

A close-up photograph of industrial equipment, likely a Fischer-Tropsch synthesis reactor. The image shows a complex network of stainless steel pipes, valves, and fittings. Several blue-capped valves are visible in the upper left. A black rectangular label with the INERATEC logo is affixed to a horizontal pipe in the center-right. The background is blurred, showing more of the industrial structure.

INERATEC GmbH

COMPACT FISCHER-TROPSCH SYNTHESIS IN GAS-TO-LIQUID APPLICATIONS

2nd COMSYN workshop - Future of BTL products in Europe, Prague and Litvinov, Czech Republic, from May 23rd to 24th, 2019

We are depending on hydrocarbons made from oil and gas



Worldwide energy consumption 2035: >55% oil and gas

Annual CO₂ emissions: >35,000,000,000 tons

The revised renewable energy directive

- > **Target of 32 % renewable energy by 2030**
- > **Fight against climate change**
- > **Reduce air pollution**
- > **Clean energy production**
- > **Energy security**
- > **Create jobs and investments**
- > **Provide new policy frameworks**



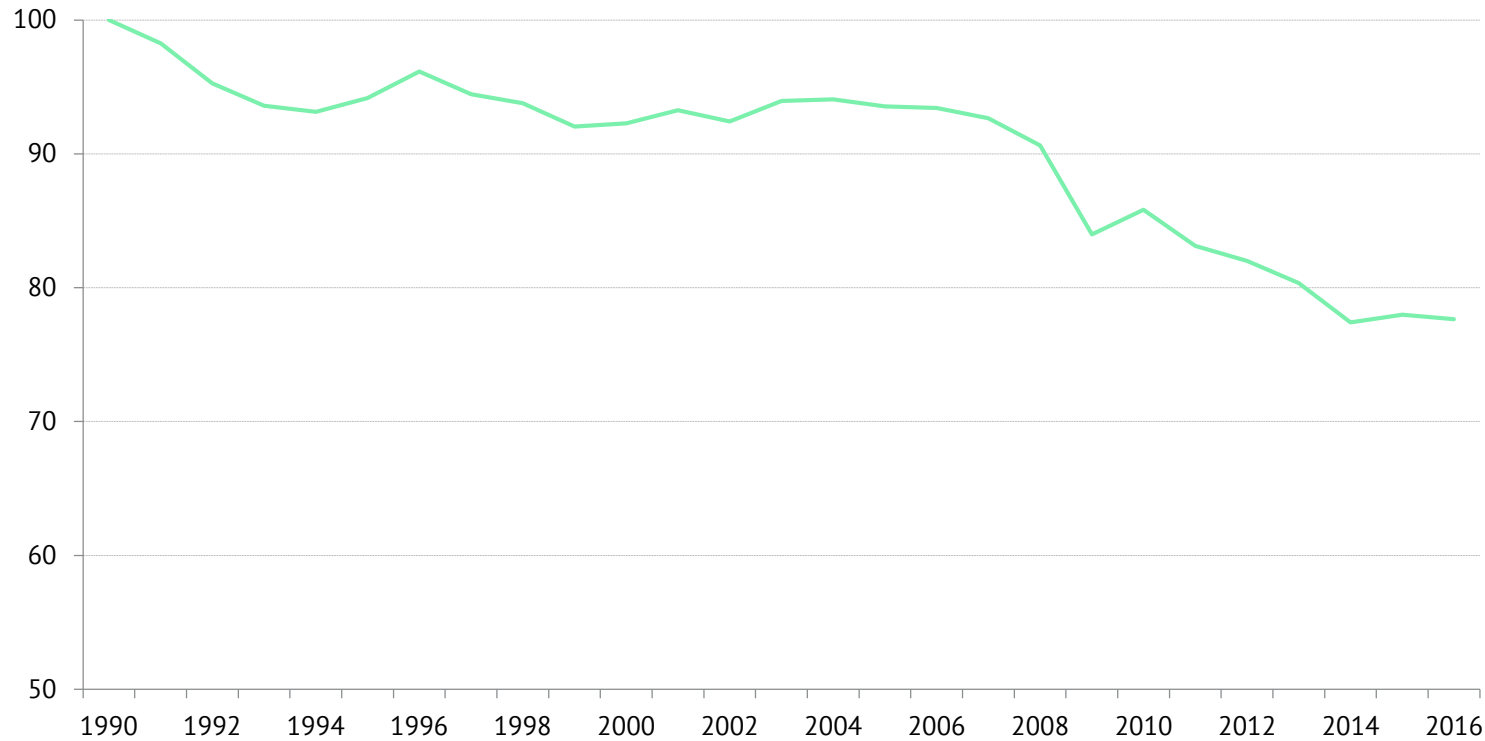
Renewable energy can be produced from a variety of sources, such as wind, solar, hydro, tidal, geothermal and biomass.

**RENEWABLES ARE GOOD FOR EUROPE
AND EUROPE IS GOOD AT RENEWABLES.**

Europe is successfully reducing GHG emissions since 1990

23.05.2019

Greenhouse gas emissions trend, EU-28, 1990 - 2016 (Index 1990=100)



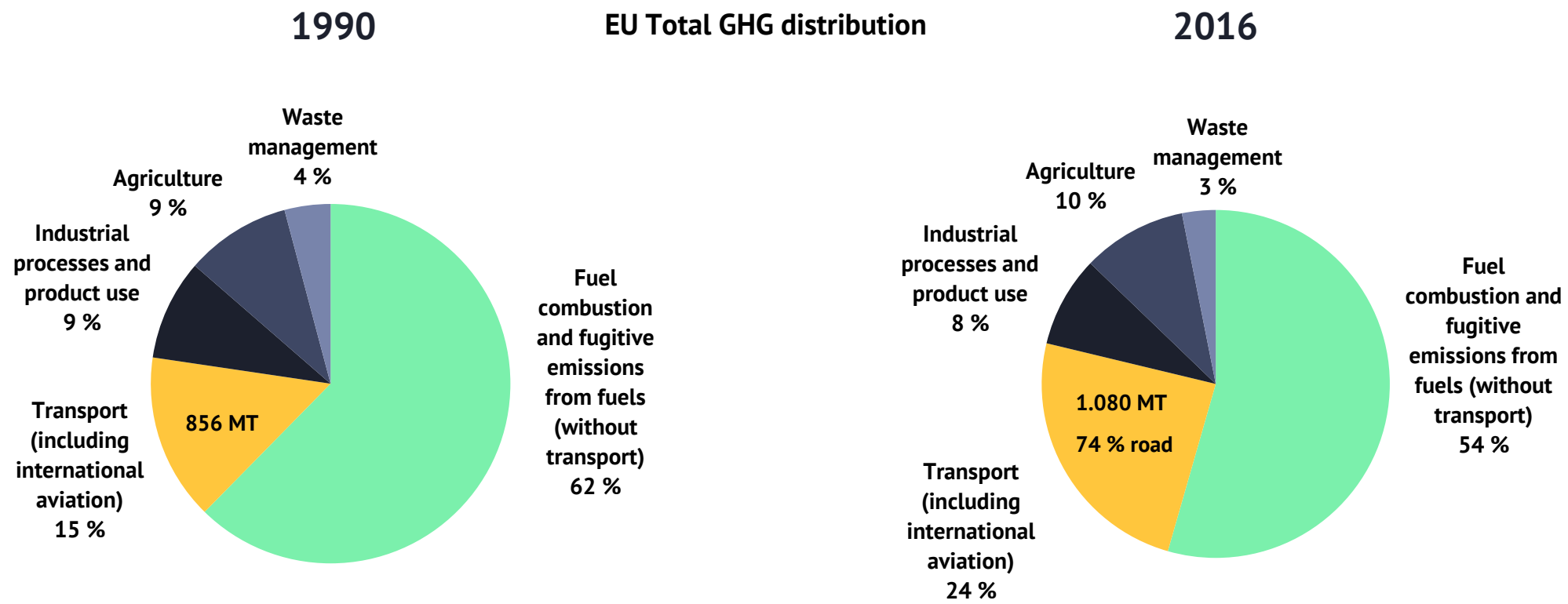
EU Total GHG:

1990: 5.715 MT CO₂ eq.

2016: 4.439 MT CO₂ eq.

Huge demand for solutions in the transport sector

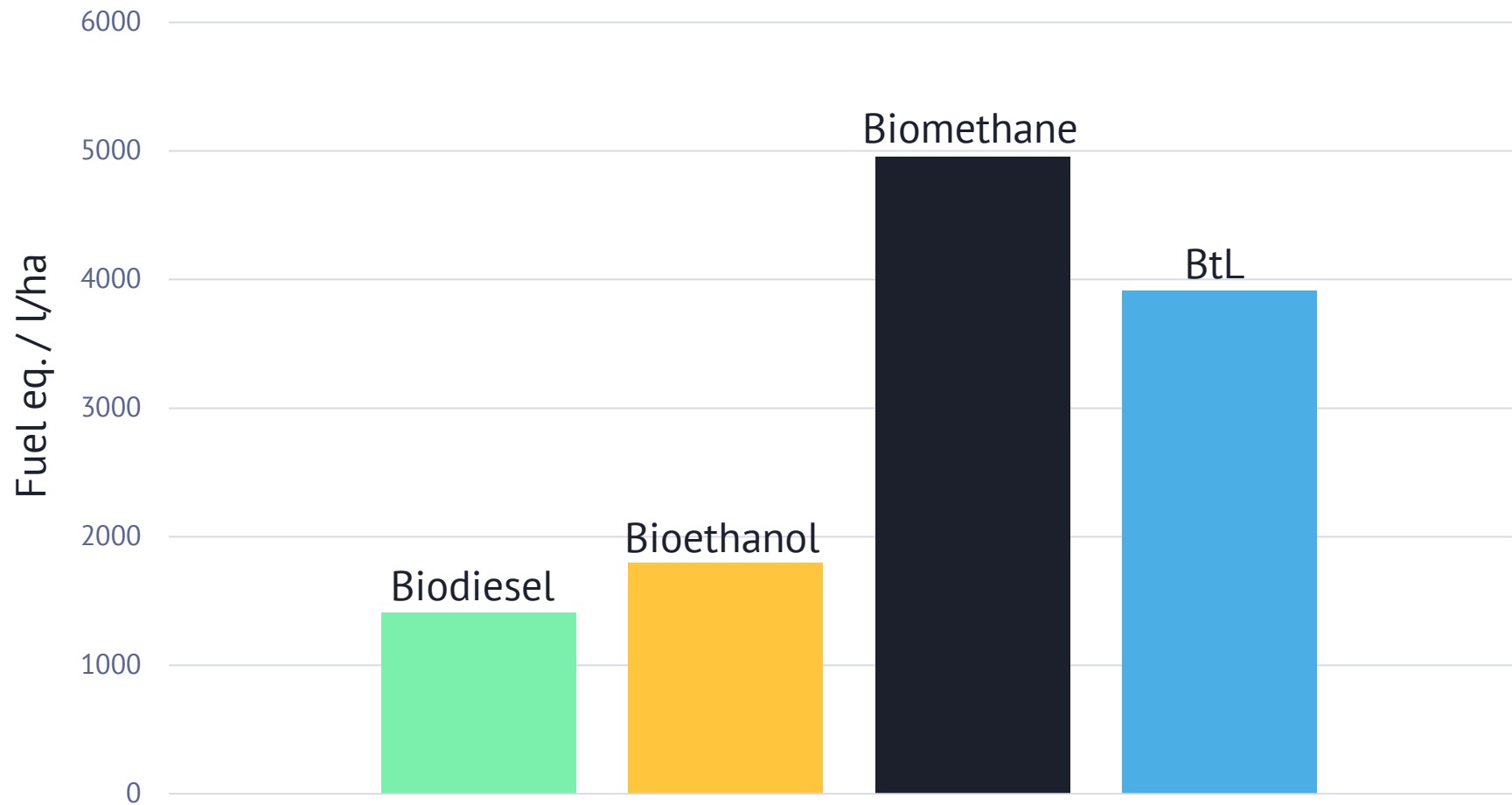
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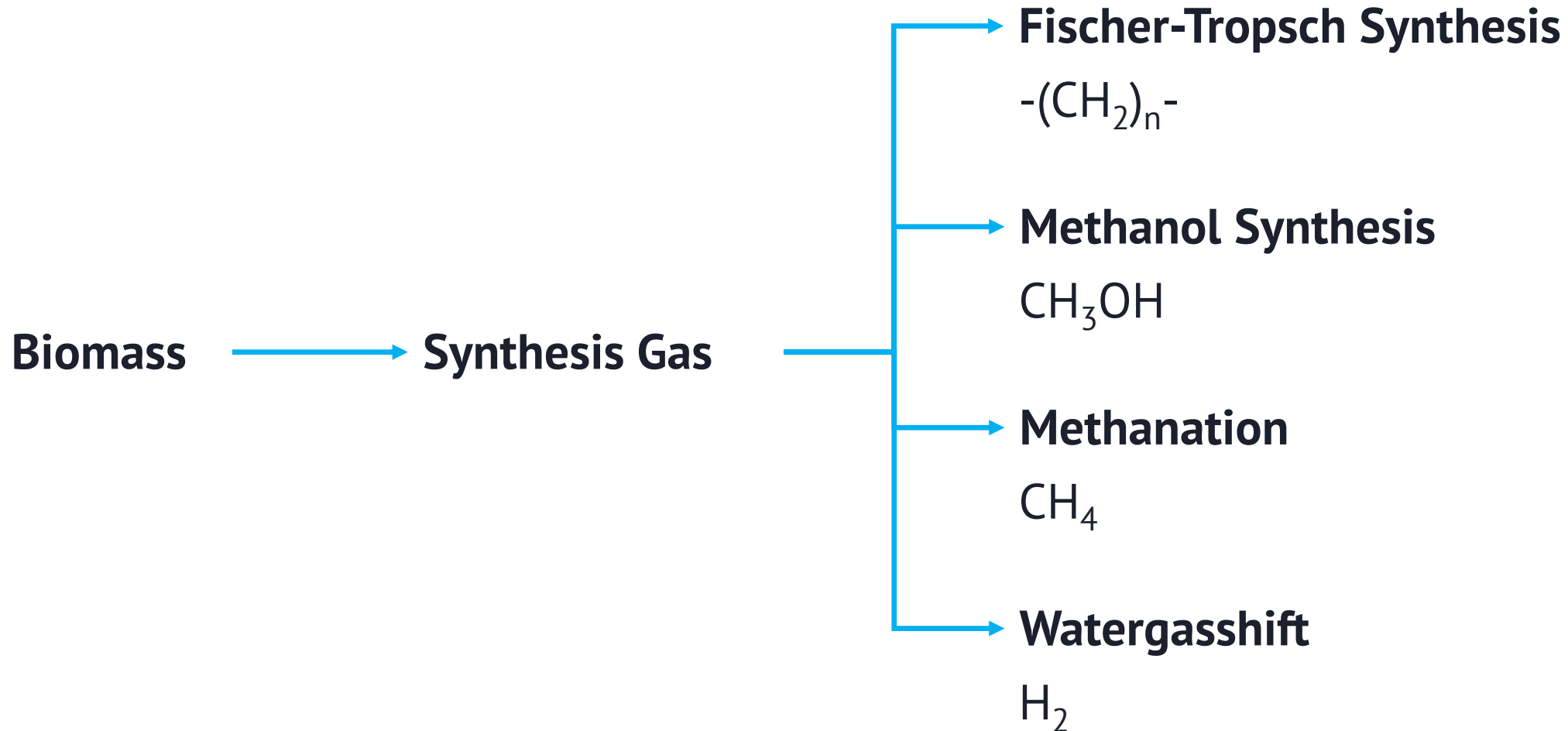
Huge potential for growth of biofuels in Europe

- > 1 % of total energy consumption is covered by biofuels**
- > 3.4 % biofuels in transport sector**
- > 80 % biodiesel, 20 % bioethanol**
- > 2/3 produced in EU, 1/3 produced outside of EU**

BtL offers the highest biofuel yield from biomass after CH₄



Process routes to produce biofuels

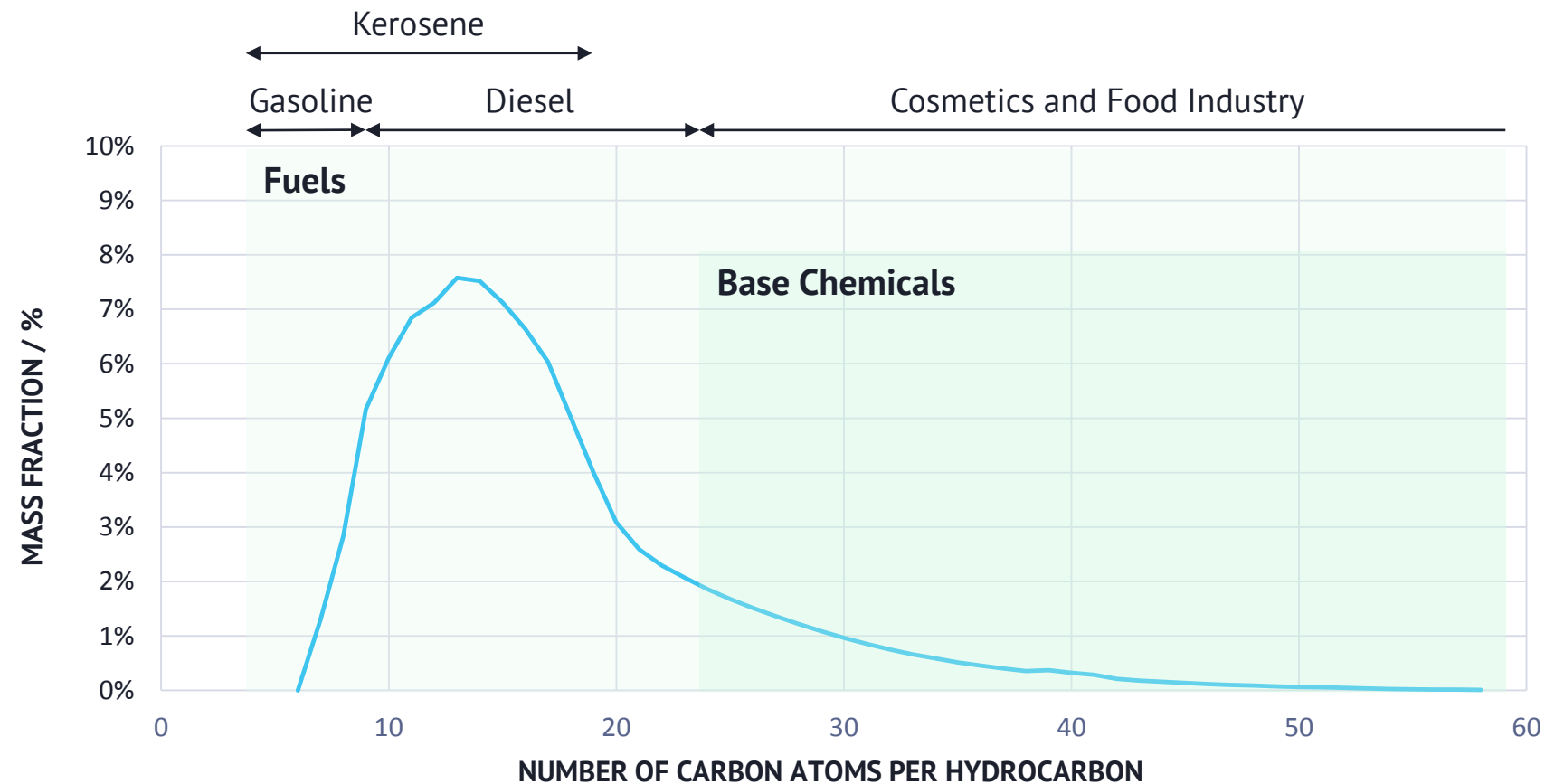


Fischer-Tropsch products offer the highest energy density and can be implemented in existing infrastructure using available technology

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Synthesis Products	$-(CH_2)_n-$	CH_3OH	CH_4	H_2
Energy density (MJ/m ³)	30000	16000	36	11
State of aggregation	Liquid	Liquid	Gas	Gas
Infrastructure available	Yes	Yes	Partially	Partially
Vehicles technology	State of the art	Blend, Fuel cell	State of the art	Fuel Cell
Production technology	Available and comparable			

Refining needed to produce end products

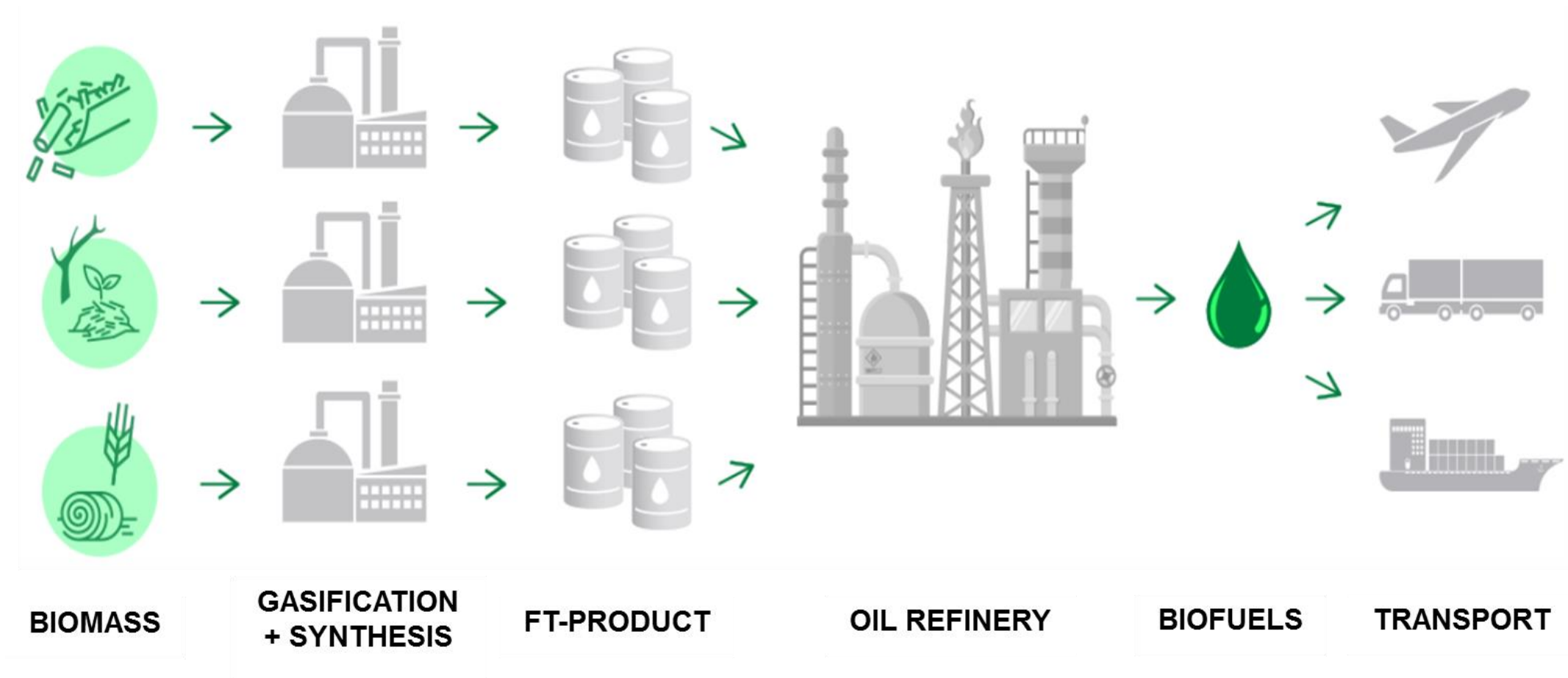


Competing technologies do not match with renewable energies

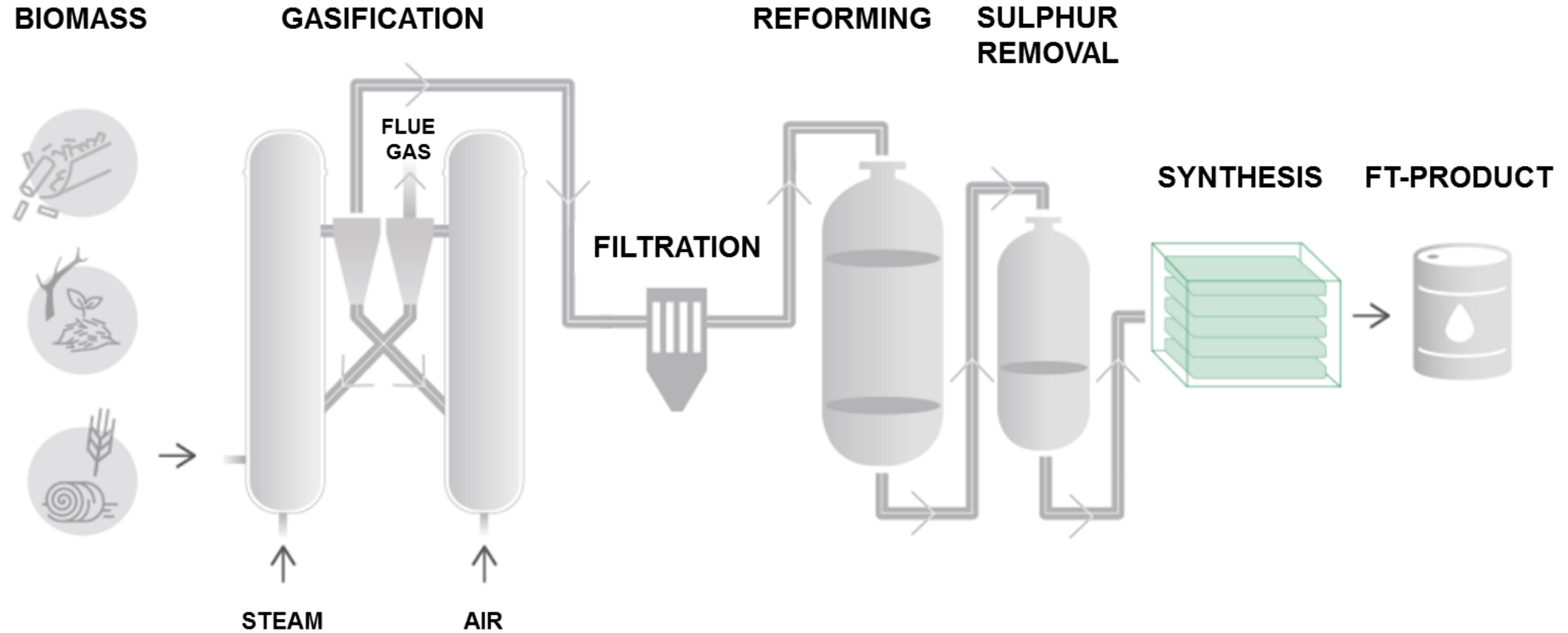


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Decentralized approaches are necessary to harvest biomass



Matching technologies need to be developed



Micro process engineering can scale down Fischer-Tropsch Synthesis



ADVANTAGES

- High surface to volume ratio
- High product yield per mass of catalyst
- Isothermal reaction conditions by advanced cooling for optimal reaction conditions
- In-situ steam generation for heat integration
- Short start-up and shut down times
- Modular scalability by numbering up

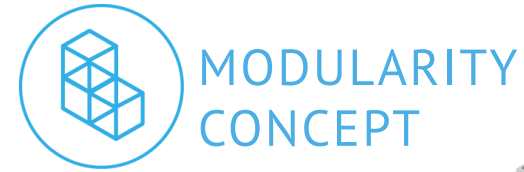
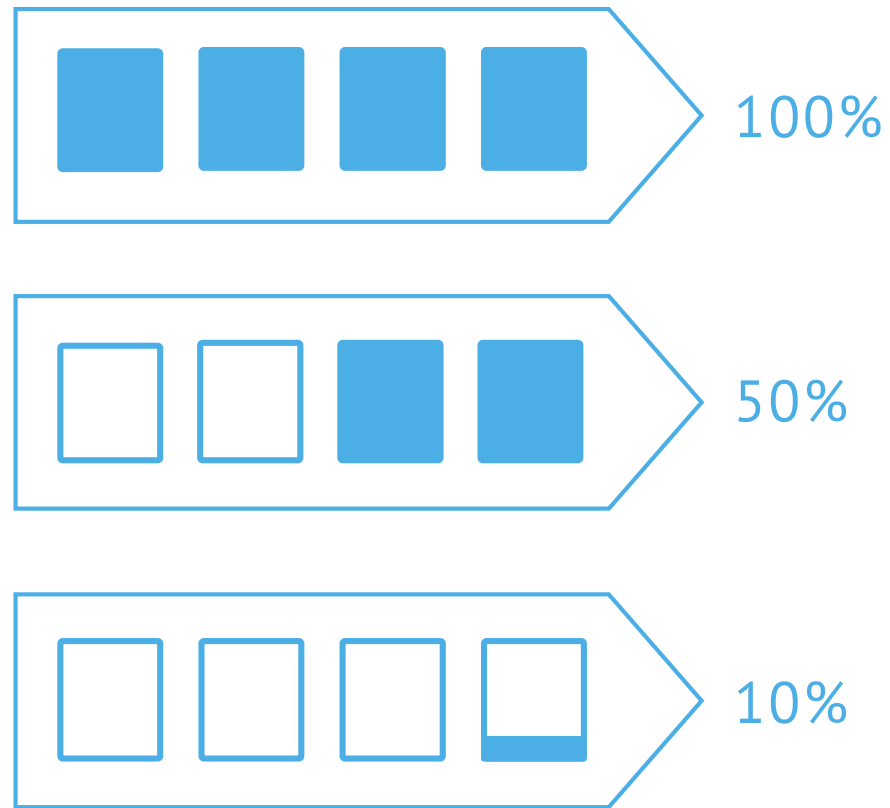
CHALLENGES

- Innovative process
- Establishment of serial production for scaling the business model

INERATEC offers the most compact Fischer-Tropsch Synthesis

Technology	Reactor productivity (C ₅₊ /reactor weight)	Space time yield (C ₅₊ /reaction volume)
INERATEC	16.7 bpd/t	1785 kg/m ³ h
Velocys	13 bpd/t	1600 kg/m ³ h
Oryx GTL – Sasol	8 bpd/t	20.6 kg/m ³ h

Numbering up to reduce costs and risks for small to medium scale applications





Conclusions

- > By addressing biofuels we are able to tackle one of the major energy sinks and CO₂ emitting sectors in Europe**
- > Huge demand and potential growth for biofuels in the transport sector**
- > BtL offers the highest biofuel yield from biomass after CH₄**
- > FT products offer high energy density and existing technologies for distribution and application**
- > Decentralized approaches are necessary to produce biofuel and we are developing them in COMSYN**

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