Institut für Energetik und Umwelt
Institute for Energy and Environment

Alternative biofuels in Europe and Germany

What contribution is possible?

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- Introduction
- Biomass Potential
- Biomass Conversion
- Potential of Alternative Fuels
- Final Considerations

Introduction (I)

- (Potential) environmental effects caused by the use of energy are the driving force for the implementation of various policy measures in recent years; this is especially true for the reduction of the anthropogenic greenhouse effect.
- A more environmentally sound energy system should be achieved without reducing the current level of our living standard which is mainly based on an unlimited provision of cheap (fossil) energy.
- Within the wide range of energy services provided to our modern society the high level of ground and air mobility is one of the most outstanding one.
- Therefore the identification of alternative fuels which are environmentally sound and neutral to the climate become more and more important; this importance is reflected by various policy measures in force already to secure our mobility.

Introduction (II)

- There are various options for providing alternative fuels like e.g.
  - Natural gas
  - Liquefied lignite or hard coal
  - Hydrogen from nuclear power
  - Hydrogen from e.g. solar radiation, hydro power, or wind energy
  - Electricity from e.g. solar radiation, hydro power, or wind energy
  - Liquid fuels from biomass containing vegetable oil or sugar respectively starch
  - Liquid fuels from solid biofuels via e.g. FT-synthesis
  - Gaseous fuels from biomass (e.g. biogas)
- Only fuels based on renewables are climatic sound.
- Only fuels from biomass can contribute significantly to an environmentally sound energy system on short to medium term.

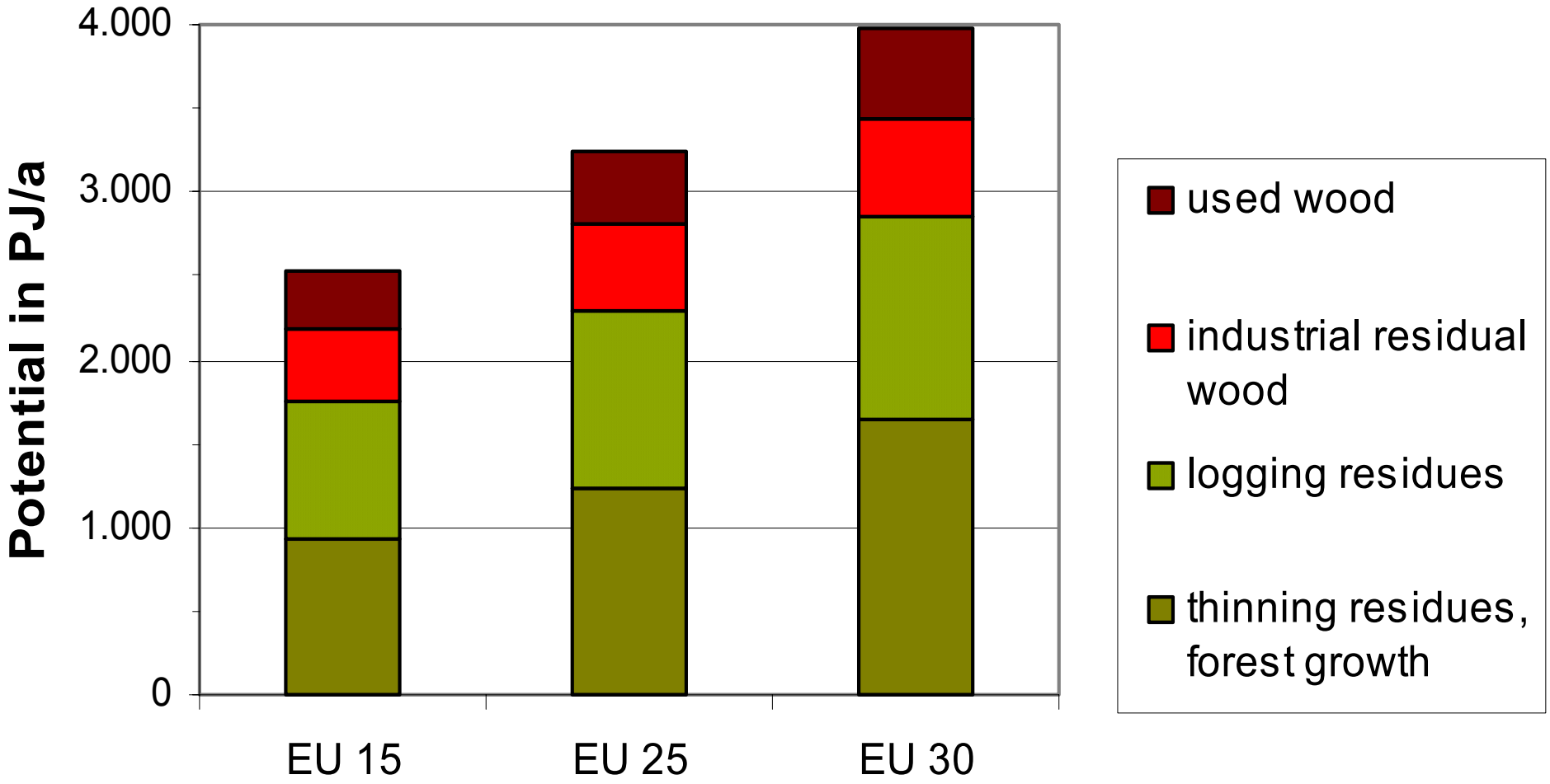
Biomass Potential

- Biomass Resources -

- By-products, residues, and/or wastes like e.g.
  - Solid biofuels from herbaceous biomass (like straw) or woody biomass (like residual wood, demolition wood)
  - Biomass for biogas provision (like animal manure, waste water)
- Energy crops like e.g.
  - Ligno-celluloses plants,
  - Plants containing vegetable oil or sugar respectively starch

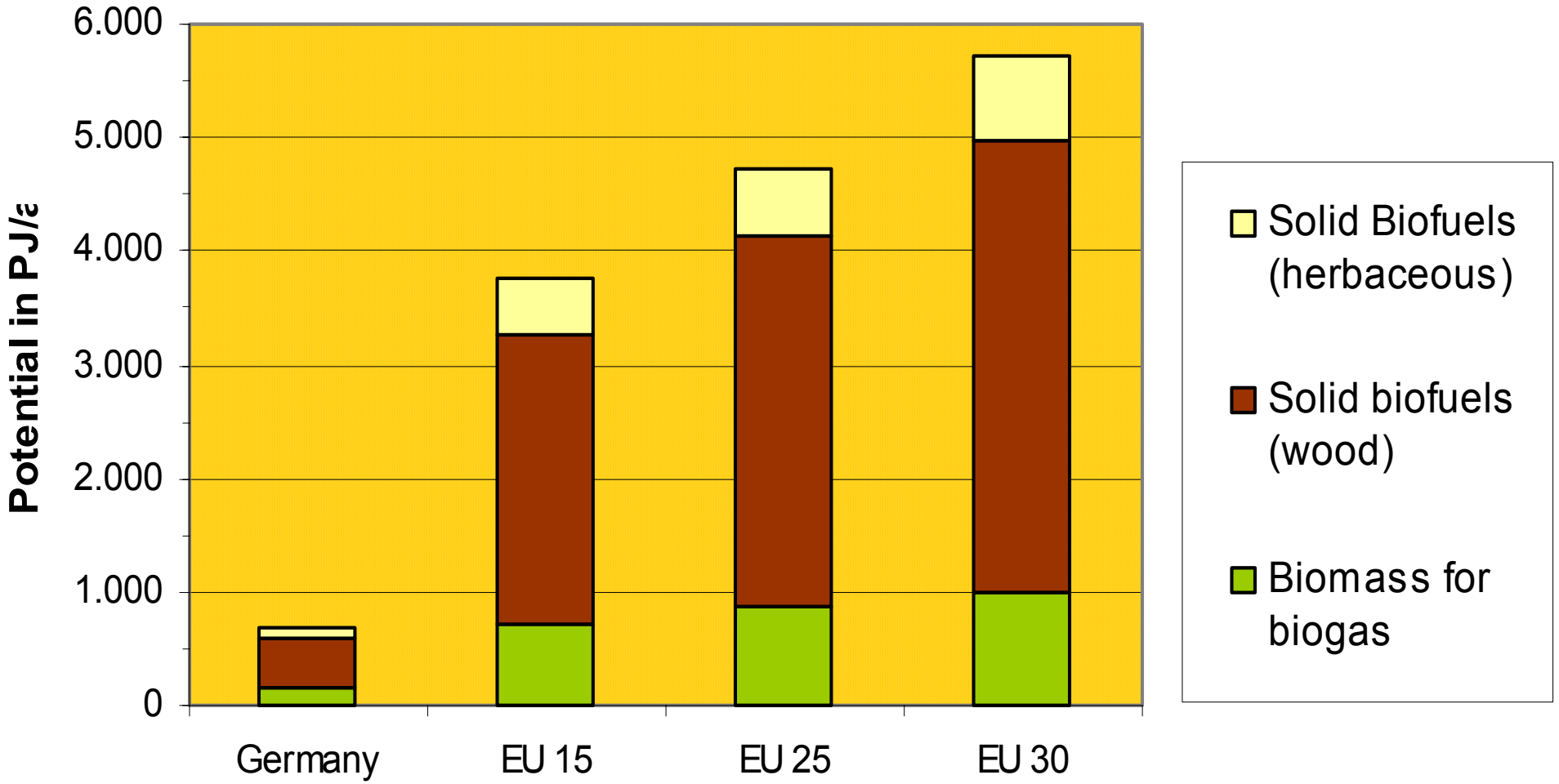
Biomass Potential

- Example: Wood Potential in Europe -



Biomass Potential

- Potential of Waste, Residues, and By-products -



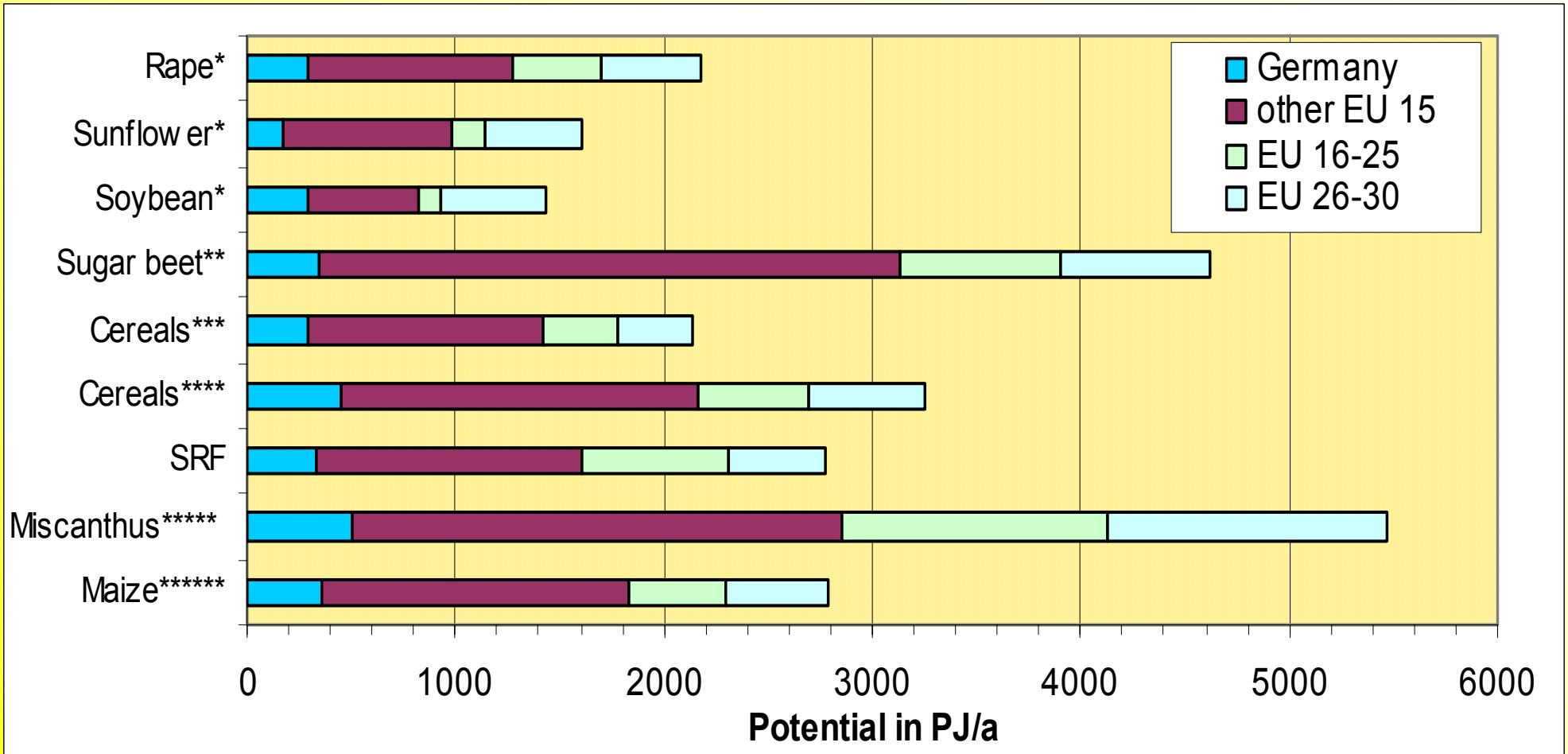
Biomass Potential

- Energy Crops (Frame Conditions) -

- Between 15 and 20 % of the existing arable land in each EU country is available for the cultivation of energy crops.
- Various crops can be cultivated containing
  - oil like e.g. rape, sunflower
  - sugar like e.g. sugar beet
  - starch like e.g. wheat, barley, rye
  - ligno-celluloses like herbaceous plants (e.g. Miscanthus, giant reed) or wood plants (e.g. willow, poplar, eucalyptus)
- The yield corresponds to the site-specific yield for food and fodder.
- Increased land use due to a more ecological production and a reduced land use due to increasing yields and changing nutrition behaviour compensate each other.

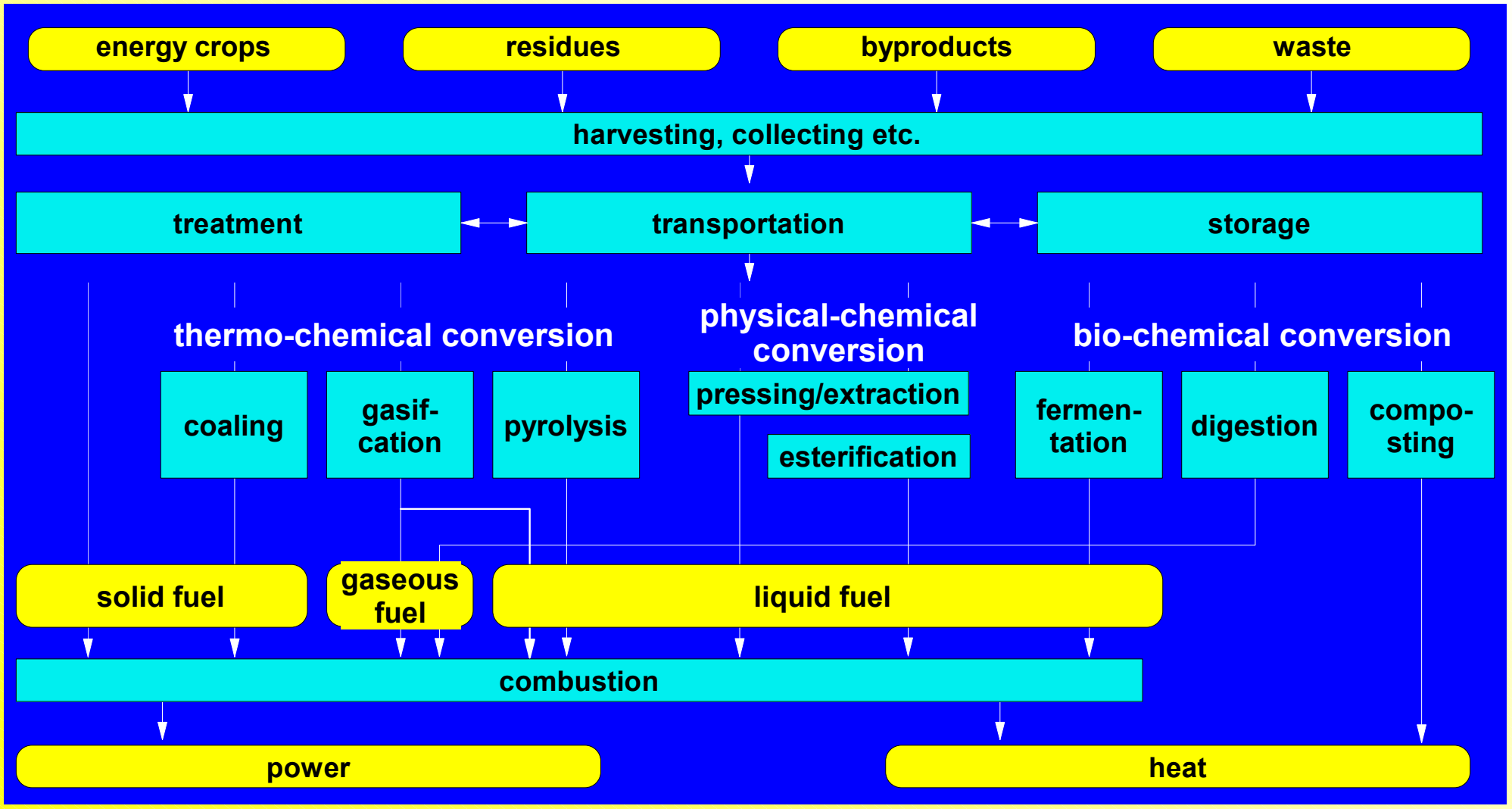
Biomass Potential

- Energy Crops (Potential) -



*oil+meal+straw; **ethanol+biogas; ***ethanol+biogas+straw; ****whole crop; *****rainfed; ****** for biogas production

Biomass Conversion
- Possibilities -



Biomass Conversion

- Thermo-chemical Conversion (Synthetic Fuels) -

- Approach: Conversion of solid biofuels to a synthesis gas via gasification (and gas conditioning) and synthesis of a fuel (e.g. FT-Diesel, Methanol, DME)
- Status: R&D-stadium for biomass; first pilot-plant for the production of FT-Diesel in Freiberg/Germany
- Costs (WTW): medium
- Advantages: wide feedstock basis, liquid fuels with defined characteristics (easy adaptation for existing and future ICE´s), synthesis technique available for fossil fuel energy
- Disadvantages: complex overall provision chain (e.g. gasification, gas-conditioning, synthesis, distillation, hydro-cracking process)

Biomass Conversion

- Thermo-chemical Conversion (Hydrogen) -

- Approach: Conversion of solid biofuels to a hydrogen-rich gas by gasification and subsequent gas cleaning, CO-shift conversion and hydrogen purification (typically pressure-swing-adsorption for tail gas separation)
- Status: basic research stadium for biomass
- Costs (WTW): high to very high
- Advantages: wide feedstock basis, low emissions at the place of use, technology available for fossil fuel energy (e.g. natural gas)
- Disadvantages: high effort for the distribution infrastructure and for the usage in car engines

Biomass Conversion

- Physical-chemical Conversion (FAME) -

- Approach: extraction of oil from oil seeds, conversion of the oil (trans-esterification) into a fuel similar to fossil Diesel fuel (FAME) or blended to fossil Diesel fuel
- Status: market mature; in 2003 more than 650,000 t of FAME have been sold in Germany with an installed production capacity of more than 1 Mio. t/a; vegetable oil blended to fossil Diesel fuel is sold since early 2004
- Costs (WTW): medium
- Advantages: liquid fuel, blended with fossil Diesel fuel, techno-logy fully available (WTW)
- Disadvantages: limited feedstock basis, FAME as pure fuel could not be used in future ICE´s (EU IV etc.), ICE´s adapted for pure vegetable oil have often a limited life time so far

Biomass Conversion

- Bio-chemical Conversion (Ethanol) -

- Approach: digestion of biomass containing sugar or starch and provision of the pure ethanol; blended to gasoline (maximum 5 % according to DIN EN 228)
- Status: market mature; in 2003 three plants using starch started to be build in Germany; Ethanol plays an important role in some countries (e.g. Brazil, USA)
- Costs (WTW): medium
- Advantages: liquid fuel, wide feedstock basis, technology available, easily used in existing ICE´s
- Disadvantages: only energy crops can be used as a feedstock, limited blending rate with gasoline

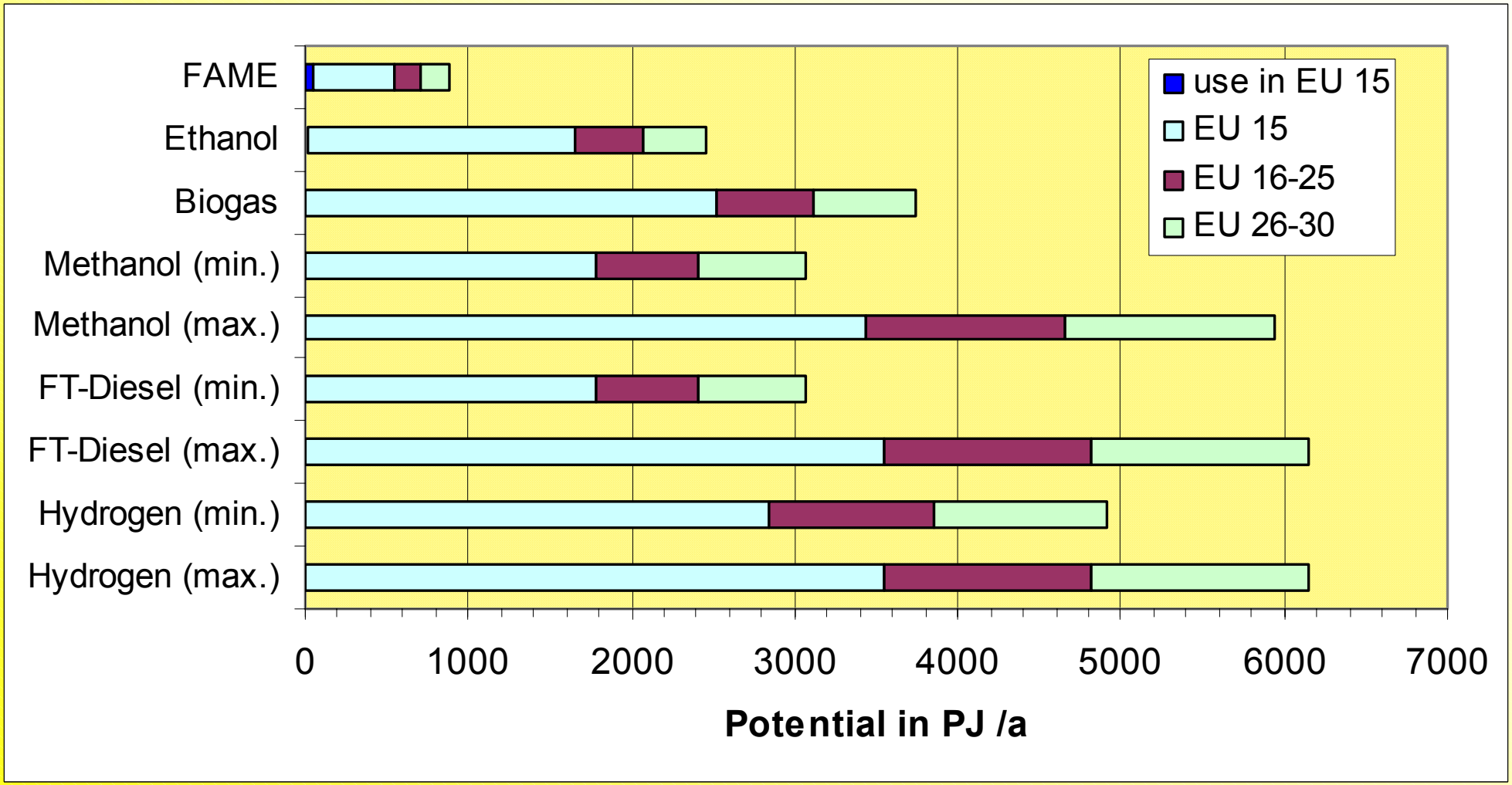
Biomass Conversion

- Bio-chemical Conversion (Biogas) -

- Approach: anaerobic digestion of biomass with high water content; removal of impurities (e.g. CO_2, H_2O, H_2S) form the biogas and compression of the pure methane
- Status: R&D-stadium, fist pilot-plants are in operation
- Costs (WTW): medium to high
- Advantages: existing gas infrastructure (natural gas) could be used (partly)
- Disadvantages: decentralised production of biogas, high effort for the provision of pure methane from biogas, distribution infra-structure for gaseous fuels is complex

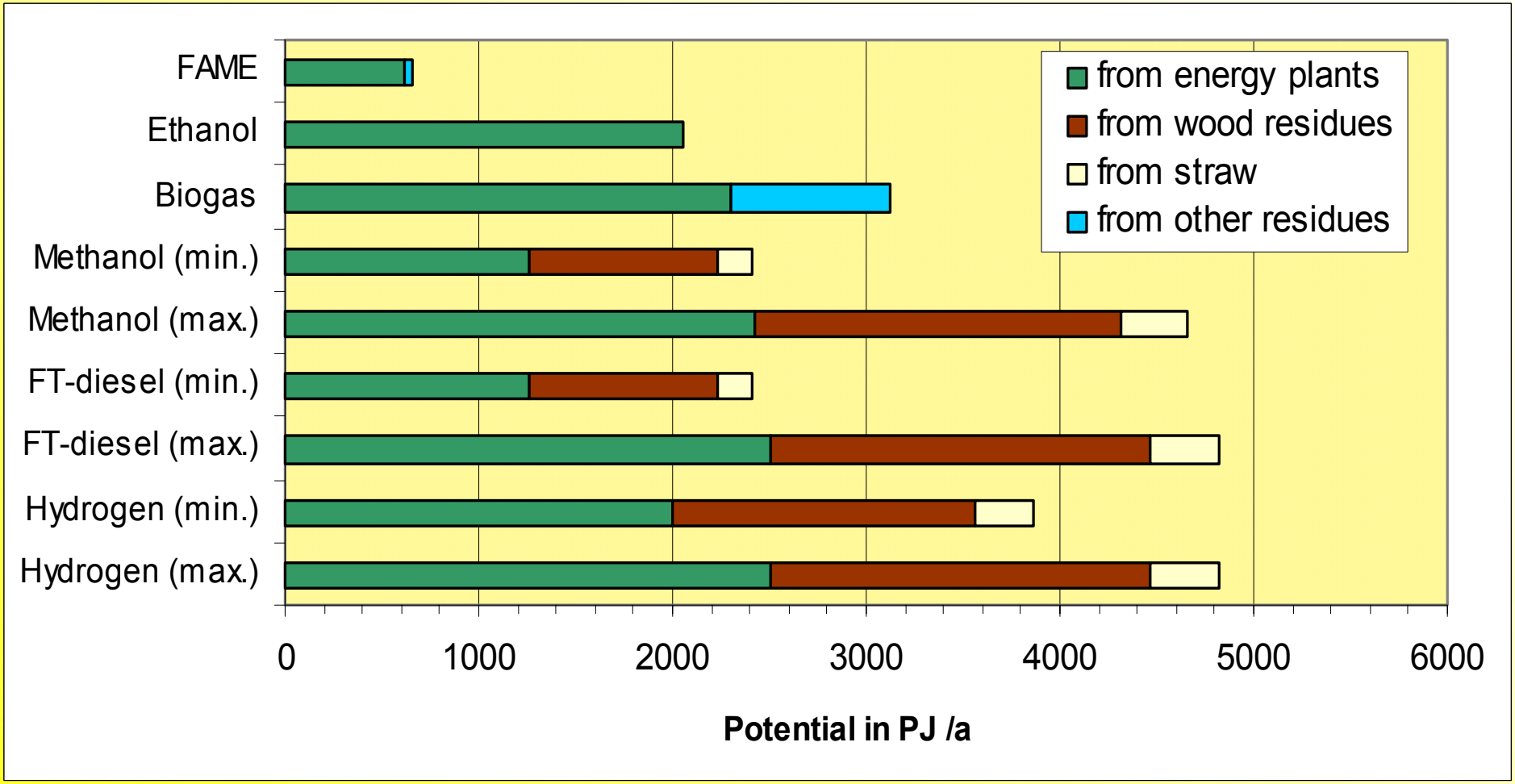
Potentials of Alternative Fuels

- Overall Potential and Use -



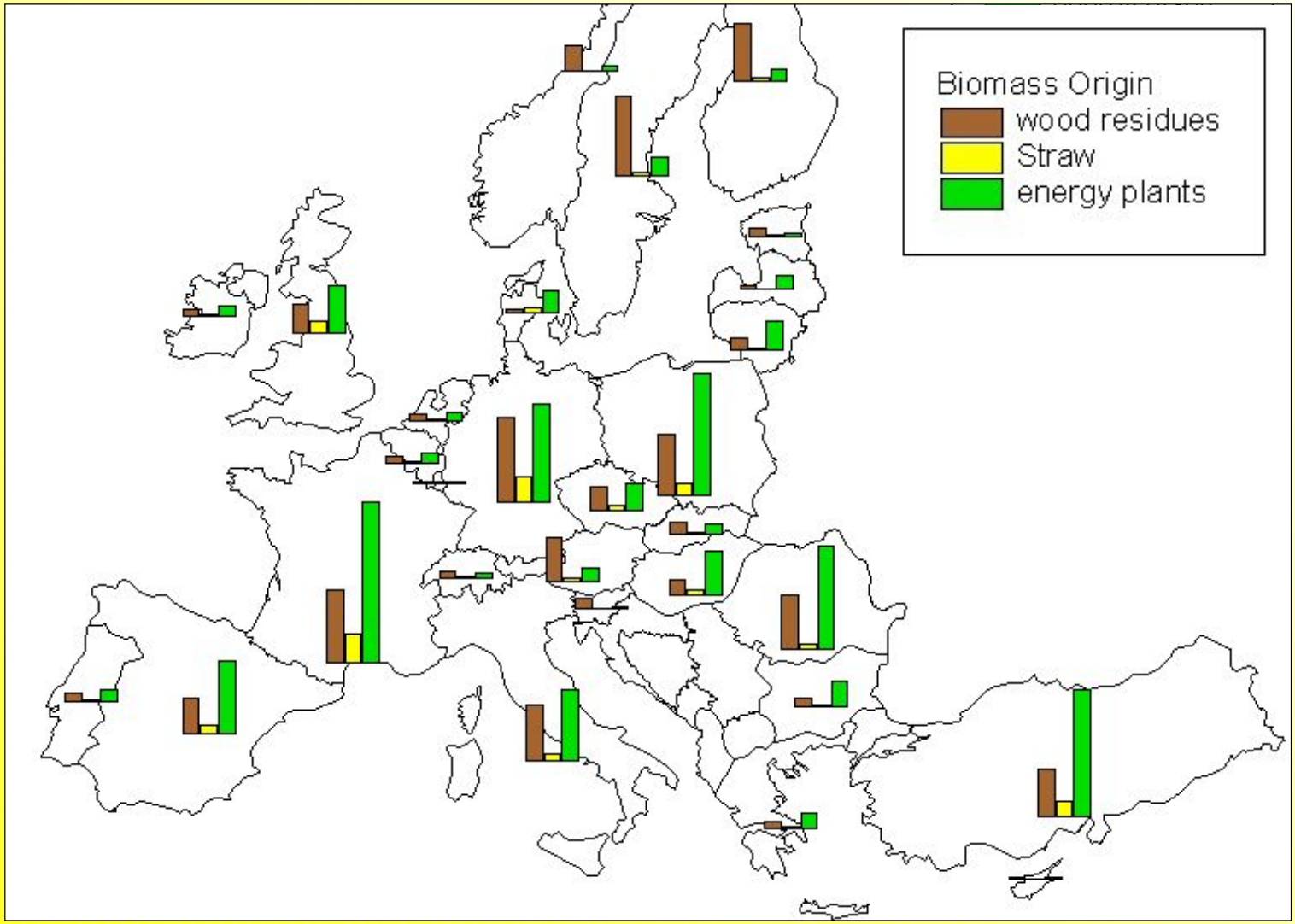
Potentials of Alternative Fuels

- Potential according to Origin (EU 25) -



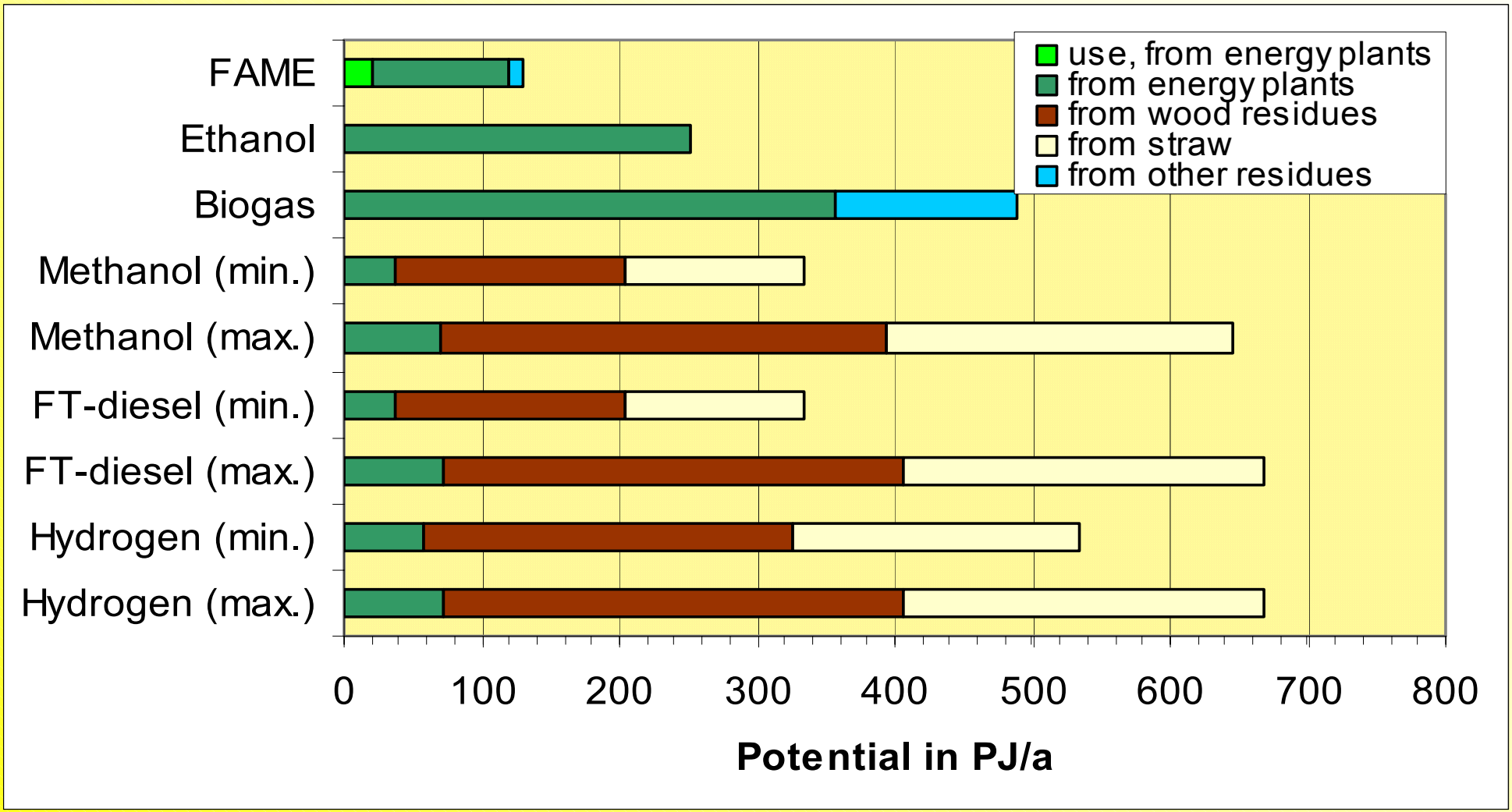
Potentials of Alternative Fuels

- Regional Distribution; Example: FT-Diesel -



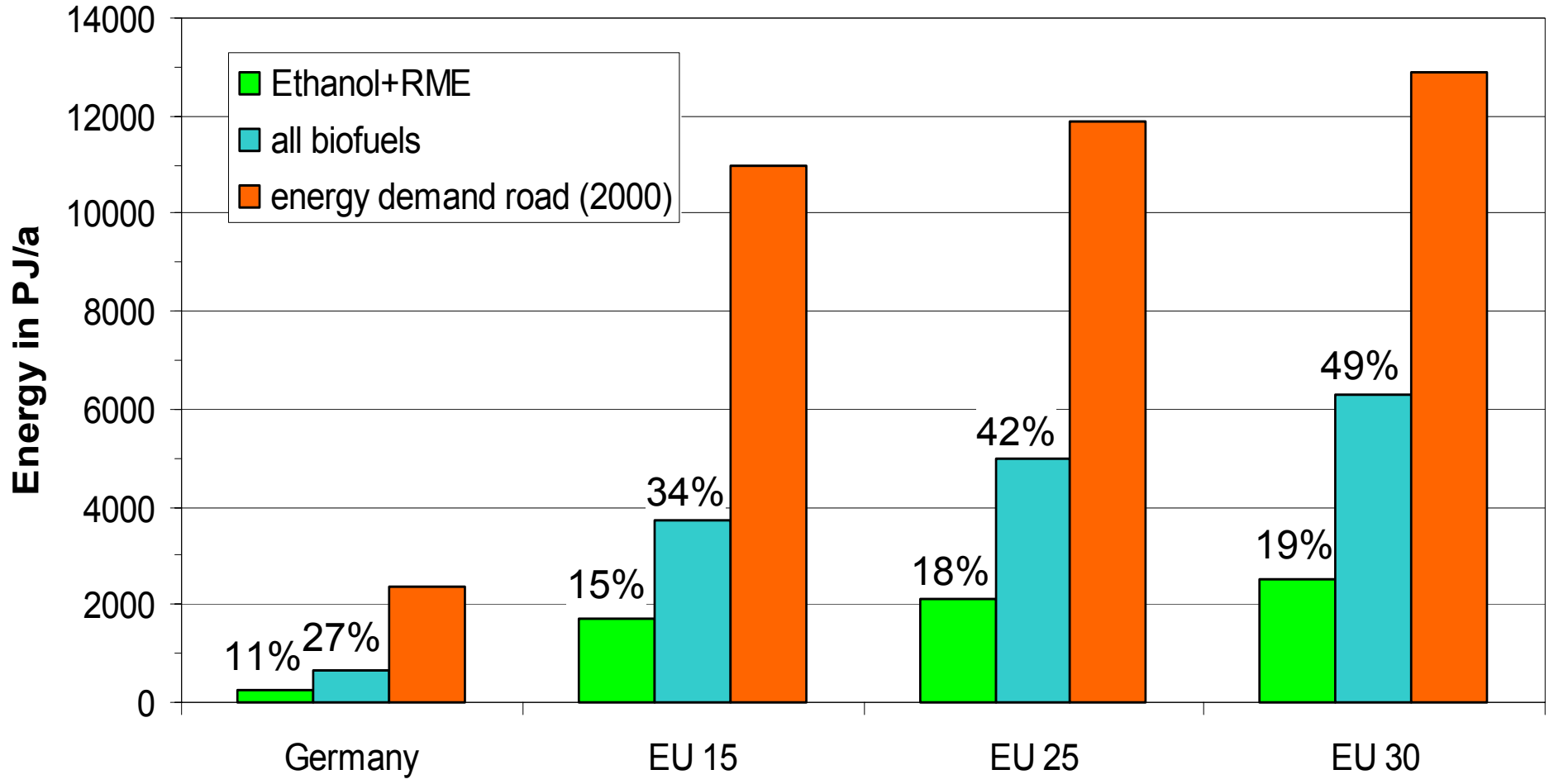
Potentials of Alternative Fuels

- Germany: Use and Potential -



Potentials of Alternative Fuels

- Possible Contribution of Alternative Fuels -



Final Consideration (I)

- There are various possibilities to provide alternative fuels for Europe.
- For all options analysed here the basic approach, the status, the costs, and the potential are significant different; additionally these options have different advantages and disadvantages.
- These options are supported by various policy measures (e.g. European Biofuel Directive); additionally the tax exemption helps to increase the use.
- Therefore the options with the lowest overall production costs will survive on the market in the years to come; for the time being it is fully open which option will gather which market share.

Final Consideration (II)

Option	Potential	Overall costs	Status	Comments	Overall
FAME	+	++	+++	Market mature	+
Ethanol	++	++	++(+)	Blended fuel	++
FT-Diesel	+++	++	+(+)	Designer fuel	+++
DME	+++	+(+)	+	Partly new distribution system	+(+)
Methanol	+++	+(+)	+	New distribution system	+(+)
Hydrogen	+++	(+)	-	New engines, distribution system	-
Biogas	++(+)	+(+)	+(+)	Distribution system	+(+)

+ less promising, +++ very promising

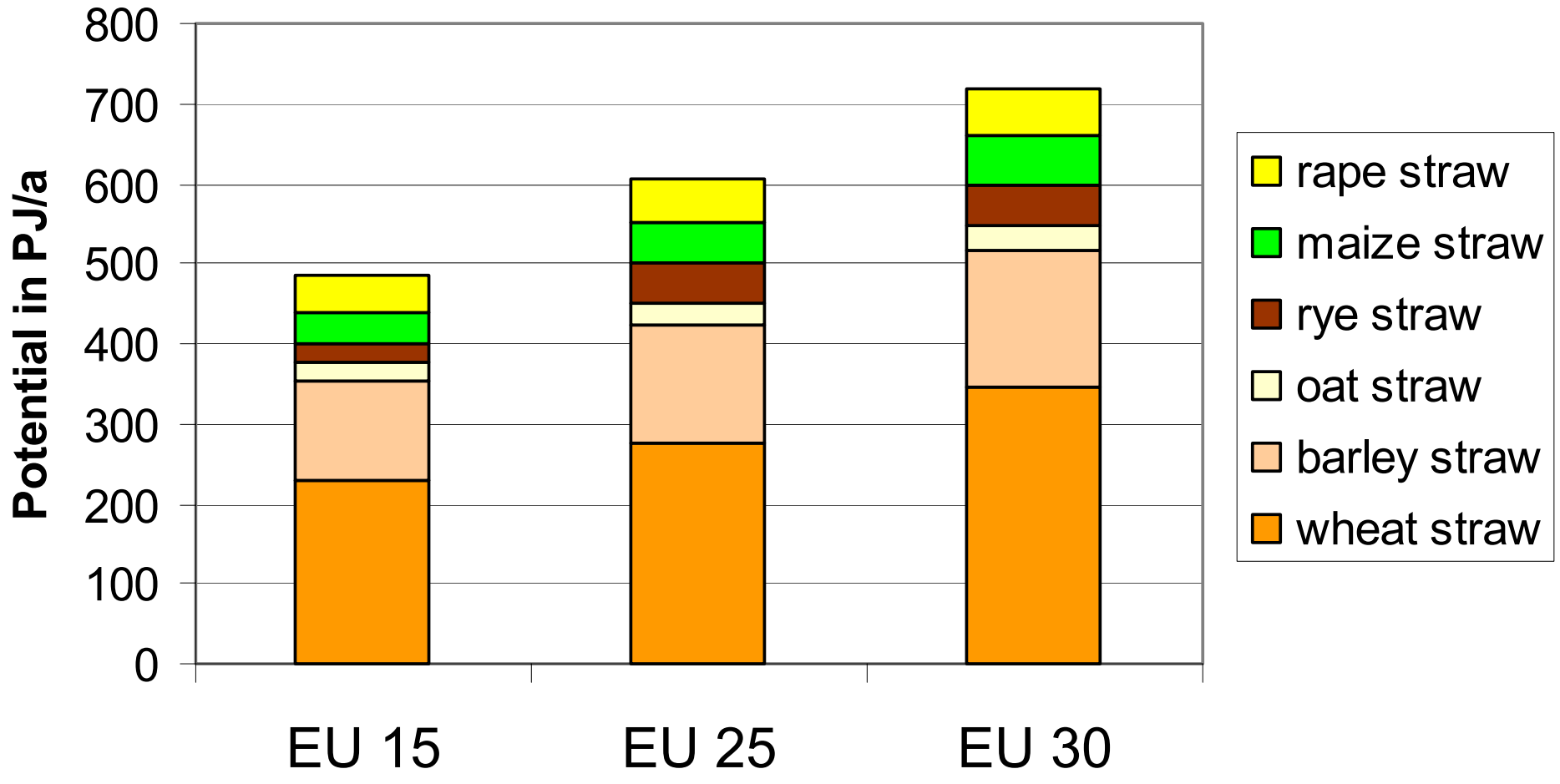
Final Consideration (III)

- The importance of fuels based on vegetable oil will not increase significantly in the future.
- Bioethanol as a fuel will become more important; but on the long term this option is limited due to the need for biomass with specific characteristics.
- Biogas and especially hydrogen will probably not make a significant contribution within the energy system due e.g. high costs for the infrastructure in the years to come.
- The currently most promising option are synthesised fuels from gasified solid biofuels (especially FT-Diesel); the results of the ongoing R&D-activities will show if this rating will be verified in the years to come.
- Nevertheless basically there is enough biomass to achieve the targets defined within the European Biofuel Directive.

Thank you very much for your attention!

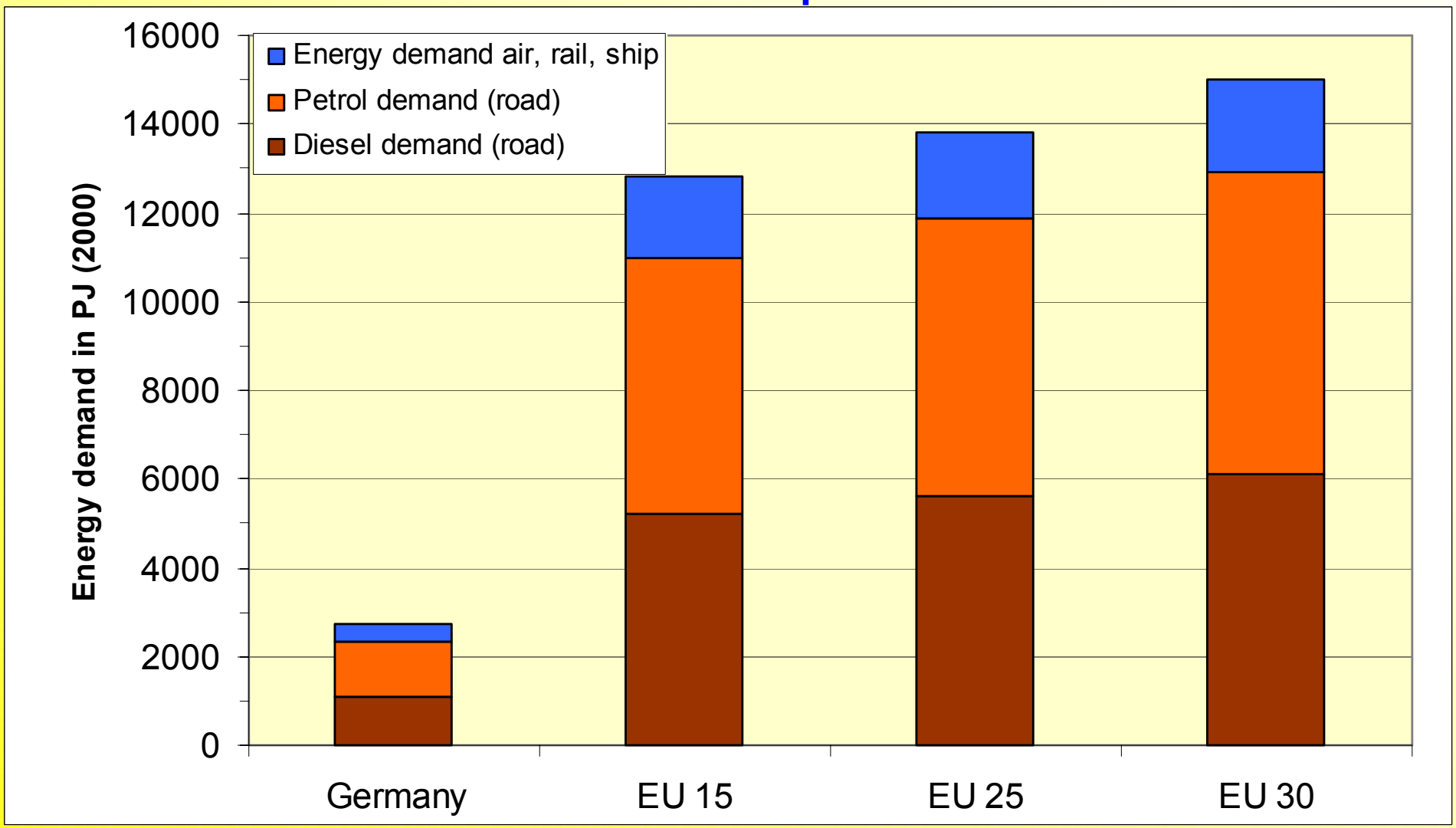
Biomass Potential

- Example: Straw Potential -



Potentials of Alternative Fuels

- Fuel Demand for Transportation in 2000 -



Final Consideration (II)

Option	Potential	Overall costs	Status	Comments	Overall
FAME	+	++	+++	Market mature	+
Ethanol	++	++	++(+)	Blended fuel	++
FT-Diesel	+++	++	+(+)	Designer fuel	+++
DME	+++	+(+)	+	Partly new distribution system	+(+)
Methanol	+++	+(+)	+	New distribution system	+(+)
Hydrogen	+++	(+)	-	New engines, distribution system	-
Biogas	++(+)	+(+)	+(+)	Distribution system	+(+)

+ less promising, +++ very promising

Final Consideration (II)

- Investment Needs -

fuel	investments in agriculture	investments in conversion plants	investments in distribution	investments in vehicles	estimated final price level
fuels based on energy plants					
FAME	→	→	↘	↓	↘
Ethanol	→	→	→	→	→
Sunfuel (FT-Diesel)	↗	↗	↘	↓	→
Methanol	↗	↗	→	↗	↗
Hydrogen	↗	↗	↗	↗	↗
fuels based on residues					
Sunfuel (FT-Diesel)	↓	↗	↘	↓	→
Methanol	↓	↗	→	↗	↗
Hydrogen	↓	↗	↗	↗	↗

Legend: ↗ = high → = medium ↘ = low ↓ = none

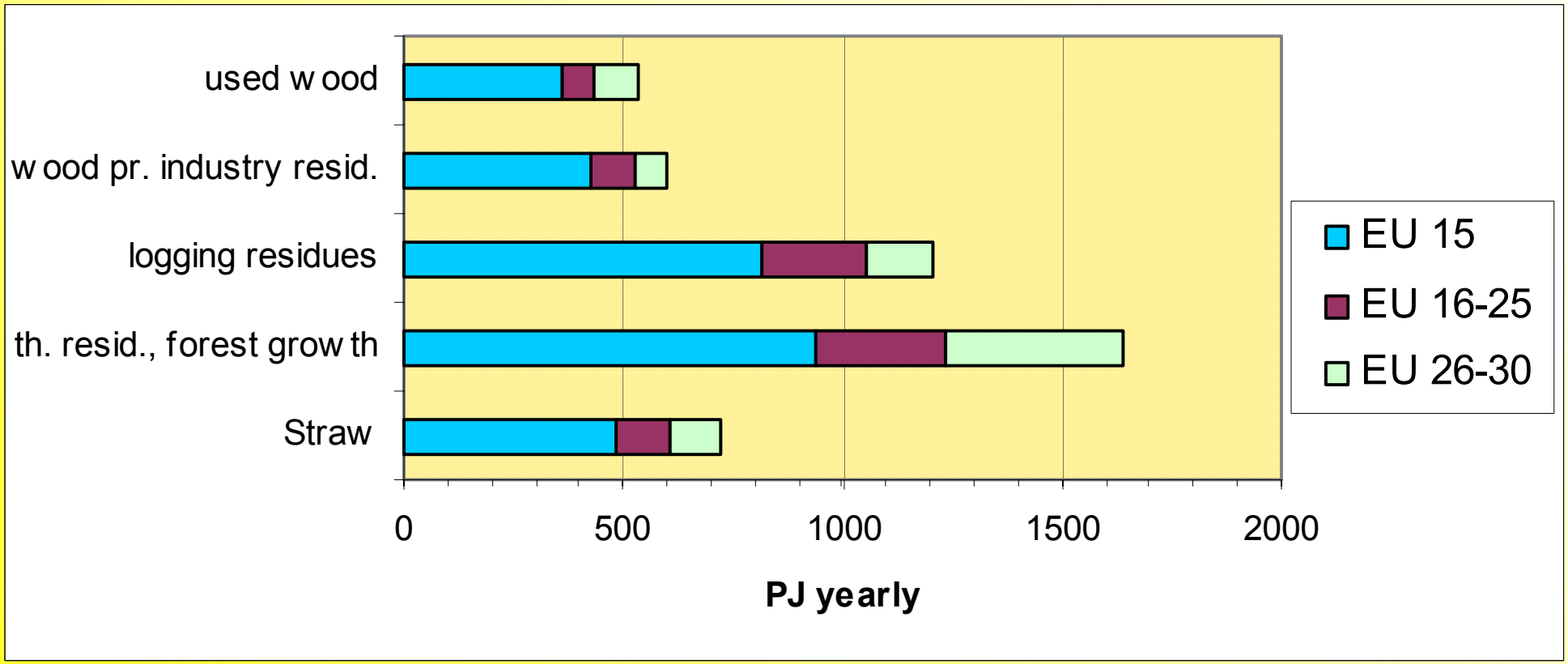
Introduction and Obstacles

Influences on the introduction timetable

Conversion route	changes in agricultural structures	R & D demand for conversion technology	number of concerned actors	number of concerned filling stations	number of vehicles to exchange	general trend for the timetable
fuels based on energy plants						
FAME	more oil plants: soon possible	low	rather limited number of actors	only indirect concern	none	**short term**
Ethanol	more sugar beet: soon possible	low	high number of car owners	> 100.000 in EU-15 to reconstruct	high share of the total fleet	**medium term**
Sunfuel (FT-Diesel)	wood plantations: long-term	R&D demand important	limited, mostly in agriculture	only indirect concern	none	**long-term**
Methanol	wood plantations: long-term	R&D demand important	high number of car owners	> 100.000 in EU-15 to reconstruct	high share of the total fleet	**very long-term**
Hydrogen	wood plantations: long-term	R&D demand important	high number of car owners	> 100.000 in EU-15 to reconstruct	high share of the total fleet	**very long-term**
fuels based on residues						
Sunfuel (FT-Diesel)	none	R&D demand important	limited, mostly in agriculture	only indirect concern	none	**long-term**
Methanol	none	R&D demand important	high number of car owners	> 100.000 in EU-15 to reconstruct	high share of the total fleet	**very long-term**
Hydrogen	none	R&D demand important	high number of car owners	> 100.000 in EU-15 to reconstruct	high share of the total fleet	**very long-term**

Available Biomass for Biofuels

Biogene Residues and By-producs (to be added)



moreover: 41 PJ used cooking oils (EU 15), 49 PJ (EU 25), 60 PJ (EU 30)

Biofuels and their Contribution

Maximal Contribution of Conventional and Synthetic Biofuels to the Road Transport Energy Demand in 2020

Assumptions:

- Combination of the technical potentials of all residues and of the most effective energy plant for biofuel production in each country
- Maximal conversion efficiency by all technologies (e. g. 60% of the energy content in woody biomass to be transformed into FT-Diesel)
- Maximal vehicle efficiency, thus road transport energy demand in EU 15 will decrease from 11 000 PJ (1999) to 9 700 PJ (2020)

Final Consideration (I)

- European Biofuel Directive
  - 2 % of the energy content of all gasoline and Diesel fuels must be biogenous by the end of 2005
  - 5,75 % of the energy content of all fuels must be biogenous by the end of 2005
  - yearly reports of the member states about the implementation progress
  - member states are allowed to reduce the taxation level for biofuels