Nachhaltige Mobilität – eine Utopie?

Sebastian Dörr
Lubtrading GmbH

Content

- History and Meaning of Mobility
- What means Sustainability
- Looking into history
- The Future Goes Electric?
- Experience with HVO
- The new Challenges Megacities
- Why we need xTL
- Roadmap to Sustainability
- Outlook

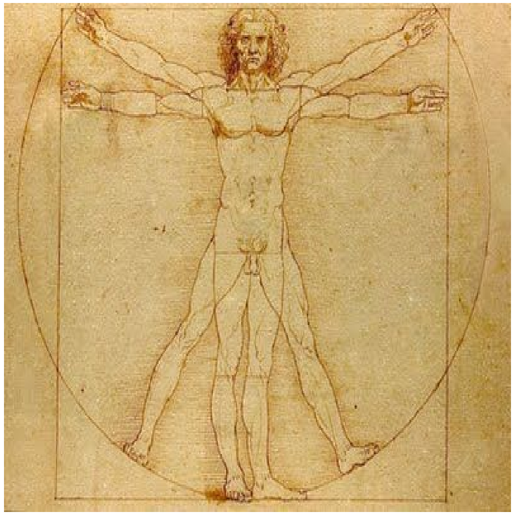
One of the most genius Inventions….

Sebastian Dörr
Lubtrading GmbH

Mobility in more than 2000 years….

Nachhaltige Mobilität – eine Utopie?

Es wird Wagen geben, die von keinem Tier gezogen werden und mit unglaublicher Gewalt daherfahren



Sebastian Dörr
Lubtrading GmbH

Steam and Combustion Engine have changed our live!

It starts with Fire

Sebastian Dörr
Lubtrading GmbH

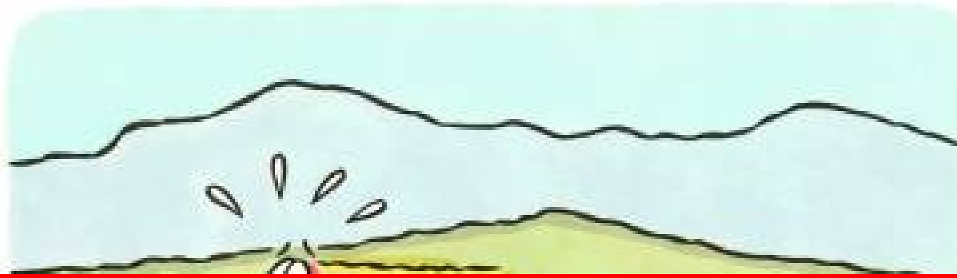
Fire Improves Quality of Life....

LIGHT

HEAT

COOKING

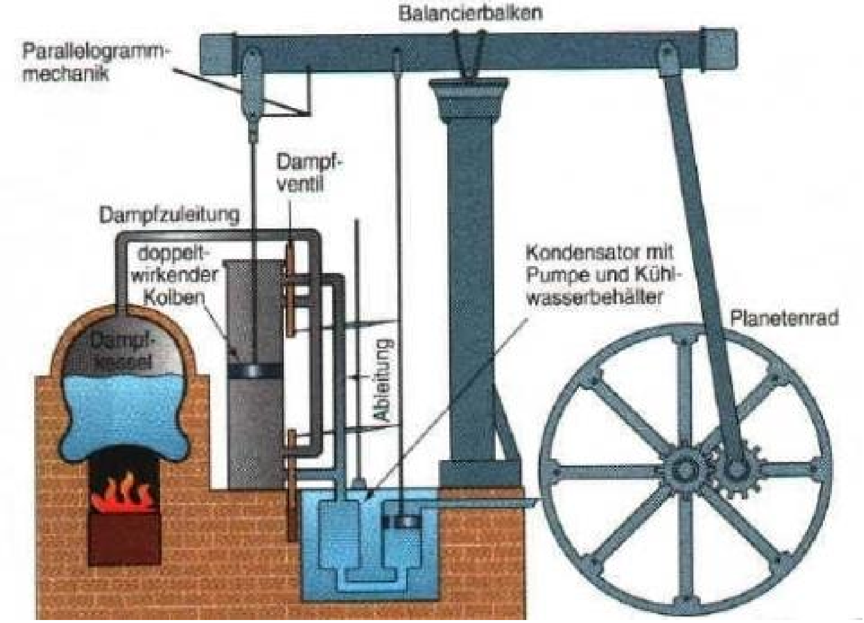
but.....

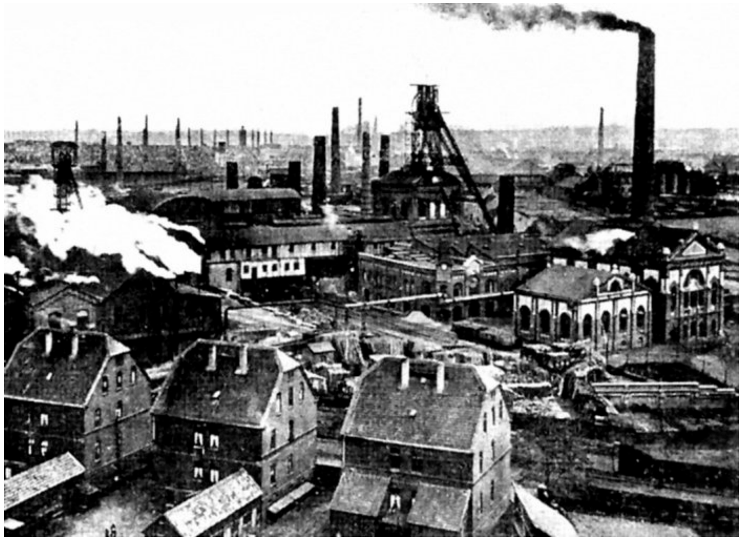


”I have just invented the fire – and this means pollution...”
Fire means also danger, damage and emissions

The industrial revolution has created additional demand...

- Steam machines in UK consumed by far more wood than UK was able to produce ....
- The development of efficient black coal mining safed the forests...





Sustainability is Key!

- Renewable Energy is not automatically sustainable
- Sustainable use of resources is key!!!!!

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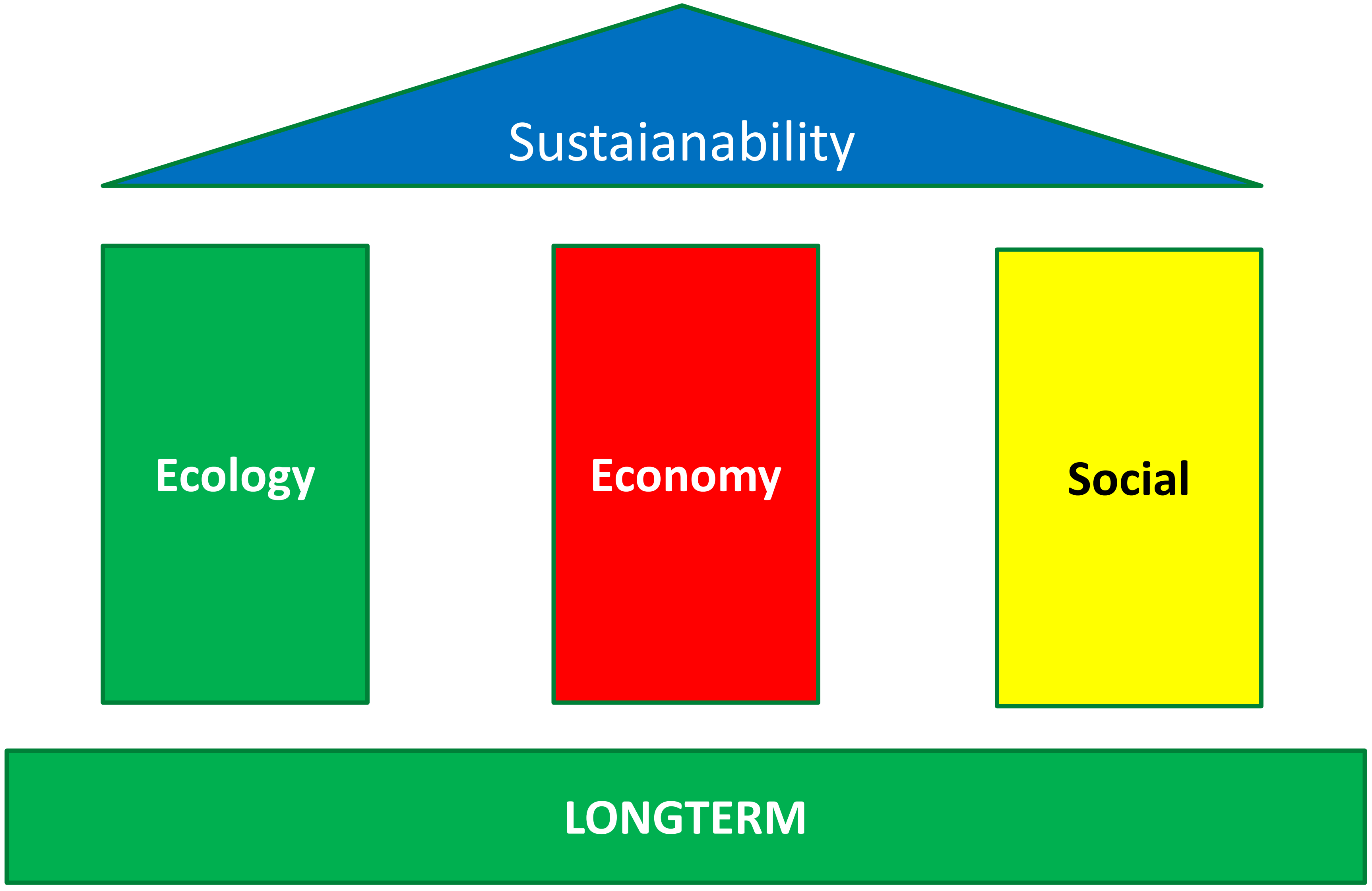
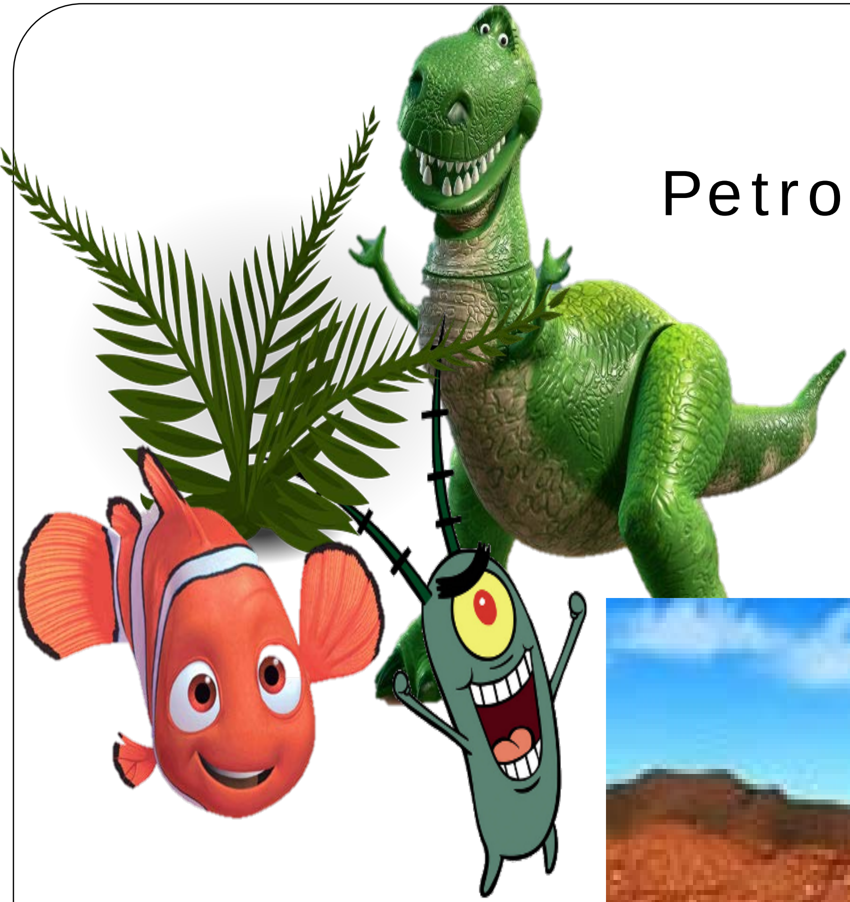
What means Sustainability? A more generation contract!!!

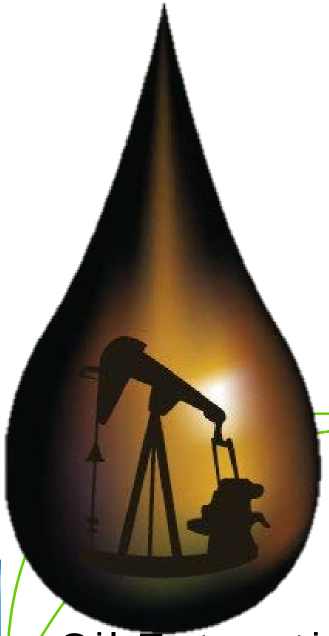
Three Pillars of Sustainability



Individual Mobility without horses became reality

Petroleum Crude Oil





Oil Extraction reintroduces sequestered carbon into the biosphere


Transport accounts for some
25% of the CO_2
emissions in Europe

How to meet the increasing energy demand in an economic and environmentally sound manner?

- Climate change - one of the most pressing reasons for seeking alternative sources of energy and fuel
- By 2030 global CO_2 emissions will be more than 50% higher than today (according to current policies scenario)

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Climat Targets 2030

Germany

40% GHG Savings in Traffic

27% Renewable Energy

10 mio BEV (PHEV)

Is E-Mobility the solution for future?

Electrification is not new….

Full Hybrid

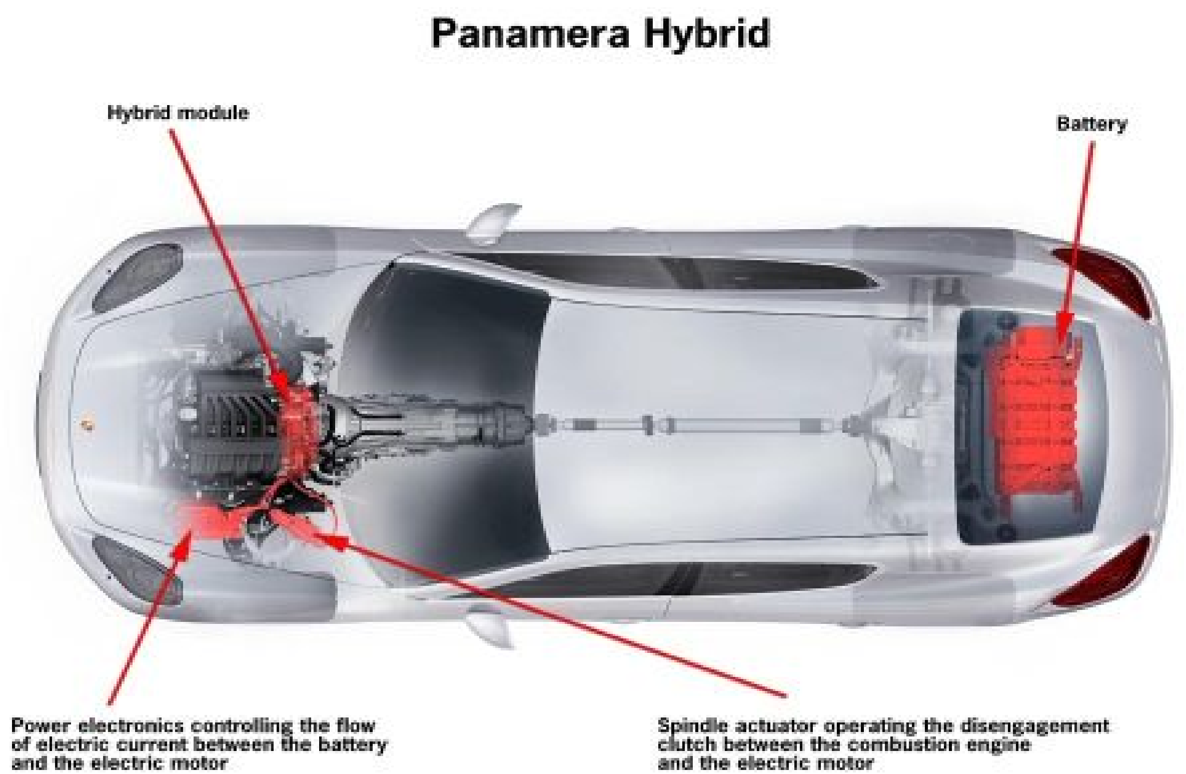
Lohner – Porsche

Weight!

Costs!

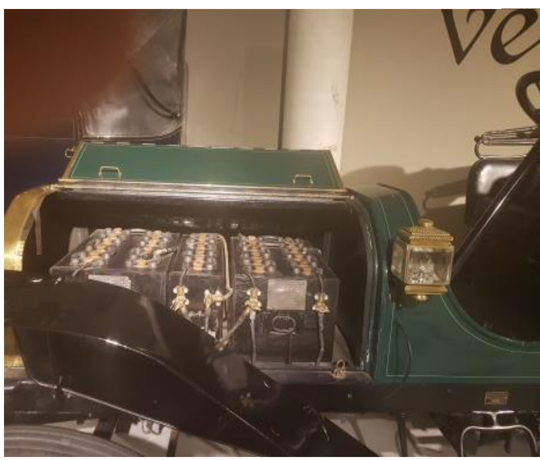
Range!

But will have increasing impact….

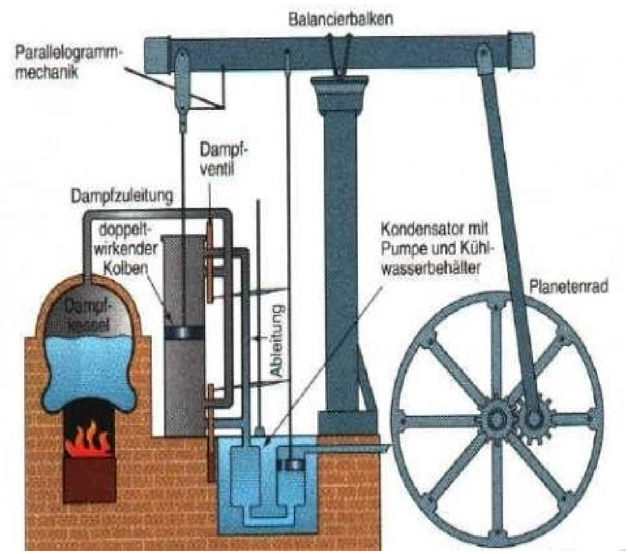


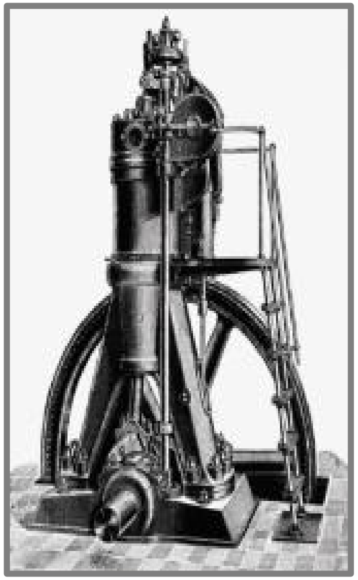
2. Diesel became a success story…

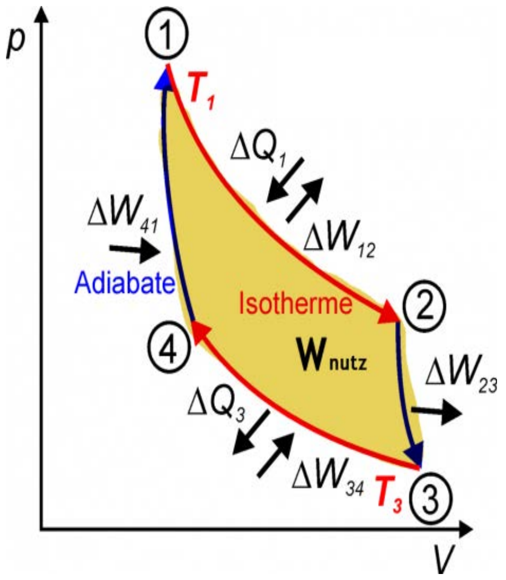
…while some alternatives failed



Learning From History…







While Steam Engines has Efficiency about 3%,
diesel started with more than 25%!

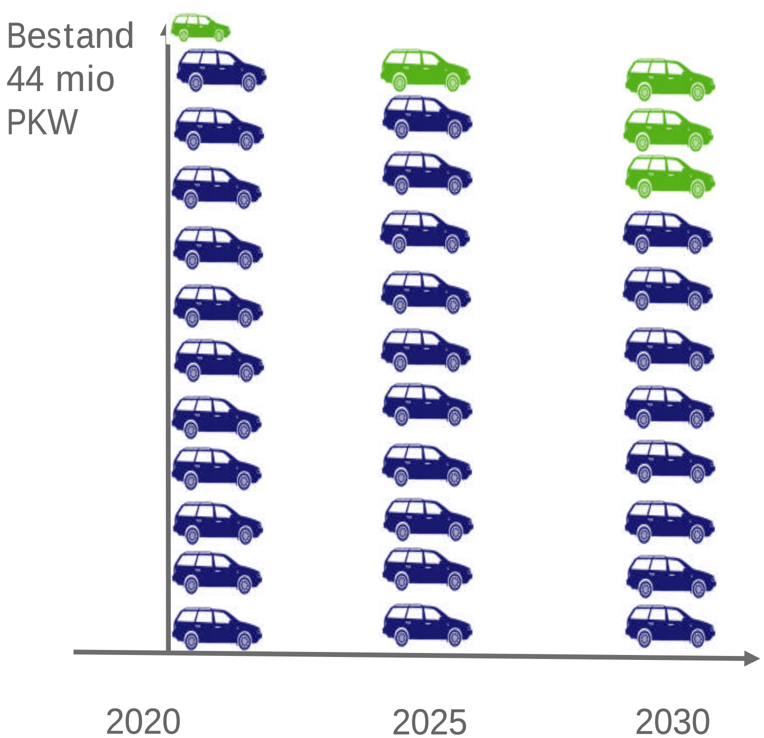
Still today Diesel Engine is most efficient thermodynamic maschine – closed to Carnot process

Entwicklung der Fahrzeugflotte bis 2030
Ziel: 10 mio Elektroautos

Juli 2019 180.000 E Autos einschl PHEV

Ab 2020 300.000 BEV pro Jahr

Ab 2025 1,6 mio BEV pro Jahr



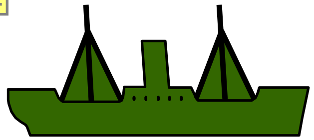
Was bedeuten 10 mio BEV für die Erreichung der Klimaziele?

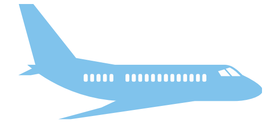
O Wie hoch ist der „Batterie Rucksack“
O Wie ist der Strommix 2030?
O Welche Fahrleistungen haben BEV?

Annahme: Batterierucksack bis 2030 ausgeglichen, Strommix 100% erneuerbar, Fahrleistungen entsprechen dem Durchschnitt aller PKW

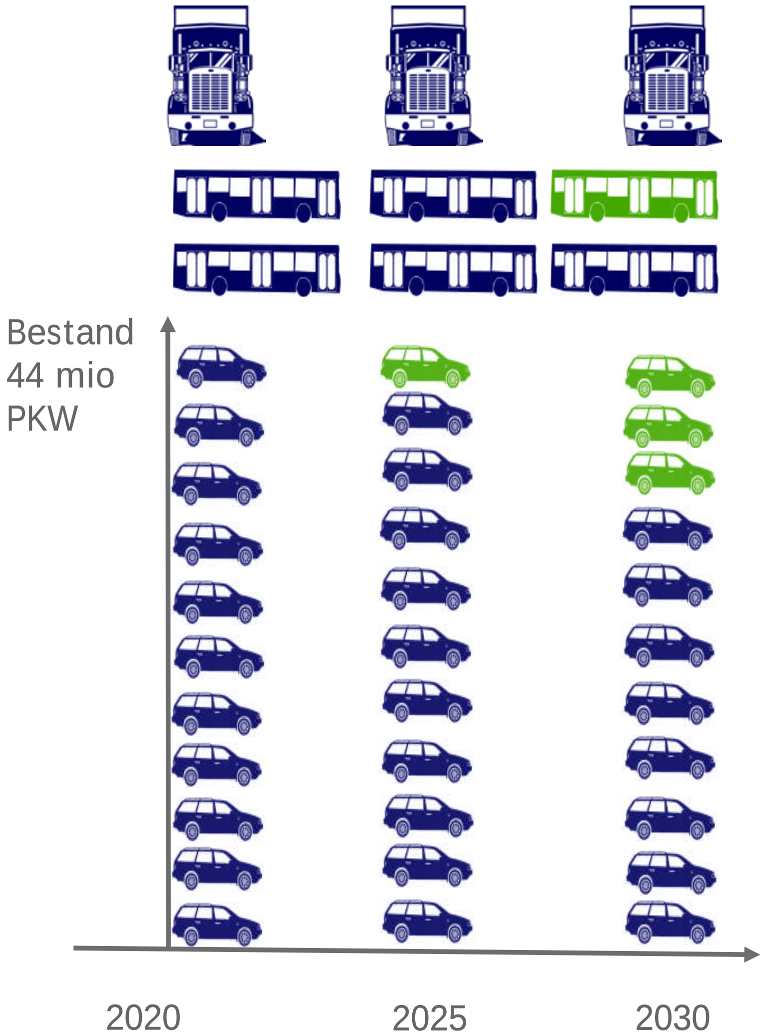
BEV können die THG im PKW Bereich um 20% - 25% senken

NESTE





Entwicklung der Fahrzeugflotte bis 2030

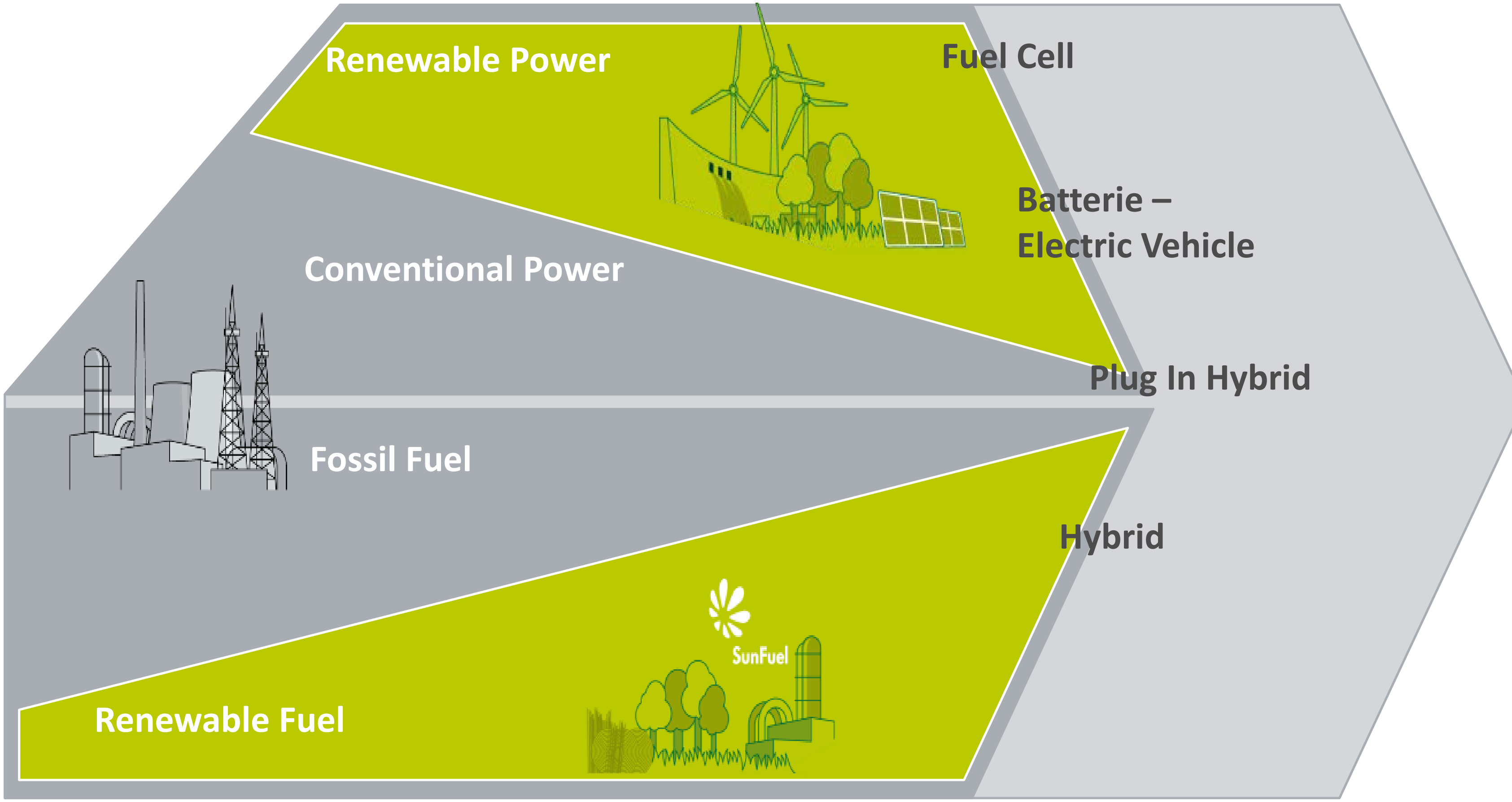


Was bedeuten 10 mio BEV für die Erreichung der Klimaziele?

- 75 % des PKW Bestandes sind ICE
- Nutzfahrzeuge und Busse haben zu über 80% Verbrennungsmotoren
- Schiffe und Flugzeuge werden noch langfristig flüssige Kraftstoffe benötigen

Regenerative flüssige Kraftstoffe werden benötigt

Decarbonisation Strategy



Decarbonisation needs all options:
E mobility as well as sustainable clean fuels

How to handle complexity?

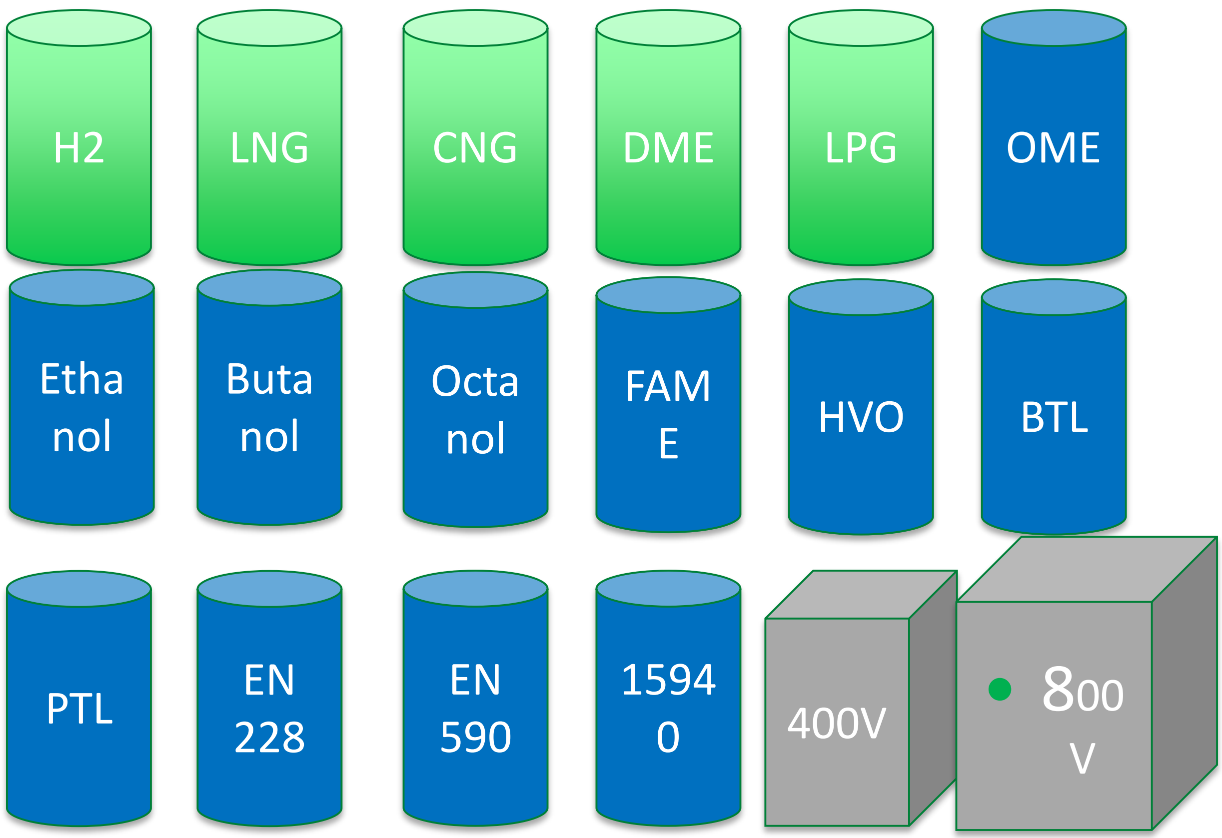
	Micro Hybrid	Mild Hybrid	Full Hybrid	Plug-in Hybrid	Electric
Tech-nology	• Engine shut-down during idling • Recuperation energy is used in board net • Advanced systems use belt/integrated starter generator	• Small motor supplements downsized engine e.g. during acceleration and uphill driving but no pure electric mode	• ICE is complemented by 1 or 2 electric motors of significant power • "Electric only" driving possible for short distances/low speeds	• Battery can be charged from external source • "Electric-Only" driving for longer distances and higher speeds, but ICE still existent	• Vehicle exclusively powered by electric motors
Benefits	• Low technology hurdle and low cost option • Typically **3-10%** fuel saving, more in heavy traffic	• **10-20%** fuel saving potential • Easy to integrate	• **30-50%** fuel saving potential in urban traffic but much less at higher speeds • No infrastructure requirement	• Fuel Economy benefit dependent on battery size, but **50-75%** possible for typical commute	• Zero emission vehicle (ZEV) at tailpipe → **100%** fuel economy benefit • Low noise
Dis-advantages	• No engine downsizing possibility • Consumer acceptance in some markets/segments • Limited FE benefit in motorway driving	• Expensive • Limited FE benefit over micro hybrids • Packaging	• Very expensive • Increased transmission losses possible	• Expensive due to battery requirements and dual set-up • Vehicle charging infrastructure required	• Expensive battery requirements • Vehicle charging infrastructure • CO_2 emissions depend on energy source

Examples PC/CV

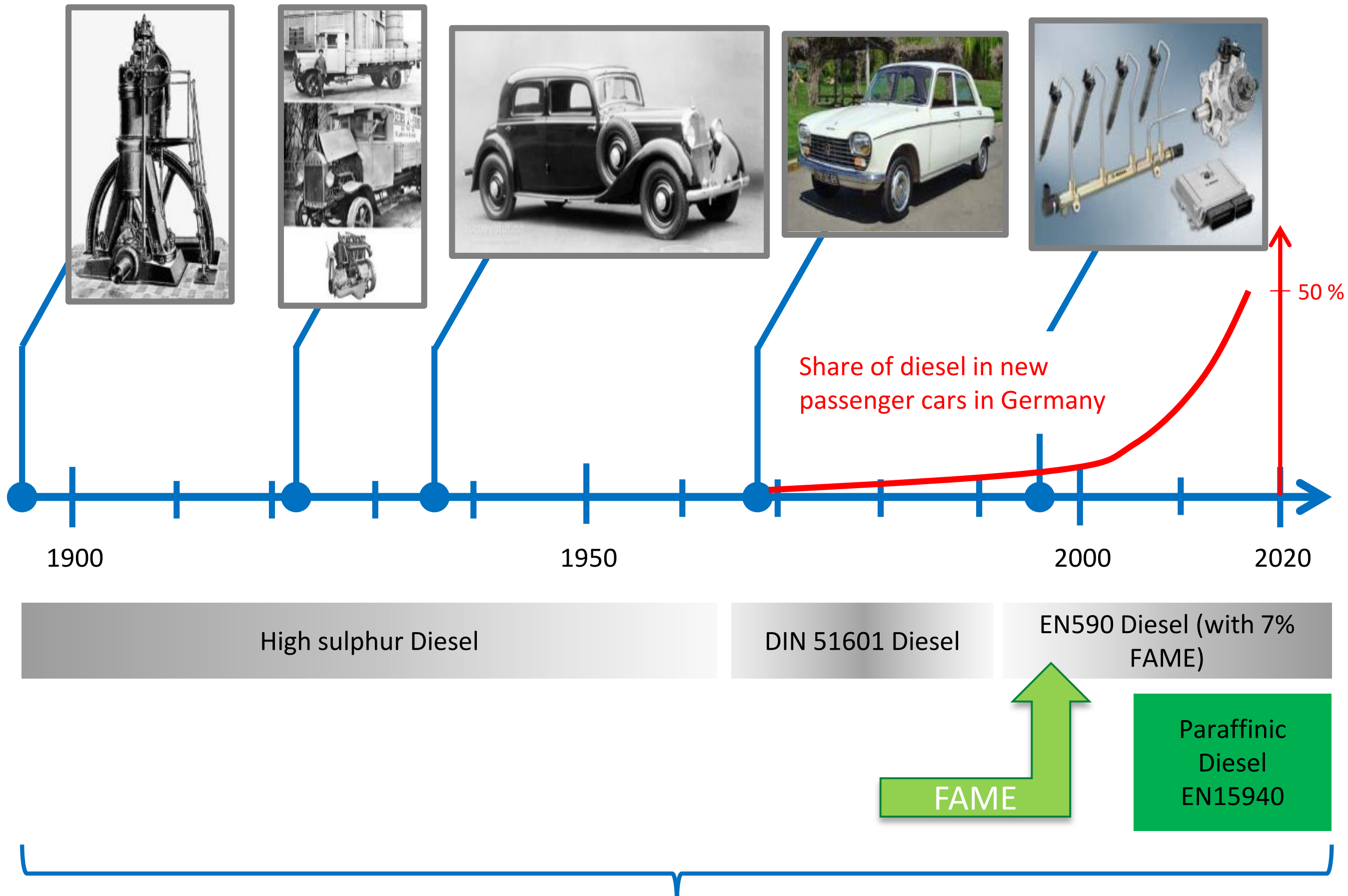
FEV

NESTE

Complexity in car design and energy options

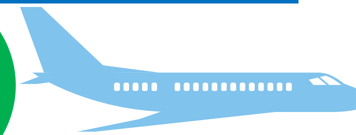


Development of Diesel engine and fuel over the past century



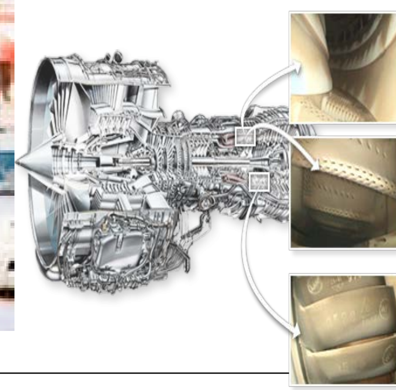
For over 100 years, Diesel fuel has not developed much and combustion engine was developed around the fuel

HVO Go To Market in Figures

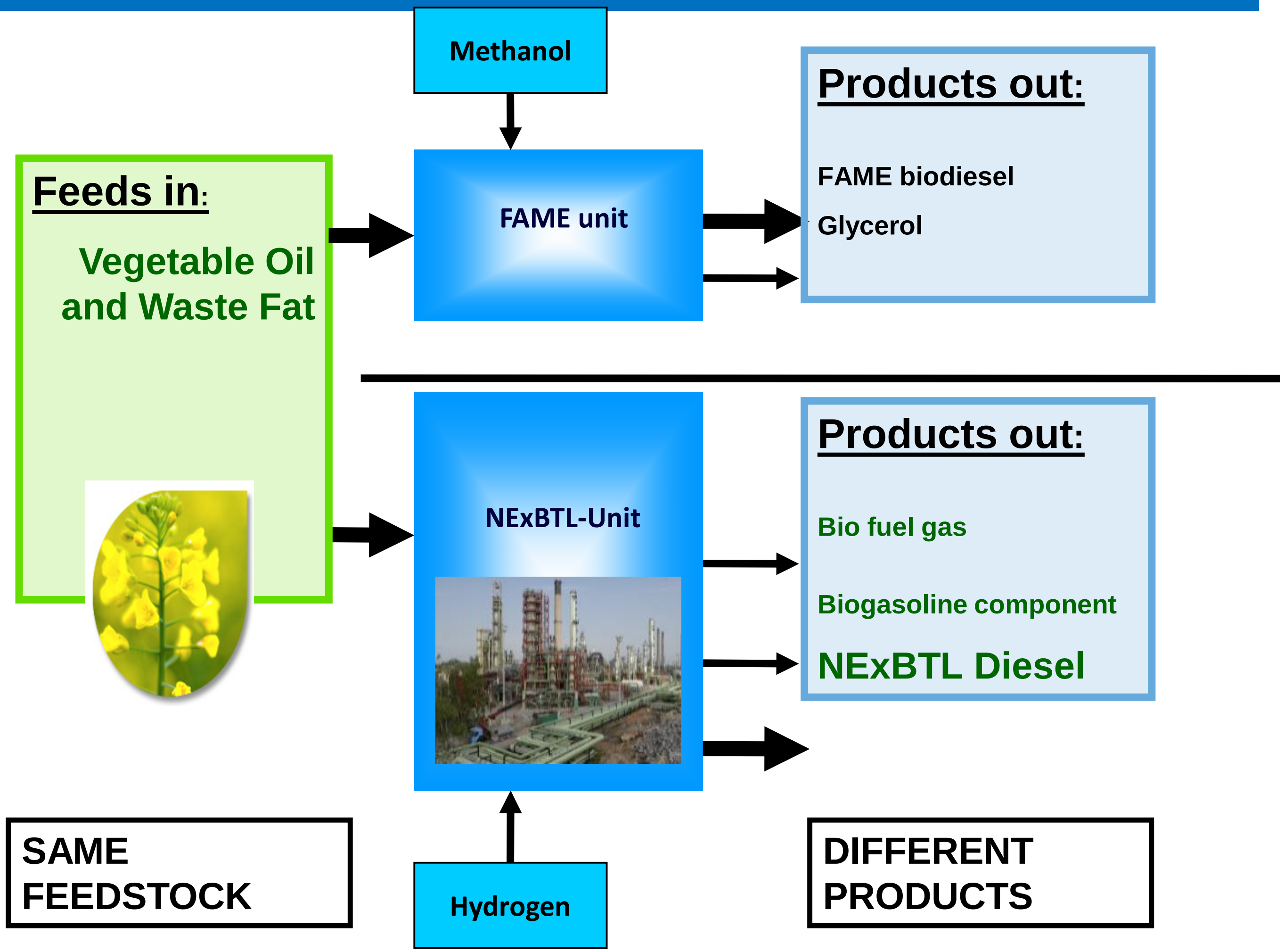


1980–2005	2007	2009	2010	2011	2015
Process Development Lab Samples Invest ??? First 1 Cyl + Rigg Testing	Porvoo 1 200 kt Invest 300 M€ Start Of Helsinki Bus Tests	Porvoo 2 200 kt Invest 300 M€ DHL Daimler + Other Fleet Tests Blending	Singapore 1000 kt >1000 M€ End Of Helsinki Bus Tests Burn Fair	Rotterdam 1000 kt >1000 M€ Blending Component EU + US R33 Diesel	Fuel Standard EN 15940 established Neste My Renewable Diesel Euro 6 testing

NEXBTL



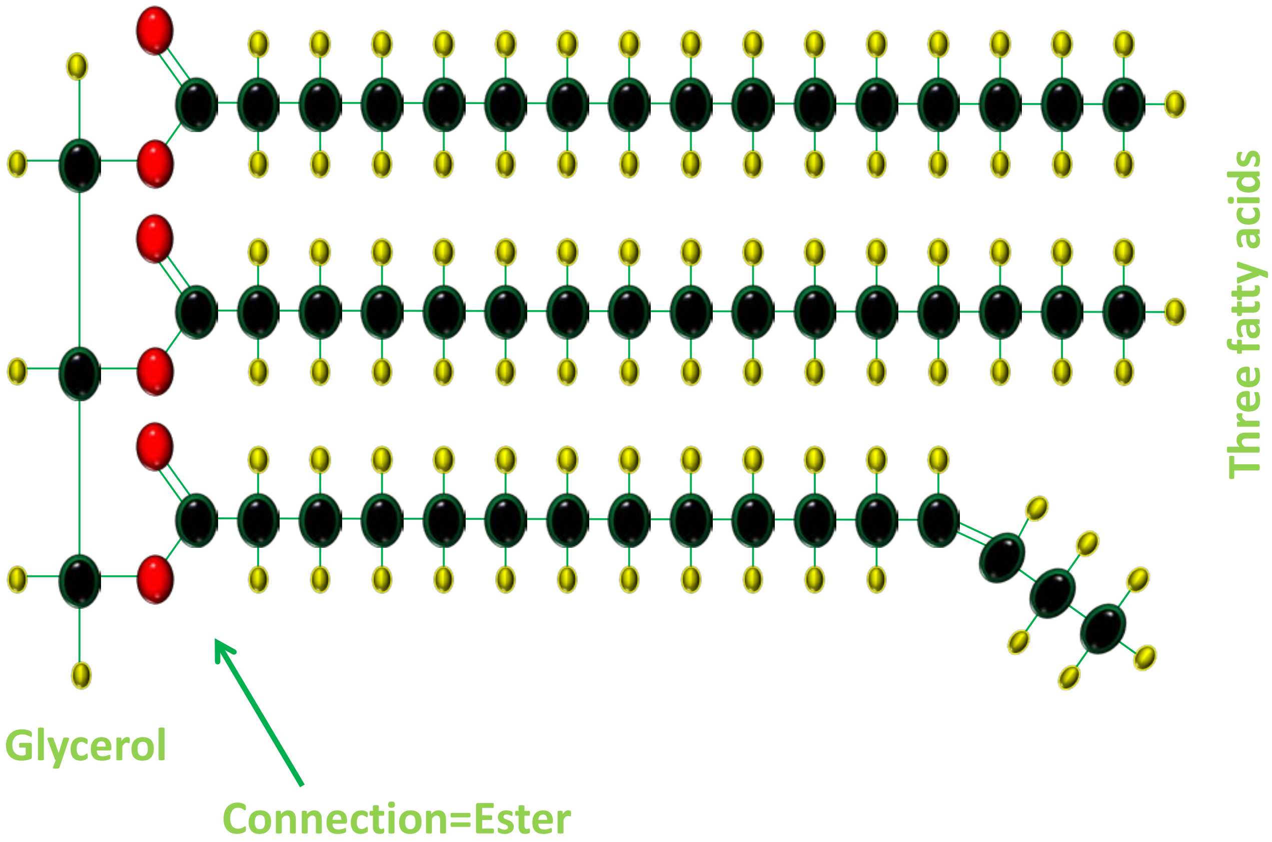
NExBTL & FAME Process



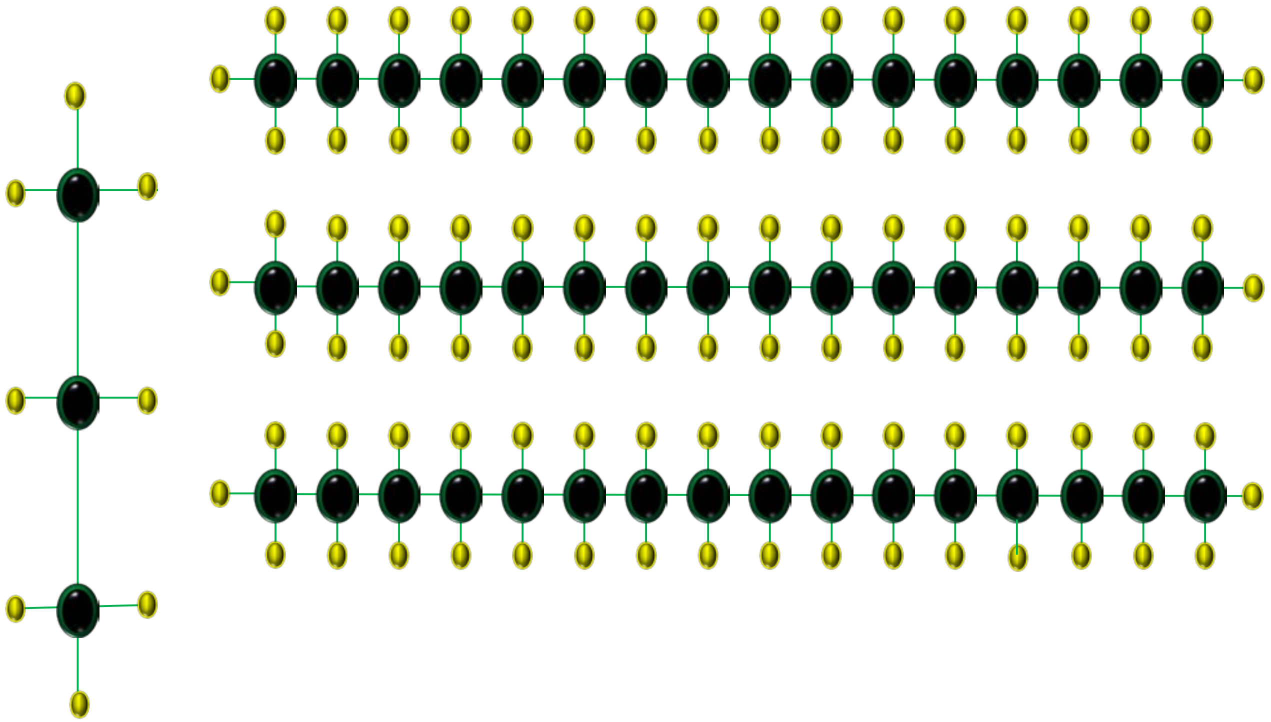
What is HVO diesel?

- Next step from traditional Biodiesel
- Improved technology and product
- Pure Hydrocarbon, fully compatible with Mineral Diesel
- No compromises on Fuel Quality or Vehicle Performance
- In Commercial Production

What is a Triglyceride?



3 Renewable Diesel Molecules & 1 Renewable Propane Molecule



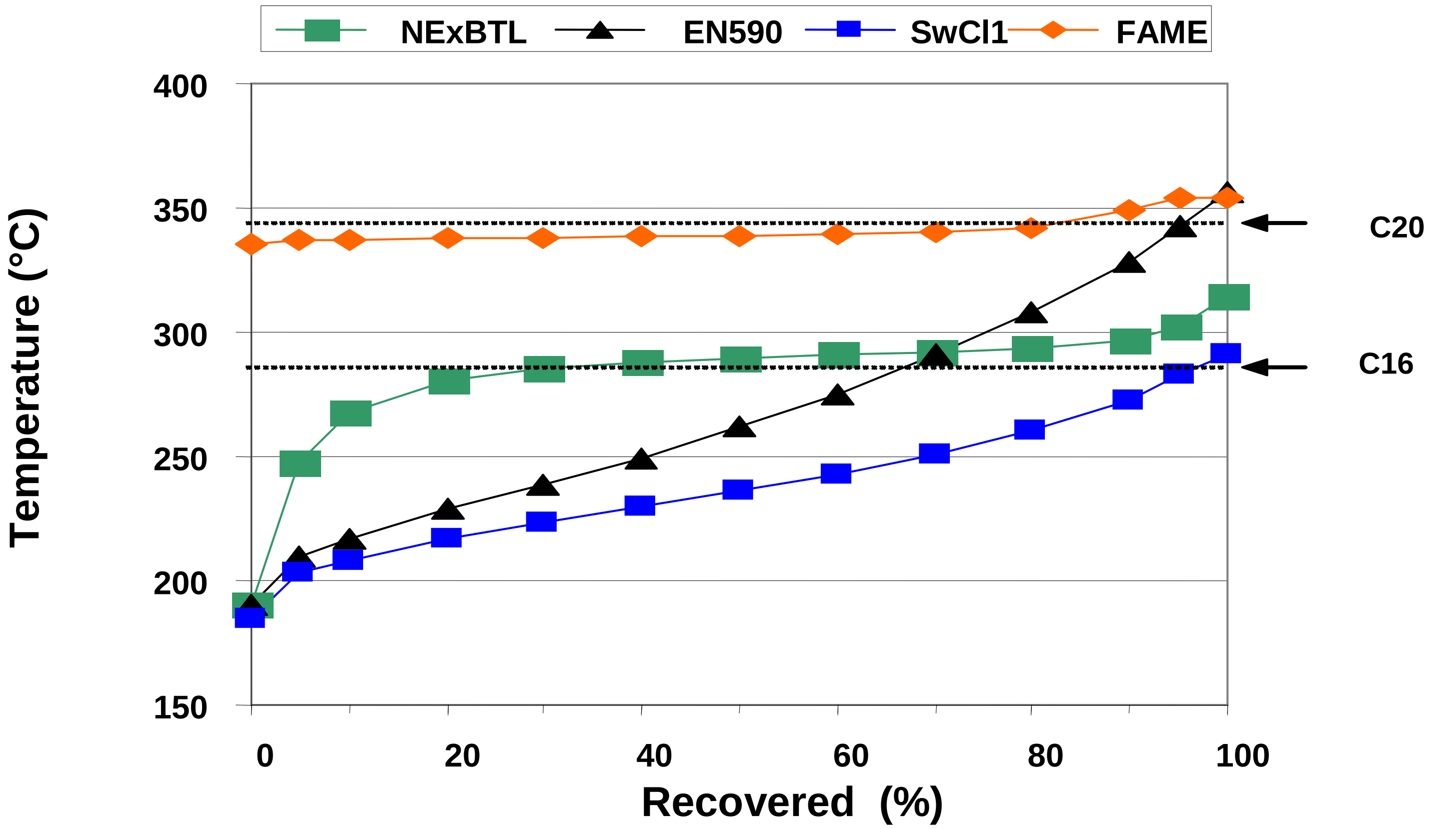
HVO is a high quality bio-based hydrocarbon

	Biodiesel FAME / RME	NExBTL renewable diesel	Fischer-Tropsch	Fossil diesel
Feedstock	Vegetable oils & animal fats (mainly rapeseed oil)	Vegetable oils & animal fats	Biomass	Mineral Oil
Technology	Esterification	Hydrogenation	Gasification & Fischer-Tropsch	Refining
End product	Ester-based biodiesel O II $H_3C\text{-}O\text{-}C\text{-}R$	Bio-based hydrocarbon C_nH_{2n+2}	Bio-based hydrocarbon C_nH_{2n+2}	Hydrocarbon C_nH_{2n+2} C_nH_{2n} C_nH_n

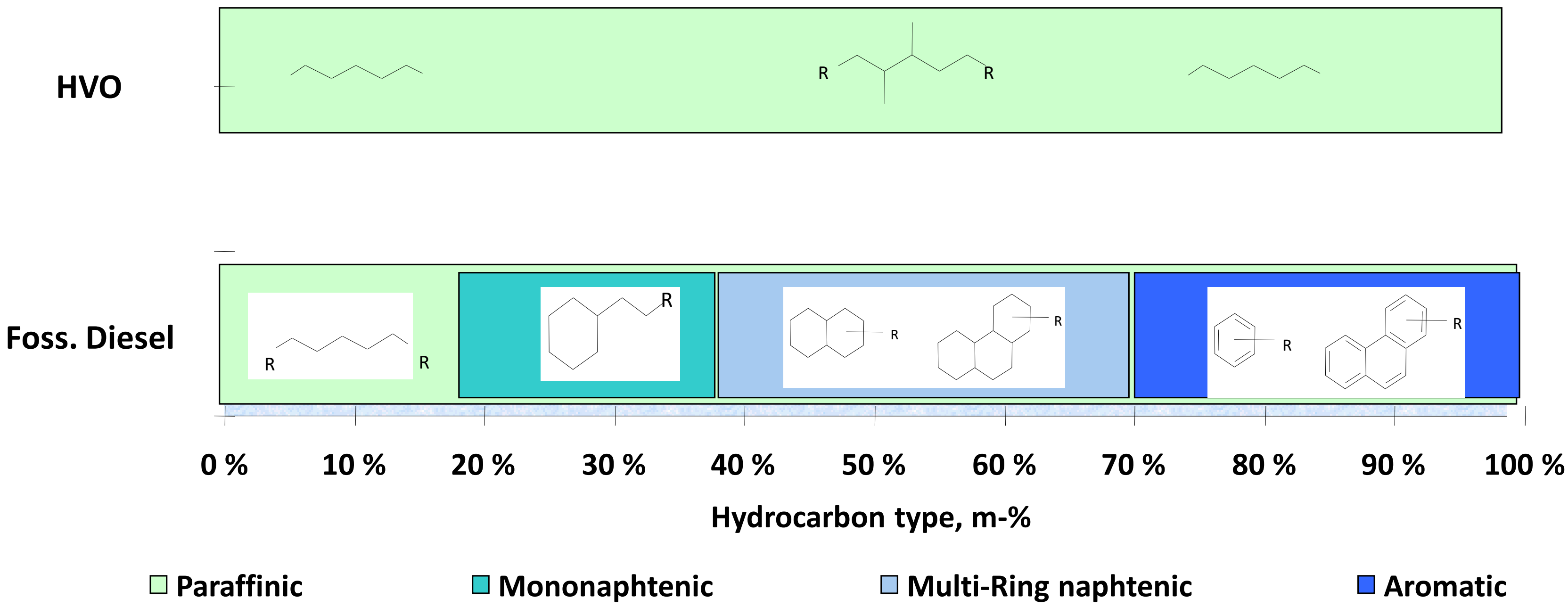
HVO - Superior Quality

Fuel Properties Typical values	**EN590 diesel fuel**	**HVO**
Cetane number	**53**	**75-99**
Cloud point (°C)	**0 - -12**	**-5...-30**
Heating value (lower) (MJ/kg)	**43**	**44**
Heating value (lower) (MJ/l)	**36**	**34**
Density at +15 °C (kg/m3)	**835**	**780**
Sulfur content (mg/kg)	**< 10**	**0**
Distillation range °C	**180-360**	**180 - 320**

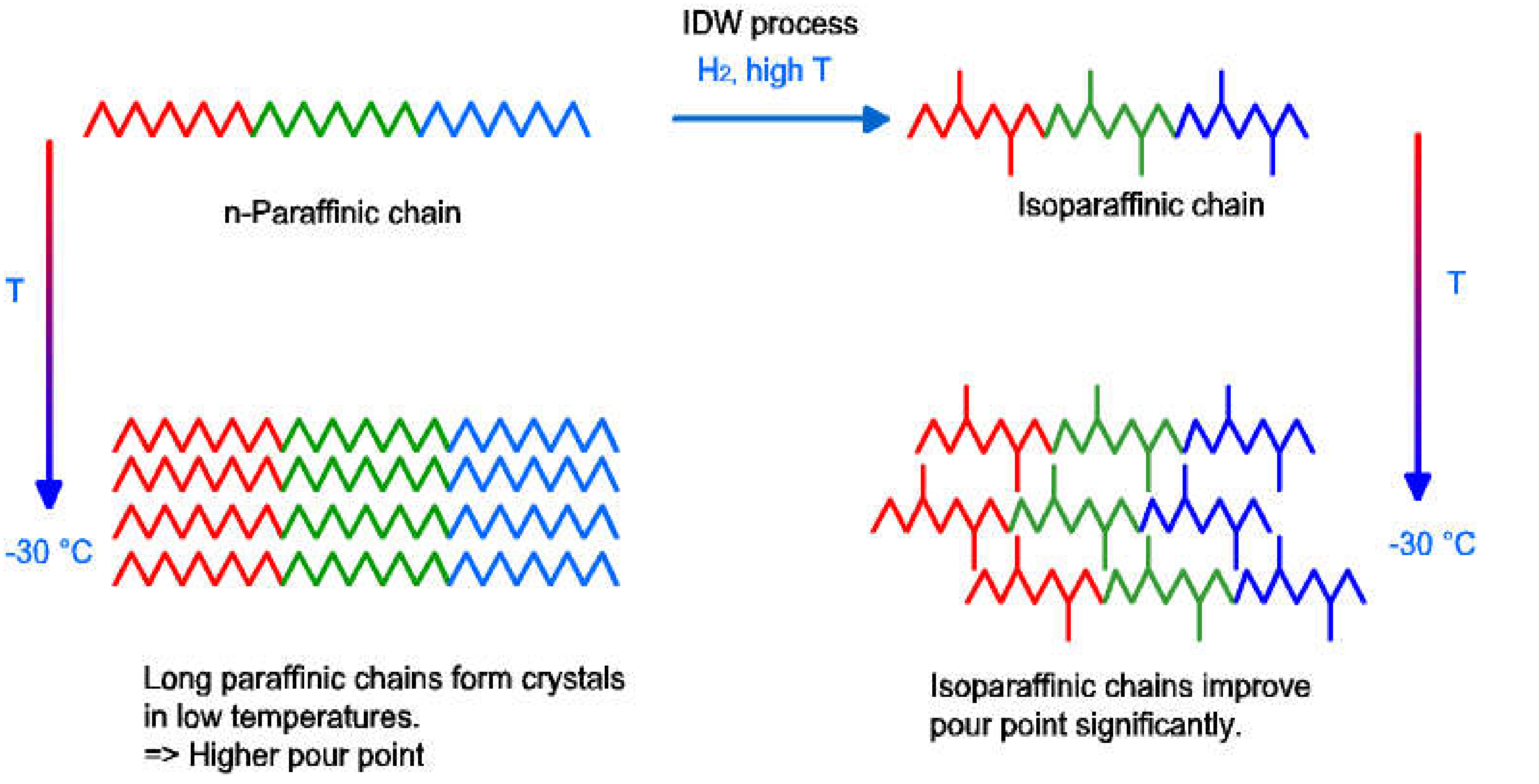
Distillation curves



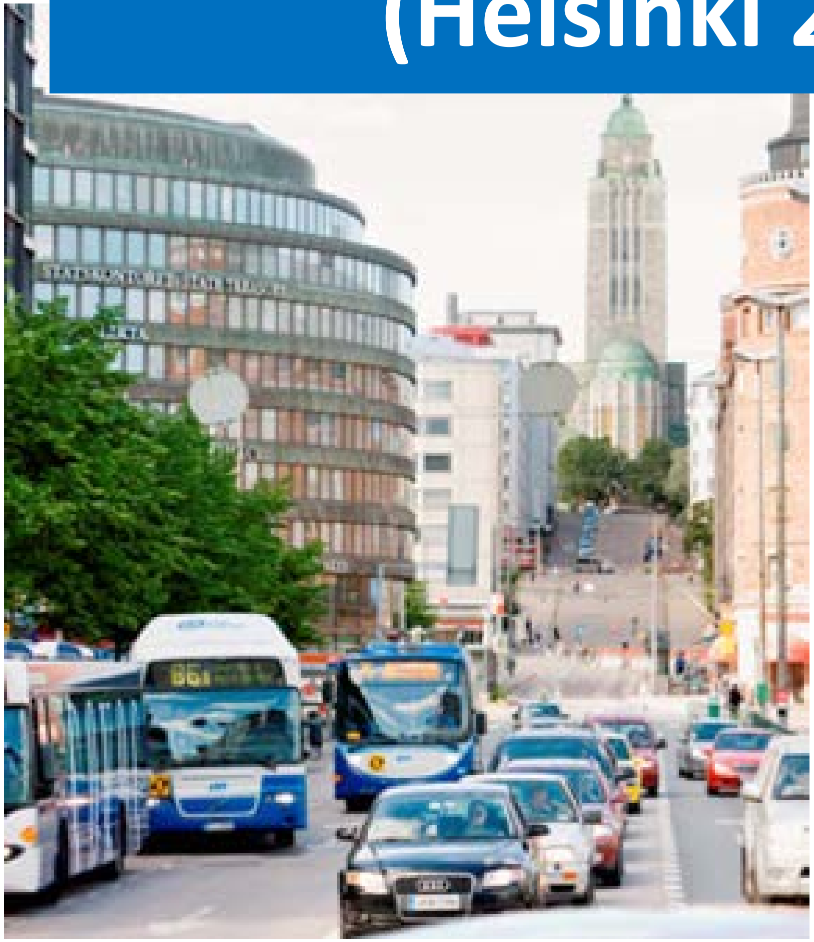
Chemical structure by MS-FI



IDW process
Low temperature properties



50 million kilometers covered in the world's largest biofuel trial (Helsinki 2007-2010)



HVO contributes to a significant reduction in exhaust emissions:

Nitrogen oxide (NOx)
10% reduction

Particulates (PM)
30% reduction

Greenhouse gases (LCA-GHG)
>50% reduction

Mercedes-Benz is confident about NEXBTL diesel

- Significant reduction of emission
  - NOx decrease up to 15 %
  - GHG reduction over 60 %
- After 2 years field testing:
  - 3.000.000 km @ no issues
  - Engine wear monitored
  - Regular vehicle service intervals
  - Summer and winter vehicle operation
- Totally 3.3 million kilometers driven and more than 2 000 tons of CO_2 have been saved

”The results from the first year of testing show that the fuel works perfectly in Mercedes-Benz trucks and busses and is tolerated very well by the engines”.

Dr. Schuckert, Daimler AG.

Project burnFAIR : Facts

Duration: 15th July – 27th December 2011,
8 flights/day

Route: Hamburg – Frankfurt – Hamburg
(1h flight time)

Aircraft: Airbus A321

Biofuel quantity: 800 tons

Biofuel ratio: 50% in one engine

Total cost: 8.4m USD

Emission savings: approx. – 1,500 tons CO_2

Use in the aircraft – The „Drop In“ Concept

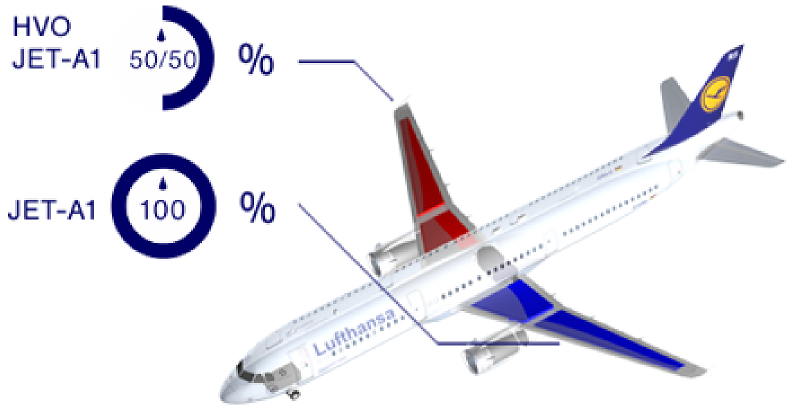
Research of engine performance:
One engine to operate with 50% blend of HVO kerosene

First truck supplies bioblend to the starboard wing tank

Second truck supplies conventional JET A-1 to the backboard wing tank

No major changes in normal cockpit procedures

“Bio-Engine” shows expected data and operates normal



First Results of the Project Aviation Biofuel

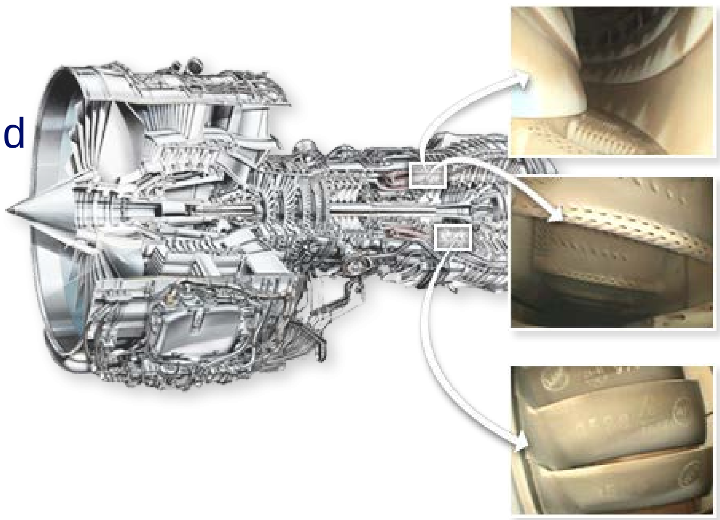
Bottom line

On December 27th 2011, the aircraft D-AIDG completed its last flight with biofuel

Total number of flights: 1187
Biofuel blend [volume in tons]: 1557
Emission saving [CO_2 in t]: 1471

Perfect fuel for aviation

1. During the operation
Aircraft and engine performed excellently
1% lower fuel consumption due
to the higher energy content
2. Inspection after the program
Fuel system, combustion chamber and
turbines in a perfect condition
Normal function and tightness of
fuel bearing parts
3. Storage stability
Density steady at 783 kg/cbm
No microbial issues



Source of the picture: Lufthansa

But where does the raw material come from?

Expanding our raw material portfolio

Short-term

Waste animal fats, waste oils, residue and side streams

Long-term

Biological pathways

Thermo-catalytic pathways

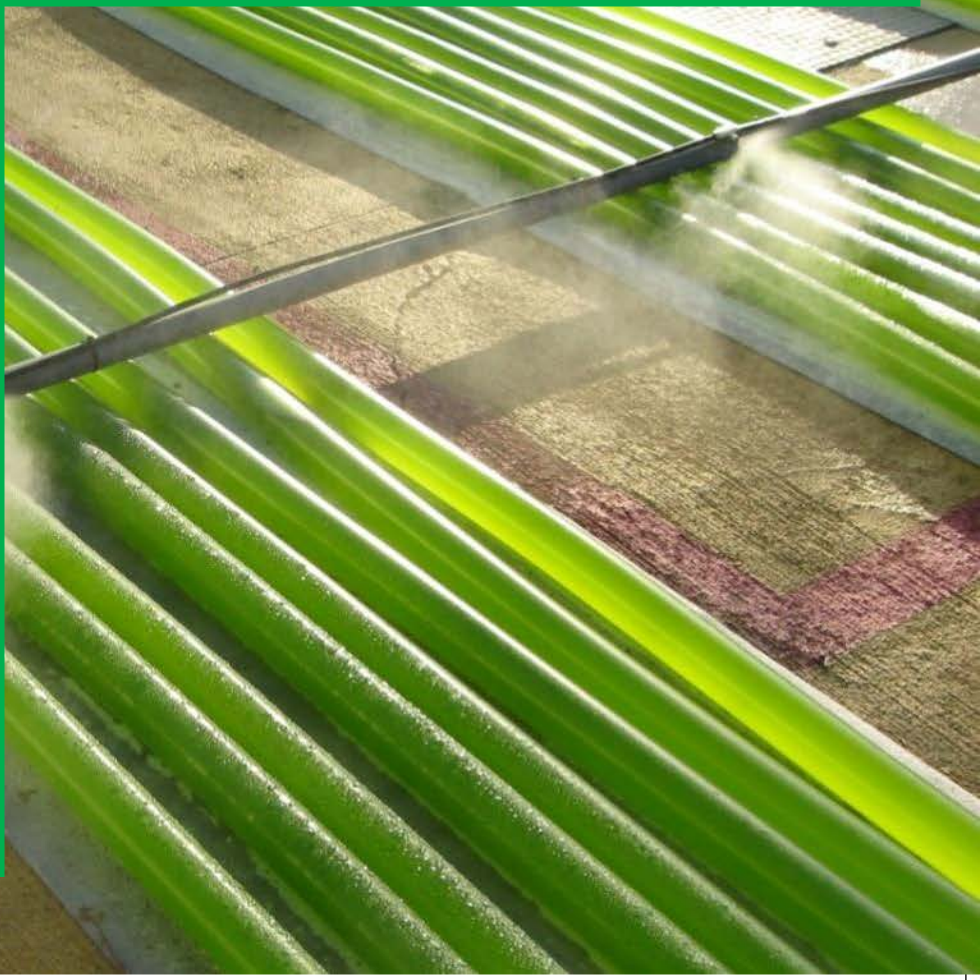
Photo-synthesis

Cutting-edge research

- Continuous research to expand renewable raw material base and further develop NExBTL technology
- 70% approx. eur 41 million of R&D costs in 2015
- Cooperation with over 20 research institutions around the world
- Approx. 1 000 people working with research and engineering

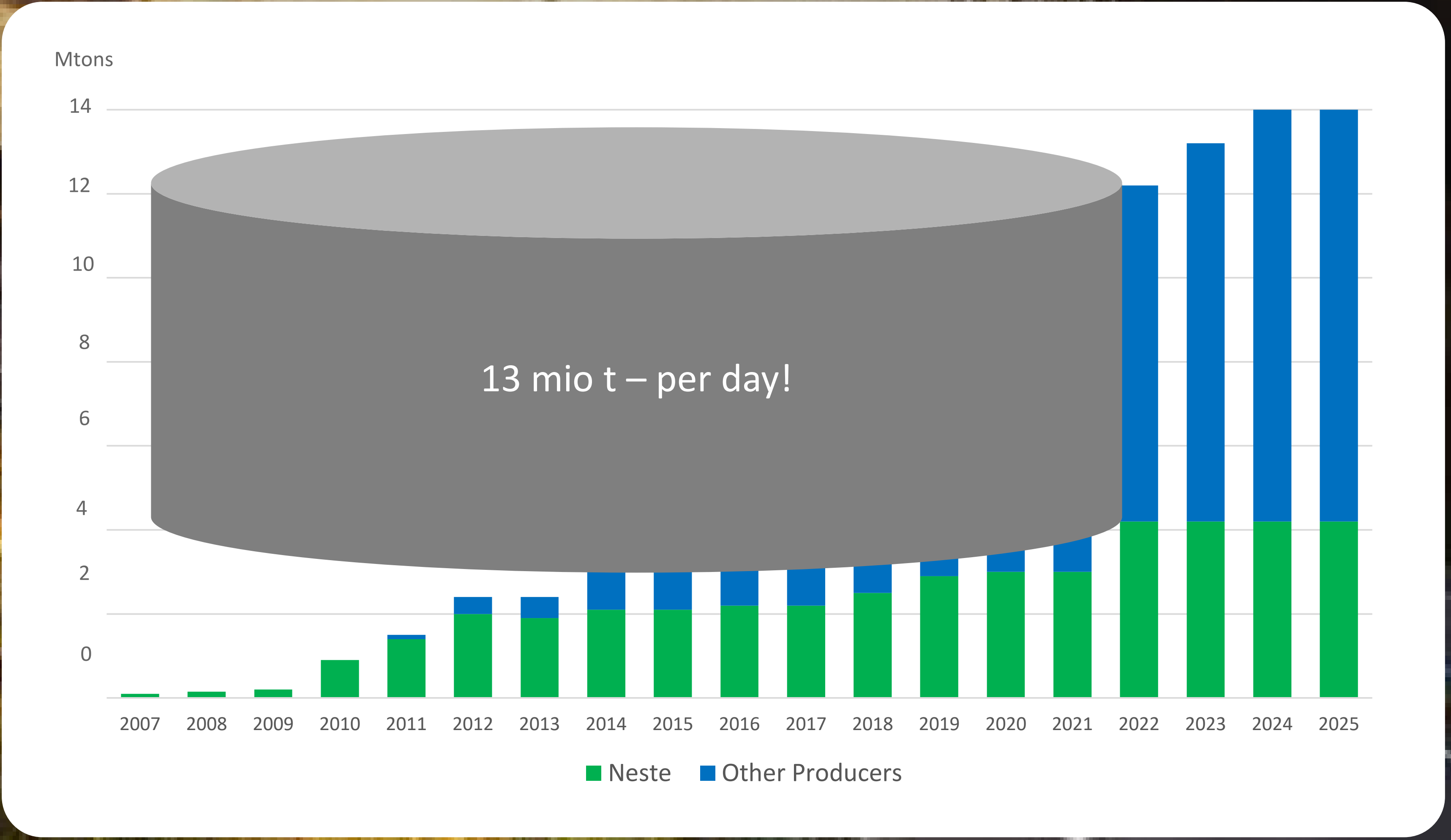
Microalgae oil – one of the future raw material alternatives

- Algae oil is a suitable feedstock for renewable fuel production
- Not yet available on industrial scale
- Neste has been involved in several global research projects
- Commercial contingent algae oil off-take agreements with Cellana and RAE in the USA

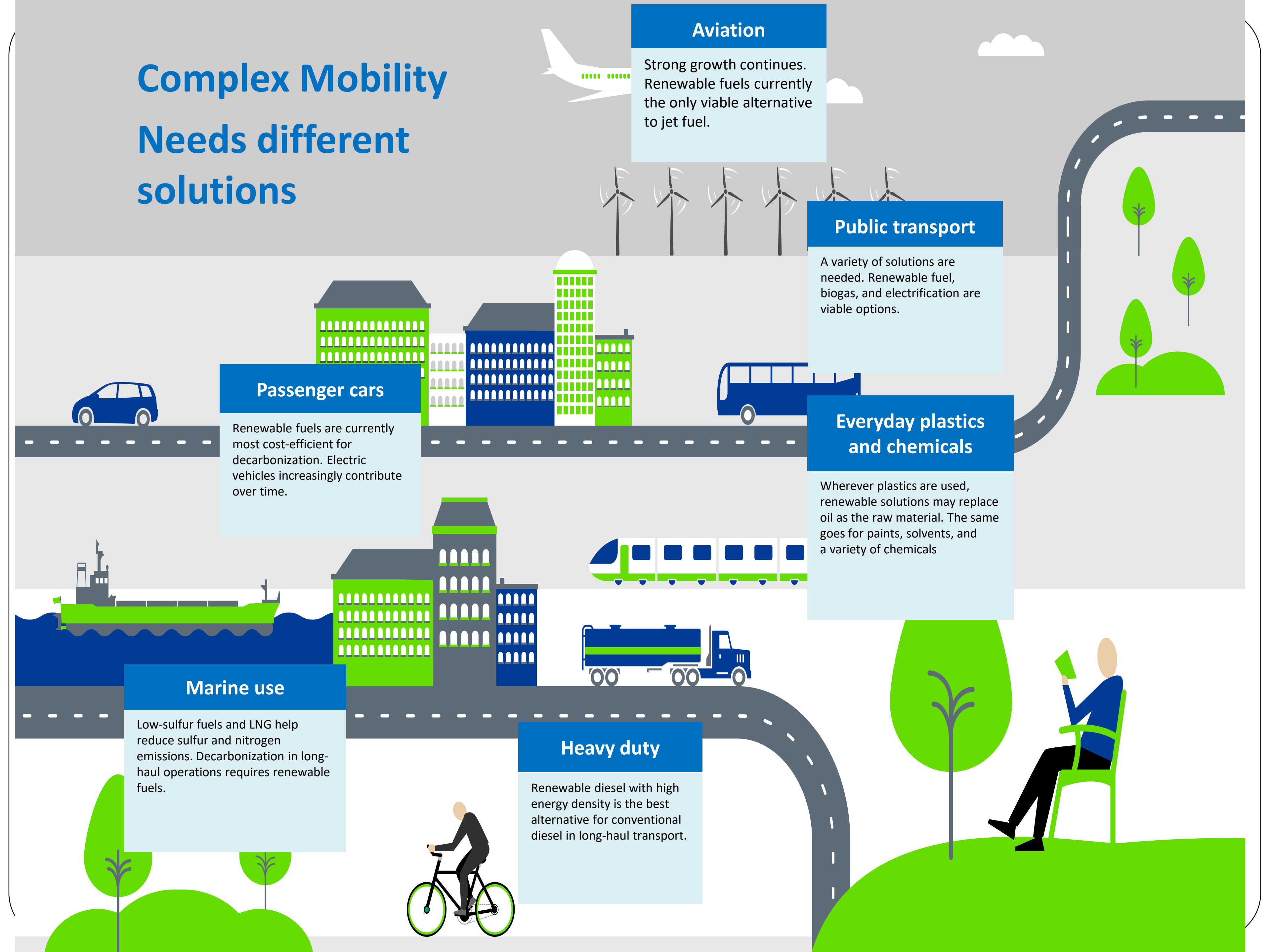


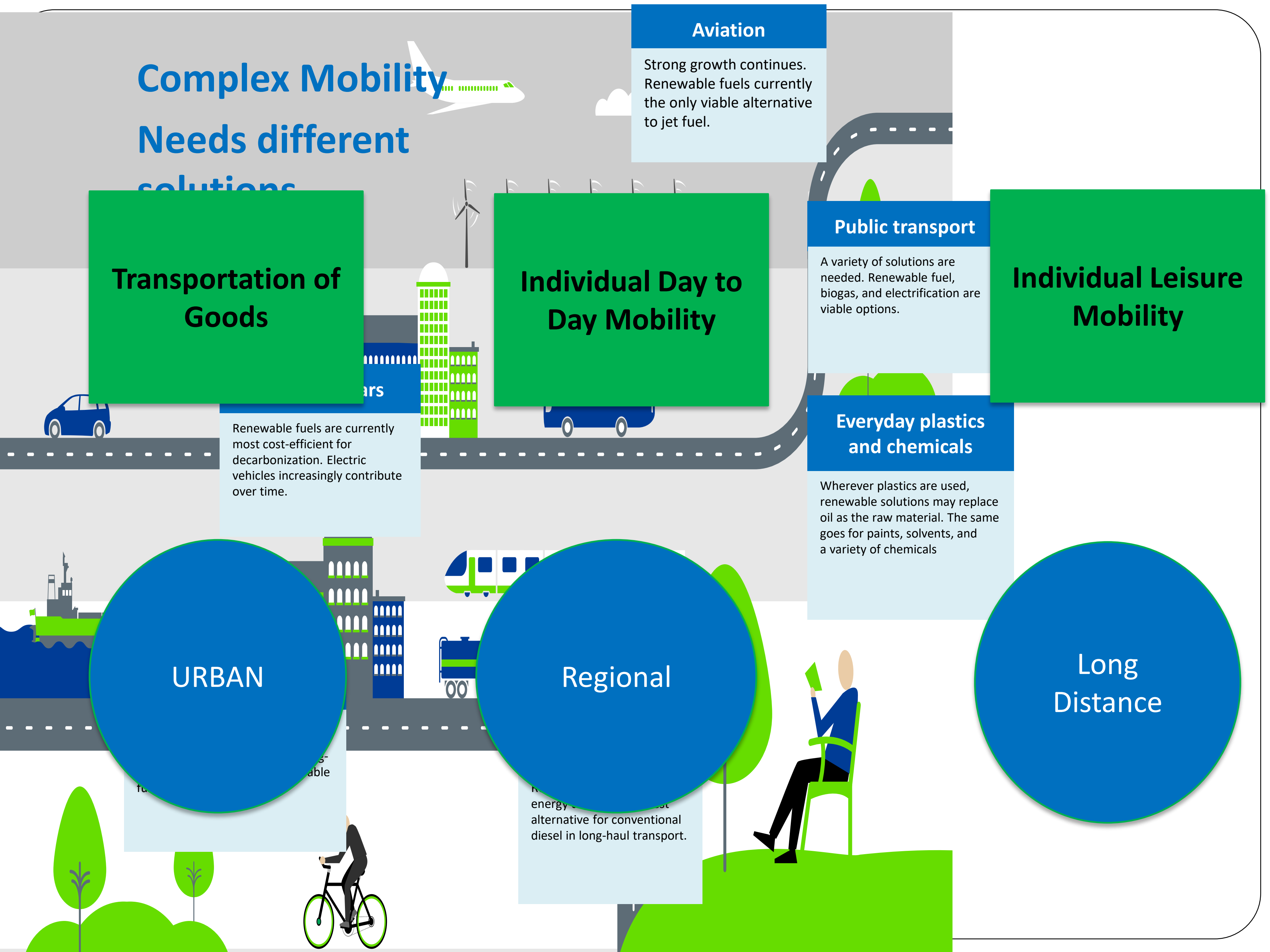

OUR VISION:
We create responsible choices every day.
Global 100: Neste is the world's
3rd
most sustainable company.

Global volumes of renewable diesel increasing



So what will be the future of mobility?


Complex Mobility
Needs different solutions
Aviation
Strong growth continues. Renewable fuels currently the only viable alternative to jet fuel.
Public transport
A variety of solutions are needed. Renewable fuel, biogas, and electrification are viable options.
Passenger cars
Renewable fuels are currently most cost-efficient for decarbonization. Electric vehicles increasingly contribute over time.
Everyday plastics and chemicals
Wherever plastics are used, renewable solutions may replace oil as the raw material. The same goes for paints, solvents, and a variety of chemicals
Marine use
Low-sulfur fuels and LNG help reduce sulfur and nitrogen emissions. Decarbonization in long-haul operations requires renewable fuels.
Heavy duty
Renewable diesel with high energy density is the best alternative for conventional diesel in long-haul transport.



Complex Mobility
Needs different
Aviation
Strong growth continues. Renewable fuels currently the only viable alternative to jet fuel.
Transportation of Goods
Individual Day to Day Mobility
Public transport
A variety of solutions are needed. Renewable fuel, biogas, and electrification are viable options.
Individual Leisure Mobility
Renewable fuels are currently most cost-efficient for decarbonization. Electric vehicles increasingly contribute over time.
Everyday plastics and chemicals
Wherever plastics are used, renewable solutions may replace oil as the raw material. The same goes for paints, solvents, and a variety of chemicals
URBAN
Regional
Long Distance
alternative for conventional
diesel in long-haul transport.

MEGACITY TREND

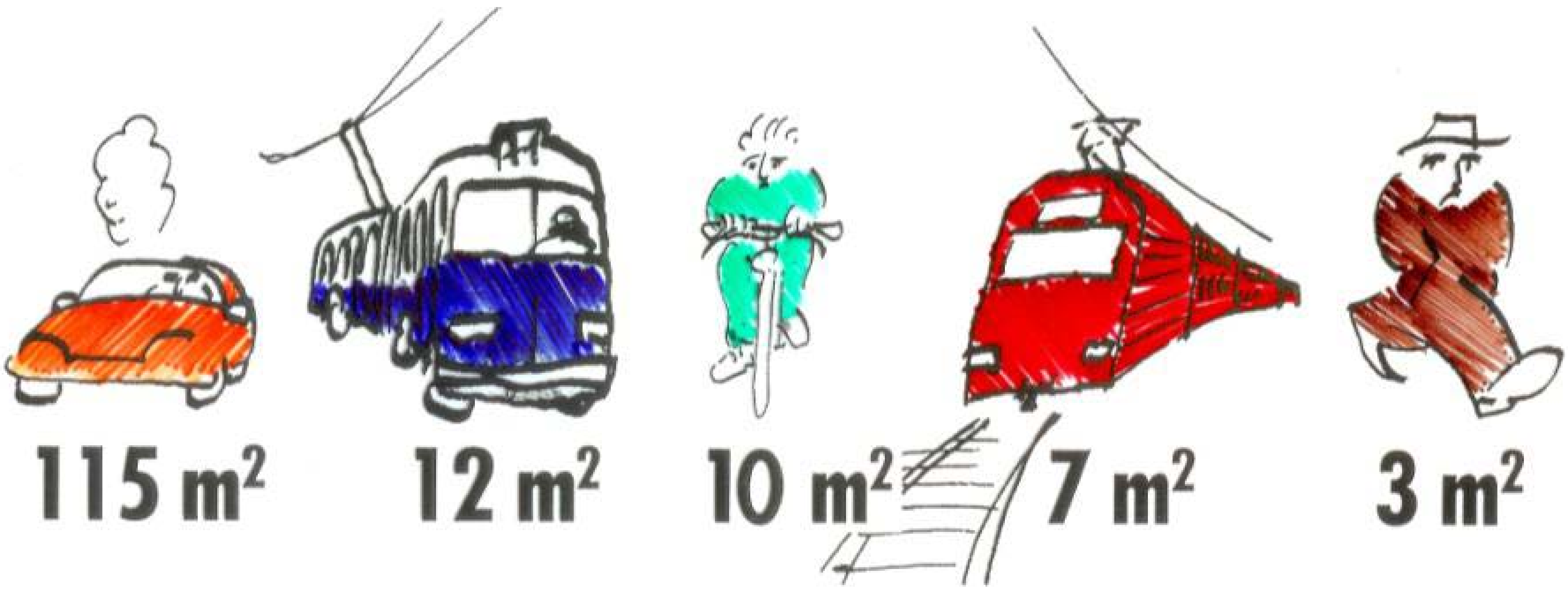
In 2025 more than 5 Bln People will live in Urban regions – this is seen as the main driver for growth of world economy!

But how does this influence mobility?

Traffic Jam…

Own passenger car is seen in emerging areas still as one key element of better standard of live, but in Europe and US growing concerns mainly at young generation are seen……

Space demand and Noise will become important criteria in City Mobility and Quality of Life



Define Life Style…

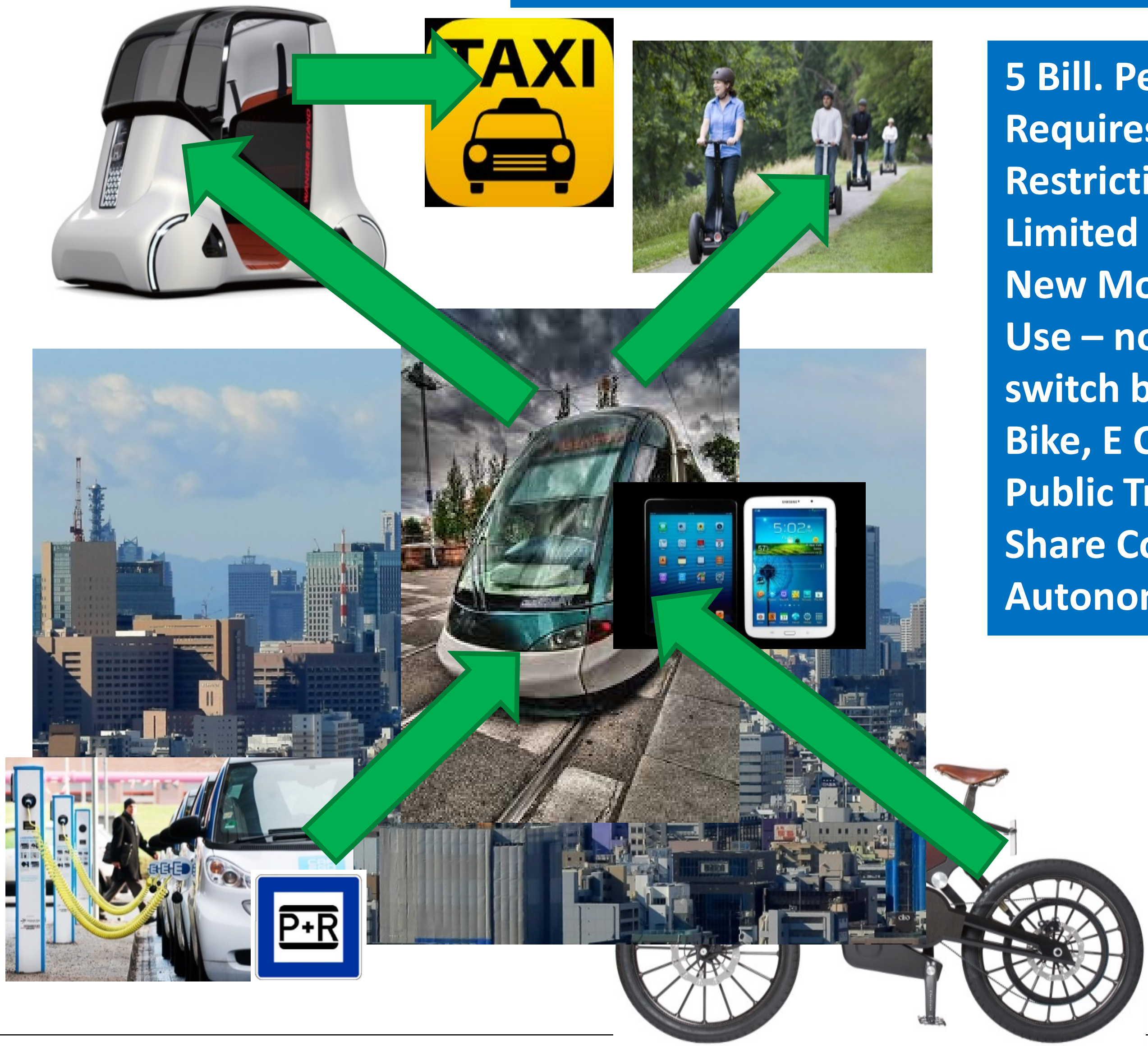
While own car was a dominant element to define own personality and life style, younger generation has different attitudes….

Will Connectivity Change The Game?

Connectivity gains growing impact to day to day live:

HOME WORKING OR MOBILE OFFICE
MOBILITY MANAGEMENT WITH PUBLIC AND PRIVATE MODES
ONE MOBILITY PLATFORM WITH HIGH MOBILITY (UBER)
SHARE CONOMY MANAGEMENT
E CAR CHARGING CONCEPT

City Mobility will be much more complex and not focused on individual own car



- 5 Bill. People in Urban Regions
- Requires „better urban life“
- Restrictions (Emissions + Noise)
- Limited Space in City
- New Mobility Concepts
- Use – not own with flexible switch between modes
- Bike, E Car / PHEV / P + R
- Public Transport / Walk / E Taxi
- Share Conomy + Connectivity
- Autonomous E Taxi (UBER)

A I R Principle

A

I

R

- **Avoid**
- processes and products identified as not necessary
  - Folia for Banana / Unnecessary Transports / telecon vs meeting
- **Improve** processes and products in terms of
  - demand of resources,
  - energy consumption,
  - recycling
- **Replace** Processes and products being:
- harmful, toxic, dangerous in handling
- Resource inefficient, energy consuming
- Non recycle potential,

Efficient City Design

COPENHAGEN winner 2014
EUROPEAN GREEN CAPITAL
An initiative of the European Commission

Work and Living in short distances
High quality of Live in Quarter
Utilities, Shops, Restaurants
Education, Care Near
Convenient to walk or use bike
Well connected public transportation
Solutions for Goods deliveries
Individual offers

Dilemma Climate vs Cost

The current business model:
Long term transportation and complex supply chain:
Company benefits
Society pays external costs and impacts
Environmental and Climate Consequences
are shifted to next generations

Logistic
Truc
Driv
Fue
Operat

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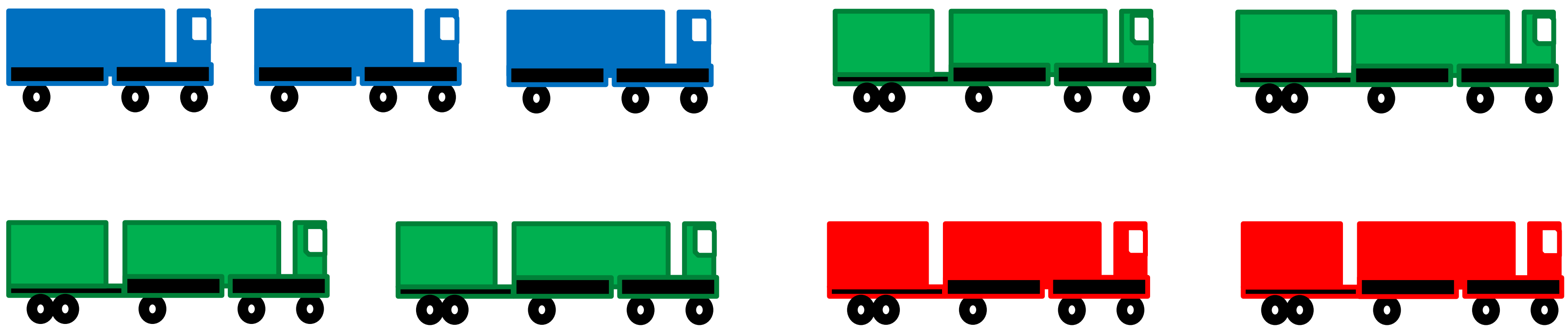
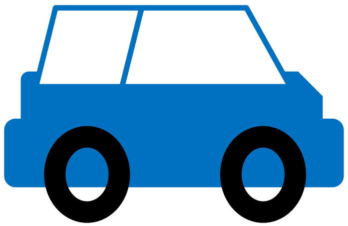
Company 100
any ?? %

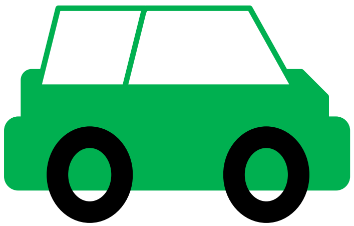
Over Compensation Effects

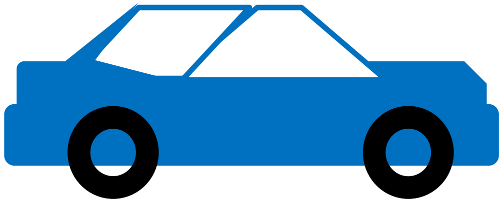


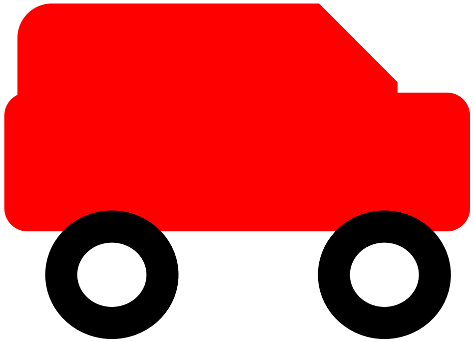
Conventional trucks can be replaced by Giga Liners	2 Giga Liner consume about 80% fuel of 3 normal trucks	Operation Cost of 2 Giga Liners is about 75% of 2 normal trucks	Cost Saving makes long distance operations attractive
3 vs only 2	GHG Saving 20%	25% Cost Saving	Giga + 80% GHG

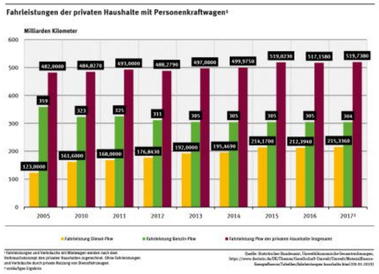
Rebound Effects











Compact Cars
Golf 2 1990
845 kg / 40,5kW
8,1 l / 100 km
Golf 6 2010
1217 kg 59kW
8,2 l / 100 km

Total Milage of all PC
In Germany in
Bill. Km / Year
1990: 431,5
2000: 559,5
2015: 653,8

Tendency of
Consumers to buy
bigger and more
luxury cars
continues

The Tricky Part Of LCA

We can easily calculate heat exchanger values up to three digits,

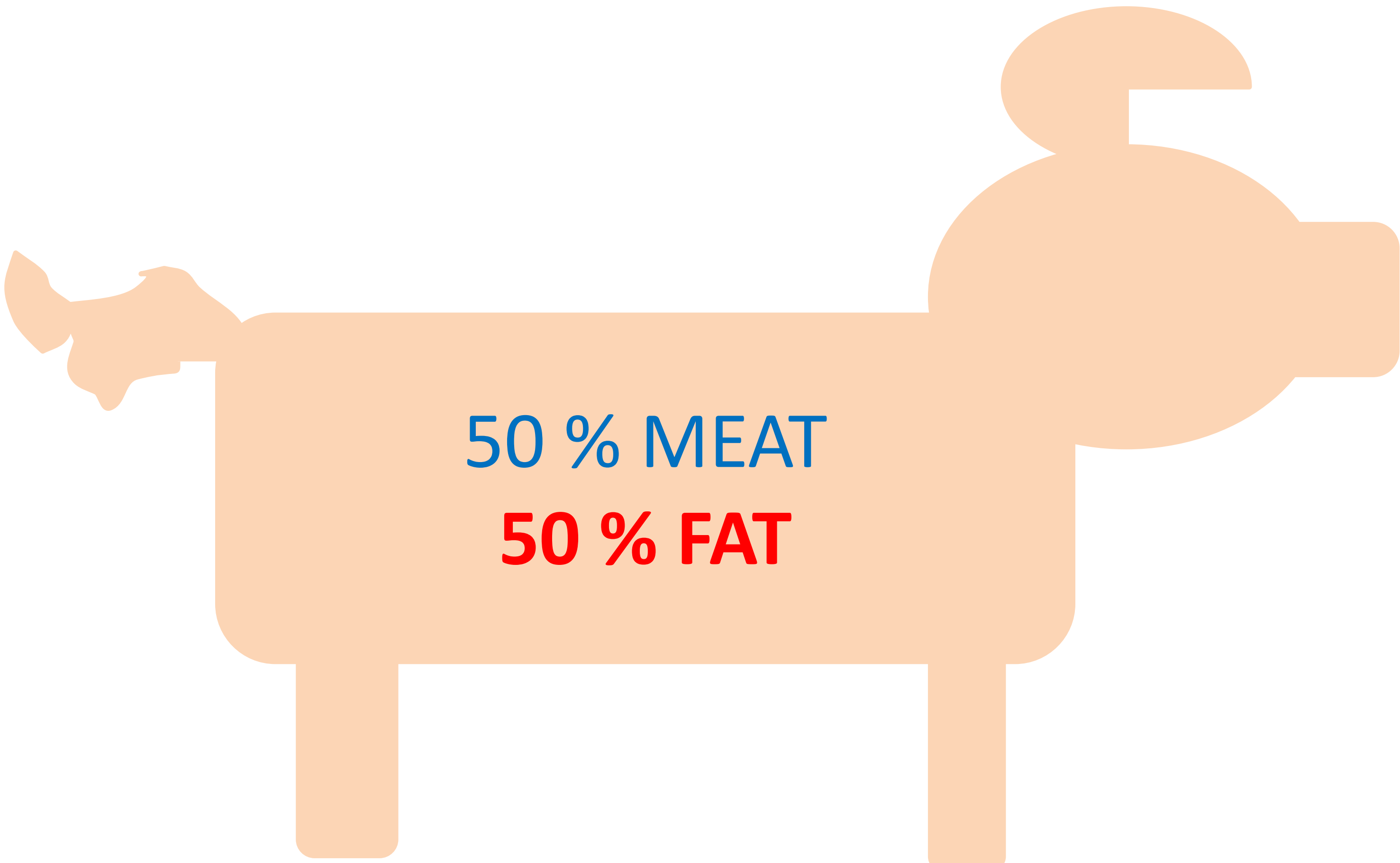
but what about the

boundary conditions,

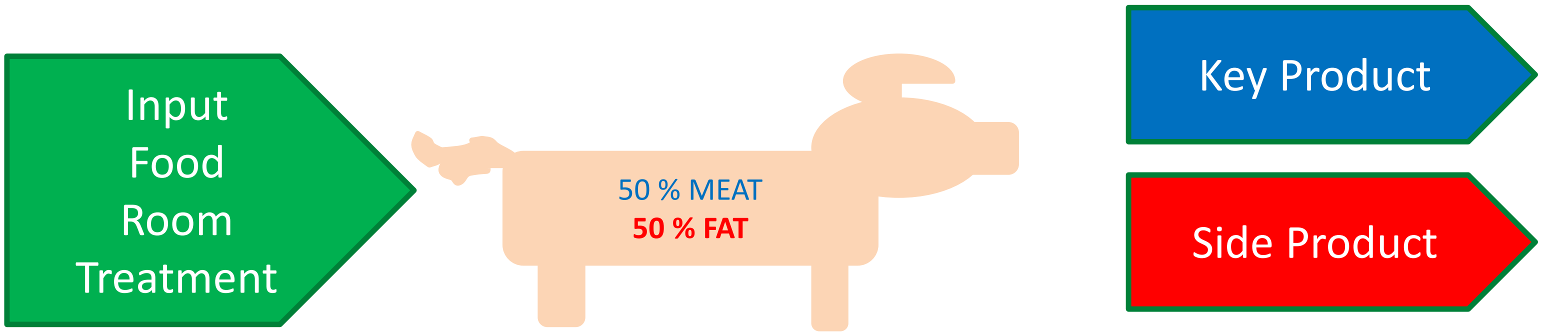
asumptions

allocations???

The Model Pig

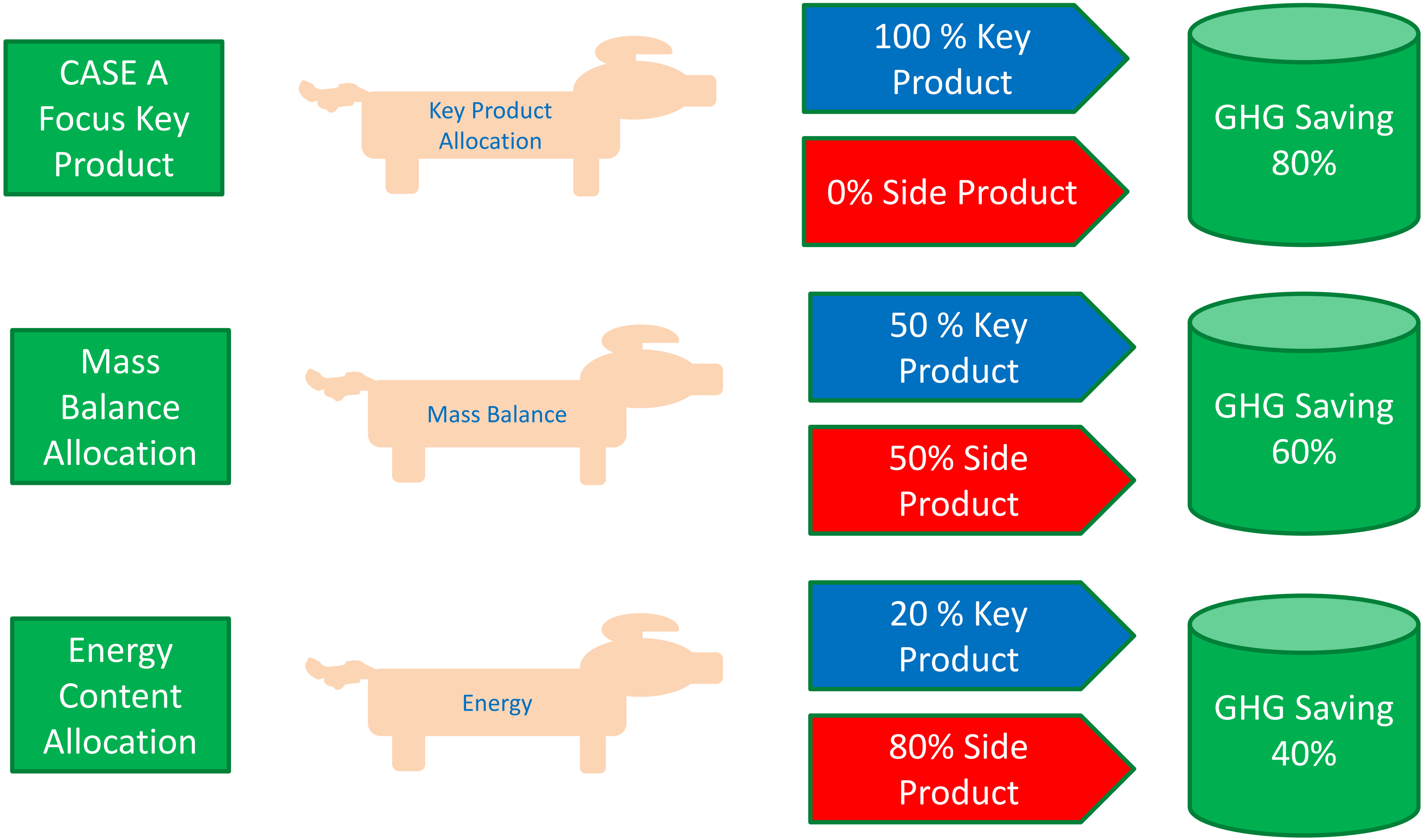


The Model Pig

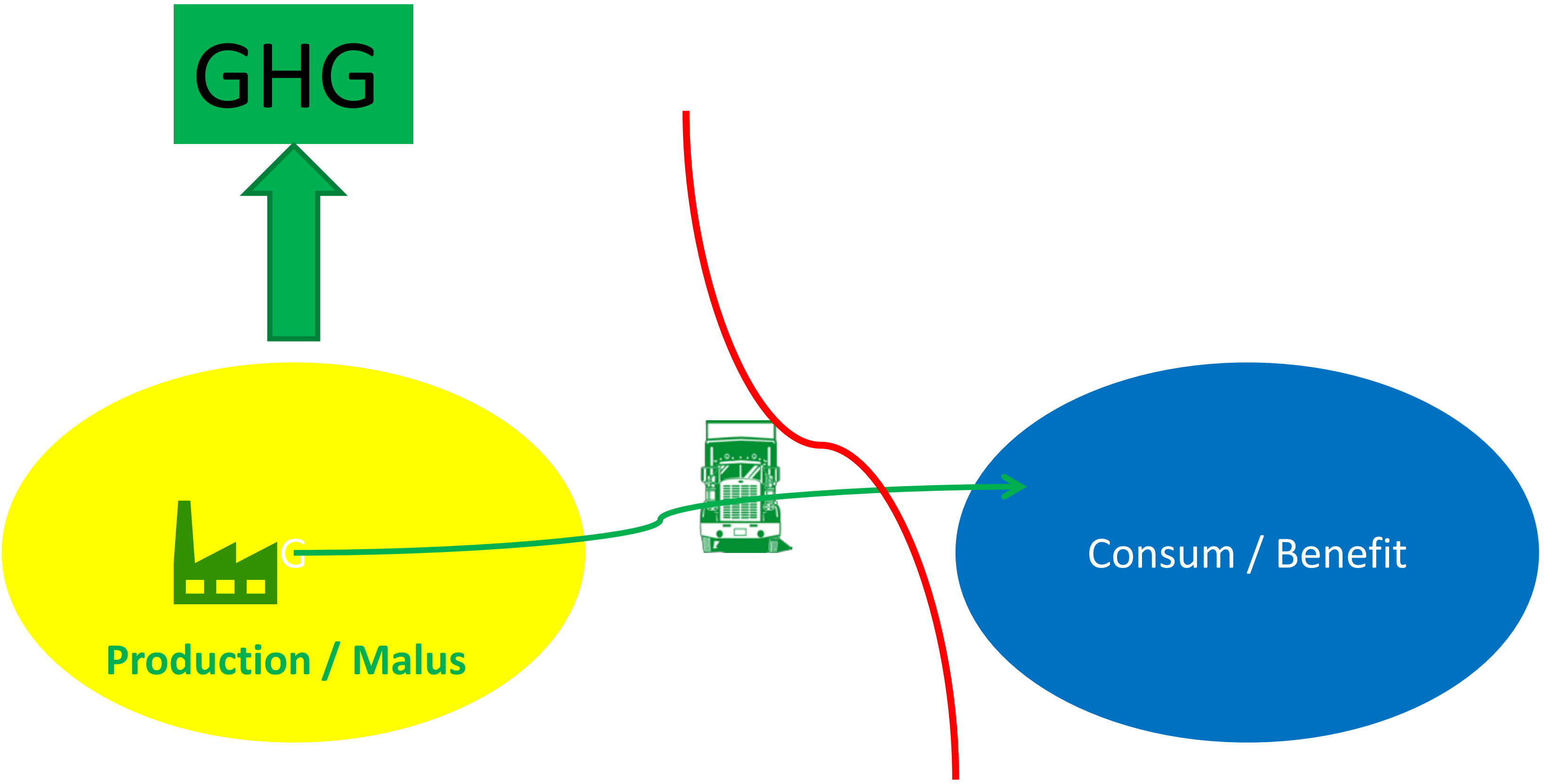


Any LCA starts with feedstocks or workpieses with complex process history and side products, process efforts have to be split between the different raw materials, feedstocks or workpieces!

The Model Pig and Bioenergy



Indirect GHG Emissions and Impacts



So whats the future of cars?

Ferry Porsche statement:

The last ever built car will be a sportscar!

Sure?

Horses in Germany

1900: 4 mio

Mainly in Agriculture

1950: 2,3 mio

Mainly in Agriculture

2015: more than

1 mio horses

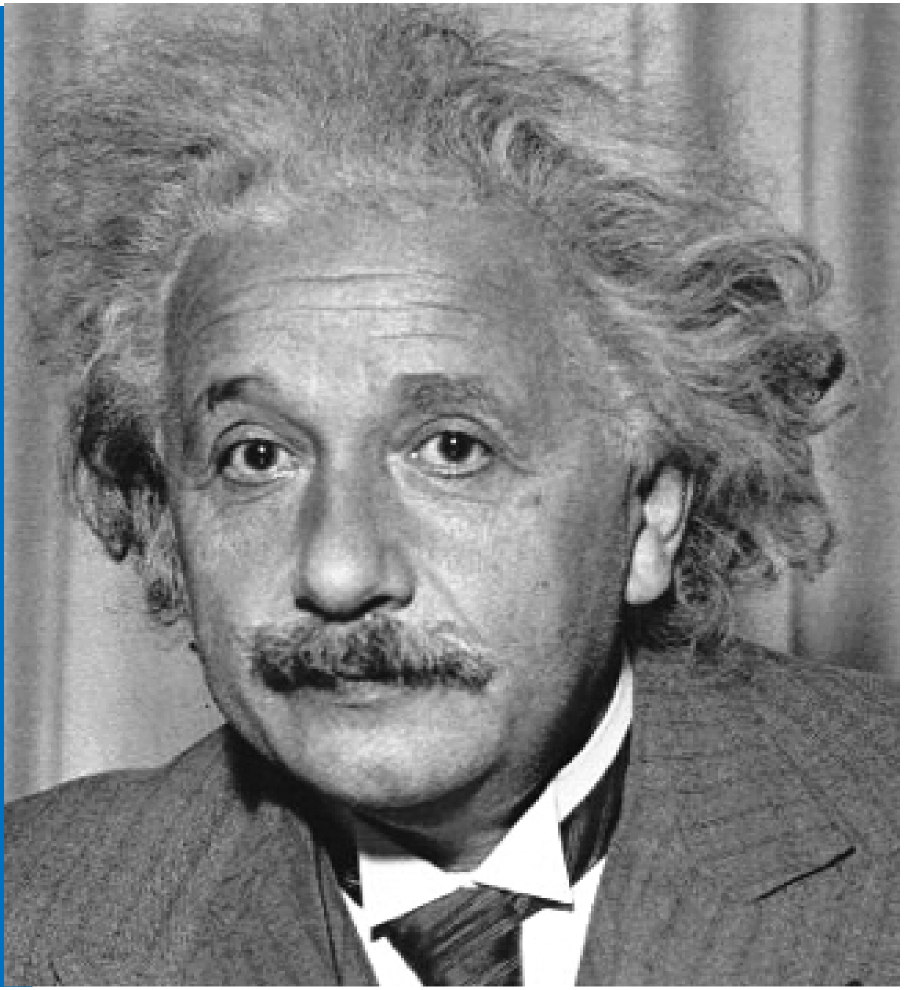
for private use....

Innovations and Alternatives are better than Prohibition!

Red Flag Act from 1865 to 1896 was the biggest draw back for GB automotive industry, while Germany and France were developing inoovations in cars due to strong competition about speed

……Summary

- Car Population will grow to 2 Billion units
- Complexity will increase as well as quality requirements
- 5 Billion People live in Urban Regions
- BEV **and** E Fuel are needed
- New City mobility concepts
- All available sustainable energy should be used!!!



Why xTL?

How it has started......

1888: Berta Benz first „long distance“ trip

Pharmacy of Willi Ockel Wiesloch became the first „Fuel Station“
2 liters of „Ligroin“ fueld

Ligroin? Light benzine density aprox 0,700 kg/l

Main use cleaning – no fuel spec.....

Any New Fuel Needs A Defined Standard

Benzin

E10 E85

Diesel

B7 B100 XTL

Gases

CNG H2 LNG LPG

XTL From Molecule To Market




LAB → PILOT → Industry Demo → 1st large scale Unit

5 l

200 l

50 kt / year

200 k t / y

200 k t / y




XTL From Molecule To Market

1st large scale Unit

200 k t / y

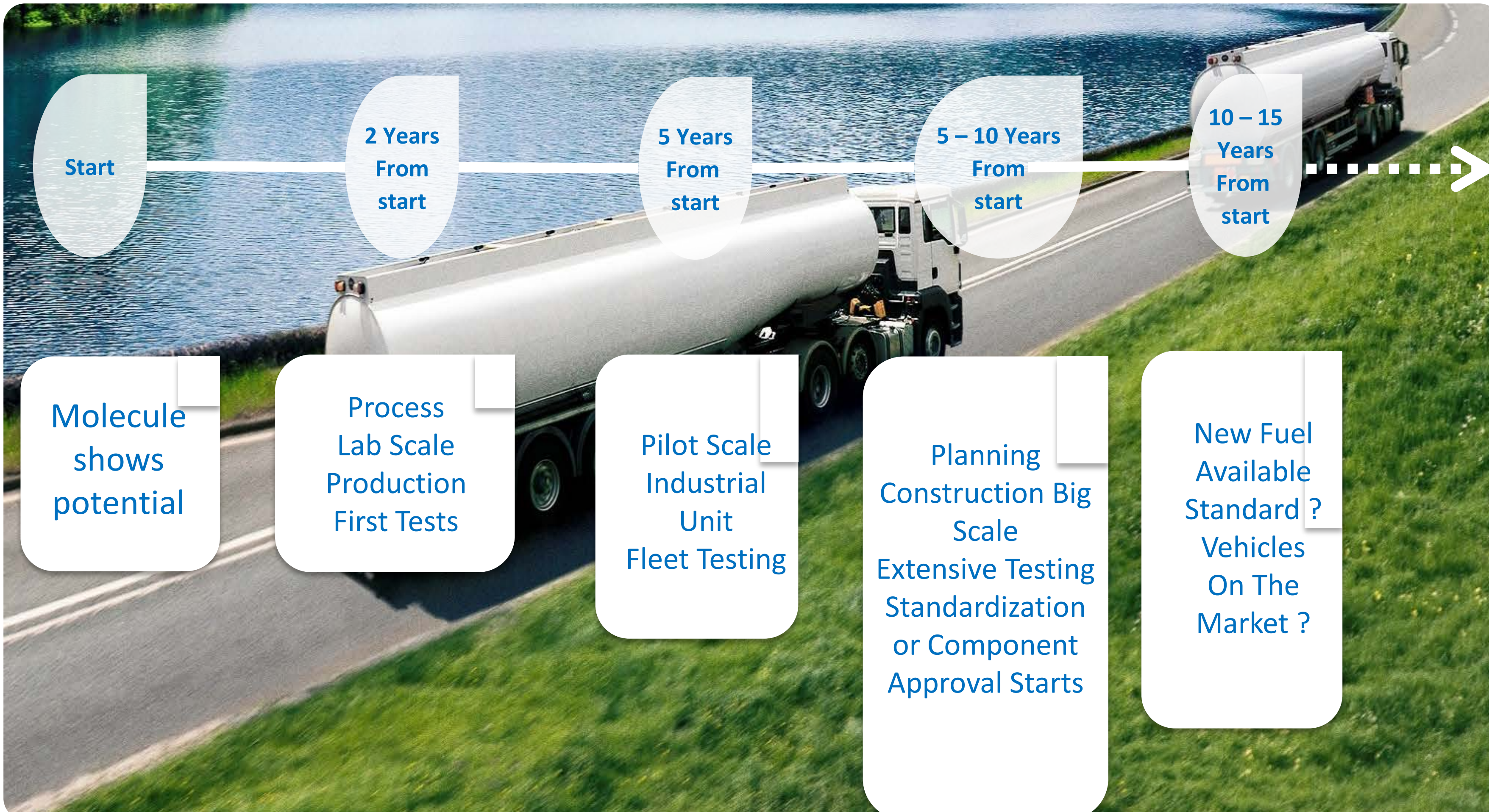
200 k t / y

German Diesel Market 2018

38 mio t

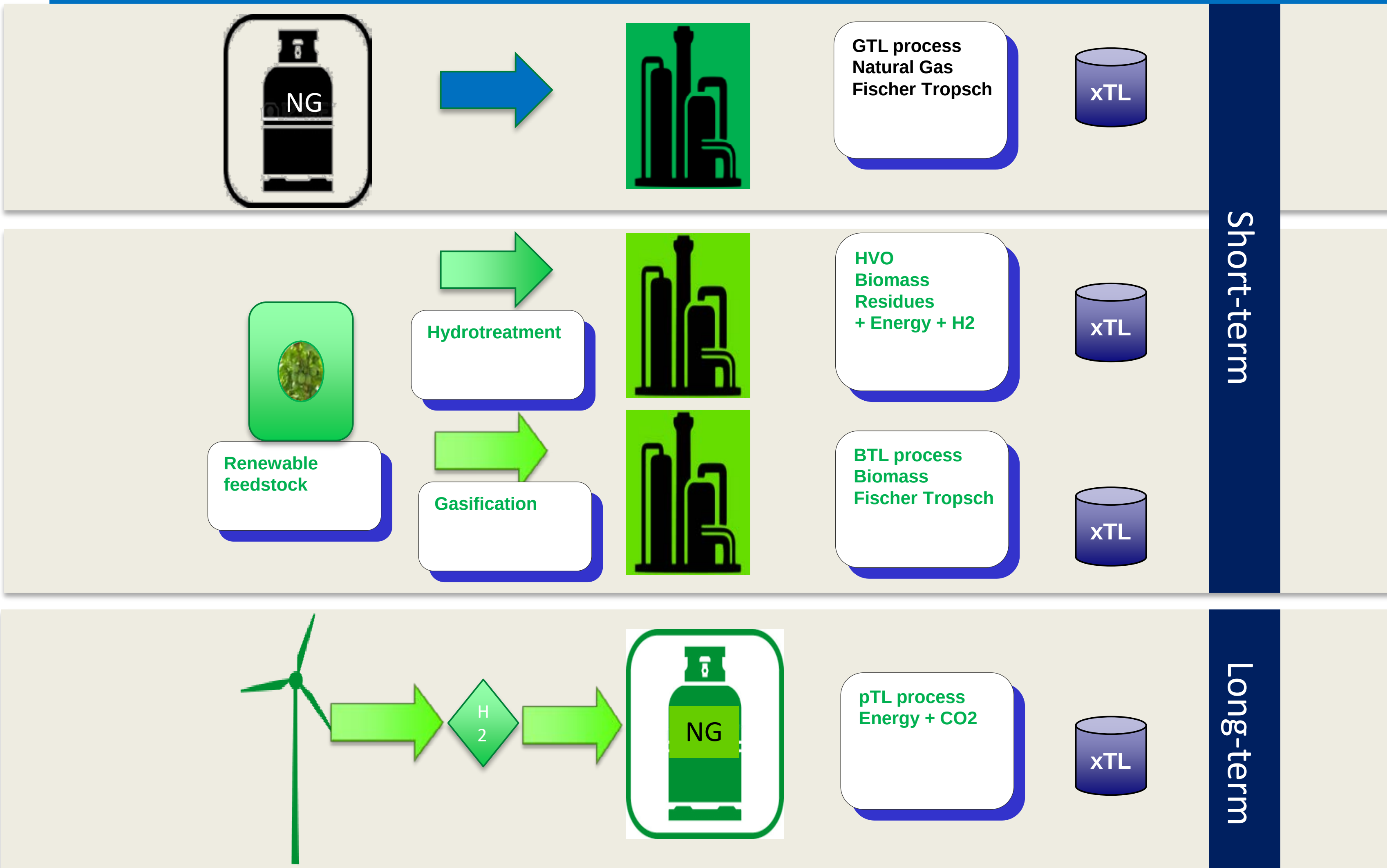
400 kt < 1,5 %

The Typical Time Line For New Molecules…



To Reach 2030 Climate Goals means…

XTL EN 15940 - Standard from several processes



Renewable Paraffinic Fuels – Pioneer for e-Fuels?!

Release for EN 15940

Effects on system & engine application to be checked, primarily:

☐ volumetric flow capacity of the high pressure pump

☐ temperature strain of nozzle tip

☐ peak firing pressure

Release status of OEMs*

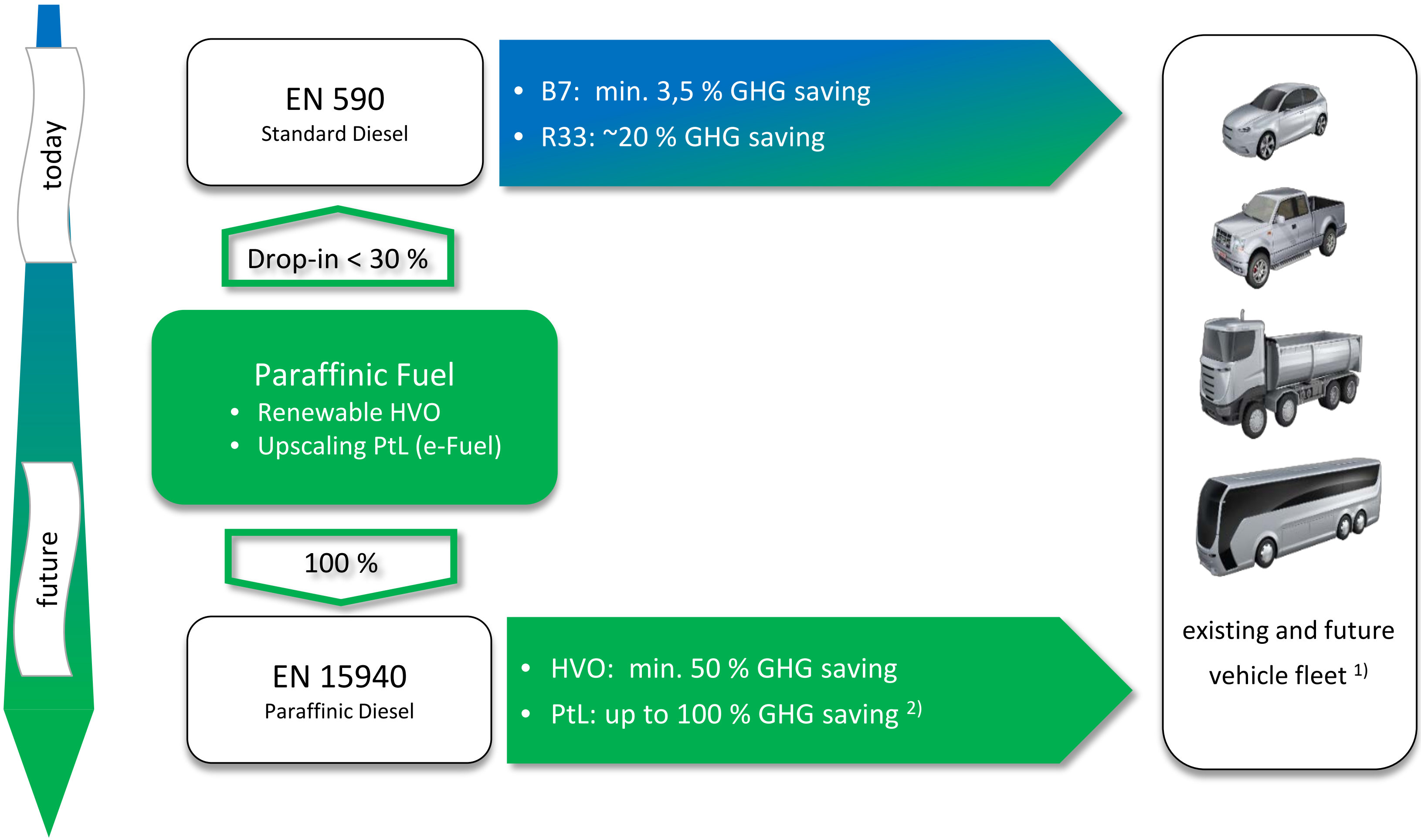
- DAF: Euro-3,-4,-5,-6 engines
- DEUTZ: all engines
- MAN Truck & Bus: D0834, D0836, D2066, D2676, D3876 Euro-5/6
- MERCEDES Trucks: OM470, OM471, OM934, OM936
- PSA (Peugeot und Citroen): Euro-5/6 engines
- Scania: Euro-6 engines
- Steyr Motors Marine: all engines
- VOLVO Penta: all engines
- VOLVO Trucks: Euro-5/6 engines

High share of fleet compatibility possible after release of OEM.
Number of OEM-releases for EN 15940 is continuously increasing.

Source: Robert Bosch GmbH C. Uhr, FEV ZeroCO2Mobility Conference, 2018

Renewable Paraffinic Fuels – Pioneer for e-Fuels?!

Summary 1/2



1) release of OEM necessary for EN 15940 2) depending on PTL share and source of renewable energy

Source: Robert Bosch GmbH C. Uhr, FEV ZeroCO2Mobility Conference, 2018

Renewable Paraffinic Fuels – Pioneer for e-Fuels?!

Engine Results at a Glance: Example Small OHW Engine

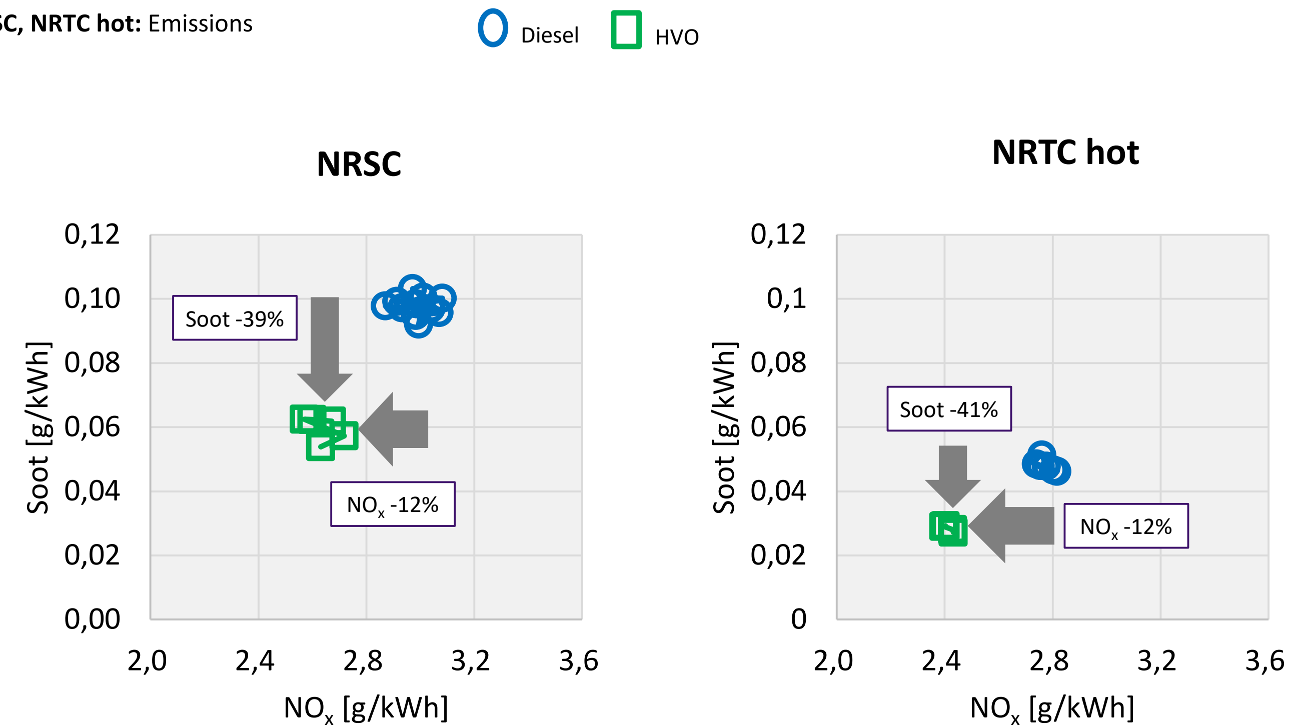
Engine, Engine Dyno

- Stage V / Tier 4f with DPF
- Displacement ca. 2,5 l, 4 cylinder
- Ca. 50 kW
- CRI 2-16 OHW

Test Program

- NRTC (hot)
- NRSC
- Engine map
- Full load curve
- EGR sweeps
- Assessment without DOC/DPF
- Diesel vs. 100% HVO

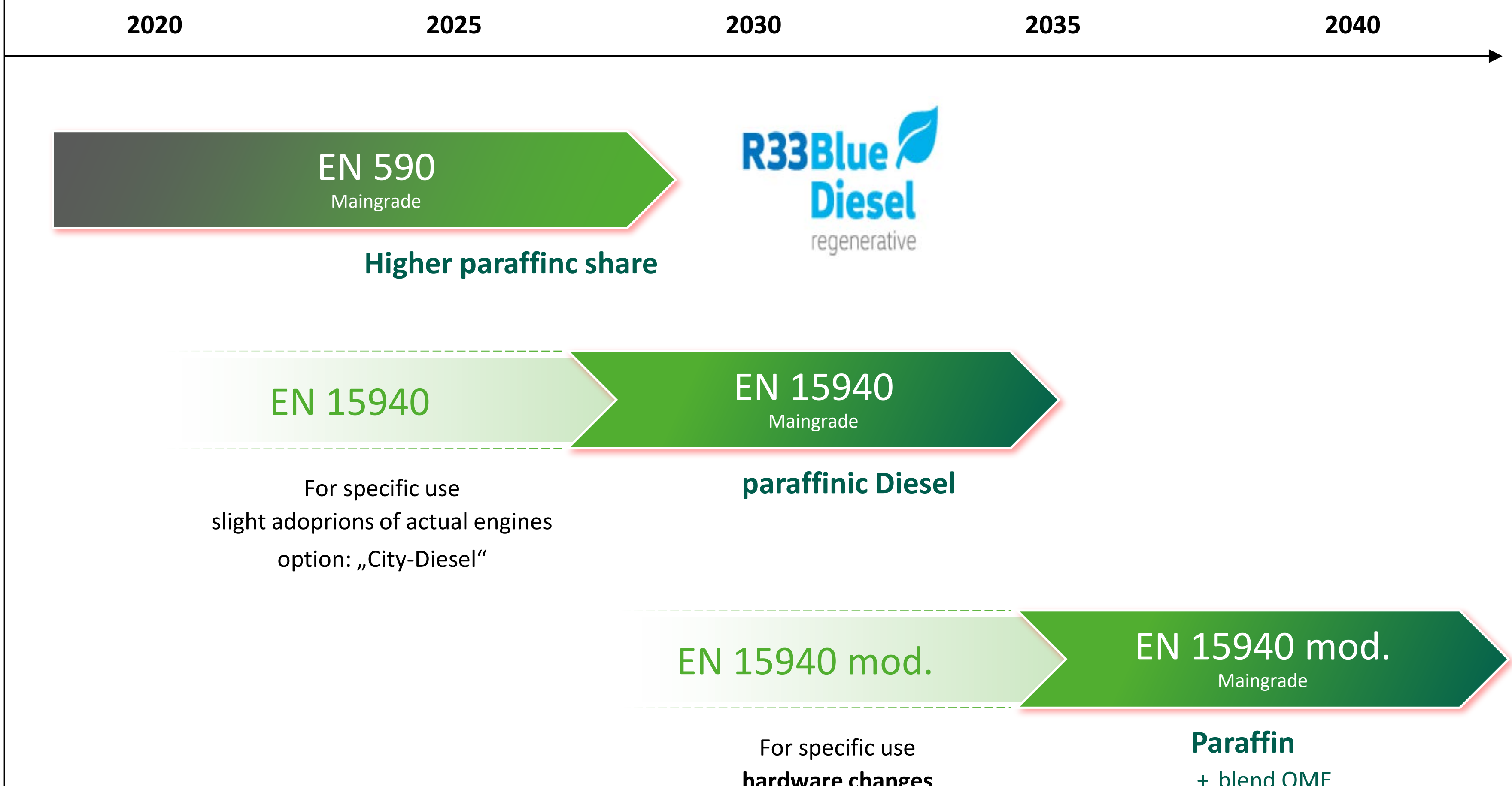
NRSC, NRTC hot: Emissions



Improved raw emissions → improved tail pipe emissions for strategies without exhaust gas treatment (e.g. < 56 kW Tier 4f with DOC only)

Source: Robert Bosch GmbH C. Uhr, FEV ZeroCO2Mobility Conference, 2018

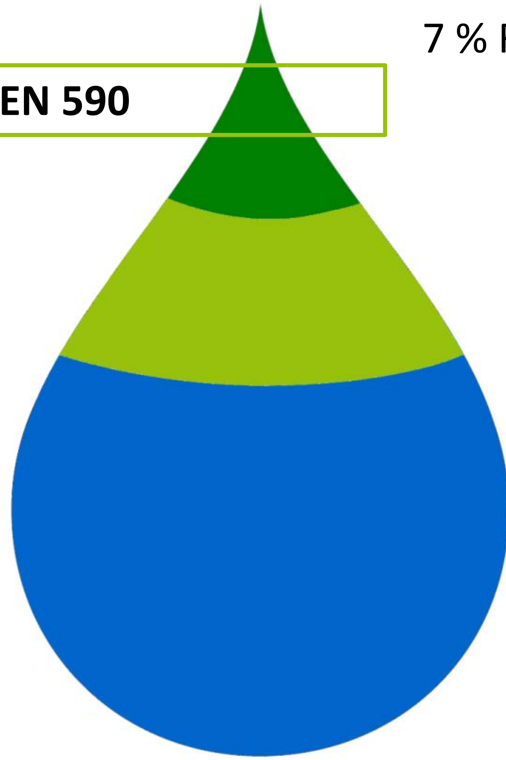
New fuels will be blends – VW Diesel fuel Roadmap



T. Garbe, H. Broeker, L. Kunkel, M. Unglert, J. Krahl

Composition of Diesel R33

Diesel R33 fullfills **DIN EN 590**

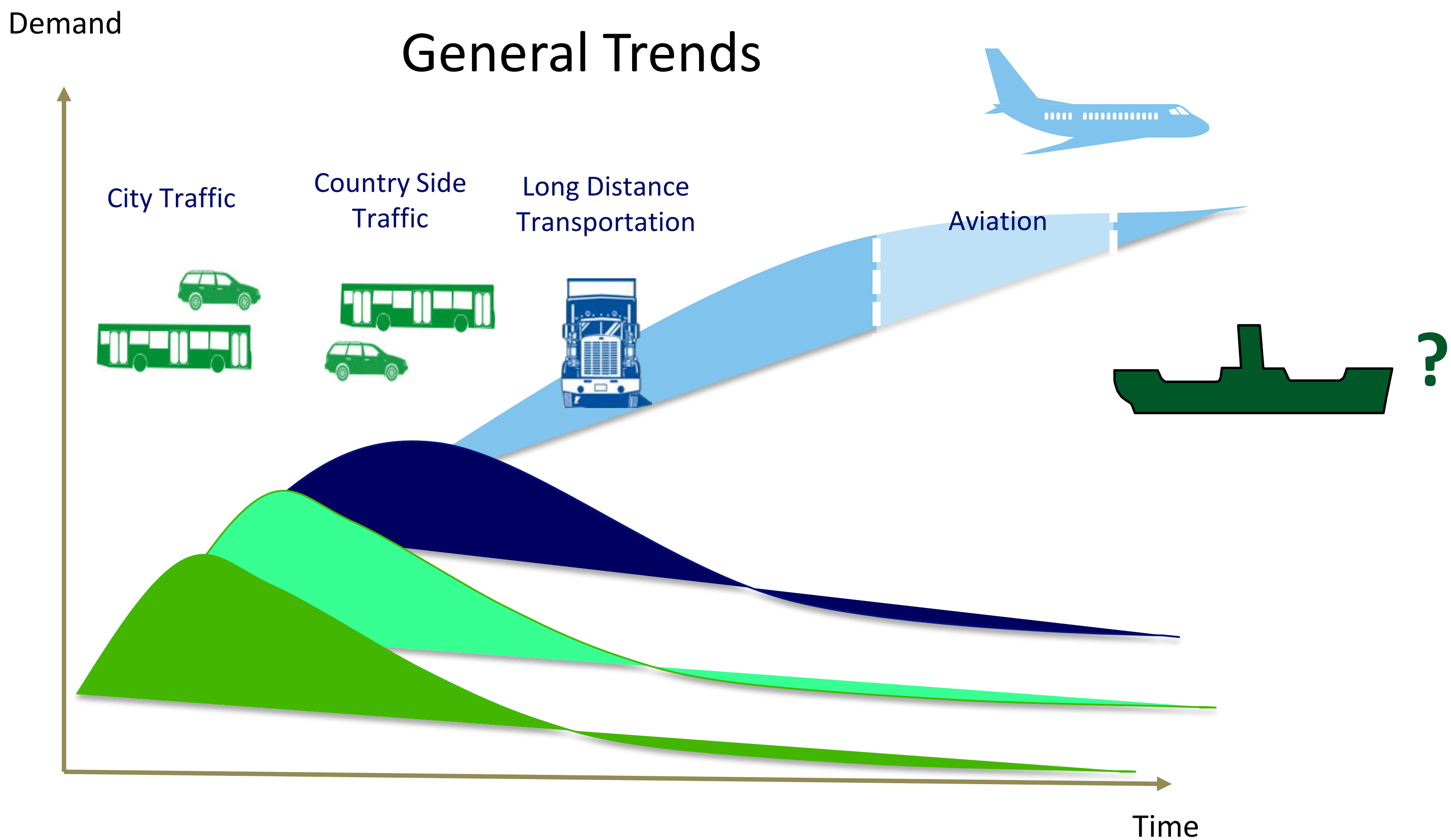


7 % FAME (UCOME)

26 % HVO from Waste and Residues

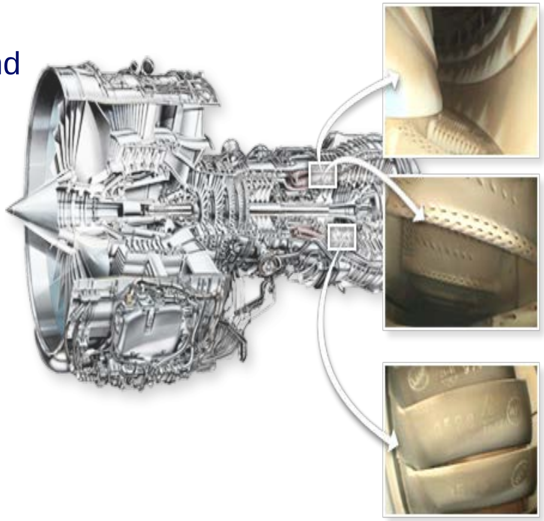
67 % high quality Diesel Fuel + Performance Additive

xTL Demand over Time and Application



Perfect fuel for aviation

1. During the operation
Aircraft and engine performed excellently
1% lower fuel consumption due
to the higher energy content
2. Inspection after the program
Fuel system, combustion chamber and
turbines in a perfect condition
Normal function and tightness of
fuel bearing parts
3. Storage stability
Density steady at 783 kg/cbm
No microbial issues



Source of the picture: Lufthansa

CO_2 reduction with XTL

- Engine optimization for XTL fuels opens new possibilities
- 10 % TtW CO_2 reduction is reported for GTL (SAE 2010-01-0737)
- We have results with Neste Renewable diesel that shows also for Euro 6c even higher TtW CO_2 savings!

XTL in future mobility

EN 15940 Parafinic
Diesel Plattform

WWFC Category V
Field test experience and
Euro VI approvals

Engine Optimisation brings
significant efficiency gains!

Together with Bio Oxygen
Componets Ultra clean
Diesel Fuel Concept

ADVANCED FUEL FORMULATION APPROACH USING BLENDS OF PARAFFINIC AND OXYGENATED BIOFUELS: ANALYSIS OF EMISSION REDUCTION POTENTIAL IN A HIGH EFFICIENCY DIESEL COMBUSTION SYSTEM

Presenter:

Christian Castanien	NESTE US Inc.

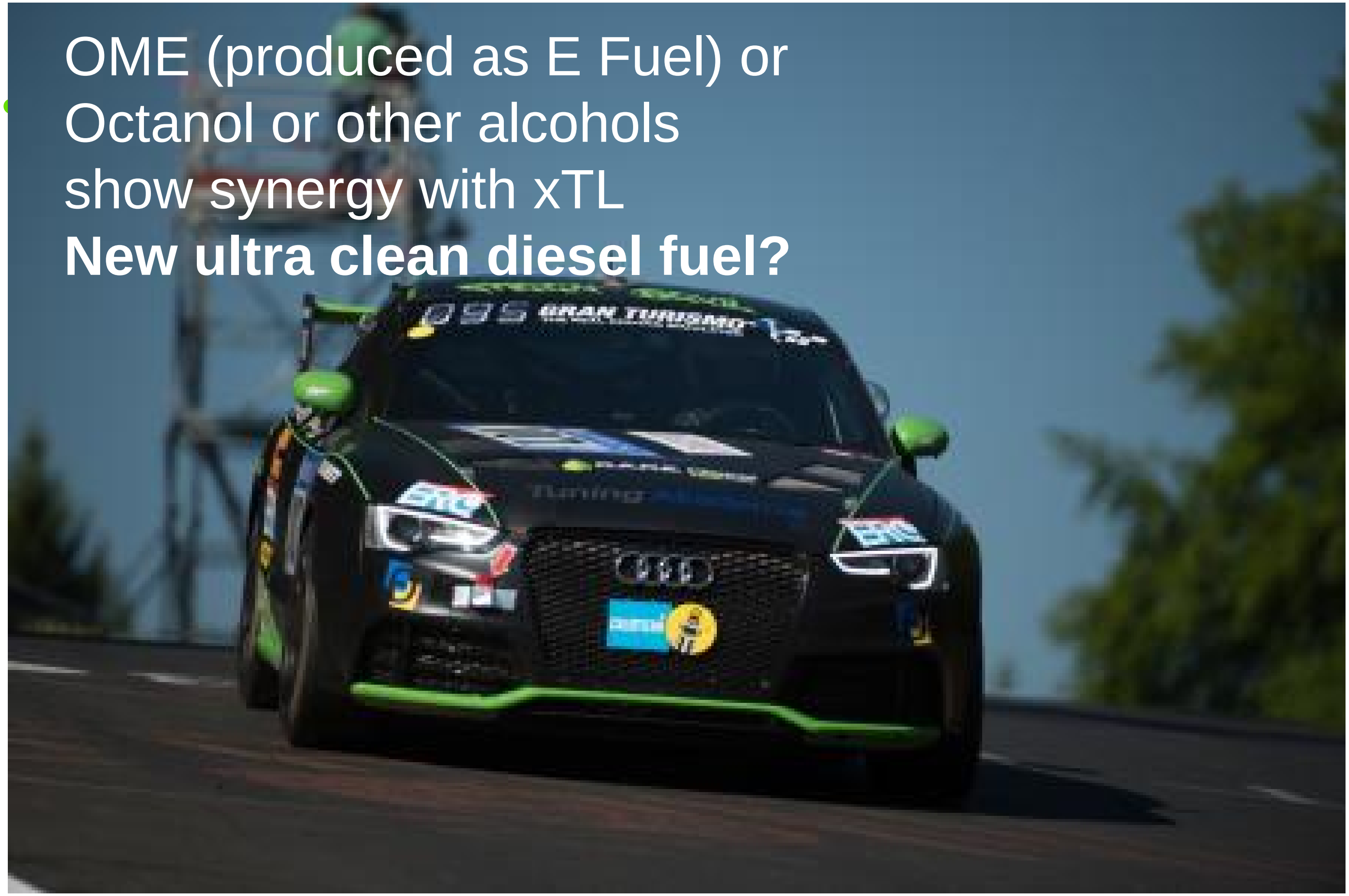
Author & Co-authors:

M. Zubel, B. Heuser	Institute for Combustion Engines, RWTH Aachen University, Germany
O.P. Bhardwaj, B. Holderbaum	FEV GmbH, Aachen, Germany
S. Doerr and J.Nuottimäki	NESTE Inc.

Ultra Clean xTL+Alc platform?

OME (produced as E Fuel) or Octanol or other alcohols show synergy with xTL

New ultra clean diesel fuel?



NESTE

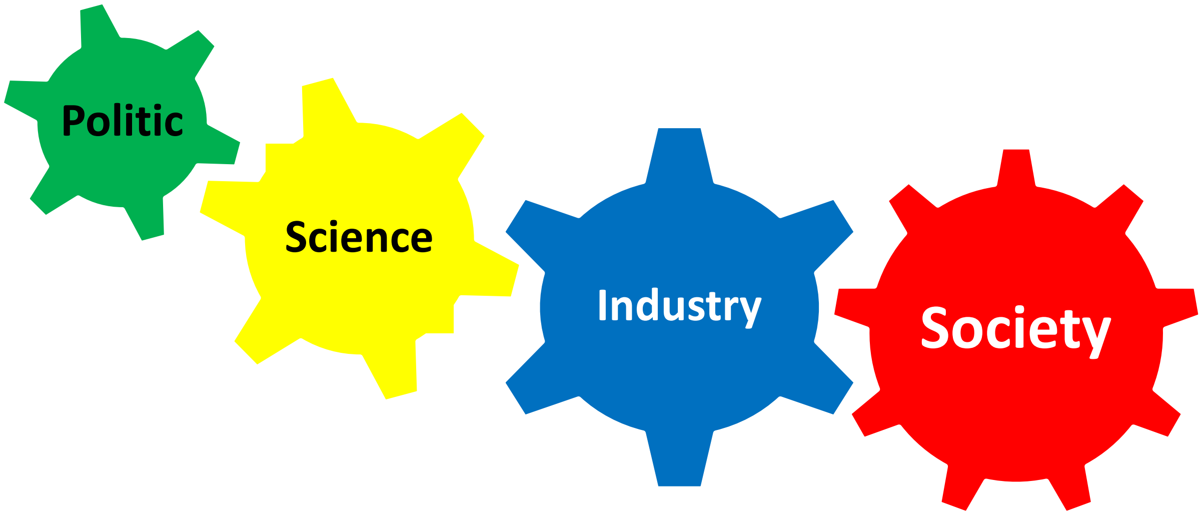
Climate Change is now – we have to act!

Competition makes stronger
E mobility infrastructure and fleet , complementary all existing renewable fuels are needed as well!

xTL fuels can be rolled out asap and bring strong savings in existing fleet

Renewable Hydrogen Infrastructure has to be build
power storage, H2 processes, fuel cells and E fuels

Sustainability Needs All of Us



Frame Work and long term ambitious targets

Innovations and Improved Processes

Investments and new Business Models

Acceptance and new priorities – new life style

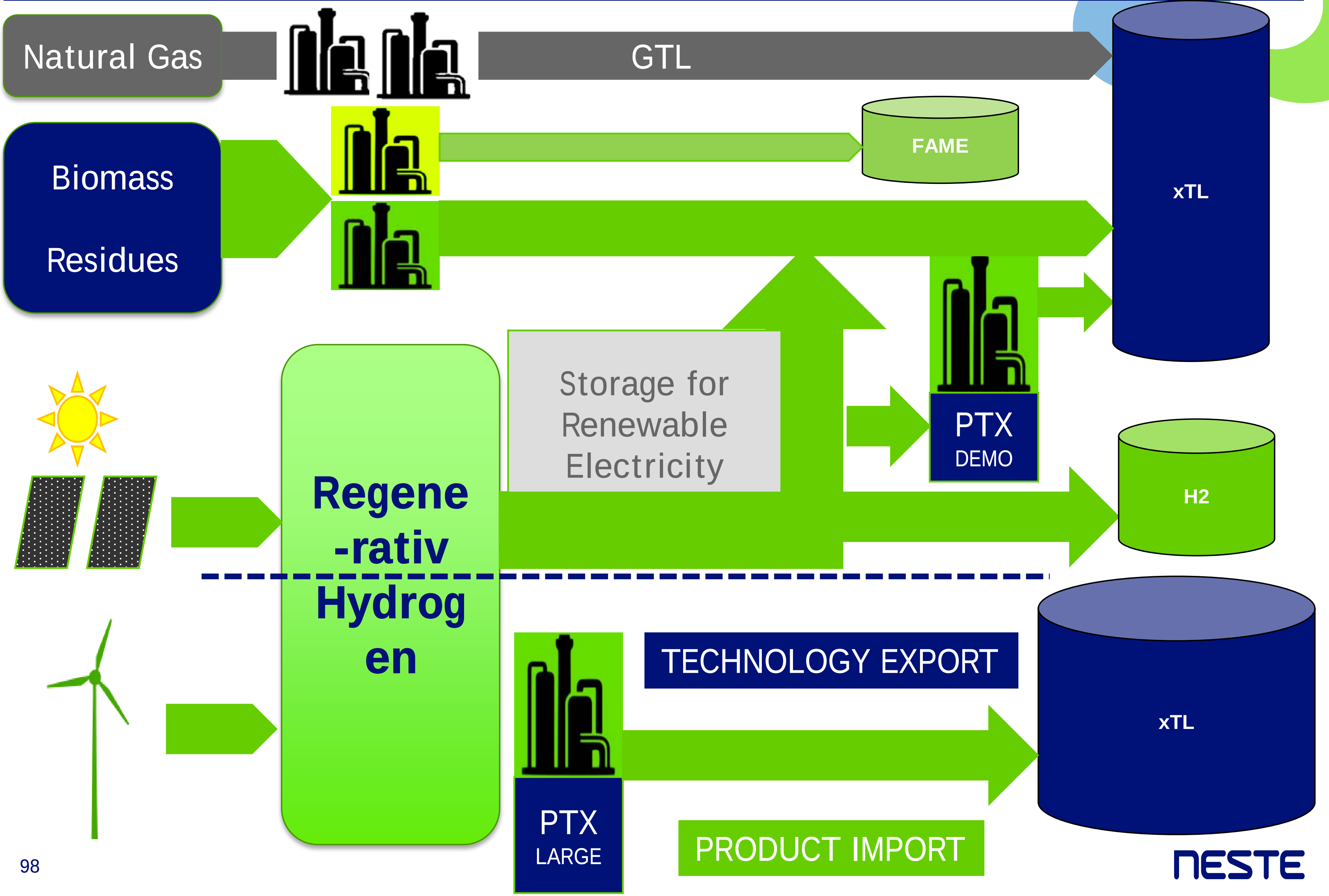
How to make it happen?

BEV is seen as key technology for sustainable mobility
But we need all options available!

Diesel R 33 shows that „more bio is possible“
If all Diesel would be replaced by R33 till 2030
This would reduce GHG by 20% within existing fleet!
Joint coalition Of OEM, Science fuel

xTL platform strategy of Science, Aviation Shipping and road transport towards sustainable mobility

Strategy for more xtl Fuel



Technology versus Ideology?