Potential of regenerative Fuels to acchieve Climate Targets in Traffic

Tom Garbe
Jörg Theobald
Karsten Michels
Thorsten Lippmann
(Volkswagen AG)

9.10.2024

Climate Fuels - Agenda

- The Challenge
- The Concept
- The Ramp Up
- Latest Developments
- Summary and Conclusion

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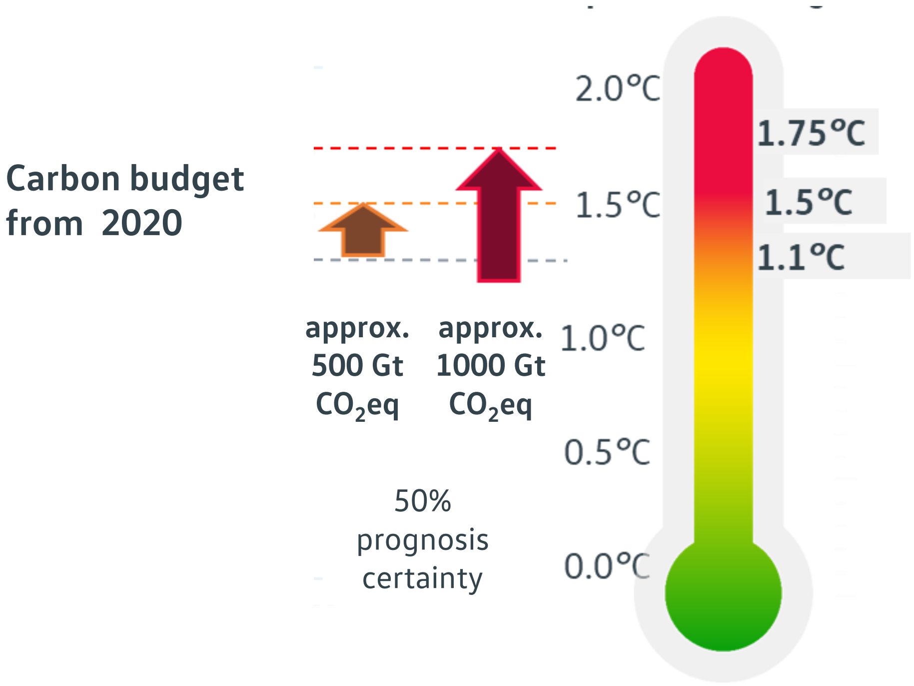
Traffic Impact on Greenhouse Gas Budget

Global temperature rise



World wide THG-Emission 2023: 36,8 Gt CO_2eq

- **Traffic share on GHG emissions**
  total 22% (EU)
  on road 14% (EU)

- **Electric Vehicles in the Fleet 2024**
  BEV's 2.96% | PHEV's (1,9%)
- **Share of total new registrations 2024**
  BEV 13.7% | PHEV 6.9%
- **Regenerative Fuels in the market**
  share on total fuel sales7.1%
  Average reduction of CO_2 emissions: ~87% (2022)

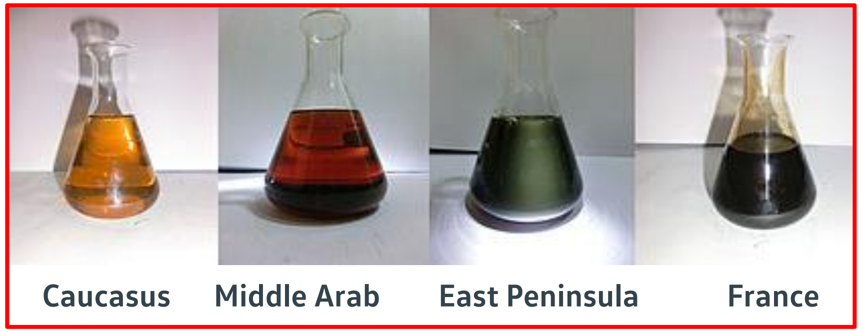
- **Increase of Passenger Car km from 1991 to 2023** ~23%
- **Willingness to pay for climate friendly technology**
  ~ 40% of all customers

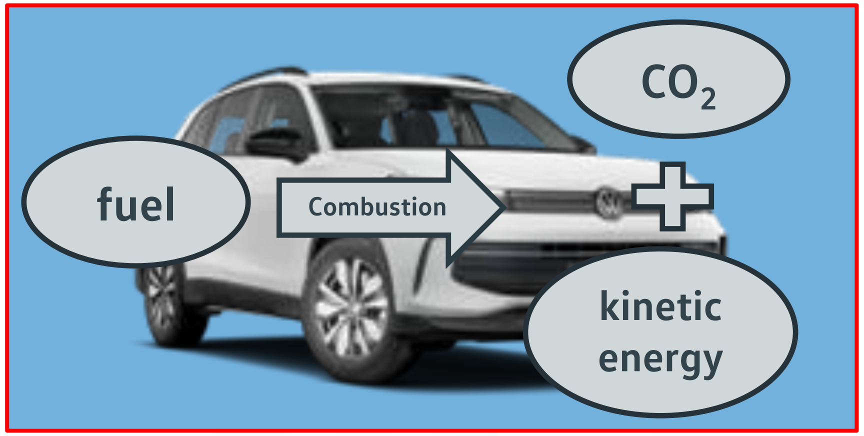
Think global.....

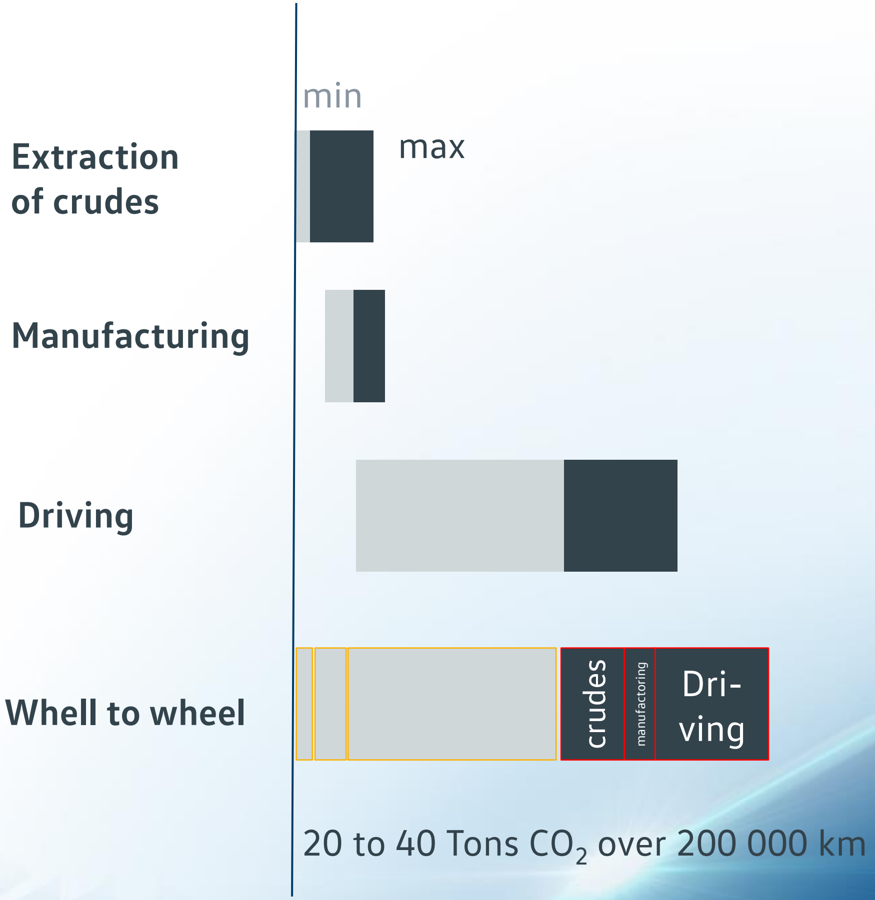
.....act local (on European & German level)

Sources:
Verbleibendes CO2-Budget - Mercator Research Institute on Global Commons and Climate Change (MCC) (mcc-berlin.net)
NOW GmbH Elektromobilitätsreport (ElektromobilitätsReport | 08/2024 - Monitor (elektromobilitaetsmonitor.de)); Umweltbundesamt, BLE

Emissions counted in the Use Phase of an actual ICE Vehicle







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Technology Choice for quick and cost effective Transition

Main Restrictions/Bottlenecks*:

overall: existing ICE Fleet

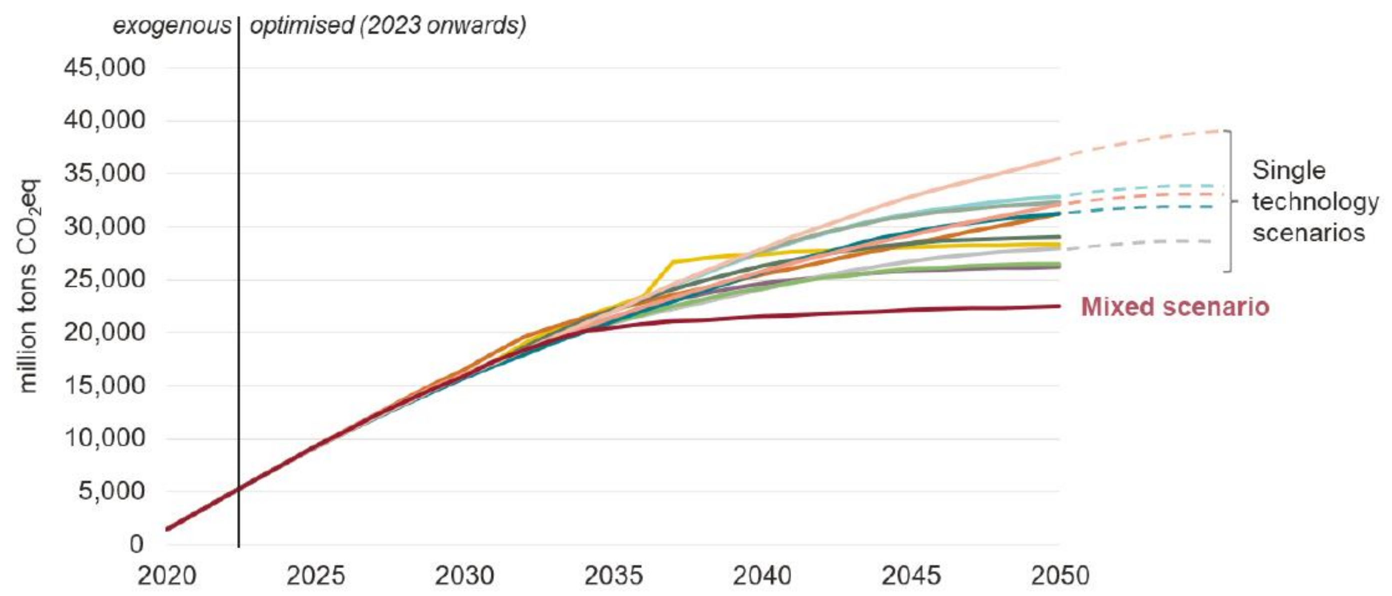
BEV: Cobalt, electricity Grid, Chargers
FCEV: Platinum, H_2 Gas stations

Optimisation of fossil fuel production:**
unsufficient potential

Biofuels: technology ramp up 2nd Gen, total mass potential

eFuels: CO_2 capture technology, synthesis technology ramp up, electrolyser

Cumulated GHG emissions in traffic for Europe, cost optimized simualtion including max ramp up speed, optimal legal framework



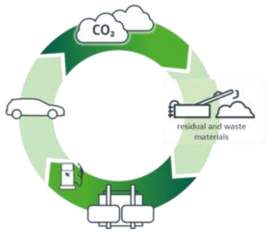
Climate targets can only be acchieved by a synergistic technology mix

Source: FVV Fuel Study 4b
* selected
** not included in fuel study

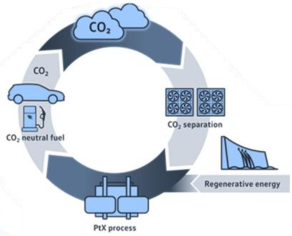
Synergistic Powertrain Concept

Battery electric Vehicle (increasing share of green electricity)

+ Hybridisation + Efficiency measures



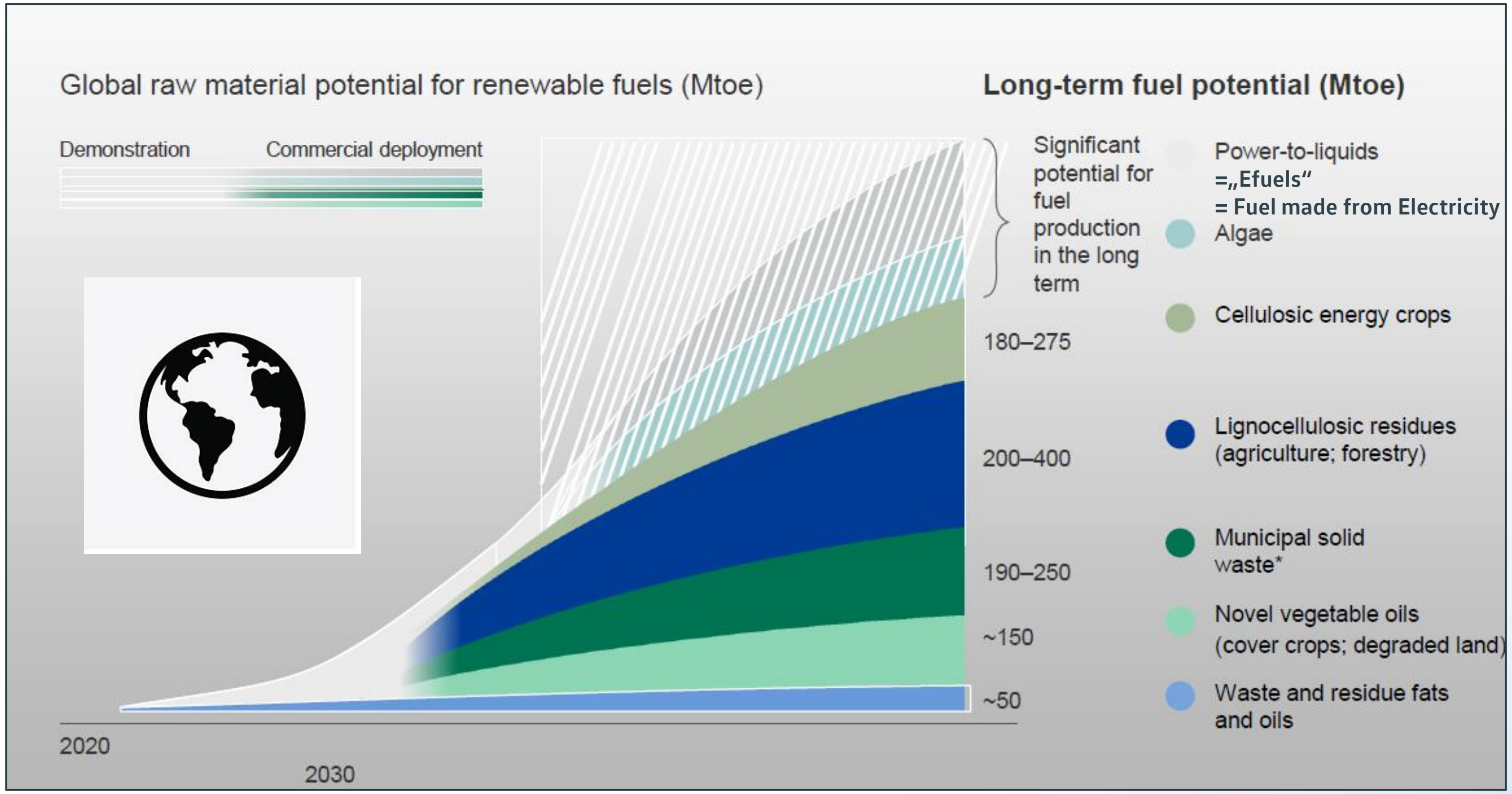
+ Biofuels: short term effective



+ efuels: (Fuels from Electricity and CO_2): medium term effective

Climate Fuels

"Climate Crudes": The new Oil



World wide crude oil use 5000 Mtoe

Biomass Potential for substitution of refinery output in Germany and Europe
Metastudy by
„Deutsche Biomasse Zentrum"

10 – 49% of refinery Output
(50 to 250 Mtoe)

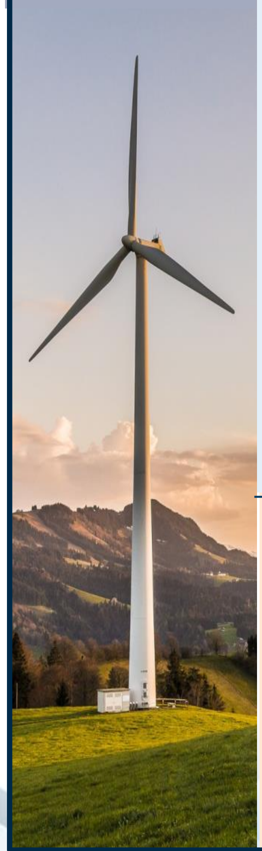
7 – 28% of refinery Output
(7 to 28 Mtoe)

Efuel Potential in Europe: secondary

Source:EntX Meta Study, Neste

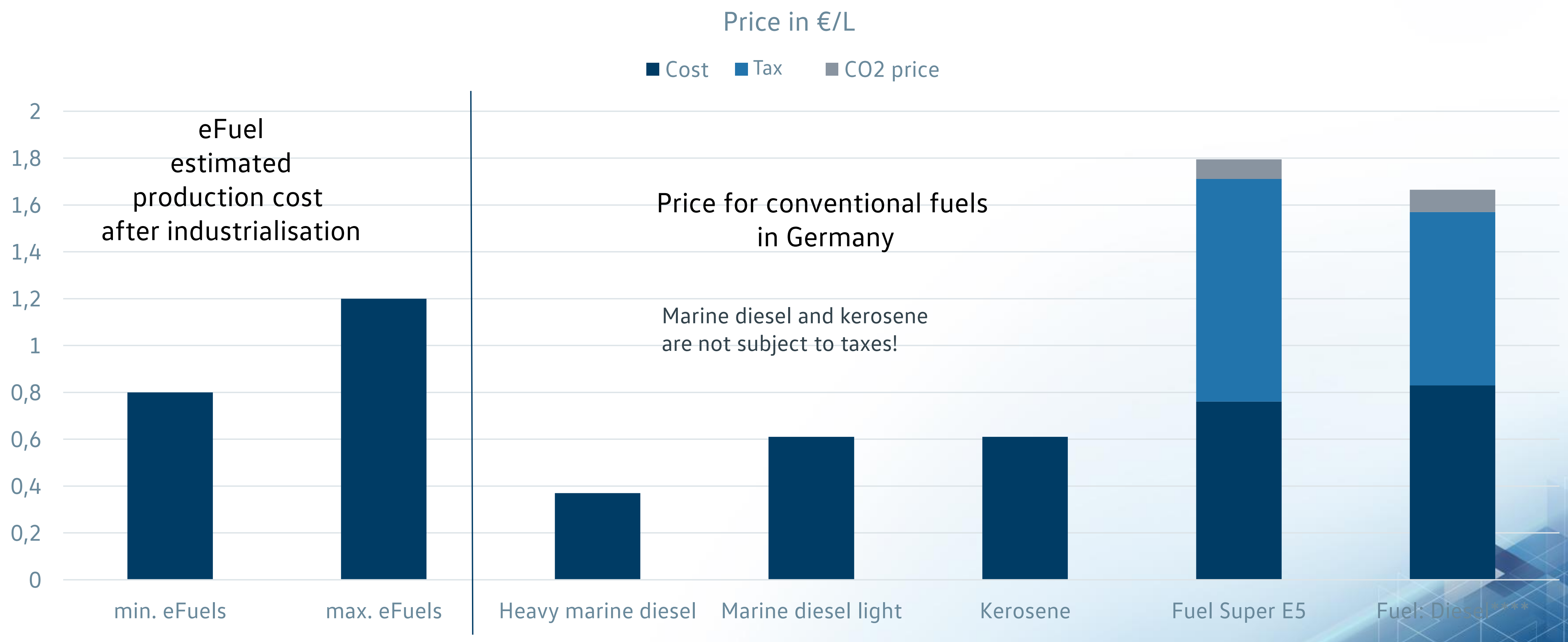
System Efficiency evaluation of eFuels

Investment	Production site	Wind Potential	fuel	vehicle	Number of vehicles in Germany to be supplied with driving energy*
1 wind engine **power** 3 Megawatt	Germany	2000 **full load hours** per year	**Electricity for dring** local production	New BEV	≃ 1600 pure BEV
	Germany		**eFuel** local production	ICE in the fleet	≃ 400 in the fleet + heating of ≃ 100 homes + Oxygen + grid stabilisation
	Chile	6500 **full load hours** per year	**eFuel** import	ICE in the fleet	≃ 1300 in the fleet



*compact class typical distance

Economic efficiency: Costs and prices of fuels



Prices May 2023

The greater willingness to pay for on-road fuels can facilitate the industrialization of eFuels

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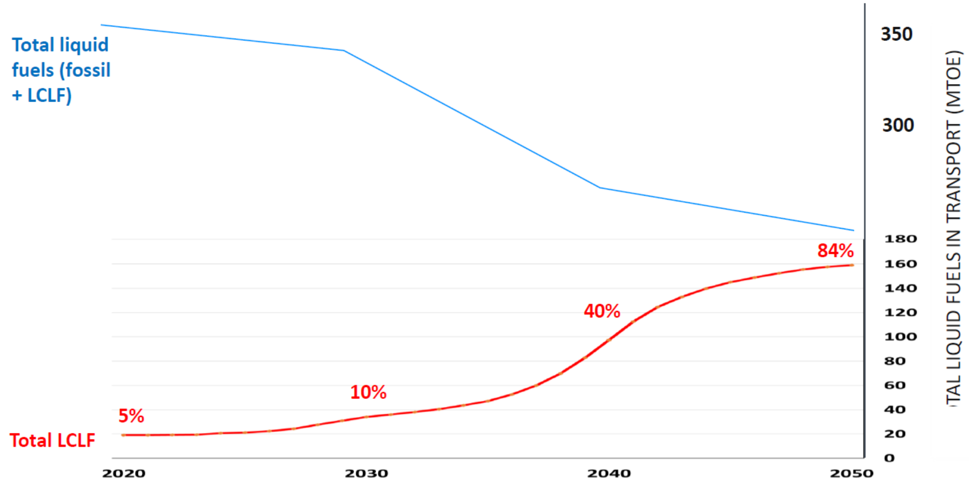
1. Biofuels
2. eFuels

Szenarios for Fuels Transformation in Europe

FuelsEurope

Low-Carbon Liquid Fuels progressively replacing fossil fuels in transport



FuelsEurope's elaboration, based on Concawe's scenario assuming LCLF in all transport modes.

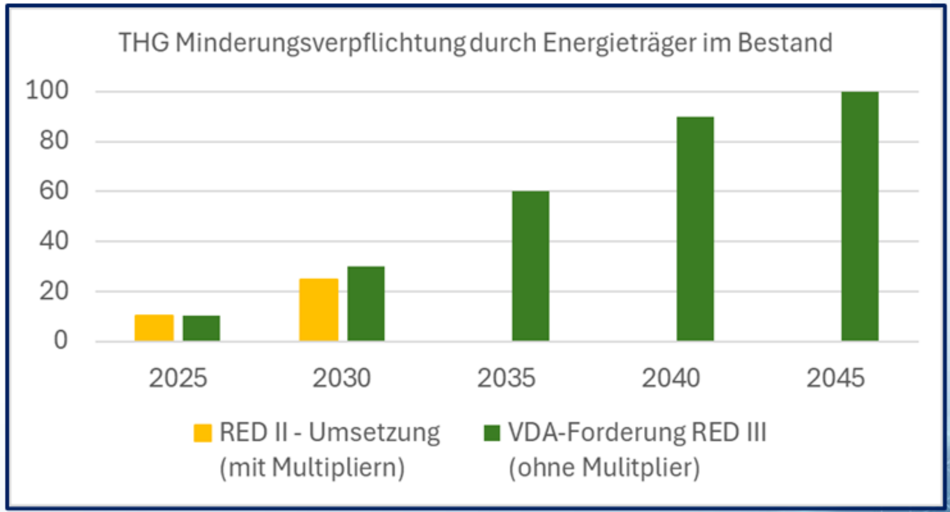
Powertrain Solutions | PS/PRM-PC | 2023-01-24

Positionspapier

RED III

VDA | Verband der Automobilindustrie

Umsetzung der Erneuerbare-Energien-Richtlinie in nationales Recht

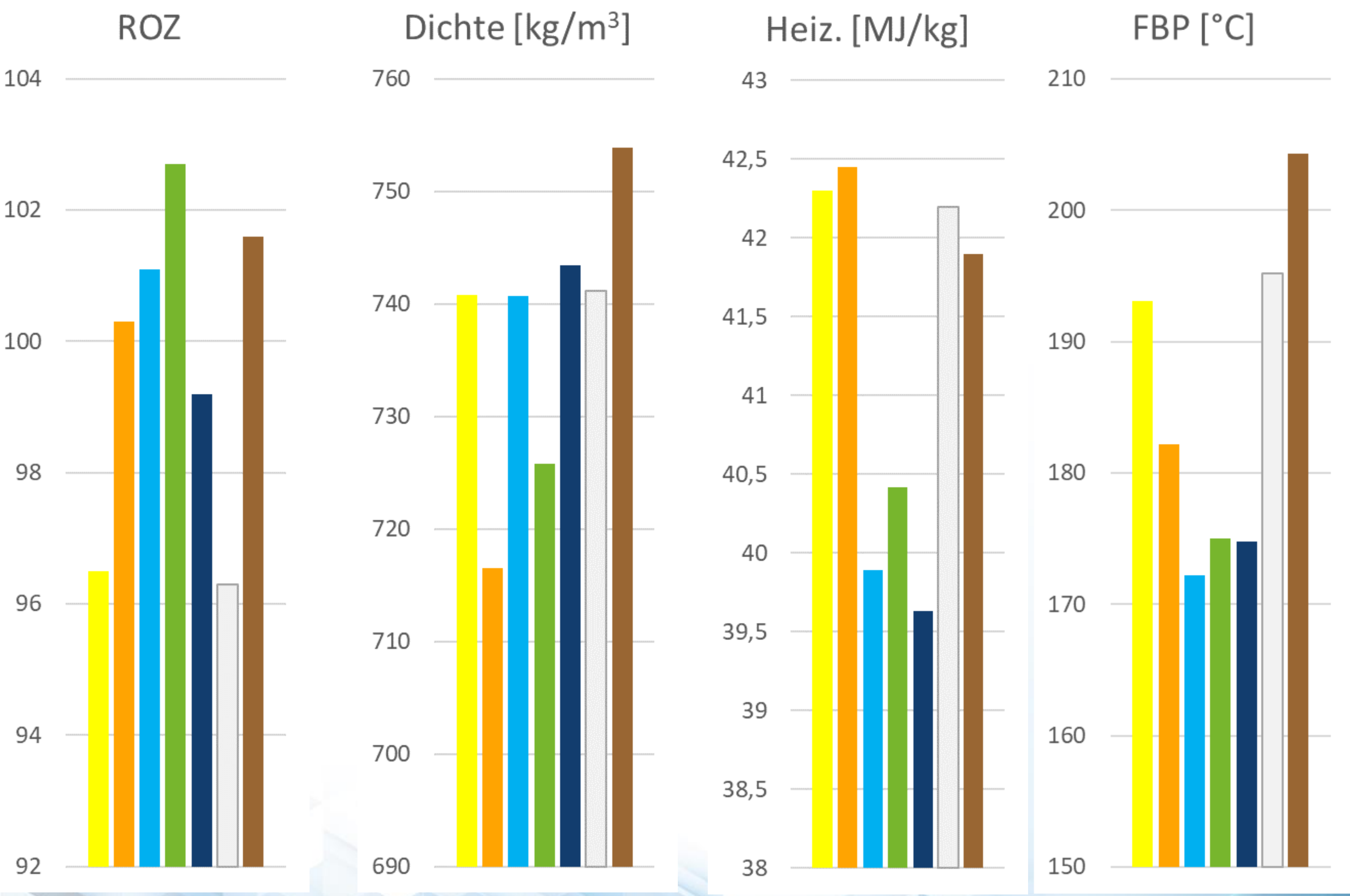


Fuels of the Future – Selected production Processes

Category	Process	Material streams	properties
bio	encymatic from sugar, starch, lignocellulose	ethanol	High octane number, high evaporation enthalpy, low energy densitiy, drop in (EU) ≅20%
bio	Hydrotreatment of plant-algae fat, used cooking oil	Paraffinic Diesel, naphta	Diesel: high CZ gasoline: low octane numer
eFuel	Fischer-Tropsch	Paraffinic Diesel, naphta	Diesel: high CZ gasoline: low octane numer
eFuel/bio	Methanol via synthesis gas		High octane number, high evaporation enthalpy low energy densitiy,
Secondary process	Methanol to Gasoline	gasoline stream	RON ≅ 90
Secondary process	Ethanol to Gasoline	ETBE	High RON, lowered energy density
Secondary process	Advanced refinery Process	alkylate	High RON

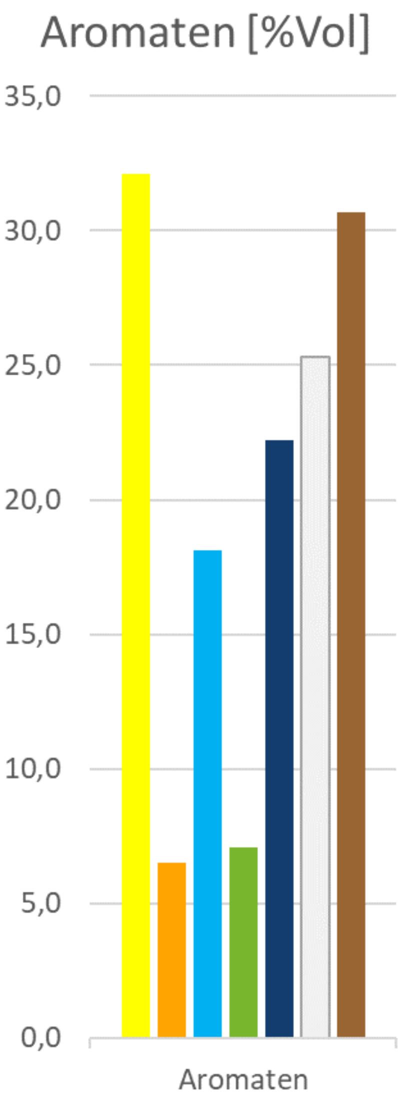
Risk of bad cold flow properties and hight sooting

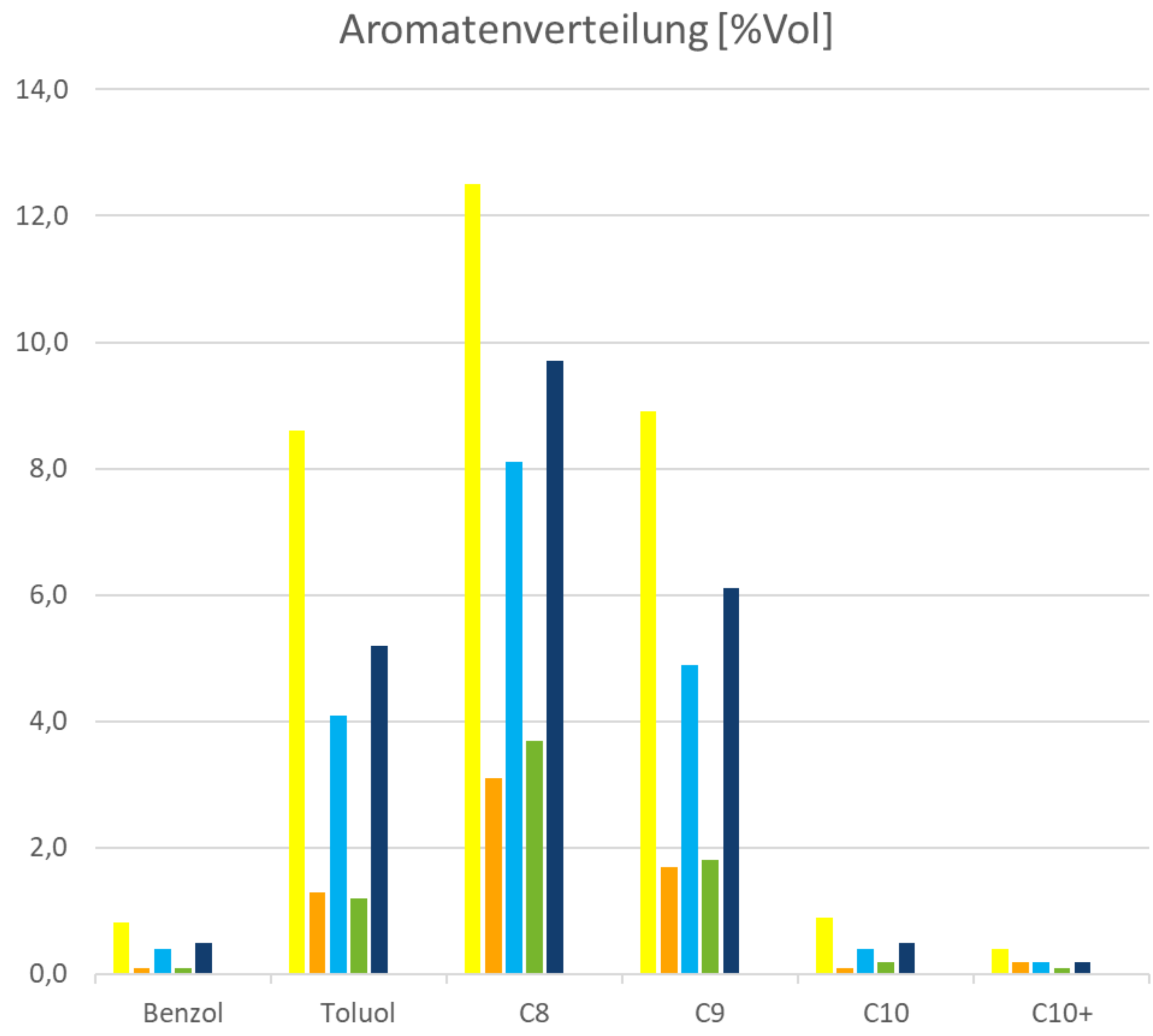
How to blend new components – Joint Program OMV/VW



	OMV-Ref.-KRST [%]	Alkylat [%]	MtG [%]	ETBE [%]	EtOH [%]
OMV Referenz	100	-	-	-	-
Test Fuel 1	6	50	22	22	-
Test Fuel 2	34	-	34	22	10
Test Fuel 3	-	34	34	22	10
Test Fuel 4	46	-	34	-	20
EN228 PN Worst					
E10 - Winter					

How to blend new components – Joint Program OMV/VW





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OMV Referenz	100	-	-	-	-
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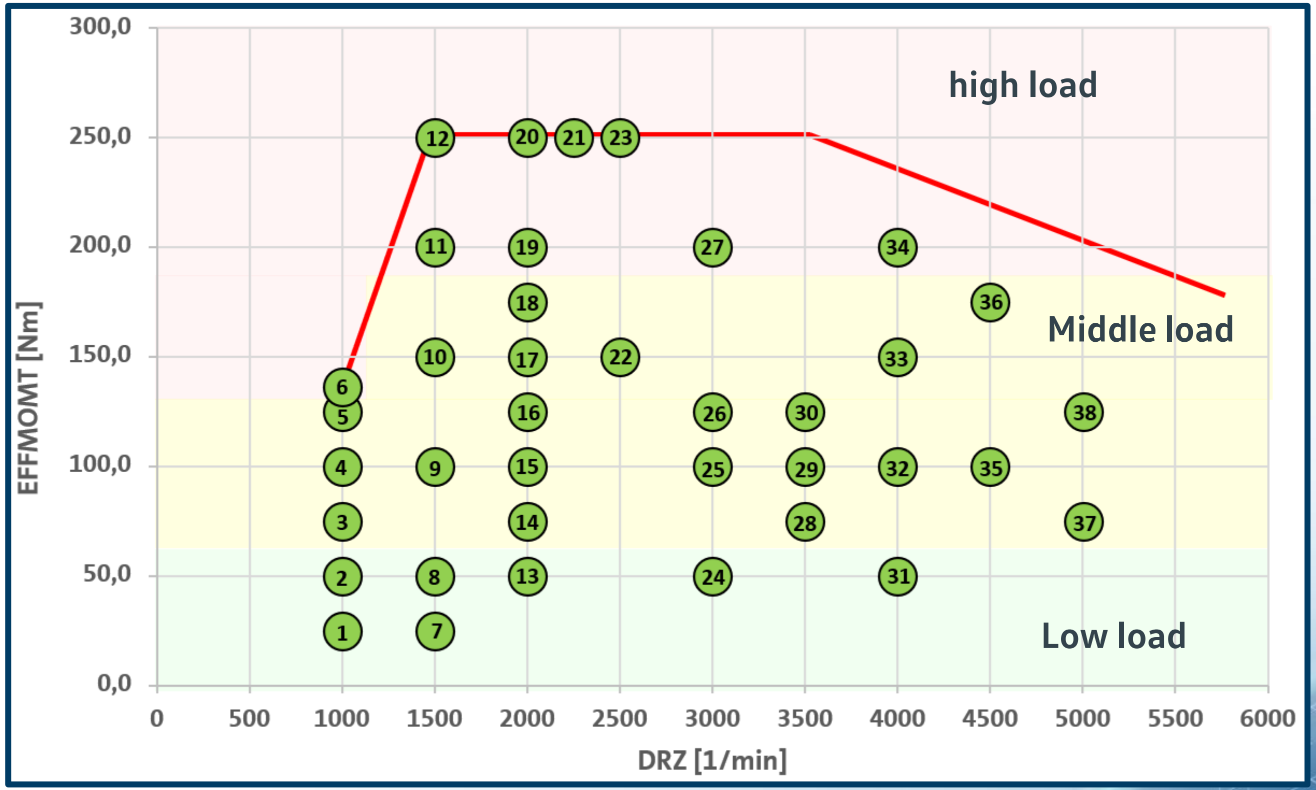
Test Fuel 2	34	-	34	22	10
Test Fuel 3	-	34	34	22	10
Test Fuel 4	46	-	34	-	20
EN228 PN Worst					
E10 - Winter					

Engine test bench: Test vehicle – 1.5 TSI evo 110 kW



Engine Test Bench: Classification of Raw Particulate Emissions

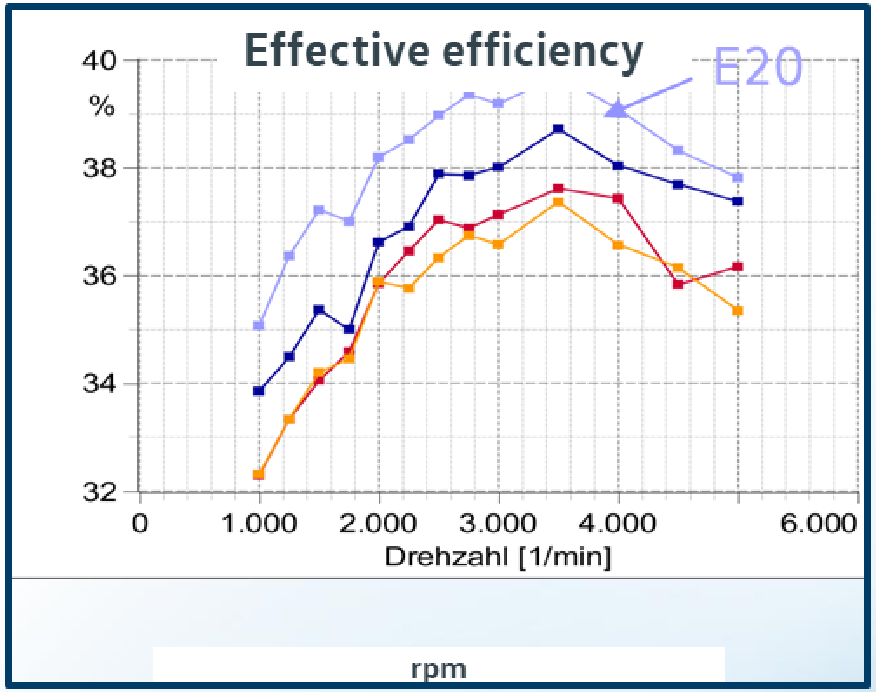
	OMV-Ref.-KRST [%]	Alkylat [%]	MtG [%]	ETBE [%]	EtOH [%]
OMV Referenz	100	-	-	-	-
Test Fuel 1	6	50	22	22	-
Test Fuel 2	34	-	34	22	10
Test Fuel 3	-	34	34	22	10
Test Fuel 4	46	-	34	-	20
EN228 PN Worst					
E10 - Winter					
E20					

Engine Test Bench: Classification of Raw Emissions

	NO_x			CO_2			Verbrauch			OMV-Referenz-KRST [%]	Alkylat [%]	MtG [%]	ETBE [%]	EtOH [%]
	LL	ML	HL	LL	ML	HL	LL	ML	HL					
EN228 PN Worst	-10,5%	-7,0%	-4,1%	-4,5%	-3,8%	-3,4%	-1,0%	-0,1%	0,2%					
E10 - Winter	-4,6%	-6,9%	-4,3%	-3,8%	-3,4%	-3,4%	3,1%	3,6%	3,5%					
E20	-8,9%	-7,4%	-4,9%	-3,1%	-2,6%	-1,9%	4,8%	5,4%	5,9%					
OMV Referenz	0%	0%	0%	0%	0%	0%	0%	0%	0%	100	-	-	-	-
Test Fuel 1	-16,5%	-12,6%	-12,1%	-5,6%	-5,6%	-5,4%	4,5%	4,7%	4,7%	6	50	22	22	-
Test Fuel 2	-12,3%	-8,8%	-7,5%	-2,5%	-2,4%	-1,9%	6,5%	6,6%	7,1%	34	-	34	22	10
Test Fuel 3	-17,9%	-14,0%	-12,1%	-4,4%	-4,5%	-4,1%	7,6%	7,6%	7,8%	-	34	34	22	10
Test Fuel 4	-8,1%	-7,0%	-5,3%	-2,0%	-2,2%	-1,8%	7,2%	7,0%	7,4%	46	-	34	-	20

x < -15%	-15% < x < -3%	-3% < x < 3%	3% < x < 15%	15% > x

Chances: Fuel Application Potential of E20



Engine:
1.5 L TSI evo2, 4 cylinder, 110 kW,
250 => 220 Nm

Modification: other pistons
Compression ratio from 12:1 to 14.5:1
max. torque lowered to 220 NM

ROZ 96.6, E10 (Blue Gasoline)

ROZ 95.5, E15

ROZ 99.6, 11% Ether („Super Plus")

ROZ 100.4 E20 („Super Eco 20")

Ethanol/Gasoline Blends like E20 define a „Sweetspot“ for the European Market

fast ramp up possible

visuable step for the customer

car range not significantly affected

high number of cars from the legacy fleet are probably compatible

high RON is enabler for regenerative base fuels

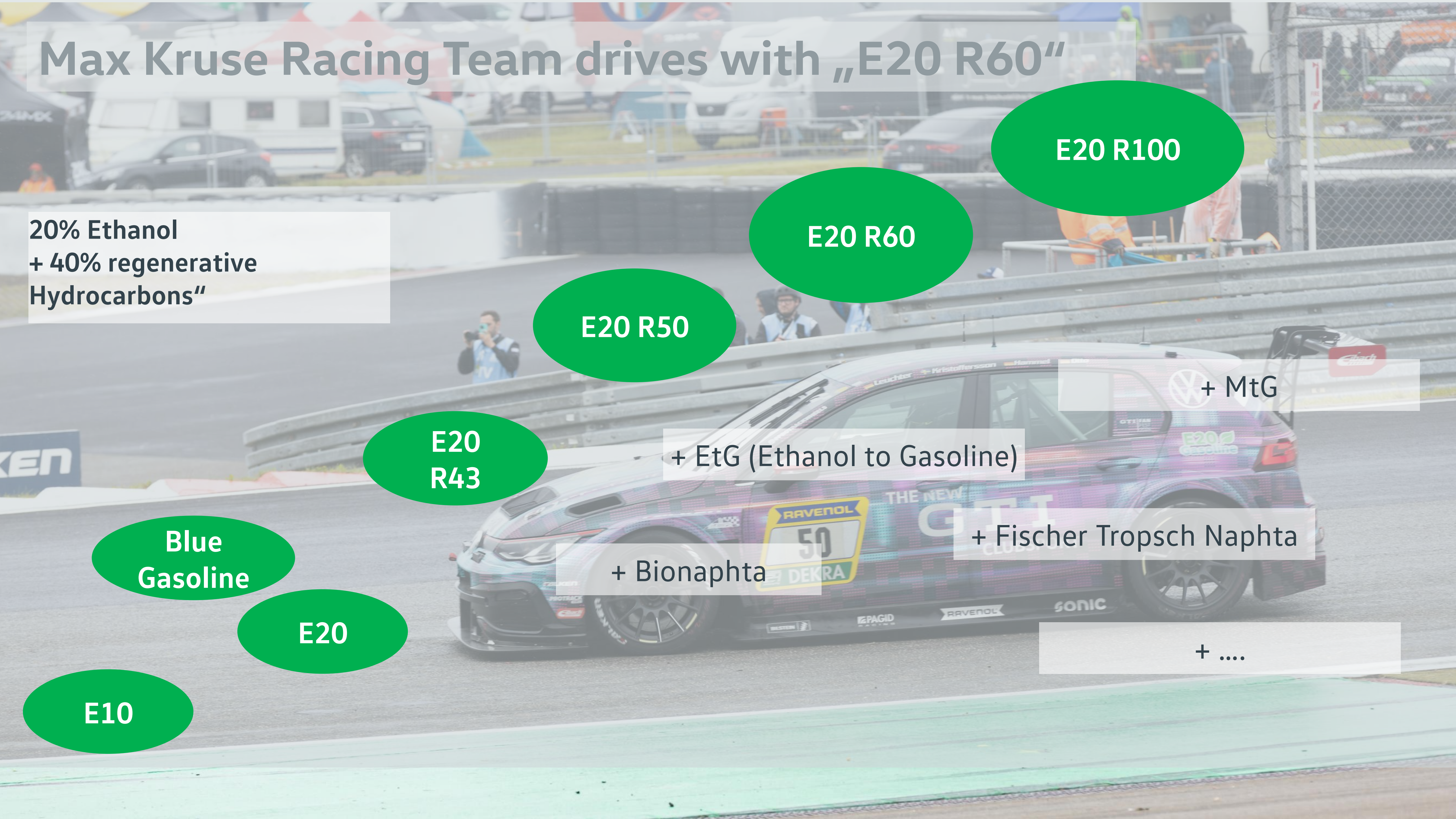
production technology have high technology rediness level

Future cars could be operated more efficient thanks to RON and evaporation enthalpie

raw material capacity for the EU – market ≅ 20%

Ethanol can be produced cost effective from waste and residues

Max Kruse Racing Team drives with „E20 R60“



20% Ethanol
+ 40% regenerative
Hydrocarbons“

E20 R100

E20 R60

E20 R50

E20
R43

Blue
Gasoline

E20

E10

+ MtG

+ EtG (Ethanol to Gasoline)

+ Fischer Tropsch Naphta

+ Bionaphta

+ ....

Blend definitions: New Standardisation understanding needed

Today: 70 refineries in Europe + some biofuel factories
Target: remaining refineries modyfied + import of biofuels and eFuels
+ new factories for existing and new processes

- Acceleration of running E 20 standardisation:
  - lowered boiling range to hinder rising PN emissions => common understanding
  - minimum Ethanol => actually no common understanding!
- PN potentials for inner cities e.g. via YSI or comparable PN index => no common understanding!
- release process for new processes and fuels => no common understanding
  (actually lots of fuel producers cooperate bilateral with car industry or contribute to research programms)

- Sustainability criteria should be included into fuel standards

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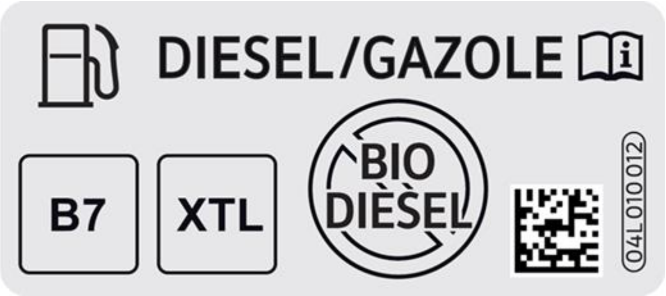
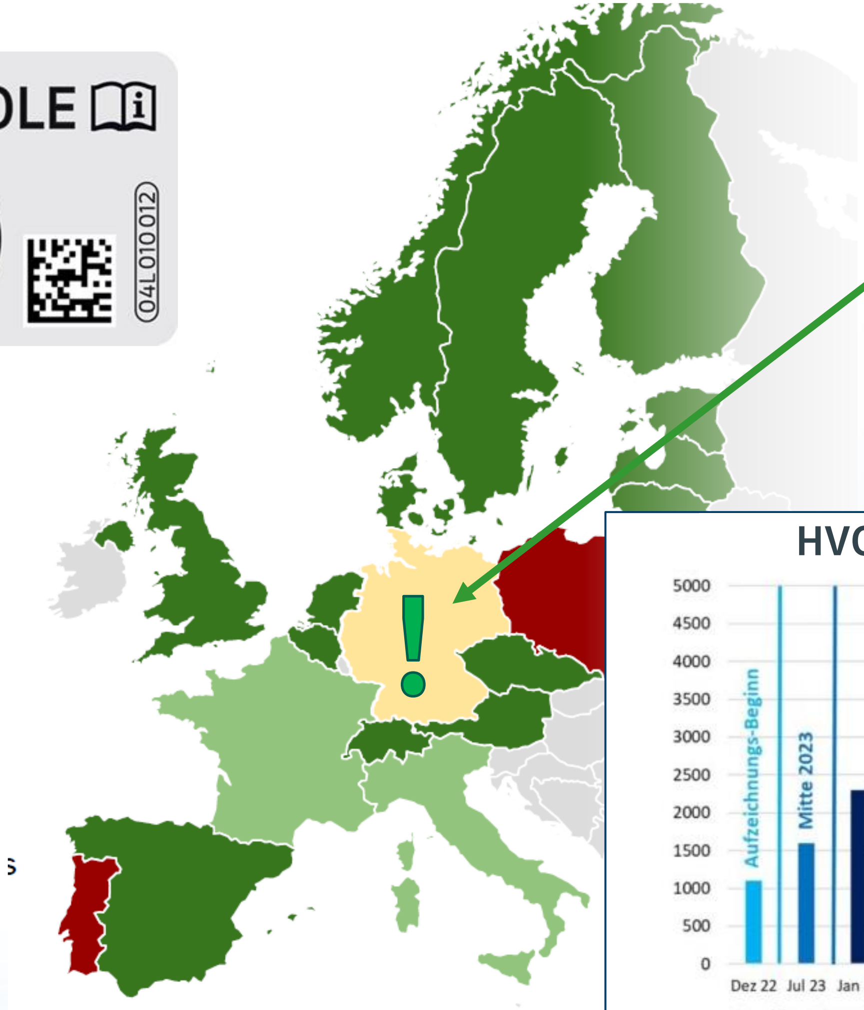
R100 Diesel:
Paraffinic Diesel (HVO and Fischer Tropsch eDiesel)

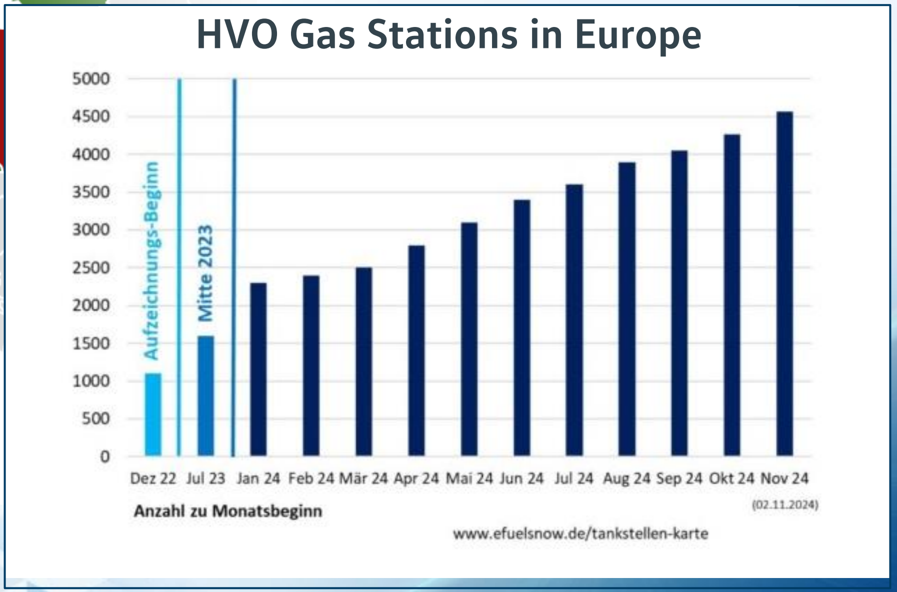


All actual VW cars are allowed to use XTL = Paraffinic Diesel



From April 2024 Paraffinic Diesel (HVO and future eDiesel) allowed to be sold on German Gas stations

Today 300 HVO Gas stations in Germany, 4370 in Europe



Mission Letters of Dr. Ursula von der Leyen

Selected Missions for designated Commissioners (Sept. 2024)

Wopke Hoekstra (Climate)
- Anchoring the 90% emission reduction target for 2040 in the European Climate Law
- A technology-neutral approach to the goal of climate neutrality of passenger cars by 2035: **Ensuring that e-fuels will play a role in the CO2 fleet limits for passenger cars and light commercial vehicles.**
- Revision of the Energy Taxation Directive

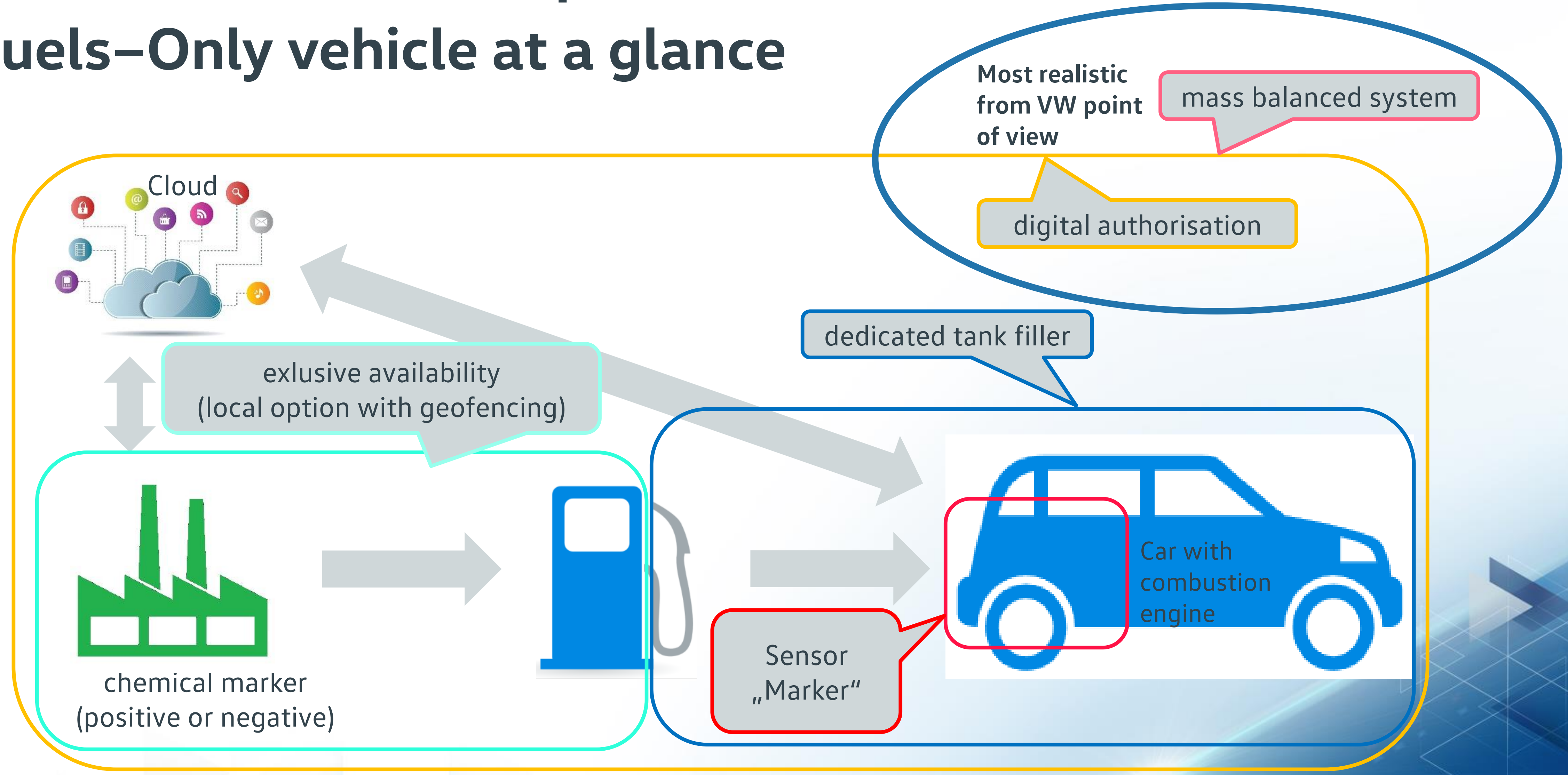
Dan Jørgensen (Energy and Housing)
- Acceleration of the ramp-up of carbon capture (CCS and CCU)
- Presentation of an action plan for affordable energy prices
- Proposal for an action plan on electrification

MtG E10 Blend (R100) use in Wolfsburg from DeCartrans Project

22.-28. October 2024
12 500 l EN 228 compliant Gasoline based on MtG wer use in regular fueling business at Volkswagen.
Round about 500 fuel users informed about the actual project .
Discussions with lots of collegues.

CO_2
DeCarTrans
Demonstrating a Circular Carbon Economy in Transport along the Value Chain
MEMBER
OF THE PROJECT

Selected fulfillment options for the Carbon Neutral Fuels–Only vehicle at a glance



combinations are also possible

Summary and Conclusion

- **Mitigation of Climate Change** is one of the most urgent and most challenging responsibilities for mankind, affecting all regions and economic sectors
- We need a **technology mix** to master the challenges, including BEV (1^{st} choice for future cars), CO_2 neutral fuels and others
- The **world wide legacy fleet** of billions of vehicles, ships and planes will run for a long time with combustion engines, **climate neutral fuels** have to be developped and scaled up into all markets of the world.
- Two types of “Climate Fuels” are in sight: BioFuels and “Efuels”
  - **Biofuels** on the short to mid term but with restricted potential
  - **eFuels** on the long term with unrestricted poetential
- From the technical side **Alcohols, FAME, Paraffinic Diesel and different kinds of regenerative Hydrocarbons** will be blended to “ready to operate” fuels
- **Fuel standardisation** must reach a new level

Thanks for your attention

T. Garbe Volkswagen AG, Wolfsburg

15.1.2024

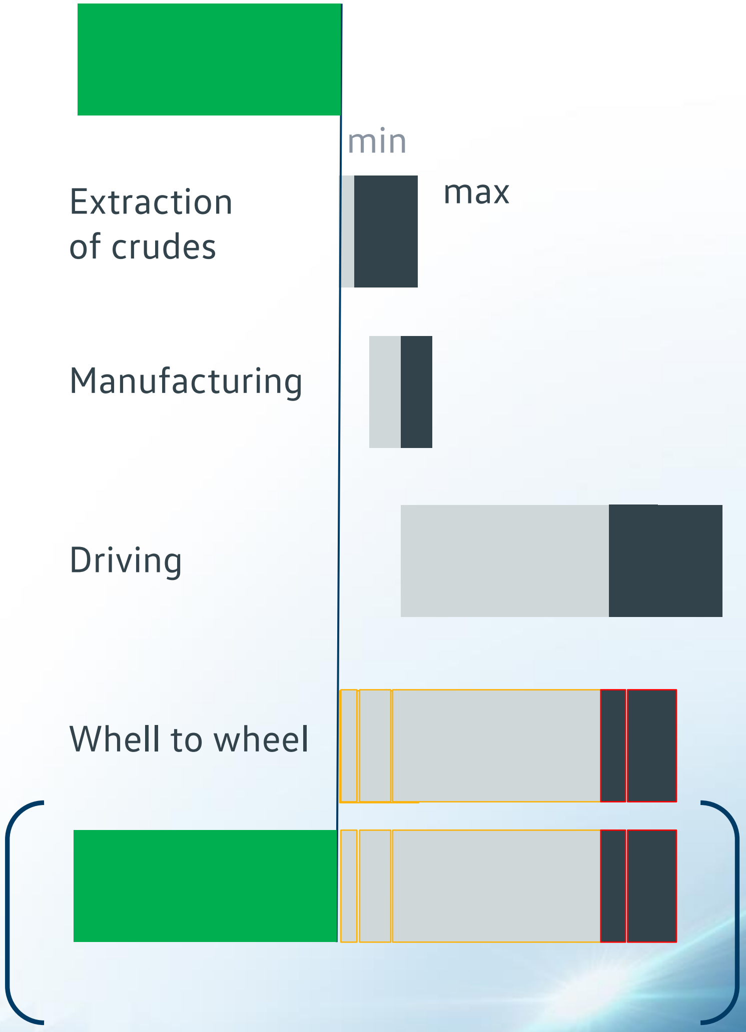
Options to improve vehicles with Combustion Engine

Get the Carbon from the CO_2 in the atmosphere

Optimize the extraction process
- stop methane leackage
- use of flur gas

Optimize the manufactatoring
- use of green Hydrogen
- carbon capture

Change driving behaviour
- drivers responsibility



illustrative

Vision to reach Carbon negative GHG emissions

illustrative

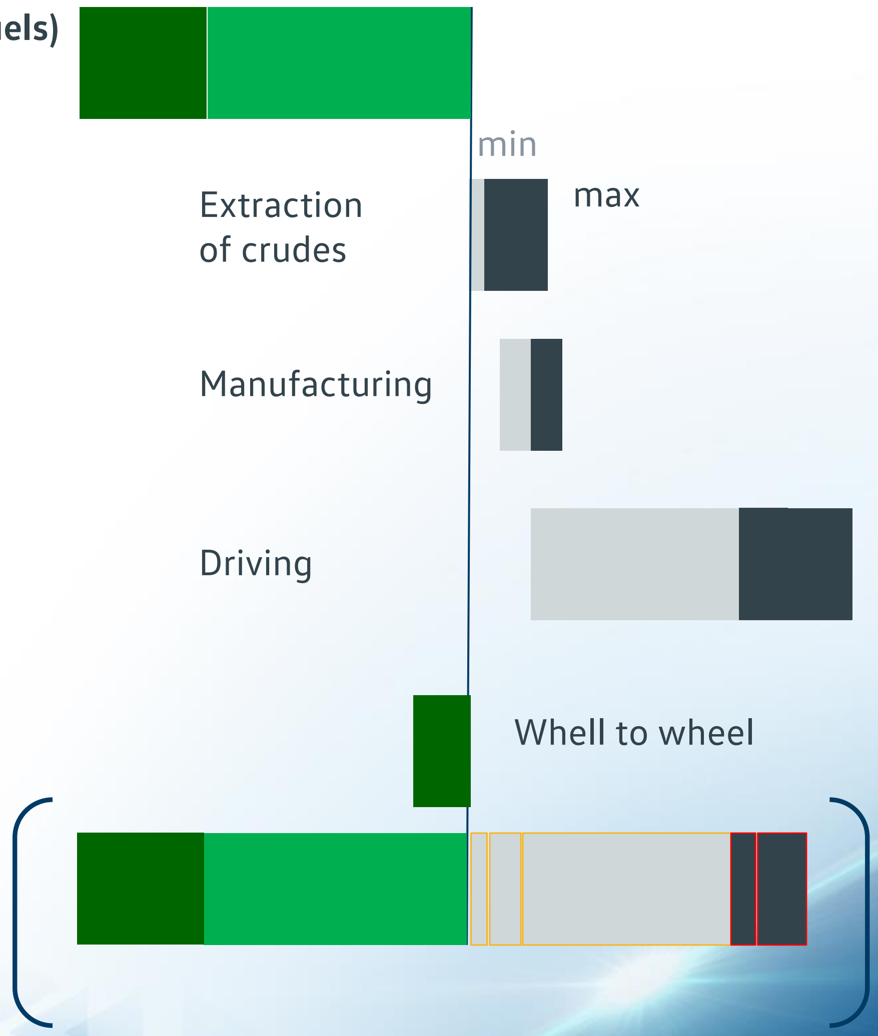
Get the Carbon from the CO_2 in the atmosphere (=> Climate Fuels)

Extract more CO_2 than needed for the fuel and store it

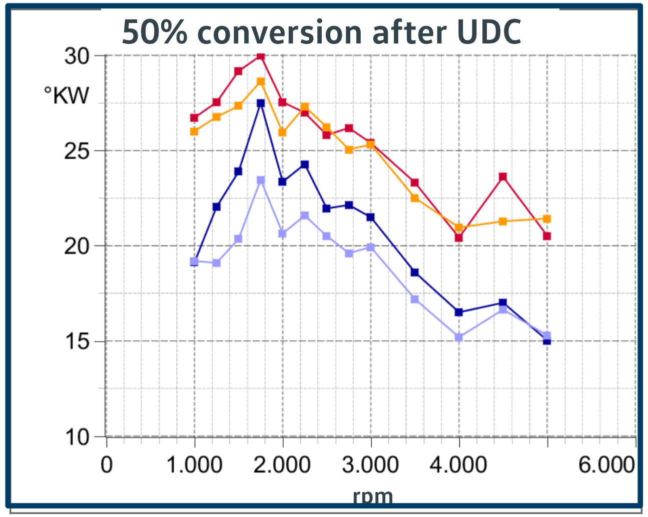
Optimize the extraction process
- stop methane leackage
- use of flur gas

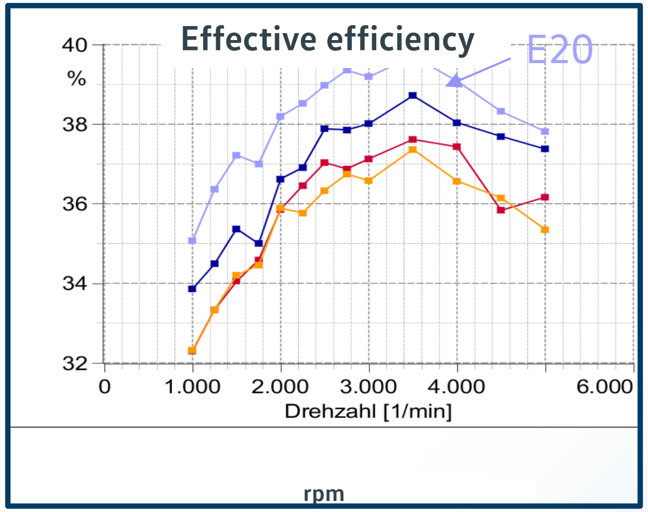
Optimize the manufactatoring
- use of green Hydrogen
- carbon capture

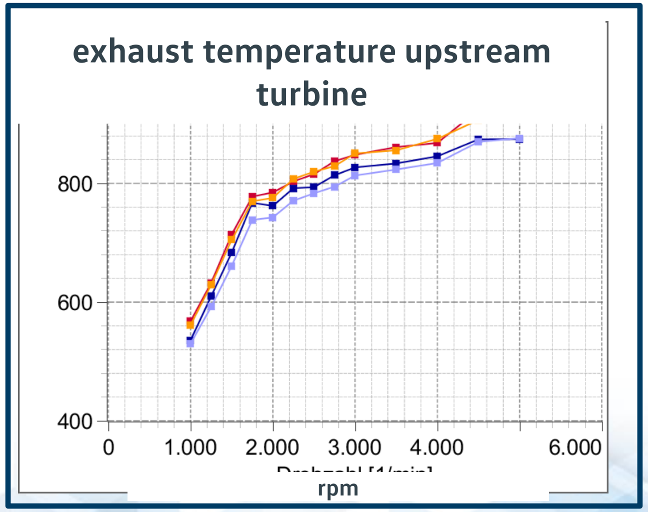
Change driving behaviour
- drivers responsibility

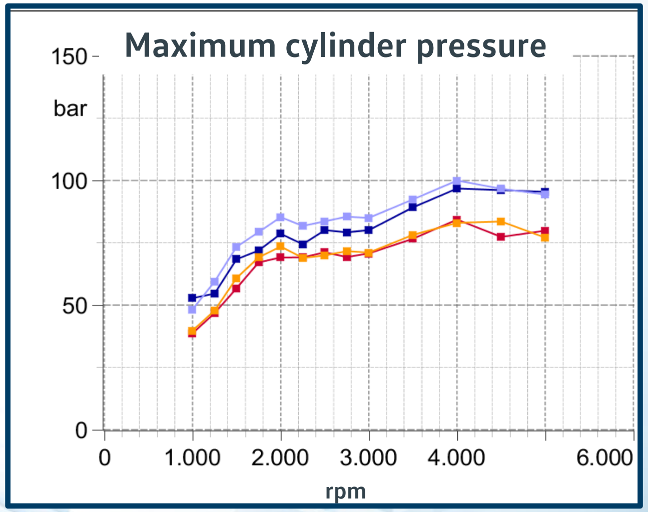


Influence of Fuel variation on Combustion and Efficiency









ROZ 96.6, E10 (Blue Gasoline)

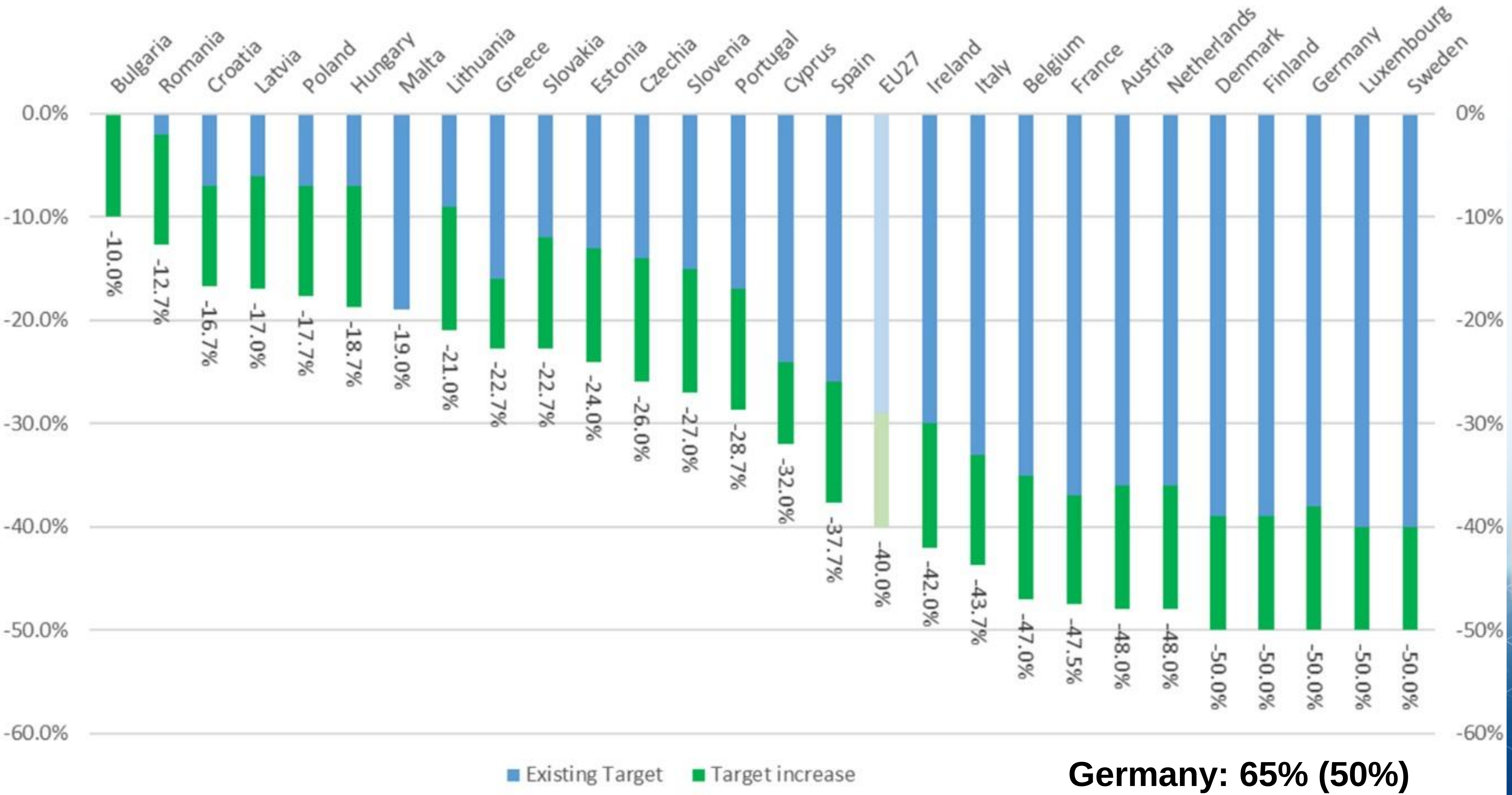
ROZ 95.5, E15

ROZ 99.6, 11% Ether („Super Plus")

ROZ 100.4 E20 („Super Eco 20")

(All fuels can be used in actual engines.
Release in EU possible as soon as accaptable standard in place)

Driving Force 2030 - ambitious Effort Sharing Regulation



Germany: 65% (50%)

Source: EU-Commission

Engine test bench: Test vehicle – 1.5 TSI evo 110 kW

Technische Daten

Motorkennbuchstabe	DXDB
Bauart	4-Zylinder-Reihenmotor
Hubraum	1498 cm^3
Bohrung	74,5 mm
Hub	85,9 mm
Ventile pro Zylinder	4
Verdichtungsverhältnis	12,0 : 1
max. Leistung	110 kW bei 5000-6000 1/min
max. Drehmoment	250 Nm bei 1500-3500 1/min
Kraftstoff	Super E10
Motormanagement	Bosch
Abgasnachbehandlung	Motornahe Abgasreinigung, Hauptkatalysator mit OPF
Abgasnorm	EU6 AP

Drehmoment- und Leistungsdiagramm