Brazilian biodiesel and the EU

— Fuel quality aspects and effect on sustainability

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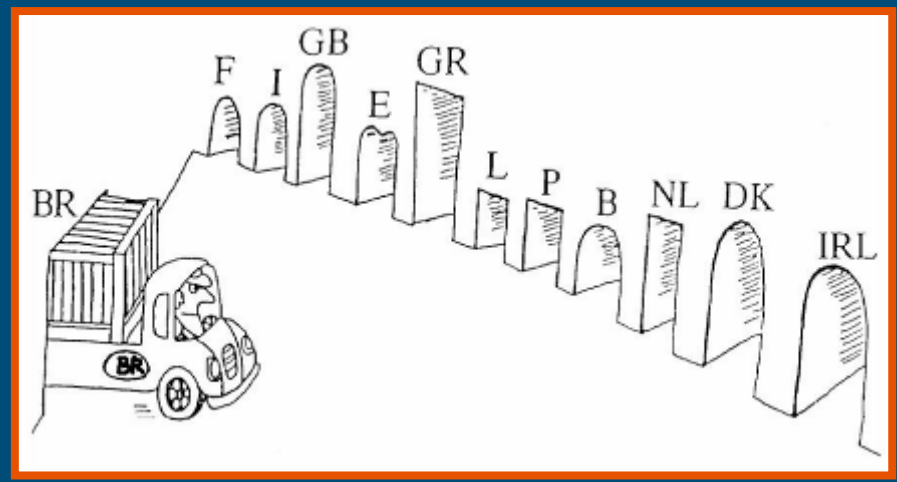
Objectives and Research questions

- Objective:
  - To know which technical issues have to be solved before Brazilian biodiesel can comply to EU quality standards



- Research questions:
  - Does Brazilian biodiesel currently comply to EU standards, and if not, why not?
  - How can Brazilian biodiesel comply to current and future EU standards?

Current biological diesel alternatives

- 1st generation (oils and fats): small part of crop is used
  - PPO (Pure Plant Oil)
  - FAME (Fatty Acid Methyl Ester) and some FAEE (Fatty Acid Ethyl Ester) = 'biodiesel' today

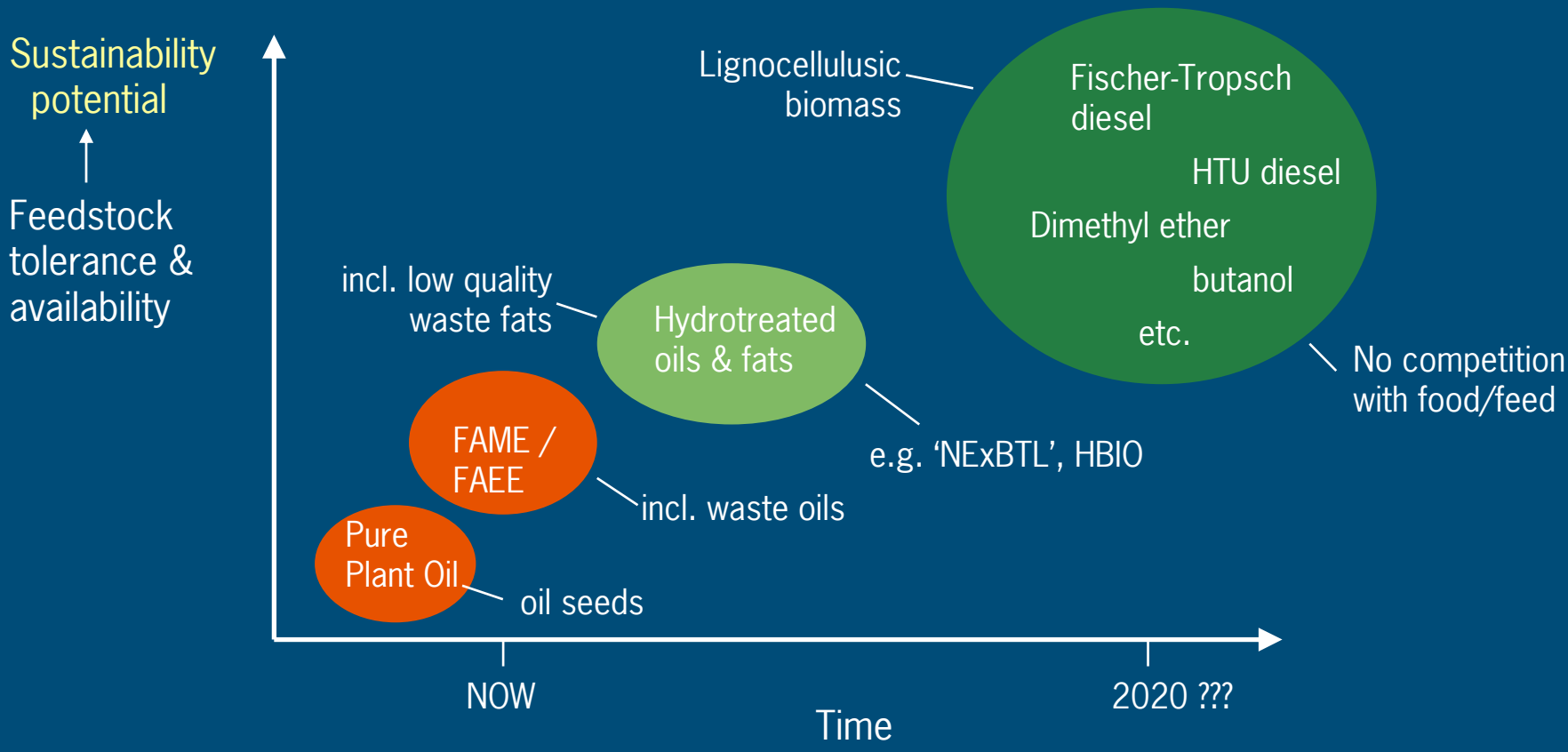
- '1.5th' generation (can use lower quality oils and fats): 'renewable diesel'
  - "Hydro-treatment": production of paraffins by hydrogenolysis
  - 'NExBTL' by Neste Oil
  - 'HBio' by Petrobras
  - Very energy intensive: only feasible at large scale

‘Second generation’ diesel alternatives (R&D)

- Made from cheap, abundant, ‘non-food’ biomass), *e.g.*:
  - Fischer-Tropsch diesel (paraffins from CO/H_2)
  - Dimethylether (DME from CO/H_2): CH_3OCH_3 (kind of LPG for diesel engines)
  - HTU-diesel (Hydro Thermal Upgrading, ‘Bio-oil’)
  - Pyrolysis-diesel (hydrocarbons by anaerobic combustion)
  - Butanol (by fermentation of carbohydrates)

- Regarded as being potentially more sustainable
  - High feedstock flexibility
  - Almost whole crop can be used, less land needed
  - However: Fischer-Tropsch only viable on a large scale (i.e. refinery)

Diesel substitution by biofuels – outlook



Conventional biodiesel production

Oil seeds

EU: mainly rapeseed

Cake (feed)

PPO

Fossil Methanol

Oil extraction & purification

Transesterification

Biodiesel (FAME)

Waste vegetable oils, animal fats

Pretreatment

Glycerol

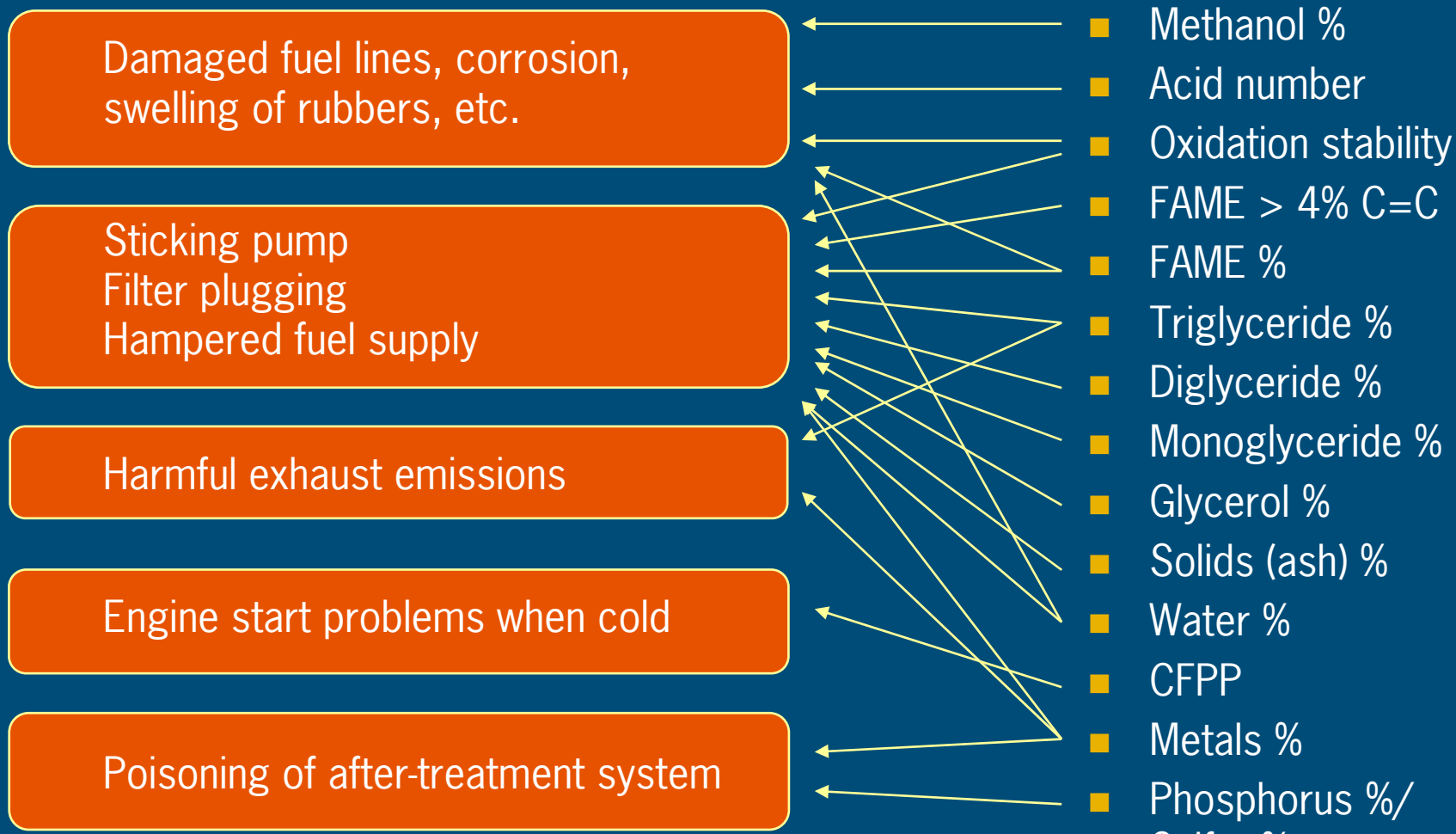
Developments towards 100% 'green' biodiesel:

- Biodiesel-derived glycerol → biomethanol → transesterification
- Use of bioethanol instead of methanol

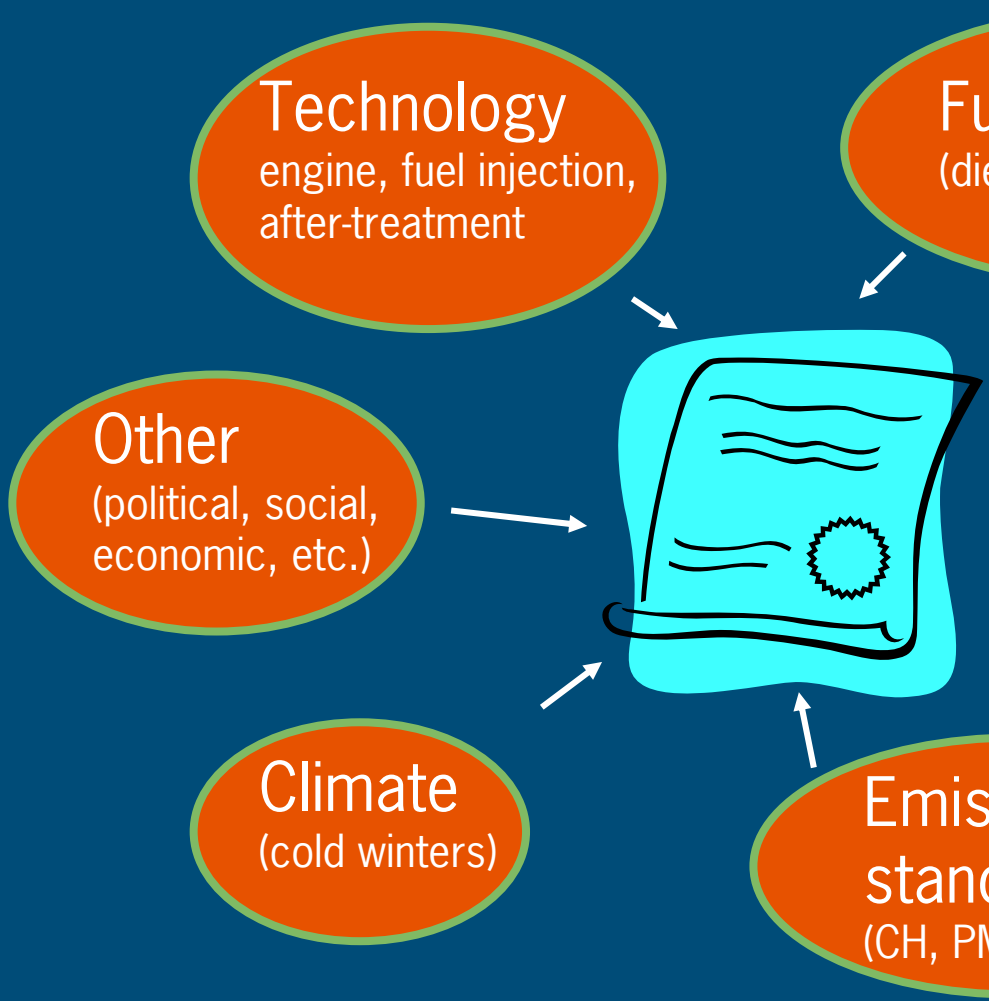
Biodiesel fuel quality

- Emission reduction and better fuel economy only possible with good quality fuels
- Fuel properties and quality determined by
  - Feedstock type, *e.g.* soybean versus rapeseed oil
  - Alcohol type, *e.g.* methanol versus ethanol
  - Feedstock purity, *e.g.* free fatty acid content (FFA%)
  - Production process (degree of conversion, purification)
  - Fuel additives
  - Storing and transportation conditions (air oxidation, hydrolysis)
- Trend: Multi-feedstock biodiesel factories (also in EU) to reduce cost
  - Quality control becomes even more important
- Poor quality = big problems

Potential problems with poor quality biodiesel



Fuel quality standards



- CEN: 'Standardization diminishes trade barriers, promotes safety, allows interoperability of products, systems and services, and promotes common technical understanding.'

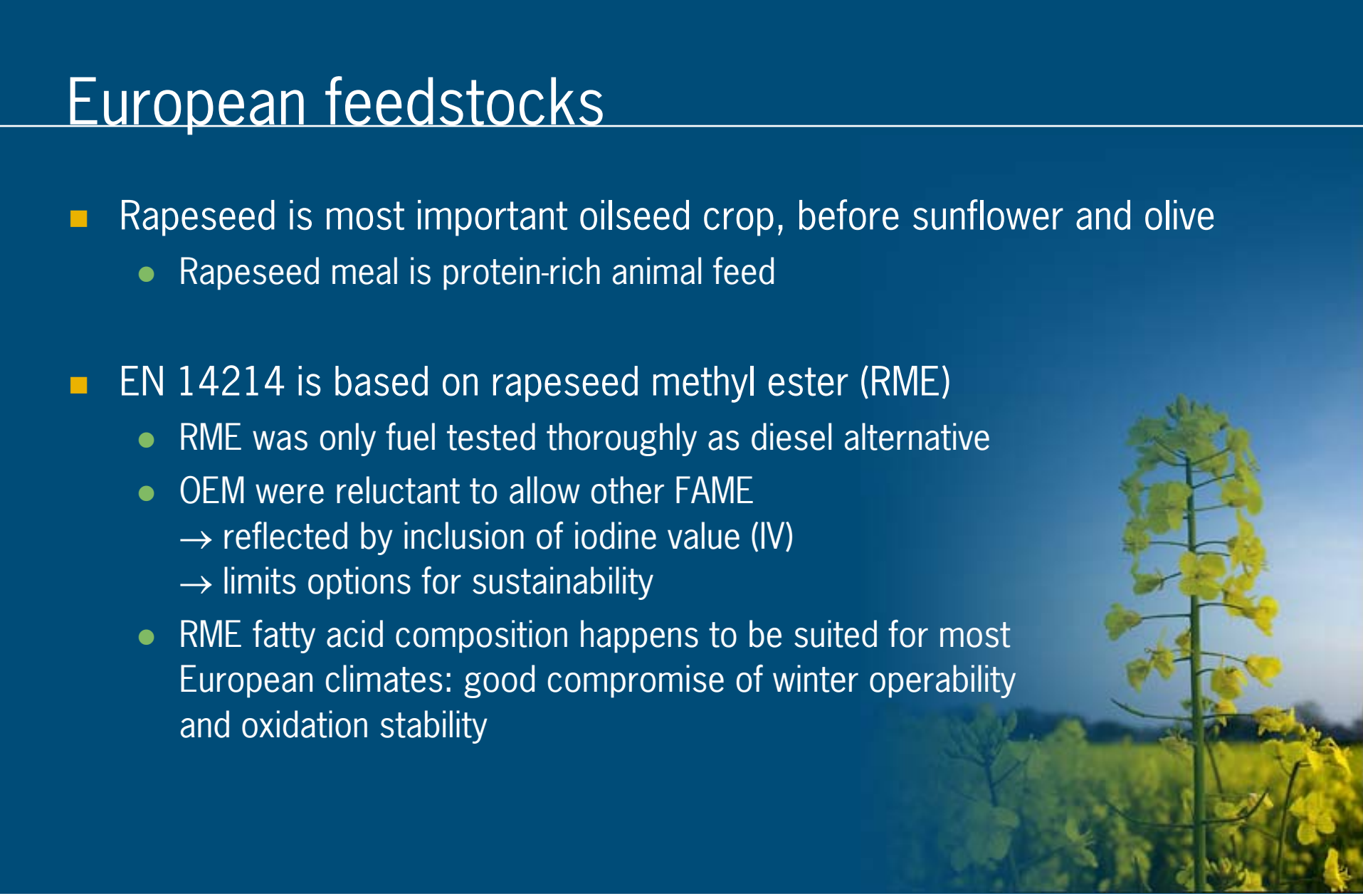
(Bio)diesel quality standards in EU

- EN 14214 (2003): Biodiesel for transport (*)
  - Based on existing national standards for FAME
  - FAME only (not FAEE)
  - 26 properties, to be measured with standardized test methods
  - Cold flow properties differ per region
- EN 590 (2003): diesel fuel
  - Adapted to allow up to 5% of biodiesel as FAME
  - FAME has to comply to EN 14214
- No standard for PPO, and no standard for 2nd generation fuels

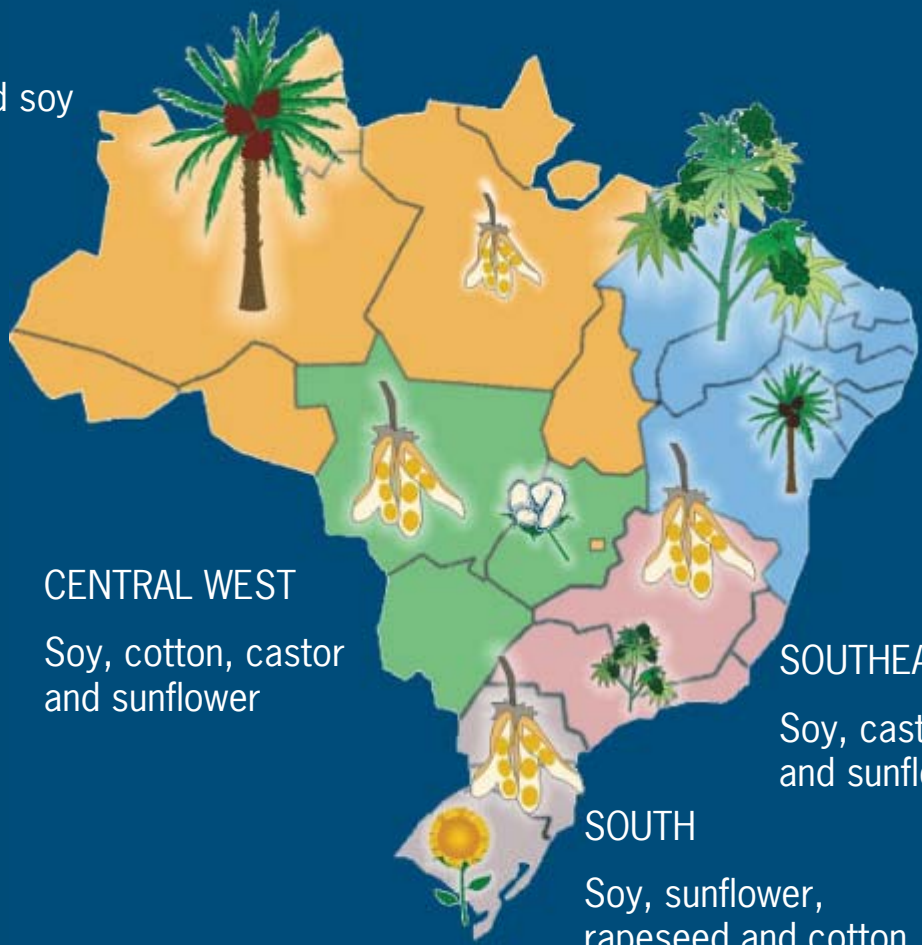
(*) Biodiesel for heating: EN 14213

European feedstocks

- Rapeseed is most important oilseed crop, before sunflower and olive
  - Rapeseed meal is protein-rich animal feed
- EN 14214 is based on rapeseed methyl ester (RME)
  - RME was only fuel tested thoroughly as diesel alternative
  - OEM were reluctant to allow other FAME
    → reflected by inclusion of iodine value (IV)
    → limits options for sustainability
  - RME fatty acid composition happens to be suited for most European climates: good compromise of winter operability and oxidation stability



Feedstocks in Brazil: almost no rapeseed



NORTH

Palm and soy

NORTHEAST

Castor, palm, soy, cotton and babassu

CENTRAL WEST

Soy, cotton, castor and sunflower

SOUTHEAST

Soy, castor, cotton and sunflower

SOUTH

Soy, sunflower, rapeseed and cotton

(Bio)diesel quality standards in Brazil

- National Biodiesel Program
  - Reduce diesel imports
  - Create income for family farmers in poor regions (North, North-East)
    - Tax incentives for biodiesel producers that buy crops from family farmers
  - Law: 2% in blends mandatory in 2008; 5% mandatory in 2013
- ANP 255 (2003): for blends up to B20
  - For private fleets
  - Properties and test methods based on EU and US standards
  - Both FAME and FAEE
- ANP 42 (2004): current biodiesel standard
  - To allow 2% in blends in 2008
  - Special test methods for fatty acid esters of 'uncommon' oils, e.g. castor oil
- ANP 310 : Diesel fuel

EU 14214 versus Brazilian ANP 42/2004

Property	*Unit*	*ANP 42*	*EN 14214*
Aspect	-	LII	-
Ester content	% (m/m)	Take note	≥ 96.5
Density at 20°C (BR)/15°C (EU)	kg/m^3	ANP 310	860–900
Kinematic viscosity at 40°C	mm^2/s	ANP 310	3.5–5.0
Flash point	°C	≥ 100	≥ 120
Sulfur content	mg/kg	Take note	≤ 10.0
Carbon residue 90% (EU)/100% (BR)	% (m/m)	≤ 0.10	≤ 0.30
Cetane number	–	Take note	≥ 51
Cold Filter Plugging Point	°C	ANP 310	*a*
Sulfated ash	% (m/m)	≤ 0.020	≤ 0.02
Water content	mg/kg	-	≤ 500
Water and sediments	% v/v	≤ 0.050	-
Total contaminants	mg/kg	Take note	≤ 24

EU 14214 versus Brazilian ANP 42/2004

Copper strip corrosion (3 hours at 50°C)	–	Class 1	Class 1
Oxidative stability at 110°C	hour	≥ 6	≥ 6.0
Acid number	mg KOH/g	≤ 0.80	≤ 0.50
Iodine number	g I_2/100 g	Take note	≤ 120
Linolenic acid content	% (m/m)	-	≤ 12
FAME with ≥ 4 C=C	% (m/m)	-	≤ 1
Methanol (EU)/ethanol (BR) content	% (m/m)	≤ 0.5	≤ 0.20
Monoglyceride content	% (m/m)	Take note	≤ 0.80
Diglyceride content	% (m/m)	Take note	≤ 0,20
Triglyceride content	% (m/m)	Take note	≤ 0.20
Free glycerol	% (m/m)	≤ 0.02	≤ 0.02
Total glycerol	% (m/m)	≤ 0.38	≤ 0.25
Alkali metals (Na + K)	mg/kg	≤ 10	≤ 5.0
Earth alkali metals (Ca + Mg)	mg/kg	Take note	≤ 5.0
Phosphorus content	mg/kg	Take note	≤ 10.0

Why are EU and Brazilian standards different?

➡ Because EU and Brazil are different

- Brazil:
  - ethanol is almost as cheap as methanol
  - many different oilseed crops (but no rapeseed) in different regions
    - excluding certain crops has social consequences
  - no passenger cars on diesel
  - keep investments in testing equipment low
- EU:
  - Rapeseed is most abundant oilseed crop
  - some EU-countries have cold climates
  - more stringent emission restrictions

Brazilian feedstocks: EN 14214 compliance?

FAME	*EN 14214 (B100)*	*Critical property*	*Other drawbacks*
Rapeseed ME	PASS		
Soybean ME	FAIL	Iodine Value	Oxidation stability
Castor ME	FAIL	Viscosity	Cetane Value
Palm ME	FAIL	CFPP	
Jatropha ME	PASS		CFPP in winter

- Discussion:
  - Ethyl esters not covered by EN 14214
  - EN 14214 allows little room for additives
  - Iodine Value unnecessarily restrictive

Brazilian biodiesel and the EU standard

- In principle, Brazilian biodiesel may comply to EN 14214 by:
  - Using methanol and not ethanol
  - Blending soybean methyl ester (SME) with less unsaturated biodiesel (e.g. palm)
  - Partial hydrogenation of soybean oil or SME to reduce unsaturation → extra costs
  - Using additives such as antioxidants
- European Commission has submitted two new mandates that would allow:
  - FAEE as blend component in diesel and
  - up to 10% of biodiesel in diesel as either FAME or FAEE
- Possibly Iodine Value raised to 130 in EN 14214 (allows soybean ME)

Towards better standards

- A new standard should be focused on fuel *performance*
  - higher feedstock and technology flexibility → sustainability
    - e.g. enzyme catalysis / partial esterification (Fraunhofer/Vital Planet)
    - 2nd generation technology
    - prevent loss of biodiversity
  - more room to use *additives*
  - fatty acid *ethyl* esters (FAEE)
- UN: International Biofuels Forum → ISO standards desired
  - Brazil, US, EU, China, India, South Africa

Global standards harmonization efforts

- Worldwide Fuel Charter: fuel quality recommendations
  - Published by an alliance of automobile and engine manufacturers
  - Four categories of fuel quality, based on emission requirements (Cat. 4 is best, allows e.g. Euro 4 and Euro 5 emission standards)

- ISO Technical Committee 28 'Petroleum products and lubricants', Subcommittee 'Liquid Biofuels"
  - Global standard hard to accomplish
  - Probable outcome: 'two-tier approach':
    - one 'base fuel' standard that can be traded
    - several regional 'fit-for-purpose' standards

Future quality standards developments

- Recent ‘renewable biodiesel’ (NExBTL, HBio-blends) even better/cleaner than fossil diesel
  - easily comply to EN 590
  - enables better after-treatment technology
  - ready for EURO 5
- Second generation biofuels standards
  - many different feedstocks
  - large availability
  - more sustainable than conventional biofuels

Conclusions

- Wide range of feedstock options contributes to overall sustainability
- Investments in conventional biodiesel technologies (incl. area expansions for oil crops) should be weighed against arrival of 2nd generation technologies and standards
- Current EU standard should be adapted to allow for a larger number of feedstocks
- Currently, many Brazilian one-crop biodiesels do not comply to EN 14214 (does Brazil care?)
- High costs for testing equipment will be a major hurdle for small scale initiatives
- A global quality standard is unlikely to appear, due to large regional differences
- Much is expected from HBio and related 'renewable biodiesel' technologies