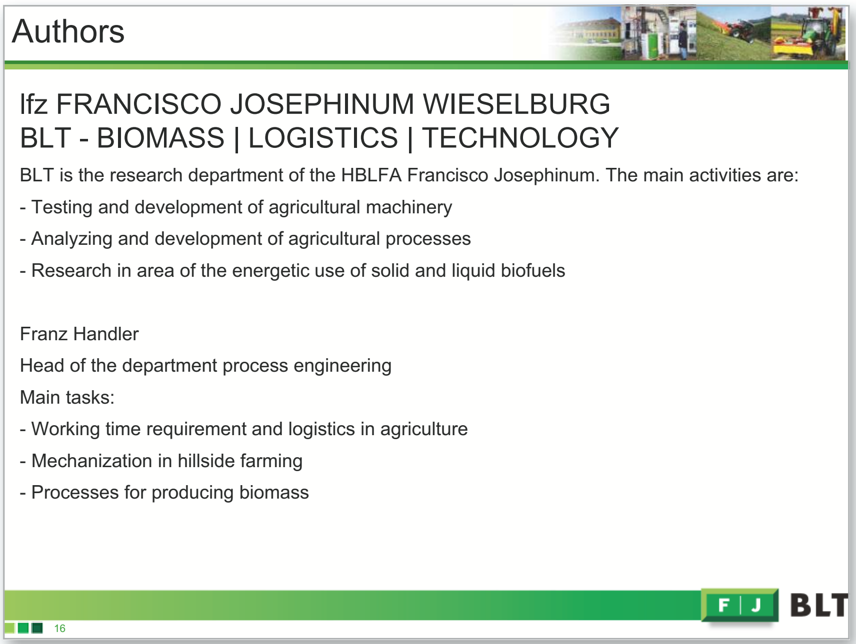
## Are there any questions?

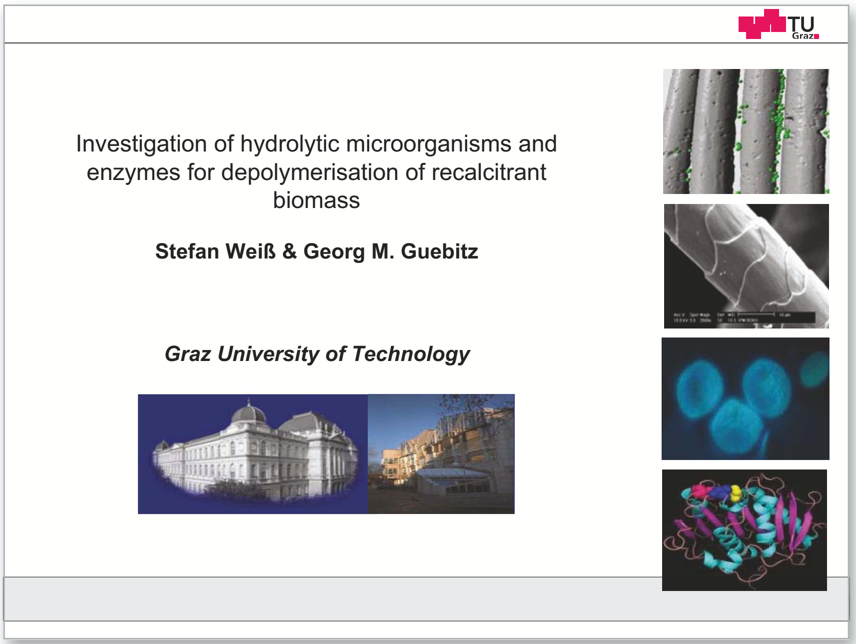
14

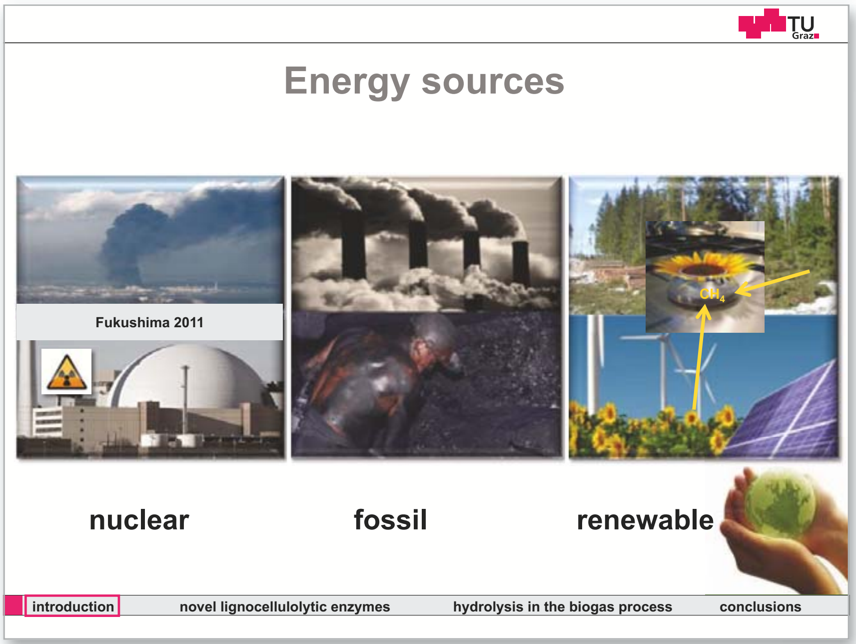
## Related publications

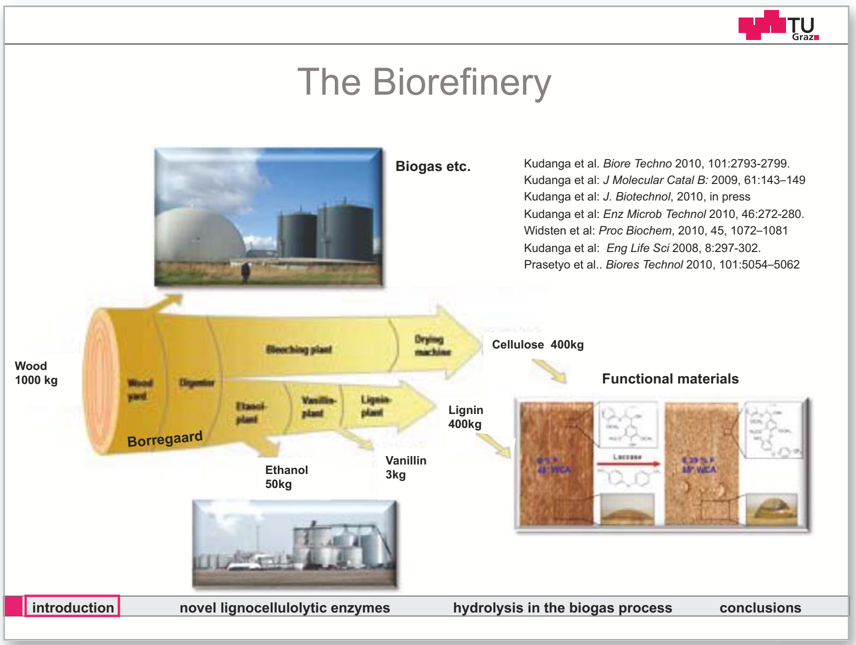

- HANDLER F., BLUMAUER E.: Arbeitswissenschaftlicher Vergleich verschiedener Systeme zum Setzen von Stecklingen zur Anlage von Kurzumtriebsflächen. Bornimer Agrartechnische Berichte, Heft 66/2009, S. 144-156.
- HANDLER F., BLUMAUER E.: Analysis of working time requirement and logistics for growing short rotation forestry (SRF) in Austria. Proceedings of XXXIII CIOSTA CIGR V Conference 2009 "Technology and Management to Ensure Sustainable Agriculture, Agro Systems, Forestry and Safety", 17 - 19 June 2009, Reggio Calabria, p. 2233-2237.
- HANDLER F., BLUMAUER E.: Logistics chains for wood chips from short rotation forestry. Proceedings of International Conference on Agricultural Engineering AgEng 2010, Clermont-Ferrand, 6 - 8 September 2010.
- HANDLER F., BLUMAUER E.: Hackgutlogistik bei der Ernte von Kurzumtriebsflächen mit einem Feldhäcksler. Tagungsband zum 4. Rostocker Bioenergieforum "Zukunftstechnologie für Bioenergie", 27. - 28. Oktober 2010, Rostock, S. 91-101.
- HANDLER F., BLUMAUER E.: Arbeitszeitbedarf für die Ernte von Kurzumtriebsflächen. Tagungsband zum 17. Arbeitswissenschaftlichen Kolloquium des VDI-MEG Fachausschusses Arbeitswissenschaften im Landbau, 14.-15. März 2011, Weihenstephan, ISBN 978-3-00-034001-7, S. 32 – 42.


15


Authors
lfz FRANCISCO JOSEPHINUM WIESELBURG
BLT - BIOMASS | LOGISTICS | TECHNOLOGY
BLT is the research department of the HBLFA Francisco Josephinum. The main activities are:
- Testing and development of agricultural machinery
- Analyzing and development of agricultural processes
- Research in area of the energetic use of solid and liquid biofuels
Franz Handler
Head of the department process engineering
Main tasks:
- Working time requirement and logistics in agriculture
- Mechanization in hillside farming
- Processes for producing biomass
F | J BLT
16


TU Graz
Investigation of hydrolytic microorganisms and enzymes for depolymerisation of recalcitrant biomass
Stefan Weiß & Georg M. Guebitz
Graz University of Technology


TU Graz
Energy sources
Fukushima 2011
nuclear
fossil
renewable
introduction
novel lignocellulolytic enzymes
hydrolysis in the biogas process
conclusions


TU Graz
The Biorefinery
Biogas etc.
Kudanga et al. Biore Techno 2010, 101:2793-2799.
Kudanga et al: J Molecular Catal B: 2009, 61:143–149
Kudanga et al: J. Biotechnol, 2010, in press
Kudanga et al: Enz Microb Technol 2010, 46:272-280.
Widsten et al: Proc Biochem, 2010, 45, 1072–1081
Kudanga et al: Eng Life Sci 2008, 8:297-302.
Prasetyo et al.. Biores Technol 2010, 101:5054–5062
Wood 1000 kg
Borregaard
Cellulose 400kg
Functional materials
Lignin 400kg
Vanillin 3kg
Ethanol 50kg
Laccase
introduction
novel lignocellulolytic enzymes
hydrolysis in the biogas process
conclusions

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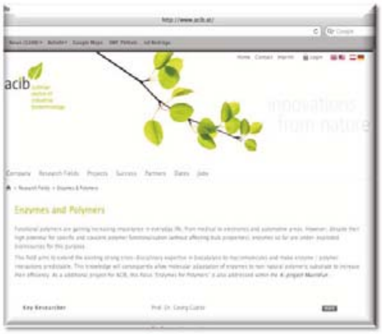
## MacroFun and ACIB

**K/K2 Comet Centres Industrial Biotechnology and Polymer Processing**


**Funded project opportunities!**

introduction | novel lignocellulolytic enzymes | hydrolysis in the biogas process | conclusions

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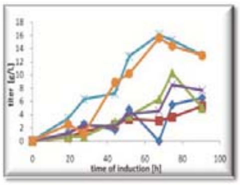
## Progress

- Novel enzymes/organisms
  - Via MS sequencing of relevant proteins
- Enzymes successfully engineered
  - Towards higher stability
- Highest level of expression
  - of polymer modifying enzymes using
  - new promotor variants
  - efficient strain selection
  - activity base screening
- Factors limiting hydrolysis identified for
  - process engineering
  - enzyme engineering





M E Himmel et al. Science 2007;315:804-807

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## Biogas I

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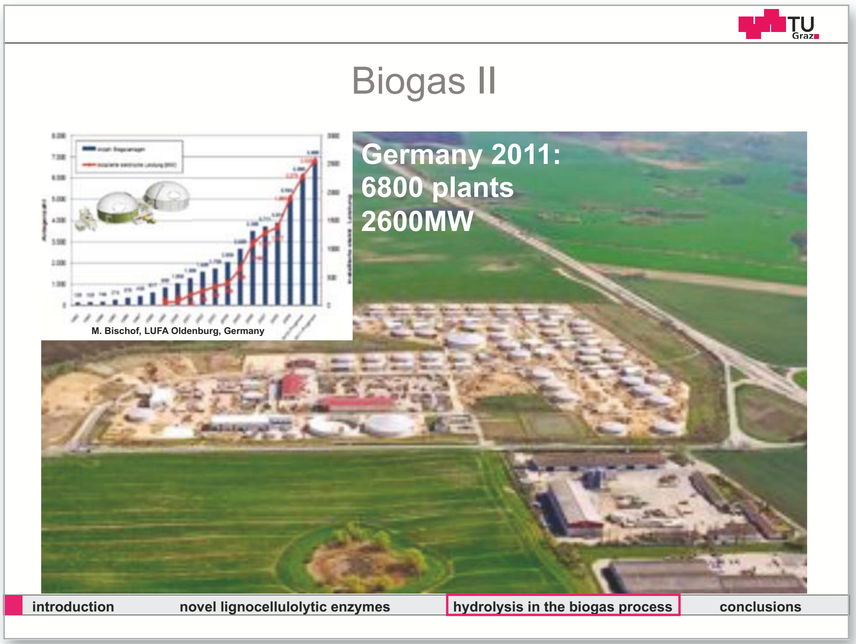
TU Graz
Biogas II
Germany 2011:
6800 plants
2600MW
M. Bischof, LUFA Oldenburg, Germany
introduction
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hydrolysis in the biogas process
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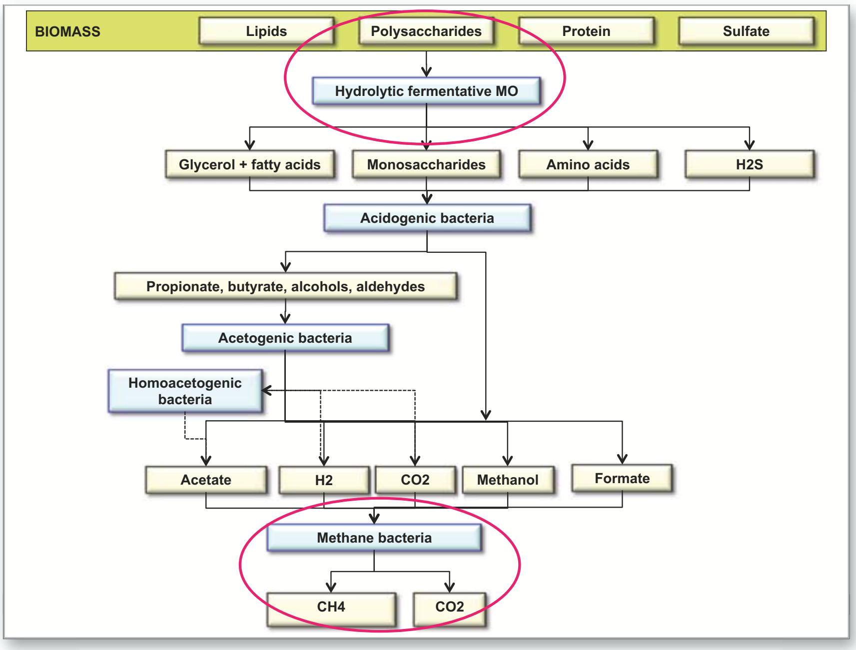
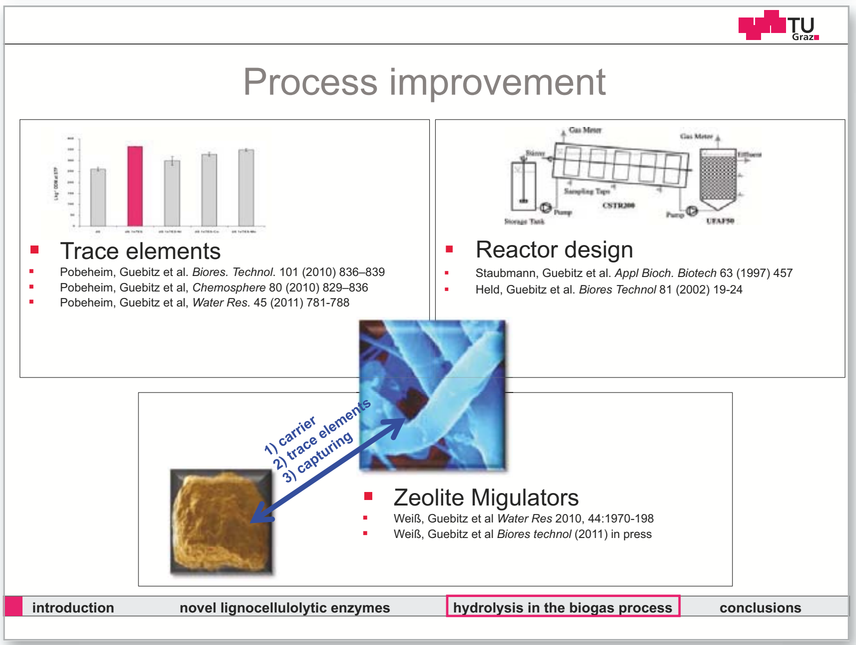

BIOMASS
Lipids
Polysaccharides
Protein
Sulfate
Hydrolytic fermentative MO
Glycerol + fatty acids
Monosaccharides
Amino acids
H2S
Acidogenic bacteria
Propionate, butyrate, alcohols, aldehydes
Acetogenic bacteria
Homoacetogenic bacteria
Acetate
H2
CO2
Methanol
Formate
Methane bacteria
CH4
CO2


TU Graz
Process improvement
Trace elements
Pobeheim, Guebitz et al. Biores. Technol. 101 (2010) 836–839
Pobeheim, Guebitz et al, Chemosphere 80 (2010) 829–836
Pobeheim, Guebitz et al, Water Res. 45 (2011) 781-788
Reactor design
Staubmann, Guebitz et al. Appl Bioch. Biotech 63 (1997) 457
Held, Guebitz et al. Biores Technol 81 (2002) 19-24
1) carrier
2) trace elements
3) capturing
Zeolite Migulators
Weiß, Guebitz et al Water Res 2010, 44:1970-198
Weiß, Guebitz et al Biores technol (2011) in press
introduction
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hydrolysis in the biogas process
conclusions

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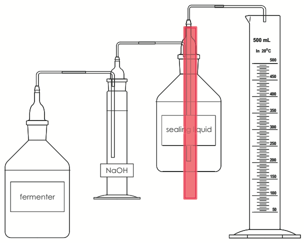
## Experiments

**Gras silage**

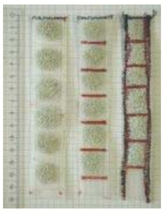
**Model substrate:**

*SSCP/ADRA analysis: Hemicellulose hydrolysing Methanoculleus sp.* (Pobeheim et al, Chemosphere 80 (2010) 829–836)




| compounds | composition [%] | amount per 1 g | amount per 5 g |
|---|---|---|---|
| cellulose | 16.7 | 0.334 | 1.67 |
| xylan | 25.8 | 0.516 | 2.58 |
| lignin | 7.2 | 0.144 | 0.72 |
| pectin | 0.5 | 0.01 | 0.05 |

***in sacco* technique** for **continuously operated bioreactors** (LfL Institute)



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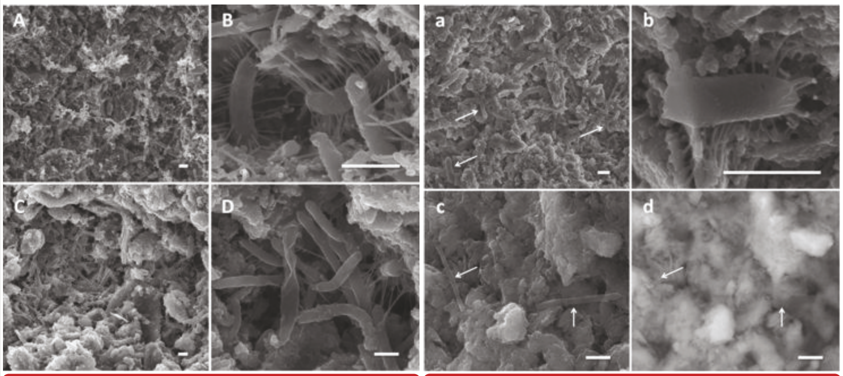
## SEM analysis

A CPD dried zeolite with area-wide biofilm formation
B CPD dried zeolite, cells forming fibrous structures
C Lyophilised zeolite with biofilm formation mainly in a pit
D Lyophilised zeolite, microorganisms colonising a pit

a Zeolite with biofilm formation
b Microorganism with fibrous structures on the surface of a zeolite
c, d Two rod-shaped cells, vanishing when AsB detector is used
(Bar length: 1 µm)




5 d batch-wise cultivation on a model substrate for grass silage at 45°C

84 d *in sacco* incubation in continuously operated bioreactors (28 l) fed with grass silage at 45 °C

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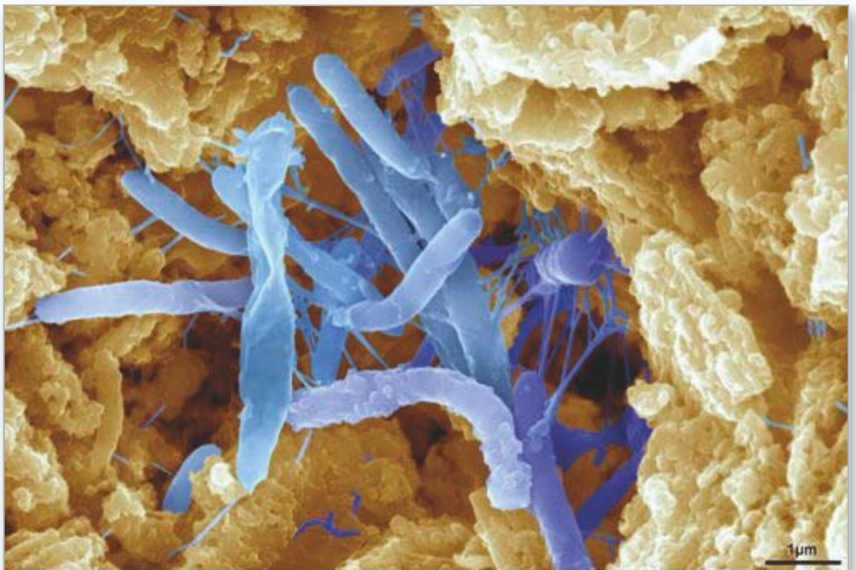


Scanning electron microscopic image of a zeolite particle (clinoptilolite) colonized by bacteria
from: *Investigation of activated zeolites as carriers in anaerobic biogas production processes*
Weiß S., Zankel A., Petrak S., Somitsch W., Guebitz G.M. (2010)

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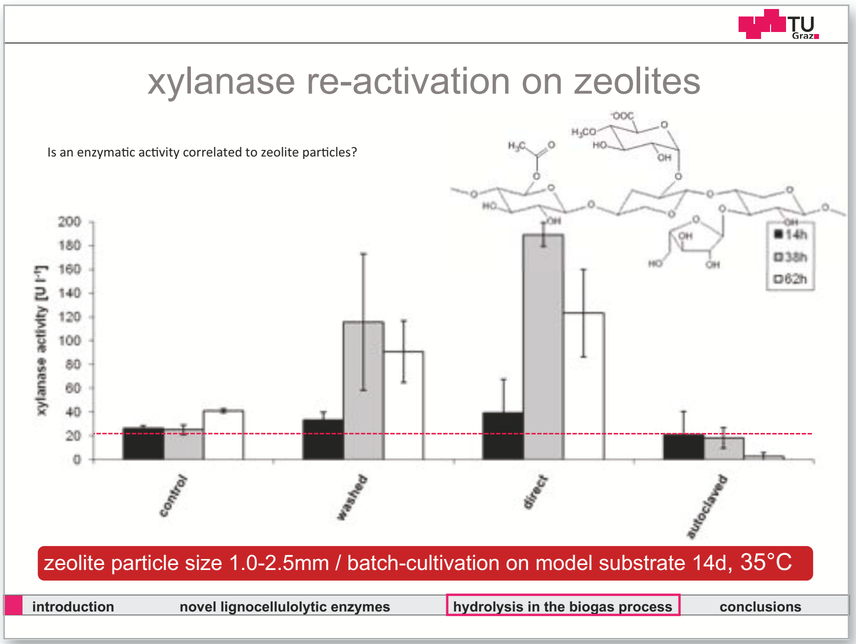
TU Graz
xylanase re-activation on zeolites
Is an enzymatic activity correlated to zeolite particles?
xylanase activity [U l⁻¹]
14h
38h
62h
control
washed
direct
autoclaved
zeolite particle size 1.0-2.5mm / batch-cultivation on model substrate 14d, 35°C
introduction
novel lignocellulolytic enzymes
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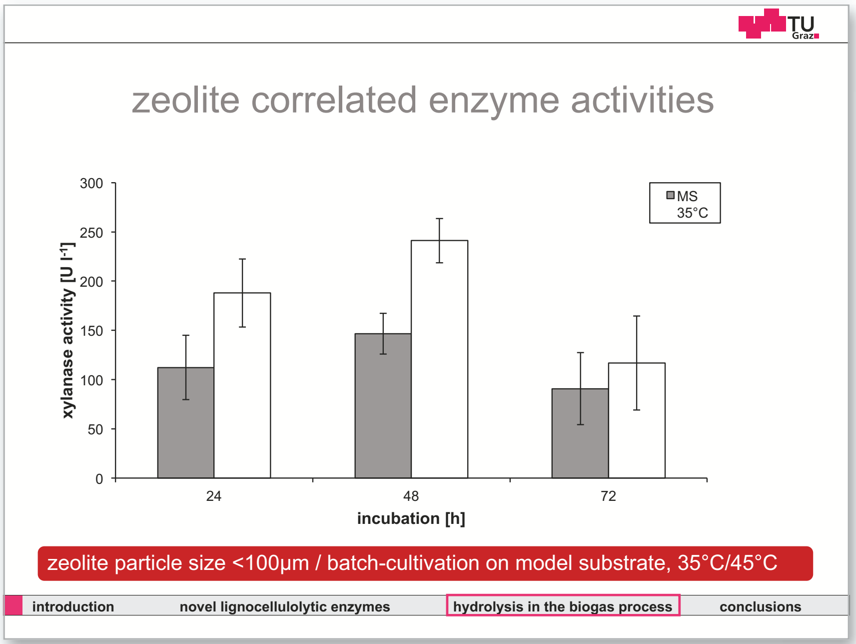
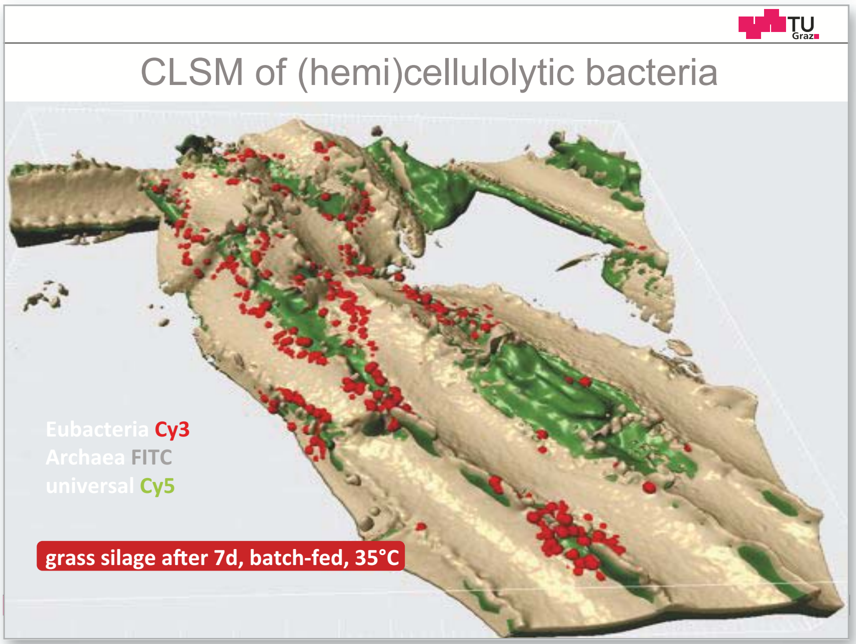
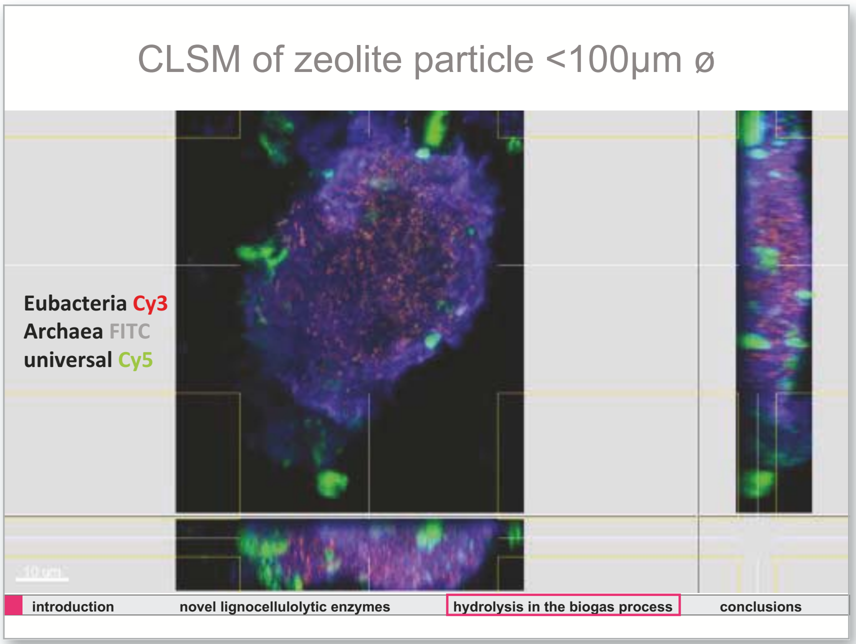
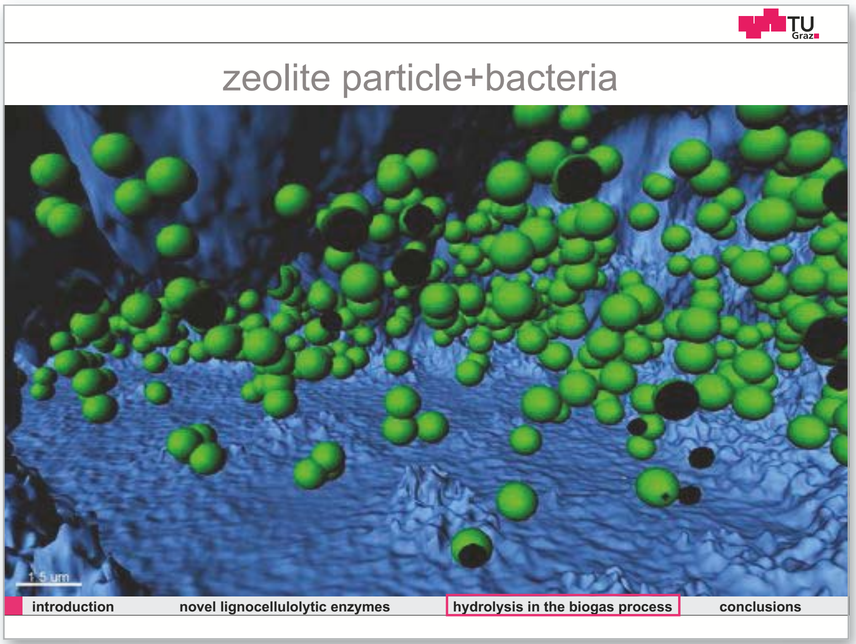

TU Graz
zeolite correlated enzyme activities
xylanase activity [U l⁻¹]
MS 35°C
incubation [h]
zeolite particle size <100µm / batch-cultivation on model substrate, 35°C/45°C
introduction
novel lignocellulolytic enzymes
hydrolysis in the biogas process
conclusions


TU Graz
CLSM of (hemi)cellulolytic bacteria
Eubacteria Cy3
Archaea FITC
universal Cy5
grass silage after 7d, batch-fed, 35°C


CLSM of zeolite particle <100µm ø
Eubacteria Cy3
Archaea FITC
universal Cy5
introduction
novel lignocellulolytic enzymes
hydrolysis in the biogas process
conclusions


TU Graz
zeolite particle+bacteria
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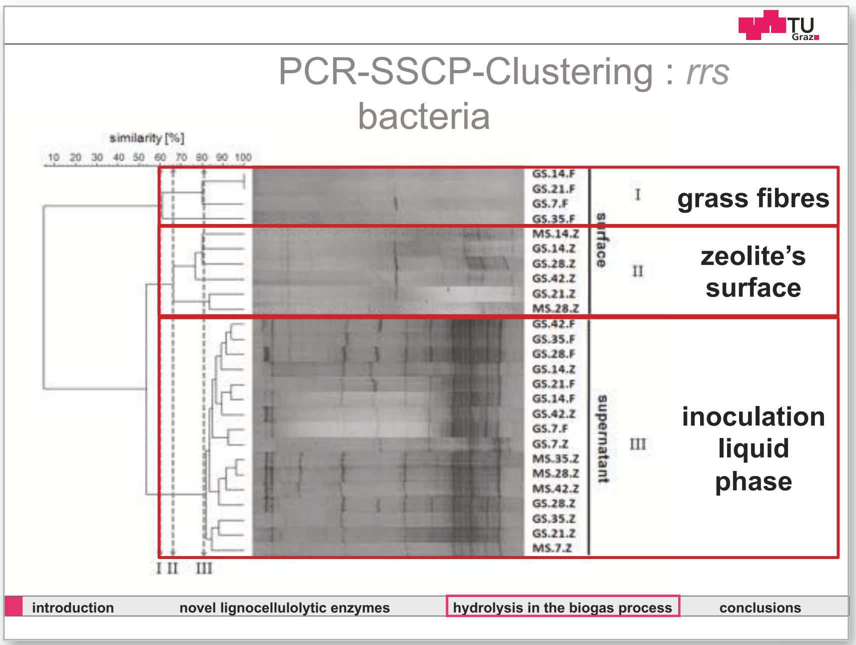
conclusions


TU Graz
PCR-SSCP-Clustering : rrs bacteria
similarity [%]
10 20 30 40 50 60 70 80 90 100
GS.14.F
GS.21.F
GS.7.F
GS.35.F
MS.14.Z
GS.14.Z
GS.28.Z
GS.42.Z
GS.21.Z
MS.28.Z
GS.42.F
GS.35.F
GS.28.F
GS.14.Z
GS.21.F
GS.14.F
GS.42.Z
GS.7.F
GS.7.Z
MS.35.Z
MS.28.Z
MS.42.Z
GS.28.Z
GS.35.Z
GS.21.Z
MS.7.Z
surface
supernatant
I
grass fibres
II
zeolite's surface
III
inoculation liquid phase
I II III
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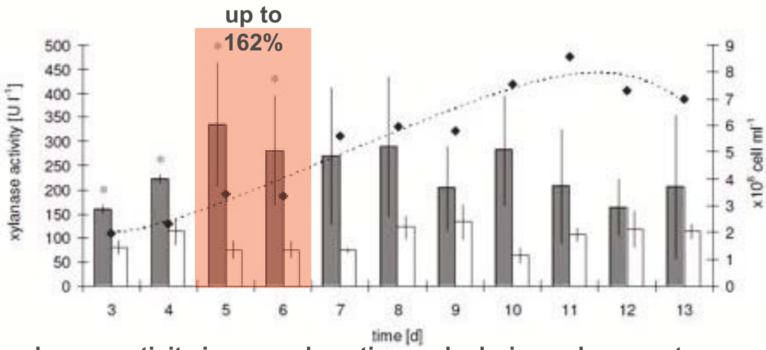
novel lignocellulolytic enzymes
hydrolysis in the biogas process
conclusions

## Sequencing : *rrs* bacteria/archaea

| sample site | inoculation time [d] | organism | phylum/order* | sequence identity [%] | accession no. |
|---|---|---|---|---|---|
| zeolite's surface grass fibres | 14-42 | *Ruminofilibacter xylanolyticum* | Bacteroidetes | 98-99 | DQ141183 EU551120 |
| zeolite's surface grass fibres supernatant | 14-42 | uncultured bacterium | Thermotogae | 98 | CU924654 CU919517 |
| supernatant | 28 | *Bacillus* sp. | Firmicutes | 97 | AF548884 |
| zeolite's surface | 7-42 | *Methanocarcina barkeri* | *Methanosarcinales | 89 | AF028692 |
| zeolite's surface | 7-42 | uncultured archaeon | *Methanomicrobiales | 94 | AB479397 |
| zeolite's suface supernatant | 21 | *Methanoculleus* sp. | *Methanomicrobiales | 91 | AF107105 AJ550158 |
| zeolite's suface | 21 | *Methanoculleus bourgensis* | *Methanomicrobiales | 91 | AY196674 DQ150254 |

introduction | novel lignocellulolytic enzymes | hydrolysis in the biogas process | conclusions

## Enrichment of enzyme producers

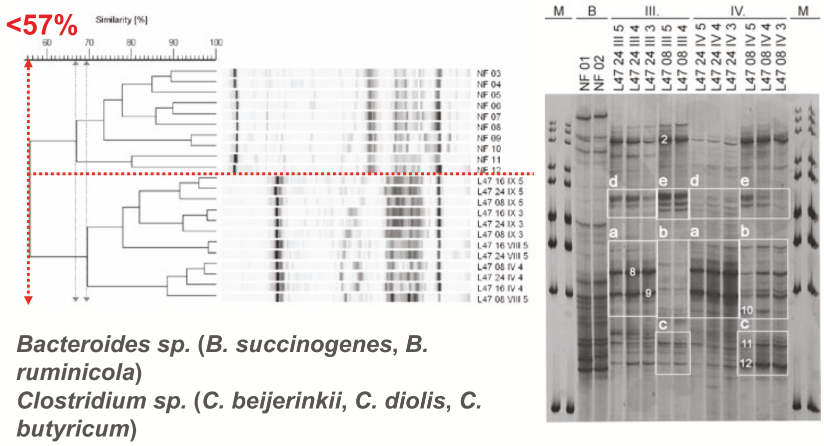



**xylanase activity increased continuously during subsequent enrichment cycles significantly higher ($P < 0.05$) when compared to the origin seeding sludge**

•Weiß et al *Water Research* 2010, 44:1970-1980.

introduction | novel lignocellulolytic enzymes | hydrolysis in the biogas process | conclusions

## Enriched strains




***Bacteroides* sp. (*B. succinogenes, B. ruminicola*)**
***Clostridium* sp. (*C. beijerinkii, C. diolis, C. butyricum*)**
***Azospira oryzae***

•Weiß et al *Water Research* 2010, 44:1970-1980.

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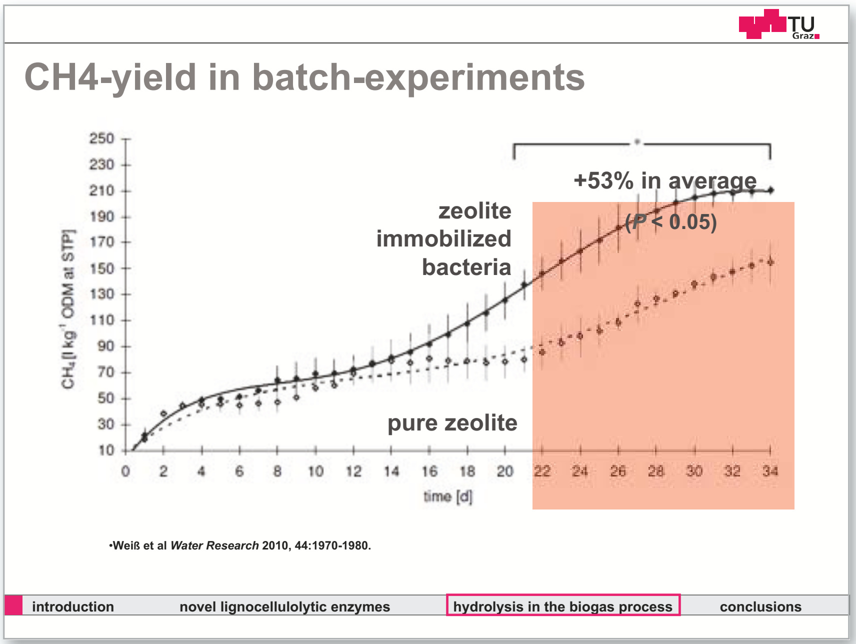


## Conclusions

- More efficient (hemi)cellulolytic enzymes via
  - Screening
  - Protein engineering
  - Novel expression systems
  - Improved process conditions
- Specific populations develop on zeolite (SSCP, CLSM)
- (Hemi)cellulase producers enriched
- (Hemi)cellulase producers immobilsed on zeolite

introduction | novel lignocellulolytic enzymes | hydrolysis in the biogas process | conclusions

VOGELBUSCH
Biocommodities

Highlights der Bioenergieforschung
March 2011 | Wieselburg | Austria

## Is 2G Bioethanol Commercialized Yet?

**Technical issues and challenges of second generation demonstration plants**

**Markus Lehr**
**VOGELBUSCH Biocommodities GmbH | Vienna | Austria**

## VOGELBUSCH Biocommodities GmbH

| We make biotechnology work

Complementing client's 2G process with proven first generation bioethanol technology

- Process design for pilot and demonstration plants
- Assist in developing fermentation and separation strategies
- Equipment supply for separation, distillation and dehydration
- Examples
  - demo plant of IOGEN | CD
  - demo plant of INBICON | DK
  - pilot plant ABENGOA BIOENERGY | US
  - demo plant of MITSUI/SIME DARBY | MY

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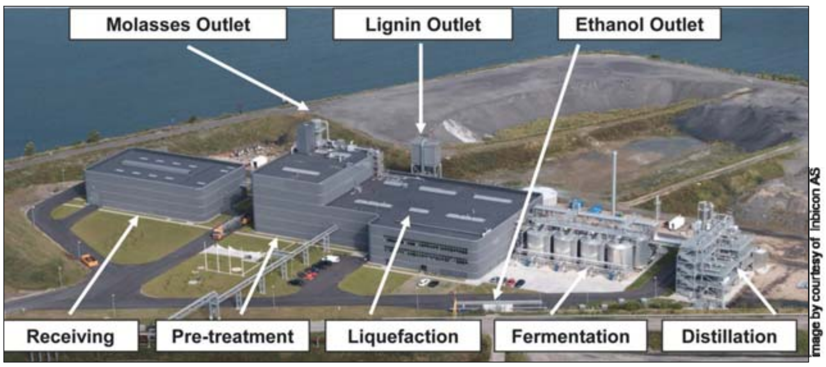
## EXAMPLE: Inbicon | Kalundborg | DK

| 2G demonstration plant

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## EXAMPLE: Inbicon | Kalundborg | DK

| | |
|---|---|
| **Raw material** | wheat straw (4 t per hour = 30,000 t per year) |
| **Capacity** | 4,300 t / 5,400 m³ of ethanol per year |
| **Technology** | a combination of existing and new:<br>DONG - experienced with biomass logistics from power plants (> 30 t per hour)<br>INBICON - pilot tested mechanical/hydrothermal/ enzymatic pretreatment and C6 fermentation<br>VOGELBUSCH - license and process design for fermentation, distillation, dehydration and evaporation |
| **By-product** | 11,000 t of C5 molasses / year (feed, biogas, bioethanol) |
| **Start-up** | 2010 |

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## Comparison G1 vs G2 plant

| | G1 plant | G2 plant (estimates) |
|---|---|---|
| Raw material | wheat | wheat straw |
| Yield (l alcohol / t raw material) | 390 | 180 |
| Fermentation time (hours) | 60 – 80 | 120 – 150 |
| Alcohol content (%vol in mash) | 11 – 16 | 5.0 – 10 |
| Steam consumption (t / 1000 l alc) | | |
| Liquefaction | 0.4 | 2.0 – 4.0 |
| Distillation/Dehydration | 1.2 | 1.7 |
| Estimated investment 75,000 m³/y plant (Mio €) | 60 – 80 | 180 – 220 |

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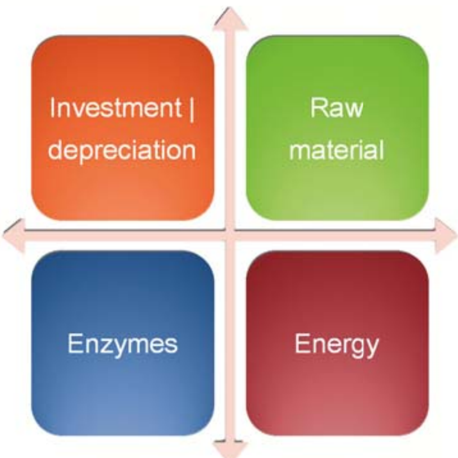
## Cost drivers in production

| Issues and challenges

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## Cutting process energy consumption

| Saving costs AND improving greenhouse gas balance!

Incineration of lignin and/or biogas
➔ self-contained steam supply possible

Thermal integration = internal use of latent heat of waste streams (dryer)
➔ utmost energy efficiency

Increase alcohol content in mash
➔ reduced energy demand for distillation and stillage treatment

VB Multi-pressure distillation
➔ minimized energy costs for distillation

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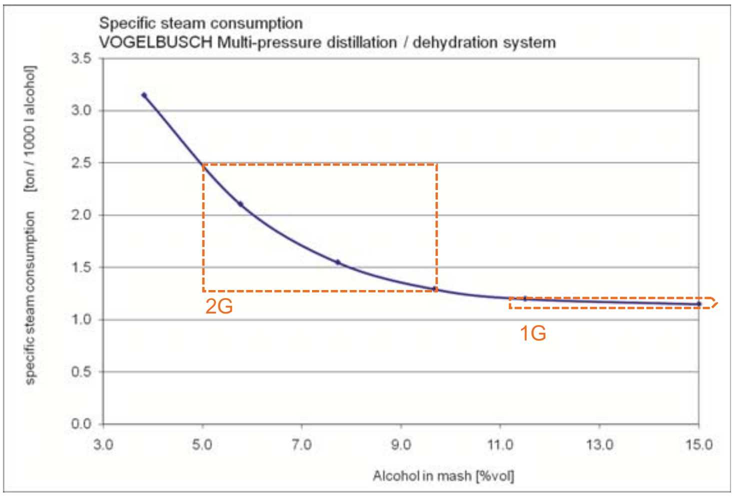
## Energy saving plant design

| High alcohol concentration in mash reduces steam demand




## Requirements for raw materials

- Availability
- Short transport distance
- High density / content of fermentable sugars
- Low price
  (€ 90 / ton wheat straw is equivalent to € 195 / ton wheat)

Alternatives to straw

- Bagasse
- Corn cobs
- EFB (empty fruit bunches from palm oil production)
- …

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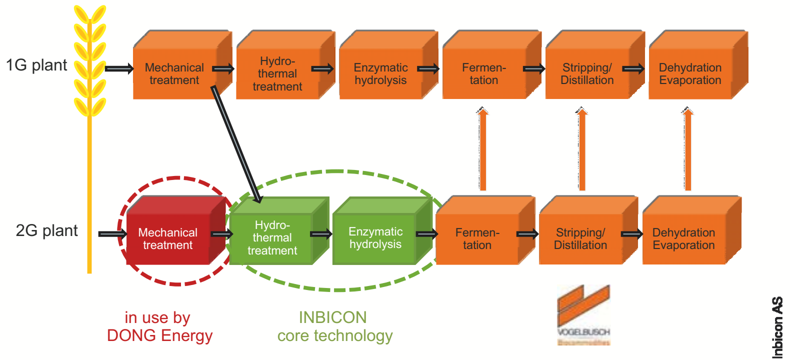
## Future concept for plant integration




graph by courtesy of Inbicon AS

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## Revamping of G1 plants for G2 feedstock?

| Expensive and difficult

RETROFIT AND LICENSE COSTS

- Raw material storage and liquefaction need proprietary process

TECHNICAL HURDLES

- Fermentation performance reduced to appx. 30 %
  - Lower alcohol content and
  - Increased fermentation time of G2 substrate
- Specific properties of G2 media to be considered
  - Viscosity of mash
  - High content of suspended solids

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## The bottom line

**Achieved**

- *Stable, proven process*
- *Plant in industrial design available*
- *Industrial product quality requirements*

**Unresolved**

- *High investment costs compared to G1 plants*
- *Still higher production costs then G1 product*
- *Raw material availablity*

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Thank you for your attention!!
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Biocommodities
www.vogelbusch-biocommodities.com

## Is second generation bioethanol commercialized yet

*Markus Lehr, VOGELBUSCH Biocommodities*

## JOANNEUM RESEARCH Forschungsgesellschaft mbH

Assessment of Lingo-cellulosic Bioethanol Concepts in Austria – Technical, Economic and Environmental Aspects

Kurt Könighofer, Philipp Kravanja, Lorenza Canella, Gerfried Jungmeier, Anton Friedl
Wieselburg, 31.3.2011

www.joanneum.at

ISO 9001:2000 certified

a TRADITION of INNOVATION

## Outline

1. Project Overview
2. Bioethanol Plant Concepts
3. Technical Data
4. Greenhouse Gas Assessment
5. Economic Analysis
6. Conclusions

www.joanneum.at

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## Project Overview

- Title: Assessment of Lingo-cellulosic Bioethanol Concepts in Austria – Technical, Economic and Environmental Aspects
- JOANNEUM RESEARCH – RESOURCES, Research Group Energy Research
- Vienna University of Technology, Institute of Chemical Engineering, Thermal Process Engineering – Process Simulation
- Financed by Austrian Climate and Energy Fund
- Project time: 1.3.2009 – 30.4.2011

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3

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*Kurt Könighofer, Joanneum Research – Resources*

JOANNEUM RESEARCH
TU WIEN
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## Bioethanol Plant Concepts

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## Key concept characteristics

- Use of C6 + C5 sugar
- Pretreatment: Steam Explosion
- Enzymatic Hydrolysis
- On-site enzyme production
- Process heat and electricity demand produced from residues (e.g. Lignin)
- Plant size (t Bioethanol per year)
  - Softwood: 50,000 / 100,000 t/y
  - Straw: 50,000 / 100,000 t/y

5
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## Concepts


| Feed Stock | Fermentation of sugars | By-products | |
|---|---|---|---|
| Straw | C6 | Electricity | |
| Straw | C6+C5 | Electricity | |
| Straw | C6 | Electricity | Heat |
| Straw | C6 | Ligninpellets | |
| Straw | C6+C5 | Ligninpellets | |
| Straw | C6 | Ligninpellets | Heat |
| Straw | C6 | C5 Molasses | Ligninpellets |
| Straw | C6 | C5 Molasses | Heat |
| Straw | C6 | Biomethane | Electricity |
| Softwood | C6 | Electricity | |
| Softwood | C6 | Ligninpellets | |
| Softwood | C6 | Biomethane | Electricity |

6

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## Technical Data

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ISO 9001:2000 certified

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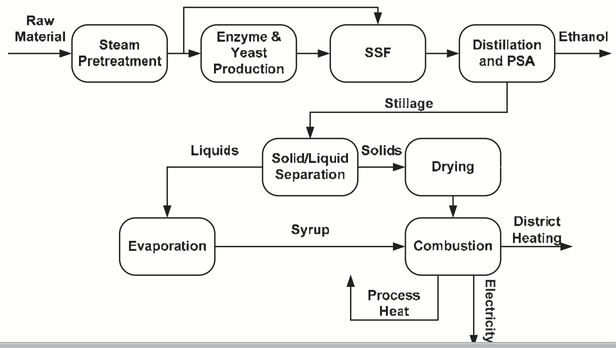
## 100,000 t/y Bioethanol Concepts Overview

| Feedstock | | Conversion | By-products | | | | | |
|---|---|---|---|---|---|---|---|---|
| Type | Total Mass | Sugars in Fermentation | Bioethanol | Heat | Electricity | C5 Molasses (dry) | Lignin-pellets (dry) | Bio-methane |
| | kt/a | | kt/a | GWh/a | GWh/a | kt/a | kt/a | GWh/a |
| Straw | 648 | C6 | 100 | | 379 | | | |
| | 447 | C5+C6 | 100 | | 160 | | | |
| | 648 | C6 | 100 | 1.003 | 305 | | | |
| | 648 | C6 | 100 | | | | 246 | |
| | 447 | C5+C6 | 100 | | | | 117 | |
| | 648 | C6 | 100 | 580 | | | 191 | |
| | 648 | C6 | 100 | | | 202 | 56 | |
| | 648 | C6 | 100 | 551 | | 202 | | |
| | 648 | C6 | 100 | | 78 | | | 822 |
| Soft-wood | 867 | C6 | 100 | | 176 | | | |
| | 867 | C6 | 100 | | | | 114 | |
| | 867 | C6 | 100 | | 114 | | | 219 |

## 100,000 t/y Bioethanol from straw; electricity and heat (EtOH-Straw-C6/Electricity+Heat)

| | | | | | |
|---|---|---|---|---|---|
| *Straw (90%DM)* | 648.063 | [t/y] | *Straw (LHV, dry)* | 365,1 | [MW] |
| *SO2* | 5.832 | [t/y] | | | |
| *NH3 (28w/w% in H2O)* | 12.970 | [t/y] | *Ethanol (LHV)* | 93,4 | [MW] |
| *Molasses (80% DM)* | 6.621 | [t/y] | *Electricity* | 38,1 | [MW] |
| *Corn Steep Liquor (50%DM)* | 19.874 | [t/y] | *District Heat* | 125,3 | [MW] |
| *Diammoniumphosphate* | 2.499 | [t/y] | | | |

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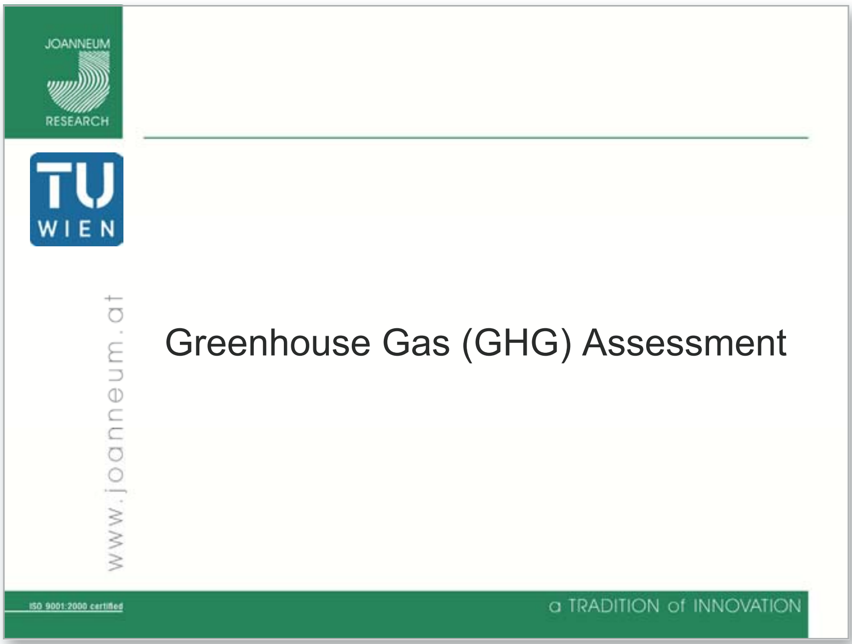


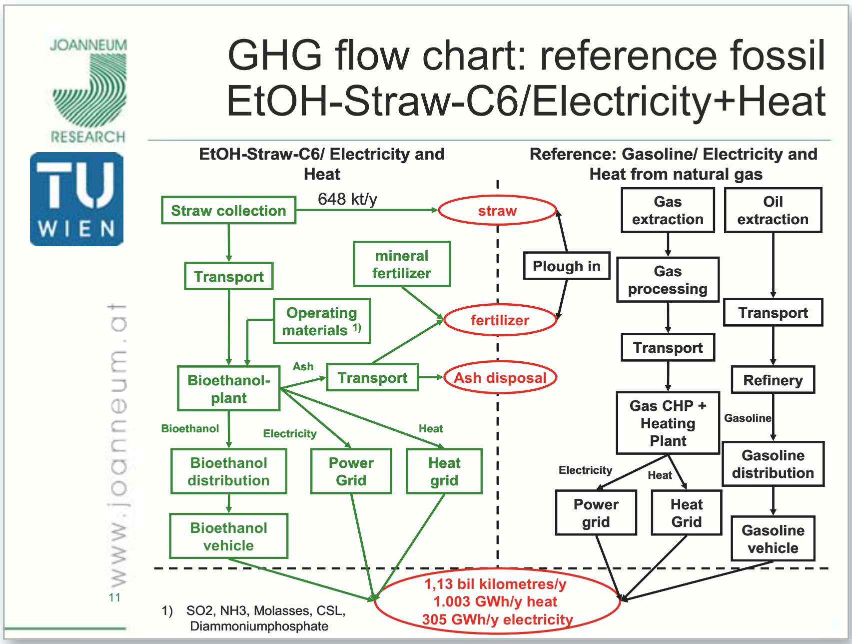


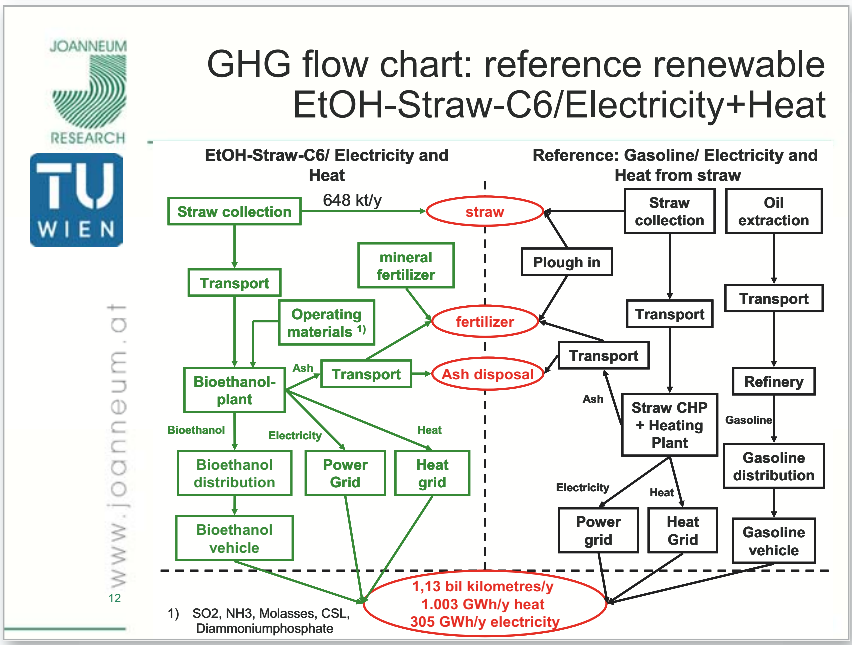


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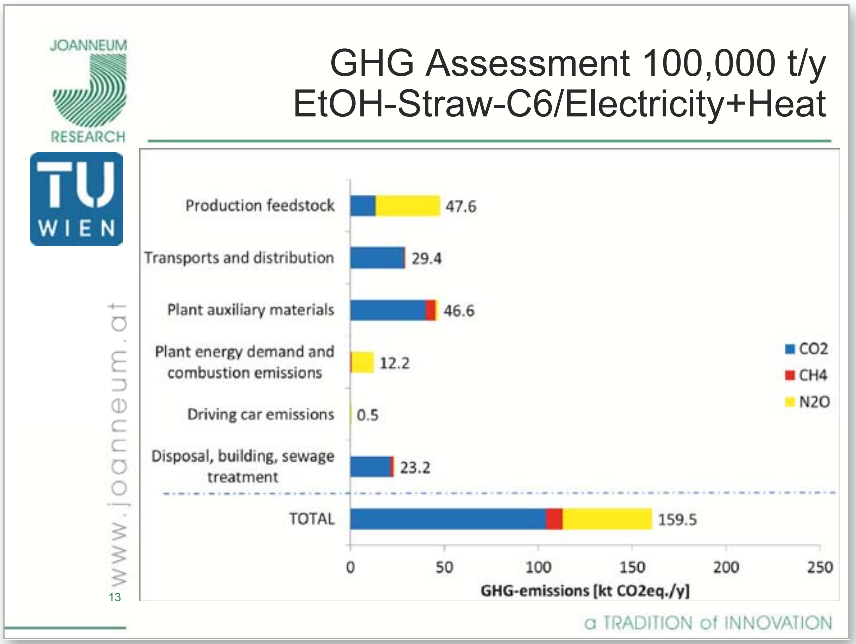
JOANNEUM RESEARCH
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GHG Assessment 100,000 t/y
EtOH-Straw-C6/Electricity+Heat
Production feedstock
47.6
Transports and distribution
29.4
Plant auxiliary materials
46.6
Plant energy demand and combustion emissions
12.2
Driving car emissions
0.5
Disposal, building, sewage treatment
23.2
TOTAL
159.5
CO2
CH4
N2O
0
50
100
150
200
250
GHG-emissions [kt CO2eq./y]
13
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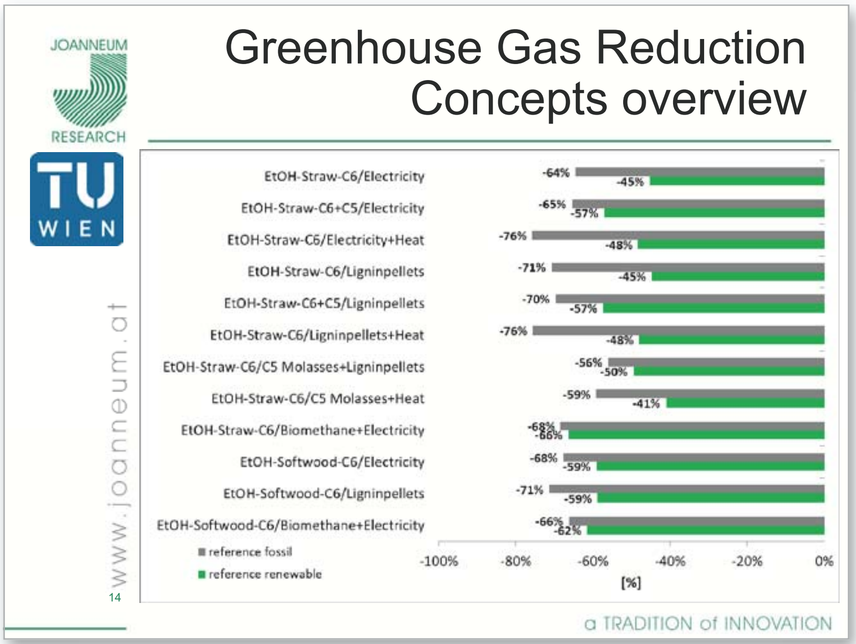
JOANNEUM RESEARCH
TU WIEN
www.joanneum.at
Greenhouse Gas Reduction
Concepts overview
EtOH-Straw-C6/Electricity
-64%
-45%
EtOH-Straw-C6+C5/Electricity
-65%
-57%
EtOH-Straw-C6/Electricity+Heat
-76%
-48%
EtOH-Straw-C6/Ligninpellets
-71%
-45%
EtOH-Straw-C6+C5/Ligninpellets
-70%
-57%
EtOH-Straw-C6/Ligninpellets+Heat
-76%
-48%
EtOH-Straw-C6/C5 Molasses+Ligninpellets
-56%
-50%
EtOH-Straw-C6/C5 Molasses+Heat
-59%
-41%
EtOH-Straw-C6/Biomethane+Electricity
-68%
-66%
EtOH-Softwood-C6/Electricity
-68%
-59%
EtOH-Softwood-C6/Ligninpellets
-71%
-59%
EtOH-Softwood-C6/Biomethane+Electricity
-66%
-62%
reference fossil
reference renewable
-100%
-80%
-60%
-40%
-20%
0%
[%]
14
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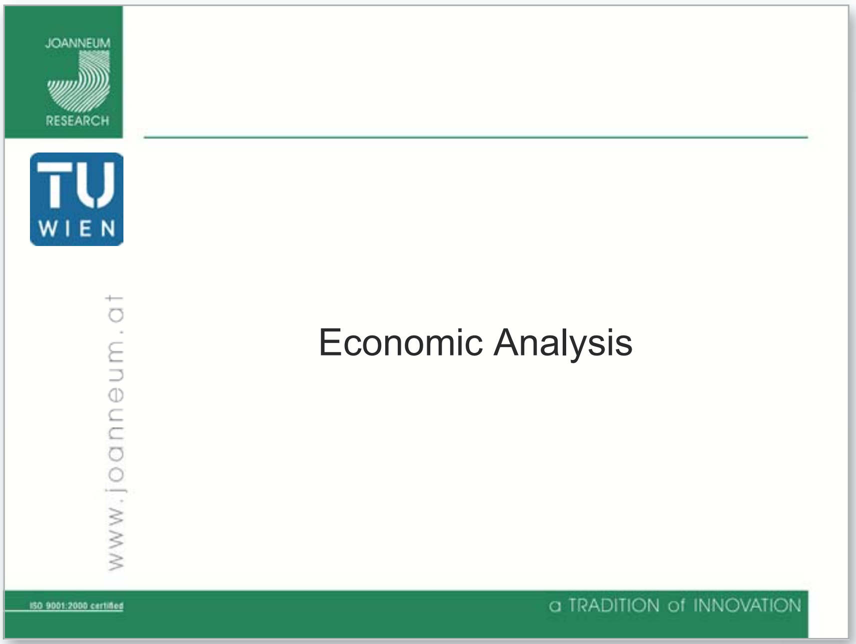
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Economic Analysis
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TU WIEN

# Economic Analysis Methodology

- Costs
  - Investment costs
  - Insurance, maintenance
  - Operating costs
    - Raw material (straw, woodchips)
    - Personal
    - Operating materials
    - Water demand
    - Waste water
- Revenues
  - Heat
  - Electricity
  - Ligninpellets
  - C5 molasses

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# Economic Analysis 100,000 t/y EtOH-Straw-C6/electricity+heat

| Cost Analysis | | |
|---|---|---|
| **Capital costs** | **[ mil € / y ]** | **26.3** |
| **Fix operating costs** | **[ mil € / y ]** | **11.5** |
| **Variable operating costs** | **[ mil € / y ]** | **61.5** |
| of it Personal | [ mil € / y ] | 1.8 |
| of it Raw material | [ mil € / y ] | 51.9 |
| of it Operating material | [ mil € / y ] | 6.6 |
| **Total costs** | **[ mil € / y ]** | **99.3** |
| *Spec. total costs* | *[ € / GJ $_{Bioethanol}$ ]* | *36.9* |
| | | |
| **Revenues** | | |
| **Electricity** | **[ mil € / y ]** | **15.2** |
| **Heat** | **[ mil € / y ]** | **20.1** |
| **Total revenues** | **[ mil € / y ]** | **35.3** |
| *Spec. total revenues* | *[ € / GJ $_{Bioethanol}$ ]* | *13.1* |
| | | |
| **Total costs Bioethanol** | **[ mil € / y ]** | **64.0** |
| *Spec.costs Bioethanol* | *[ € / GJ $_{Bioethanol}$ ]* | *23.8* |
| *Spec.costs Bioethanol* | *[€ / L $_{gasoline\ equiv.}$ ]* | *0.74* |

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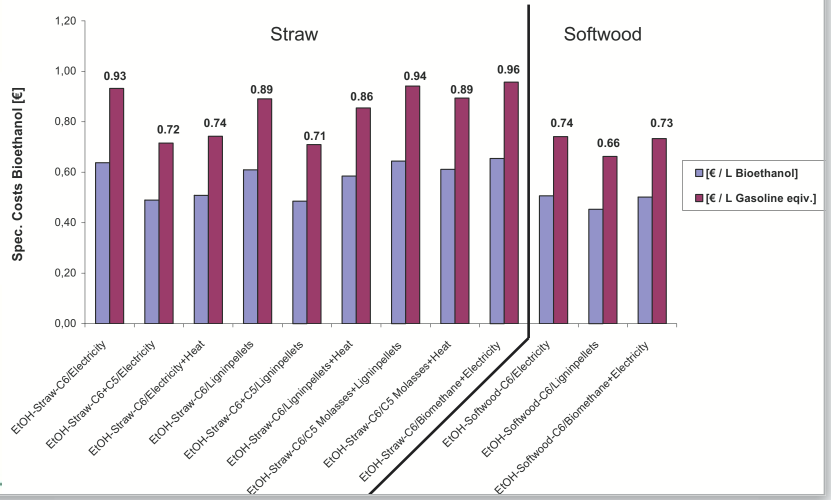
# Economic Analysis Concepts overview

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## Conclusions



## Conclusions 1

- Straw and wood are interesting raw materials for lingnocellulosic bioethanol in Austria
- Lingnocellulosic bioethanol always in coproduction with by-products from lignin, e.g. power, heat,
- Type and amount of by-products influences technical, economic and environmental performance
- Commercial technology not available, technology under development, e.g. pilot plant for wood in Sweden, demo plant for straw in Denmark
- Priority to integration of lingnocellulosic bioethanol plant in existing infrastructure, e.g. from wood in P&P-industry, from straw in EtOH from wheat plant

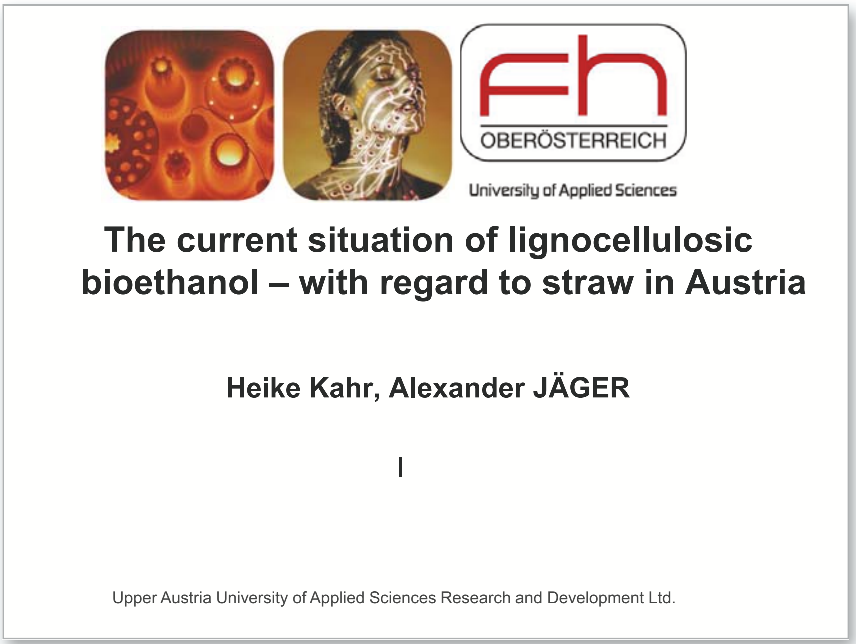


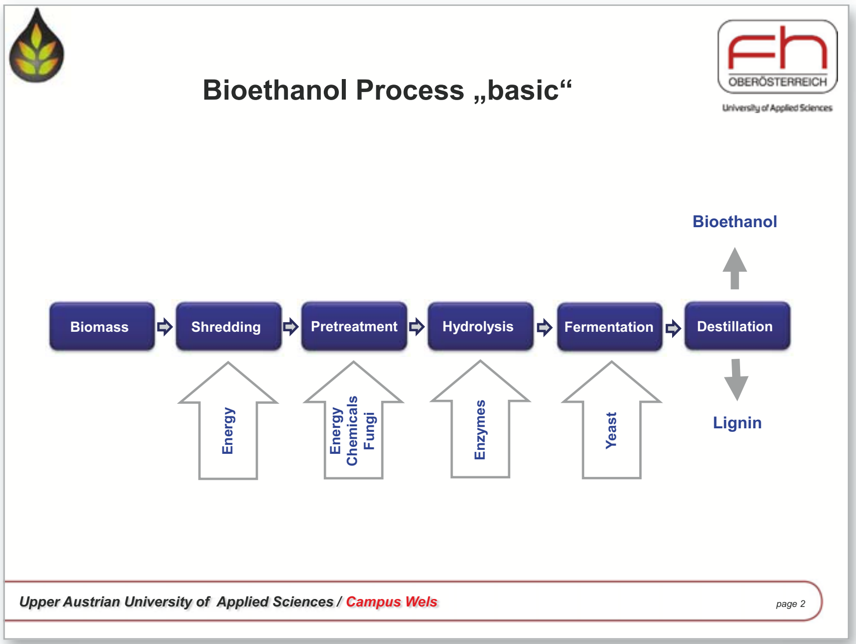
## Conclusions 2

- GHG-reduction between 41% and 76% possible
- Costs of lingnocellulosic bioethanol possible between 0,6 – 1 €/L gasoline equivalent
- Lingnocellulosic bioethanol in comparison to FT-fuels: similar range of costs and environmental effects
- Further R&D necessary, e.g. in Austrian demo plant

## Assessment of ligno-cellulosic bioethanol concepts in Austria – technical, economic and environmental aspects

*Kurt Könighofer, Joanneum Research – Resources*


fh OBERÖSTERREICH
University of Applied Sciences
The current situation of lignocellulosic bioethanol – with regard to straw in Austria
Heike Kahr, Alexander JÄGER
Upper Austria University of Applied Sciences Research and Development Ltd.


Bioethanol Process „basic“
fh OBERÖSTERREICH
University of Applied Sciences
Bioethanol
Biomass
Shredding
Pretreatment
Hydrolysis
Fermentation
Destillation
Energy
Energy
Chemicals
Fungi
Enzymes
Yeast
Lignin
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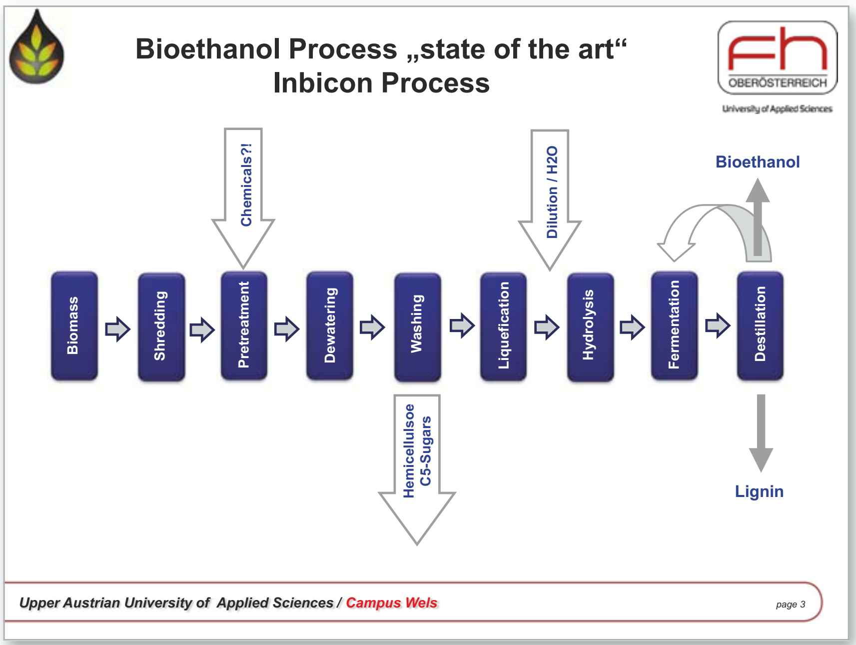
page 2


Bioethanol Process „state of the art“
Inbicon Process
fh OBERÖSTERREICH
University of Applied Sciences
Chemicals?!
Dilution / H2O
Bioethanol
Biomass
Shredding
Pretreatment
Dewatering
Washing
Liquefication
Hydrolysis
Fermentation
Destillation
Hemicellulsoe
C5-Sugars
Lignin
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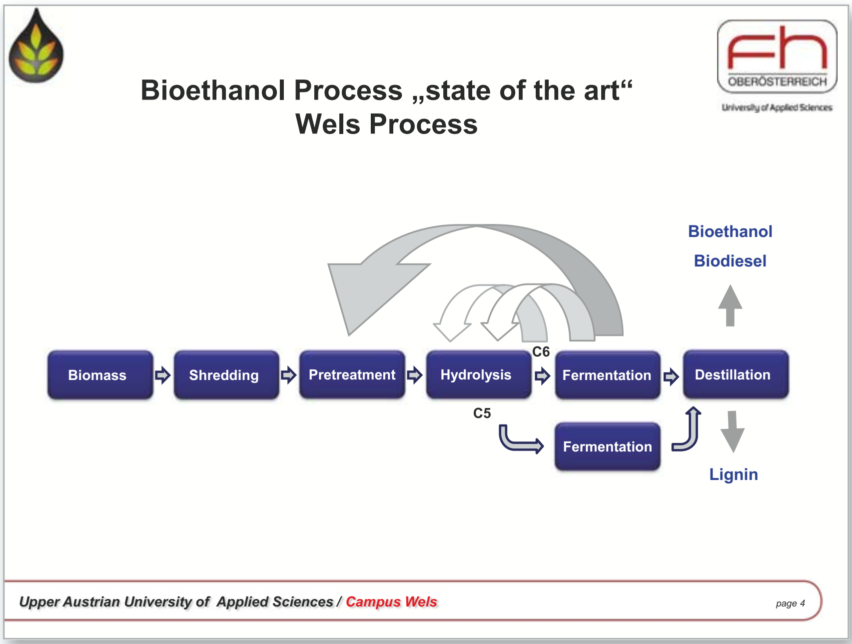
page 3


Bioethanol Process „state of the art“
Wels Process
OBERÖSTERREICH
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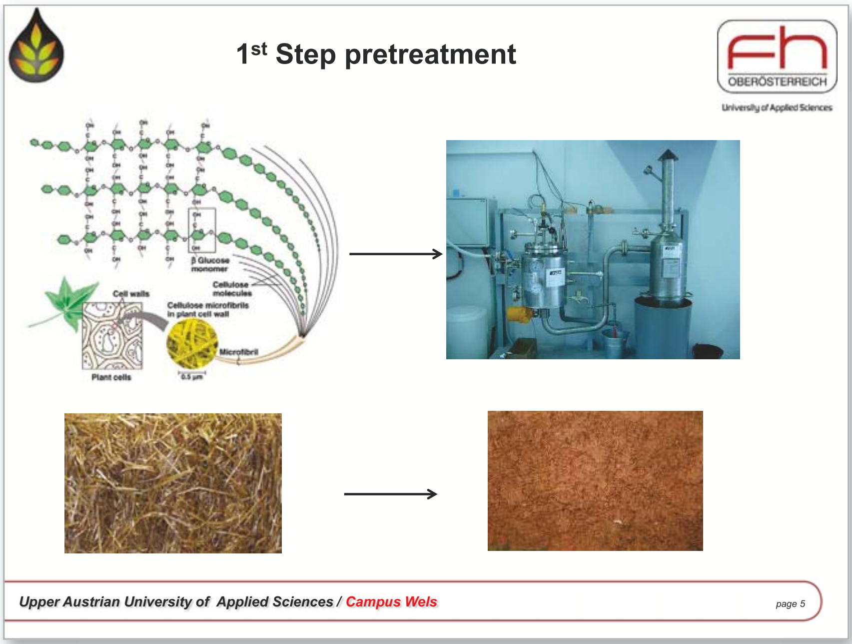
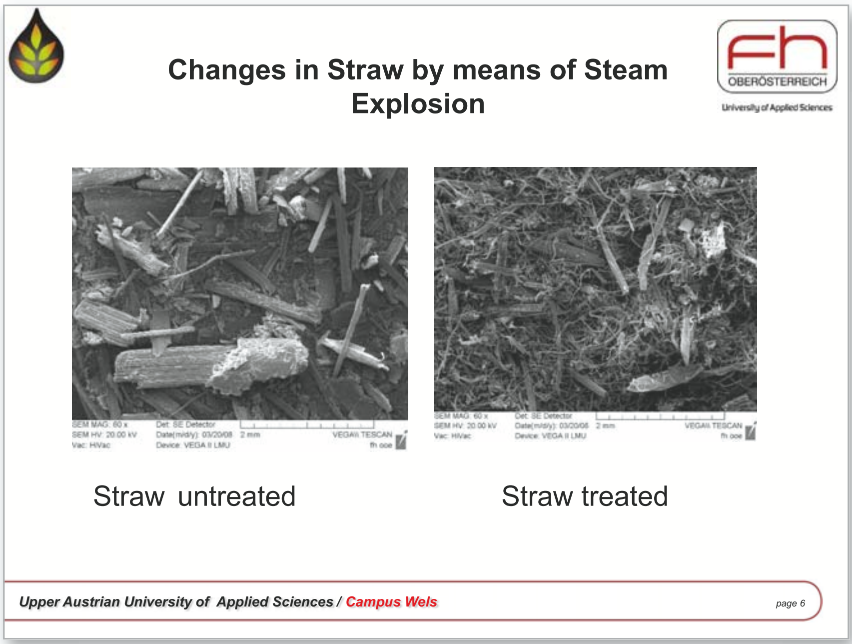
Bioethanol
Biodiesel
Biomass
Shredding
Pretreatment
Hydrolysis
C6
Fermentation
Destillation
C5
Fermentation
Lignin
Upper Austrian University of Applied Sciences / Campus Wels
page 4


1st Step pretreatment
OBERÖSTERREICH
University of Applied Sciences
Upper Austrian University of Applied Sciences / Campus Wels
page 5


Changes in Straw by means of Steam Explosion
OBERÖSTERREICH
University of Applied Sciences
Straw untreated
Straw treated
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page 6

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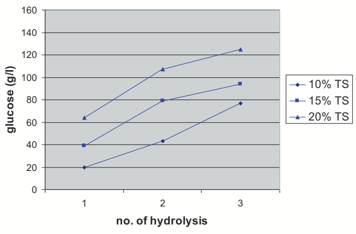
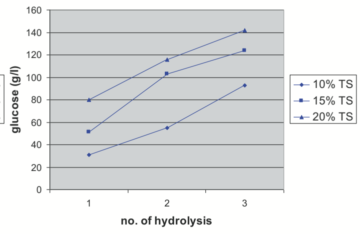
## Results: Glucose concentration after raising the dry substance and recirculation




Standard assay




Inhibitor control

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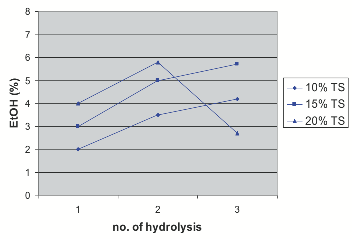
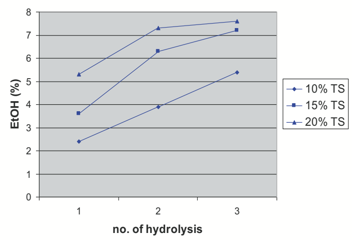
## Results: EtOH concentration after raising the dry substance and recirculation




Standard assay




Inhibitor control

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## Bioethanol Potential Austria
## Residual Materials incl. Wood

| | Straw | Recycled paper | Wood unused | Total |
|---|---|---|---|---|
| Quantity available tons pa | 2.000.000 | 800.000 | 6.000.000 | |
| Usage rate | 50% | 50% | 25% | |
| Tons pa | 1.000.000 | 400.000 | 1.500.000 | |
| Cellulose content | 40% | 80% | 40% | |
| Yield sacharification | 90% | 90% | 18% | |
| Yield fermentation | 95% | 95% | 65% | |
| l Bioethanol / ton | 342 | 684 | 47 | |
| m3 Bioethanol pa | 342.000 | 273.600 | 70.200 | 685.800 |
| Total Mileage(6 l/100 km) | 5.700.000.000 | 4.560.000.000 | 1.170.000.000 | 11.430.000.000 |
| Average mileage Km | 15.000 | 15.000 | 15.000 | |
| No of cars | 380.000 | 304.000 | 78.000 | 762.000 |

*Upper Austrian University of Applied Sciences / Campus Wels* *page 9*

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## Scenario: Complete replacement of fuel by means Bioethanol

| | | |
|---|---|---|
| Agricultural area | ha | 1.375.822 |
| Usage rate for Bioethanol production | 33% | 454.021 |
| Extensive wasteland | ha | 900.980 |
| Usage rate | 33% | 297.323 |
| Intensive grassland | ha | 909.407 |
| Usage rate | 33% | 300.104 |
| Total | ha | 1.051.449 |
| Ethanol Yield Crops | $m^3$ p.a. | 4.894.495 |
| Ethanol Yield Straw | $m^3$ p.a. | 2.796.855 |
| Total | $m^3$ p.a. | 7.691.349 |
| Rate of Substitution | % | 100 |

*Upper Austrian University of Applied Sciences / Campus Wels* page 10

## Thanks to our research group

## Thanks for your attention

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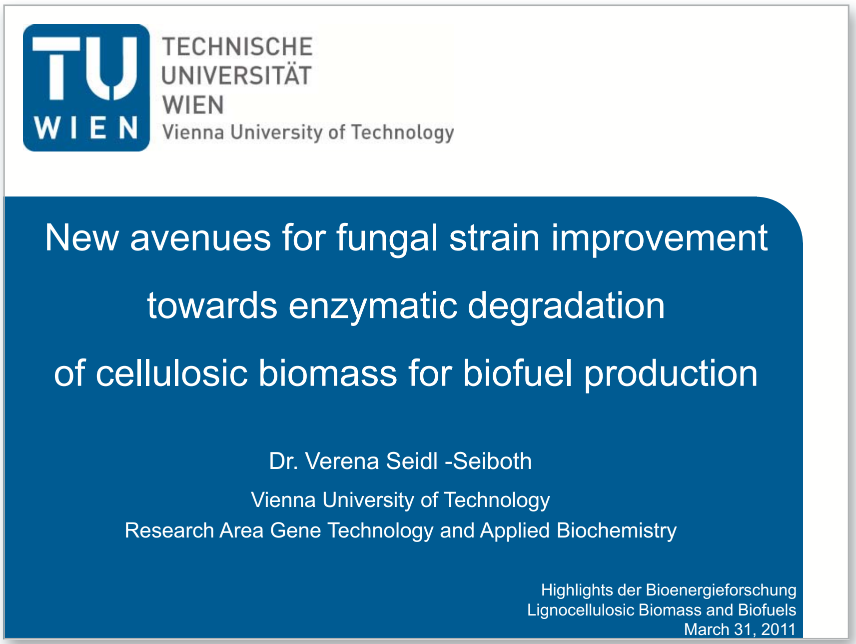
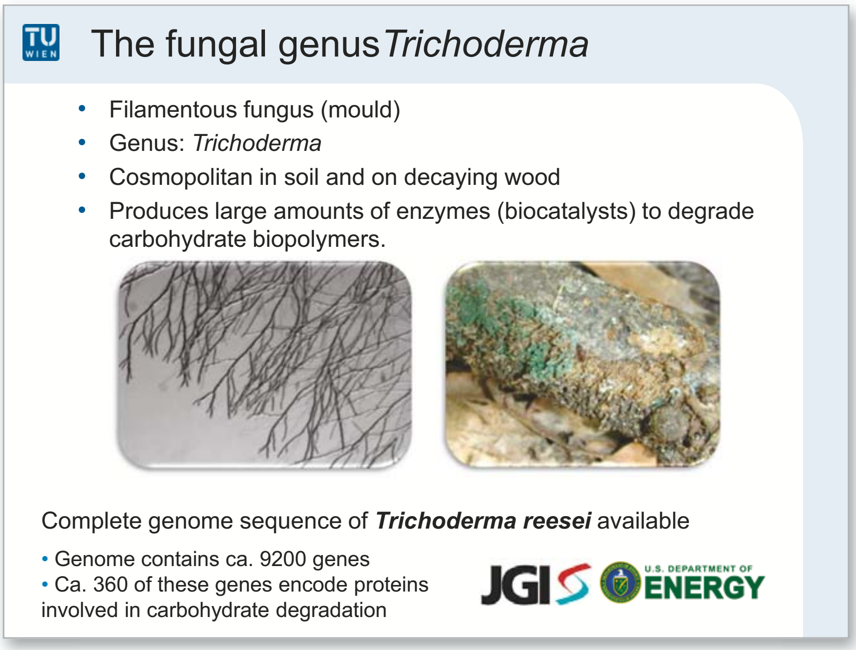
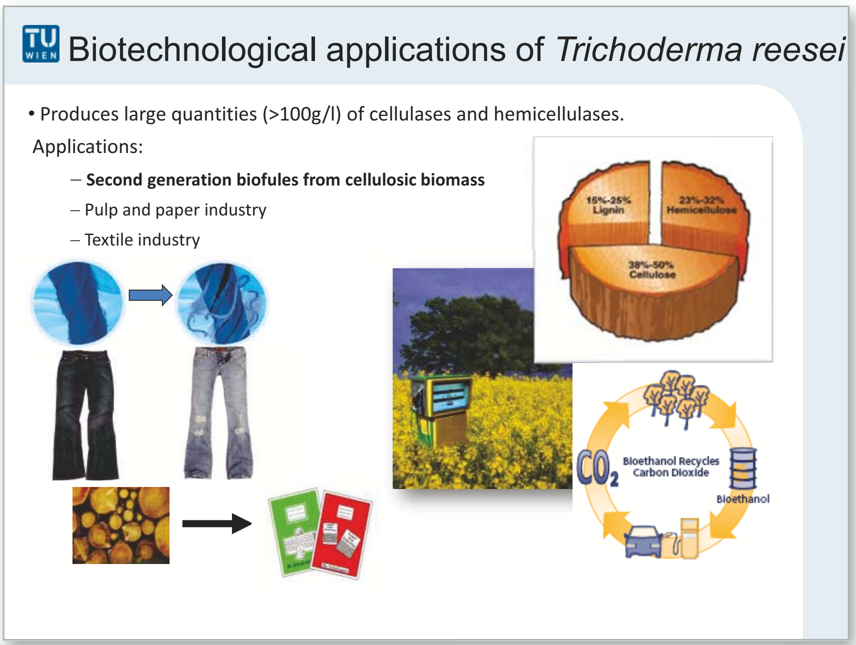
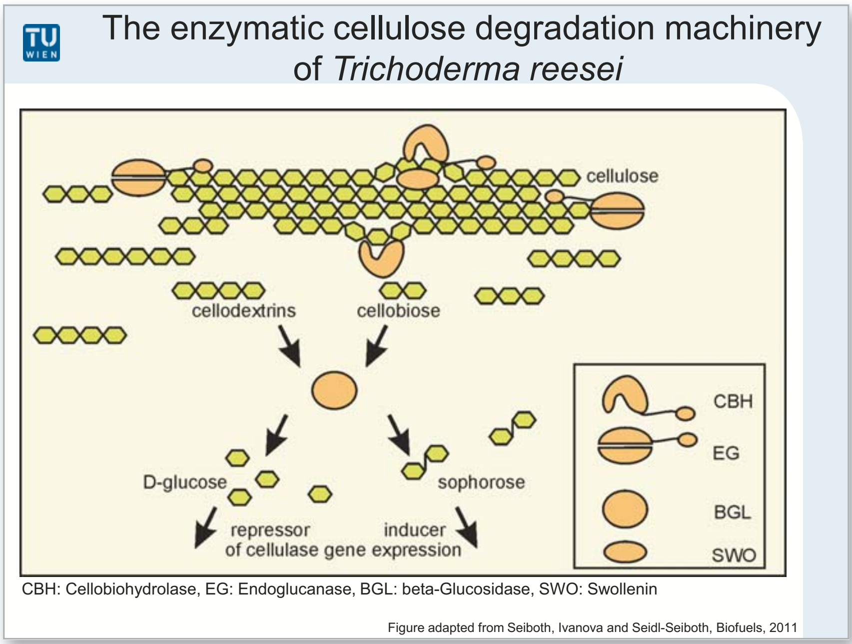

TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology
New avenues for fungal strain improvement
towards enzymatic degradation
of cellulosic biomass for biofuel production
Dr. Verena Seidl -Seiboth
Vienna University of Technology
Research Area Gene Technology and Applied Biochemistry
Highlights der Bioenergieforschung
Lignocellulosic Biomass and Biofuels
March 31, 2011


The fungal genus *Trichoderma*
• Filamentous fungus (mould)
• Genus: *Trichoderma*
• Cosmopolitan in soil and on decaying wood
• Produces large amounts of enzymes (biocatalysts) to degrade carbohydrate biopolymers.
Complete genome sequence of ***Trichoderma reesei*** available
• Genome contains ca. 9200 genes
• Ca. 360 of these genes encode proteins involved in carbohydrate degradation
JGI
U.S. DEPARTMENT OF ENERGY


Biotechnological applications of *Trichoderma reesei*
• Produces large quantities (>100g/l) of cellulases and hemicellulases.
Applications:
– **Second generation biofules from cellulosic biomass**
– Pulp and paper industry
– Textile industry
15%-25% Lignin
23%-32% Hemicellulose
38%-50% Cellulose
$CO_2$
Bioethanol Recycles Carbon Dioxide
Bioethanol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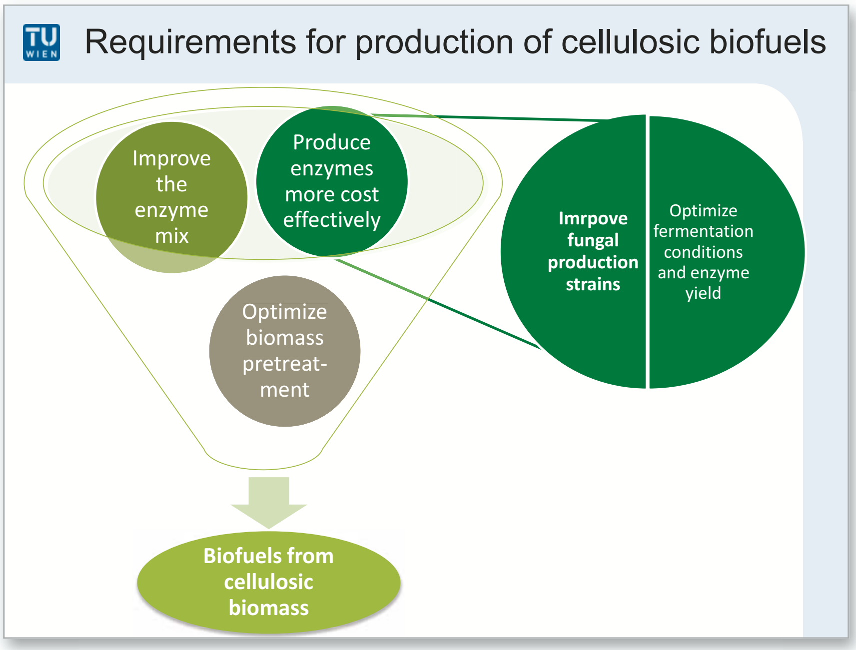
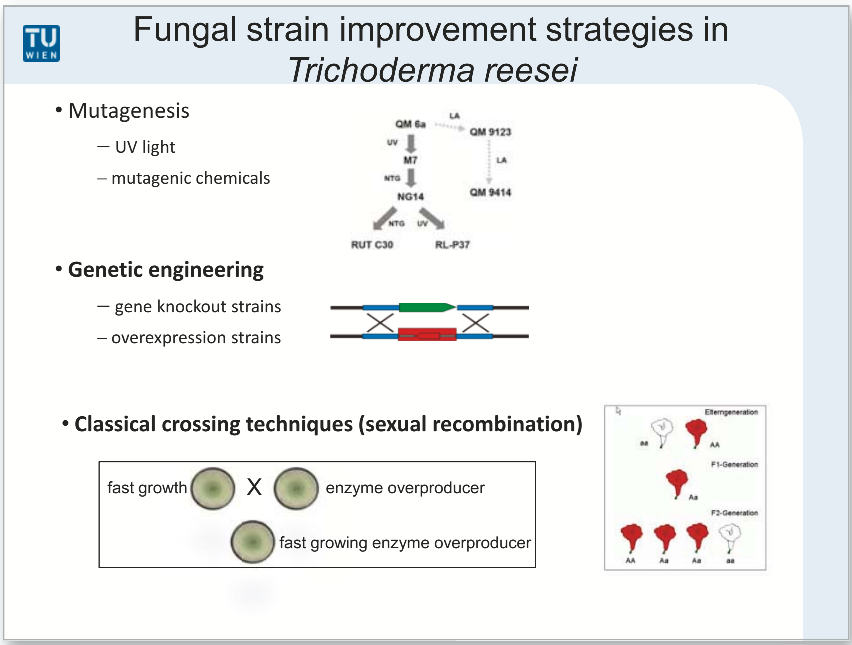
The enzymatic cellulose degradation machinery of *Trichoderma reesei*
cellulose
cellodextrins
cellobiose
D-glucose
sophorose
repressor
inducer
of cellulase gene expression
CBH
EG
BGL
SWO
CBH: Cellobiohydrolase, EG: Endoglucanase, BGL: beta-Glucosidase, SWO: Swollenin
Figure adapted from Seiboth, Ivanova and Seidl-Seiboth, Biofuels, 2011

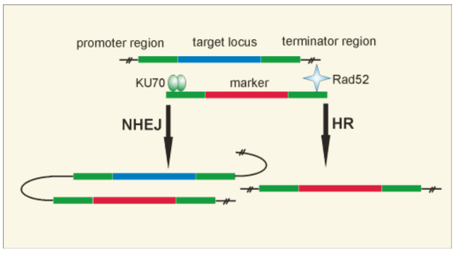

TU WIEN
Requirements for production of cellulosic biofuels
Improve the enzyme mix
Produce enzymes more cost effectively
Optimize biomass pretreat-ment
Imrpove fungal production strains
Optimize fermentation conditions and enzyme yield
Biofuels from cellulosic biomass


TU WIEN
Fungal strain improvement strategies in *Trichoderma reesei*
• Mutagenesis
– UV light
– mutagenic chemicals
QM 6a
LA
QM 9123
UV
M7
LA
NTG
NG14
QM 9414
NTG
UV
RUT C30
RL-P37
• Genetic engineering
– gene knockout strains
– overexpression strains
• Classical crossing techniques (sexual recombination)
fast growth
X
enzyme overproducer
fast growing enzyme overproducer
Elterngeneration
F1-Generation
F2-Generation

## Gene targeting in *Trichoderma reesei*

Genes of interest need to be replaced by other genes to improve the production capacity of *T. reesei* for more cost-efficient cellulase production:

- Introduce new genes that encode cellulases with improved properties (e.g. protein stability, enzyme performance, etc.)
- Alter the regulatory regions of cellulases to produce more enzymes.




NHEJ: non-homologous end joining, HR: homologous recombination

Figure adapted from Seiboth, Ivanova and Seidl-Seiboth, Biofuels, 2011

## Gene targeting in *Trichoderma reesei*

A *T. reesei tku70 gene*-knockout strain resulted in > 95 % gene-targeting efficiency in comparison to 5-10 % in the partental – *tku70* non-deleted strain.

This enables the development of high-throughput approaches on the genomic level to improve the biotechnological potential of *T. reesei*.

Publication: Guangtao et al, 2009, Journal of Biotechnology.

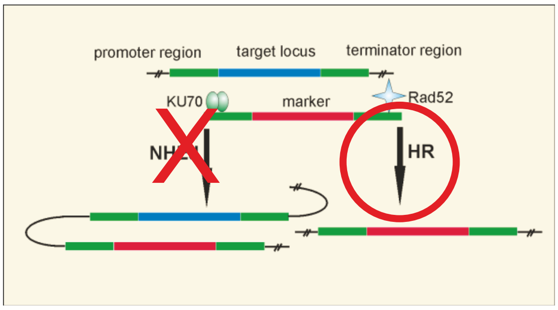



Figure adapted from Seiboth, Ivanova and Seidl-Seiboth, Biofuels, 2011

## Sexual recombination in *Trichoderma reesei*

All industrial mutants are derived from one isolate, *T. reesei* QM6a.

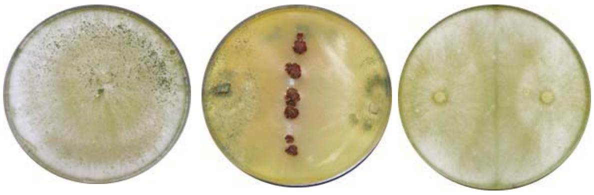

- ***Hypocrea jecorina*** **is the sexual form of** ***T. reesei*** **.**
  (Kuhls et al, 1996; PNAS)
- *T. reesei* QM6a was repeatedly reported to be an asexual clonal line.
- Few examples of *Hypocrea* spp. Undergoing sexual reproduction *in vitro*.
  (Samuels, 2006; Phytopathology)

## Sexual recombination in *Trichoderma reesei*

Genome analysis revealed that *T. reesei* is a heterothallic species and that for sexual recombination a fungal strain with the opposite mating type is required.

Using appropriate wild-type strains from a fungal culture collection, strain QM6a, the ancestor of ALL industrial *T. reesei* strains could be sexually crossed for the first time in 2008, more than 50 years after its discovery.

The crossing technique was already sucessfully applied to currently biotechnologically applied *T. reesei* strains.

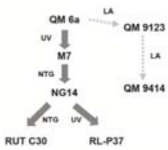


*T. reesei* on agar plate — *T. reesei* strains with opposite mating types produce fruiting bodies. — No production of fruiting bodies in *T. reesei* strains with the same mating type.

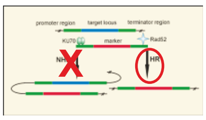
Seidl et al, PNAS, 2009
Applied Research Award (VRW Forschungspreis) of the ÖGMBT 2010

## Fungal strain improvement strategies in *Trichoderma reesei*

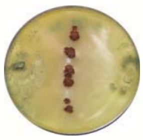
- Mutagenesis
  - UV light
  - mutagenic chemicals




✓ **Genetic engineering**
  - gene knockout strains
  - overexpression strains



✓ **Classical crossing techniques (sexual recombination)**



## Affiliation and further information

**Vienna University of Technology**

Research Area Gene Technolgoy and Applied Biochemistry

Head: Univ. Prof. Christian Kubicek

Working Group Molecular Biotechnology

Contact: verena.seidl@tuwien.ac.at

Related publications:
D. Martinez et al, 2008, Nature Biotechnology
Z. Guangtao et al, 2009 J. of Biotechnology
V. Seidl et al 2009, PNAS

Recent reviews:
V. Seidl and B. Seiboth, 2010, Biofuels
B. Seiboth et al 2011, Biofuels 2 (book chapter, in press)

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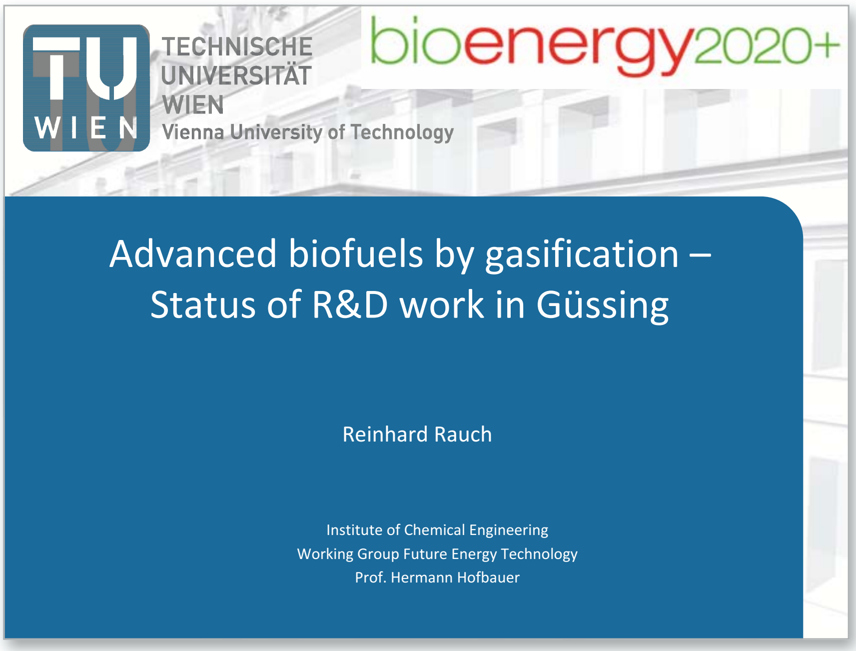
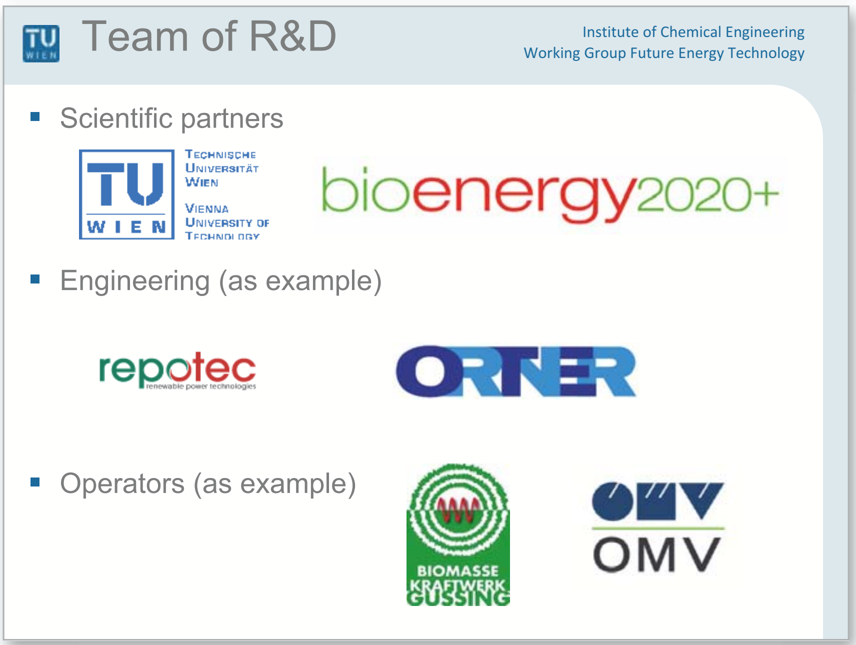
## Innovative Technologies

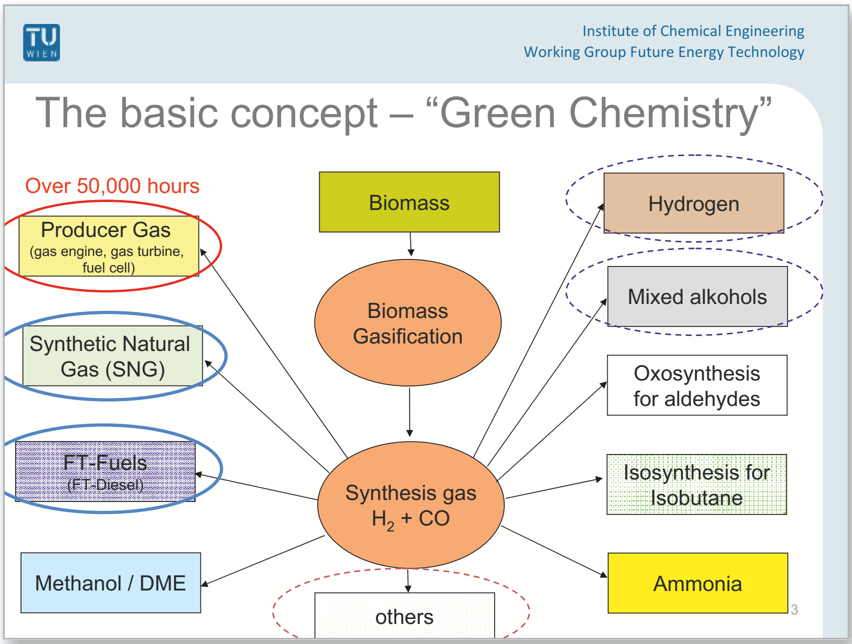
***Chair: Dina Bacovsky**, BIOENERGY 2020+*

# Advanced biofuels by gasification – Status of R & D work in Güssing

***Reinhard Rauch**, TU Wien – VT; BIOENERGY 2020+*







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## Commercial FICFB gasifiers

| Location | Electricity production | Fuel / electr. MW, MWel | Start up | Status |
|---|---|---|---|---|
| Güssing, AT | Gas engine | 8.0 / 2.0 | 2002 | Operational |
| Oberwart, AT | Gas engine / ORC | 8.5 / 2.8 | 2008 | Operational |
| Villach, AT | Gas engine | 15 / 3.7 | 2010 | Commissioning |
| Klagenfurt, AT | Gas engine | 25 / 5.5 | 2011 | planing |
| Ulm, DE | Gas engine / ORC | 15 / 5.3 | 2010 | Under construction |
| Geislingen, DE | AER-process / Gas engine / ORC | 10 / 3.3 | 2010 | planing |
| Göteborg, Sweden | BioSNG | 32/20 (BioSNG) | 2012 | planing |

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## Gas Composition (after gas cleaning)

| Main Components | | |
|---|---|---|
| $H_2$ | % | 35-45 |
| CO | % | 22-25 |
| $CH_4$ | % | ~10 |
| $CO_2$ | % | 20-25 |
| **Minor Components** | | |
| $C_2H_4$ | % | 2-3 |
| $C_2H_6$ | % | ~0.5 |
| $C_3H_4$ | % | ~0,4 |
| $O_2$ | % | < 0,1 |
| $N_2$ | % | 1-3 |
| $C_6H_6$ | g/m³ | ~8 |
| $C_7H_8$ | g/m³ | ~0,5 |
| $C_{10}H_8$ | g/m³ | ~2 |
| TARS | mg/m³ | 20-30 |

| Possible poisons | | |
|---|---|---|
| $H_2S$ | mgS/Nm³ | ~200 |
| COS | mgS/Nm³ | ~5 |
| Mercaptans | mgS/Nm³ | ~30 |
| Thiophens | mgS/Nm³ | ~7 |
| HCl | ppm | ~3 |
| NH3 | ppm | 500-1000 |
| HCN | ppm | ~100 |
| Dust | mg/Nm³ | < 20 |

**$H_2$:CO = from 1.7:1 to 2:1**

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## BioSNG Demonstration Project

A 1 MW SNG Process Development Unit (PDU) is erected within the EU project BioSNG and allows the demonstration of the complete process chain from wood to SNG in half-commercial scale.

A consortium consisting of four partners is responsible for the PDU:

- CTU – Conzepte Technik Umwelt AG
- Repotec GmbH
- Paul Scherrer Institute
- Technical University Vienna

The project BioSNG is co-funded by

- the European Commission
- 6th Framework Programme PrNo TREN/05/FP6EN/ S07.56632/019895
- Swiss electric research
- Bundesförderung Österreich
- WIBAG

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## Results

- December 2008: First conversion of product gas into rawSNG
- June 2009: BioSNG at H-Gas quality produced

- June 24th : inauguration – CNG cars were fuelled using BioSNG from wood
- June 2009 CNG-car was successfully used for 1000km with BioSNG

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## Quality BioSNG

| | unit | Germany DVGW regulation G260 | Austria ÖVGW regulation G31 | BioSNG |
|---|---|---|---|---|
| Wobbe Index | [kWh/m³] | 12,8-15,7 | 13,3-15,7 | 14,15 |
| Relative density | [-] | 0,55-0,75 | 0,55-0,65 | 0,56 |
| Higher heating value | [kWh/m³] | 8,4-13,1 | 10,7-12,8 | 10,7 |

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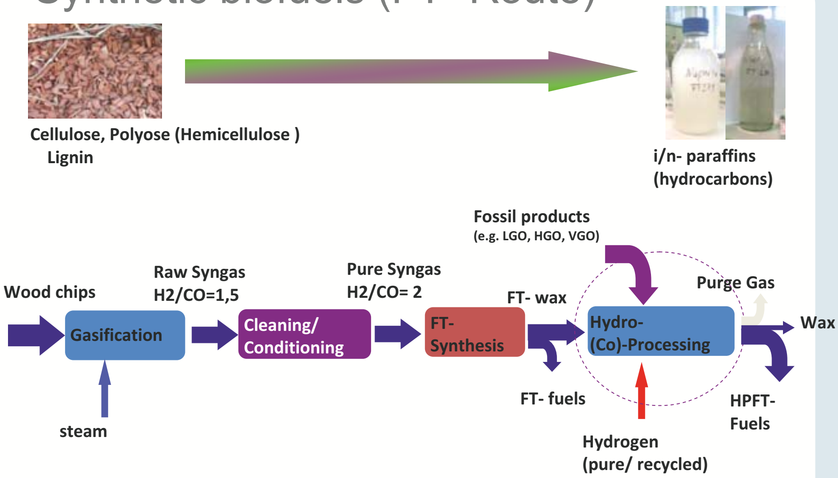
## Synthetic biofuels (FT- Route)

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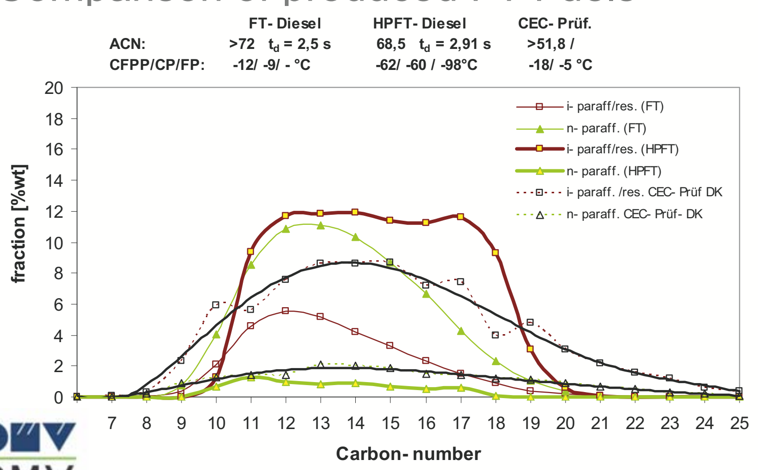
## Comparison of produced FT Fuels




OMV

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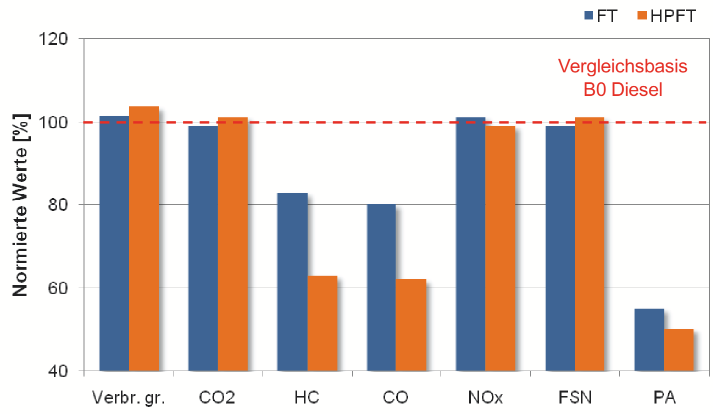
## Results on engine tests with 20% blends

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## Mixed alcohols

- Funded by “Klima und Energiefonds” and Bioenergy 2020+
- Aim is to get fundamental know how in the synthesis of mixed alcohols from biomass
- Main advantage is very simple gas cleaning, due to sulphur resistant catalyst

bioenergy2020+ klima+energie fonds

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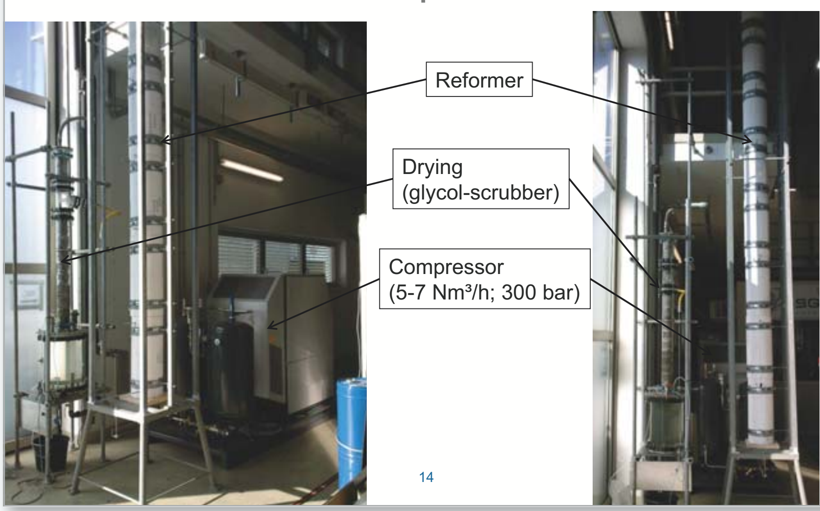
## Actual status: first experiments are done

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## BioH2-4Refineries

Economic evaluation of production of hydrogen for a refinery

- 50 MW fuel plant to replace fossil hydrogen
- Evaluation of the biomass resources available for such a plant
- Basic – engineering of the gasifier as well as of all other sub units, including pipelines, utility systems, logistic needs
- Optimal use of by-products
- Economic evaluation

klima+energie fonds

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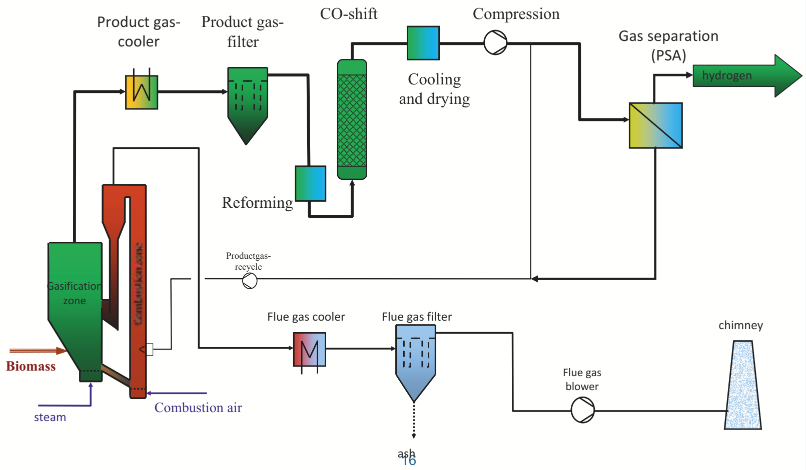
## Simplified flow chart

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## Summary

- Biomass CHP Güssing has excellent frame conditions for R&D on synthesis gas applications
- Focus of R&D is on small CHP and on synthesis gas applications (BioSNG, Fischer Tropsch, Mixed Alcohols, Hydrogen)
- Gasification enables the conversion of biomass to many useful products

More info at
http://www.ficfb.at

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***BIOKRAFTSTOFFE***
***BIOFUELS***

# A new way to AVIATION BIO-FUELS

Doz. Dr. Alfred Ecker

Wieselburg, 2011-03-31

## Aviation Fuels

| | |
|---|---|
| **AVGAS** | Aviation Gasoline |
| **AVTUR** | Aviation Turbine Kerosene |
| **AVDIESEL** | Aviation Diesel fuel |

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Fuels
Properties

| | | Methane | Methanol | DME | Diesel |
|---|---|---|---|---|---|
| Formula | | CH4 | CH3OH | CH3OCH3 | CxHy |
| Molmass | | 16 | 32 | 46 | 200 |
| BoilingPoint | °C | -161 | 65 | -25 | 150/350 |
| Density | kg/m3 | 0,72 | 792 | 665 | 845 |
| Heating value | MJ/kg | 48 | 20 | 29 | 42 |

Not suitable as aviation fuels:
Methane , DME because of high volatility and low density
DME, Methanol because of low HV

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**Much Oxygen in product and feed is a problem !**

| | | *O-content,%Mol* |
|---|---|---|
| **Methanol** | **CH4O** | **50** |
| **Ethanol** | **C2H6O** | **34,7** |
| **Butanol** | **C4H10O** | **21,6** |
| **DME** | **C2H6O** | **34,7** |
| **Biodiesel** | **C19H36O2** | **10,8** |
| **CNG, Diesel** | **CH4, CH1,9** | **0** |
| **Wood** | **CH1,6O0,7** | **45** |
| **Sugar** | **C6H12O6** | **53** |

***Oxygen reduces energy content, makes worse water tolerance, stability…***

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***Important requirements on alternative (Bio)-Fuels***

Infrastructure
- Must not demand a new infrastructure
- Must be blendable with conventional fuels
- Must be usable in existing engines

Sustainability
- Must not harm the environment
- Must not competitive to food
- Should create new jobs
- Should be competitive with other fuels

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**Assessment of Fuels**

| | H2 | Biogas | DME | MeOH | Biosprit | FT-Diesel | Oligomerisat |
|---|---|---|---|---|---|---|---|
| Density, kg/m3 | 0,086 | 0,78 | 660 | 792 | 794 | 780 | 810 |
| Heating value, MJ/kg | 12 | 40 | 28 | 20 | 27 | 44 | 45 |
| Liquid | no | no | no | yes | yes | yes | yes |
| Blendable with HC | no | no | no | partly | partly | yes | yes |
| Engine adapting necess. | yes | yes | yes | partly | partly | no | no |
| Infrastructure usable | no | no | no | partly | partly | yes | yes |
| Conv. Storage | no | no | no | yes | yes | yes | yes |
| Conv. Transport | no | no | no | yes | yes | yes | yes |
| No S, N, Metalle | yes | yes | yes | yes | yes | yes | yes |
| Max. H pro C | | partly | no | no | no | yes | yes |

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## What should biofuels consist of ?

- ❖ No elements such as S,N,Metals, O?
- ❖ Consist only of C und H
- ❖ Contain Maximum H (for Minimum $CO_2$)

**These reqirements are only met by Liquid Hydrocarbons (HC) with a high portion of (Iso)-Paraffins**

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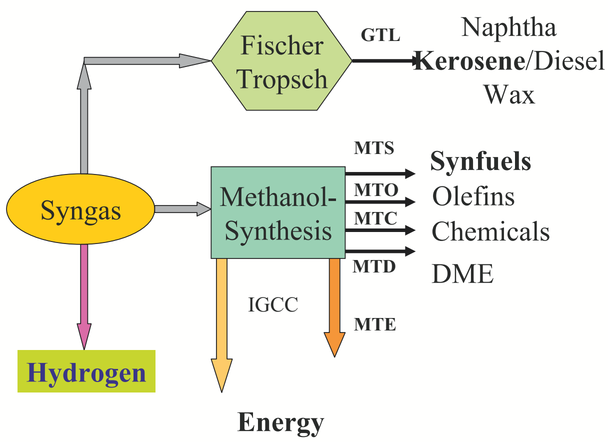
## Synthesis Gas
## A multi purpose source for synthesis

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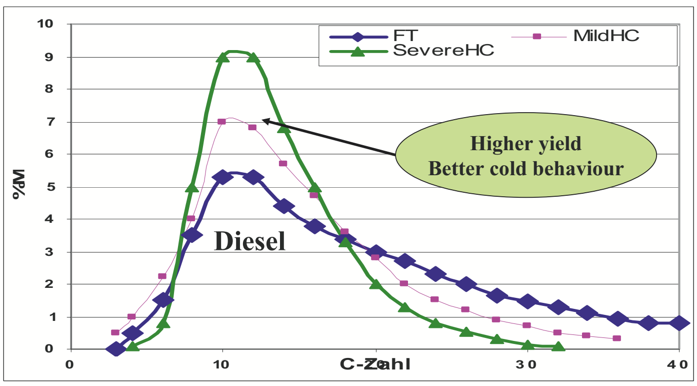
## FT-Products
## Bevor and after Hydrocracking




Hydrocracking produces more diesel fuel with better cold behaviour
Big plants are necessary for economical reasons -
But scale up is not possible for syngas from solid biomass

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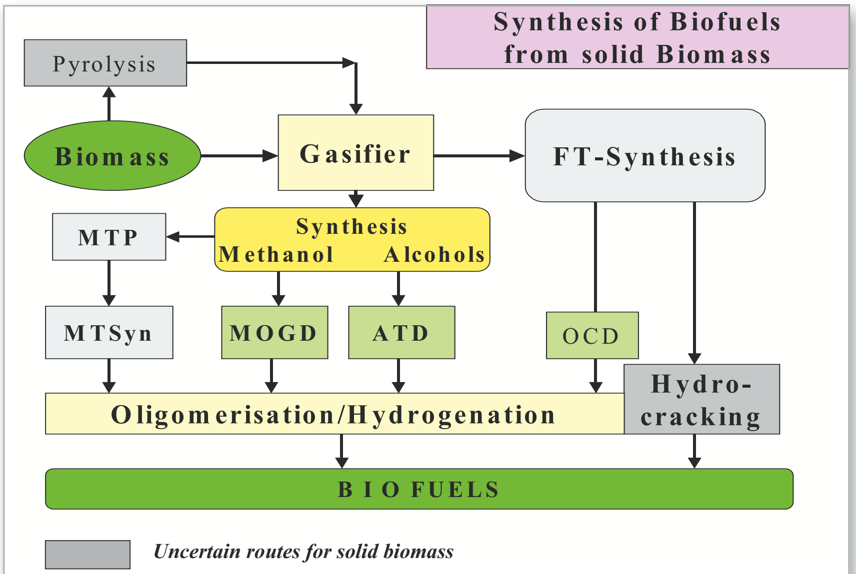


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## Properties of Pyrolysis oil

| | |
|---|---|
| **Yield** | **60-70%** |
| **Water content** | **20-30%** |
| **pH** | **2-3** |
| **Density** | **1,2 g/cm³** |
| **Viscosity/40°C** | **40-100 cP** |
| **Heating value** | **17-19 MJ/kg** |
| **Content C** | **56%** |
| **O** | **37%** |
| **H** | **7%** |

Pyrolysis oil

Pyrolysis coke (10-20%)

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## Pyrolysis oil Upgrading

| | Pyrolysis oil | HDO |
|---|---|---|
| C, %M | 54 | 63 -74 |
| H | 7 | 9 -10 |
| O | 39 | 28 -16 |
| H2O | 25 | 16 - 2 |
| HHV(MJ/kg) | 17 | 25 -35 |

| Biomass | Pyrolysis oil | HDO-Oil | FCC |
|---|---|---|---|
| 100% | 65 | 26 | 20 |

F.De M.Mercader et al, University Twente

*Upgrading in FCC plant yields gasoline but no kerosene and gasoil of good quality*

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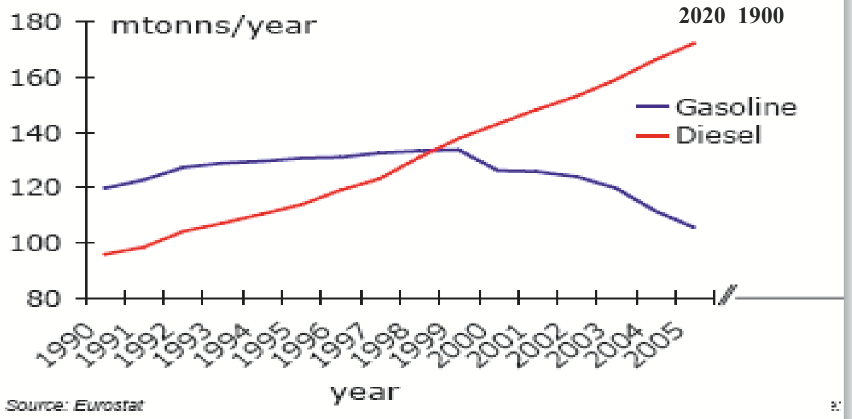
## Which fuels do we need?
Consumption in EU

**Consumption world OK+DK: 2005 1600 Mt/a**
**2020 1900**

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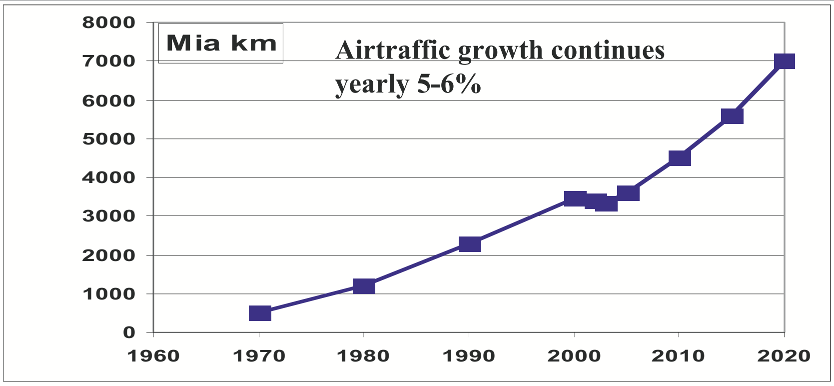


**Consumption Jet A1**

| 1990 | 1995 | 1998 | 2007 | |
|---|---|---|---|---|
| 158 | 168 | 178 | | Mio gal/d |
| 174 | 185 | 196 | 220 | Mio t/a |
| | | | 276 | Mio m3/a |
| 2010-2020 | | >2000 Mio to<br>>6000 Mio to CO2 | | |

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## Diesel- Fuels as Aviation diesel

| | 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 |
| Destillation10% Vol | 230 | 350 | 200 | 210 | 235 |
| 50% Vol | 270 | 350 | 290 | 270 | 250 |
| 90% Vol | 330 | 350 | 300 | 300 | 330 |

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*Alfred Ecker, JKU Linz, CEFL*

***Oligo- Jet and Bio-SPK***

***in comparison to conv. JP-8/JetA1***

Oligo-Jet from Syngas FT-Olefins oligomerised/hydrogenated

Bio-SPK from Camelina-Öl hydrogenated and isomerised

| | Oligo-Jet | Bio-SPK | JP-8/Jet A1 |
|---|---|---|---|
| Specific Gravity/15°C | 0,781 | 0,753 | 0,804 |
| API/60°F | 49,7 | | 44,4 |
| Flash Point, °C | 74 | 42 | 51 |
| Freezing Point, °C | -78 | -63,5 | -50 |
| Viscosity/-20°C, cSt | 7,2 | 3,34 | 4,9 |
| Visciosity/-40°C, cSt | 18,4 | | 9,9 |
| Smoke Point, mm | 40 | | 22 |
| Existent Gum, mg/100 ml | <0,5 | <1 | 0,4 |
| Thermal Stability/260°C | | | |
| Tube Deposit Rating | 1 | 1 | 1 |
| Change Pressure, mm Hg | 0 | | 2 |
| Copper Strip Corrosion | 1a | | 1a |
| Total Acid Number, mg KOH/g | 0,004 | 0,002 | 0,003 |
| Hydrogen content, %m | 14,8 | 15 | 13,8 |
| Sulfur, %m | 0 | 0 | 0,04 |
| Distillation | | | |
| IBP, °C | 194 | | 159 |
| 10% recovered, °C | 202 | 162 | 182 |
| 20% rec.,°C | 206 | | 189 |
| 50% rec.,°C | 215 | 186 | 208 |
| 90% rec.,°C | 257 | 226 | 244 |
| FBP, °C | 278 | 251 | 265 |
| Cetane Index | 61,8 | | 46 |

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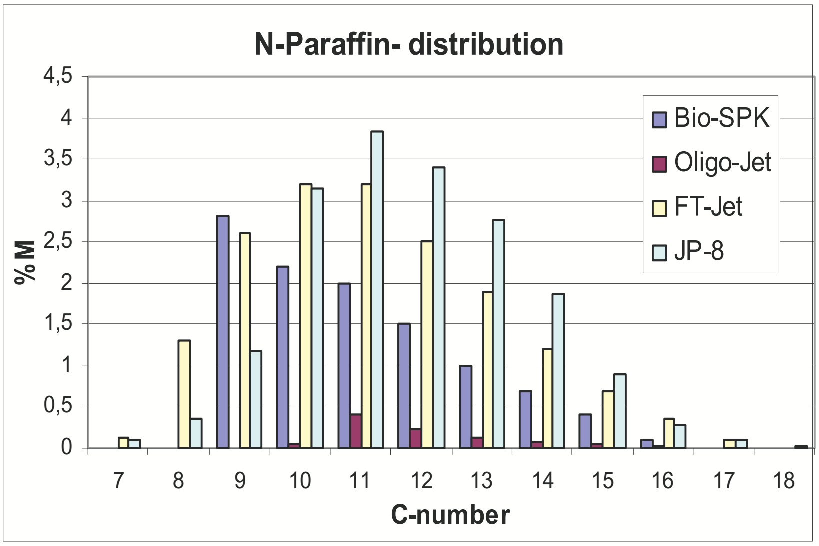


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**Synth.Aviation turbine fuels JP8/JetA1/JP7**

| | | | | | | Specifications | |
|---|---|---|---|---|---|---|---|
| | FT/HC | FT/IPK | FT/COD | Bio-SPK | Oligo-Jet | JP7 | JP8 |
| Density/15°C, kg/m3 | 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 |

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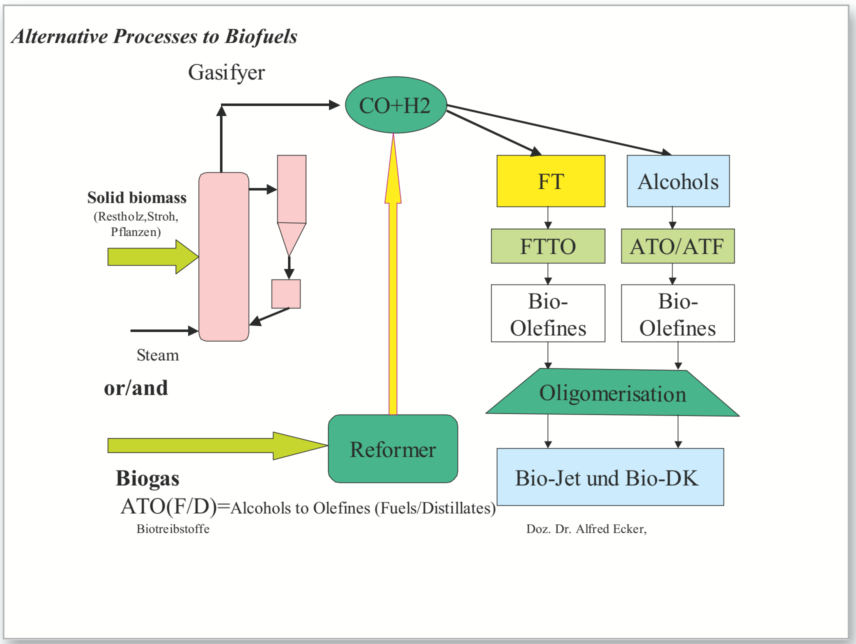
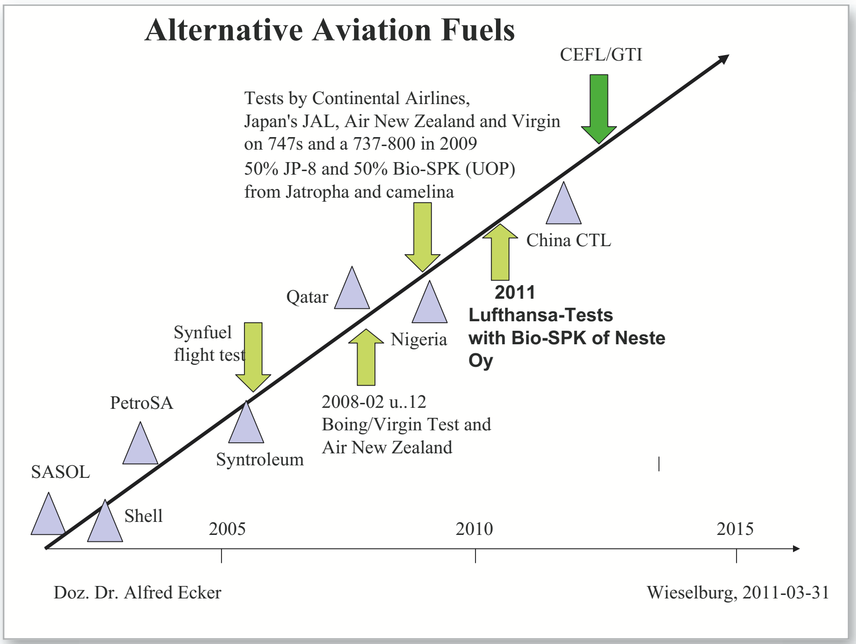

Alternative Processes to Biofuels
Gasifyer
CO+H2
FT
Alcohols
Solid biomass
(Restholz,Stroh, Pflanzen)
FTTO
ATO/ATF
Bio-Olefines
Bio-Olefines
Steam
or/and
Oligomerisation
Reformer
Bio-Jet und Bio-DK
Biogas
ATO(F/D)=Alcohols to Olefines (Fuels/Distillates)
Biotreibstoffe
Doz. Dr. Alfred Ecker,


Alternative Aviation Fuels
CEFL/GTI
Tests by Continental Airlines, Japan's JAL, Air New Zealand and Virgin on 747s and a 737-800 in 2009
50% JP-8 and 50% Bio-SPK (UOP) from Jatropha and camelina
China CTL
Qatar
2011 Lufthansa-Tests with Bio-SPK of Neste Oy
Synfuel flight test
Nigeria
2008-02 u..12 Boing/Virgin Test and Air New Zealand
PetroSA
Syntroleum
SASOL
Shell
2005
2010
2015
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Wieselburg, 2011-03-31

## New Ways to Aviation Biofuels

*Alfred Ecker, JKU Linz, CEFL*

Vienna University of Technology
Institute of Chemical Engineering

Research Group:
Fluidized Bed Systems and
Refinery Technology

## Direct use of biomass in FCC -plants

Dr. A. Reichhold
DI H. Schablitzky
DI P. Bielansky
DI A. Weinert

Highlights Bioenergy Research, Wieselburg, March, 30-31, 2011

## Content

### Catalytical Cracking of Bio Oils

- Based on Biomass: Natural Oils (Rape Seed Oil, Sunflower Oil, Soya Oil, Palm Oil),Fatty Acids, Used Frying Oils, Animal Fat
- Results from Testruns with an FCC- pilot plant
- Addition of Bio Oils to Vacuum Gas Oil
  up to 100 m%:
  - Continuous Cracking of Bio Oils possible?
  - Effects on Products?
  - Effects on the FCC Pilot Plant?

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## Content

### Catalytic Cracking of Bio Oils to Fuels and Monomers for Polymer Industry

- Possibilities of an oil refinery:
  - Hydrogenation to split the ester bond
  - FCC to crack the big molecules of fatty oils
- After the treatment in the refinery the products appear to be similar to crude oil products
  - No difference in material compatibility
  - No biodegradability
  - Additives work as usual

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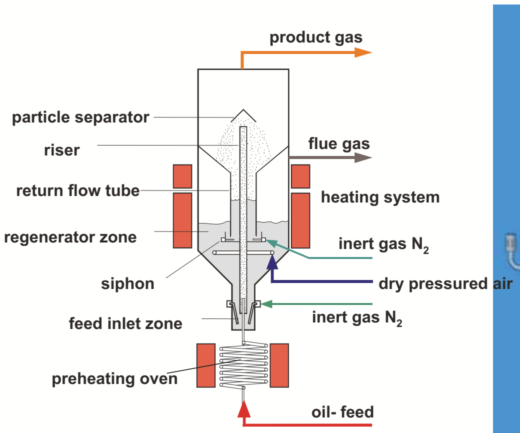
## The Fluidized Bed System

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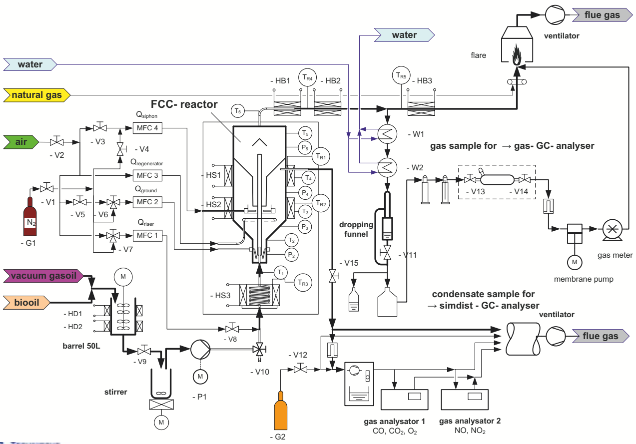
## Experimental Setup

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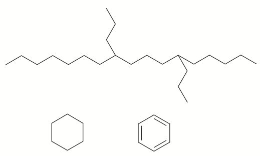
## Chemical Composition of applied Oils

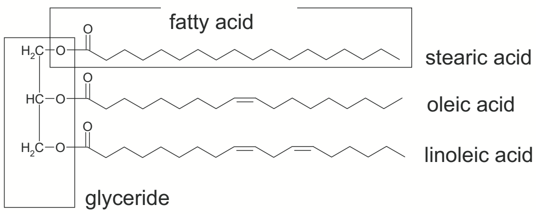
- Hydr. Vacuumgas Oil:
  ( Crude Oil- Product )

| | |
|---|---|
| Density (20°C) | 0.895 g/cm³ |
| Viscosity (100°C) | 6.476 mm²/s |
| Aromatic Carbons | 23.3 w% |
| Paraffinic and Naphtenic Carbons | >70 w% |
| Boiling Range | 281°C-588°C |



- Bio Oil:

| | |
|---|---|
| Chain lenght of fatty acids | C12 – C22 |
| Boiling Point | < 300°C |

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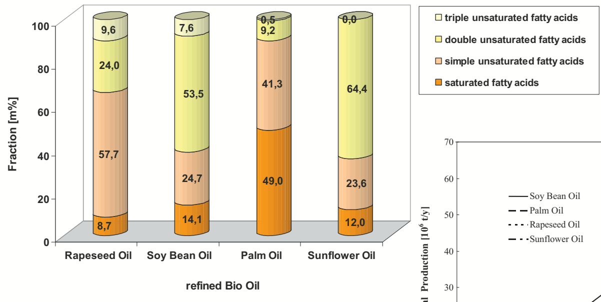
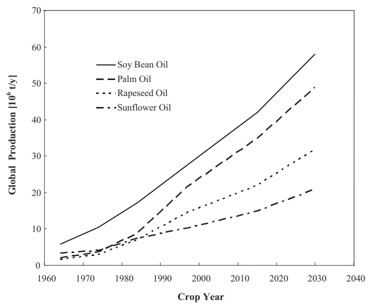
## Bio Oil Composition (C12 – C22)




*Source: VFI

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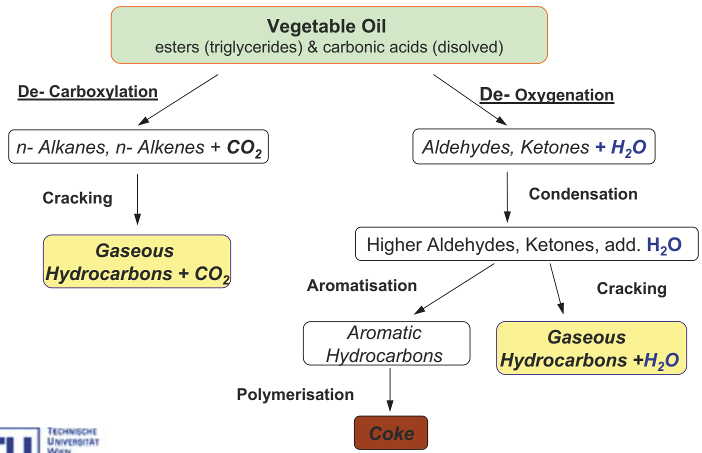
## Suggested Reaction Pathes

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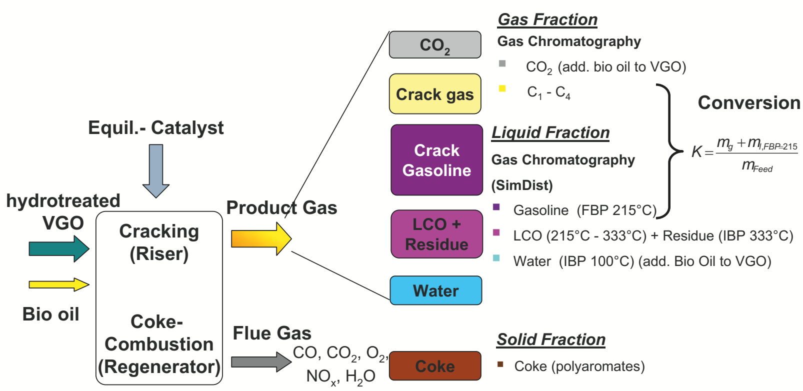
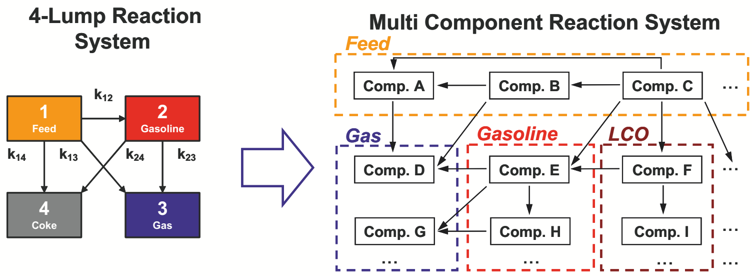
## Cracking- Products (Lumps)




Highlights Bioenergy Research, Wieselburg, March, 30 -31, 2011

## Cracking- Products (Lumps)




$$\frac{dy_1}{dt} = -k_{12,n} \cdot \Phi_n \cdot y_1^2 - k_{13,n} \cdot \Phi_n \cdot y_1^2 - k_{14,n} \cdot \Phi_n \cdot y_1^2$$

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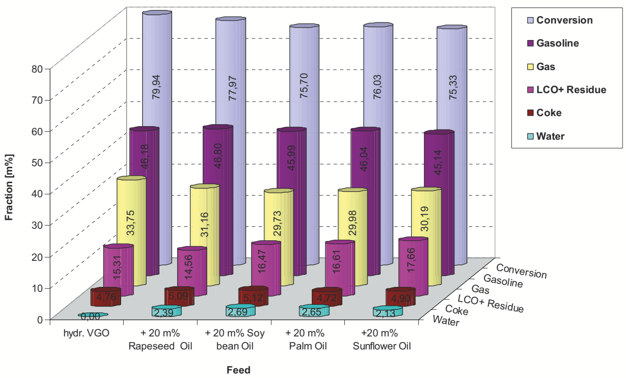
## Product Composition

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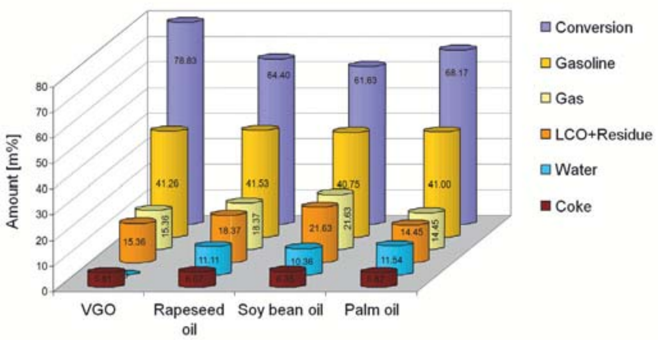
## Product Composition

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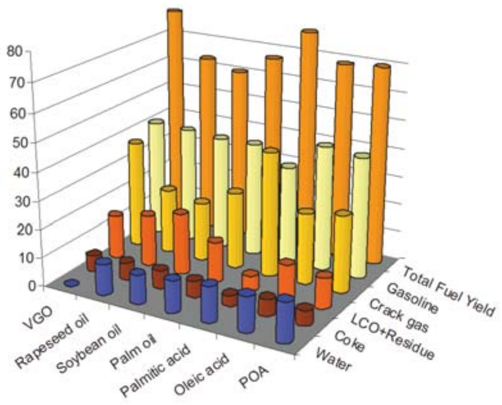
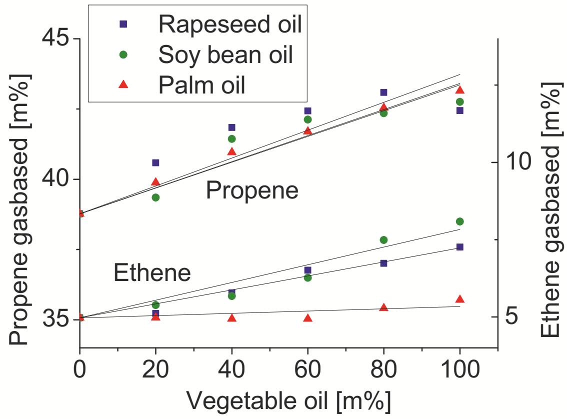
## Product Composition



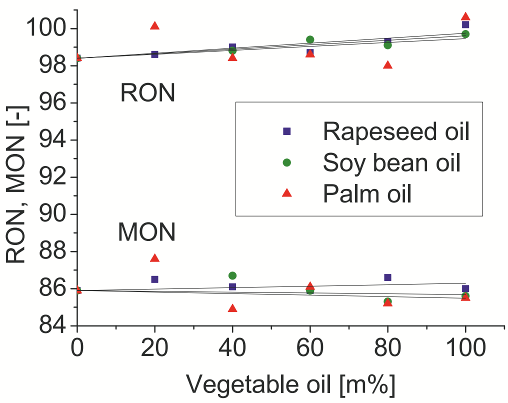

Highlights Bioenergy Research, Wieselburg, March, 30 -31, 2011

## Product Composition




Highlights Bioenergy Research, Wieselburg, March, 30 -31, 2011

## Product Quality

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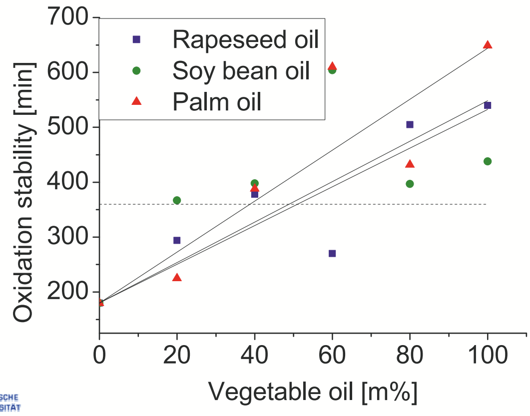
## Product Quality

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## Conclusions

- The addition of bio oils has no significant influence on the routine operation of the FCC-plant
- It does result in a slightly modified product spectrum
- It has to be pointed out that the slight decrease in conversion was mainly caused by the oxygen content of the feed
- The production of up to 12 percent mass water from the oxygen in the bio oils does not constitute a problem in downstream processing of the products, since industrial FCC-units utilize steam for fluidization of the riser and the stripper
- The obtained liquid product contained a high octane (RON 99) gasoline fraction, which is comparable to high quality gasoline pools from traditional refineries
- The obtained light hydrocarbons contained a high percentage of propylene and ethylene – so the FCC process further offers a possibility to produce bio polymers without supporting the greenhouse effect.

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**Vienna University of Technology**
**Institute of Chemical Engineering**

**Research Group:**
**Fluidized Bed Systems and Refinery Technology**

## Thank you for attention

**Dr. A. Reichhold**
**DI H. Schablitzky**
**DI P. Bielansky**
**DI A. Weinert**

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**ecoduna productions GmbH**

ecoduna is the European innovation leader in algal photo bioreactors,
Ecoduna has been several fold awarded for its outstanding technology.

The company was funded 2008 by Franz Emminger and Martin Mohr,
changed into an Austrian limited company (GmbH) in 2010 and reinforced by Energy Park Bruck as core investor


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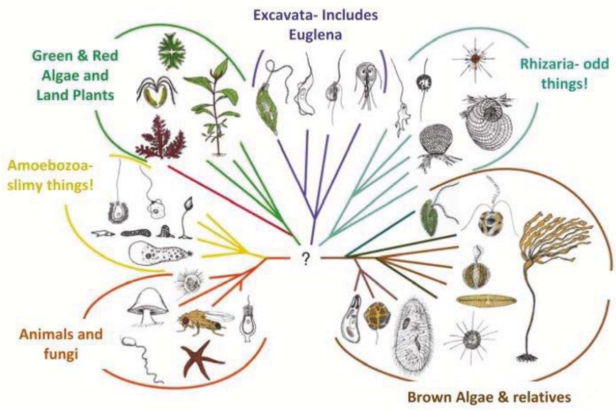
**TREE OF LIVE**

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**EFFECTIVENESS**

Products from algae are the most promising renewable recourse

The measured quantity of global biomass from algae is only 0,2%

Algae can have a high conversion

Therefore the total annual global biomass from algae adds up to 55%

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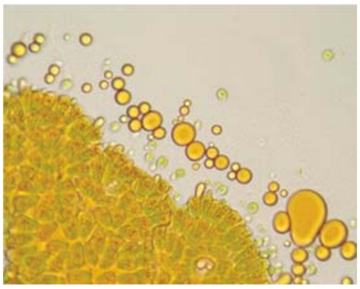
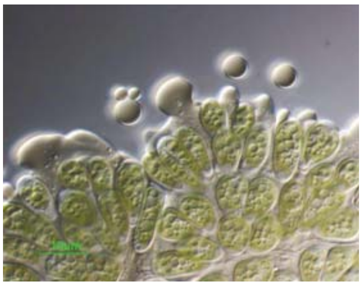
**WHAT ELSE?**





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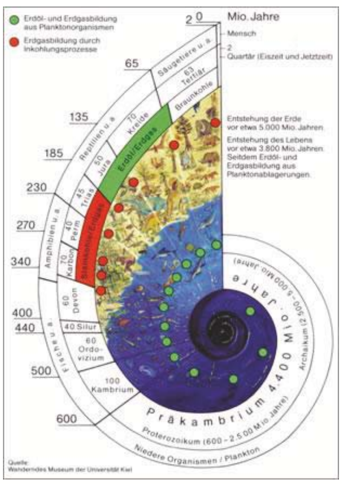
**Crude OIL**

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**Fast Evolution**

First 7000 years

200 Y. till do day

No limits in variations



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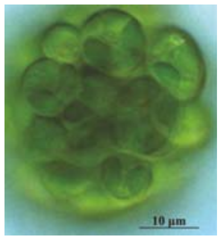
**Fast Evolution**

There are thousands of specie of algae to start the breeding process.


- Algae can divide within hours, up to1000 generations are possible within 1 year.
- Genetic selection will help to quicken up the and advance the process additionally
- GMO



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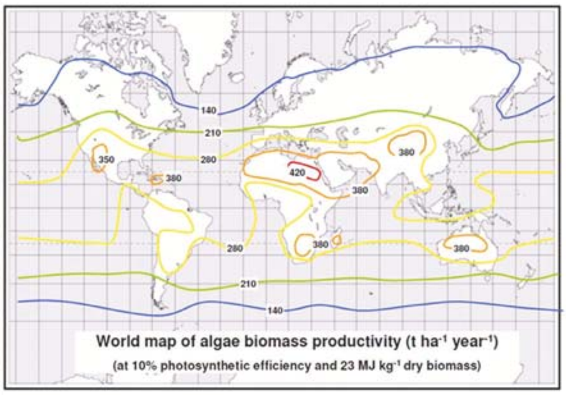
**PRODUCTIVITY**

**$6CO_2 + 6\ H_2O + 6\ (9.4 \text{ moles photons (quanta)}) = C_6\ H_{12}\ O_6 + 6O_2$ (eq. 1)**

PE = (2808 KJ mole$^{-1}$ of glucose/ 209 KJ x 9.4 mole photons x 6) x 0.45 = **10.7 %**



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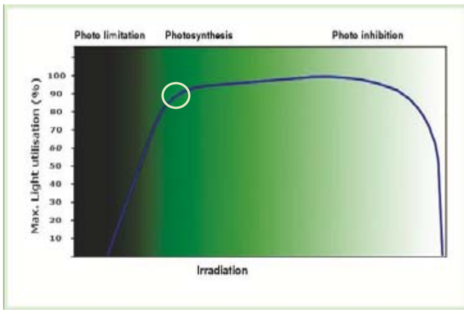
## PHOTOSYNTHESIS RATE TO LIGHT INTENSITY

The ecoduna technology avoids the disadvantages of other processes in the utilization of light.

Light from the sun is diluted from **80.000** down to **1.500 – 2.500** lux irradiation, the optimum for algae growth.

**80,000lux / 2,500lux = 32**




**By diluting the sunlight by the factor 32, ecoduna is obtaining the optimal light-density for algae growth.**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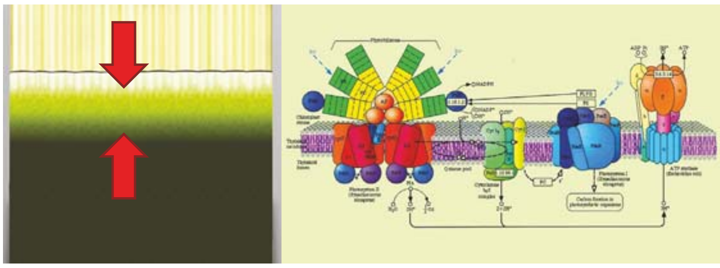
## TROPHOGENIC ZONE; PHOTO ACTIVE VOLUME

To understand the significance of photo-bio-reactors, the most important terms are **photo active volume** and **trophogenic zone**



Only the **trophogenic zone** matters, all the rest volume only expands costs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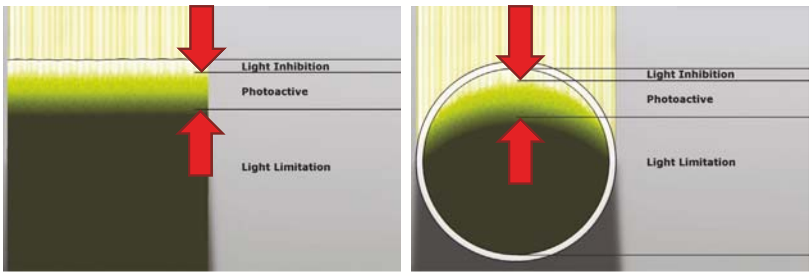
## TROPHOGENIC ZONE; PHOTO ACTIVE VOLUME

Ponds must have a certain depth to puffer temperature, pipes are of a certain diameter because of material and assembling costs.




Both systemic approaches neglect the ideal form for light integration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TRACKING THE SUN
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TECHNIQUE, HOW DOES IT WORK
Oxygen
Algae biomass
Photo Bio Reactor
Carbon dioxide
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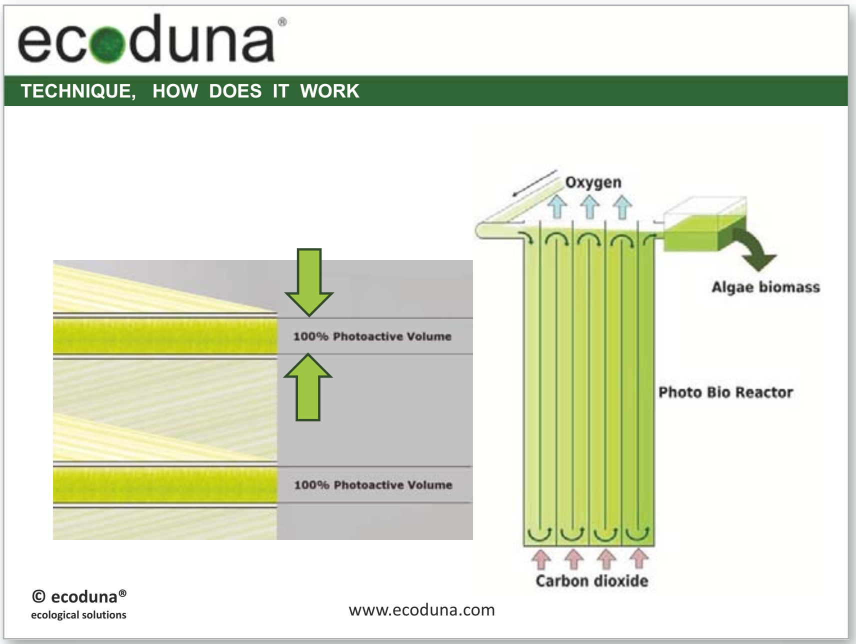
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TECHNIQUE, HOW DOES IT WORK
Oxygen
Algae biomass
100% Photoactive Volume
Photo Bio Reactor
100% Photoactive Volume
Carbon dioxide
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## FUEL

2007 was the year of the highest fuel consumption; 8,36 Mil tons*

The total area needed of fuel production for Austria would be 8550km2
(30 times the Neusiedler See, if open Pond is used)**


**Only 2 times the Neusiedler See, if ecoduna PBR are used**

* BMWA 2009
** Prof Spitzer, IEA Graz 2011



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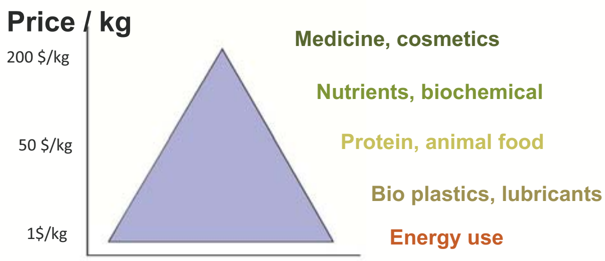
## USE OF ALGAE PRODUCTS

**At present he cost estimate is at approx. 4-6 €/litre**




**Valuable biomass can support the fuel production by cascading use of total biomass in a bio- refinery**



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## Status Quo

The European Union has granted ecoduna a substantial fund under the "Competitiveness and Innovation Framework Programme" (CIP).

ecoduna will build and run the second largest photo bioreactor unit for microalgae in in the west, from September 2011 on in Bruck an der Leitha

**Volume 90.000 litres**



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**Focus Produkt DHA**

**Docosahexaenoic acid (DHA) is an omega – 3 fatty acid.**
**In chemical structure, DHA is acarboxylic acid with a 22-carbon chain**

**DHA is a major fatty acid in sperm and brain phospholipids, particularly in the retina.**

**Dietary DHA may reduce the risk of heart Disease by reducing the level of blood triglycerides humans.**

**Low levels of DHA have been associated with Alzheimer disease.**

The market of omega 3 fatty acids nutrition products has exceptionally grown over the last years (24,3% annually), predicted to reach 1,6 bill$ in 2014 in Europe and there is no reason conceivable why this dynamic trend should stop.
(Frost & Sullivan, 2008).



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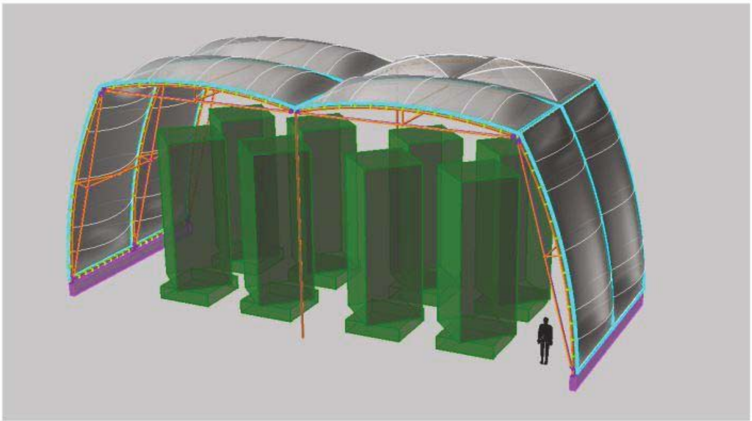
**BUILDING**



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**Vision**

Algae photo bioreactors will ideally being build next to a carbon emitting industry.

Understanding $CO_2$ as a resource and utilise it for Biomass production.

A Base for renewable chemical products and a renewable energy sources, not conflicting with food production



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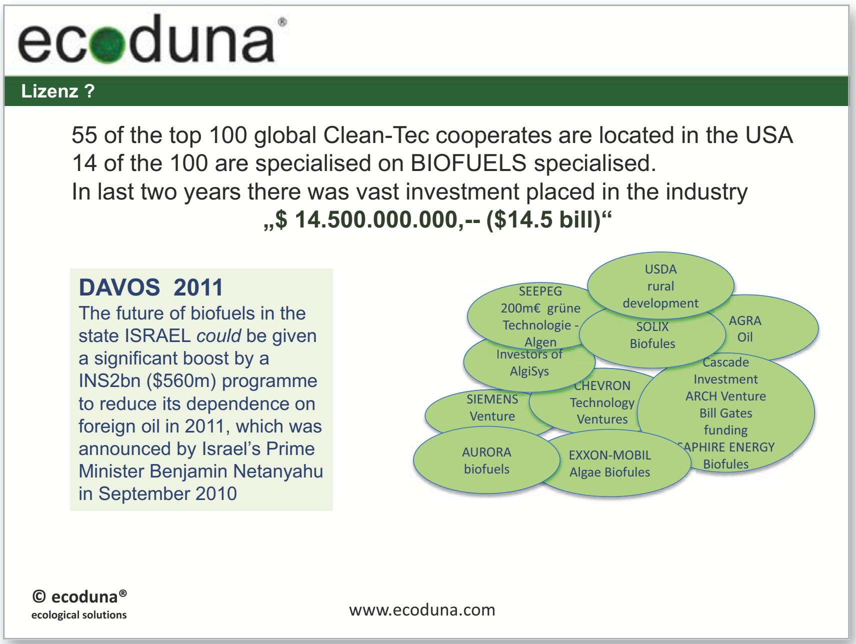
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Lizenz ?
55 of the top 100 global Clean-Tec cooperates are located in the USA
14 of the 100 are specialised on BIOFUELS specialised.
In last two years there was vast investment placed in the industry
„$ 14.500.000.000,-- ($14.5 bill)“
DAVOS 2011
The future of biofuels in the state ISRAEL *could* be given a significant boost by a INS2bn ($560m) programme to reduce its dependence on foreign oil in 2011, which was announced by Israel's Prime Minister Benjamin Netanyahu in September 2010
USDA rural development
SEEPEG 200m€ grüne Technologie - Algen
SOLIX Biofules
AGRA Oil
Investors of AlgiSys
Cascade Investment ARCH Venture Bill Gates funding
APHIRE ENERGY Biofules
SIEMENS Venture
CHEVRON Technology Ventures
AURORA biofuels
EXXON-MOBIL Algae Biofules
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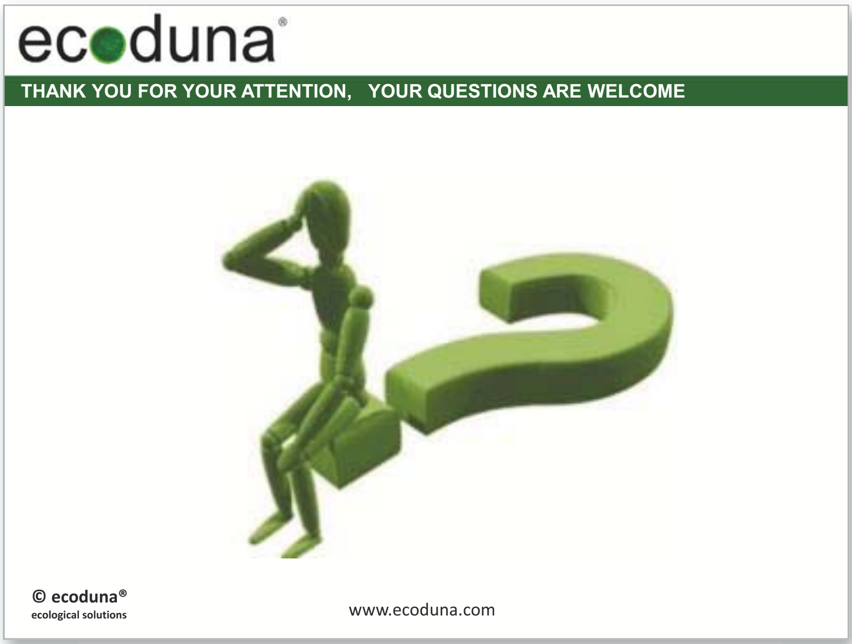
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THANK YOU FOR YOUR ATTENTION, YOUR QUESTIONS ARE WELCOME
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JOANNEUM RESEARCH Forschungsgesellschaft mbH
TU WIEN
bioenergy2020+
BOKU
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Source: http://www.igb.fraunhofer.de/www/presse/bilder/download.bis2000/IGB_Alge2.jpg
klima+ energie fonds
Algae for energy
Identification of the most promising algal-based pathways in Austria
Maria Hingsamer, Gerfried Jungmeier, Kurt Könighofer, Naomi Pena, Reinhard Rauch, Günther Bochmann, Bernhard Drosg, Dina Bacovsky, Andrea Sonnleitner
Wieselburg, 31. 03. 2011
1
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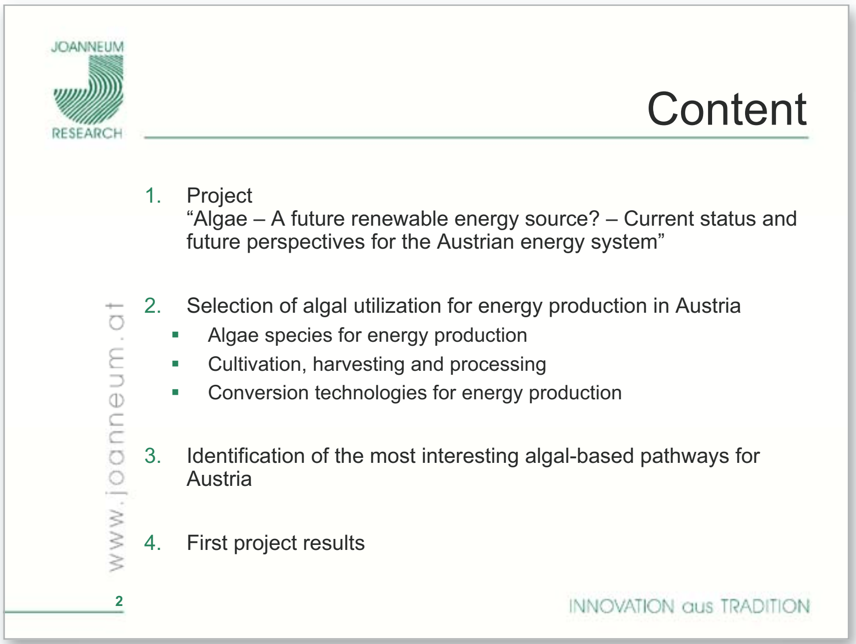
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Content
1. Project
"Algae – A future renewable energy source? – Current status and future perspectives for the Austrian energy system"
2. Selection of algal utilization for energy production in Austria
Algae species for energy production
Cultivation, harvesting and processing
Conversion technologies for energy production
3. Identification of the most interesting algal-based pathways for Austria
4. First project results
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2
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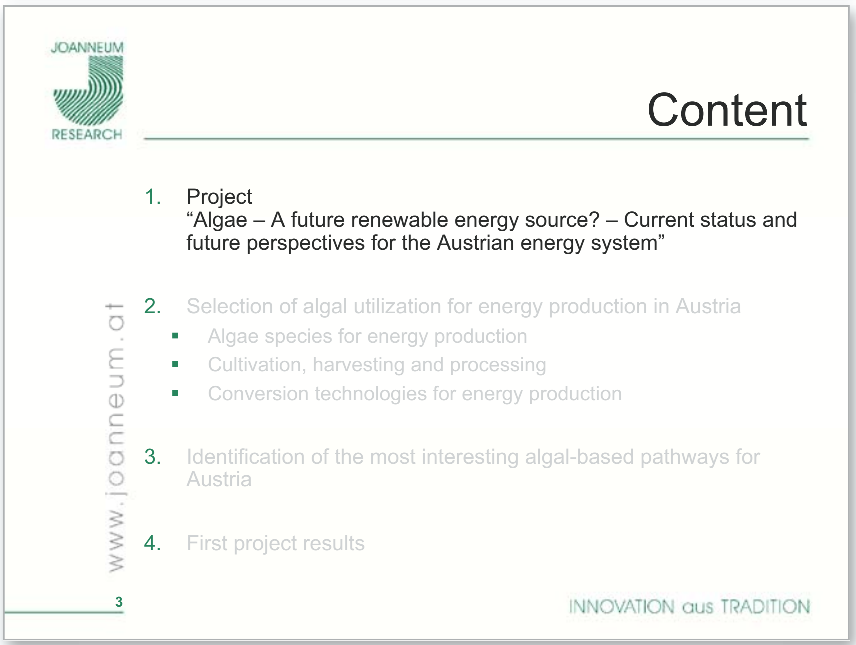
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## Content of the project

Funded by: klima+ energie fonds

**R&D Demand**
**Conclusions &**
**Perspectives**

**Scenarios (2020/2050)**
- Identification of algal-based energy pathways
- Possible role in the Austrian energy system

**Assessment**
- Technical
- Economic
- Environmental
- Energy economic

**Basics of algae**
- Algae species for energy production
- Productivity rates
- Environmental conditions

**Production**
- Cultivation methods
- Harvesting technologies
- Processing technologies

**Conversion**
- Biochemical
- Thermochemical
- Mechanical/ chemical

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## Intended results

- Identification of promising technologies for algae production (cultivation, harvesting, processing, conversion technologies)
- Determination of potential role of algae in Austria‘s energy system with scenarios for 2020 and 2050
- Determination of potential of algae to reduce greenhouse gas emissions and substitute fossil energy
- Estimation of the future potential of algae to contribute to Austrian energy and climate targets
- Consideration of the possibility of $CO_2$-sequestration
- Identification of R&D topics

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## Project – key data

- Project partners:
  JOANNEUM RESEARCH, TU WIEN, BOKU, bioenergy2020+
- Program:
  3rd call „Neue Energien 2020“
- Financing partner:
  klima+ energie fonds
- Project duration:
  18 month (May 2010 – October 2011)

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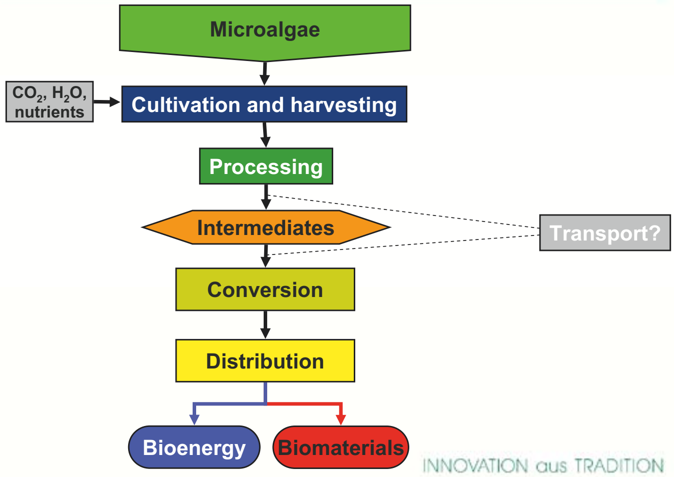
# Overview – Pathways biorefinery

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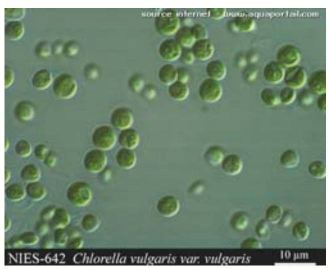
# Algae species for energy production

- Numerous algae species
  Focus on microalgae
  No consideration of macroalgae
- Selection of algae species for specified applications
  Criteria e.g.
  Productivity
  Environmental conditions
  Resistance
  Harvesting possibilities




Source: http://www.aquaportail.com/definition-4952-chlorelle.html

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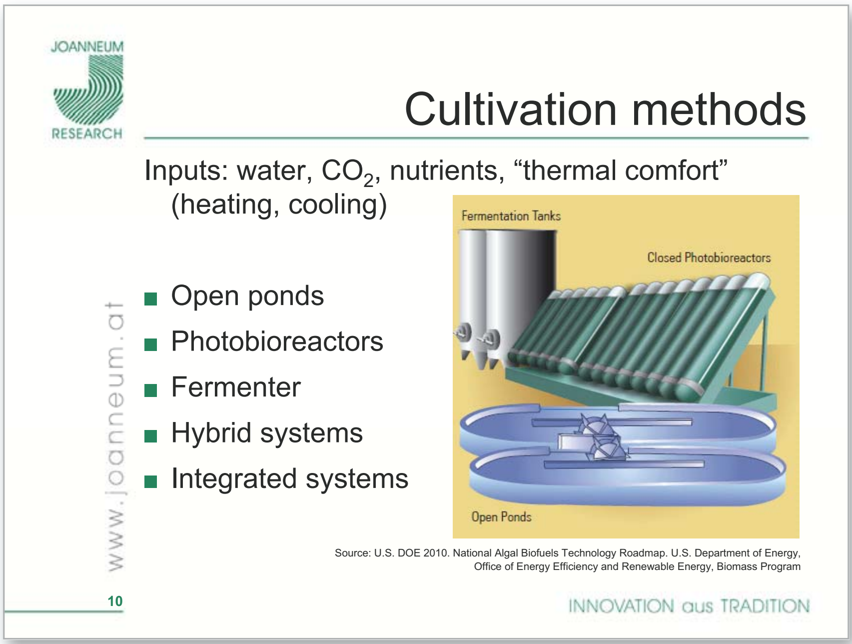


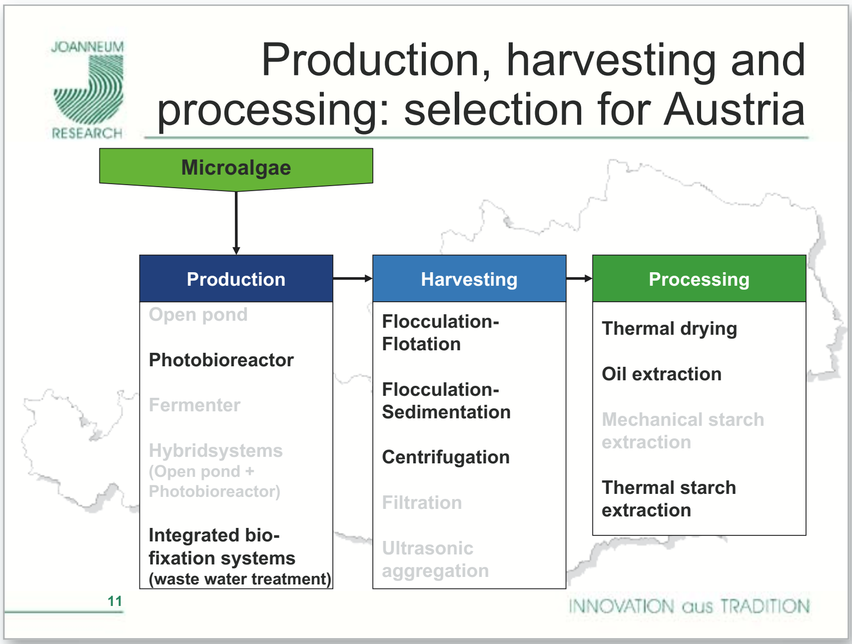


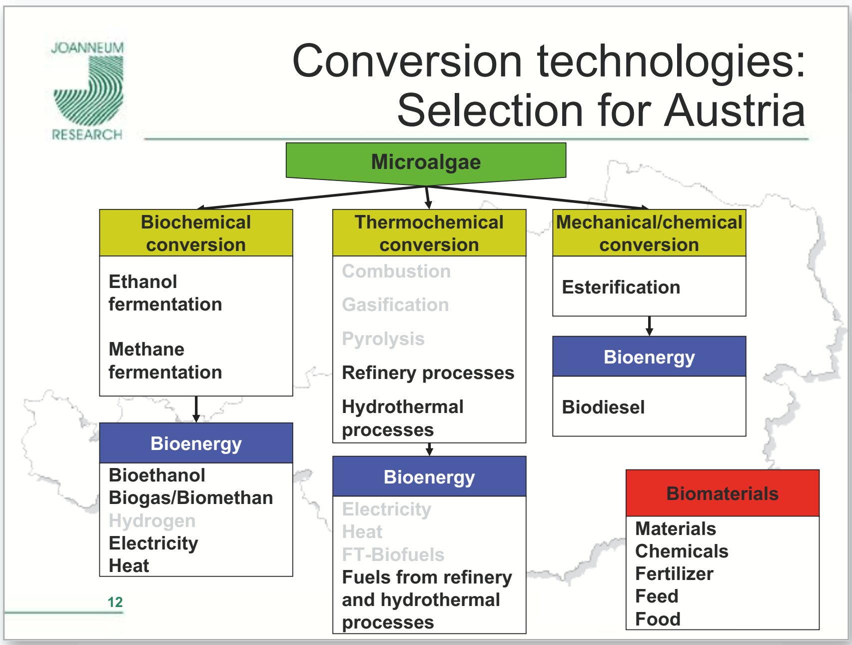


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## 4 groups of algae species

- Oleaginous microalgae
- Starchy microalgae
- High-yield microalgae
- Waste water grown algae

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## Groups of algal-based pathways biorefinery

| Nr. | Algal group | Short term |
|---|---|---|
| 1 | Oleaginous microalgae | 1a: Esterification<br>1b: Refinery processes |
| 2 | Starchy microalgae | 2: Ethanol fermentation |
| 3 | High-yield microalgae | 3a: Methane fermentation<br>3b: Hydrothermal processes |
| 4 | Waste water grown algae | 4a: Methane fermentation<br>4b: Hydrothermal processes |

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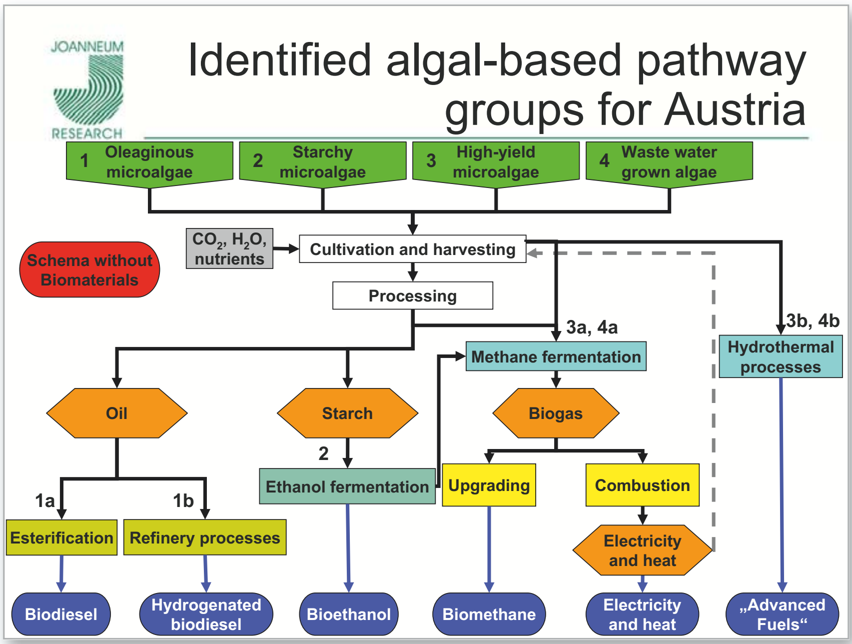
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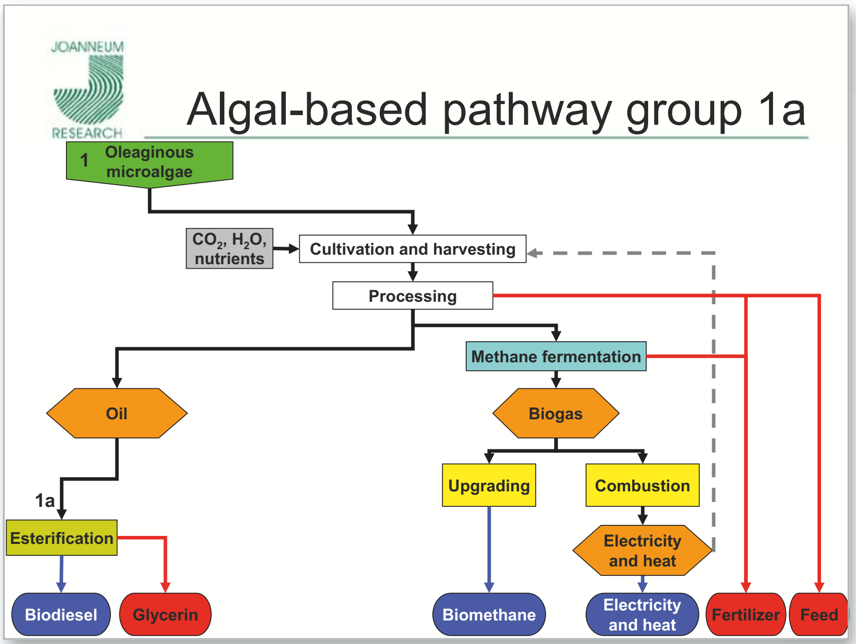
Identified algal-based pathway groups for Austria
1 Oleaginous microalgae
2 Starchy microalgae
3 High-yield microalgae
4 Waste water grown algae
Schema without Biomaterials
$CO_2$, $H_2O$, nutrients
Cultivation and harvesting
Processing
3a, 4a
3b, 4b
Methane fermentation
Hydrothermal processes
Oil
Starch
Biogas
2
Ethanol fermentation
Upgrading
Combustion
1a
1b
Esterification
Refinery processes
Electricity and heat
Biodiesel
Hydrogenated biodiesel
Bioethanol
Biomethane
Electricity and heat
„Advanced Fuels“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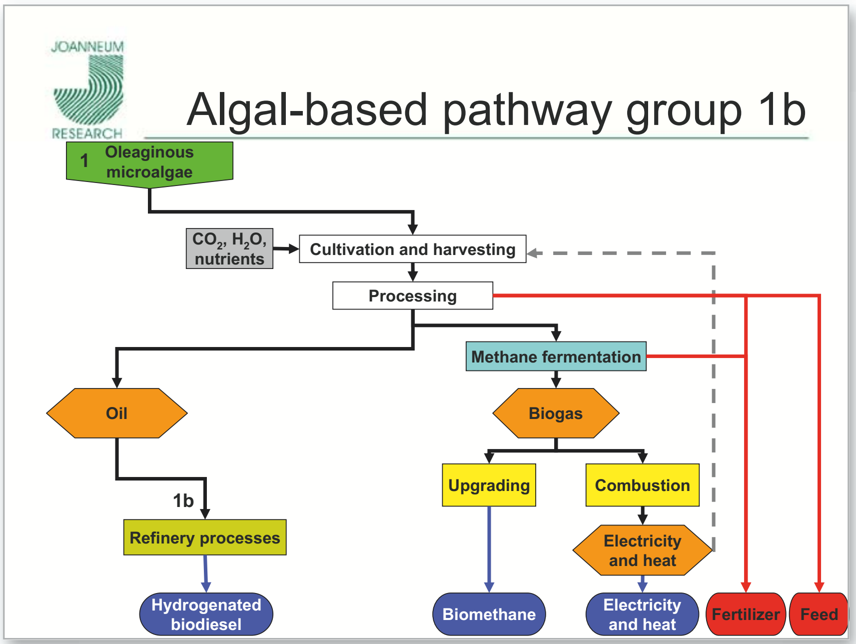
Algal-based pathway group 1a
1 Oleaginous microalgae
$CO_2$, $H_2O$, nutrients
Cultivation and harvesting
Processing
Methane fermentation
Oil
Biogas
Upgrading
Combustion
1a
Esterification
Electricity and heat
Biodiesel
Glycerin
Biomethane
Electricity and heat
Fertilizer
Feed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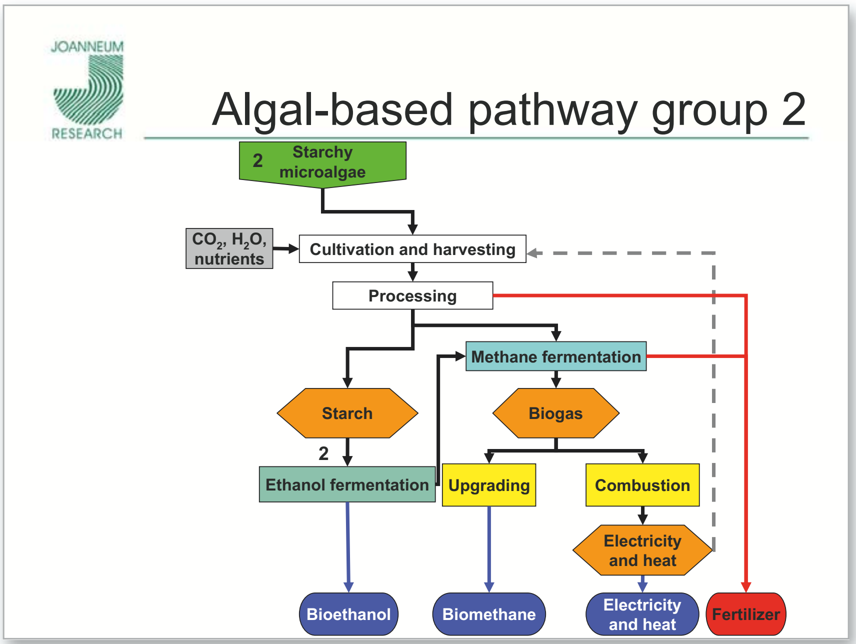
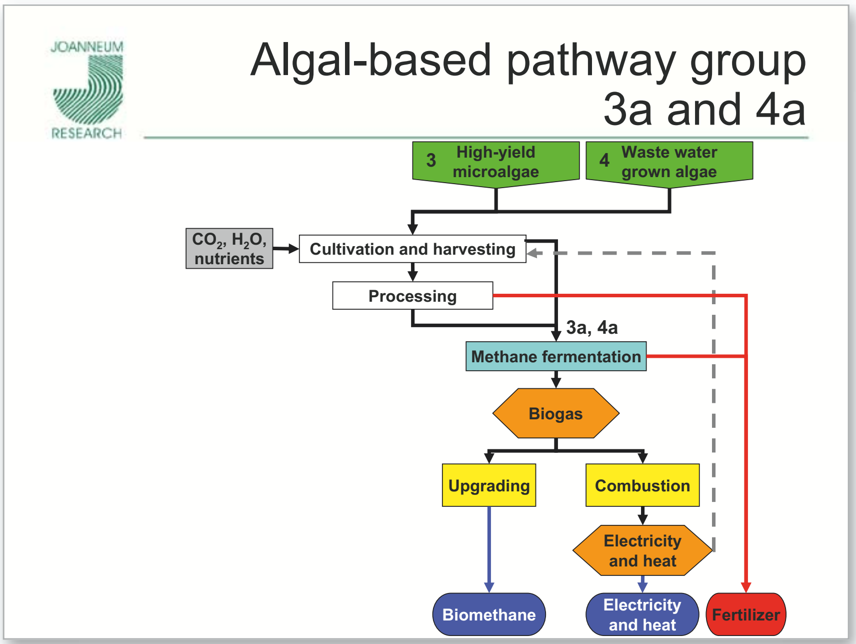
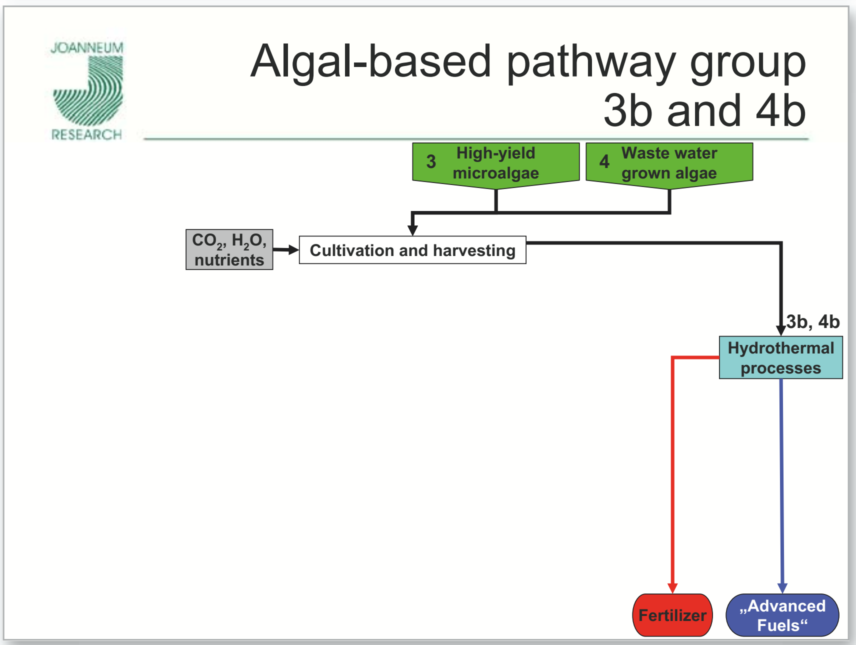
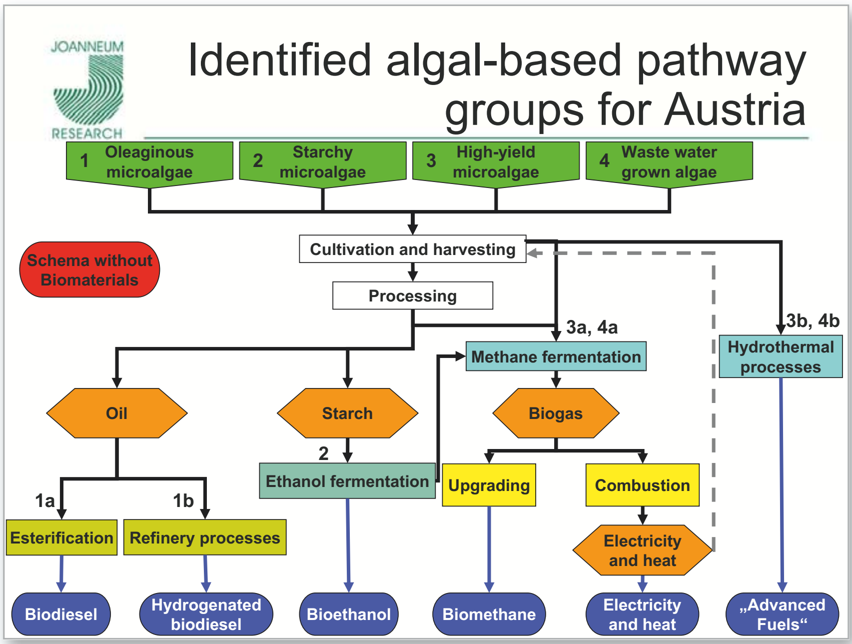
Algal-based pathway group 1b
1 Oleaginous microalgae
$CO_2$, $H_2O$, nutrients
Cultivation and harvesting
Processing
Methane fermentation
Oil
Biogas
Upgrading
Combustion
1b
Refinery processes
Electricity and heat
Hydrogenated biodiesel
Biomethane
Electricity and heat
Fertilizer
Feed


JOANNEUM RESEARCH
Algal-based pathway group 2
2 Starchy microalgae
CO2, H2O, nutrients
Cultivation and harvesting
Processing
Methane fermentation
Starch
Biogas
2
Ethanol fermentation
Upgrading
Combustion
Electricity and heat
Bioethanol
Biomethane
Electricity and heat
Fertilizer


JOANNEUM RESEARCH
Algal-based pathway group 3a and 4a
3 High-yield microalgae
4 Waste water grown algae
CO2, H2O, nutrients
Cultivation and harvesting
Processing
3a, 4a
Methane fermentation
Biogas
Upgrading
Combustion
Electricity and heat
Biomethane
Electricity and heat
Fertilizer


JOANNEUM RESEARCH
Algal-based pathway group 3b and 4b
3 High-yield microalgae
4 Waste water grown algae
CO2, H2O, nutrients
Cultivation and harvesting
3b, 4b
Hydrothermal processes
Fertilizer
„Advanced Fuels"




JOANNEUM RESEARCH

## Content

1. Project
   "Algae – A future renewable energy source? – Current status and future perspectives for the Austrian energy system"
2. Selection of algal utilization for energy production in Austria
   - Algae species for energy production
   - Cultivation, harvesting and processing
   - Conversion technologies for energy production
3. Identification of the most interesting algal-based pathways for Austria
4. First project results

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JOANNEUM RESEARCH

## First project results

- mainly photobioreactors are relevant for Austria
- optimal and efficient use of algae: biorefinery for bioenergy and biomaterials
- long way to commercialisation
- key motivation for current R&D-activities: biodiesel from algae
- algae not suitable as fuel for combustion, gasification, pyrolysis
- siting: where $CO_2$ is available
- R&D demand: cultivation
  harvesting
  hydrothermal processes
- expert workshop on 16th March 2011: agreement on pathway selection for Austria
- next steps:
  assessment: energy balance, average demand, costs, environment

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Forschungsgesellschaft mbH
Source: http://www.igb.fraunhofer.de/www/presse/bilder/download bis2000/IGB_Alge2.jpg
Maria Hingsamer
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www.joanneum.at
Elisabethstraße 5/I
8010 Graz, Austria
www.joanneum.at
25
INNOVATION aus TRADITION

## HYVOLUTION – Biological Production of Hydrogen from Biomasses: Process Balances and Process Integration

Walter Wukovits , Domenico Foglia, Anton Friedl

Vienna University of Technology, Institute of Chemical Engineering,
Getreidemarkt 9/166-2, 1060 Vienna, Austria

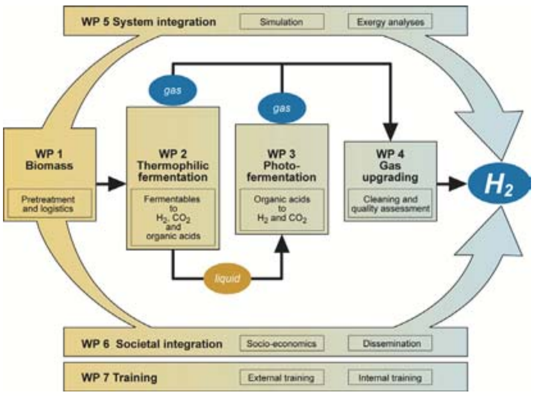
wwukov@mail.zserv.tuwien.ac.at


Highlights der Bioenergieforschung
March 31st, 2011, Wieselburg, Austria

TU WIEN TVT www.thvt.at

Hyvolution

## Project Structure




**HYVOLUTION**

**Non-thermal production of pure hydrogen from biomass**

**IP, 6th FP**

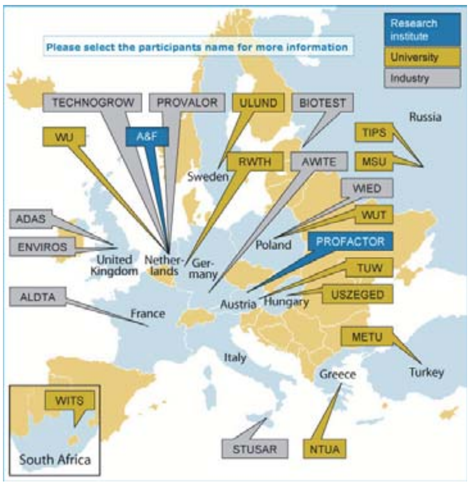
**2006 – 2011**

**14 M€ budget**

**www.hyvolution.nl**

Hyvolution

## Project Partners




- **22 Partners**
  - **11 University**
  - **2 Research Intitutes**
  - **9 Industry/SME**
- **13 Countries**
  - **10 EU**
  - **Turkey**
  - **Russia**
  - **South Africa**
- **2 Partners from Austria (TU-Wien, Profactor)**

Hyvolution

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# HYVOLUTION – Biological production of hydrogen from biomasses: process balances and process integration

*Walter Wukovits, Domenico Foglia, Anton Friedl, TU Wien – VT*

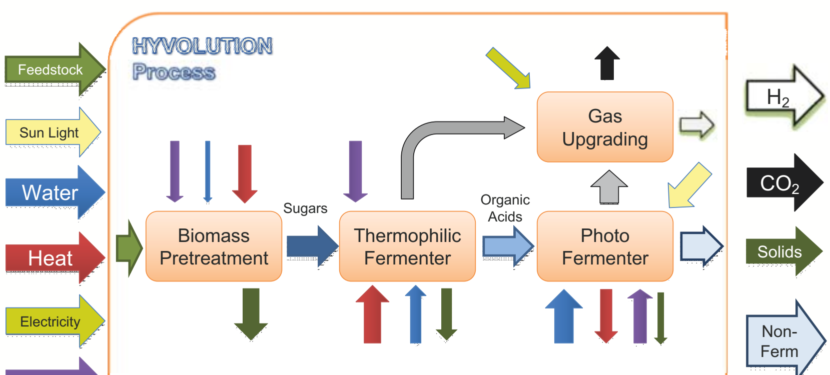
## Project Objectives / Project Goals

- Selection of suitable feedstock and development of dedicated pre-treatment procedures
- Identification of bottlenecks for hydrogen production in microorganisms
- Optimization of fermentation conditions and scale-up of bioreactors
- Development of gas-upgrading concept
- Detailed mass, energy and exergy balances of overall process
- Plant layout, process control concept as well as risk and safety analysis for Hyvolution plant
- Estimation of hydrogen production costs
- Environmental and socio-economic impact of Hyvolution plant

## Process Simulation / Process Integration

- Process simulation to provide
  - Mass balances
  - Energy balances
- Integration of single process steps to HYVOLUTION process to
  - Maximize product output
  - Minimize energy demand
  - Minimize cost
- Selection of the optimum route for overall HYVOLUTION process by applying
  - Process simulation and exergy analyses
  - Process integration and pinch technology
  - Process engineering
  - Cost estimation

## HYVOLUTION – Overall Process




$$C_6H_{12}O_6 + 2\,H_2O \rightarrow 2\,CH_3COOH + 4\,H_2 + 2\,CO_2$$

$$CH_3COOH + 2\,H_2O + light \rightarrow 4\,H_2 + 2\,CO_2$$

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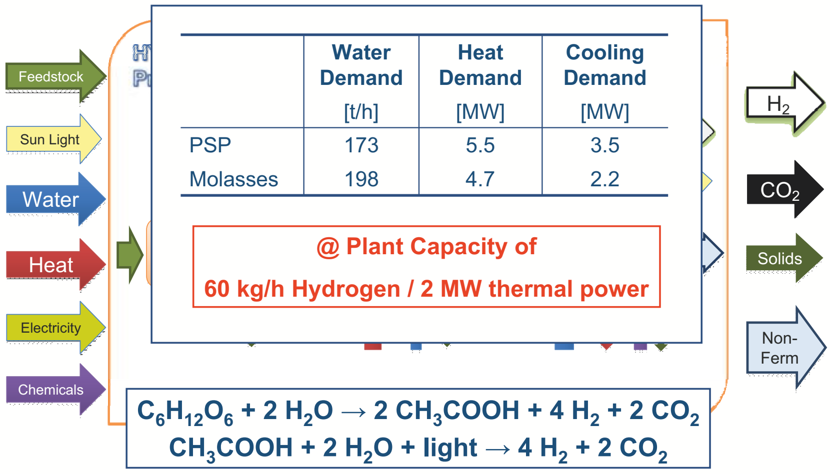
## HYVOLUTION – Overall Process

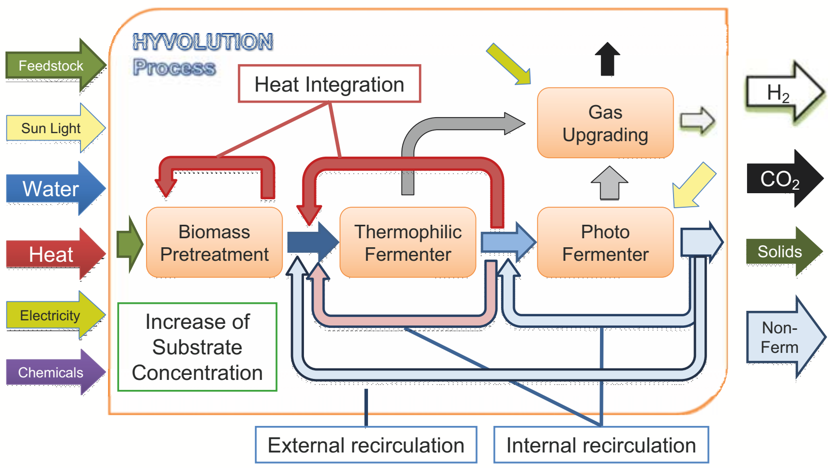



| | Water Demand [t/h] | Heat Demand [MW] | Cooling Demand [MW] |
|---|---|---|---|
| PSP | 173 | 5.5 | 3.5 |
| Molasses | 198 | 4.7 | 2.2 |

**@ Plant Capacity of 60 kg/h Hydrogen / 2 MW thermal power**

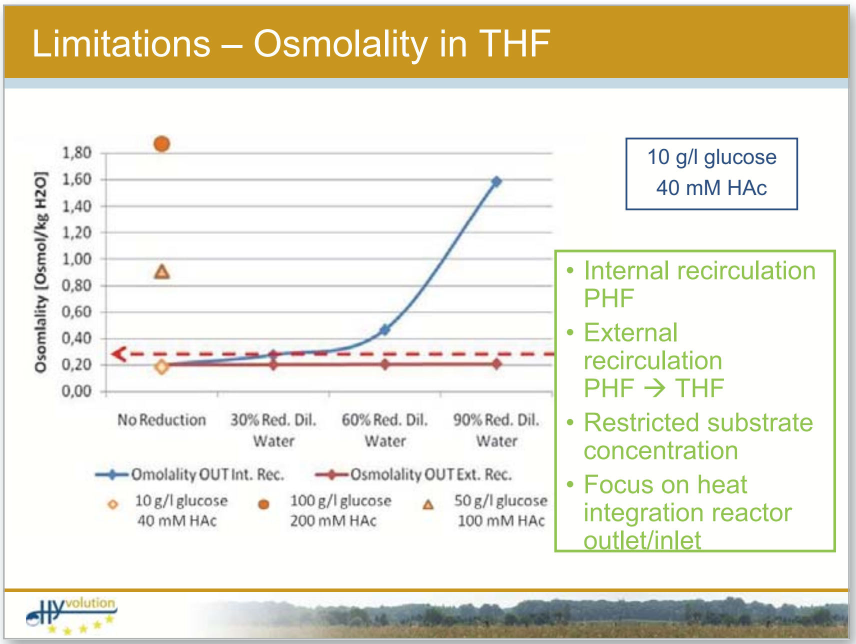
$$C_6H_{12}O_6 + 2\,H_2O \rightarrow 2\,CH_3COOH + 4\,H_2 + 2\,CO_2$$
$$CH_3COOH + 2\,H_2O + light \rightarrow 4\,H_2 + 2\,CO_2$$

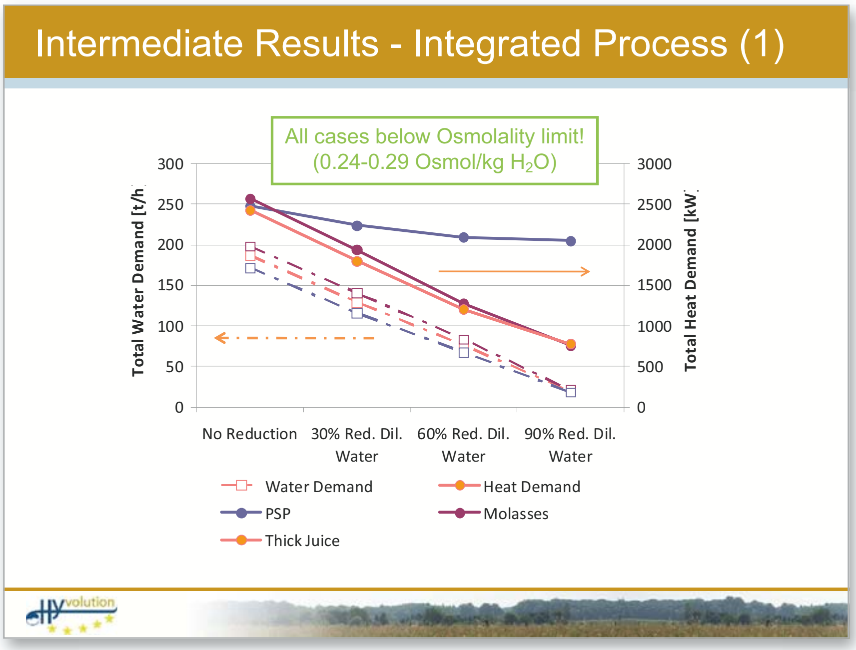
## Integration Options

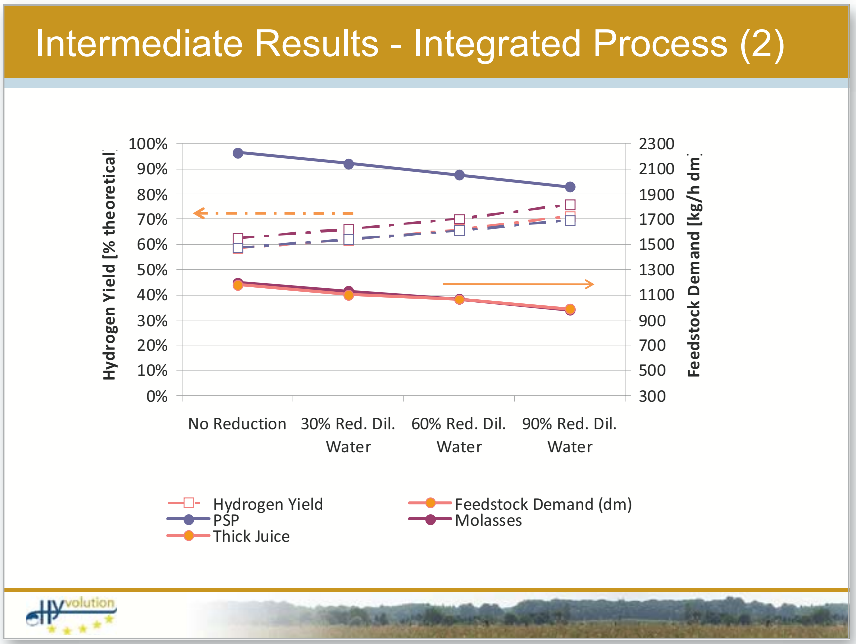



## Assumed Process Conditions (Engineering)

| | |
|---|---|
| Plant capacity | 60 kg/h Hydrogen |
| Hydrogen purity | 97 % (vol) |
| Feestock | PSP, Molasses, Thick Juice, Barley Straw |
| Gas-Upgrading | VSA |
| Hydrogen losses | 10 % (vol) |
| Substrate conversion to Hydrogen THF / PHF | 80 / 60 % (wt) |
| Substrate conversion to Cell Mass THF / PHF | 15 / 15 % (wt) |
| Substrate losses THF / PHF | 5 / 5 % (wt) |
| Temperature THF / PHF | 70 / 30 °C |
| Substrate concentration THF / PHF | 10 g/l Sugar / 40 mM Acetate |
| pH THF / PHF | 6.5 / 7.3 |


Limitations – Osmolality in THF
Osomlality [Osmol/kg H2O]
1,80
1,60
1,40
1,20
1,00
0,80
0,60
0,40
0,20
0,00
No Reduction
30% Red. Dil. Water
60% Red. Dil. Water
90% Red. Dil. Water
Omolality OUT Int. Rec.
Osmolality OUT Ext. Rec.
10 g/l glucose 40 mM HAc
100 g/l glucose 200 mM HAc
50 g/l glucose 100 mM HAc
10 g/l glucose
40 mM HAc
• Internal recirculation PHF
• External recirculation PHF → THF
• Restricted substrate concentration
• Focus on heat integration reactor outlet/inlet
HYvolution


Intermediate Results - Integrated Process (1)
All cases below Osmolality limit!
(0.24-0.29 Osmol/kg H2O)
Total Water Demand [t/h]
300
250
200
150
100
50
0
Total Heat Demand [kW]
3000
2500
2000
1500
1000
500
0
No Reduction
30% Red. Dil. Water
60% Red. Dil. Water
90% Red. Dil. Water
Water Demand
Heat Demand
PSP
Molasses
Thick Juice
HYvolution


Intermediate Results - Integrated Process (2)
Hydrogen Yield [% theoretical]
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Feedstock Demand [kg/h dm]
2300
2100
1900
1700
1500
1300
1100
900
700
500
300
No Reduction
30% Red. Dil. Water
60% Red. Dil. Water
90% Red. Dil. Water
Hydrogen Yield
Feedstock Demand (dm)
PSP
Molasses
Thick Juice
HYvolution

## Actual Results – „Engineering" Parameters

| | | PSP | Thick Juice | Molasses | Barley Straw |
|---|---|---|---|---|---|
| Feedstock Demand | t/h | 17.6 | 1.1 | 1.5 | 1.9 |
| Water Demand | t/h | 74.6 | 80.4 | 80.7 | 93.0 |
| Heat Demand | MW | 0.92 | 0.74 | 0.74 | 0.96 |
| Enzyme Demand | kg/h | 0.93 | - | - | 629 |
| KOH Demand | kg/h | 335 | 310 | 265 | 333 |
| Buffer Demand | kg/h | 273 | 250 | 221 | 283 |

Assuming no heat demand in PHF
Rearrangement of Heat Integration

"Engineering" Assumptions:

- Conversion PTR: PSP 90% / Barley Straw 45%
- Conversion to $H_2$ in THF: 80%
- Conversion to $H_2$ in PHF: 60%

## Comparison Molasses (Eng. / Real)

| | | Molasses (Eng.) | Molasses (Real/wild) | Molasses (Real/hup-) |
|---|---|---|---|---|
| Feedstock Demand | t/h | 1.5 | 1.6 | 1.3 |
| Water Demand | t/h | 80.7 | 109.0 | 71.6 |
| Heat Demand | MW | 0.74 | 0.89 | 0.74 |
| Enzyme Demand | kg/h | - | - | - |
| KOH Demand | kg/h | 265 | 403 | 310 |
| Buffer Demand | kg/h | 221 | 337 | 221 |

Conversion THF (%) : 80 → 85 → 85
Productivity THF (mmol/l*h): 20 → 16 → 16
Conversion PHF (%) : 60 → 40 → 70
Productivity PHF (mmol/l*h): 0.5 → 0.6 → 0.9

## Simulation / Integration - Summary / Outlook

- Process Simulation allows a clear view of the potential of HYVOLUTION process
- A proper recirculation setup allows reduction of water demand without comprising the osmotic pressure
- Recirculation improves heat balance and overall biomass to hydrogen conversion
- Heat integration in THF and PTR reduces considerably the heat demand (by 85% and 30%, respectively)

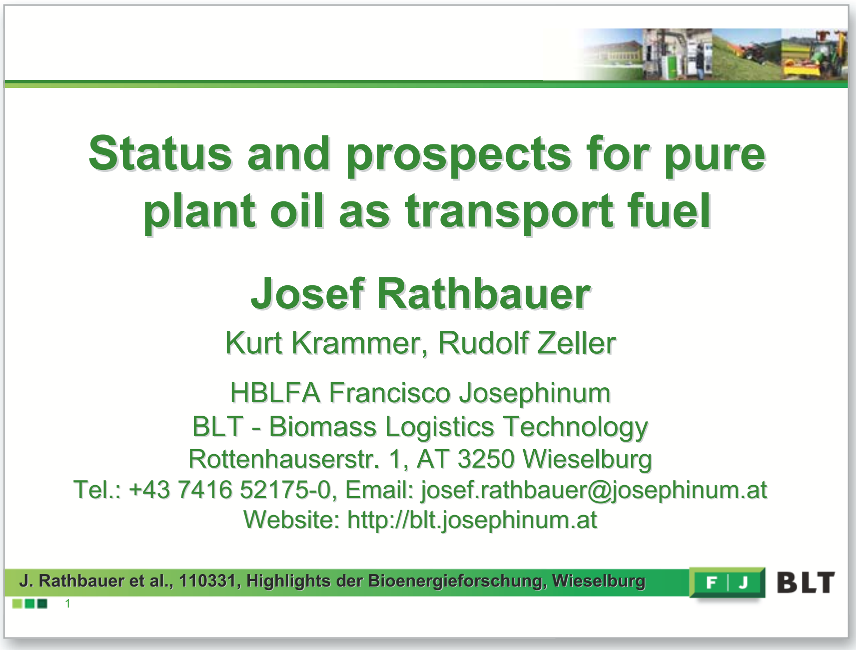
- Improvment of productivites in both fermentors
- Reduction enzyme (Barley Straw) and chemical demand
- Covering heat demand from residues

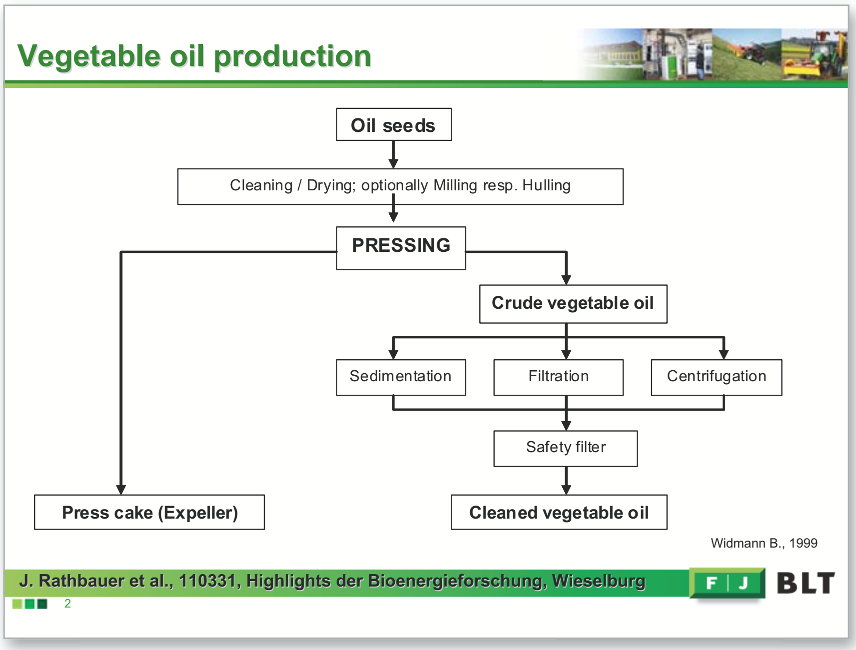

Partners and Acknowledgement
AGROTECHNOLOGY & FOOD INNOVATIONS
WAGENINGEN UR
AIR LIQUIDE
Awite
National Technical University of Athens
N.T.U.A.
Provalor
produkt valorisatie
RWTH AACHEN UNIVERSITY
TU WIEN
TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology
LUNDS UNIVERSITET
WIEDEMANN POLSKA
We gratefully acknowledge the support of the project by the European Union's 6th Framework Program (Hyvolution, Contract-No 019825).
Hyvolution

## Developments for Pure Plant Oil, Biodiesel and Biogas
***Chair: Kurt Pollak**, New Energies and Strategies*

# Status and prospects for pure plant oil as transport fuel

***Josef Rathbauer**, FJ-BLT*

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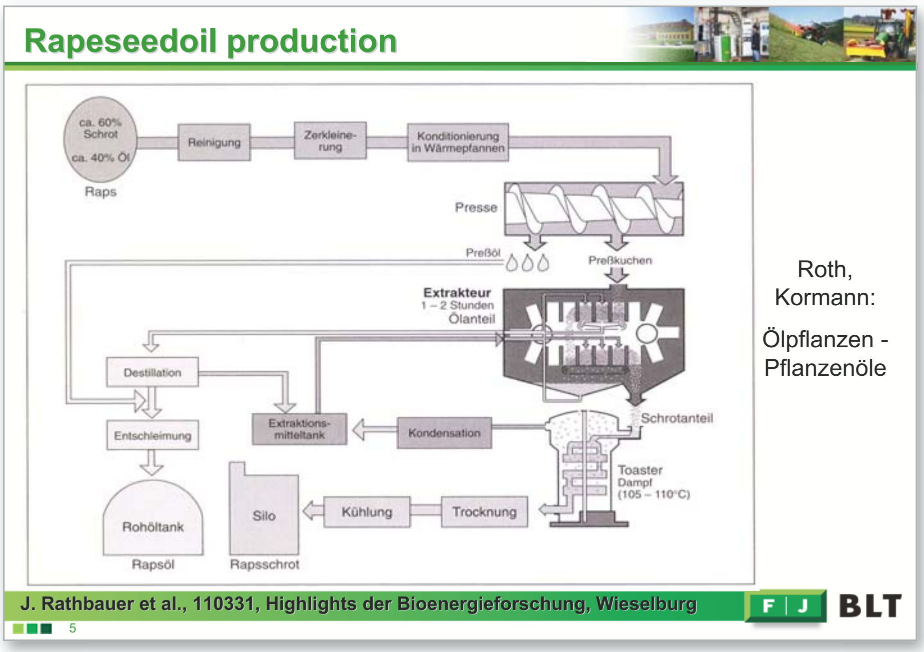


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## Comparison of properties

### Properties of different fuels for diesel engines

| | Unit | Diesel | Rape-seedoil | Rapeseed-oilmethylester |
|---|---|---|---|---|
| Calorific value | MJ/kg | 42,4 | 37,6 | 37,2 |
| Density at 20°C | kg/dm³ | 0,83 | 0,92 | 0,88 |
| Calorific value per vol. | MJ/l | 35,2 | 34,6 | 32,7 |
| Viscosity at 20°C | mm²/s | 5 | 70 | 7,2 |
| Flashpoint P.M. | °C | > 55 | > 220 | > 100 |
| Ignitability | CN | > 51 | --- | > 51 |

J. Rathbauer et al., 110331, Highlights der Bioenergieforschung, Wieselburg — F | J BLT
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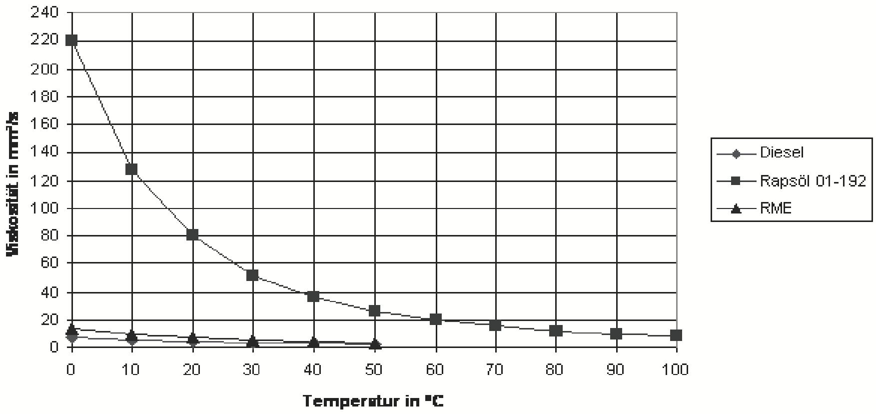
## Kinematic Viscosity: DK, RO, RME

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## Standardisation

### Parameters and limits for pure vegetable oil fuel

| Parameter | Unit | Öst. Kraftstoff-Verordnung, 11/2004 | DIN V 51605: 2006-07 Rapeseedoil |
|---|---|---|---|
| Density at 15°C | kg/m³ | 900 to 930 | 900 to 930 |
| Flashpoint P.M. | °C | ≥ 220 | ≥ 220 |
| Kinematic Viscosity at 40°C | mm²/s | ≤ 38 | ≤ 36 |
| Net Calorific Value | kJ/kg | ≥ 35.000 | ≥ 36.000 |
| Ignitability | --- | --- | ≥ 39 |
| Conradson Carbon Residue | % | ≤ 0,4 | ≤ 0,4 |
| Iodine Number | g I/100 g | 100 to 120 | 95 to 125 |
| Sulfur Content | mg/kg | ≤ 10 | ≤ 10 |
| Total Contamination | mg/kg | ≤ 25 | ≤ 24 |
| Acid Value | mg/KOH/g | ≤ 2,0 | ≤ 2,0 |
| Oxidation Stability | h | ≥ 5 | ≥ 6 |
| Phosphorous Content | mg/kg | ≤ 15 | ≤ 12 |
| Content of Mg & Ca | mg/kg | --- | ≤ 20 |
| Ash Content | % | ≤ 0,01 | ≤ 0,01 |
| Water Content | % | ≤ 0,075 | ≤ 0,075 |

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## Standardisation

| DIN 51605: 2010-09 | | | |
|---|---|---|---|
| Fuels for vegetable oil compatible combustion engines - Fuel from rapeseed oil - Requirments and test methods | | | |
| Parameter | Unit | Limit min. | Limit max |
| Visual inspection | --- | free from visible contaminations and sediments and free water | |
| Density at 15°C | kg/m³ | 910,0 | 925,0 |
| Kinematic Viscosity at 40°C | mm²/s | --- | 36,0 |
| Net Calorific Value | MJ/kg | 36,0 | --- |
| Iodine Number | g I/100 g | --- | 125 |
| Acid Value | mg/KOH/g | --- | 2,0 |
| Flashpoint P.M. | °C | 101 | --- |
| Ignitability | --- | 40 | --- |
| Oxidation Stability at 110°C | h | 6,0 | --- |
| Total Contamination | mg/kg | --- | 24 |
| Sulfur Content | mg/kg | --- | 10 |
| Phosphorous Content (till 31st Dec2011 \| 1st Jan 2012) | mg/kg | --- | 12 \| 3,0 |
| Content of Mg & Ca (till 31st Dec2011 \| 1st Jan 2012) | mg/kg | --- | 20 \| 1,0 each |
| Water Content | mg/kg | --- | 750 |

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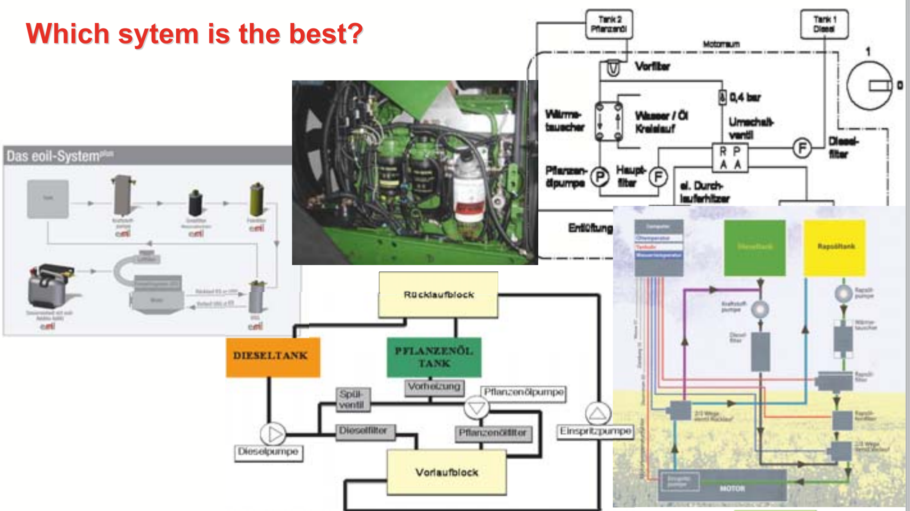
## Engine Adaptation

**Which sytem is the best?**

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## Use of vegetable oil in farm tractors

### Adaptation Systems and Suppliers

**One tank systems (Σ 18):**

**Waldland VWP 11; Hausmann 6; E-oil 1;**

**Two tanks systems (Σ 20):**

**Graml 12; Elsbett 3; Rapstruck 1; Jedinger 1; Green power 1; Gruber 1; Peck 1**

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## Engine oil

**Soot and rapeseedoil content from 1-Tank-systems approx. twice the values from the 2-Tanks-systems**

| 1-Tank | Soot [%] | Rapeseed-oil [%] | Rapeseed-oil [%] | Soot [%] | 2-Tanks |
|---|---|---|---|---|---|
| Average | 1,15% | 11,61% | 6,13% | 0,86% | Average |
| Median | 0,91% | 11,90% | 5,20% | 0,47% | Median |
| Maximum | 4,50% | 24,00% | 21,30% | 5,90% | Maximum |
| Minimum | 0,07% | 0,30% | 0,10% | 0,03% | Minimum |
| Number | 95 | 89 | 55 | 64 | Number |

**Fuchs´ statement: Up to 200 operating hours the engine oil quality was alright.**

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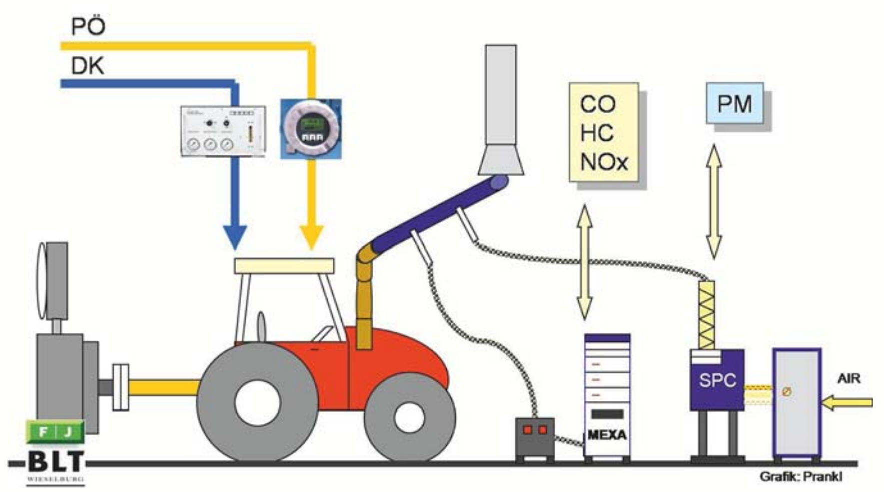
## Performance and Emissions

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## Performance and Emissions

**Change from Diesel to Rapeseedoil:**

- CO ⇩ (-11%)
- HC ⇩ (-50%)
- PM ⇩ (-33%)
- NOx ⇧ (+11%)

**Comparison final with initial results:**

- CO ⇧ (+22%)
- HC ⇨ (-3 … -9%)
- NOx ⇨ (-6 … -7%)

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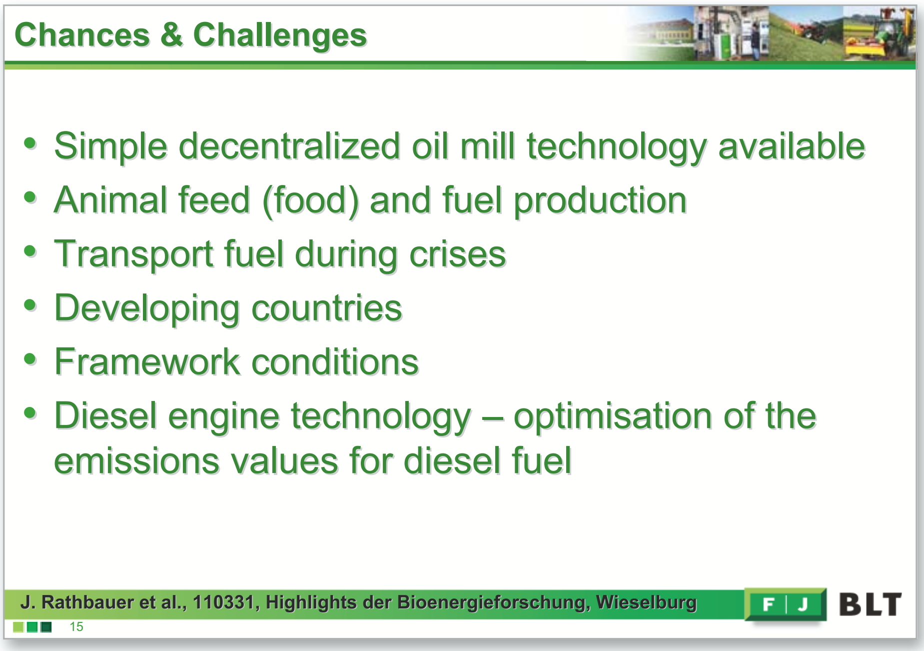
Chances & Challenges
• Simple decentralized oil mill technology available
• Animal feed (food) and fuel production
• Transport fuel during crises
• Developing countries
• Framework conditions
• Diesel engine technology – optimisation of the emissions values for diesel fuel
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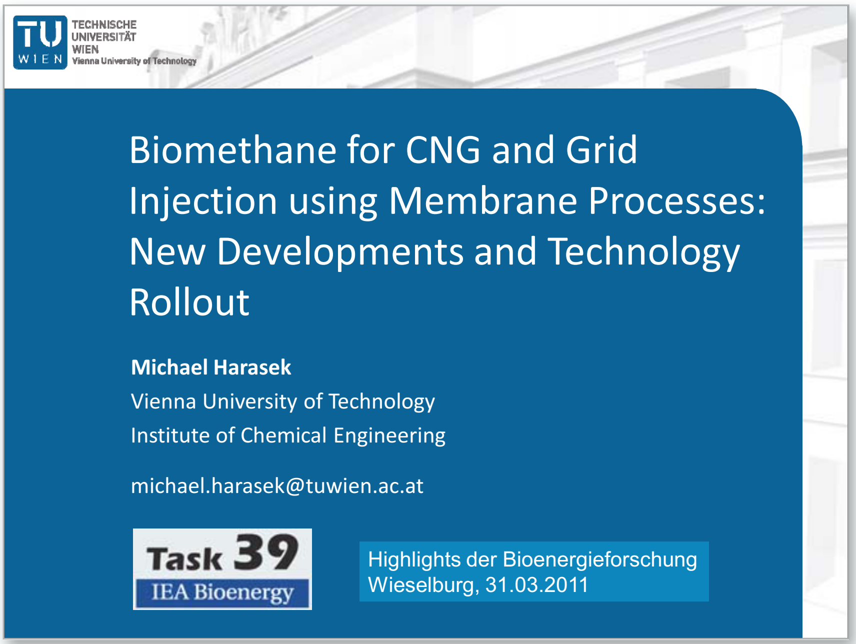
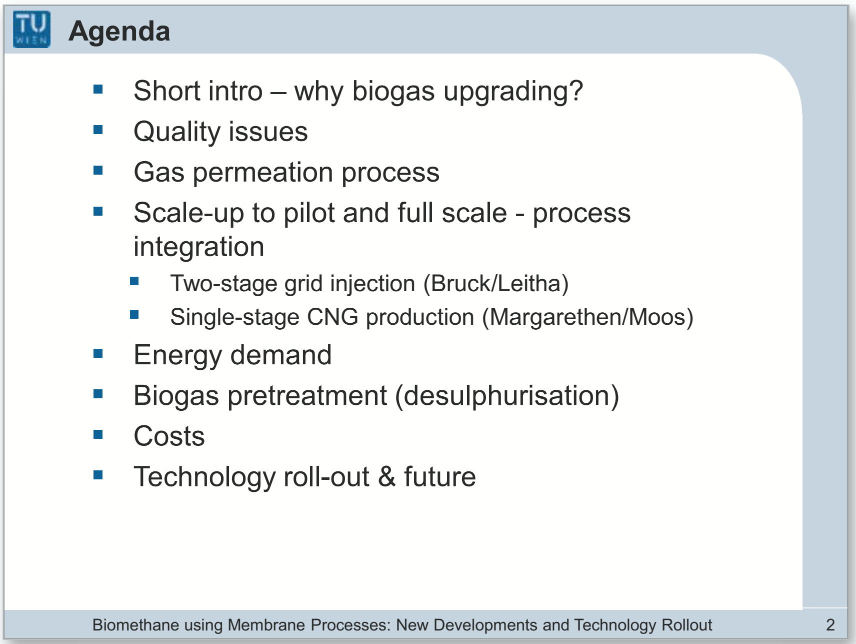
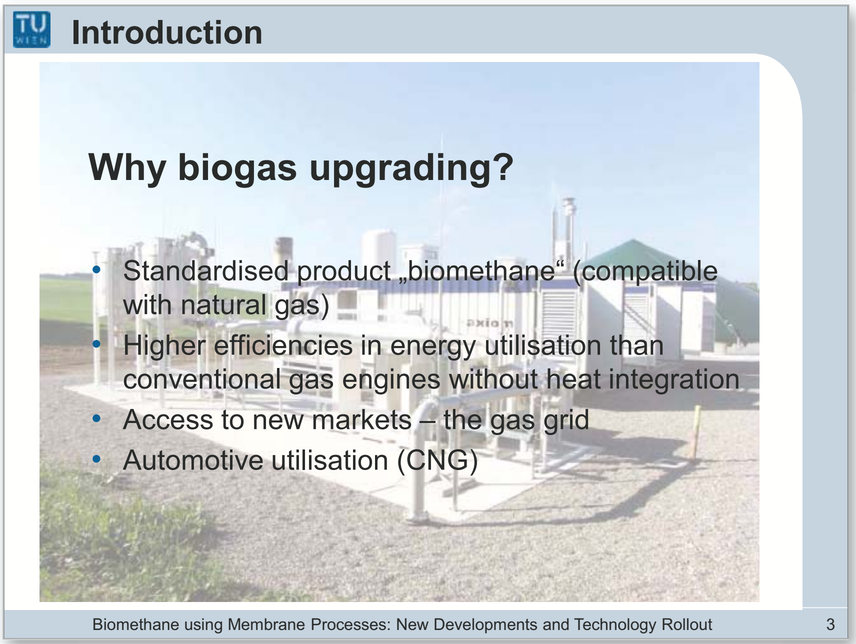

TU WIEN TECHNISCHE UNIVERSITÄT WIEN Vienna University of Technology
Biomethane for CNG and Grid Injection using Membrane Processes: New Developments and Technology Rollout
Michael Harasek
Vienna University of Technology
Institute of Chemical Engineering
michael.harasek@tuwien.ac.at
Task 39 IEA Bioenergy
Highlights der Bioenergieforschung
Wieselburg, 31.03.2011


Agenda
Short intro – why biogas upgrading?
Quality issues
Gas permeation process
Scale-up to pilot and full scale - process integration
Two-stage grid injection (Bruck/Leitha)
Single-stage CNG production (Margarethen/Moos)
Energy demand
Biogas pretreatment (desulphurisation)
Costs
Technology roll-out & future
Biomethane using Membrane Processes: New Developments and Technology Rollout
2


Introduction
Why biogas upgrading?
Standardised product „biomethane“ (compatible with natural gas)
Higher efficiencies in energy utilisation than conventional gas engines without heat integration
Access to new markets – the gas grid
Automotive utilisation (CNG)
Biomethane using Membrane Processes: New Developments and Technology Rollout
3

## Biogas Composition and Gas Grid Standards

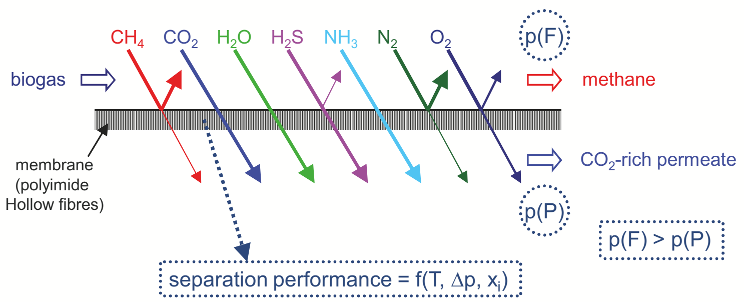
| Parameter | Biogas | Quality according to Austrian Standard ÖVGW G31 / G33 | Unit |
|---|---|---|---|
| Methane ($CH_4$) | 50 - 65 | >97 | [%] |
| Carbon dioxide ($CO_2$) | 25 - 45 | ≤ 2,0 | [%] |
| Ammonia ($NH_3$) | < 1.000 | technically free | [mg/m³] |
| Hydrogen sulphide ($H_2S$) | < 2.000 | ≤ 5 | [mg/m³] |
| Oxygen ($O_2$) | < 2 | ≤ 0,5 | [%] |
| Nitrogen ($N_2$) | ≤ 8 | ≤ 5 | [%] |
| Water ($H_2O$) - Dewpoint | < 37 @ 1 bar | ≤ - 8 bei 40 bar | [°C] |
| **Upper Heatinhg value** | 6,7 - 8,4 | 10,7 - 12,8 | kWh/m³ |
| **Wobbe-Index** | 6,9 - 9,5 | 13,3 - 15,7 | kWh/m³ |

**ÖVGW G31** defines natural gas, **ÖVGW G33** specifies grid injection standards for biogases



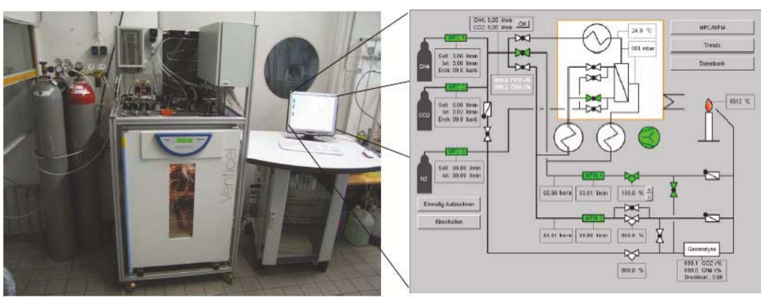
## Upgrading of Biogas using Gas Permeation (GP)

- Separation principle: different permeabilities of methane and components to be separated.
- Important parameter: permeability ratio = selectivity.
- After compression biogas is fed to membrane modules.






## Membrane Test Equipment at TU Wien



- Preparation of $CO_2/CH_4/N_2$ gas mixtures with mass flow controllers
- Thermostatic chamber
- Industrial NDIR gas analyzer for $CO_2$ and $CH_4$
- Test control, visualization and data collection using a PLC with HMI/SCADA system



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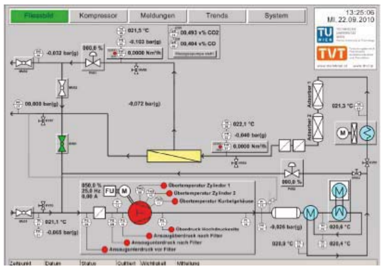
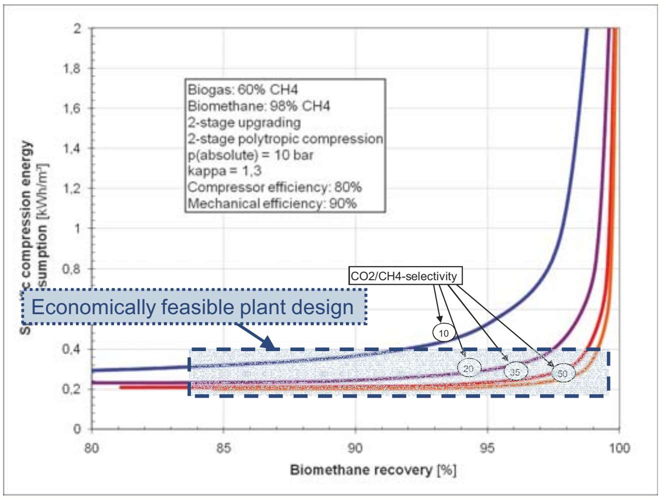
## Pilot Test Equipment at TU Wien



- Mobile pilot plant for flexible treatment of many gas mixtures including $H_2$
- Magnet-coupled two-stage piston compressor (up to 15 bar, 0-6 m³/h)
- Fully automated upgrading plant for remote operation (industrial PLC)
  - 3 adsorber fillings in series
  - Cryo condenser
  - Reheater
  - One/two stage membrane separation with/without gas recycling
  - NDIR online continuous gas

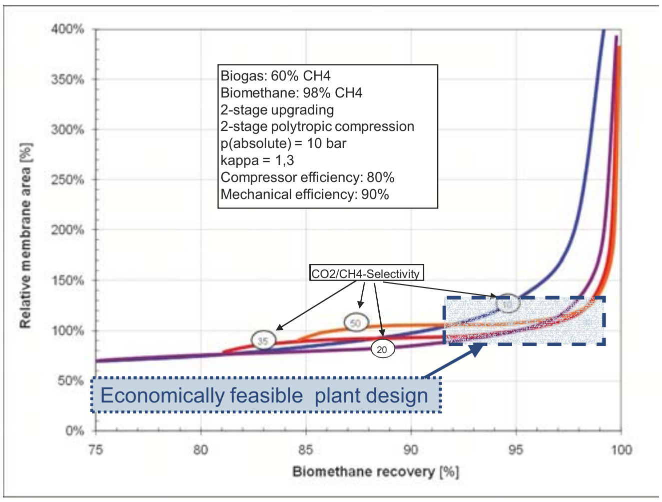
Biomethane using Membrane Processes: New Developments and Technology Rollout 7

## Compression Energy Consumption per m³ Product




Biomethane using Membrane Processes: New Developments and Technology Rollout 8

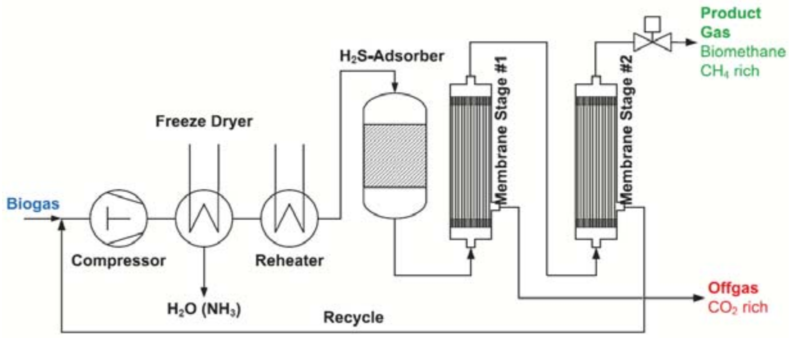
## Membrane Area as Function of Recovery




Biomethane using Membrane Processes: New Developments and Technology Rollout 9

## Process Scheme of a Two-stage Membrane System

- **Two-stage separation process** with recycle and a single compressor

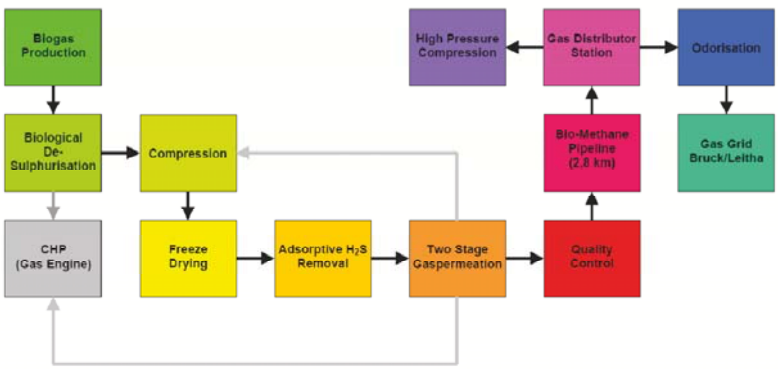



Biomethane using Membrane Processes: New Developments and Technology Rollout 10

## Biogas Upgrading Plant in Bruck/Leitha (Austria)

Biomethane using Membrane Processes: New Developments and Technology Rollout 11

## Process Integration (Two-stage design)




- **Biological desulphurisation prior to membrane treatment**
- **Permeate is recycled to CHP plant – „zero methane" emission of upgrading system**

Biomethane using Membrane Processes: New Developments and Technology Rollout 12

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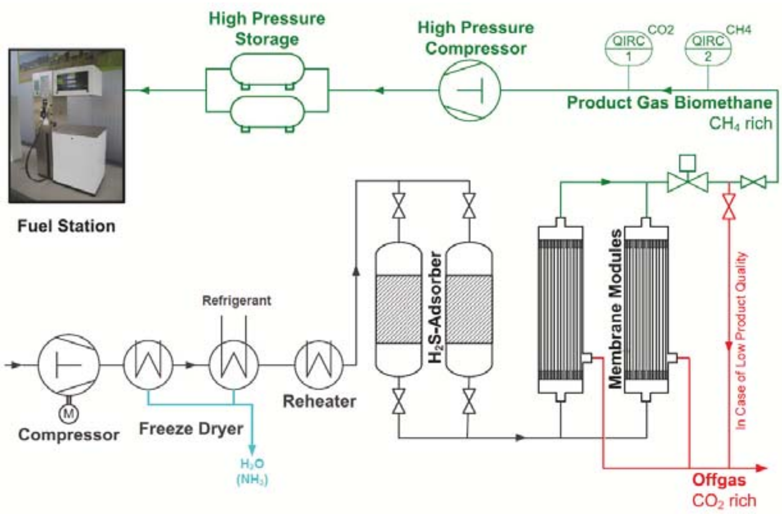
## Energy Consumption Analysis

- **Main energy consumer of upgrading is the raw biogas compressor.**
- Energy demand for constant product gas quality and quantity depends also on raw biogas methane content.
- **Effect of plant layout** (number of stages) on energy consumption:
  - **Two stage gas grid injection plant:** 0,378 kWh/m³STP of product gas
  - **Single stage Bio-CNG-plant:** 0,280 kWh/m³STP of product gas
- Energy consumption of **<0,2 kWh/m³ STP of raw biogas** possible!
- Related to the methane content of the produced biomethane gas stream:
  - **Two stage gas grid injection plant:** 3,2% (98,1vol% CH4)
  - **Single stage Bio-CNG-plant:** 2,8% (96,1vol% CH4)
- All values are valid for a product gas delivery pressure of about 3 bar(g).



## Biomethane Fuel Station: Single Stage Upgrading

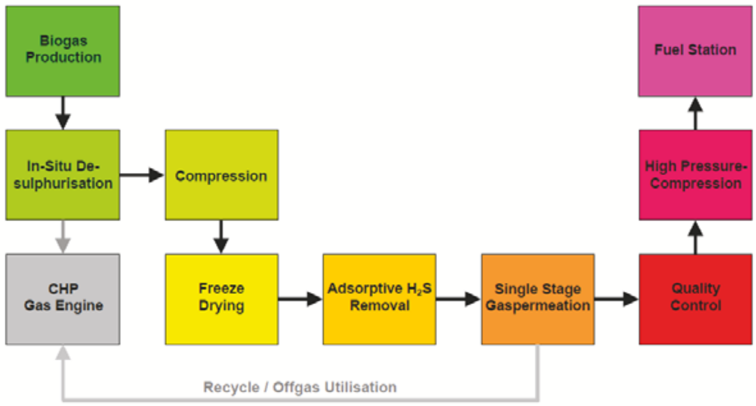





## Biomethane Fuel Station using Membrane Technology


- Permeate recycle to CHP plant
- Further information: **www.methapur.com**
  Biomethane fuel station Margarethen/Moos

## Process Integration (Margarethen am Moos)

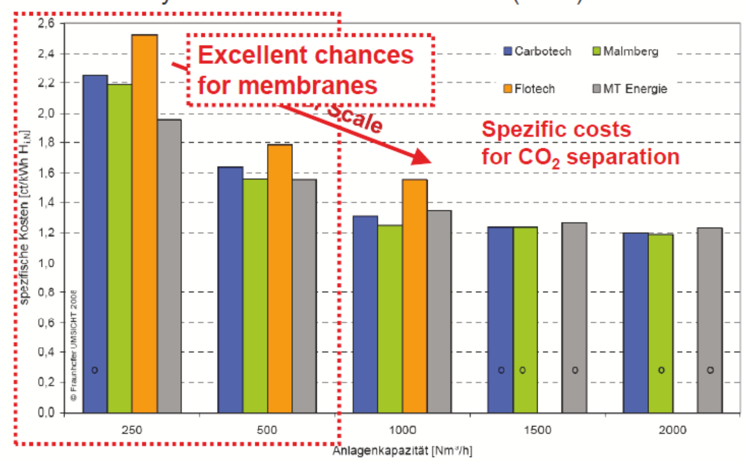



- **In-situ desulphurisation (addition of iron salts into the fermentation broth to catch suphides)**
- **Permeate is recycled to CHP plant – „zero methane" emission of upgrading system**

Biomethane using Membrane Processes: New Developments and Technology Rollout 16

## Costs for $CO_2$ Separation

Calculations by Fraunhofer Institut UMSICHT (2008)




Biomethane using Membrane Processes: New Developments and Technology Rollout 17

## Offgas Treatment & Costs

- **Offgas treatment** depends on process integration:
  - Mixing with biogas and utilisation in CHP plants
  - Thermal oxidation (flameless oxidation systems or direct combustion of low-cal gas)
  - Catalytic oxidation
  - Further treatment using additional membrane separation stage
- **Specific costs of upgrading** (depends on plant capacity):
  - **Investment** (depreciation 10 years, 8%):
    **0,05 – 0,08 €/m³ biomethane**
  - **Operation** (> 8000 h/a):
    **0,10 – 0,14 €/m³ biomethane**

Biomethane using Membrane Processes: New Developments and Technology Rollout 18

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## Compatible Desulphurisation Technologies


**Compatible:**

- External biological desulphurisation in combination with pure oxygen injection
- In-situ desulphurisation using iron salts
- **External chemical scrubber with oxidation using $NaOH/H_2O_2$, recommended for fluctuating $H_2S$ concentrations in the biogas**
- Adsorptive desulphurisation technologies with low excess of $O_2$ (impregnated activated carbon adsorbents)

**Not suitable / incompatible:**

- Air injection
- External biological desulphurisation with air injection



## Reference Plants


**In operation:**

- since 2004: Pilot plants (up to 6 m³/h biogas, Vienna University of Technology)
- 2007: Bruck an der Leitha (180 m³/h biogas, 100 m³/h biomethane)
- 2007: Margarethen am Moos (80 m³/h biogas, 35 m³/h bio-CNG)
- Start-up 05/2010: Kißlegg / Baden-Württemberg, Germany (500 m³/h biogas)

**Start-up:**

- Feed-in operation starts in 03/2011: Wiener Neustadt (220 m³/h biogas)

**Supplier:**

Axiom Angewandte Prozesstechnik GmbH

axiom



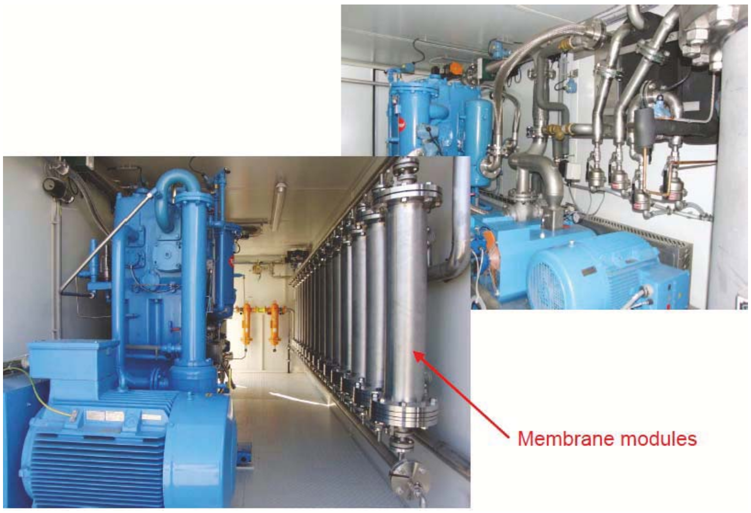
## Recent Start-up of First AXIOM Plant in Germany

- Capacity 500 m³/h biogas, 300 m³/h biomethane, approx. 8 km pipeline for grid injection and high pressure compression to 60 bar

## Recent Start-up of First AXIOM Plant in Germany

Biomethane using Membrane Processes: New Developments and Technology Rollout 22

## Recent Start-up of First AXIOM Plant in Germany




Biomethane using Membrane Processes: New Developments and Technology Rollout 23

## Recent Start-up of First AXIOM Plant in Germany



Biomethane using Membrane Processes: New Developments and Technology Rollout 24

## Further Information…

- Contact & WWW:
  michael.harasek@tuwien.ac.at
  www.virtuellesbiogas.at
  bio.methan.at
- Technology (turn key plants):
  **Axiom Angewandte Prozesstechnik GmbH**
  office@axiom.at

Construction site of upgrading plant in Wiener Neustadt (Lower Austria)

Thank you for your attention!

Biomethane using Membrane Processes: New Developments and Technology Rollout 25

## Biomethane for CNG and Grid Injection using Membrane Processes:  NewDevelopments and Technology Rollout

*Michael Harasek, TU Wien – VT*

# JOANNEUM RESEARCH Forschungsgesellschaft mbH

Environmental Assessment of Biomethane Injected into the Gas Grid

Johanna Pucker, Gerfried Jungmeier, Christian Leonhartsberger, Daniel Schinnerl, Jan Bleyl

Transportation Biofuels Research in Austria 2011

Wieselburg, 2011-03-31

*The work for this presentation was conducted in the Austrian project "Biogas" which is financed by the Austrian "Klima- und Energiefonds" and is carried out within the framework of the programme "Energiesysteme der Zukunft".*

INNOVATION aus TRADITION

## Content

- Background information
- Project „Biogas Gesamtbewertung"
- Modeling
- Results
- Conclusions

2

## Emissions in Agriculture in Austria

- Greenhouse gas emissions (2008):
  - 8.8% of total GHG emissions
  - 72% of total $N_2O$ emissions
    - Use of fertilizers on agricultural soils
  - 62% of total $CH_4$ emissions
    - Enteric fermentation
    - Manure management
- Air pollutants (2008):
  - 92% of total $NH_3$ emissions
    - Livestock breeding and manure management
    - Use of fertilizers on agricultural soils



4

*Johanna Pucker, Joanneum Research – Resources*

## „Biogas Gesamtbewertung“

- Environmental, economic and socio-scientific assessment of biogas from the gas grid used as transport fuel and in stationary applications
- Work packages

| | |
|---|---|
| 1 | Cost and potential analysis of biomass production and fermentation |
| 2 | Environmental assessment of biomethane energy services |
| 3 | Economic analysis and assessment of biomethane energy services |
| 4 | Social science analysis of framework conditions for implementation |
| 5 | Analysis of agricultural and energy policy |
| 6 | Energy market perspectives of biomethane |
| 7 | Macro economic analysis: employment, fiscal and foreign trade balance |

*The project is financed by the Austrian "Klima- und Energiefond" and is carried out within the framework of the program "Energiesysteme der Zukunft".*

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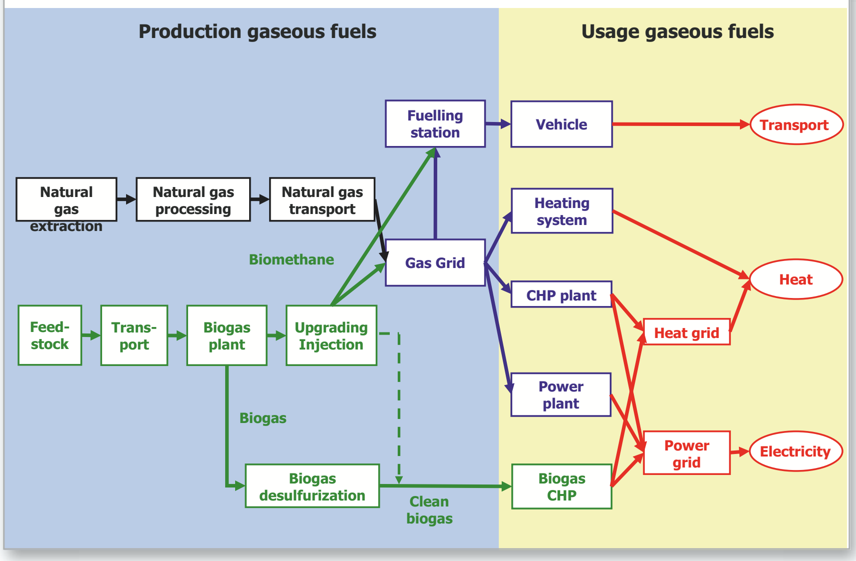
## Overview biomethane path




## Investigated production paths

- 15 different production paths investigated
- Results presented focus on 5 production paths

| Name [Capacity injection, share feedstock] | Feedstock | Biogas production [Nm³/h] | Upgrading technology |
|---|---|---|---|
| 600 Nm³/h_85% energy crop rotation+15% manure | corn, triticale, green rye, sunnflower, cattle manure | 1,500 | pressurized water washer |
| 400 Nm³/h_100% residues | foul food, lecithin, grease seperator, sugar beet residues, vegetable residues, kitchen residues | 800 | gas permeation |
| 130 Nm³/h_52% Int. crop rotation+6% straw + 43% manure* | corn straw, sunflower straw, clover gras silage , corn silage, green rye silage, pig manure | 450 | amine gas treating |
| 22 Nm³/h_50% gras+50% manure | gras, cattle manure | 45 | pressure swing adsorption (PSA) |
| 20 Nm³/h_25% pig manure+75% cattle manure | cattle and pig manure | 45 | pressure swing adsorption (PSA) |

* future technology

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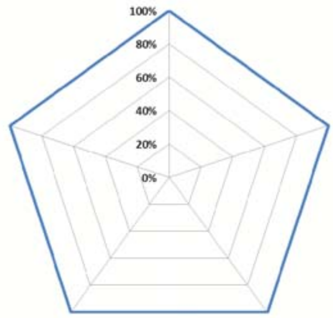
# Investigated environmental impacts

Greenhouse gas emissions




Fossil primary energy use

Acidification potential

Particulate Emissions

Ozone creation potential

9

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# Content

- Background information
- Project „Biogas Gesamtbewertung“
- Modeling
- Results
- Conclusions

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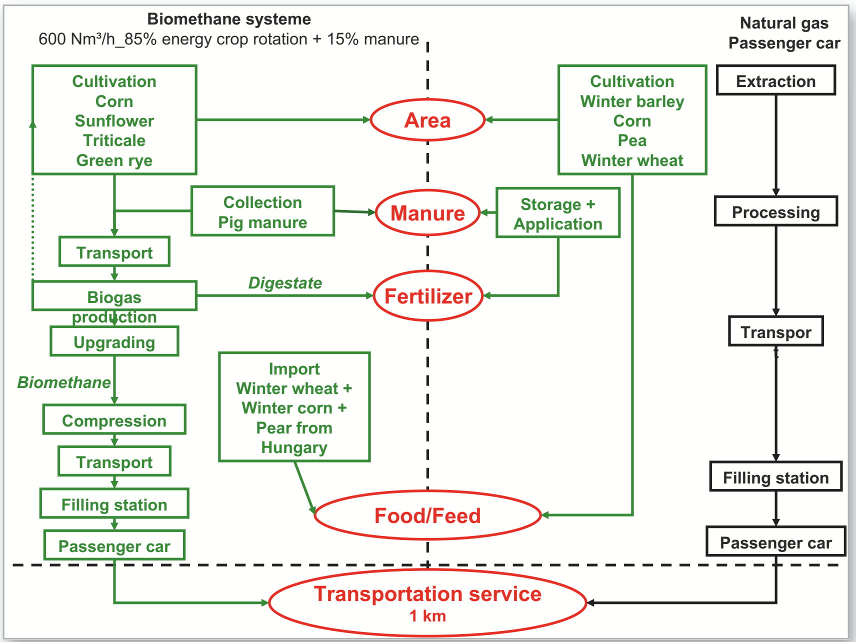

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## Content

- Background information
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- **Results**
- Conclusions

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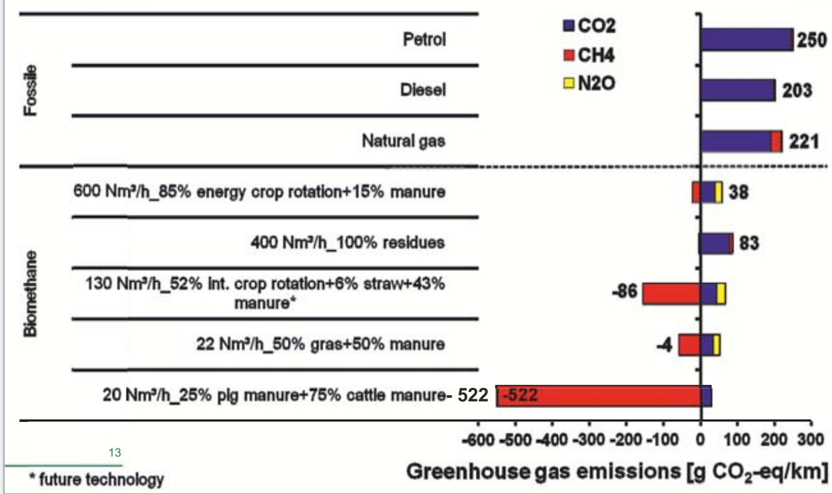
## Greenhouse gas emissions
### biomethane as transportation fuel

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* future technology

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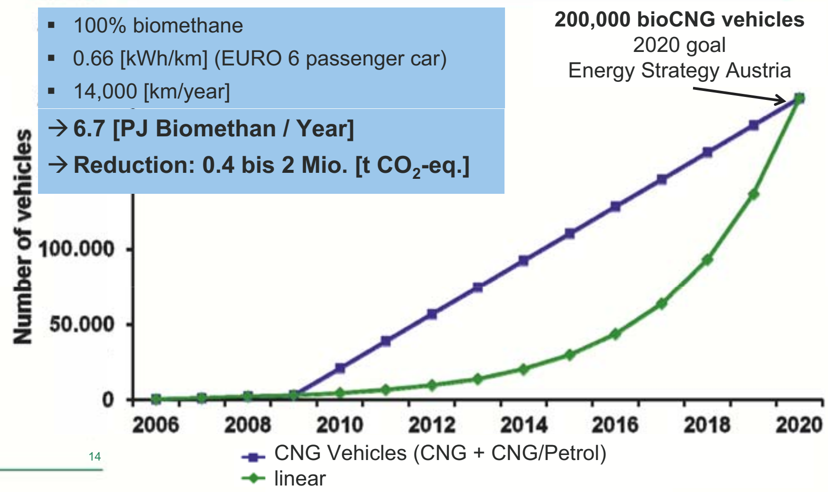
## GHG reduction potential with 200,000 bioCNG vehicles

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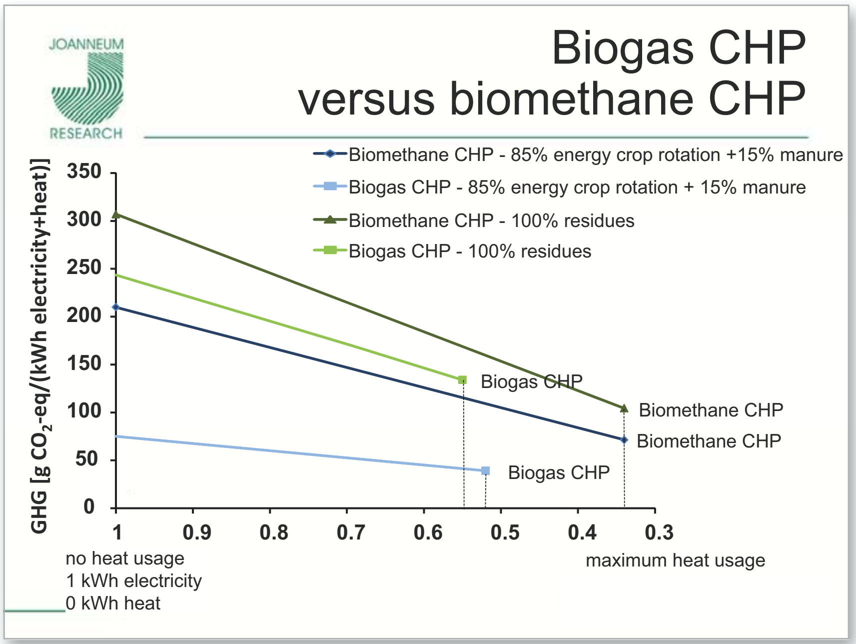
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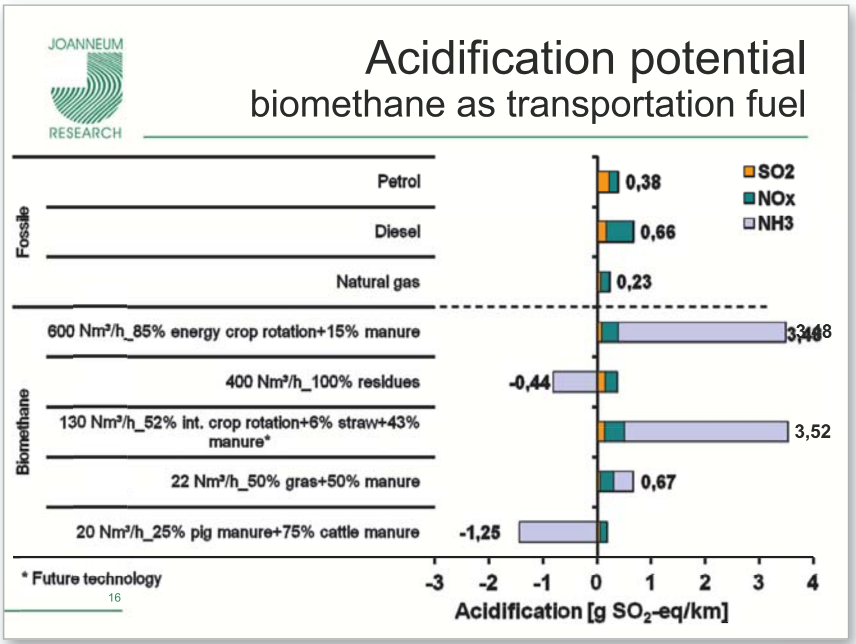
Biogas CHP versus biomethane CHP
Biomethane CHP - 85% energy crop rotation +15% manure
Biogas CHP - 85% energy crop rotation + 15% manure
Biomethane CHP - 100% residues
Biogas CHP - 100% residues
GHG [g CO2-eq/(kWh electricity+heat)]
350
300
250
200
150
100
50
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
Biogas CHP
Biomethane CHP
Biomethane CHP
Biogas CHP
no heat usage
1 kWh electricity
0 kWh heat
maximum heat usage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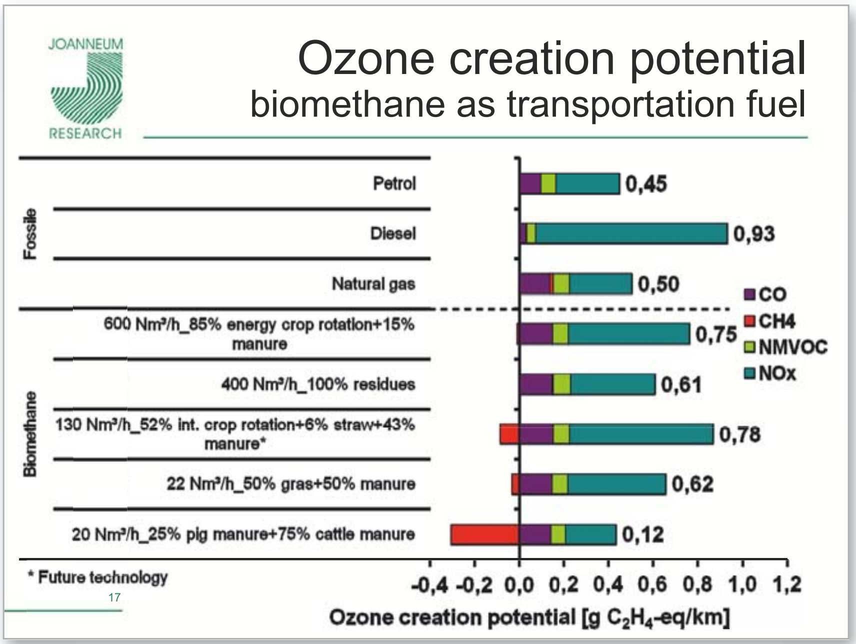
Acidification potential
biomethane as transportation fuel
Fossile
Petrol
Diesel
Natural gas
Biomethane
600 Nm³/h_85% energy crop rotation+15% manure
400 Nm³/h_100% residues
130 Nm³/h_52% int. crop rotation+6% straw+43% manure*
22 Nm³/h_50% gras+50% manure
20 Nm³/h_25% pig manure+75% cattle manure
0,38
0,66
0,23
3,48
-0,44
3,52
0,67
-1,25
SO2
NOx
NH3
* Future technology
16
-3
-2
-1
0
1
2
3
4
Acidification [g SO2-eq/km]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Ozone creation potential
biomethane as transportation fuel
Fossile
Petrol
Diesel
Natural gas
Biomethane
600 Nm³/h_85% energy crop rotation+15% manure
400 Nm³/h_100% residues
130 Nm³/h_52% int. crop rotation+6% straw+43% manure*
22 Nm³/h_50% gras+50% manure
20 Nm³/h_25% pig manure+75% cattle manure
0,45
0,93
0,50
0,75
0,61
0,78
0,62
0,12
CO
CH4
NMVOC
NOx
* Future technology
17
-0,4
-0,2
0,0
0,2
0,4
0,6
0,8
1,0
1,2
Ozone creation potential [g C2H4-eq/km]

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## Conclusions

Comparison of biomethane to natural gas:

- Environmental effects are almost independent from type of energy service
- Greenhouse gas emissions
  - Reduction in all cases (-56% to -400%)
  - Higher reduction with liquid manure than with energy crops (-90% to -400%)
  - When residues are used reduction depends on reference use of residues with its products
  - Acidification potential
  - Increasing or decreasing – depending on the feedstock
  - Highest impact: $NH_3$ emissions from digestate and manure management

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## Conclusions

- Ozone creation potential
  - Increase or decrease possible (+ 280% to -145%)
- Particulate emissions
- Higher compared to fossil systems for most cases (+5% to +650%); one case shows a reduction
- Lower compared to renewable system if solid biomass is used for heat generation (-55% to -95%)
- Fossil primary energy demand
- Reduced in all cases (-60% to -100%)

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## Thank you for your attention!


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Highlights der Bioenergieforschung - Campus Wieselburg 30. bis 31. März 2011

# BioE - Emissions from the engine combustion of biofuels and fuel mixtures

The project "BioE – Emissions in the engine combustion of biofuels and fuel mixtures" received financial assistance from the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) through the Agency for Renewable Resources (FNR) as part of the development program for renewable raw materials.

J. Blassnegger, Institut für Verbrennungskraftmaschinen und Thermodynamik, Technische Universität Graz

M. Knauer, M. Carrara, R. Nießner, Lehrstuhl für Analytische Chemie, Technische Universität München

J. Kunze, Lehrstuhl für Chemisch-Technische Analyse und Chemische Lebensmitteltechnologie , Technische. Universität München, 85350 Freising, Weihestephaner Steig 23, Deutschland

K.-W. Schramm, Department für Biowissenschaftliche Grundlagen, Technische Universität München, 85350 Freising, Weihestephaner Steig 23, Deutschland & Institut für Ökologische Chemie, Helmholtz Zentrum München , 85764 Neuherberg, Ingolstädter Landstr. 1, Deutschland

TUG · Wieselburg

## BioE – tasks

The project examined the limited (CO, HC, $NO_x$, $CO_2$, particle mass) and not limited exhaust emissions (PAK, particle number, mutagenicity) of a EURO V HDV with SCR system and of a STEP III A tractor engine operating on different kinds of fuels.

Test fuels

- Diesel fuel max. 10 ppm Sulfur (ECE - Fuel)
- Biodiesel (FAME) according to EN 14214
- B10 (10% FAME, 90% diesel fuel)
- B7 (7% FAME, 93% diesel fuel)
- B7+3 (3% plant oil hydrotreated, 7% biodiesel, 90% diesel fuel)
- Plant oil according to V 51605

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## BioE – test vehicle

HDV EURO V

6-cylinder turbodiesel, common rail system, 324 kW/1900 rpm

*Exhaust gas aftertreatment*
SCR- System (Oxikat und SCR Kat)

*Plant oil system with 2 tanks*
Variation → diesel- or plant oil operation
*established criteria*
Engine speed >900 rpm, coolant temperature >60 °C,
fuel temperature >60 °C

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## BioE – test engine

STEP III A tractor engine

6-cylinder turbodiesel, common rail system, EGR, 124 kW

*Plant oil system (mono-tank-system)*
Fuel heating system, plant oil application

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## BioE - measuring program

EURO V HDV: ESC - European Stationary Cycle
FIGE Cycle

The FIGE cycle was developed by the FIGE Institute, Aachen, Germany based on real road cycle measurements of heavy duty vehicles (FIGE Report 104 05 316, January 1994). For the purpose of engine certification/type approval, the ETC cycle was developed out of the FIGE dataset.

STEP III A tractor engine : NRSC - Non Road Steady Cycle
NRTC - Non Road Transient Cycle

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## BioE - sampling PAH und carbonyl

- sampling of PAH and carbonyl at the end of the dilution tunnel
- at particle boundet PAH und Nitro-PAH → quartzfilament filter (∅ 70 mm)
- gaseous carbonyl → gas washing bottle

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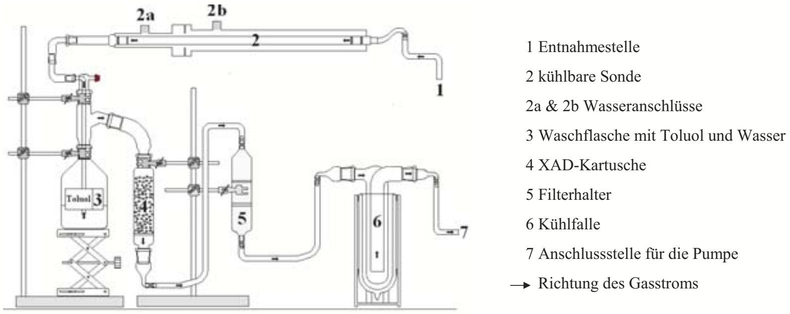
## BioE - sampling for mutagenicity test

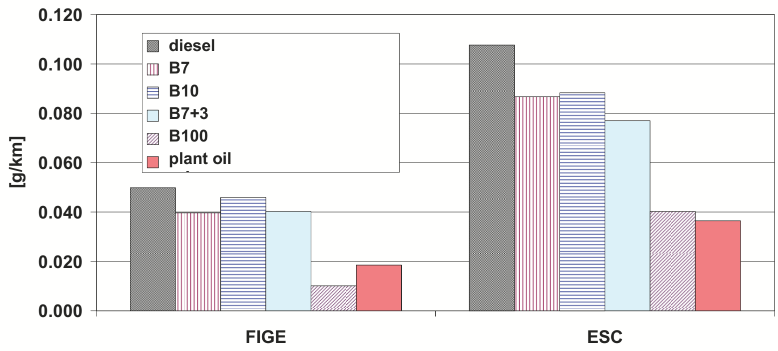



- composite sample sediment / condensate
- acording to VDI-Norm 3499, extra condensation trap
- sampling out of raw exhaust gas

*Mutagenicity test:* AMES-test (Maron und Ames, 1983)
Salmonella typhimurium TA98 und TA100

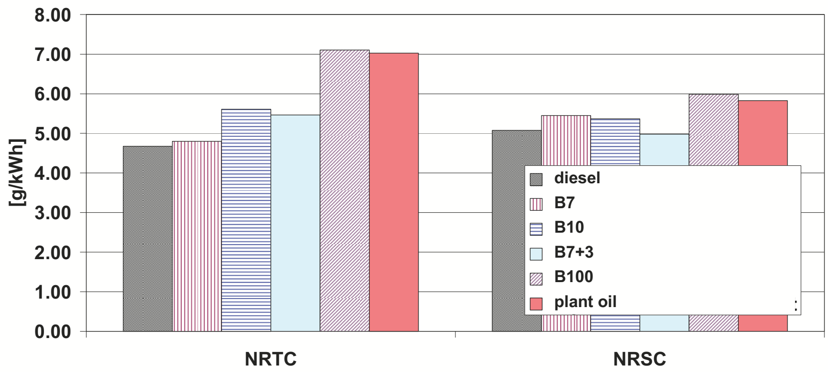
## BioE – results, limited emissions

HDV EURO V particle mass emissions



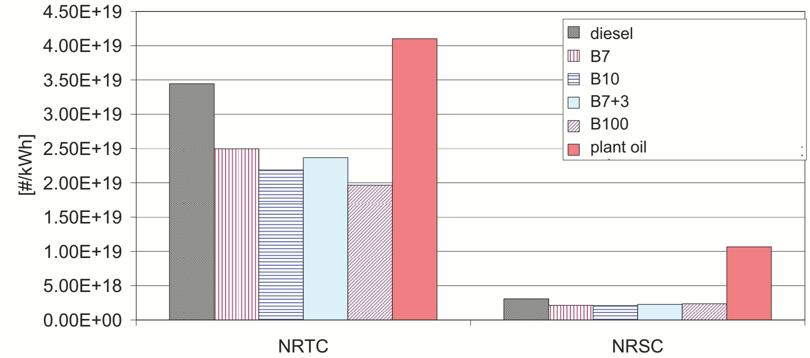

## BioE – results, limited emissions

STEP III A tractor engine $NO_x$ emissions



## BioE – results, particle number

STEP III A  tractor engine, particle number

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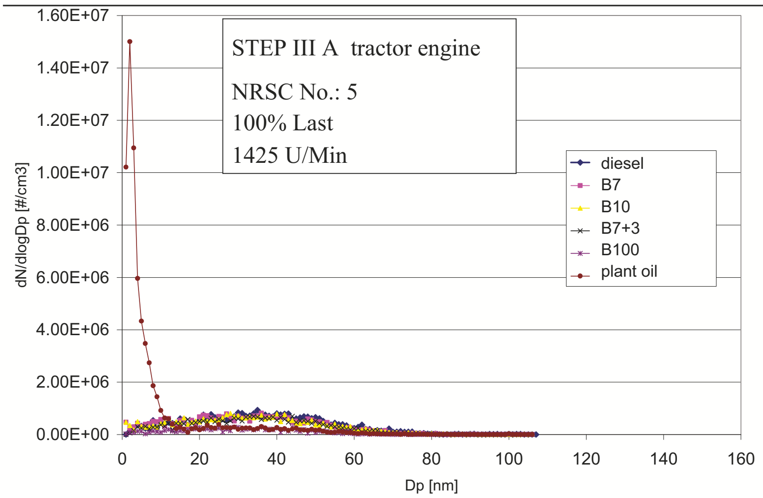
## BioE – results, particle size distribution

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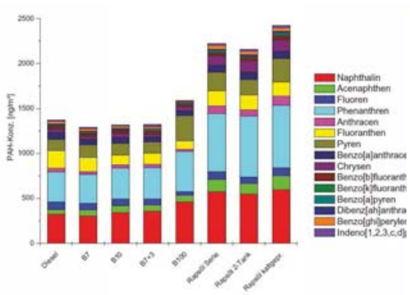
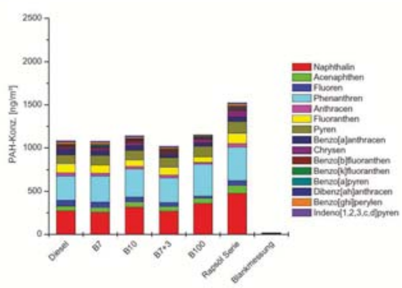
## BioE – results, PAH




EURO V HDV
FIGE Cycle

STEP III A
tractor engine
NRSC

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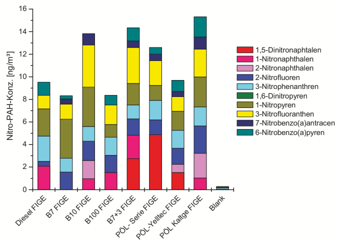
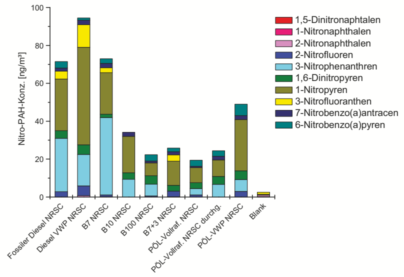
## Ergebnisse – results, NITRO PAH




EURO V HDV
FIGE Cycle

STEP III A
tractor engine
NRSC

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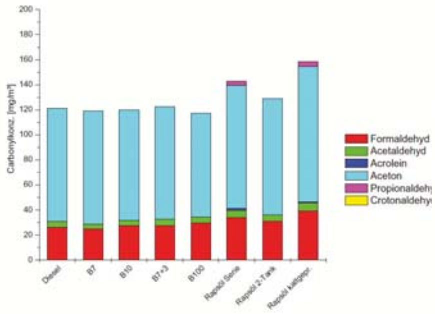
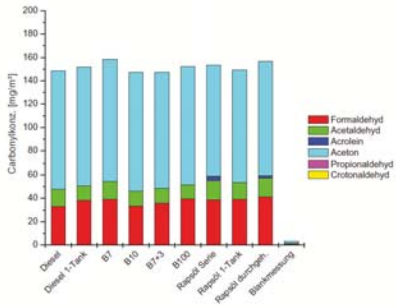
## BioE – results, carbonyl




EURO V HDV
FIGE Cycle

STEP III A
tractor engine
NRSC

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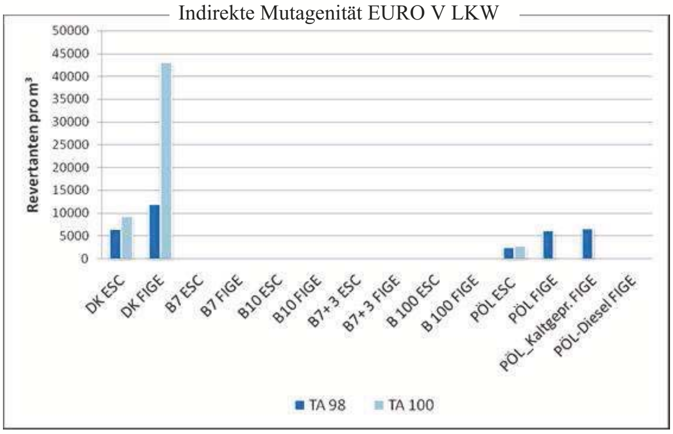
## BioE – results mutagenicity EURO V HDV

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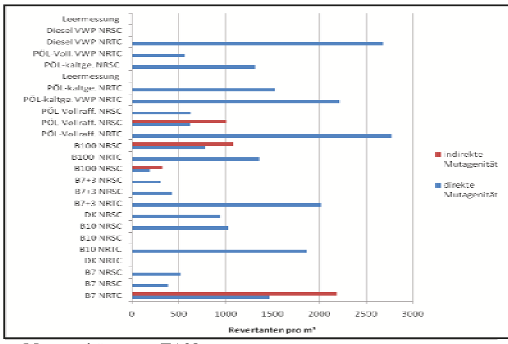
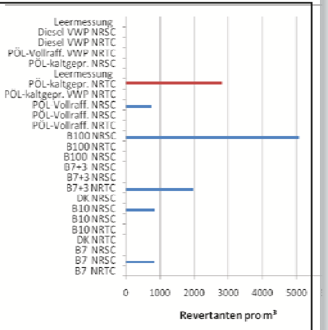
## BioE – results mutagenicity STEP III A tractor engine




Mutagenitäten von TA98




Mutagenitäten von TA100

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## BioE - summary

The results for limited gaseous emission components derived from the measurement series correspond to a large extent with the results from previous measurements.

Concerning the emission components $NO_x$ and particulate mass, which are critical for diesel engines, increases ($NO_x$) and decreases (particle mass) occur when biofuels are used.

An increase in PAH in emissions for both test vehicles was found for operation with vegetable oil.

No significant change in emissions could be detected for nitro PAHs in the tested EURO V HDV with SCR system. For the STEP III A tractor engine, the use of biofuels and fuel mixtures thereof resulted in a significant reduction of nitro PAH emissions.

As for polycyclic aromatic hydrocarbons and carbonyl compounds results showed that their emissions are influenced by the use of biofuels. Both increases when biofuels are used.

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## BioE - summary

In the mutagenicity analyses (AMES tests), there was no evidence of direct mutagens for the EURO V HDV engine used. However, an increase in premutagens was found for vegetable oil used in the test strains TA98 and TA100. The difference to the reference fuel diesel was not clear though. Similar effects were found for the tested STEP III A tractor engine, although the revertant level proved to be much lower in this case.

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## BioE - cross references

The same results, at least in terms of the trend, as well as deviating results in mutagenicity tests with vegetable oil from other projects are being discussed at the moment. A proposal for standardizing the collection of samples is currently being worked out in a follow-up project in order to be able to run standardized evaluations and comparisons of future results of test series from different research projects and institutions.

TUG Wieselburg

Highlights der Bioenergieforschung - Campus Wieselburg 30. bis 31. März 2011

BioE

Emissions from the engine combustion of bio fuels and fuel mixtures

Thank you for your attention!

TUG Wieselburg

## Emissions in the engine combustion of biofuels and fuel mixtures

*Jürgen Blassnegger, TU Graz – VKMB*

**March 31, 2011 – Highlights der Bioenergieforschung – Wieselburg**

# Impact of Oxygenates in Diesel Fuel Blends on Engine Emissions and Combustion Properties

Institute for Powertrains & Automotive Technology

Philipp Teiner, Bernhard Geringer, Peter Hofmann
Markus Maly, Peter Staub

Institute for Powertrains & Automotive Technology

## Impact of Oxygenates in Diesel Fuel Blends on Engine Emissions and Combustion Properties

### Outline

- ☐ Introduction and Task Description
- ☐ Technical Data of Test Engine
- ☐ Chemical Analysis
- ☐ Combustion Properties
- ☐ Consumption
- ☐ Engine Emissions
- ☐ Summary and Outlook

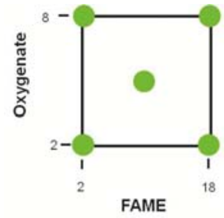


## Introduction

- ☐ Climate protection conventions (e.g. Kyoto Protocol)
  - ➡ Increased utilization of renewable primary products
- ☐ EU: Renewable Energy Directive (RED) and Fuels Quality Directive (FQD)
  - ➡ 10 energ.% biofuels from transport fuel pool
  - ➡ 6% green house gas savings
- ☐ Currently used substitutes: FAME, BTL or HVO
  - ➡ Bad quality (viscosity, stability) for higher blends
  - ➡ Inadequate raw material base
  - ➡ Expensive production process
  - ➡ Maximum 7 vol.% FAME approved by car manufacturers

## Task Description

- Investigation of new biogenic oxygenates which fulfill ethical, ecological and economical requirements
  - ➡ Diesel substitute
  - ➡ Interaction with FAME containing diesel
- Design of Experiments of fuel blends




- Investigated oxygenates
  - ➡ Glyme, Alcohol, Polyether, Tributylcitrat, Levulinat, Valeriat
- Presented oxygenates
  - ➡ Glyme (Tetra-Glyme)
  - ➡ Alcohol (Butanol)

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## Technical Data of Test Engine

| Diesel engine N47 D20 U1 (BMW) | |
|---|---|
| Cylinder | 4 inline |
| Bore [mm] | 84 |
| Stroke [mm] | 90 |
| Displacement [cm³] | 1995 |
| Compression Ratio | 16 |
| Power [kW] | 105 at 4000 [rpm] |
| Max. Torque [Nm] | 320 at 1750 [rpm] |
| Injection System | Common Rail |
| Turbo Charging | Var. Turbine Geometry |


Source: BMW Group

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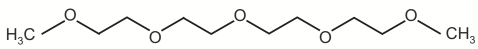
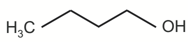
## Chemical Analysis

Tetra-Glyme ($C_{10}H_{22}O_5$)




Butanol ($C_4H_{10}O$)




| | | Oxigenat | SFME | B0 | C | H | O | C/H | CN | Density | Flash Point | Heat Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | [vol. %] | | | [mass %] | | | [-] | [-] | [kg/m³] | [°C] | [MJ/kg] |
| B0 | - | 0 | 0 | 100 | 86 | 14 | 0 | 6,14 | 52,1 | 829 | 61 | 43,5 |
| B18 | - | 0 | 18 | 82 | 84,5 | 13,5 | 1,8 | 6,26 | 54,1 | 838,6 | 64,5 | 41,955 |
| Glyme | Tetra-Glyme | 8 | 2 | 90 | 82,9 | 13,4 | 3,5 | 6,19 | 60,2 | 842,9 | 63,5 | 41,209 |
| | | 8 | 16,56 | 75,44 | 81,6 | 13,1 | 4,8 | 6,23 | 57,8 | 851 | 66,5 | 40,431 |
| Alcohol | Butanol | 8 | 2 | 90 | 84,7 | 13,7 | 1,6 | 6,18 | 48,1 | 828,2 | 39,5 | 42,201 |
| | | 8 | 16,56 | 75,44 | 82,7 | 13,5 | 3,2 | 6,13 | 49,9 | 835,8 | 38,5 | 41,083 |

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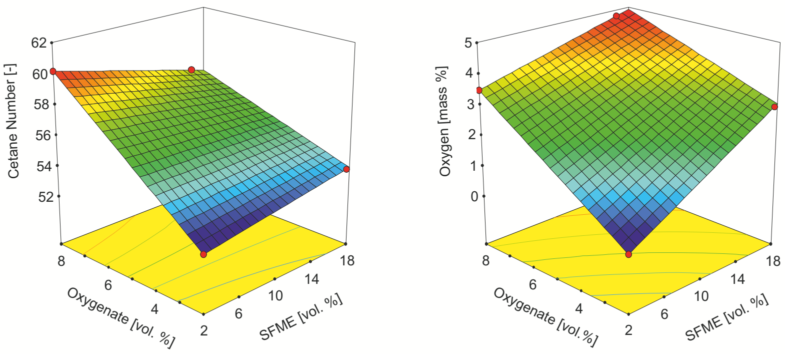
## Chemical Analysis

Tetra-Glyme

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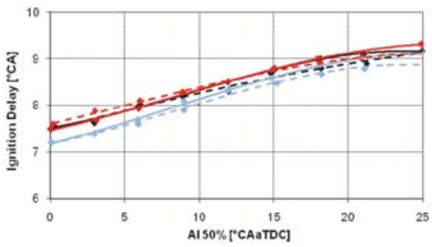
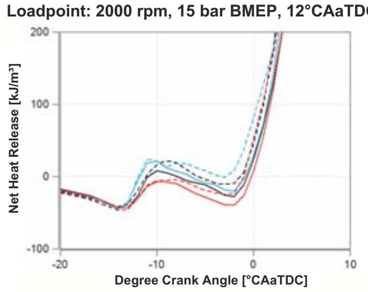
## Combustion Properties

Variation of AI 50% at 2000 rpm and 15 bar BMEP




Loadpoint: 2000 rpm, 15 bar BMEP, 12°CAaTDC




- Additivation of Tetra-Glyme increases CN
  ➡ higher and faster net heat release
- Additivation of Buranol decreases CN
  ➡ lower and slower net heat release
- Additivation of SFME has only minor impact on CN and combustion properties

| | | CN [-] |
|---|---|---|
| —— | B0 | 52,1 |
| - - - | B18 | 54,1 |
| —— | Tetra-Glyme | 60,2 |
| - - - | Tetra-Glyme + SFME | 57,8 |
| —— | Butanol | 48,1 |
| - - - | Butanol + SFME | 49,9 |

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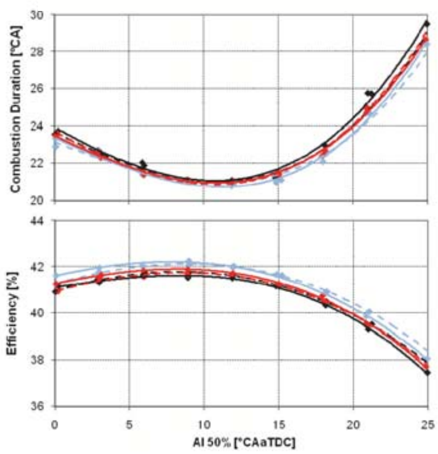
## Combustion Properties

| | | CN [-] |
|---|---|---|
| —— | B0 | 52,1 |
| - - - | B18 | 54,1 |
| —— | Tetra-Glyme | 60,2 |
| - - - | Tetra-Glyme + SFME | 57,8 |
| —— | Butanol | 48,1 |
| - - - | Butanol + SFME | 49,9 |

Variation of AI 50% at 2000 rpm and 15 bar BMEP




- Additivation of Tetra-Glyme reduces combustion duration
  ➡ Increase of efficiency
- Additivation of butanol has only minor impact on combustion duration and efficiency
- Additivation of SFME has only minor impact on combustion duration and efficiency

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Impact of Oxygenates in Diesel Fuel Blends on Engine Emissions and Combustion Properties
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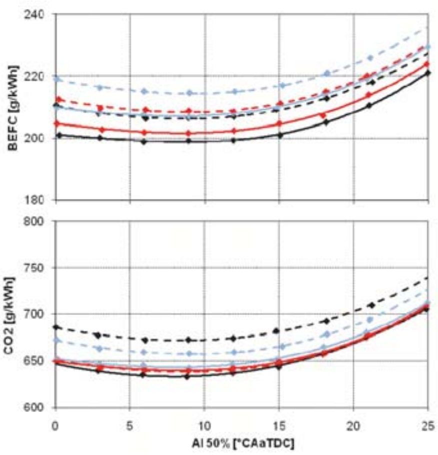
## Consumption

| | | Density [kg/m³] | Heat Value [MJ/kg] | C [mass %] |
|---|---|---|---|---|
| —— | B0 | 829 | 43,5 | 86 |
| · – – | B18 | 838,6 | 41,955 | 84,5 |
| —— | Tetra-Glyme | 842,9 | 41,209 | 82,9 |
| – – – | Tetra-Glyme + SFME | 851 | 40,431 | 81,6 |
| —— | Butanol | 828,2 | 42,201 | 84,7 |
| · – – | Butanol + SFME | 835,8 | 41,083 | 82,7 |

Variation of AI 50% at 2000 rpm and 15 bar BMEP




- Additivation of oxygenate decreases heat value
  ➡ Increase of gravimetric consumption
- Additivation of SFME further decreases heat value
  ➡ Further increase of gravimetric consumption
- $CO_2$-emissions dependent on relation between gravimetric consumption and mass of carbon in fuel blend

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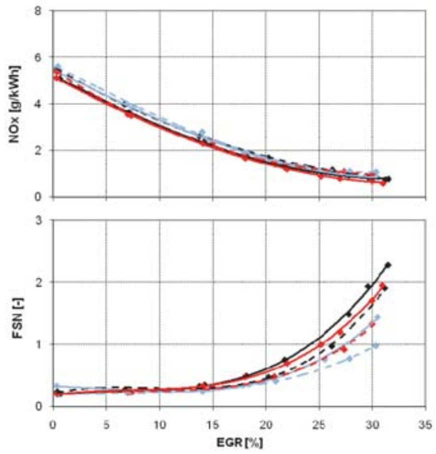
## Limited Emissions ($NO_x$ and Particle)

| | | CN [-] | O [mass %] |
|---|---|---|---|
| —— | B0 | 52,1 | 0 |
| · – – | B18 | 54,1 | 1,8 |
| —— | Tetra-Glyme | 60,2 | 3,5 |
| – – – | Tetra-Glyme + SFME | 57,8 | 4,8 |
| —— | Butanol | 48,1 | 1,6 |
| – – – | Butanol + SFME | 49,9 | 3,2 |

Variation of EGR at 2000 rpm and 1 bar BMEP




- Additivation of Tetra-Glyme decreases combustion duration
  ➡ Higher combustion chamber temperatures
  ➡ Higher $NO_x$-emissions
- Additivation of oxygenate and SFME increases oxygen content
  ➡ Reduction of substoichiometric zones
  ➡ Decrease of particle emissions

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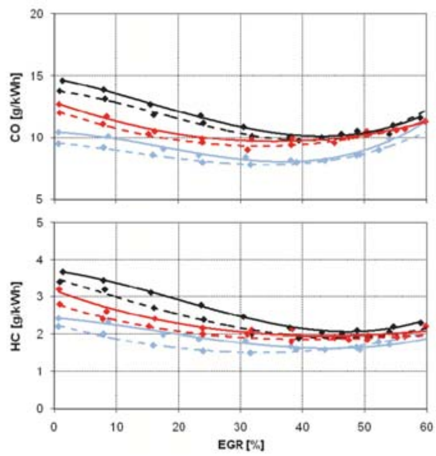
## Limited Emissions (CO and HC)

| | | O [mass %] |
|---|---|---|
| —— | B0 | 0 |
| · – – | B18 | 1,8 |
| —— | Tetra-Glyme | 3,5 |
| – – – | Tetra-Glyme + SFME | 4,8 |
| —— | Butanol | 1,6 |
| – – – | Butanol + SFME | 3,2 |

Variation of EGR at 1500 rpm and 6,5 bar BMEP




- Additivation of oxygenate and SFME increases oxygen content
  ➡ More homogeneous mixture preparation
  ➡ Decrease of CO- and HC-emissions

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## Summary and Outlook

- The additivation of the investigated oxigenates to diesel fuel leads to:
  - ➡ a slight decrease of the combustion duration
  - ➡ an increase of the gravimetric fuel consumption
  - ➡ a high decrease of the CO-, HC- and particle emissions
- The additivation of SFME to the investigated diesel-oxigenate blends:
  - ➡ has only minor impact on the combustion properties
  - ➡ increases further the gravimetric fuel consumption
  - ➡ leads to a further decrease of the CO-, HC- and particle emissions
- Biogenic oxygenates deliver an ecological alternative as a diesel substitute and enable a high decrease of the CO-, HC- and particle emissions in combination with SFME. In this context further investigations (Tributylcitrat, Valeriat, Levulinat) will be undertaken.

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## Thank you for your attention!

Institute for Powertrains & Automotive Technology

**Philipp Teiner**
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Impact of oxygenates in diesel fuel blends on engine emissions andcombustion properties

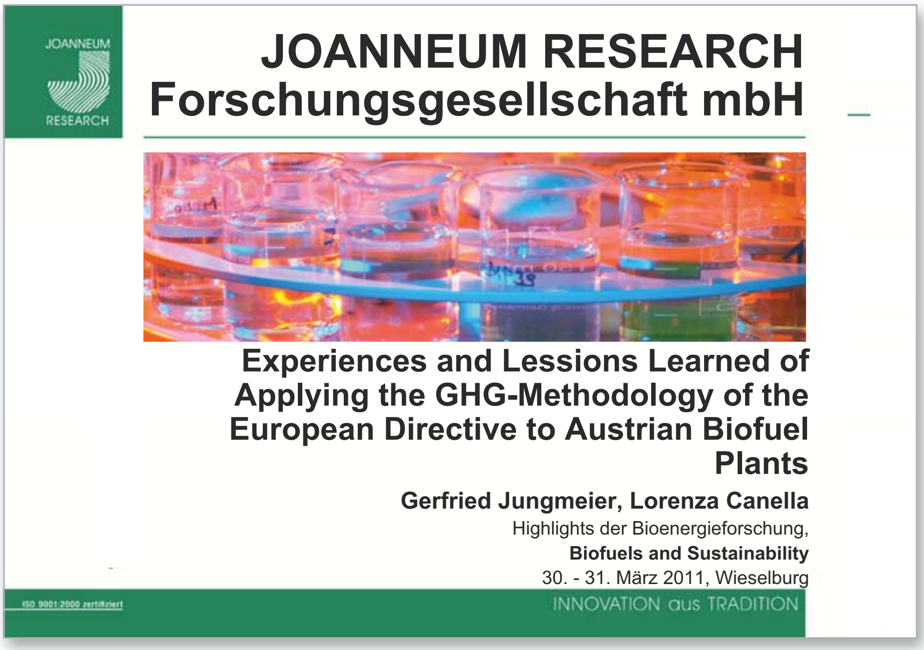
*Philipp Teiner, TU Wien – IFA*

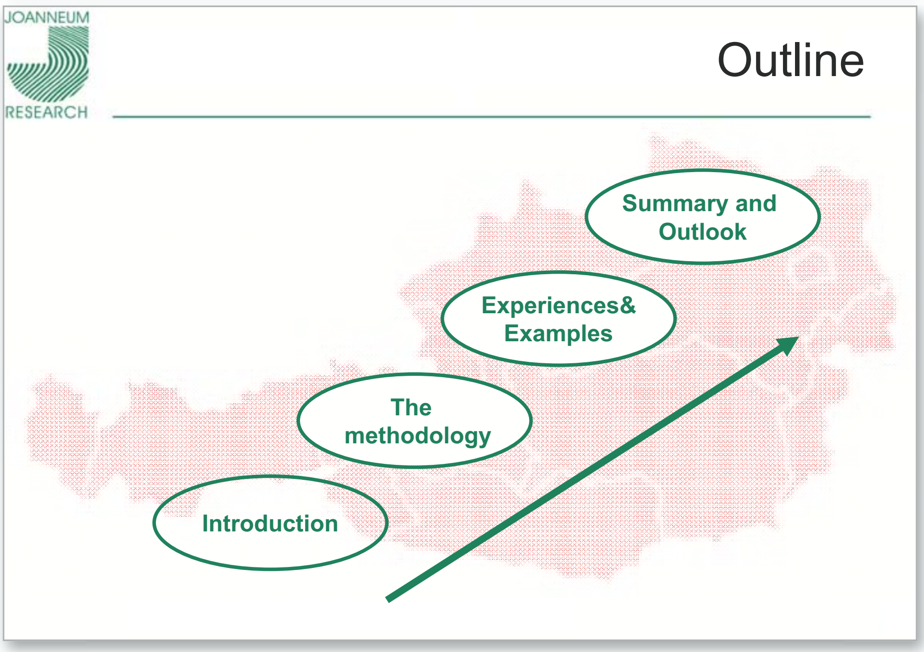
## Biofuels and Sustainability

***Chair: Kurt Könighofer**, Joanneum Research – Resources*

# Experiences and lessons learned of applying the GHG-methodology of the European Directive to Austrian biofuel plants

***Gerfried Jungmeier**, Joanneum Research – Resources*

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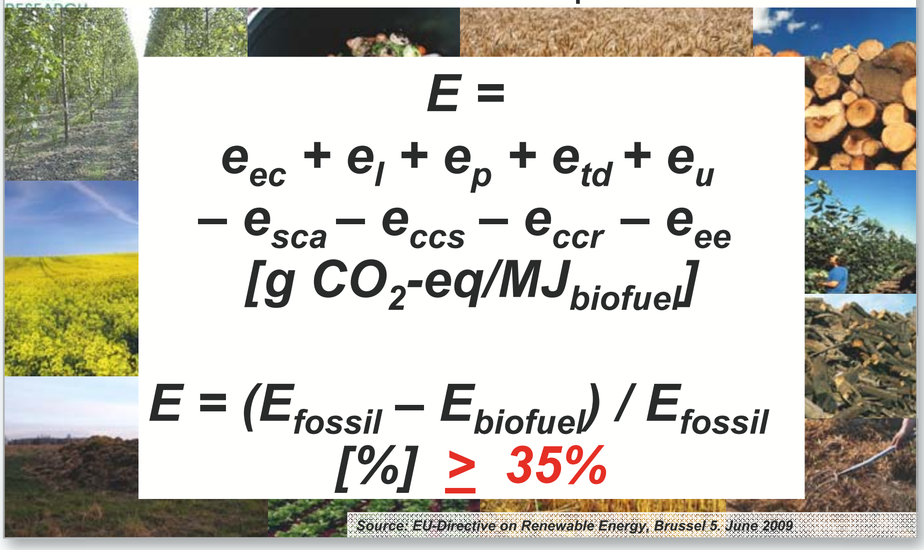
## This is Biomass for Transportation Biofuels

## …and this is the Formula for Greenhouse Gas Calculation of Transportation Biofuels



$$E =$$
$$e_{ec} + e_l + e_p + e_{td} + e_u$$
$$- e_{sca} - e_{ccs} - e_{ccr} - e_{ee}$$
$$[g\ CO_2\text{-}eq/MJ_{biofuel}]$$

$$E = (E_{fossil} - E_{biofuel}) / E_{fossil}$$
$$[\%]\ \geq\ 35\%$$

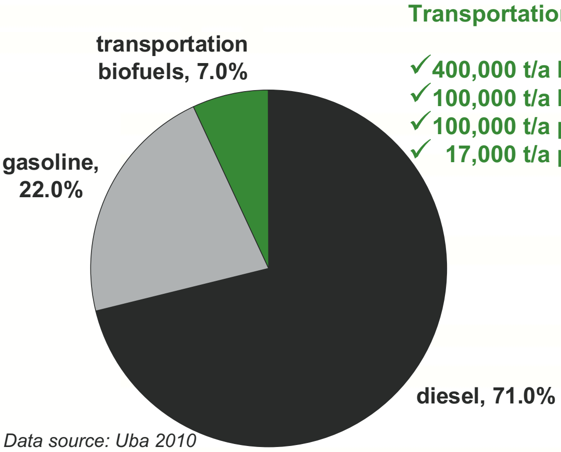
*Source: EU-Directive on Renewable Energy, Brussel 5. June 2009*

## The Austrain Transportation Sector in 2009

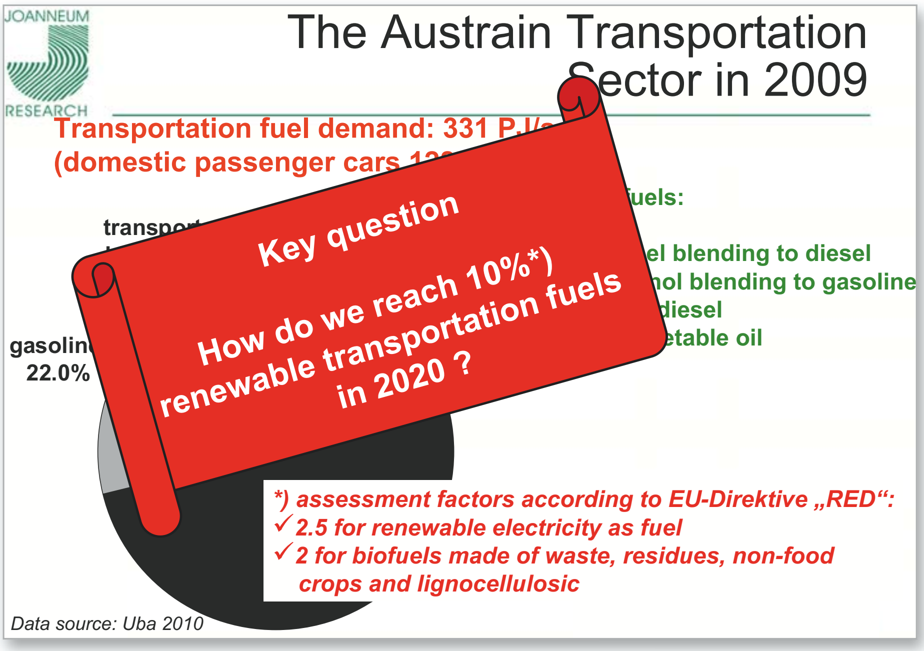
**Transportation fuel demand: 331 PJ/a**
**(domestic passenger cars 128 PJ/a)**

**Transportation biofuels:**

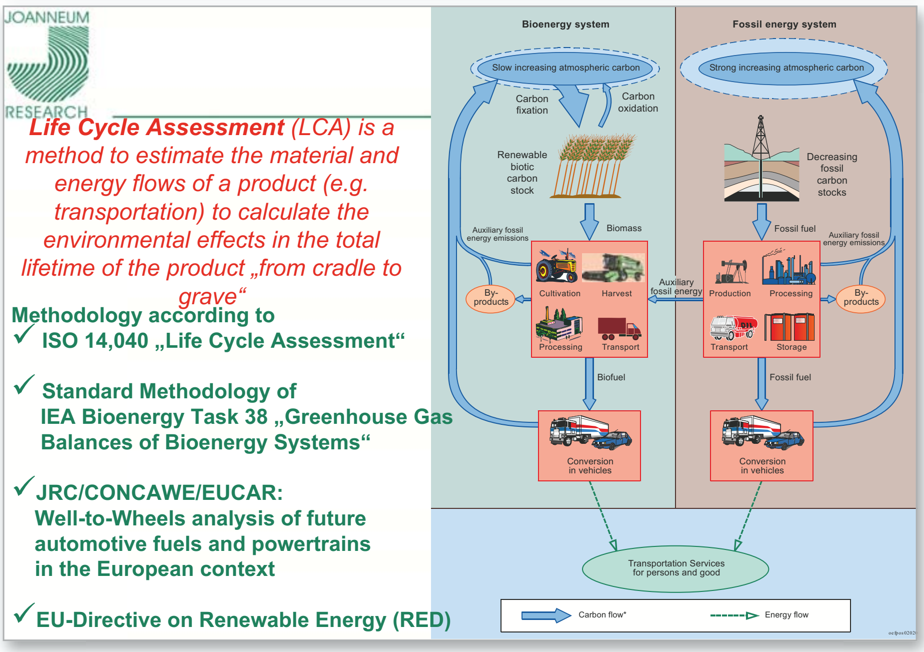
- ✓ 400,000 t/a biodiesel blending to diesel
- ✓ 100,000 t/a bioethanol blending to gasoline
- ✓ 100,000 t/a pure biodiesel
- ✓ 17,000 t/a pure vegetable oil




*Data source: Uba 2010*





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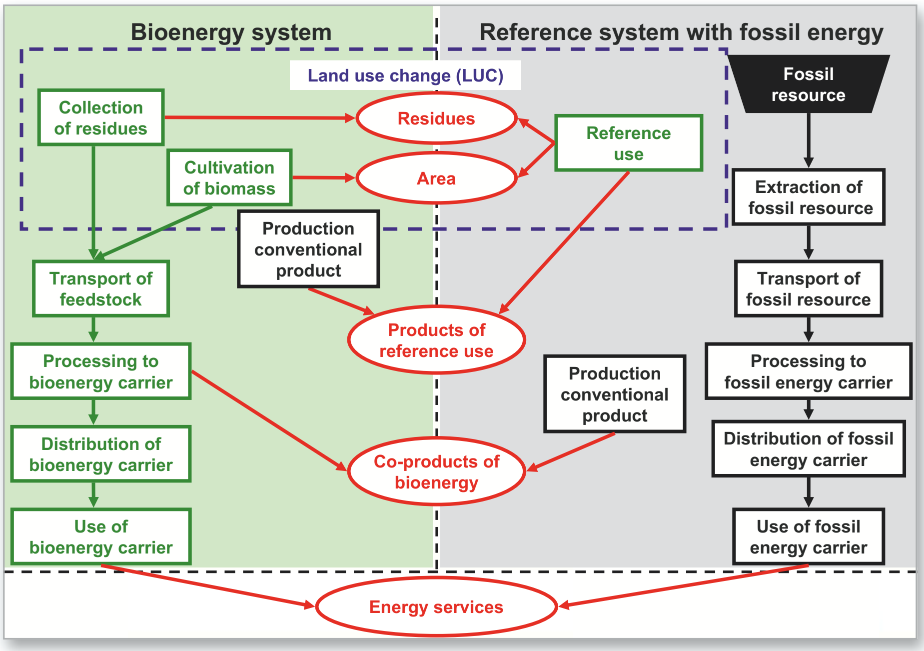
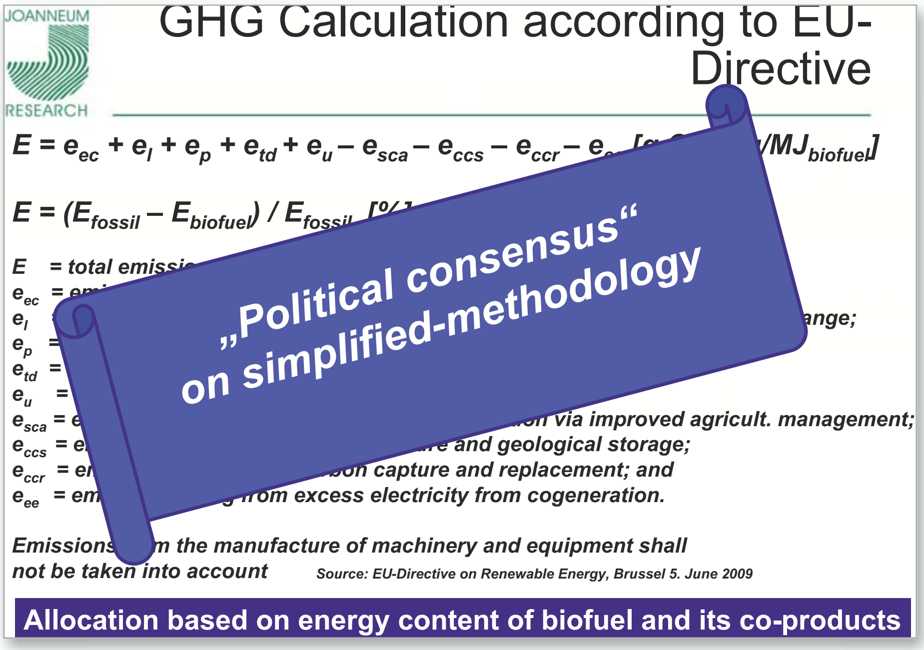
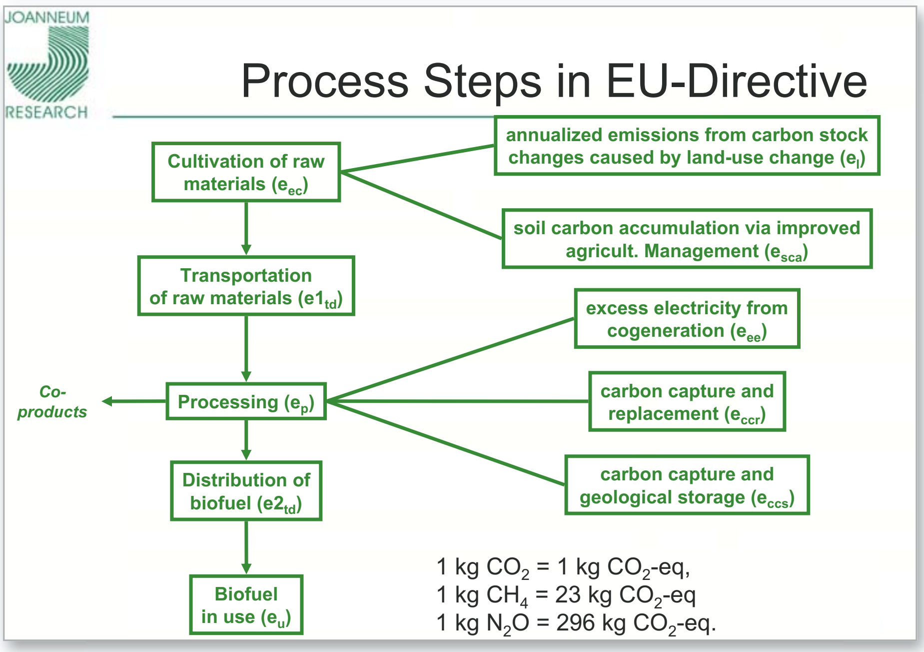

Bioenergy system
Reference system with fossil energy
Land use change (LUC)
Collection of residues
Residues
Reference use
Cultivation of biomass
Area
Fossil resource
Extraction of fossil resource
Production conventional product
Transport of feedstock
Transport of fossil resource
Products of reference use
Processing to bioenergy carrier
Production conventional product
Processing to fossil energy carrier
Distribution of bioenergy carrier
Co-products of bioenergy
Distribution of fossil energy carrier
Use of bioenergy carrier
Use of fossil energy carrier
Energy services


JOANNEUM RESEARCH
GHG Calculation according to EU-Directive
E = e_ec + e_l + e_p + e_td + e_u – e_sca – e_ccs – e_ccr – e_ee [g CO2-eq/MJ_biofuel]
E = (E_fossil – E_biofuel) / E_fossil [%]
E = total emissi...
ange;
...via improved agricult. management;
...and geological storage;
...capture and replacement; and
...from excess electricity from cogeneration.
Emissions from the manufacture of machinery and equipment shall not be taken into account
Source: EU-Directive on Renewable Energy, Brussel 5. June 2009
„Political consensus“ on simplified-methodology
Allocation based on energy content of biofuel and its co-products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Process Steps in EU-Directive
Cultivation of raw materials (e_ec)
annualized emissions from carbon stock changes caused by land-use change (e_l)
soil carbon accumulation via improved agricult. Management (e_sca)
Transportation of raw materials (e1_td)
excess electricity from cogeneration (e_ee)
Co-products
Processing (e_p)
carbon capture and replacement (e_ccr)
carbon capture and geological storage (e_ccs)
Distribution of biofuel (e2_td)
Biofuel in use (e_u)
1 kg CO2 = 1 kg CO2-eq,
1 kg CH4 = 23 kg CO2-eq
1 kg N2O = 296 kg CO2-eq.

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## Lessons Learnt

- **Energy allocation between biofuel and its co-products**
- **System boundaries for energy allocation and data availability**
- **Emissions from the manufacture of machinery and equipment shall not be taken into account**
- **Emissions from vehicles are zero**
- **Use of aggregated or disaggregated default or actual calculated values possible "Cherry picking"**
- **Emisisons from Cultivation data on country level only available as allocated values to biofuel**
- **$e_{ccr}$ = emission saving from carbon capture and replacement allocation only to biofuel?**
- **Greenhouse gas emissions of gasoline and diesel might be higher than in RED**

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## EU-Directive on Allocation Method

*„..... Co-products from the production and use of fuels should be taken into account in the calculation of greenhouse gas emissions. The* ***energy allocation method is appropriate for the regulation of individual economic operators and individual consignments of transport fuels****. The energy allocation method is the most appropriate method, as it is easy to apply, is predictable over time, minimizes counter-productive incentives and produces results that are generally comparable with those produced by the substitution method.* ***For the purposes of policy analysis the Commission should also, in its reporting, present results using the substitution method.***

***Source: DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the promotion of the use of energy from renewable sources, Brussels, June 5, 2009***

JOANNEUM RESEARCH

## Typical and Standard Greenhouse Gas Emissions&Savings of Directive RED

- **'actual value': greenhouse gas emission saving for some or all of the steps of a specific biofuel production process calculated in accordance with the methodology laid down in RED;**

- **'typical value': an estimate of the representative greenhouse gas emission saving for a particular biofuel production pathway;**

- **'default value' means a value derived from a typical value by the application of pre-determined factors and that may, in circumstances specified in the Directive, be used in place of an actual value.**

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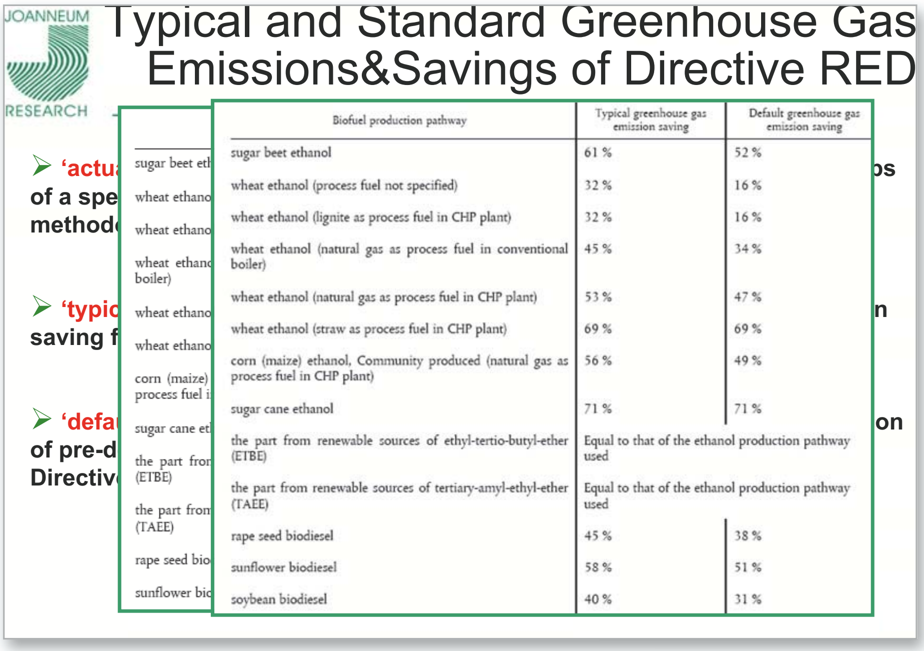
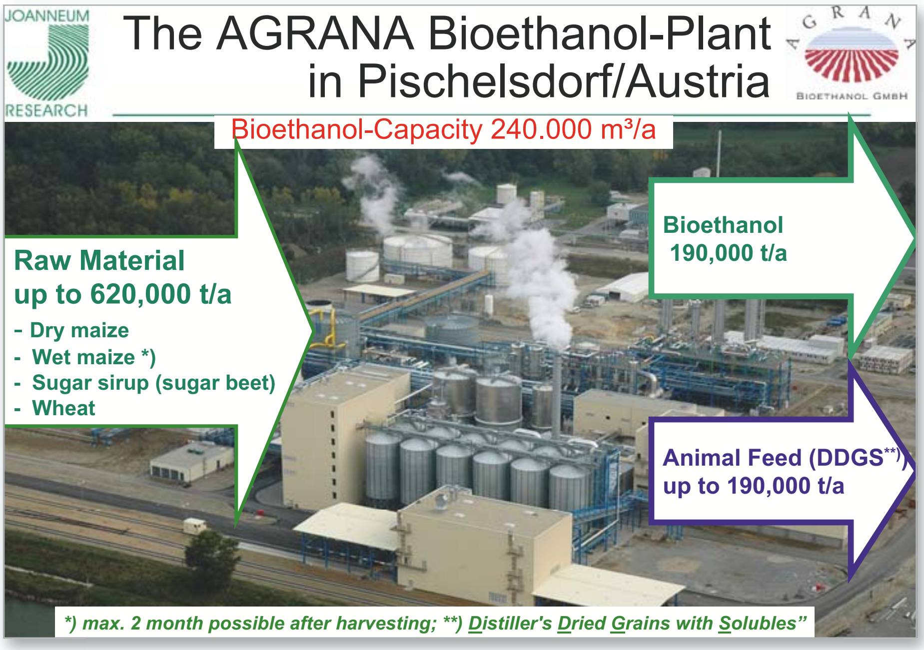
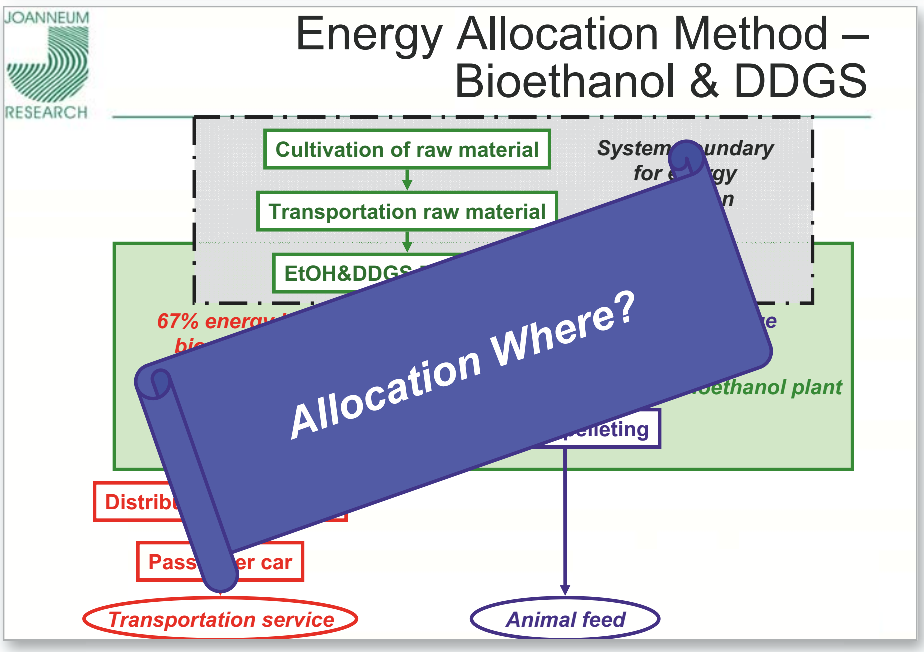



| Biofuel production pathway | Typical greenhouse gas emission saving | Default greenhouse gas emission saving |
|---|---|---|
| sugar beet ethanol | 61 % | 52 % |
| wheat ethanol (process fuel not specified) | 32 % | 16 % |
| wheat ethanol (lignite as process fuel in CHP plant) | 32 % | 16 % |
| wheat ethanol (natural gas as process fuel in conventional boiler) | 45 % | 34 % |
| wheat ethanol (natural gas as process fuel in CHP plant) | 53 % | 47 % |
| wheat ethanol (straw as process fuel in CHP plant) | 69 % | 69 % |
| corn (maize) ethanol, Community produced (natural gas as process fuel in CHP plant) | 56 % | 49 % |
| sugar cane ethanol | 71 % | 71 % |
| the part from renewable sources of ethyl-tertio-butyl-ether (ETBE) | Equal to that of the ethanol production pathway used | |
| the part from renewable sources of tertiary-amyl-ethyl-ether (TAEE) | Equal to that of the ethanol production pathway used | |
| rape seed biodiesel | 45 % | 38 % |
| sunflower biodiesel | 58 % | 51 % |
| soybean biodiesel | 40 % | 31 % |

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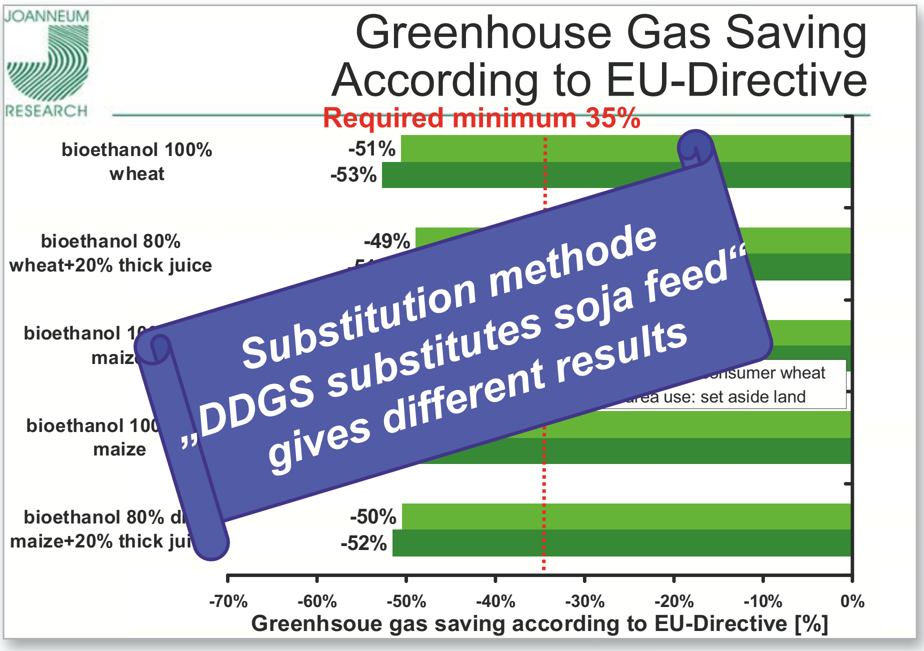
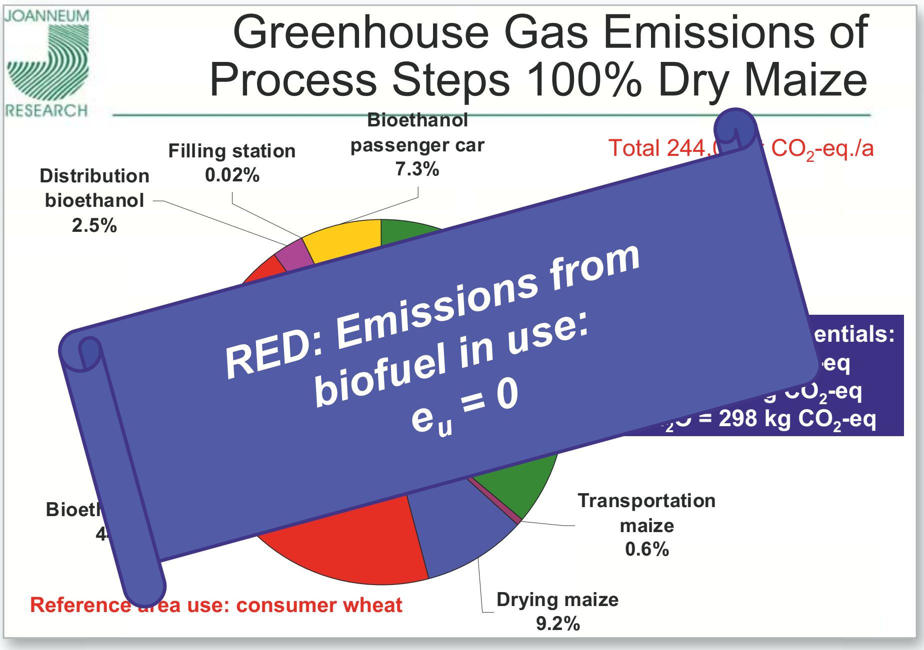
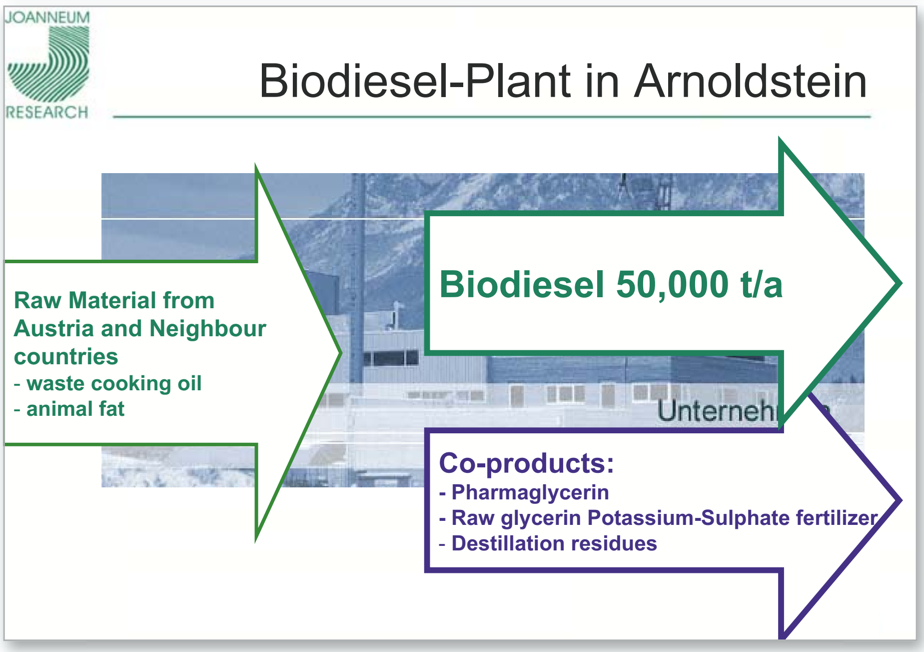
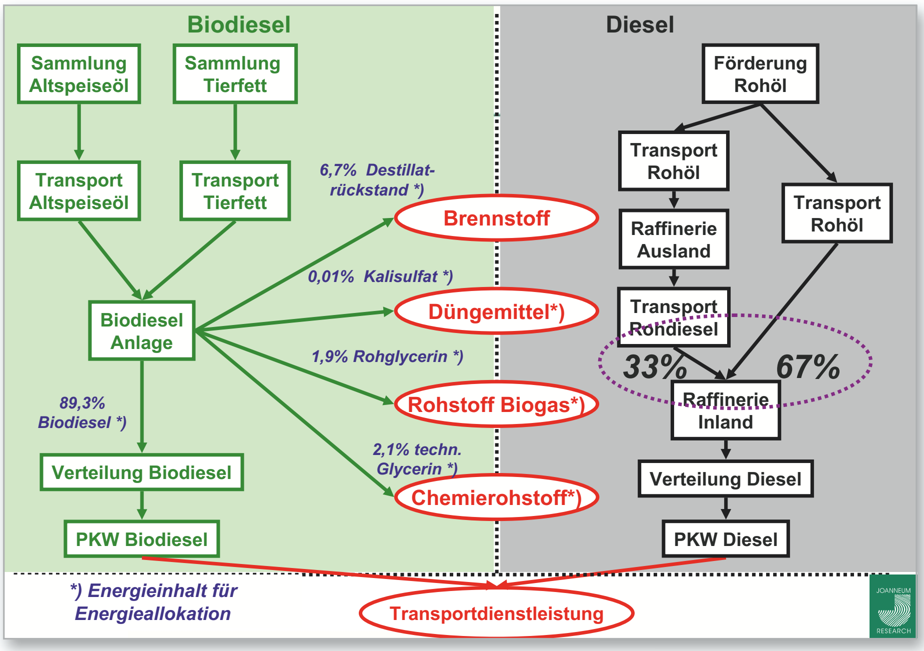
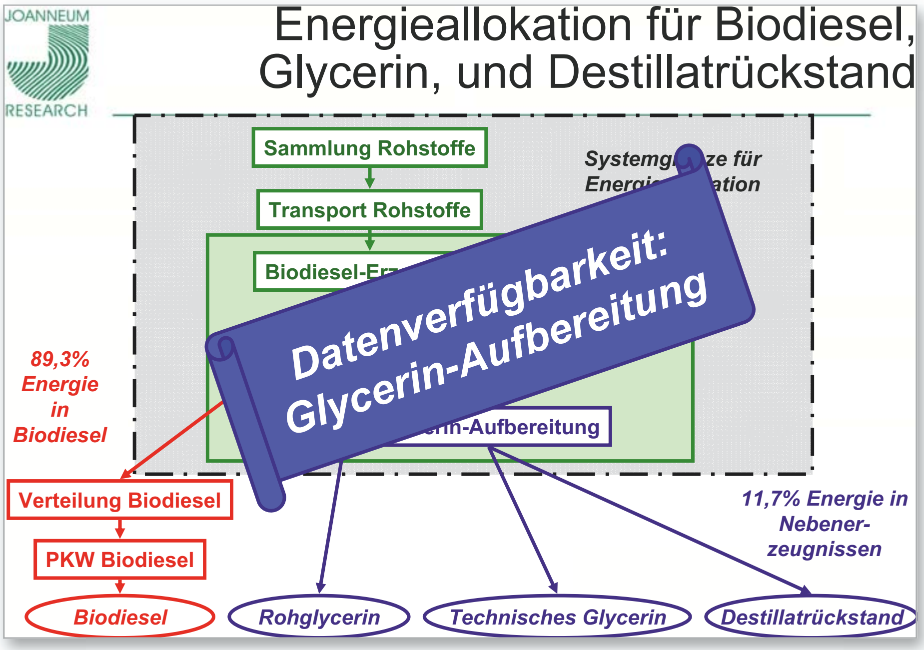


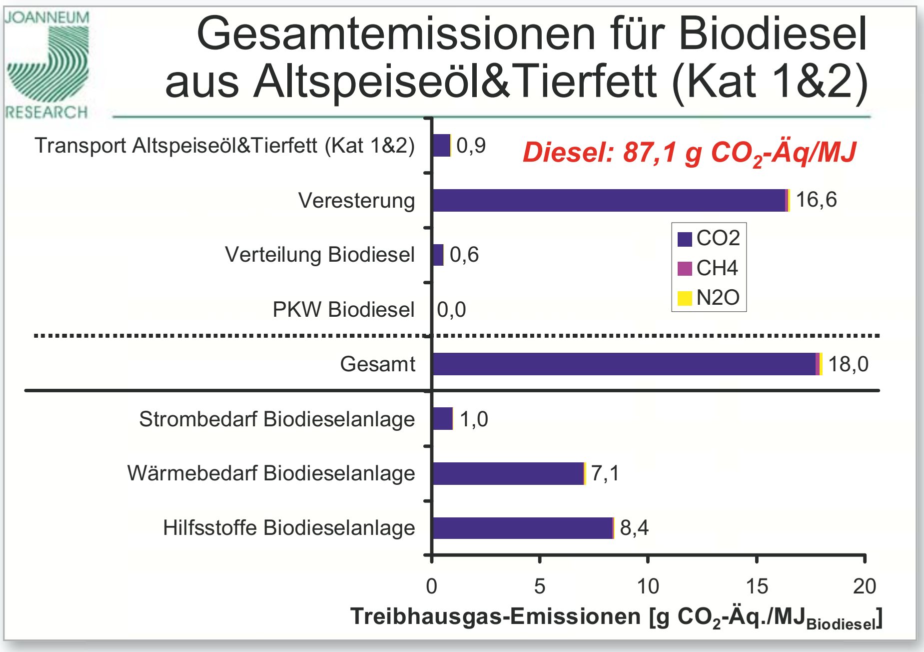



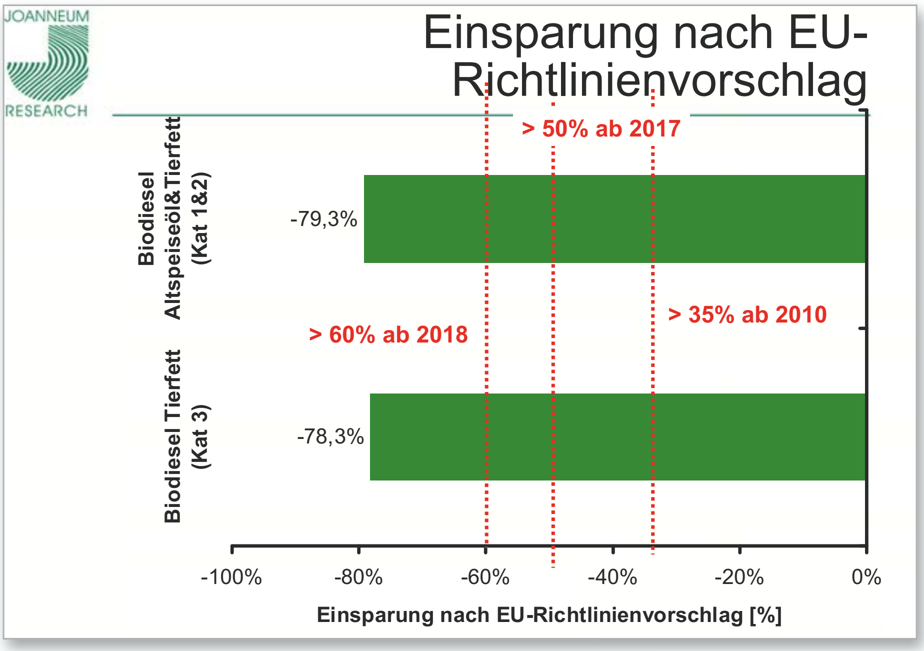




FORSCHUNGS KOOPERATION


Biodiesel
Diesel
Sammlung Altspeiseöl
Sammlung Tierfett
Transport Altspeiseöl
Transport Tierfett
Biodiesel Anlage
89,3% Biodiesel *)
Verteilung Biodiesel
PKW Biodiesel
6,7% Destillat-rückstand *)
Brennstoff
0,01% Kalisulfat *)
Düngemittel*)
1,9% Rohglycerin *)
Rohstoff Biogas*)
2,1% techn. Glycerin *)
Chemierohstoff*)
Förderung Rohöl
Transport Rohöl
Raffinerie Ausland
Transport Rohdiesel
Transport Rohöl
33%
67%
Raffinerie Inland
Verteilung Diesel
PKW Diesel
*) Energieinhalt für Energieallokation
Transportdienstleistung


Energieallokation für Biodiesel, Glycerin, und Destillatrückstand
Sammlung Rohstoffe
Transport Rohstoffe
Biodiesel-Er
Systemgr ze für Energi ation
Datenverfügbarkeit: Glycerin-Aufbereitung
rin-Aufbereitung
89,3% Energie in Biodiesel
Verteilung Biodiesel
PKW Biodiesel
11,7% Energie in Nebener-zeugnissen
Biodiesel
Rohglycerin
Technisches Glycerin
Destillatrückstand


Gesamtemissionen für Biodiesel aus Altspeiseöl&Tierfett (Kat 1&2)
Diesel: 87,1 g $CO_2$-Äq/MJ
Transport Altspeiseöl&Tierfett (Kat 1&2) 0,9
Veresterung 16,6
Verteilung Biodiesel 0,6
PKW Biodiesel 0,0
Gesamt 18,0
Strombedarf Biodieselanlage 1,0
Wärmebedarf Biodieselanlage 7,1
Hilfsstoffe Biodieselanlage 8,4
CO2
CH4
N2O
0
5
10
15
20
Treibhausgas-Emissionen [g $CO_2$-Äq./$MJ_{Biodiesel}$]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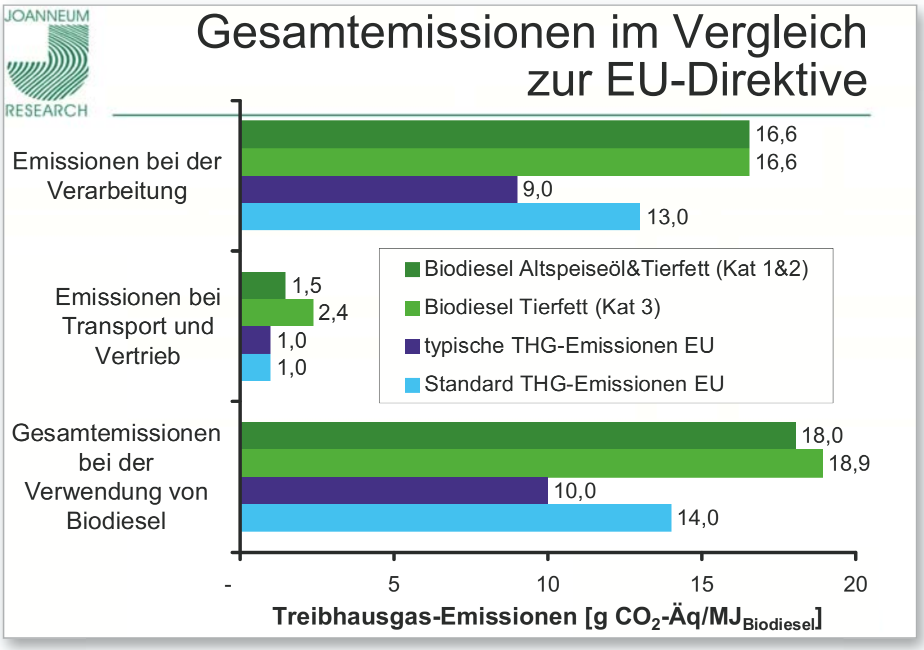
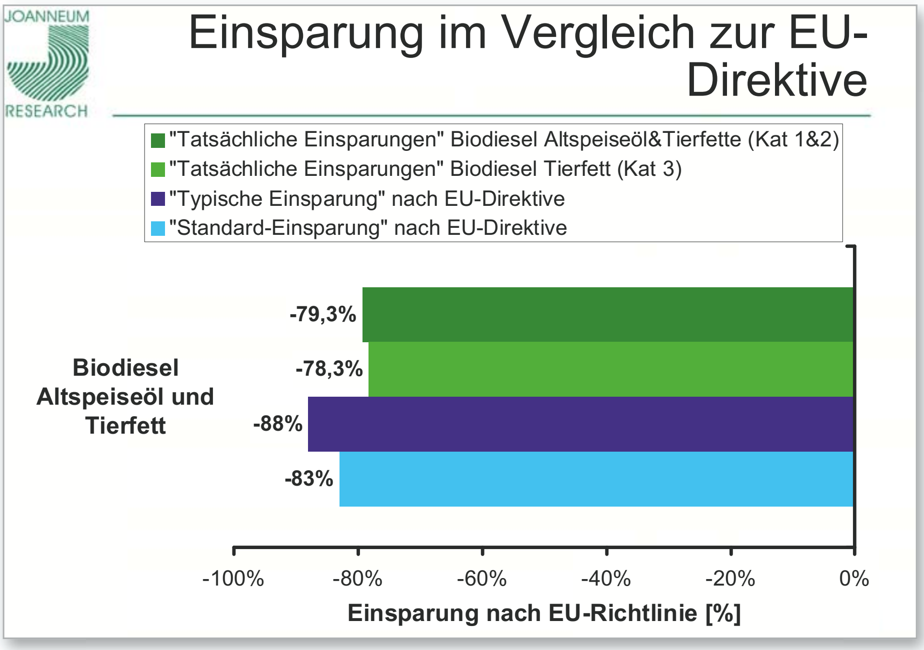
Einsparung nach EU-Richtlinienvorschlag
> 50% ab 2017
> 60% ab 2018
> 35% ab 2010
Biodiesel Altspeiseöl&Tierfett (Kat 1&2)
Biodiesel Tierfett (Kat 3)
-79,3%
-78,3%
-100%
-80%
-60%
-40%
-20%
0%
Einsparung nach EU-Richtlinienvorschlag [%]


JOANNEUM RESEARCH
Gesamtemissionen im Vergleich zur EU-Direktive
Emissionen bei der Verarbeitung
16,6
16,6
9,0
13,0
Emissionen bei Transport und Vertrieb
1,5
2,4
1,0
1,0
Gesamtemissionen bei der Verwendung von Biodiesel
18,0
18,9
10,0
14,0
Biodiesel Altspeiseöl&Tierfett (Kat 1&2)
Biodiesel Tierfett (Kat 3)
typische THG-Emissionen EU
Standard THG-Emissionen EU
-
5
10
15
20
Treibhausgas-Emissionen [g $CO_2$-Äq/$MJ_{Biodiesel}$]


JOANNEUM RESEARCH
Einsparung im Vergleich zur EU-Direktive
"Tatsächliche Einsparungen" Biodiesel Altspeiseöl&Tierfette (Kat 1&2)
"Tatsächliche Einsparungen" Biodiesel Tierfett (Kat 3)
"Typische Einsparung" nach EU-Direktive
"Standard-Einsparung" nach EU-Direktive
Biodiesel Altspeiseöl und Tierfett
-79,3%
-78,3%
-88%
-83%
-100%
-80%
-60%
-40%
-20%
0%
Einsparung nach EU-Richtlinie [%]

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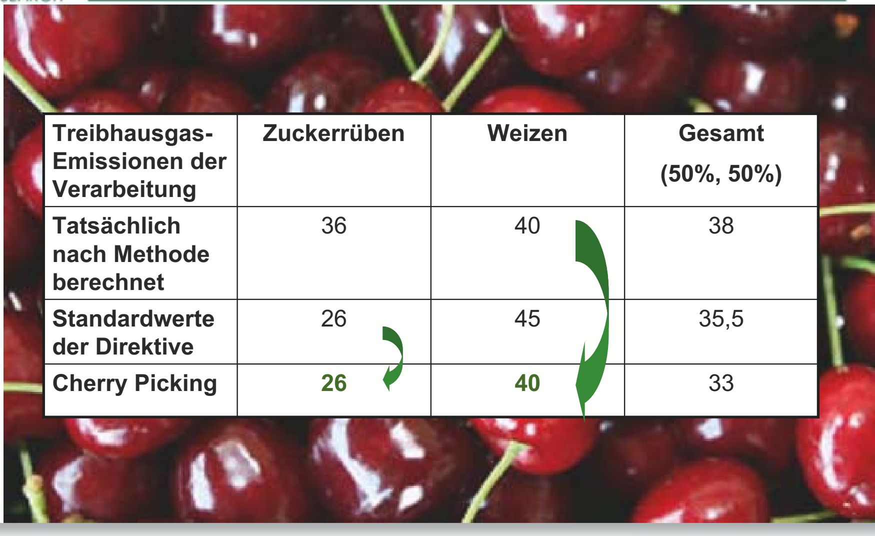
## Example „Cherry Picking“



| Treibhausgas-Emissionen der Verarbeitung | Zuckerrüben | Weizen | Gesamt (50%, 50%) |
|---|---|---|---|
| **Tatsächlich nach Methode berechnet** | 36 | 40 | 38 |
| **Standardwerte der Direktive** | 26 | 45 | 35,5 |
| **Cherry Picking** | **26** | **40** | 33 |

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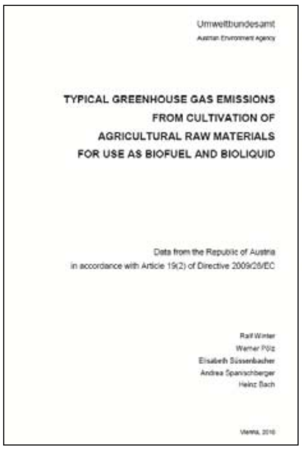
## Greenhouse Gas Emissions from Cultivation I


Umweltbundesamt
Austrian Environment Agency

TYPICAL GREENHOUSE GAS EMISSIONS
FROM CULTIVATION OF
AGRICULTURAL RAW MATERIALS
FOR USE AS BIOFUEL AND BIOLIQUID

Data from the Republic of Austria
in accordance with Article 19(2) of Directive 2009/28/EC

Ralf Winter
Werner Pölz
Elisabeth Süssenbacher
Andrea Spanischberger
Heinz Bach

Vienna, 2010

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## Greenhouse Gas Emissions from Cultivation II

Since the Directive contains no data on the energy density of the products (main products and co-products) and therefore no fixed allocation code is defined in it – this depends very much on the specific installations involved in each case – the values corresponding to the Austrian installation structure were used for the analysis. The data come from the GEMIS-Austria database. The respective allocation codes are given with the results.

| Crop types | Biofuel and bioliquid | Standard GHG emission [gCO2eq/M] | Min. GHG emission [gCO2eq/M] | Max. GHG emission [gCO2eq/M] | Cultivation in the f | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | B AT11 | K AT21 | NÖ AT12 | OC AT3 |
| Sugar beet | *Sugar beet ethanol* | *12* | *7.46* | *7.70* | X | X | X | X |
| Wheat | *(Common) wheat ethanol* | *23* | *18.78* | *20.82* | X | X | X | X |
| Grain maize | *Grain maize ethanol* | *20* | *9.86* | *12.54* | X | X | X | X |
| Rape | *Rape seed biodiesel* | *29* | *19.36* | *2338* | X | X | X | X |
| | *Pure vegetable oil from rapeseed* | *30* | *20.62* | *24.06* | X | X | X | X |
| Sunflower | *Sunflower biodiesel* | *18* | *10.76* | *13.83* | X | X | X | X |
| Soya bean | *Soybean biodiesel* | *19* | *9.71* | *12.05* | X | X | X | X |

*Source: Umweltbundesamt 2010*

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## Greenhouse Gas Emissions from Cultivation II

*Biodiesel 55%*

In accordance with the energy allocation method, taking into account the Austrian data basis 54.69%[5] of the emissions are allocated to biodiesel (FAME) and 45.31% to the coproducts (the separation is made in the installation at the point where the fuel is produced). This value is independent of the raw materials going into the production process (rapeseed oil, sunflower oil, etc.).

*Vegetable Oil 56%*

In accordance with the energy allocation method, taking into account the Austrian data basis 56.29%[6] of the emissions are allocated to vegetable oil (VO) and 43.71% to the co-products (divided up in the installation at the point where the fuel is produced).

*Bioethanol 67%*

In accordance with the energy allocation method, taking into account the Austrian data basis 67.00%[7] of the emissions are allocated to bioethanol (or ETBE) and 33.00% to the coproducts (divided up in the installation at the point where the fuel is produced). This value is independent of the raw materials going into the production process (sugar beet, wheat, etc.). In the emissions from cultivation no distinction is made with regard to the limit values according to Directive 2009/28/EC between bioethanol and the bio-ETBE made from it (see fig. 7).

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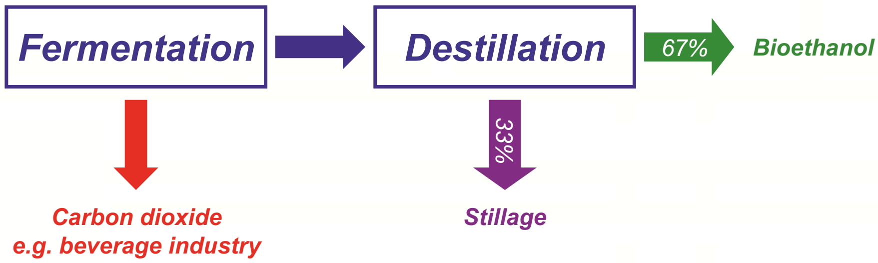
## $e_{ccr}$ = emission saving from carbon capture and replacement




- **RED: The CO2-benefit shall only be allocated to the biofuel, not to co-products**
- **Mistake in Directive or intension to stimulate improvements?**

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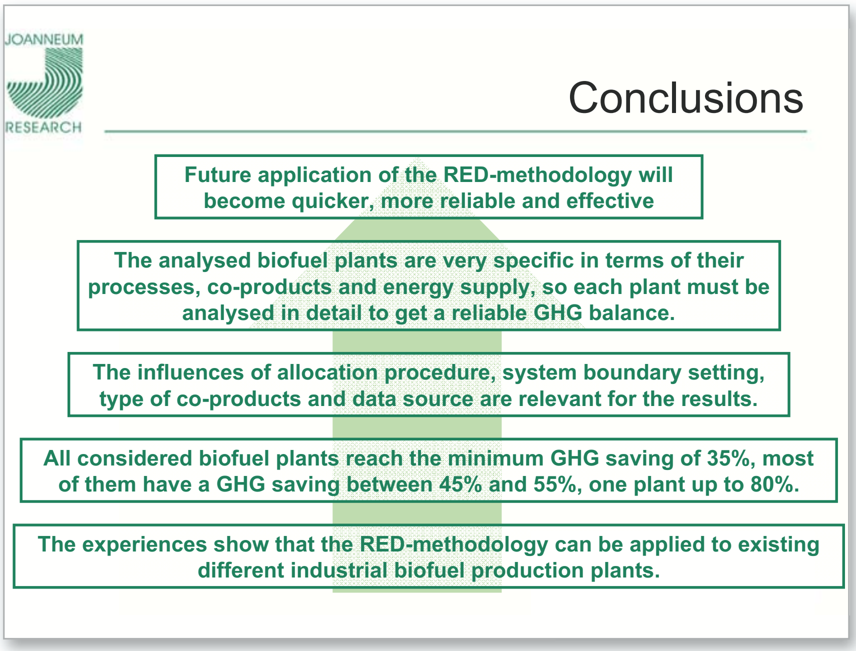
## Greenhouse Gas Emissions from Construction and Dismantling

- ***RED: Emissions from the manufacture of machinery and equipment shall not be taken into account***

***Greenhouse gas saving:***

$$E = (E_{fossil} – E_{biofuel}) / E_{fossil} >$$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Conclusions
Future application of the RED-methodology will become quicker, more reliable and effective
The analysed biofuel plants are very specific in terms of their processes, co-products and energy supply, so each plant must be analysed in detail to get a reliable GHG balance.
The influences of allocation procedure, system boundary setting, type of co-products and data source are relevant for the results.
All considered biofuel plants reach the minimum GHG saving of 35%, most of them have a GHG saving between 45% and 55%, one plant up to 80%.
The experiences show that the RED-methodology can be applied to existing different industrial biofuel production plants.

BIOGRACE
Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe

# BioGrace – Harmonising calculations of biofuel GHG emissions in Europe

Nikolaus Ludwiczek
BIOENERGY 2020+
Highlights der Bioenergieforschung, Wieselburg
March 31, 2011

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BIOGRACE
Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe
Intelligent Energy Europe

## Renewable Energy Directive (RED)

Sustainability criteria for biofuels

- Minimum GHG emission savings (Art. 17.2)
  - 35%
  - for installations that were in operation on 23 January 2008: binding from 1 April 2013
  - 2017 50%
  - 2018 60% for new installations
- Economic operators may use (Art. 19.1)
  - default values
  - actual values calculated according to Annex V.C
  - sum of actual value and disaggregated default value
- Independent auditors must check information (Art. 18.3)
- Can be part of voluntary certification schemes (Art. 18.4)

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March 31, 2011
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Harmonised Calculatio[...] Biofuel Greenhouse G[...]
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## RED Annex V.a

A. *Typical and default values for biofuels if produced with no net carbon emissions from land-use change*

| Biofuel production pathway | Typical greenhouse gas emission saving | Default greenhouse gas emission saving |
|---|---|---|
| sugar beet ethanol | 61 % | 52 % |
| wheat ethanol (process fuel not specified) | 32 % | 16 % |
| wheat [illegible] HP plant) | 32 % | 16 % |
| [illegible] nventional | 45 % | 34 % |
| [illegible] | 53 % | 47 % |
| [illegible] | 69 % | 69 % |
| [illegible] gas as | 56 % | 49 % |
| [illegible] | 71 % | 71 % |
| the part [illegible] yl-tertio-butyl-ether (ETBE) | Equal to that of the ethanol production pathway used | |
| the part from renewable sources of tertiary-amyl-ethyl-ether (TAEE) | Equal to that of the ethanol production pathway used | |
| rape seed biodiesel | 45 % | 38 % |
| sunflower biodiesel | 58 % | 51 % |
| soybean biodiesel | [illegible] | 31 % |
| palm oil biodiesel (process not specified [illegible] | [illegible] | 19 % |
| palm oil biodiesel (process with me [illegible] | [illegible] | [illegible] 6 % |
| waste vegetable or animal (*) oil b [illegible] | [illegible] | [illegible] |
| hydrotreated vegetable oil from ra [illegible] | [illegible] | [illegible] |
| hydrotreated vegetable oil from sun [illegible] | [illegible] | [illegible] 2 % |
| hydrotreated vegetable oil from palm oil [illegible] | [illegible] | 26 % |
| hydrotreated vegetable oil from palm oil (process [illegible] ane capture at oil mill) | [illegible] | 65 % |
| pure vegetable oil from rape seed | 58 % | 57 % |
| biogas from municipal organic waste as compressed natural gas | 80 % | 73 % |
| biogas from wet manure as compressed natural gas | 84 % | 81 % |
| biogas from dry manure as compressed natural gas | 86 % | 82 % |

Ethanol form sugar beet
Typical savings: 61%
Default value: 52%

Rape seed biodiesel
Typical savings: 45%
Default value: 38%

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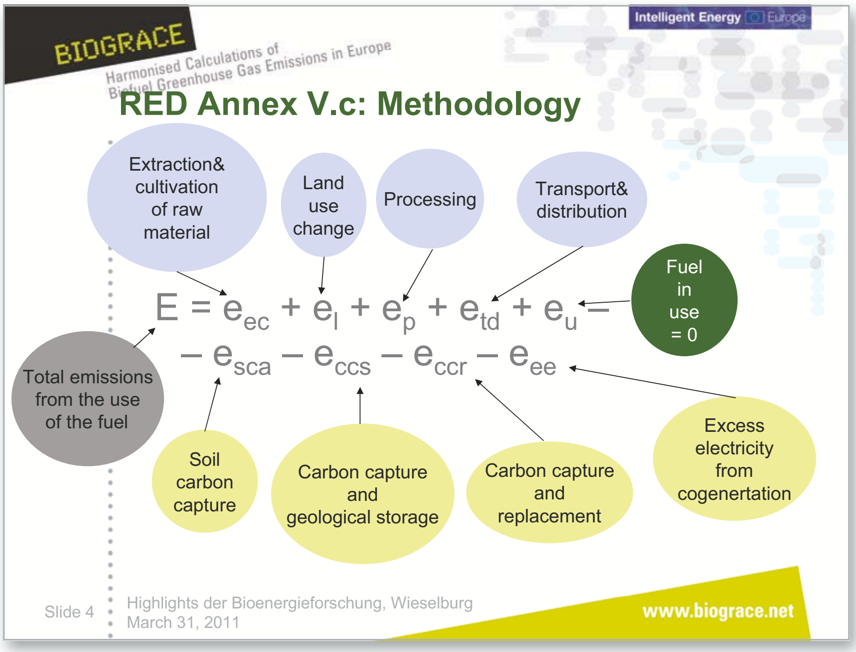


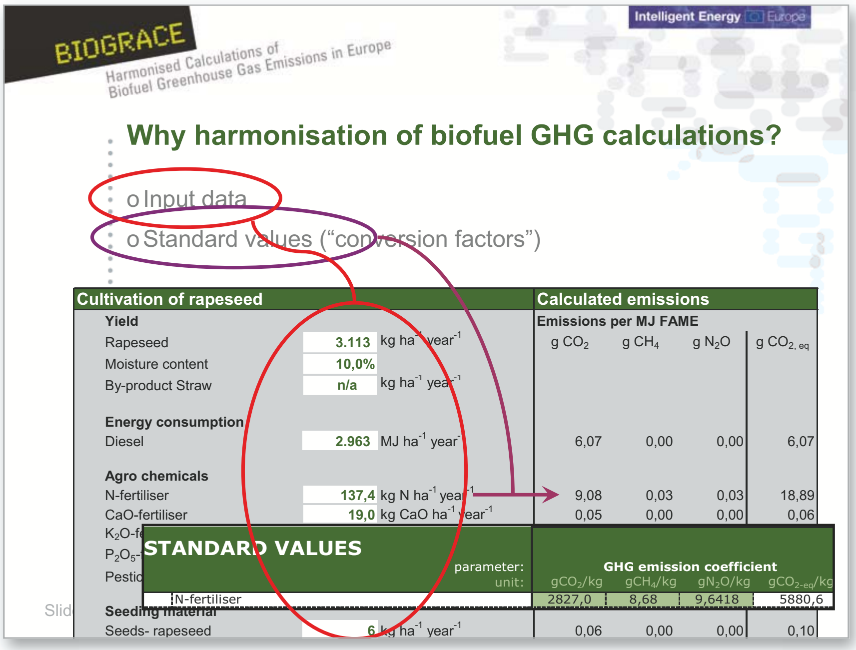


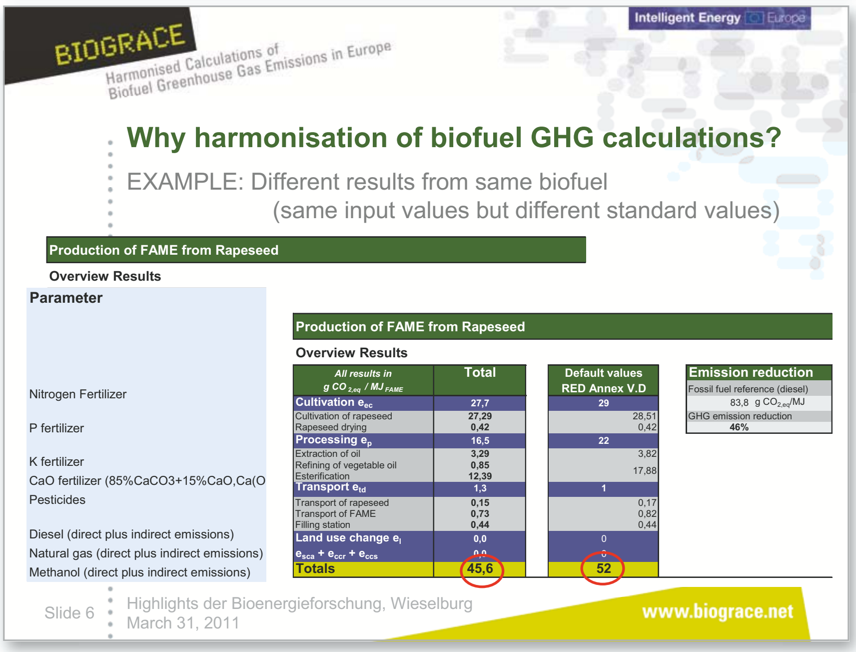


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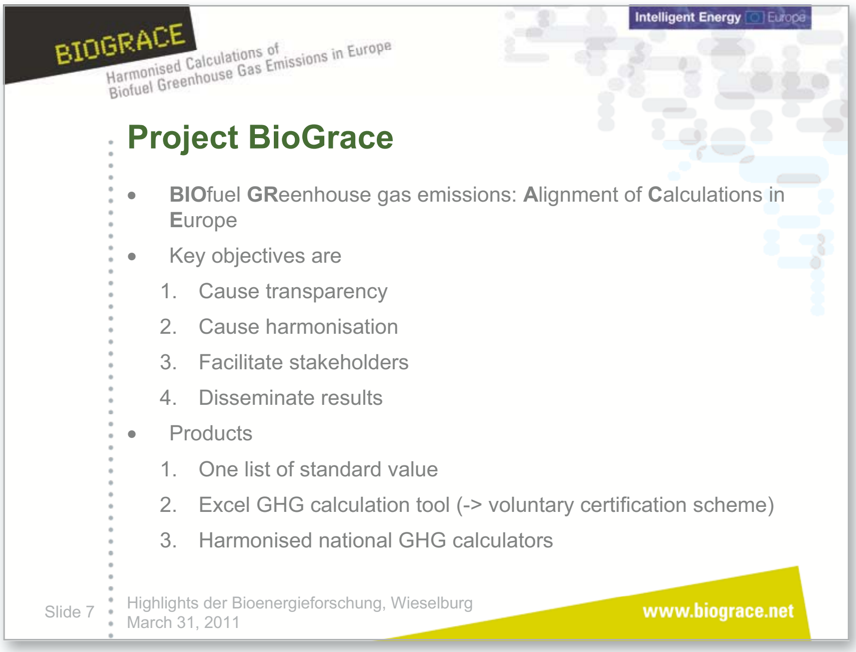


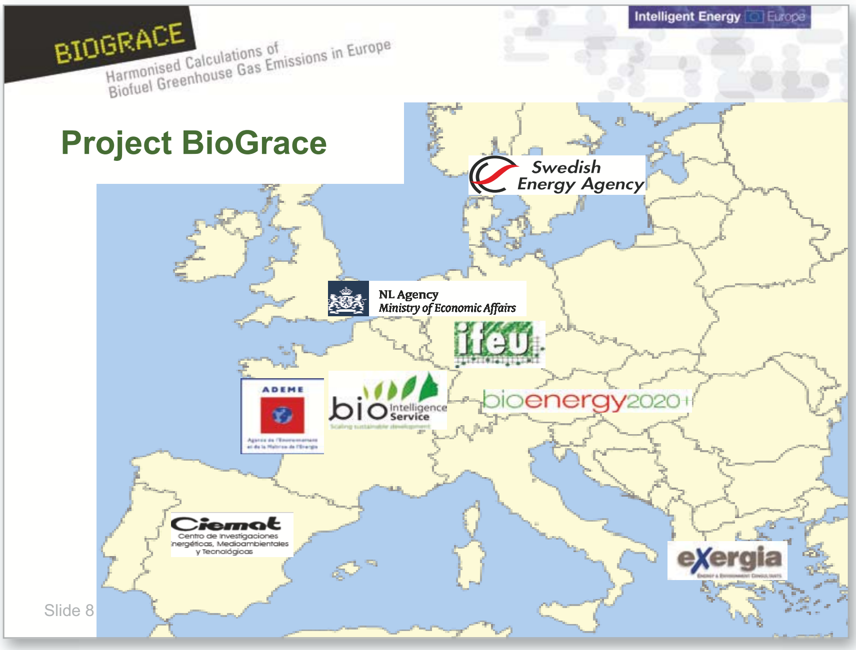


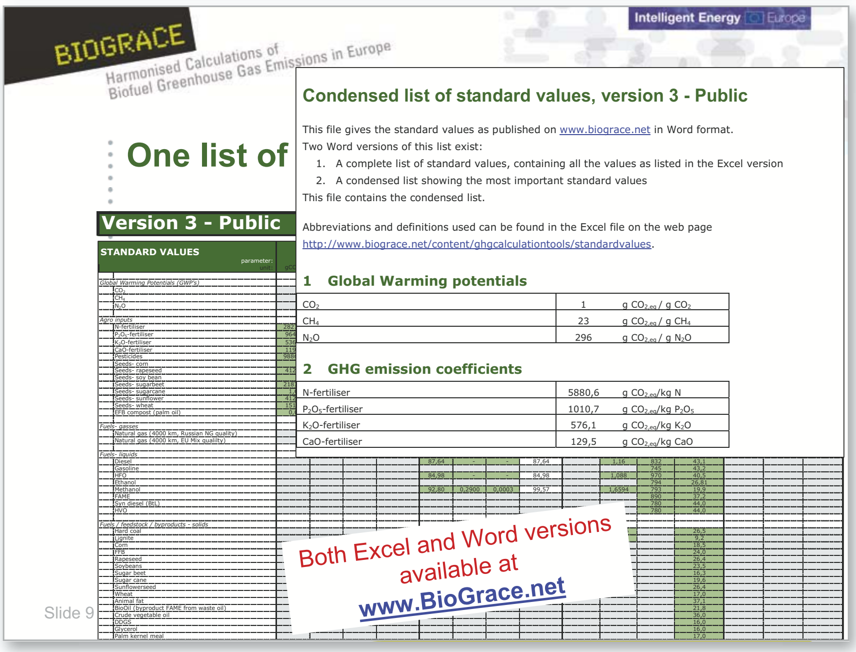


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BIOGRACE
Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe

Intelligent Energy Europe

## One list of standard values

- European Commission makes reference to list
- Member States include list in Technical Guidance:
  - Austria, Sweden, UK are preparing to do
  - Germany, Ireland, Netherlands are about to decide to do so
- Example (from UK consultation on C&S Technical Guidance)
  - *The RFA therefore proposes the following approach to which standard values should be used:*
    *1. For the reporting period 2011/2012, the RFA proposes to **align its current standard emission factors with the ones proposed by the BioGrace project**.*

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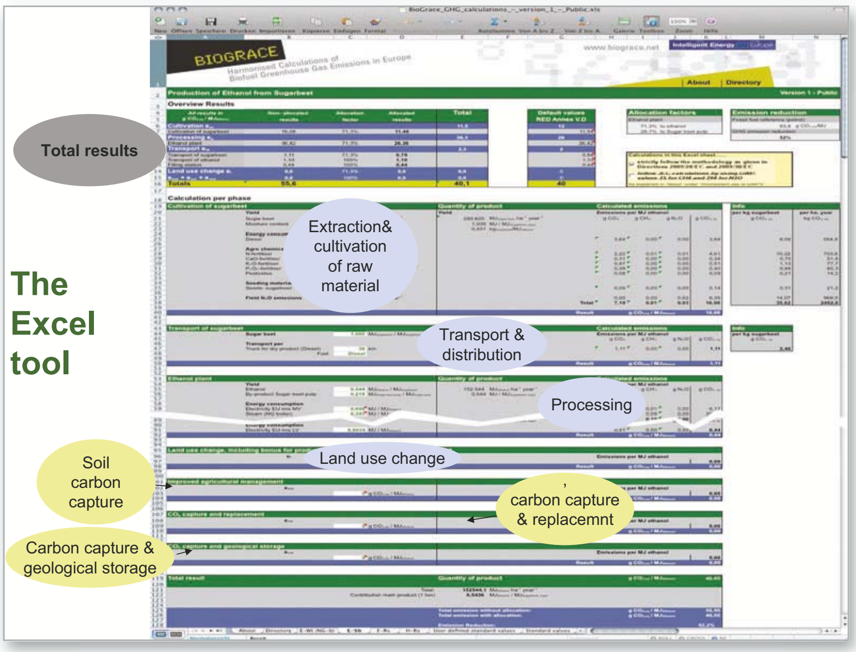
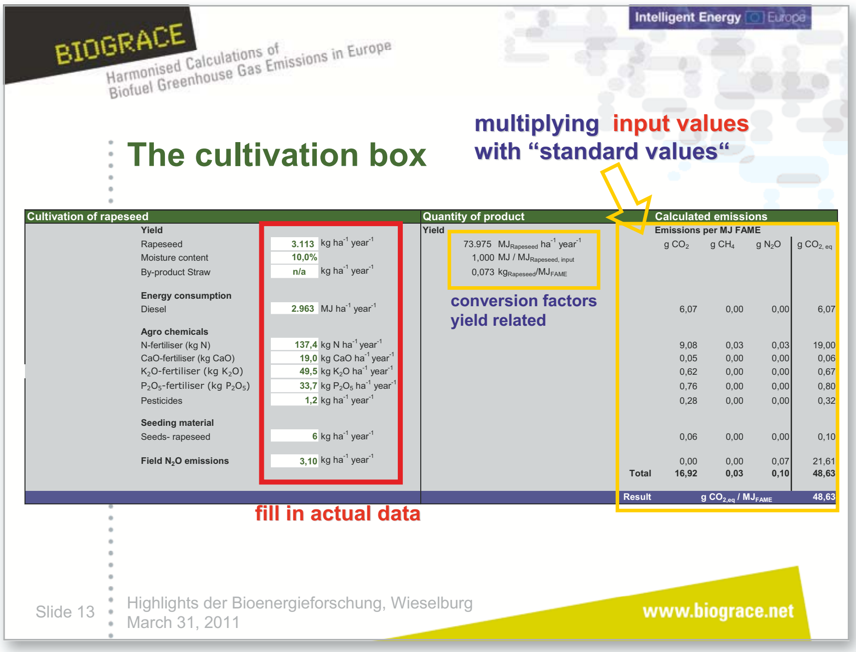



IEA FORSCHUNGS KOOPERATION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Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe
Intelligent Energy Europe
The cultivation box
multiplying input values with "standard values"
Cultivation of rapeseed
Yield
Rapeseed 3.113 kg ha-1 year-1
Moisture content 10,0%
By-product Straw n/a kg ha-1 year-1
Energy consumption
Diesel 2.963 MJ ha-1 year-1
Agro chemicals
N-fertiliser (kg N) 137,4 kg N ha-1 year-1
CaO-fertiliser (kg CaO) 19,0 kg CaO ha-1 year-1
K2O-fertiliser (kg K2O) 49,5 kg K2O ha-1 year-1
P2O5-fertiliser (kg P2O5) 33,7 kg P2O5 ha-1 year-1
Pesticides 1,2 kg ha-1 year-1
Seeding material
Seeds- rapeseed 6 kg ha-1 year-1
Field N2O emissions 3,10 kg ha-1 year-1
Quantity of product
Yield
73.975 MJ ha-1 year-1
1,000 MJ / MJ
0,073 kg/MJ
conversion factors yield related
Calculated emissions
Emissions per MJ FAME
g CO2 g CH4 g N2O g CO2,eq
6,07 0,00 0,00 6,07
9,08 0,03 0,03 19,00
0,05 0,00 0,00 0,06
0,62 0,00 0,00 0,67
0,76 0,00 0,00 0,80
0,28 0,00 0,00 0,32
0,06 0,00 0,00 0,10
0,00 0,00 0,07 21,61
Total 16,92 0,03 0,10 48,63
Result g CO2,eq / MJFAME 48,63
fill in actual data
Slide 13
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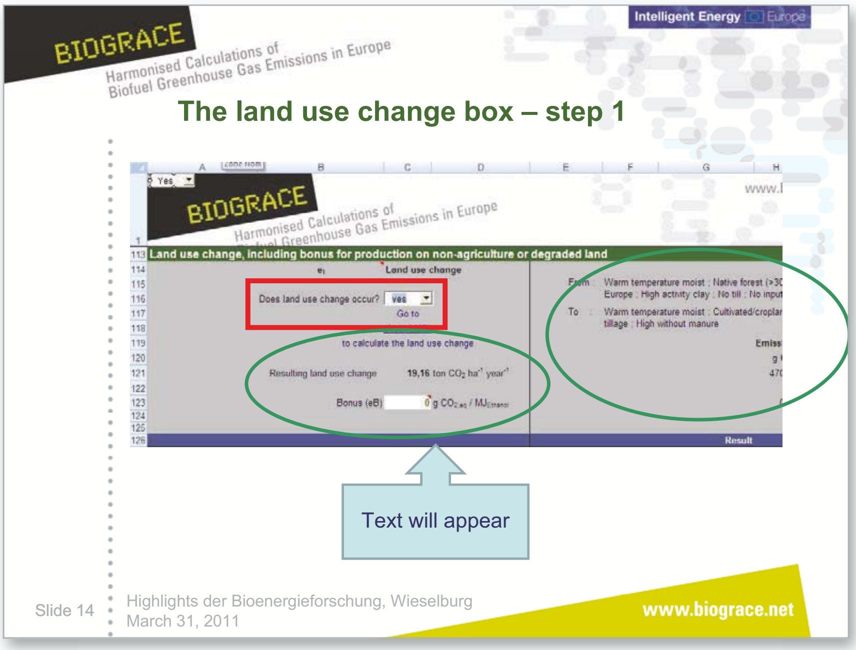
BIOGRACE
Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe
Intelligent Energy Europe
The land use change box – step 1
Land use change, including bonus for production on non-agriculture or degraded land
Land use change
Does land use change occur? yes
Go to
to calculate the land use change
Resulting land use change 19,16 ton CO2 ha-1 year-1
Bonus (eB) 0 g CO2,eq / MJEthanol
From Warm temperature moist : Native forest
Europe : High activity clay : No till : No input
To Warm temperature moist : Cultivated/cropland
tillage : High without manure
Result
Text will appear
Slide 14
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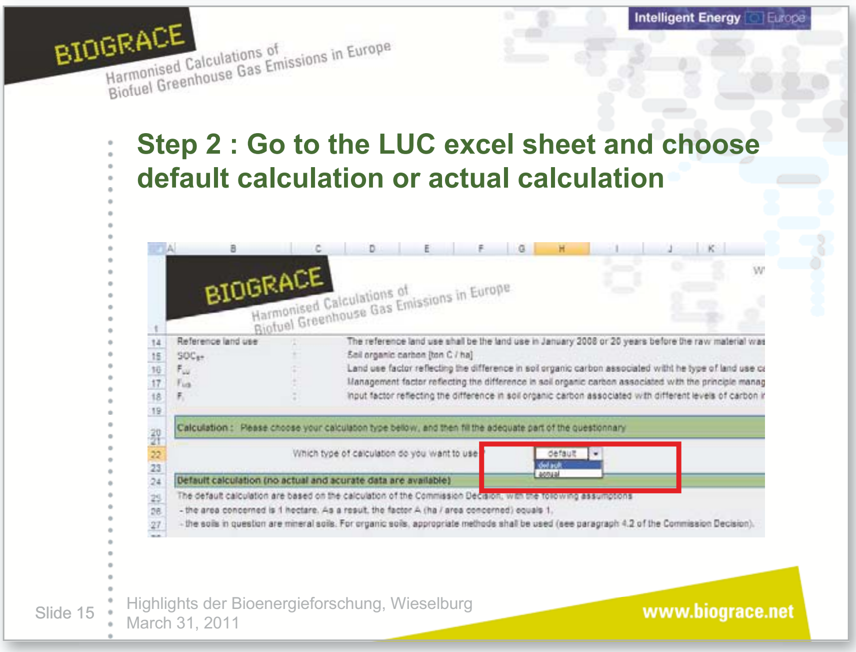
BIOGRACE
Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe
Intelligent Energy Europe
Step 2 : Go to the LUC excel sheet and choose default calculation or actual calculation
Reference land use
The reference land use shall be the land use in January 2008 or 20 years before the raw material was
Soil organic carbon [ton C / ha]
Land use factor reflecting the difference in soil organic carbon associated with the type of land use
Management factor reflecting the difference in soil organic carbon associated with the principle manag
Input factor reflecting the difference in soil organic carbon associated with different levels of carbon i
Calculation : Please choose your calculation type below, and then fill the adequate part of the questionnary
Which type of calculation do you want to use default
Default calculation (no actual and acurate data are available)
The default calculation are based on the calculation of the Commission Decision, with the following assumptions
- the area concerned is 1 hectare. As a result, the factor A (ha / area concerned) equals 1.
- the soils in question are mineral soils. For organic soils, appropriate methods shall be used (see paragraph 4.2 of the Commission Decision).
Slide 15
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## Step 3a : default calculation according to the Commission's guidelines

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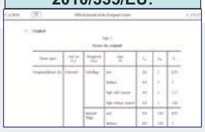
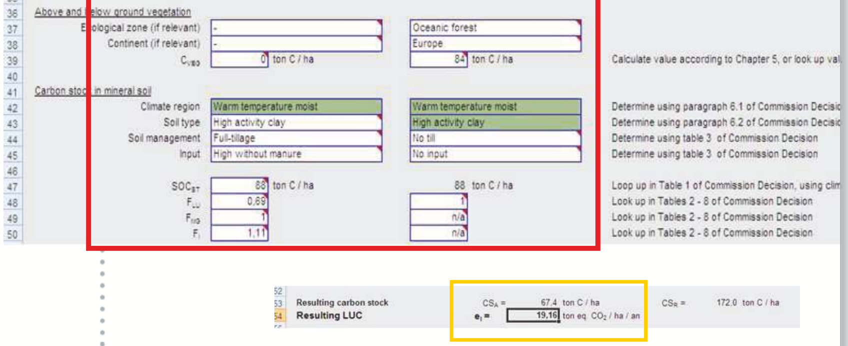
Commission Decision 2010/335/EU:








BIOGRACE
Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe

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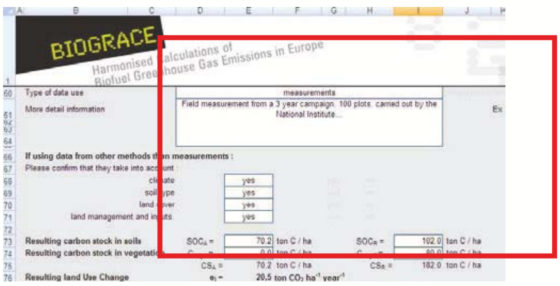
## Step 3b (actual calculation) : fill in detailed information about your method






BIOGRACE
Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe

Intelligent Energy Europe

## Additional tools

- User manual
- rules for making calculations of actual value
- extra sheets for calculation of
  - direct land use change (based on Commission Decision)
  - $N_2O$ emissions (based on IPCC Tier 1)
- list of recommended standard values
- **BioGrace will not:**
  - add pathways to the Excel file with GHG calculations that are not listed in RED Annex V
  - help stakeholders make actual calculations
  - check actual calculations at the request of stakeholders



IEA FORSCHUNGS KOOPERATION

BIOGRACE
Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe

Intelligent Energy Europe

## Recognition as a voluntary certification scheme

Observations:

- Current voluntary cert. schemes do not include GHG tool
  - ISSC, REDcert, NTA8080, RSPO, RTRS, Bonsucro (BSI)
- European Commission only allows use of GHG tool if it is recognised as a voluntary cert. scheme
- To our knowledge no GHG tools have been send to Commission for recognition
  - Some schemes will be send in, eg. National GHG tools
  - Information on actual developments is scarce
- GHG tool can be used as “add-on” to existing schemes

Time schedule

- Submit BioGrace tool to EC for recognition in March or April
- Recognition period of 5 years probably

Slide 19 Highlights der Bioenergieforschung, Wieselburg
March 31, 2011
www.biograce.net

BIOGRACE
Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe

Intelligent Energy Europe

## Thank you for your attention

INTELLIGENT ENERGY
EUROPE

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Slide 20 Highlights der Bioenergieforschung, Wieselburg
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## BioGrace – Harmonising calculations of biofuel GHG emissions

*Nikolaus Ludwiczek, BIOENERGY 2020+*

# Biofuel Production in Africa – Case Studies

Katharina Zwiauer


Highlights der Bioenergieforschung
Wieselburg, March 31, 2011

## Overview

- Africa's Biofuels Strategy
- Motives and Key Drivers
- Senegal:
  - Overview
  - Case Studies
  - Opportunities and Risks
- Conclusions

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## "Africa's Biofuels Strategy"

- **The "Green Opec "**
  *Pan-African Non-Petroleum Producers Association* was formed in 2006 to promote the biofuel sector in Africa (15 member states) and to become biofuel exporters
- **Addis Ababa Declaration (2007)**
  A joint activity of the African Union, the Brazilian Government and UNIDO
- **Regional strategies**
  Regional economic communities: ECOWAS, SADC ...
- **National policies**
  Co-operation with international organisations, transnational industries, south–south and triangular co-operation on technology transfer

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## Motives and Key Drivers

### “Green Opec“

- **International trade**
- Reduction of energy dependencies – improvement of energy security
- **Stimulation of African economies**
- **Encouragement of foreign investment**

### Investors

- **Land availability:** large land areas, low level of utilisation of arable lands
- **High biomass potential**
- Suitable soils – climate
- Low labour costs and low labour law standards
- Lack of national sustainability criterias

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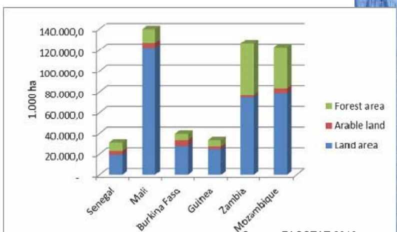
## Senegal: Geography and Land Area


**Geography and climate**

Source: IRD

**Land area and arable land area in different African countries**




Source: FAOSTAT 2010

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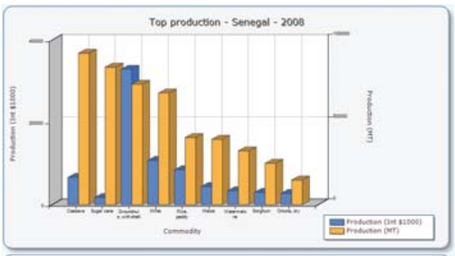
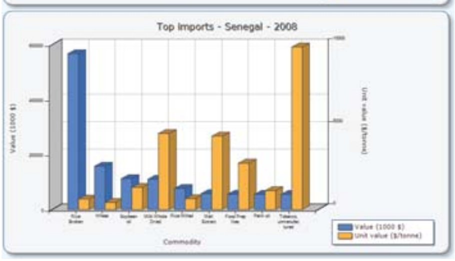
## Senegal: Food Supply




**Food production**




**Imports of food**

Source: FAOSTAT 2010

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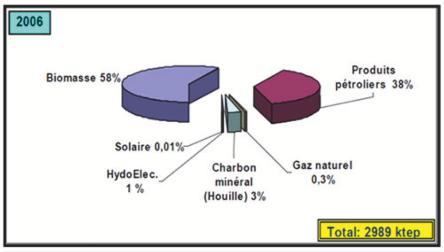
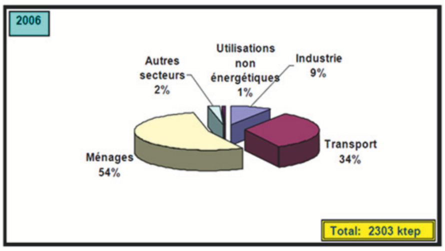
## Senegal: National Energy System




**Energy supply per energy type**




**Energy consumption per sector**

Source: FAO, SIE-Senegal 2007

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## Targets for Biofuel Production

### Senegal's national policy objective: self-sufficiency

**Biodiesel - "Jatropha program" :**

- Target: 321.000 ha by 2012
  - Up to the end of 2010 ~3000 ha had been planted
- Production goal: 1.190 million litres of refined oil

**Ethanol (sugar cane):**

- 10 to 12 million litres/year

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## Case Study 1

**Compagnie Sucrière Sénégalaise (CSS)** Senegal River Valley

- **Cultivation area:** **8.700 ha**
- **Sugar cane:** **1 mio t/y**
- **Sugar:** **100.000 t/y**
- **Ethanol:** **60.000 l/d**

**Positive Impacts:**

**Generation of jobs**
3000 permanent employees
4000 seasonal workers

**Negative Impacts:**

- **High water pollution**
  - **Hazard for drinking water savety (Lac de Guier)**
  - **Hazard for wildlife (birds)**

Source: CSS

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## Case Study 2

**Dangote Group**

Senegal River Valley

- **Cultivation area: 40.000 ha**
- **Sugar cane**

**"The investment makes Dangote the biggest wholly African investor ever in the Francophone country. The Senegalese government has allocated Dangote Industries about 40,000 hectares of land ."**

Source: bonsucro

**Potential negative impacts:**

- **High water consumption**
- **Damage of *Acacia* forests**
- **Competition for food production**
- **Loss of land and water rights for Fulani people and small scale farmers**

**Dangote Invests $1 Billion in Senegal**

| 29 views
admin | Mar 02, 2011 | 0 comments

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## Case Study 3

**Tozzi Group (Italy)**

Region: Tambacounda

- **Cultivation area: 50.000 ha**
- **Jatropha**

**Potential negative impacts:**

- **Damage of natural and `classified forests`**
  - **Destruction of bamboo habitats**
- **Loss of land tenure rights, transition to contract farming**
- **Loss of fuelwood**

**Natural forests in Senegal**:

1960: 11 million ha

2010: 8.3 million ha

Carbon stock in living forest biomass (mio t): 340

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## Opportunities and Risks

### Opportunities

- Creation of jobs
- Stimulation of agriculture
- Diversification of agricultural production
- Improvement of local energy supply
- Local value creation
- Improvement of the trade balance

### Risks

- Biodiversity loss and ecosystem damage
- Unsecurity in food supply
- High water consumption and water pollution
- Loss of land use rights:
  - Marginalization of subsistence farmers and pastoralists
  - Increase in landlessness
  - Migration

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## Conclusions

### Key to development:

- Integration of small scale farmers and "landless" pastoralists into medium-sized and large scale projects
  - Legal acceptance of water rights, land and land use rights (including informal land rights)
  - Subsidization of small scale farmers and local agricultural cooperatives
  - Long-term and reliable cooperations between agro-industries and farmers

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## Conclusions

### Requirements for sustainable biomass production:

- Development and implementation of legal provisions and policies by African governments with regard to
  - Large scale land allocations – land rights
  - Labour conditions: models of contract farming, outgrower schemes
  - Use of natural ressources in general and water in particular
  - etc.

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## Thank you!

### More Information:

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Thanks to my cooperation partners ENDA and Mr. Amadou G. Ba and his son

Katharina Zwiauer

FORSCHUNGS KOOPERATION


Developing Countries
Programs and Lessons learned
Austrian Development Agency (ADA)
Mr. Hannes Bauer, Sustainable Energy
March 2011
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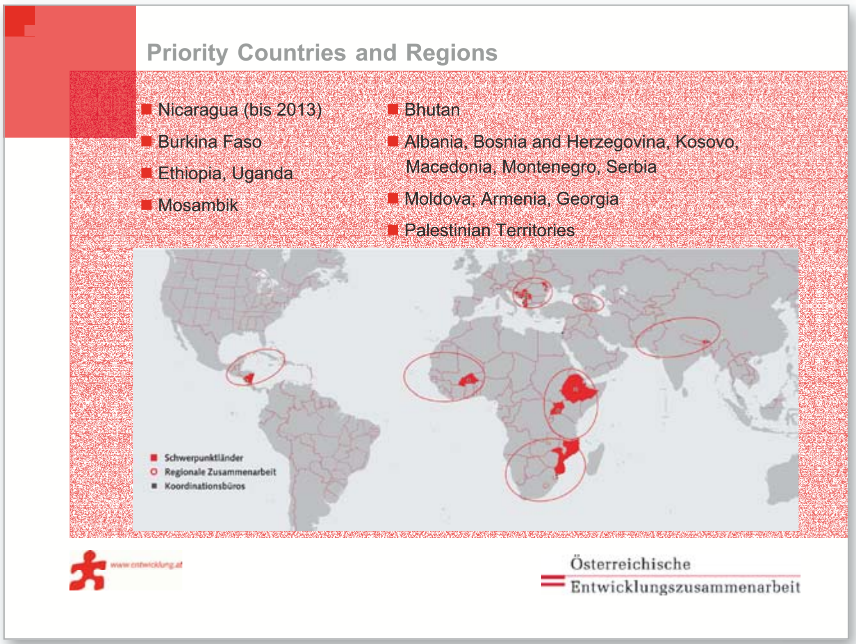
Entwicklungszusammenarbeit


Priority Countries and Regions
Nicaragua (bis 2013)
Burkina Faso
Ethiopia, Uganda
Mosambik
Bhutan
Albania, Bosnia and Herzegovina, Kosovo, Macedonia, Montenegro, Serbia
Moldova; Armenia, Georgia
Palestinian Territories
Schwerpunktländer
Regionale Zusammenarbeit
Koordinationsbüros
Österreichische
Entwicklungszusammenarbeit


Millennium Development Goals (MDGs)
Overall Goal: Half poverty by 2015
In 2000 all 192 UN Member States have agreed to achieve by 2015:
keep the promise
Millennium Development Goals
2015
Goal 1: Eradicate extreme poverty and hunger
960 Mio human beings are malnourished or have to hunger in 2008
Goal 2: Achieve universal primary education
Goal 3: Promote gender equality & empower women
Goal 4: Reduce child mortality rate
Goal 5: Improve maternal health
Goal 6: Combat HIV/AIDS, malaria, and other diseases
Goal 7: Ensure environmental sustainability
Goal 8: Develop a global partnership for development
WB 2008: The effects of the food and fuel crisis on malnutrition and schooling can undermine years of progress on the MDGs*
Contribution of Austria: Minister Spindelegger shorted the budget for Development Co-operation (ADA) 2011–2014: 10% annually
* Source: RISING FOOD AND FUEL PRICES, ADDRESSING THE RISKS TO FUTURE GENERATIONS, October 12, 2008
Human Development Network (HDN), Poverty Reduction and Economic Management (PREM) Network, The World Bank
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*Hannes Bauer, Austrian Development Agency*

## Background on Biofuels

Bioethanol mainly from sugarcane or maize; blended with gasoline

Biodiesel mainly from rapeseed and palm oil

Biofuels account for > 1 percent of road transport fuels and are expected to account for 4 – 7 percent by 2030

Biofuel generation booming, in response to high energy prices and driven by gov. blending targets and subsidies, justified by energy security concerns and the wish to increase energy independence and government

Biofuels have potential to create rural employment and contribute to rural development by providing decentralized small-scale sources of energy (off-grid rural electrification, substitution of diesel)

Tropical countries have the highest potential to produce biofuel crops

Tripling of oil prices since 2000 has severely affected net importers among developing countries, forcing them to divert funding from critical development needs such as health and education, and increasing public debt

Energy efficiency measures, intelligent transport and fuel switching (e.g. away from coal) offer much greater and cheaper potentials for climate change mitigation than expansion of biofuel production.

Biofuel production from food crops, along with rising food demand in emerging countries have already led, and will continue to lead, to food price increases. This is a threat to the urban poor and to non-self sufficient farmers, but may also be an opportunity for farmers in the South

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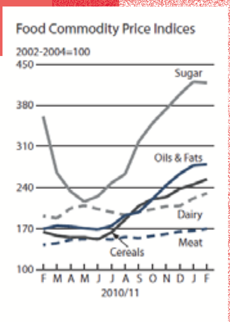
## Global food price monitor (FAO)





**FAO Food Price Index** (FFPI): av. 236 points in 2–2011 as the highest rate since 1–1990, the inception date of the index, driven mostly by higher prices of cereals, meat and dairy products

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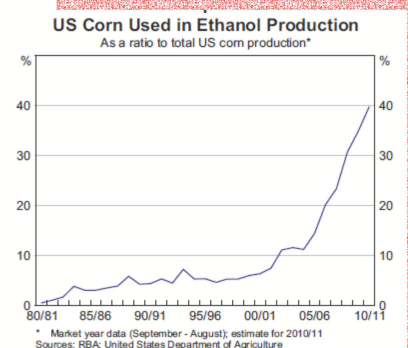
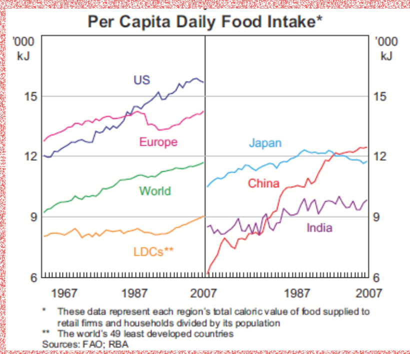
## Background in Biofuels and Food

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Source: FAO and Reserve Bank of Australia

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## Biofuels concerning poverty reduction

- Influences on Security of alimentation and cultivation of staple crops
  Biofuel for 75% of increasing of food prices responsible
  IBRD 2008, A note on rising food prices
- Biofuels may be interesting when local population can benefit:
  - additional income generation
  - diversify agriculture
  - fuel also/primarily for local use (motor vehicles, stat.applications, etc)
  - positive interactions in the existing system
- Critical review large scale cultivation and (investor driven) exports
- National, local authorities and NRO should be involved
- Holistic Assessment of bioenergy generation in disponible land areas
  - Ownership
  - Area "used" as fallow
  - Are there temporal nomads or pastoralists?
  - Is there a risk of any other displacement or migration?
  - Influences on ground and sub terrain water
  - Moving in of people in ecological areas (e.g. tropical rain forest)

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## Running Energy Activities financed by ADA

**Energy Programs**:
- EEP Energy and environmental partnership in Southern & Eastern Africa
  www.eepafrica.org
- EEP Energy and environmental partnership in Central America
  www.sica.int/energia
- ECREEE – ECOWAS Regional Centre for Renewable Energy and Energy Efficiency: 15 Countries of the ECOWAS region in West Africa
  www.ecreee.org

**Conferences**:
- GFSE Energy between Danube and Caucasus The role of Renewable Energy and Energy Efficiency as a key issue for economic development, 28th–29th of April 2011, Vienna
- Energy for All – Time for Action 21–23 June 2011, Austria

**ADA Homepage**: www.entwicklung.at/themes/energy/en
**Contact**: Mr. Hannes Bauer, hannes.bauer@ada.gv.at +43 1 90399 2557

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## Jatropha Project in Guatemala

### POTENTIAL FOR ECONOMICAL AND SOCIAL IMPACT

- **Excellent alternative to marginal areas**: low watering need, high adaptability to soils with low nutrient concentrations
- **High oil content**: aprox.1900 l/ha
- **Low implementation costs**, with **long lifespan** (30 – 50 years)
- **Common in Guatemala,** where it is used in **fences**
- **High economical value: biodiesel and Sub-products (organic fertilizer, *briquettes*, biogas)**
- **New opportunities for the women in the communities,** who are responsible for the sub products

*Green fruit*

*Seed*

*Jatropha bush*

*Jatropha fence*

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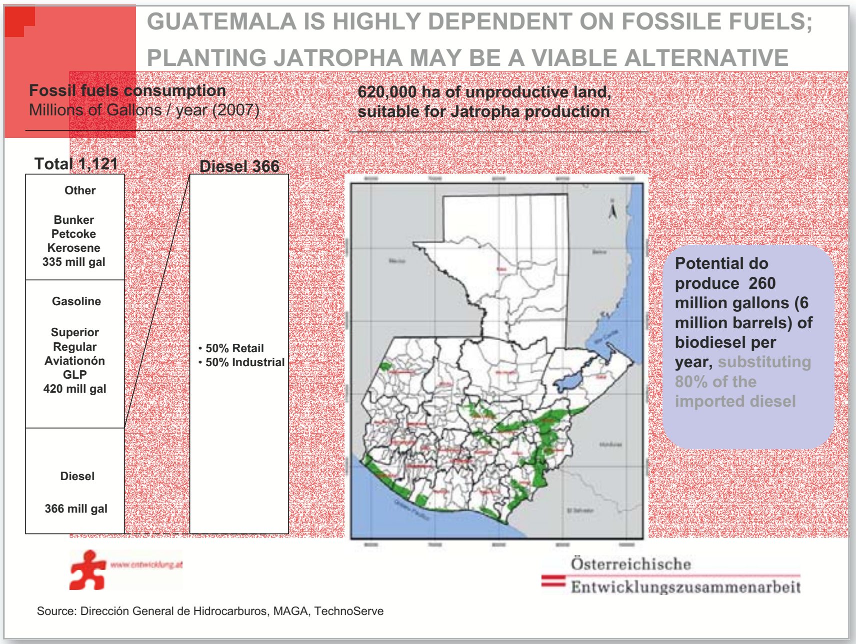
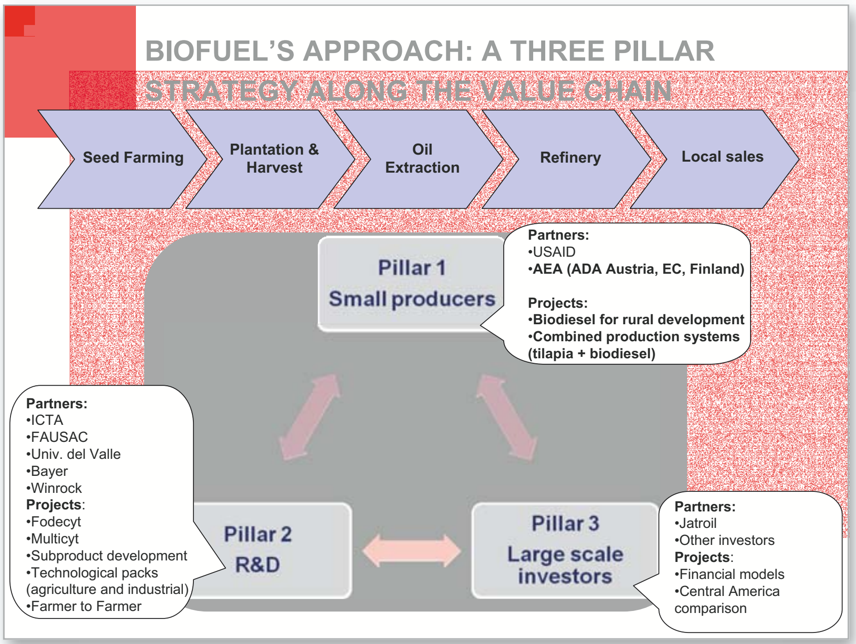
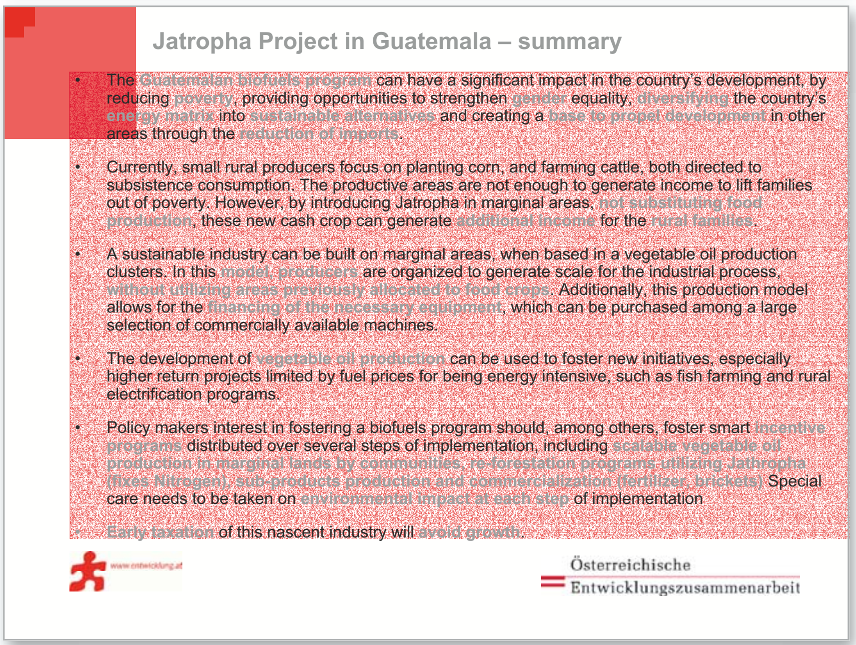
*Hannes Bauer, Austrian Development Agency*

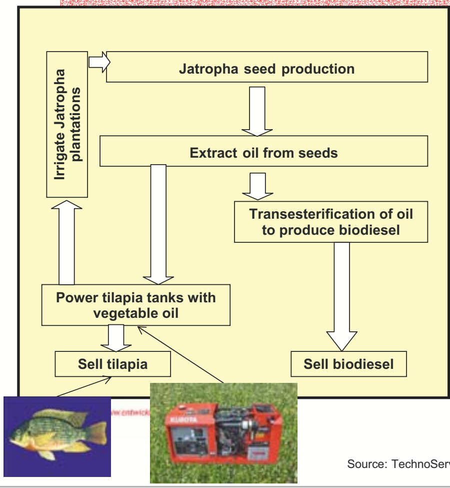


## THE STRAIGHT VEGETABLE OIL INDUSTRY CREATES NEW OPPORTUNIES FOR OTHER DEVELOPMENT PROJECTS

**Example: combined *Jatropha* and fish (Tilapia) production**




- Tilapia is a high return production system, however high fuel costs in remote areas can limit the access of small communities to it.
- High complementary between *Jatropha* and tilapia production systems:
  - Estimation of up to 30% costs reduction, by substituting diesel for straight vegetable oil to operate tilapia tanks
  - Over 40% increase in *Jatropha* seed production by watering with water disposed from ponds (rich in nutrients from fish excrements)
- Pilot being implemented in the Zacapa Department, to validate the economical model

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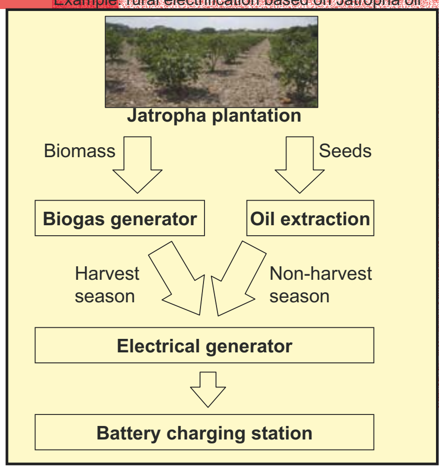
Source: TechnoServe - Guatemala

## RURAL ELECTRIFICATION PROJECTS AS EXAMPLE OF DEVELOPMENT WITH STRAIGHT VEGETABLE OIL

Example: rural electrification based on Jatropha oil




- A **battery charging station can be built based on Jatropha oil and biomass.**
  - During harvest season the generator station runs on biogas.
  - During the non-harvesting season, the generator runs on stored vegetable oil
- Each **involved family owns two batteries**, and a wiring kit in their house to power light bulbs and small appliances (approximate cost per family of $400 dollars).
- Model advantages include lower electrification costs for low density area (no transmission costs) and the possibility of families better controlling their energy expenditure.

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Source: EEP, TechnoServe - Guatemala

## OVERALL CONCLUSIONS TO CONSIDER WHEN FOSTERING THE CREATION OF A BIOFUELS INDUSTRY

- A detailed mapping and identification of unproductive arable areas suitable for jatropha crops can ensure that investments are directed toward marginal areas and ensure that no food substitution or deforestation occurs.
- The trans-esterification process produces as a deject water that should be "cleaned" before it can be reintegrated to the environment. This can be substituted by a "dry washing" method, which should be encouraged. To ensure the correct environmental precautions are taken, transesterification plants should be operated by large players, with incentives to comply with regulators and that can be inspected / certified.
- Additional research opportunities are related to substituting the methanol required in a economical way (currently it is not economical interesting to substitute the methanol for ethanol).
- The taxation of different components of the supply chain can make biodiesel not competitive (price –wise) with petroleum derived diesel, or reduce margins throughout the production chain that would limit the benefit received by small producers. As an example, in Mozambique biodiesel can be produced at a cost of $0.76 / liter. However, after taxation (fuel tax and VAT), the cost of selling is $ 1.09 / liter, while regular diesel is sold for $0.97 / liter (2007).
- Sub-products (organic fertilizers, etc.) are needed to ensure the economical attractiveness of jatropha production, and their use and commercialization should be promoted. Additionally, they provide an opportunity to integrate women into the production chain, thus strengthening their social position.
- The creation of a complete, nation-wide and sustainable industry must be constructed in timed steps, initially assuring that the model is economically validated thru pilots and that sufficient research is done, then scaling up until the industry is stable and demand driven.

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Source: EEP, TechnoServe

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## Summary of Day

***Theodor Zillner**, BMVIT, III/I 3*

# Postersession

**PROFACTOR – BIOBUTANOL AS AN ALTERNATIVE BIOFUEL**
***V. Kastner***, *S. Nöbauer, W. Schnitzhofer*

**Effective communication as a critical factor in woody biomass mobilization**
***Dr. Astin Malschinger***, *Matthias Jax B.A.*

**Contribution of a regional energy concept to mobilization of bio fuel production**
***Mag. (FH) Josef Walch***, *Martin Gosch B.A.*

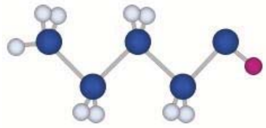
**Cold Temperature Properties of Fatty Acid Methyl Esters**
***Josef Rathbauer***, *Rudolf Zeller*

**ERA-ARD:**
**Bioenergy in Africa – Opportunities and Risks of Jatropha and Related Crops**
***Andrea Sonnleitner***, *Dina Bacovsky*

**Mapping of 2$^{nd}$ Generation Biofuel Demonstration Plants**
***Dina Bacovsky***, *Andrea Sonnleitner, Manfred Wörgetter*

**Netzwerk Biotreibstoffe**
***bioenergy2020+***

**Animal Waste for the Production of Biofuels and Biopolymers**
***Katharina Strohmeiera***, *Sigurd Schobera, Martin Kollerb, Martin Mittelbach*



# BIOBUTANOL AS AN ALTERNATIVE BIOFUEL

**V. Kastner, S. Nöbauer, W. Schnitzhofer**
PROFACTOR GmbH, Department of Innovative Energy Systems

## Introduction

In order to meet the aims of Kyoto, several national as well as european initiatives were launched to replace fossil fuels by biofuels to a certain extent. Beside biodiesel and bioethanol, biobutanol is another type of biofuel, which can serve to reach these aims. In Austria several biodiesel plants are in operation with a total capacity of 240000 t biodiesel per year[1], as well as a large bioethanol plant with a capacity of 190000 t[1]. Biobutanol is not produced to this date. Butanol (1-Butanol, n-Butanol, $CH_3$-$CH_2$-$CH_2$-$CH_2OH$), an aliphatic, saturated C4-alcohol (properties table 1) can be used as a fuel additive for transport. It is miscible with gasoline as well as with gasoil. At present time, butanol is used primarily as a solvent for industrial applications. The estimated world market for this product is 1,3 billion liters per year, and the U.S. share of this amount is 830 million liters per year.

Biobutanol requires no modification to gasoline-powered engines and can easily fuel today's standard vehicles in gasoline blends or added to ethanol to reduce evaporative emissions.

It is far less corrosive than ethanol and can be distributed through existing oil and gas pipelines more easily than ethanol. Biobutanol will not damage automobile components, such as valves and gaskets or any segment of fuel distribution systems.

**Table 1:** Properties butanol

| | |
|---|---|
| Molecular weight | 74.12 g/mol |
| Specific weight | 810 kg/m³ |
| Boiling point | 117.7°C |
| Vapour pressure | 5.6 hPa (at 20°C) |
| Flash point | 35 – 37°C |
| Solubility in water | 90 g/L (at 25°C) |
| Volumetric energy content | Ca. 27.0 MJ/liter |
| Research Octane number | 94 |

## Process

An especial sustainable pathway for its production is the biotechnological way, the so called ABE fermentation, a strict anaerobic process, which was well known as Weizmann-process in world war one. Therein different substrates are converted to acetone, butanol and ethanol, by different *Clostridia sp*. (Table 2), under participation of several metabolic pathways interacting in a complex manner. Butanol can be produced from many kinds of renewable organic material such as corn, wheat, wood pulp, sugar cane, sugar beets and even cheese whey.

**Table 2:** Microorganisms investigated for biobutanol production

| Organism | Product |
|---|---|
| *Clostridium beijerinckii* | ABE |
| *Clostridium acetobutylicum* | ABE |
| *Clostridium aurantibutyricum* | Acetone, butanol and isopropanol |
| *Clostridium tetanomorphum* | Butanol and ethanol |

During exponential growth of the cells the main products are different acids like lactate, acetate und butyrate as well as hydrogen and $CO_2$ (acidogenesis). Only at the stationary growth phase the production of solvents is taking place (solventogenesis). During the fermentation using *C. acetobutylicum* acetone, butanol und ethanol are produced in a ratio of 3:6:1 and up to a concentration of 12 g/L butanol. Usually, maximum total ABE concentration of 20 g/L is achieved.

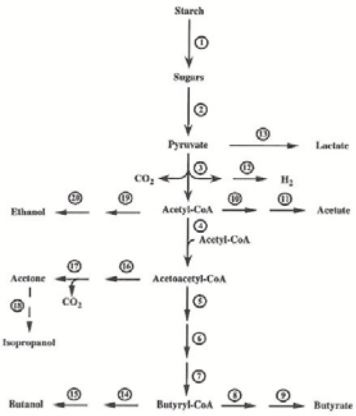



**Figure 1:** Metabolic pathways of solvent forming microorganisms with starch as initial substrate (numbers indicate enzyme catalysed steps and are not described here)[3]

## Challenges

However, this process is hampered by end product inhibition, uneconomical product recovery, and the use of dilute substrate solutions, thereby resulting in large process stream volumes as well as process instabilities. Different bioreactors and different operation modes are in investigation. Using online product recovery the total ABE content could be increased to 230 g/L.[4]

Methods of product separation:[3,5]

- Adsorption using silicagel or ion exchange resins
- Gas stripping and subsequent condensation of solvent/water vapour
- Liquid/liquid extraction: Contact of non-water miscible solvents with fermentation liquid
- Membrane evaporation: Selective diffusion through porous membranes
- Perstraction: Separation of extraction liquid and fermentation broth by a membrane
- Pervaporation: Selective diffusion through a non-porous membrane, regeneration by vacuum or gas
- Reversed osmosis: High pressure separation of a diluted solution into a concentrate and water phase via a semipermeable membrane.

## Outlook

Currently, several international initiatives are ongoing in order to make biobutanol production economically feasible (BP etc.).

A national project is planned with the aim to set up a competitive process for biobutanol production, by approaching the main scientific goals: Identifying the optimal microbiological system, application of an innovative substrate pretreatment and concept and test of an integrated fermentor and product upgrading system.

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[1] www.wko.at
[2] Ezeji, T., Qureshi, N., Blaschek, H. World Congress on Industrial Biotechnology and Bioprocessing (2004) Paper No. 37
[3] Dürre, P. Appl Microbiol Biotechnol (1998) 49: 639-648
[4] Kumar, M., Gayen, K. Applied Energy (2011) in press
[5] Qureshi, N., Maddox, I.S., Friedl, A. Biotechnol Prog (1992) 8: 382-390

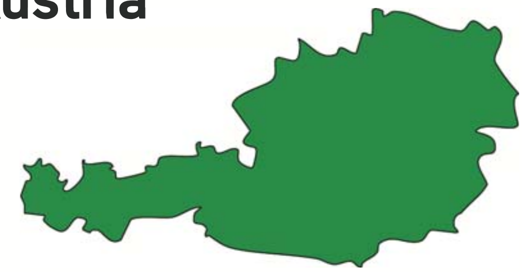
# Effective communication
as a critical factor in woody biomass mobilization

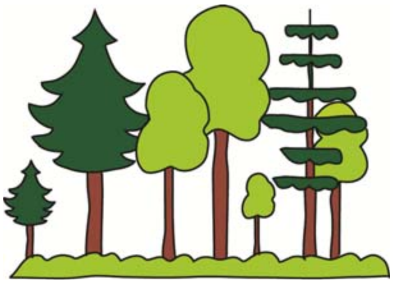
**Author:** Dr. Astin Malschinger, Matthias Jax B.A.
**References:** Project group „Waldfrequenz" (Riegler, Sulzbacher, Pavliska, Mannert)
Ländliches Fortbildungsinstitut, Forest Association Austria, University of Applied Sciences Wiener Neustadt Campus Wieselburg

## Forestry and timber industry in Austria

With a proportion of almost 50% forest, Austria is one of the most forested countries in Europe. In four million hectars there are more than one billion cubic meters of wood. Every second a wooden cube measuring 1m³ is growing in Austria. Each year this represents an increase of 30 million cubic meters of wood. Of these only two thirds are used.

More than 266,000 people make a living from the forests and the renewable resource wood. The sector has an annual turnover of over 10 billion Euro. Almost 9% of the annual exports of good come from the forestry and timber industry.





## Forest owners in Austria

According to the study, „Who are Austria's forest owners", two groups with different information behavior can be identified:

> About 2/3 of forest owners actively seek information and relies on particular „classic forestry" institution.

> About 1/3 is uninformed about forest-related aspects and will be difficult to reach in the future.

## Wooden case with media.box as optimal communication tool

### Wooden case

The wooden case features a range of communication tools. Its key purpose is to assist consultants.

The case includes an information folder and a CD/DVD-Box with audio and visual data. The content provides basic informatione on the forestry and timber industriy in Austria.

### Media.Box

The Media.Box holds basic information about the Austrian forest and timber industry. It includes a Media.CD and a Film.DVD.

### Film.DVD

The movie introduce the topic to forest owners with little knowledge of forestry and interested individuals.

### Media.CD

The aim of the Media.CD is to give the consultant the opportunity to access information related to the planning and implementation of information sessions.

Therefore the following media are available:

> Presentation
> Checklist
> Layouts (Invitations, Posters)


> University of Applied Sciences Wiener Neustadt Campus Wieselburg
> A-3250 Wieselburg . Zeiselgraben 4 . www.amu.at
> office@amu.at . Fon: +43 (0) 7416 / 53 000 - 0 . Fax: -2222

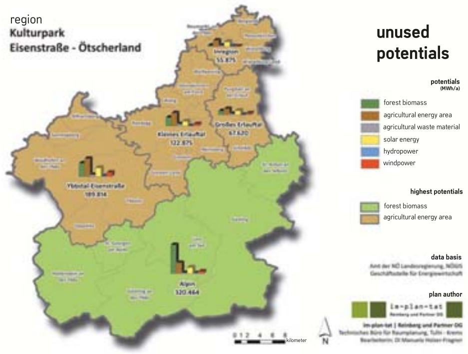
# Contribution of a regional energy concept to mobilization of bio fuel production

**Author:** Mag. (FH) Josef Walch, Martin Gosch B.A.
**References:** Enerpro OG, University of Applied Sciences Wiener Neustadt Campus Wieselburg

## 1 | potential study

### identifying unused renewable energy sources

In the region around Wieselburg biomass has the highest potential, followed by solar energy. This is one result of a potential study which was done within the regional energy concept „Kulturpark Eisenstraße" in 2010.




outcome of the potential study - a central result of a regional energy conept

## activation and using networks | 2

### setting up new human networks and connecting them with existing ones

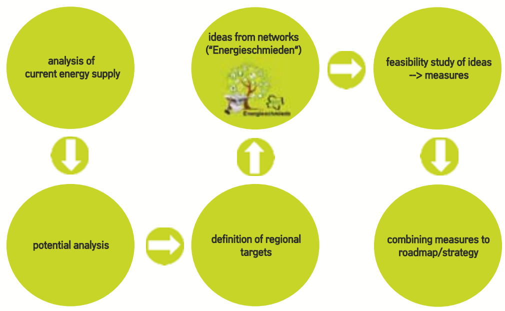
Energieschmiede

Using local networks and competences is one of the crucial factors for increasing bio fuel production. Setting up new networks (called „Energieschmieden" in this regional energy concept) and conneting them with existing know how is a further key to success.

## 3 | creating measures and a roadmap

### creating measures within the network and combining them to a roadmap

People have ideas for raising biofuel production. These ideas are bundled and structured within the „Energieschmieden". After feasibility study an idea can be transformed to a measure. Different measures are combined in a strategic roadmap.




the way to raise bio fuel production in the framework of the regional energy concept


webpage www.energie-schmiede.at
the central communication plattform to inform citizens about the regional energy concept and its results

## communication & | 4 awareness raising

### publishing ideas to gain acceptance of citizens

By communication with online-, offline media and public events the roadmap is tranfered into public. This is one of the most important steps to gain acceptance of the citizens which is needed for implementation.

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# Cold Temperature Properties of Fatty Acid Methyl Esters

**Josef Rathbauer, Rudolf Zeller**

Key words: Biodiesel, Fatty acid methyl ester, FAME, Cold temperature properties, Cloud Point (CP), Pour Point (PP), Cold Filter Plugging Point (CFPP)

The cold temperature properties of fuels are in the moderate and arctic climatic regions an essential parameter for the practical use of vehicles. For determining the cold temperature behaviour of transport fuels the methods of Cold Filter Plugging Point (CFPP), Cloud Point (CP) and Pour Point (PP) are used. The determination of these parameters based on specific standards is done in laboratories mostly with automatically operated apparatus. The target of the presented project was the development of a model for the prediction of the CFPP, CP and PP of Fatty Acid Methyl Esters (FAME) based on their fatty acid distribution.

The compilation of the melting points of individual FAME is based on the Beilstein Database. For some of the respective FAME a large number of data are available. Of these individual data average values and median values have been calculated. In general it can be stated that the respective melting point is increasing with increasing carbon chain and decreasing dramatically with increasing number of double bounds in the carbon chain (see figure 1). The red squares show the respective values for the FAME with double bounds.

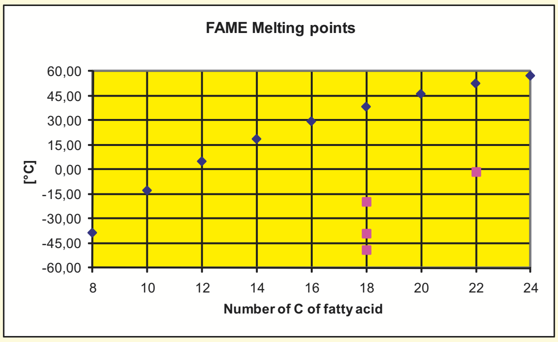


Figure 1: Melting points of different FAME versus their C-chain-length[1]

For the development of the statistical model some 102 different FAME-samples have been prepared in the laboratory, in the pilot plant or have been collected from real operated production plants. The used raw materials are covering a wide range coming from different regions all over the world (e.g. Rapeseed oil, Sunflower oil, Soybean oil, Palm oil, Jatropha oil, Animal fats, Coconut fat, Used frying oil, Blends). For the respective FAME the Average, Median, Minimum and Maximum content are listed. The iodine value ranges from 10 till 189 [g Iod / 100 g FAME]. From all samples the parameters CFPP, CP and PP have been determined. The minimum values for CFPP | CP | PP are -33 | -38 | -38°C. The maximum values for CFPP | CP | PP are +13 | +14 | +14°C.

These data have been used for multiple regression analysis with SPSS. In equation (1) to (3) the calculations for the CFPP | CP | PP are shown. The amount of the respective FAME has to be inserted as decimal fraction (e.g. 23 % of C 18:1 have to be inserted in the equation as 0,23). The results of the multiple regression between fatty acid distribution and CFPP, CP or PP were for the coefficient of determination ($R^2$) at 0,72 – CFPP, 0,66 – CP and 0,89 – PP. In the figures 1 to 3 the respective values of the determined and calculated CFPP | CP and PP are compared graphically.

These developed equations enable to estimate quickly the CFPP | CP | PP on the basis of the fatty acid distribution of different raw materials.

Eq. (1): CFPP[°C] = C18:3*-17,860+C18:0*66,075+C18:1*-13,398+ +C22:0*533,206+C18:2*-14,958+C12:0*-12,453+C16:0* *27,78

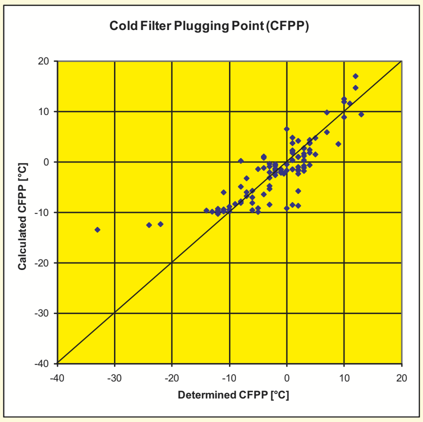


Figure 2: $CFPP_{detemined}$ versus $CFPP_{calculated}$

Eq. (2): CP[°C] = C18:3*-18,578+C16:0*31,909+C18:1*-11,554+ +C12:0*-25,653+C18:2*-13,453+C22:0*-334,926+ +C18:0*61,230

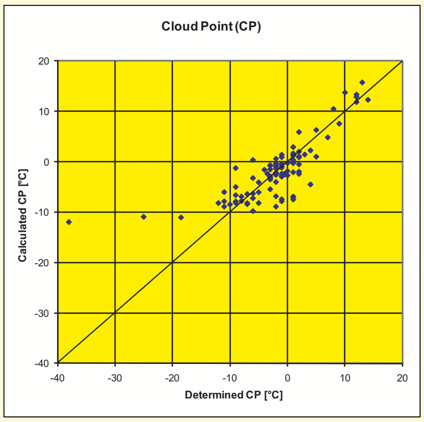


Figure 3: $CP_{detemined}$ versus $CP_{calculated}$

Eq. (3): PP[°C] = C18:1*-24,374+C18:0*77,458+C18:2*-17,014+ +C12:0*-26,846+C16:0*44,137+C22:0*283,138+C22:1*- -28,824+C18:3*-19,035+C20:0*184,402

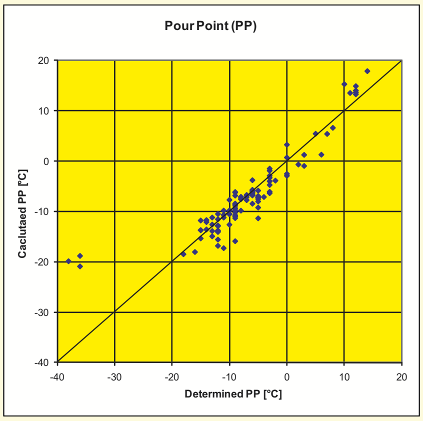


Figure 4: $PP_{detemined}$ versus $PP_{calculated}$

[1] Own diagram, based on „Beilstein"-Data

Rathbauer, J.: Kalttemperatureigenschaften von Fettsäuremethylestern (Cold Temperature Properties of Fatty Acid Methyl Esters), Dissertation, Universität für Bodenkultur, Wien, 2009.

März 2011

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FJ BLT WIESELBURG

# ERA-ARD: Bioenergy in Africa - Opportunities and Risks of Jatropha and Related Crops

Authors:
Andrea Sonnleitner
Dina Bacovsky

biofuel technologies

## The BIA Project

The Bioenergy in Africa (BIA) project was launched in June 2009 with financial support from the Agricultural Research for Development Dimension of the European Research Area (ERA-ARD). The Austrian participation is financed by the Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW). The BIA project investigates the opportunities and risks related to the production and utilisation of biofuels in East Africa and Central America. A focus on *Jatropha curcas L.* was chosen as this feedstock has experienced a strong and sometimes controversial development in both regions. The project analyses the opportunities and risks of increased *Jatropha curcas* production, appraises its social and environmental impacts and develops decision support tools for sustainable biofuel production.

The BIA project is implemented by a consortium composed of 7 European, 5 African and 3 Central American institutions. Each partner provides solid and complementary research experience and expertise ranging from natural to social sciences, making the BIA project an interdisciplinary venture.

## Modular Structure

The BIA project consists of a modular framework composed of 4 complementary modules, each addressing a specific aspect of jatropha production and utilization.

Module 1 - Crop growth and processing: Assessment of sustainable Bioenergy production potentials and processing of jatropha biomass in different cultivation systems and under different environmental and cultural settings.

Module 2 - Impacts of biofuel production: Case-study based research on the socio-economic and environmental impacts of biofuel production in the local context as well as life cycle assessments of various jatropha value chains.

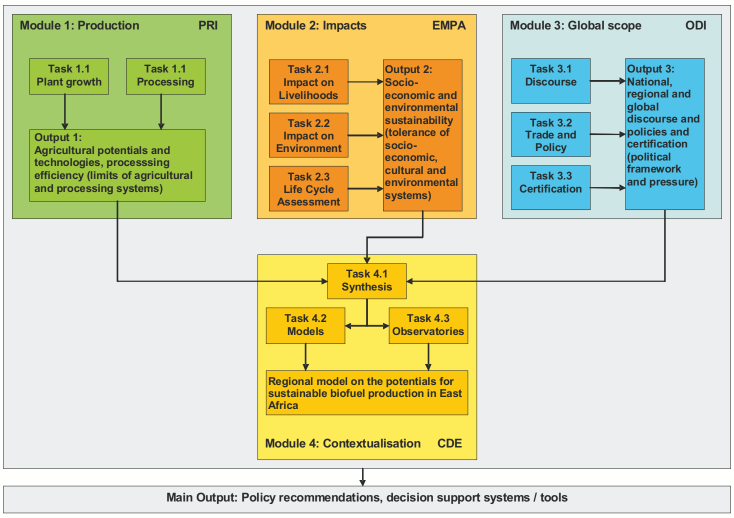
Module 3 - Global policy, trade and certification: Analysis of the influence of external socio-political and economic decision-making processes on the regional and local biofuel production processes.

Module 4 - Potentials of biofuel in Eastern Africa: Elaboration of a regional model of sustainable jatropha production and relevant policy documents for decision-making and planning tools at the national and regional levels in Eastern Africa.

## Activities of BIOENERGY 2020+

The work of BIOENERGY 2020+ concentrates on module 1 crop growth and processing. The objective is to identify viable pathways for local biofuel production from *Jatropha curcas* based on the assessment of the influence of harvesting, storage and pressing conditions on jatropha oil. Consultative work was done in module 2 on life cycle assessments.

*Jatropha curcas L.*




Conceptual framework of the BIA project

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Opportunities and Risks of Jatropha and Related Crops

Further information at www.bioenergyinafrica.net

BIA Bioenergy in Africa

innovations kompetenz

bioenergy2020+

# Mapping of 2nd Generation Biofuel Demonstration Plants


Authors

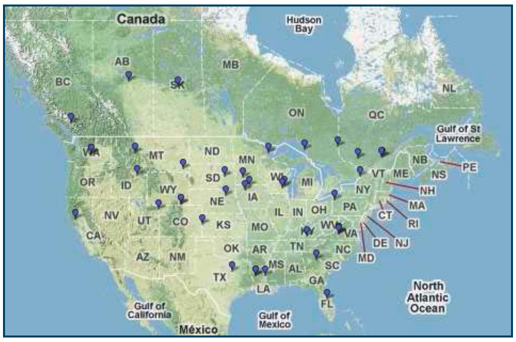
Dina Bacovsky
Andrea Sonnleitner
Manfred Wörgetter


biofuel technologies

## Mapping of 2nd Generation Biofuel Demonstration Plants

IEA Bioenergy Task 39 has commissioned an overview on pilot and demonstration facilities for the production of biofuels from lignocellulosic raw materials. Companies with projects in this area were contacted and asked to provide data for the overview.


Projects in Europe




Projects in North America


Projects in Australasia

All information collated was inserted into a database and is displayed in an interactive map: http://biofuels.abc-energy.at/demoplants/. An outline of this is displayed below.

### Biochemical Pathway – Operational Facilities:

| Project Owner | Country | Product |
|---|---|---|
| Aalborg University Copenhagen | Denmark | ethanol; biogas; |
| Abengoa Bioenergy | Spain | ethanol; |
| Abengoa Bioenergy New Technologies | United States | ethanol; |
| AE Biofuels | United States | ethanol; |
| BioGasol | Denmark | ethanol; cellulose; hemicellu-loses; lignin; |
| Borregaard Industries LTD | Norway | ethanol; |
| Chempolis Ltd. | Finland | ethanol; pulp; |
| DDCE DuPont Danisco Cellulosic Ethanol | United States | ethanol; |
| EtanolPiloten i Sverige AB | Sweden | ethanol; |
| Inbicon (DONG Energy) | Denmark | ethanol; c5 molasses; solid biofuel; |
| Iogen Corporation | Canada | ethanol; |
| KL Energy Corporation | United States | ethanol; |
| Lignol Energy Corporation | Canada | ethanol; lignin; |
| Mascoma Corporation | United States | ethanol; lignin; |
| Mossi & Ghisolfi - Chemtex Italia | Italy | ethanol; |
| Petrobras | Brazil | ethanol; |
| POET | United States | ethanol; |
| Technical University of Denmark (DTU) | Denmark | ethanol; biogas; lignin; |
| Terrabon | United States | ethanol; mixed alcohols; various chemicals; |
| Verenium | United States | cellulosic ethanol; |

### Thermochemical Pathway – Operational Facilities:

| Project Owner | Country | Product |
|---|---|---|
| Coskata | United States | ethanol; |
| CTU - Conzepte Technik Umwelt AG | Austria | SNG; |
| Cutec | Germany | FT-liquids; |
| Enerkem | Canada | ethanol; |
| Iowa State University | United States | ethanol; FT-liquids; biodiesel; pyrolysis oils; |
| NSE Biofuels Oy, a Neste Oil and Stora Enso JV | Finland | FT-liquids; |
| Range Fuels, Inc. | United States | ethanol; methanol; |
| Tembec Chemical Group | Canada | ethanol; |
| Vienna University of Technology / BIOENERGY 2020+ | Austria | FT-liquids; |

To add your project contact:
dina.bacovsky@bioenergy2020.eu.

A full report "Status of 2nd Generation Biofuels Demonstration Facilities" is available at www.task39.org.


*Die Teilnahme an den Tasks in IEA Bioenergy wird im Rahmen der IEA Forschungskooperation des BMVIT finanziert.*

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www.netzwerk-biotreibstoffe.at

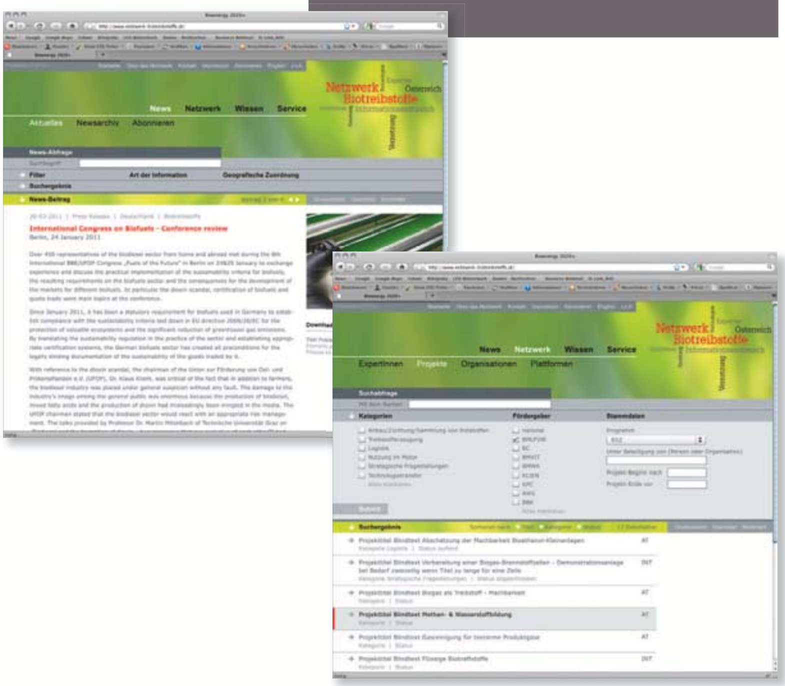
Akteure Workshop Technologien Publikationen News Biokraftstoff Experten

# Netzwerk Biotreibstoffe

Österreich Projekte Energieversorgung Aktivitäten Forschung Informationsaustausch Ergebnisse Wissen Vernetzung Fragestellungen Nachhaltigkeit Plattform erneuerbare Energie

News | **Netzwerk** | Wissen | Service

Der Netzwerkbereich stellt Details über ExpertInnen, Organisationen und Plattformen des Biotreibstoffsektors und deren Kontaktdaten zur Verfügung. Informationen über nationale Projekte oder Projekte mit österreichischer Beteiligung im Themenbereich Biotreibstoffe sind abrufbar.



- Das **„Netzwerk Biotreibstoffe“** soll einen intensiven Informationsaustausch der österreichischen Stake Holder entlang der Produktionskette von Biotreibstoffen ermöglichen. Auch Informationen aus dem internationalen Netzwerk IEA Task 39 sollen national verbreitet werden.

- Das **„Netzwerk Biotreibstoffe“** stellt allgemeine Informationen des Biotreibstoffsektors zur Verfügung, verbreitet Neuigkeiten, Publikationen und Veranstaltungen und verschafft einen Überblick über Projekte, ExpertInnen und Organisationen in der heimischen Biotreibstoffszene.

bioenergy2020+

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# Animal Waste for the Production of Biofuels and Biopolymers

Katharina Strohmeier[a*], Sigurd Schober[a], Martin Koller[b], Martin Mittelbach[a]

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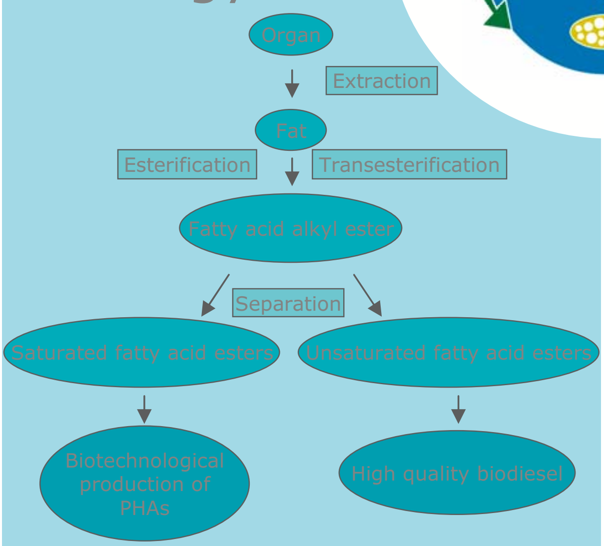
## Project Outline

Within the framework of the EU-project ANIMPOL [1] waste streams from slaughterhouses and rendering plants are converted into high value-added products and biofuels.

Animal waste samples are extracted with different methods to obtain the fatty material, which is analyzed and converted into different fatty acid esters, which are analyzed according to EN 14214 in order to evaluate the suitability as biodiesel. A method has been developed to separate efficiently saturated from unsaturated fatty acid esters. The saturated fatty acid fraction can be used as carbon source for the biotechnological production of high value added polyhydroxyalkanoates (PHAs), industrially important biodegradable biopolymers.

## Strategy




## Preliminary Results

Different animal organs are extracted with hexane. The fat fractions are converted into fatty acid alkyl esters by transesterification with methanol, ethanol, 1-propanol, 2-propanol, 1-butanol and *iso*-amyl alcohol [2]. The products are analyzed according to the European biodiesel specification EN 14214.

| Parameter | Limits EN 14214 | FAME | FAEE | FAPE | *i*-FAPE | FABE | *i*-FAAE |
|---|---|---|---|---|---|---|---|
| Viscosity at 40°C [mm²/s] | 3.50 – 5.00 | 4.57 | 4.94 | 5.57 | 5.53 | 6.08 | 6.98 |
| Oxidation stability 110°C [Hours] | ≥ 6.0 | 1.01 | 2.70 | 1.55 | 2.96 | 2.92 | 0.91 |

Tab 1: Parameters of EN 14214, which are out of specs

FAME: Fatty Acid Methyl Ester
FAEE: Fatty Acid Ethyl Ester
FAPE: Fatty Acid Propyl Ester
*i*-FAPE: Fatty Acid Isopropyl Ester
FABE: Fatty Acid Butyl Ester
*i*-FAAE: Fatty Acid Isoamyl Ester

The separation of the esters into a saturated and an unsaturated fraction achieves an upgrading of the quality of biodiesel leading to excellent cold temperature behaviour.

| CFPP | FAME | FAEE | FAPE | *i*- FAPE | FABE |
|---|---|---|---|---|---|
| Ester [°C] | 10 | 7 | 4 | 0 | 3 |
| Unsaturated ester fraction [°C] | -26 | -14 | -19 | -11 | -6 |

## References

[1] KBBE-2009-3-5-02 No.245084- ANIMPOL FP7
http://www.animpol.tugraz.at/

[2] M. Mittelbach, C. Remschmidt: Biodiesel-The Comprehensive Handbook. Ed.: M. Mittelbach, Graz (2006) ISBN 3-200-00249-2

Titelfoto: ELEN, fotolia.com

IEA FORSCHUNGS KOOPERATION

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Die Teilnahme ist kostenfrei, eine Anmeldung ist bis spätestens 23.3.2011 erforderlich.

Beschränkte Teilnehmerzahl, bitte rechtzeitig anmelden!

**Mitveranstalter:**

bioenergy2020+ Task 39 IEA Bioenergy FH Wiener Neustadt Wieselburg FJ BLT Wieselburg

*Forschungskooperation Internationale Energieagentur*

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