EU renewable energy targets: the case of transport fuels

JEC Biofuels Programme – Overview of results

A joint study by **JRC / EUCAR / CONCAWE**

– 3rd PROMITHEAS Conference, Athens 7-8 October 2010 –

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Presentation Outline

1. JEC Biofuels Programme in a nutshell
2. Background to the Study
3. “Fleet & Fuels” Model
4. Reference Case
5. Implementation Scenarios
6. Biofuel Supply Outlook
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1. JEC Biofuels Programme in a nutshell

Technical exercise to assess scenarios for achieving EU renewable energy targets in the transport sector by 2020

Objectives

- Opportunities and barriers to 10% renewable energy in transport by 2020
- Integrated approach / focus on road transport
- "Fleet & Fuels" Model as main supporting tool
- Conventional, alternative fuels and biofuel blends
- Consensus demand and supply picture
- Seamless to consumers / no negative impacts on vehicle performance and emissions
- Projections and market data 2008-2020

Disclaimer: This exercise is not intended to commit JEC partners to deliver any particular scenario or conclusion included in this study.

1. In a nutshell…key messages

- Scenario analysis is characterised by **objectives**:
  - Technical feasibility of RED*) target with associated calculation of FQD**) target
  - Assumptions on vehicles/fleet, fuels and renewables projections
  - Excluded aspects: viability, costs, or logistics / commercial readiness
  - All transport modes with a focus on road transport

- Producing given **outcomes**:
  - Scenarios exist that achieve the RED transport target
  - None of these scenarios achieves the minimum FQD target

- **Realisation** of scenarios depend on:
  - Biofuel supply
  - Standardisation, vehicle compatibility and pace of introduction
  - Compatibility of the supply and distribution system for all fuel products
  - Non-road contributions to RED-%
  - Each scenario needs policy measures (including incentives) to enable a smooth transition from today to the "theoretically achievable" projections

- Much more technical work is needed to ensure **feasibility** of these scenarios and compatibility with upcoming Euro 6 emissions limits

*) RED: EU Renewable Energy Directive (*Dir 2009/28/EC)*
**) FQD: EU Fuel Quality Directive (*Dir 2009/30/EC)*

2. Background: A Short History

The JEC research collaboration was initiated in 2000 by

- JRC: Joint Research Centre of the European Commission
- EUCAR: European Council for Automotive R&D
- CONCAWE: Research Association of the European Oil Refining Industry

Collaborative Projects

➢ 2000-2007: Projects Completed

- ❒ Well-to-Wheels (WTW) Study Versions 1, 2b, and 2c
- ❒ WTW Study Version 3: enhancing pathways and vehicles
- ❒ Impact of ethanol on vehicle evaporative emissions (SAE 2007-01-1928)
- ❒ Impact of ethanol in petrol on fuel consumption and emissions (report in preparation)

➢ 2008-2011: Projects In-progress

- ❒ 2009-11: Major revision of WTW Study (Version 4)
- ❒ **2008-10: JEC Biofuels Programme for a 2020 time horizon**

→ **All reports are freely available in the Download section of the JEC website**
http://ies.jrc.ec.europa.eu/about-jec

2. Coming Decade for European Road Transport

- Vehicles:
  - More advanced engines & aftertreatment, diversification in engines and fleet
  - Fuel consumption of LD vehicles falling, HD diesel demand slightly increasing
  - Increasing pressure on CO_2 emissions with associated higher cost
  - Customer preferences potentially in conflict with mobility policies

- Refineries:
  - Increasing diesel/gasoline demand ratio
  - Higher CO_2 emissions due to diesel demand and product specifications
  - Increasing pressure on CO_2 emissions with associated higher cost

- Biofuels and other Renewables:
  - Renewables in transport fuels mandated to 10% (energy basis) by 2020
  - Conventional biofuels widely available but with sustainability concerns
  - Slower than expected pace of development for advanced biofuels
  - Pace/priorities differ across Member States, potentially leading to fuel diversity
  - CEN specifications are struggling to keep pace with legislative mandates

2. Current Projections of Transport Demand

EU27+2 Transport Energy Demand: [Mtoe]	2008 EuroStat	2020 JEC F&F Reference Scenario	2020 DG TREN (1)
On-Road	303	281	350
Diesel	188	186	
Light Duty		69	
Heavy Duty incl. Vans		117	
Gasoline	100	66	
Biofuels	10	21.5	
Other: CNG, LPG, electricity	5	7.8	
Rail (Diesel & Electricity)	9.5		10
Aviation	54		73
Inland navigation	6.5		6
Other off-road (Diesel)	14	20 *)	
Total	**387**	**390 **)**	**419**

Studies used to base case JEC projections

- DG TREN(**)
- TREMOVE
- iTREN2030
- Wood Mackenzie, Global Biofuels Outlook (*)

"Apples to apples" comparisons not always straightforward among studies

1) DG TREN: "European Energy and transport trends to 2030, Update 2007"

2. EU Regulatory Environment

- Renewable Energy Directive (RED)
  - Member States to meet 10% renewable energy in transport by 2020
  - Biofuels sustainability and GHG savings per energy unit
- Fuels Quality Directive (FQD)
  - Fuel suppliers to achieve at least -6% GHG from fuels in 2020
  - E10 main grade / E5 'protection grade' for older vehicles
- Vehicle Regulated Emissions
  - Light-duty (LD) passenger cars: Euro 5/5b to 2014, Euro 6 from 2015 onwards
  - Heavy-duty (HD) vehicles: Euro V to 2013; Euro VI from 2014 onwards
- Vehicle CO_2 Emissions
  - LD passenger cars: new vehicle fleet average 130g/km by 2015 / review of 2020 targets
  - Light Commercial Vehicle (LCV) fleet: new fleet average 175g/km by January 1st 2016, review of 2020 targets (***proposed***)

3. 'Fleet & Fuels' Model: Model Overview

A spreadsheet-based model to
simulate EU27+2 vehicle fleet development and fuel demand

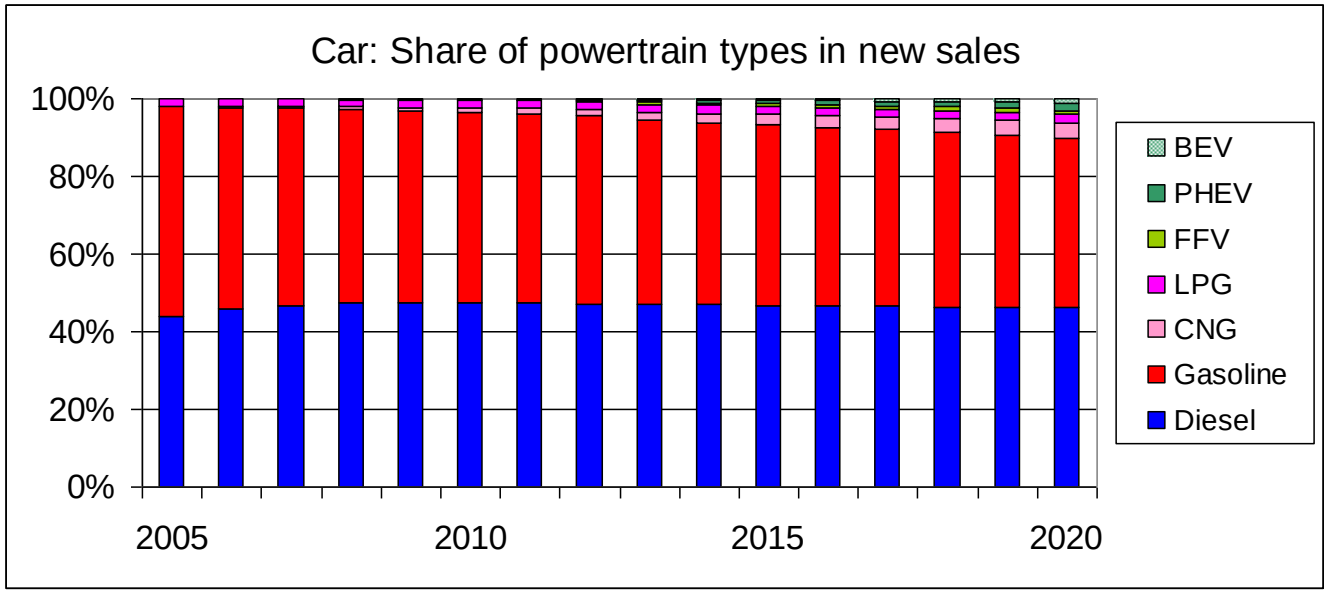
Different combinations of vehicles / fuels to assess different scenarios

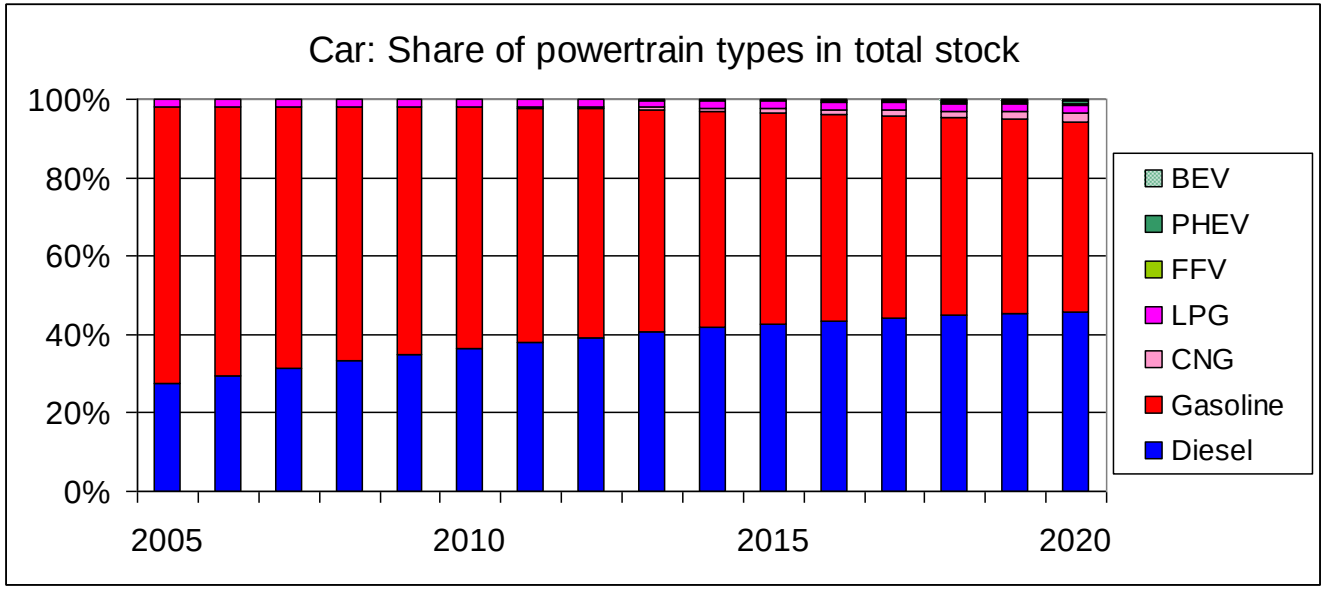
- Total fuel demand and diesel/gasoline balance
- Total biofuels demand, including ethanol and biodiesel, HVO, etc
- Total renewable energy demand, including electricity, biogas, etc
- Renewable energy demand for road transport (RED)
- GHG emissions reduction (FQD Article 7a)

Parameters relevant to fuel demand included:

- Passenger car, van, bus and coach and heavy-duty truck demand
- Vehicle efficiency and improvement in efficiency over time
- Percentage diesel in new car sales
- Introduction of alternative vehicles (FFV, LPGV, CNGV, electric vehicle, etc.)
- Vehicle model year (vintage) assumed compatible with fuel grade

3. 'Fleet & Fuels' Model: Example Model Outputs

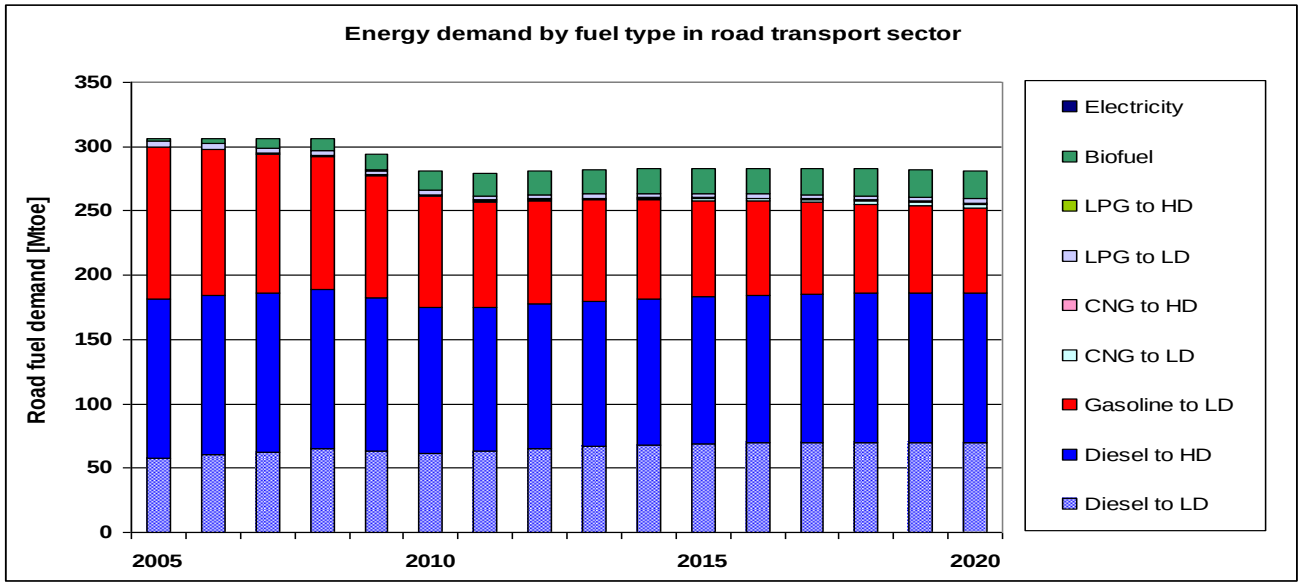




Vehicle fleet development for the Reference Scenario (1)

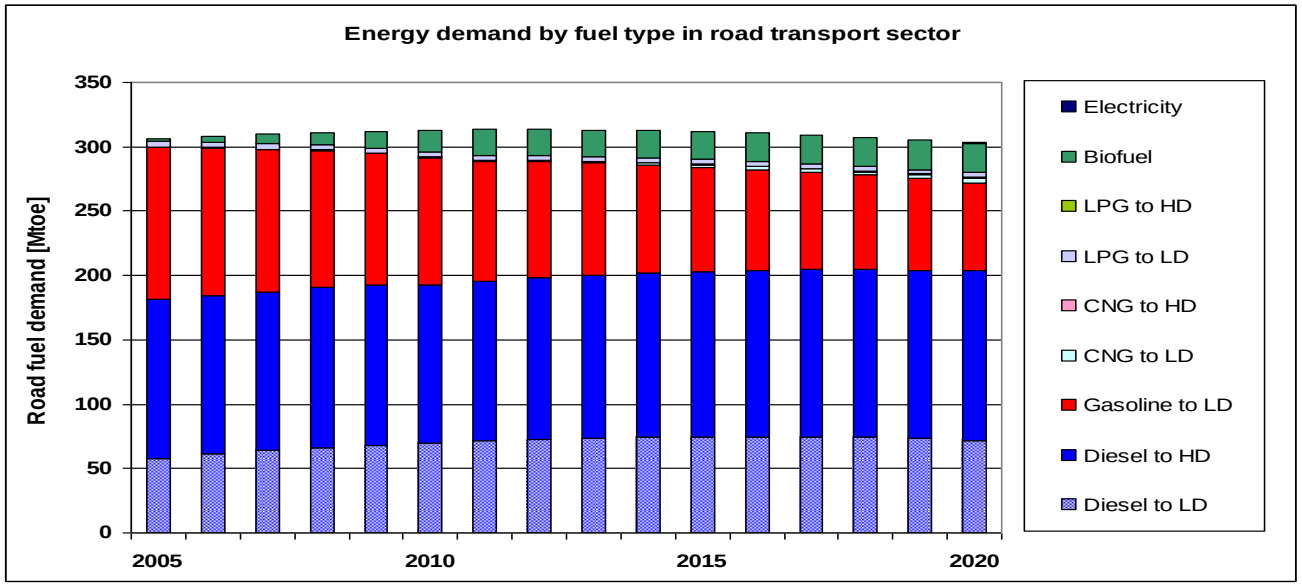
- LD new car sales showing the growth of alternative vehicles
- LD vehicle fleet showing the impact of new car sales on the overall fleet
- Note growth in the LD diesel fraction over the decade

3. 'Fleet & Fuels' Model: Example Model Outputs



Road transport fuel demands

- Reference Scenario (1) including the impact of the economic recession



- Reference Scenario excluding the impact of the economic recession

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4. Reference Case: Alternative Fleet Parameters

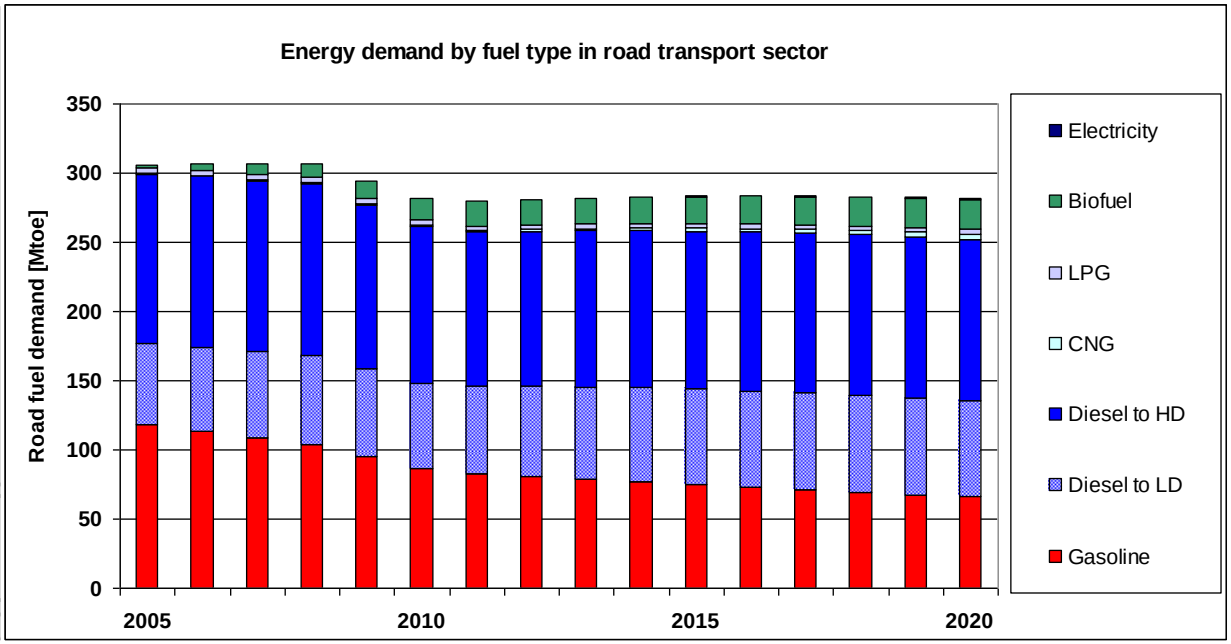
Alternative Fuel Passenger Cars	In 2020 New Sales	In 2020 Vehicle Fleet[1]
Flex-Fuel Vehicles (FFV)	1%	0.5%
Compressed Natural Gas Vehicles (CNGV)	4% 0.8 Million	2% ~5 Million
Liquefied Propane Gas Vehicles (LPGV)	2% 0.4 Million	2% ~5 Million
Electric Vehicles Battery Electric (BEV) & Plug-in Hybrid (PHEV)	3% 0.6 Million	1% 2.7 Million
Alternative Fuel Vans	**In 2020 New Sales**	**In 2020 Vehicle Fleet[1]**
Compressed Natural Gas Vehicles (CNGV)	4%	1.7%
Liquefied Propane Gas Vehicles (LPGV)	1%	0.4%
Flex Fuel Vehicles (FFV)	1%	0.3%
Electric Vehicles Battery Electric (BEV) & Plug-in Hybrid (PHEV)	2% 24 Thousand	0.4% 90 Thousand

	In 2020 New Sales			
Alternative Fuel Heavy Duty Vehicles	3.5t to 7.5t	7.5t to 16t	16t to 32t	Bus-Coach
Compressed Natural Gas Vehicles (CNGV)	2%	1%	1%	5%
Di-Methyl Ether Vehicles (DMEV)	==	==	0.5%	==
95% Ethanol (E95) Vehicles	==	==	1%	2%

1: Cars in 2020 from TREMOVE baseline: 270 million in vehicle fleet; 20 million in new car sales

4. Reference Case: Results

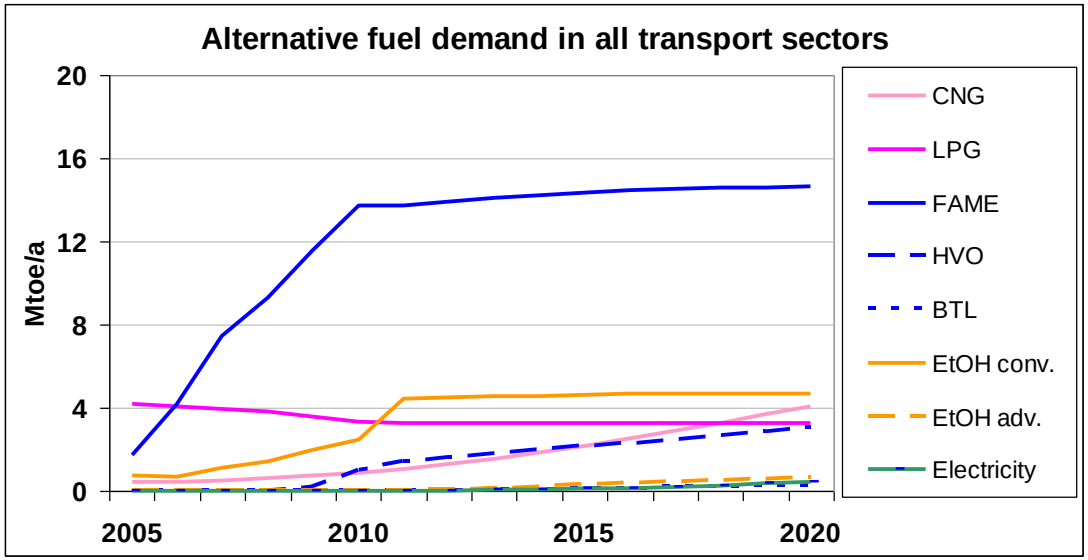
Road fuel (Mtoe)	2005	2010	2020
Fossil Gasoline to car	118	87	66
Fossil Diesel to car	58	61	69
Fossil Diesel to HD	123	114	117
Sum fossil Diesel	181	175	186
Diesel to Gasoline ratio (road only)	1,5	2,0	2,8
CNG	0,42	0,85	3,26
CBG			0,82
LPG	4,17	3,32	3,24
FAME	1,50	11,90	12,80
HVO	0,00	1,00	3,00
BTL	0,00	0,00	0,25
DME	0,00	0,00	0,09
Total Ethanol	0,72	2,47	5,32
EtOH conv.	0,72	2,47	4,68
EtOH Adv.	0,00	0,00	0,64
"Fossil" Electricity	0,00	0,00	0,28
Renewable Electricity			0,15
Sum road fuel demand	**306**	**281**	**281**
RED Contributions			
Non-road			1,0%
Road			8,6%
Sum RED-%			**9,7%**
FQD GHG saving			**-4,4%**

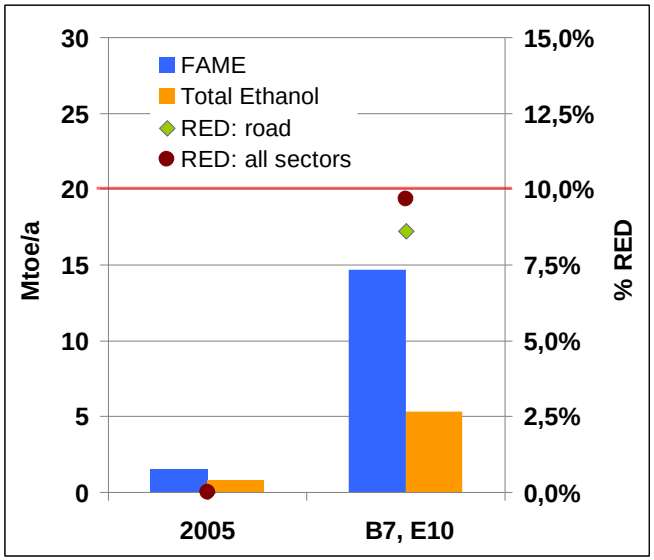


Results comparing 2010 and 2020:

- Fossil demand changes:
  - Gasoline demand decreases by 24%
  - Diesel demand increases by 6%
  - Diesel demand increases 13% for LD and 3% for HD
  - Diesel/gasoline ratio increases from 2.0 to 2.8
- Large biofuel volumes will be needed, increasing demand for CNG & CBG
- RED: 9.7% with 1.0% contribution from non-road sectors
- FQD: -4.4% GHG emissions savings reached

4. Reference Case: Results





- Alternative fuel demand results:
  - FAME dominates biofuel market
  - FAME demand increasing to 2010 driven by B7 specification
  - Ethanol demand increasing to 2010 driven by E5 specification
  - Ethanol demand increasing beyond 2010 driven by E10 introduction
  - HVO and BTL demand follow availability assumptions (backward compatible - not grade dependent)
  - CNG/CBG demand driven by introduction of CNGV mainly in LD but also in HD
- FAME / Ethanol demand by 2020, RED development
  - FAME demand in all transport sectors ~15 Mtoe/a, increasing from 1.5 Mtoe (2005), 7.9 Mtoe (2008)
  - Ethanol demand ~5 Mtoe, increasing from 0.7 Mtoe (2005), 1.8 Mtoe (2008)

5. RED Implementation Scenarios:1-6

Scenario 1	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gasoline Grade 1						E5						
Gasoline Grade 2						E10						
Gasoline Grade 3												
Diesel Grade 1						B7						
Diesel Grade 2												

Scenario 2	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gasoline Grade 1					E5				E10			
Gasoline Grade 2					E10				E20			
Gasoline Grade 3												
Diesel Grade 1						B7						
Diesel Grade 2												

Scenario 3	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gasoline Grade 1						E5						
Gasoline Grade 2						E10						
Gasoline Grade 3												
Diesel Grade 1						B7						
Diesel Grade 2									B10 (all)			

Scenario 4	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gasoline Grade 1					E5				E10			
Gasoline Grade 2					E10				E20			
Gasoline Grade 3												
Diesel Grade 1						B7						
Diesel Grade 2									B10 (all)			

Scenario 5	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gasoline Grade 1						E5						
Gasoline Grade 2						E10						
Gasoline Grade 3												
Diesel Grade 1						B7						
Diesel Grade 2									B15 (HD)			

Scenario 6	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gasoline Grade 1					E5				E10			
Gasoline Grade 2					E10				E20			
Gasoline Grade 3												
Diesel Grade 1						B7						
Diesel Grade 2									B10 (HD)			

Scenario 1: Reference Case

Scenarios 2 - 4:

- High Biofuel Grades all vehicles

Scenarios 5 - 6:

- High Biodiesel Grades HD only

5. RED Implementation Scenarios:7-9

Scenario 7	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gasoline Grade 1	E5											
Gasoline Grade 2		E10										
Gasoline Grade 3		E85										
Diesel Grade 1	B7											
Diesel Grade 2												

Scenario 8	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gasoline Grade 1	E5								E10			
Gasoline Grade 2		E10							E20			
Gasoline Grade 3		E85										
Diesel Grade 1	B7											
Diesel Grade 2												

Scenario 9	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gasoline Grade 1	E5											
Gasoline Grade 2		E10										
Gasoline Grade 3		E85										
Diesel Grade 1	B7											
Diesel Grade 2									B10 (HD)			

Scenarios 7 - 9:

- Additional Flex-Fuel Vehicles (FFV)

FFV scenarios feature sales share of 4.5%, resulting in 2.5% FFV-stock (6.5 mil) in 2020

Scenario 7:

- FFV fleet requires Ethanol supply comparable to scenario 2 (B7, E20) (and same RED-% as in scenario 2).

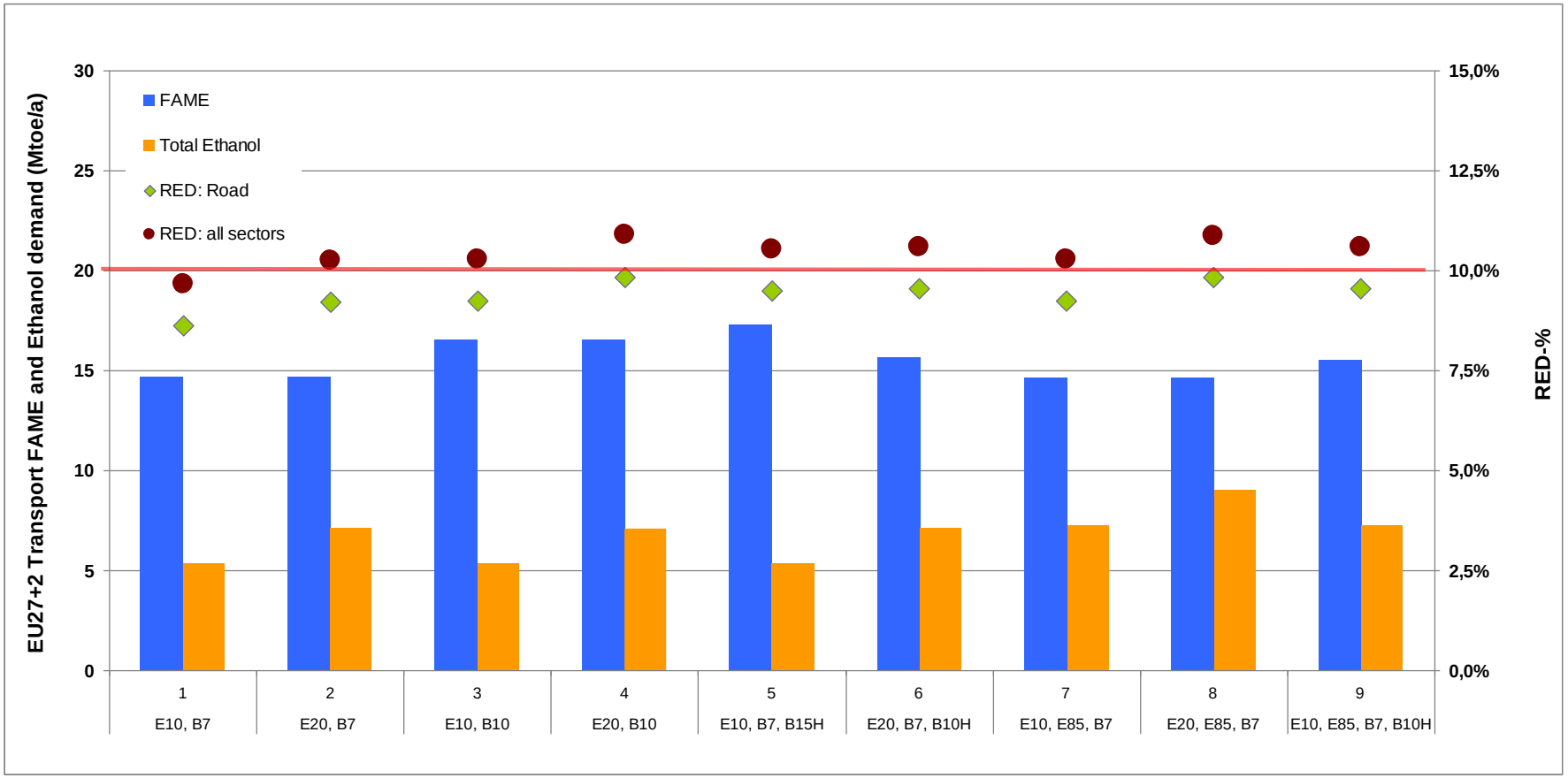
Scenario 8:

- E20 and FFVs increase the Ethanol demand and the RED-%.

Scenario 9:

- FFV fleet requires Ethanol supply comparable to scenarios 2 & 7.

5. RED Implementation Scenarios: Scenario Summary



- FAME demand: 14.6 to 17.2 Mtoe (compared to 5.7 Mtoe in 2007 as per "EurObserv'ER Biofuels Barometer")
- Ethanol demand: 5.3 to 9.0 Mtoe (compared to 1.2 Mtoe in 2007 as per "EurObserv'ER Biofuels Barometer")

- ROAD-% contribution: 8.6% to 9.8%
- RED-% (all sectors according to Directive): 9.7% to 10.9%

For further details of these scenarios refer to section 12.3

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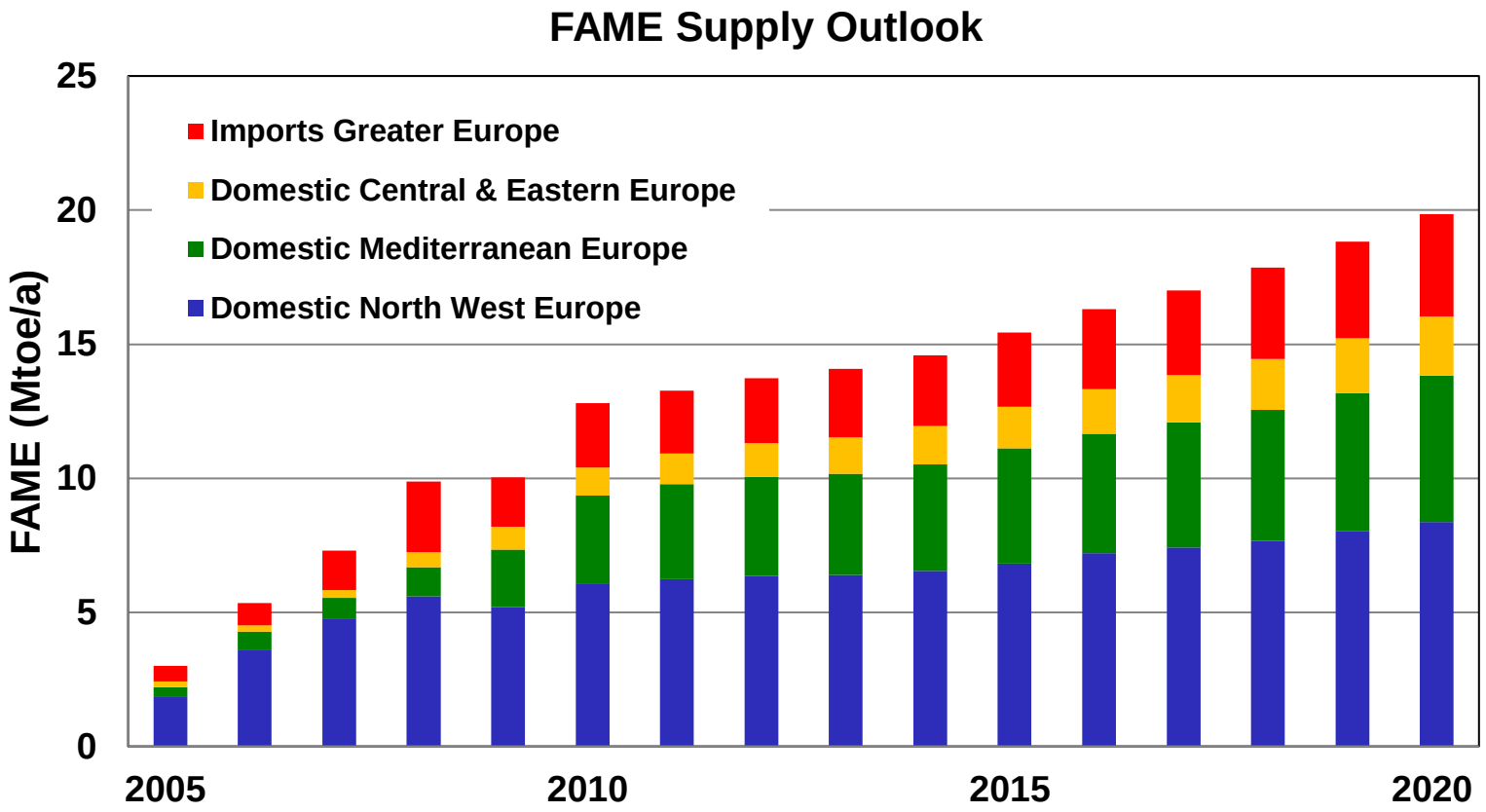
6. Biofuel Supply Outlook: Demand from scenarios

	Biofuel Type	Demand Outlook (Scenarios)	Demand Outlook (Scenarios & parameter variation)
Conventional Biofuels	Bio-ethanol from fermentation	Up to 8.5 Mtoe	Up to 12 Mtoe
	FAME (and FAEE)	Up to 17.5 Mtoe	Up to 19 Mtoe
Advanced Biofuels	Bio-ethanol from lignocellulose	0.6 Mtoe	1.3 Mtoe
	Hydrogenated Natural Oils (HVO)	3.0 Mtoe	4.5 Mtoe
	Biomass to Liquids (BTL)	0.25 Mtoe	0.5 Mtoe
Other Renewables	Biogas	Up to 0.7 Mtoe	Up to 1.0 Mtoe
	Electric from renewables	Up to 0.5 Mtoe	Up to 1.0 Mtoe

- Quantities of bio-components available for European use in 2020…
  - From domestic production and from imports?
  - From sustainable sources meeting GHG reduction targets?
  - Primary focus on availability, not costs and investments

6. Biofuel Supply Outlook: FAME Supply

Supply projection for FAME: domestically produced and imported



Source: Wood Mackenzie 'Global Biofuels Outlook' (2009)

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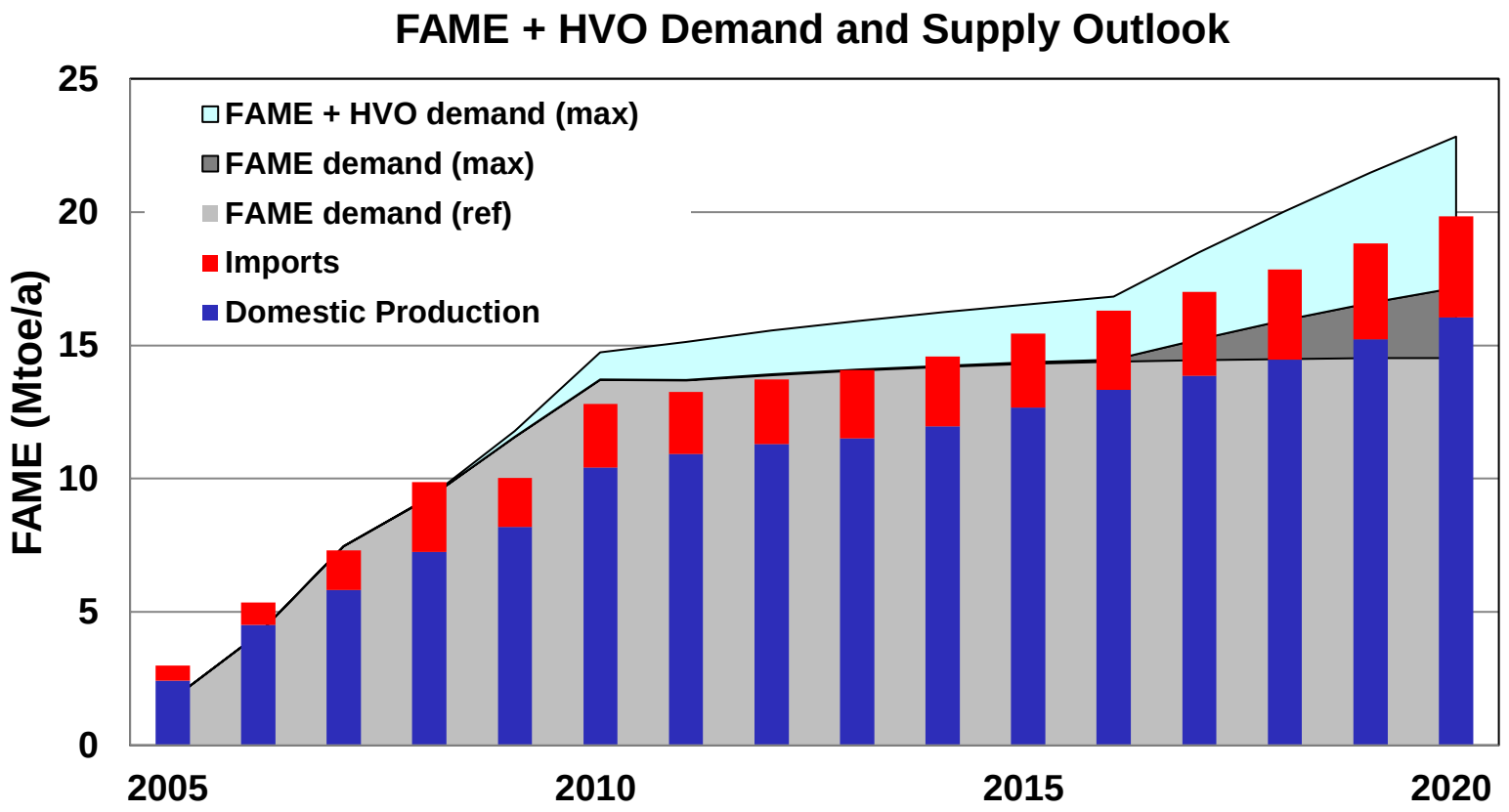
6. Biofuel Supply Outlook: FAME and HVO

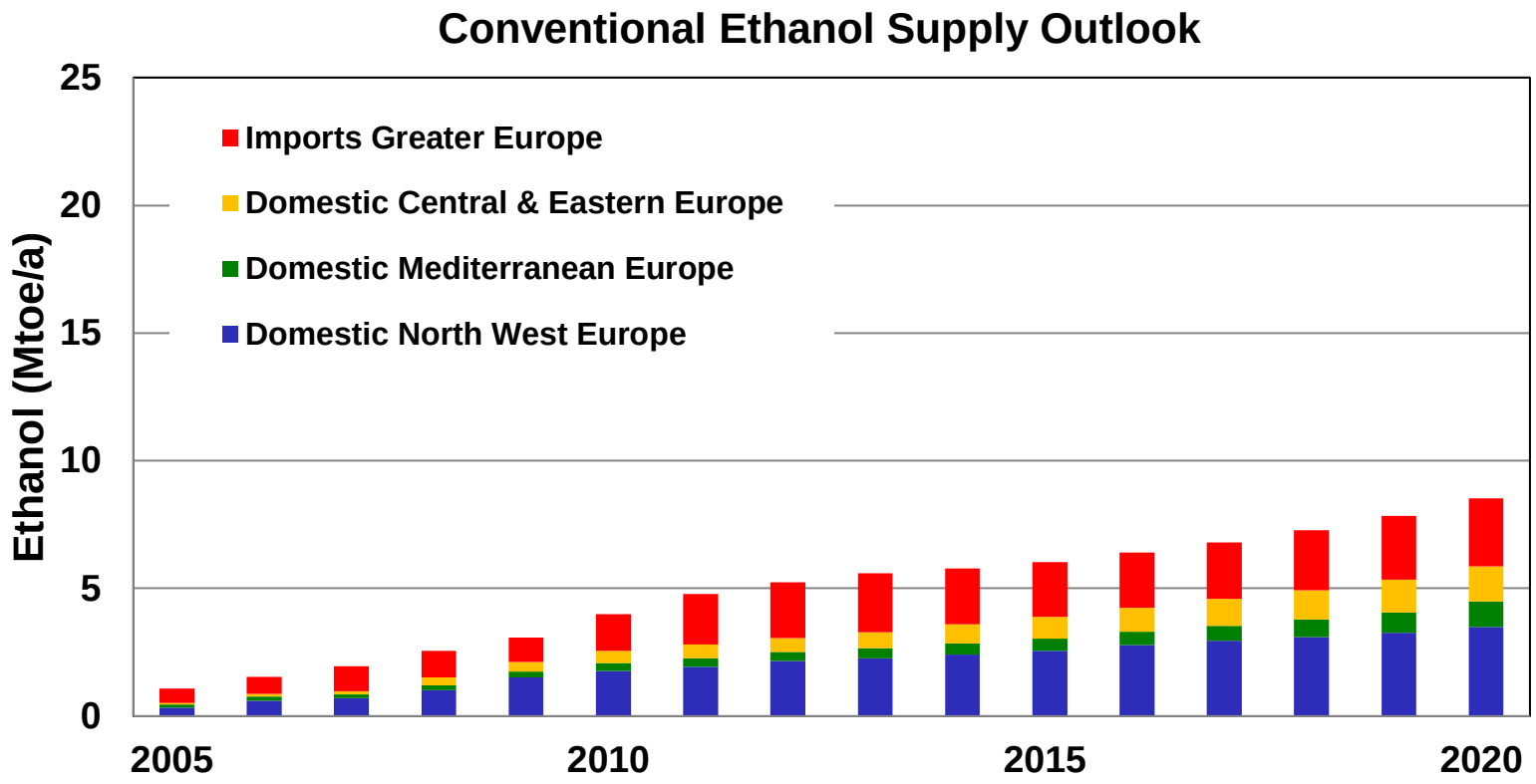


- Supply of total HVO and FAME limited by total availability of natural & waste oils
- Imports essential to fully utilise higher biodiesel blends

Supply Projection: Wood Mackenzie 'Global Biofuels Outlook' (2009)

6. Biofuel Supply Outlook: Conventional Ethanol

Supply projection for ethanol: domestically produced and imported



- Conventional ethanol supply projected to be less than half the volume of FAME supply through 2020 without a major increase in imported ethanol

Source: Wood Mackenzie 'Global Biofuels Outlook' (2009)

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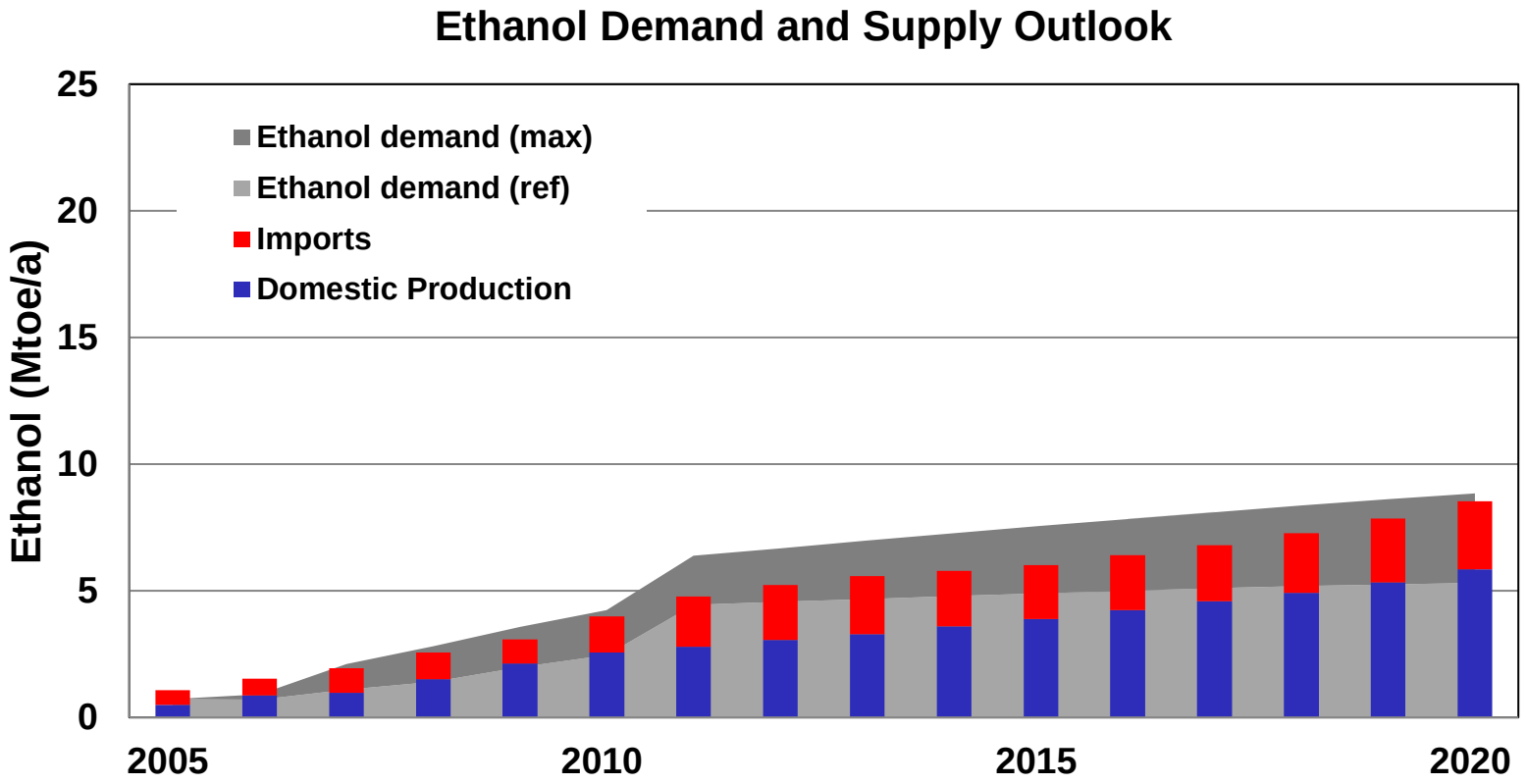
6. Biofuel Supply Outlook: Ethanol



- Ethanol demand (max) = highest ethanol demand in all scenarios
- Imports and development of advanced ethanol key to meeting demand

Supply Projection Wood Mackenzie 'Global Biofuels Outlook' (2009)

7. Summary: Key Conclusions

- Scenarios exist that achieve EU RED renewable energy target in transport with the given assumptions

- Realisation of the scenarios depend on :
  - Biofuel supply, especially the availability of sustainable biofuels to Europe
  - CEN specifications (standardisation), potential vehicle compatibility and pace of introduction
  - Compatibility of supply and distribution system for all fuel products
  - Non-road contributions to RED-%, especially HVO/BTL use by the aviation sector
  - Each scenario needs policy measures (including incentives) to enable smooth transition from today to the “theoretically achievable” projections

- Much more technical work is needed to ensure feasibility of these scenarios and compatibility with upcoming Euro 6 emissions limits
  - Multi-stakeholder coordination and timely decisions will be essential
  - Seamless transition is important to ensure continued customer confidence

ILUC*: Indirect Land Use Change

7. Summary: Key Conclusions

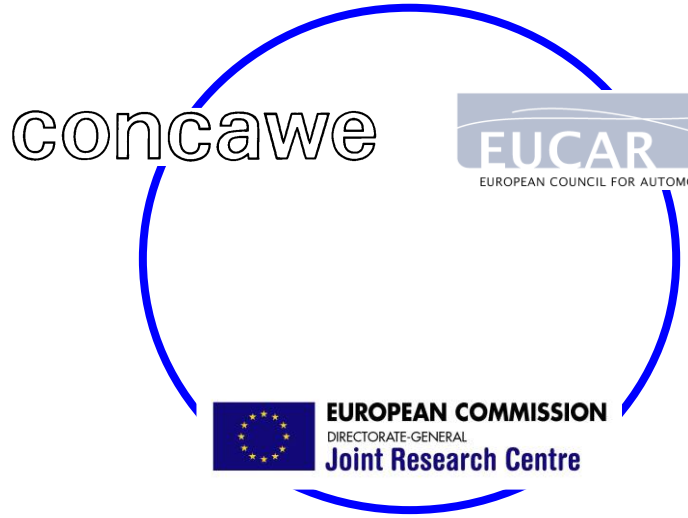
- Vehicles:
  - Today's vehicles are E10 (from MY2005) and B7 compatible
  - Compatibility of vehicles with higher biofuel blends still to be proven: time, testing and investment!

- Fuels:
  - Compatibility of existing logistics infrastructure with higher grades is uncertain
  - FQD GHG target not achieved in the chosen scenarios
  - Coordinated development of CEN specifications is needed for higher grades
  - Higher blends must be ***fully utilised*** in order to approach RED/FQD targets

- Biofuels:
  - Significant questions regarding sustainability, pace of development, and imports
  - Given uncertainties, ethanol/FAME in the range needed for the RED target
  - Non-conventional biofuel production and HVO/BTL uptake by aviation sector especially important

- Other Issues:
  - Attractiveness of different scenarios differ by Member State
  - Non-road contributions to RED-% important
  - Potential for higher biodiesel blends in non-road transport: require time, testing and investment!
  - Costs and investments could be significant: not evaluated in study!
  - Maintaining consumer confidence in fuel and biofuel strategy is critical!

8. JEC Biofuels Programme: Contributors



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The study report will be available on the WEB:
http://ies.jrc.ec.europa.eu/about-jec

For questions / inquiries / requests / notes
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Backup: 'Fleet & Fuels' Model: Model Overview

TREMOVE data and other sources used to provide historical input on vehicle fleet

- Fleet composition
- Fleet fuel economy
- Activity (km driven)
- *Per vintage*
- Separate diesel and gasoline vehicles

Forward-looking input for the development of the fleet to 2020

- New sales, total population, and total activity (km driven)
- % diesel of new car sales
- Vehicle scrappage rate assumed to follow a typical S-curve
- Alternative vehicle fleets (e.g. CNGV, FFV, EV)
- Fuel economy of new cars is based on NEDC
  - 'Real world' factor included to estimate total fuel demand

Impact of the 2008-2009 economic recession factored in:

- Model incorporates latest HD sales data (ACEA) and iTREN methodology

Backup: 'Fleet & Fuels' Model: Vehicle and Fuel Options

Seven LD passenger car types (and fuel type options)

- Gasoline, Diesel, Flex-Fuel Vehicle (FFV)
- Compressed Natural Gas (CNG), Liquefied Propane Gas (LPG)
- Plug-in Hybrid Electric Vehicle (PHEV), Battery Electric Vehicle (BEV)

Three Van classes (and fuel type options)

- Gasoline (Gasoline, CNG, LPG, xEV)
- Small Diesel <2.5 tonnes (Diesel, CNG, LPG, xEV)
- Large Diesel >2.5 tonnes (Diesel, CNG, LPG, xEV)

Five Heavy-duty vehicle classes (and fuel type options)

- 3.5 to 7.5 tonnes (Diesel, CNG)
- 7.5 to 16 tonnes (Diesel, CNG)
- 16 to 32 tonnes (Diesel, CNG, E95, DME)
- > 32 tonnes (Diesel)
- Buses and coaches (Diesel, CNG, E95)

xEV: represents the various electrified vehicles as BEV, PHEV, FCEV

Backup: 'Fleet & Fuels' Model: Vehicle and Fuel Options

Adjustable parameters that can be changed individually for each vehicle type

- Sales and stock annual growth rate
- Vehicle activity: annual km driven (LD, LCV), annual t-km (HD)
- Vehicle fuel efficiency
- Alternative vehicle 2020 sales share
- Alternative vehicle sales start year
- % replacement of gasoline or diesel cars by alternative vehicle
- % use of alternative fuel in alternative fuel vehicles (e.g. E85 take-up rate for FFV)

Fuels implementation

- Optimistic assumption for biofuel blending at max allowed specification (e.g., 10% v/v ethanol minus 0.1% v/v blending tolerance)
- Up to 3 different gasoline grades: 'protection grade', main grade, and E85
- Up to 2 different diesel grades: 'protection grade' and main grade
  - For the main diesel grade, market uptake by HD, LCV, LD vehicle and vehicle vintage compatibility can be independently set
- Vehicle vintage compatible with each fuel grade
- HVO or BTL are included in diesel pool assuming full backward compatibility
- Advanced Ethanol (lignocellulose based) is replacing/added to gasoline
- Other Oxygenates (e.g. ETBE): not specifically modeled but would be allowed up to the maximum oxygen specification

Renewable Energy Directive specifics are implemented including "extra credits" for advanced biofuels and renewable electricity

Backup: Non-road Transport Sectors: 2020 Outlook

RED denominator 2020:

- Road transport energy demand: 281 Mtoe, RED: 275 Mtoe
- Rail transport energy demand: 10 Mtoe, RED: 10 Mtoe
- Inland navigation energy demand: 6 Mtoe, RED: 6 Mtoe
- **Sum denominator RED methodology: 291 Mtoe***

Rail 2020:

- ~70% of rail fuel demand by electricity: 7 Mtoe
  - Assuming 35% RES: 2.45 Mtoe: **~0.85% RED***
- ~30% of rail fuel demand by diesel: 3 Mtoe
  - Assuming B7: 0.2 Mtoe: **~0.07% RED***

Inland navigation 2020:

- 6 Mtoe diesel, B7 in total sector 0.4 Mtoe: **~0.1% RED***

Aviation 2020: second largest energy share, ~73 Mtoe

- Assumption: no contribution

Other off-road 2020:

- 20 Mtoe, assumption: B7 in total sector: 1.3 Mtoe
- No RED-contribution as other off-road fuel consumption excluded from RED

Fuel demand non-road sectors (Mtoe)	
Rail fuel	
"fossil" Electricity	4,6
Renewable Electricity	2,5
Fossil Diesel	2,8
FAME	0,2
Sum rail	**10,0**
Aviation fuel	
Gasoline	0,15
Kerosene	72,9
Sum aviation	**73,0**
Inland navigation fuel	
Fossil Diesel	5,6
FAME	0,4
Sum inl. nav.	**6,0**
Other off-road fuel	
Fossil Diesel	18,7
FAME	1,3
Sum other off-road	**20,0**
RED Contributions non-road (%)	
Rail	0,9%
Water	0,1%
Aviation	0,0%
Other off-road	0,0%
Sum RED-% non-road	**1,0%**

*: applied in RED calculations for all scenarios

Backup: **RED Implementation Scenarios:** Grades & vintage years

Grades in Scenarios:

Grade	E5	E10	E20	B7	B10	B15
Year of grade introduction	now-2011	2011	2017	now-2011	2017	2017
Cars & Vans compatible from	All	2005	2017	All	2017	None
HD vehicles compatible from				All	2017	2017

Sensitivity cases:

Grade	E5	E10	E20	B7	B10	B15
Year of introduction			2015		2015	2015
Cars & Vans compatible from			2015		2015	None
HD vehicles compatible from					2015 & All	2015 & All

All scenarios: actual biofuels content is 0.1%v/v less than the maximum specification limit