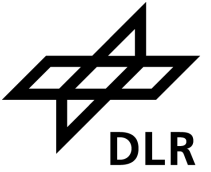


Demand for Green Fuels and Import Options for the EU

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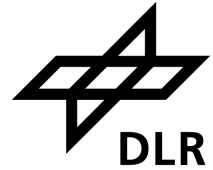


Outline



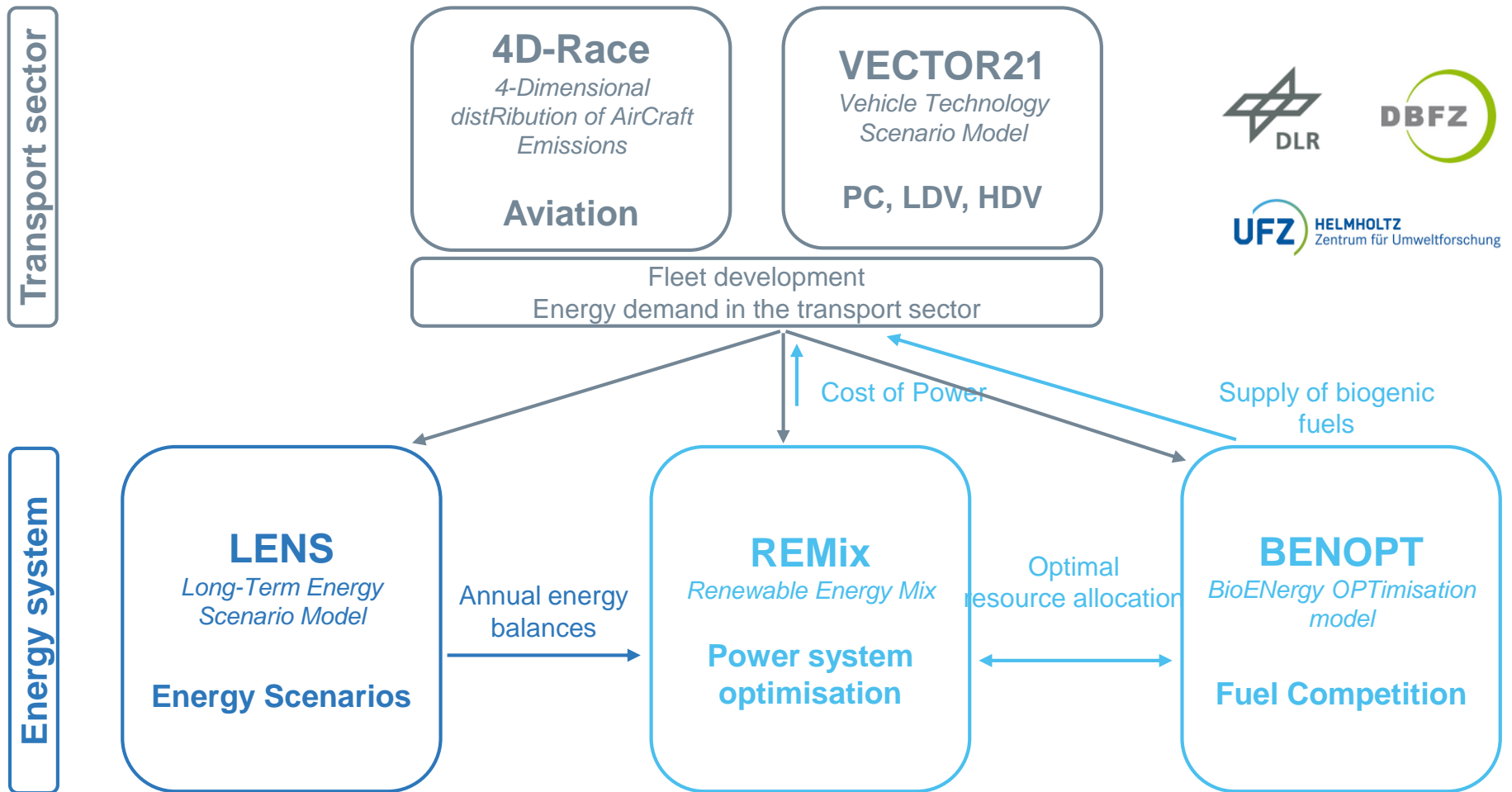
- Modelling setup
- Aviation
- Shipping
- Import from MENA
- Global fuel trade

Integrated Energy and Transport Modelling in BENiVer



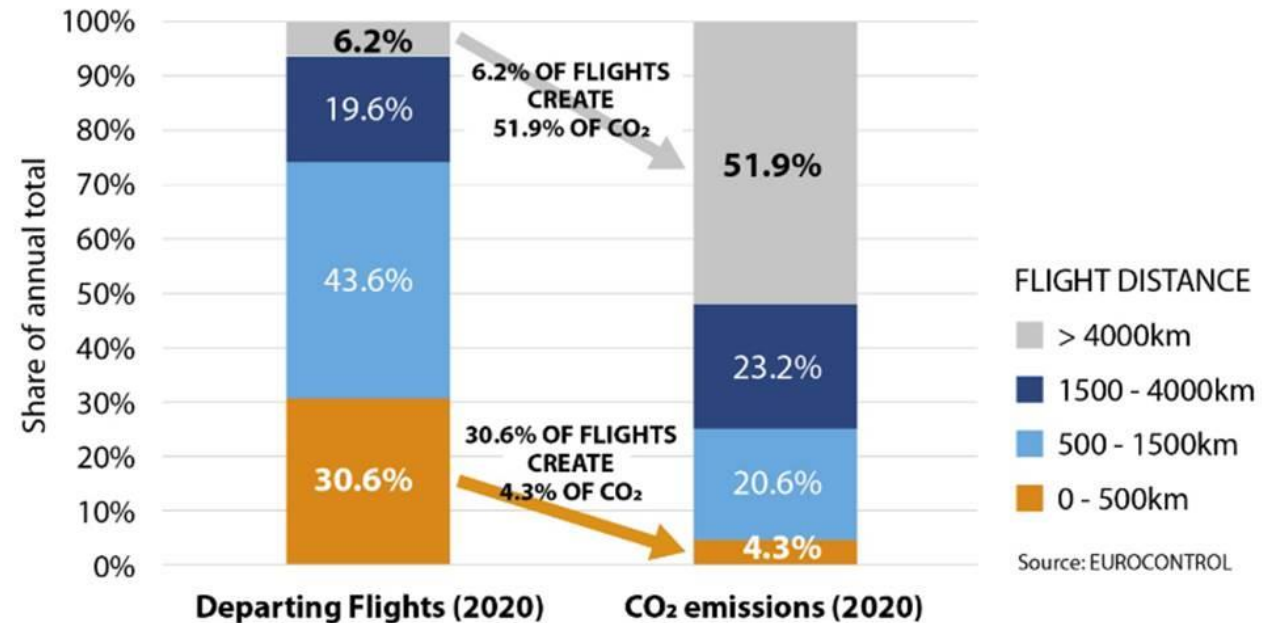
■ Coupled modelling system

- Aviation (4D-RACE)
- Road Transport (Vector21)
- Power system (REMix)
- Energy balances (LENS)
- Fuel Competition (BENOPT)



Aviation Demand

- About 25% of the flights are > 1500 km
- About 75% of the CO₂ Emissions or Fuel demand is from these flights
- Main emissions and demand come from long distance flights
- Energy carrier with a high gravimetric and volumetric density is required



Source: <https://www.eurocontrol.int/publication/eurocontrol-data-snapshot-co2-emissions-flight-distance>

Fuel demand/CO2-Emission for different Plane Sizes and Travel Distances



Aircraft Class	Seats	Flight Distance (km)											CO2	Flights	Passenger -km
		0-1000	1000-2000	2000-3000	3000-4000	4000-5000	5000-6000	6000-7000	7000-8000	8000-9000	9000-10000	>10000			
Commuter	0-19												0,08%	2,0%	0,03%
Extra-Small	20-100												4,3%	23,9%	3,6%
Small	101-210												37,3%	58,3%	41,9%
Medium	211-300												25,6%	10,2%	24,5%
Large	>300												32,7%	5,6%	29,9%
CO2		17%	22%	12%	8%	5%	5%	6%	5%	5%	5%	9%	Share of total in 2020		
Flights		55%	28%	9%	3%	1%	1%	1%	1%	0%	0%	1%			
Passenger-km		15%	25%	14%	9%	5%	5%	6%	5%	5%	5%	8%			

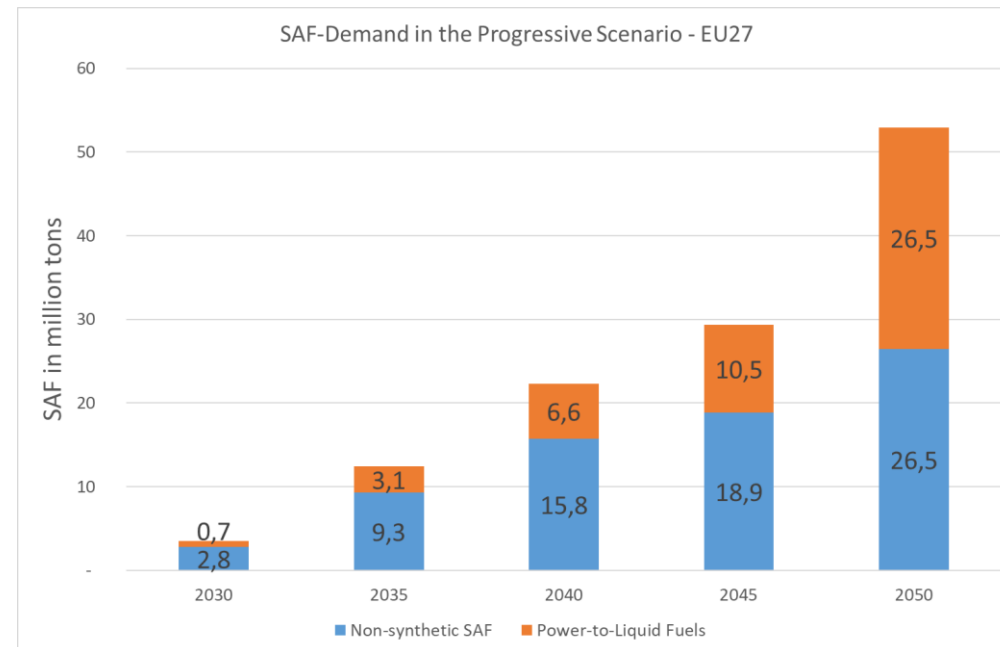
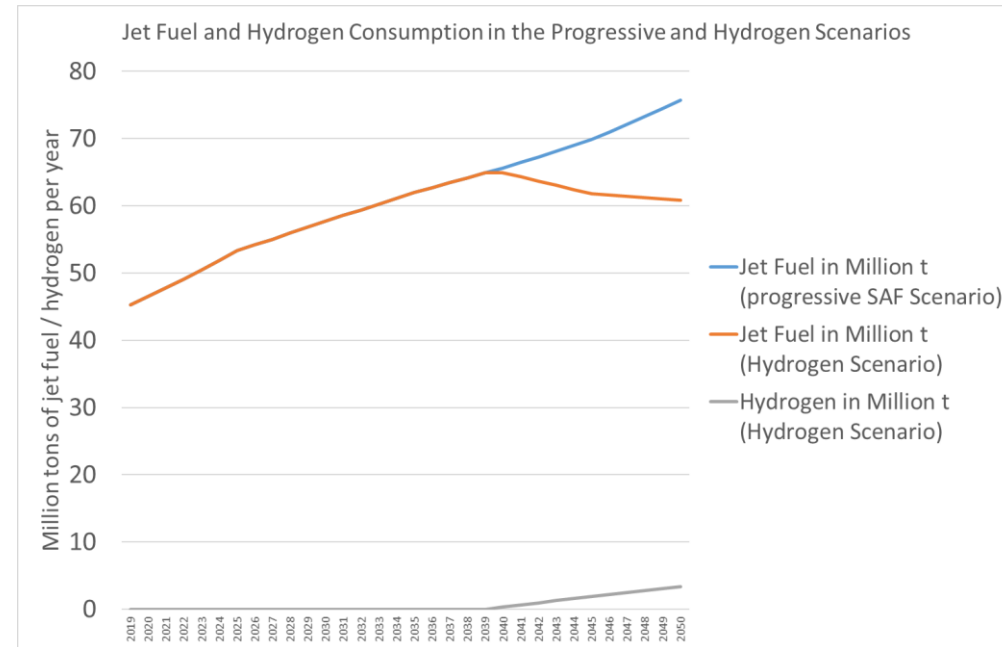


Source: Clean Sky Technology Evaluator, https://cleansky.paddlecms.net/sites/default/files/2021-10/TE-FGA-TR_en.pdf

Only 5% of all flights have a distance > 3000 km –
but these are responsible for 49% of the emissions and fuel demand

Aviation demand

- Progressive scenario: Efficiency improvement in aviation technologies
- Fuel demand is rising in EU 27
- Hydrogen planes starting 2040 for distances up to 2500 km, may slightly reduce the fuel demand
- SAF share from REFueIEU Aviation/Fit-for-55 (rising towards 70% SAF in 2050)
- High demand in Power2X Fuels, more than 25 Mio t in 2050.



Shipping

- Alternative fuels need higher storage volumes
- Recent update of IMO targets in 2023:
 - Net zero by 2050
 - Fuel uptake from 2030
- Maersk is building methanol ships
- Battery and fuel cell prototypes for inland and short distances (e.g. ferries).
- The future is still quite open
 - Possibly a multifuel world depending on distances and routes
 - New IMO targets require actions

Fuel	Relative required Tank Volume
VLSFO	1
LNG	1.6-2
LPG	1.5-2
Methanol	2.5
Ammonia	4
Hydrogen	6-10

Source: DNV Webinar Alternative ship fuels, April 28th, 2022



Source: own image

Road Transport: Special Vehicles, Agriculture, ...

Special Vehicles

- Agriculture
- Construction machines
- Firefighters, Police, Assistance
- Military
- Busses

Challenges

- High cost for replacements
- Low operation times
- High willingness to pay to continue operation



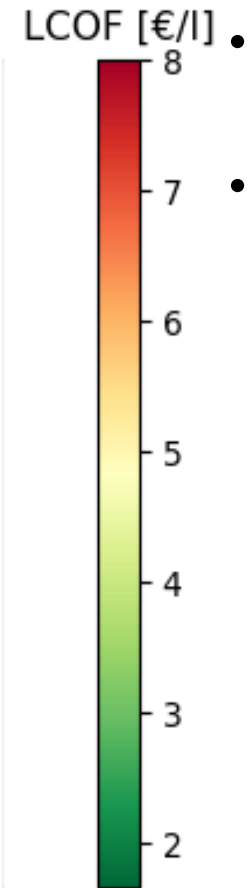
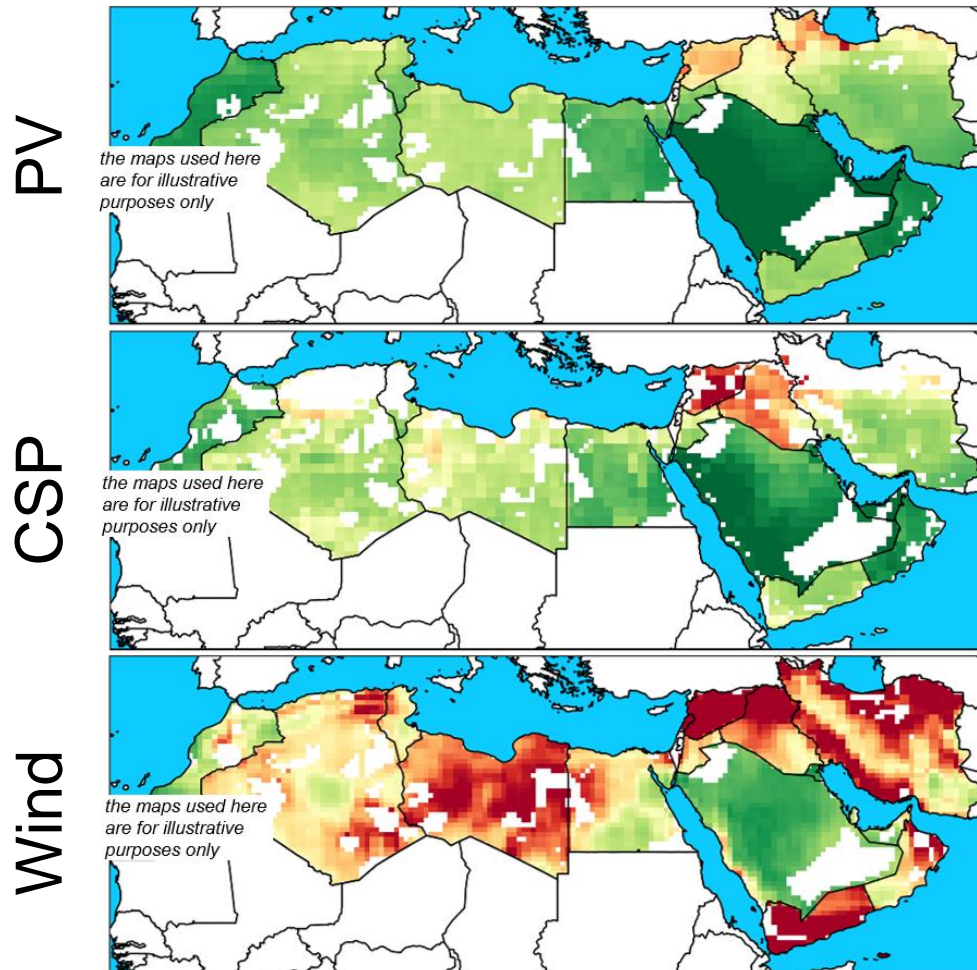
Source: Wikimedia CC0-License

Fuel demand

- 1.7 Mio tonnes per year in Germany

Import from MENA-fuels: Levelised Cost of synthetic Fuels in MENA for different RE Technologies

- With specific country risks (WACC)



• Significant influence of country specific risk assessment on LCOF

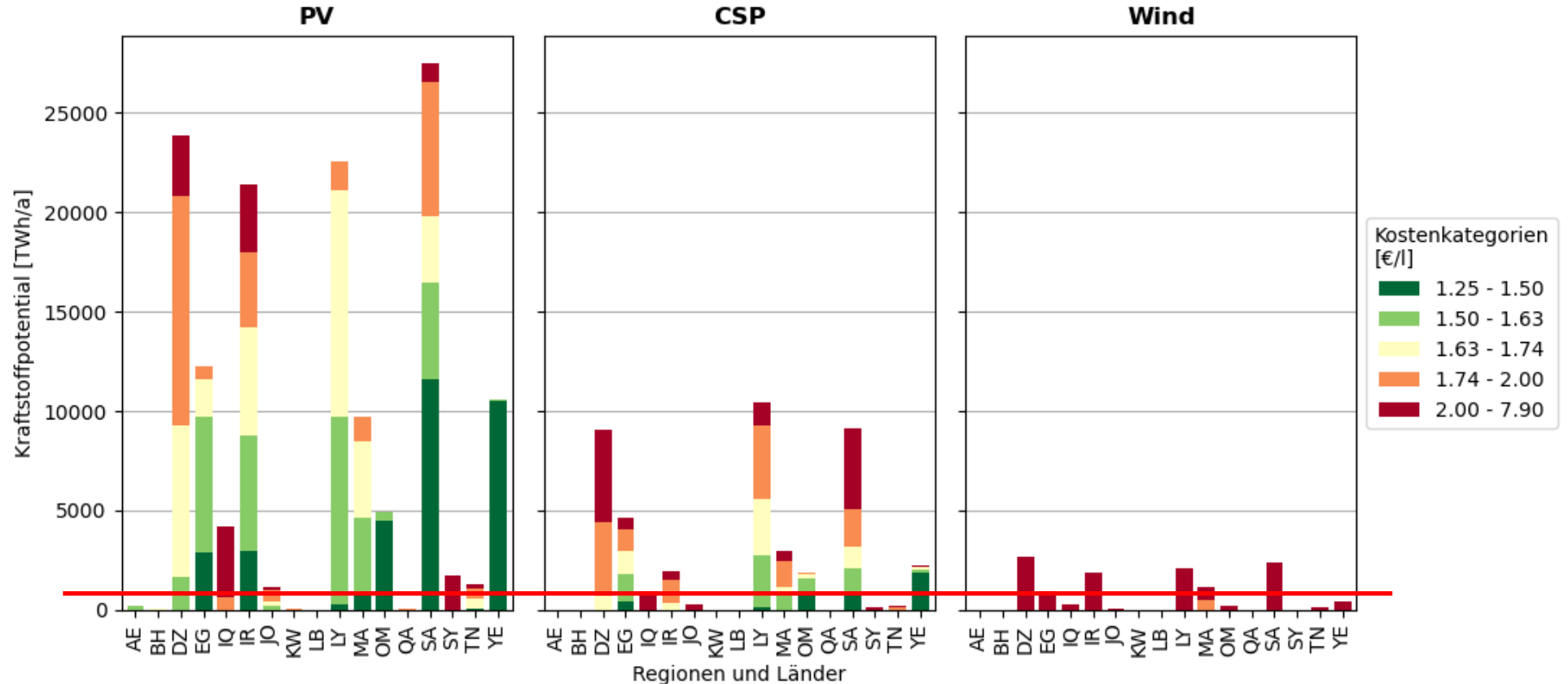
• Regions with low LCOF

- PV, CSP und Wind (all)
 - Region Morocco
- PV und CSP (Solar)
 - Red Sea (EG, JOR, S-A)
 - South of Libya
 - Yemen and Oman
- Wind
 - Algeria, Centre
 - South of Libya
 - Southeast of Egypt
 - Saudi-Arabia, Centre

MENA-fuels: Cost Potentials of synthetic Fuels in the MENA Regions for specific RE Technologies



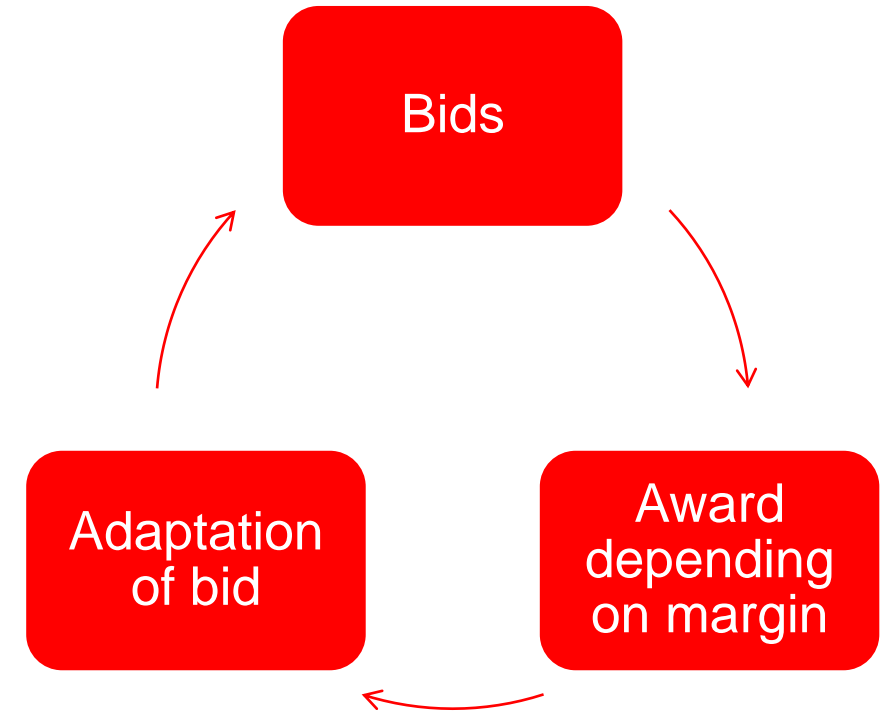
- With consideration of their own demand



- Very high export potential
- Comparison to the German demand in the transport sector (scenario classical drive trains) for 2050: ca. 435 TWh/a (red line)

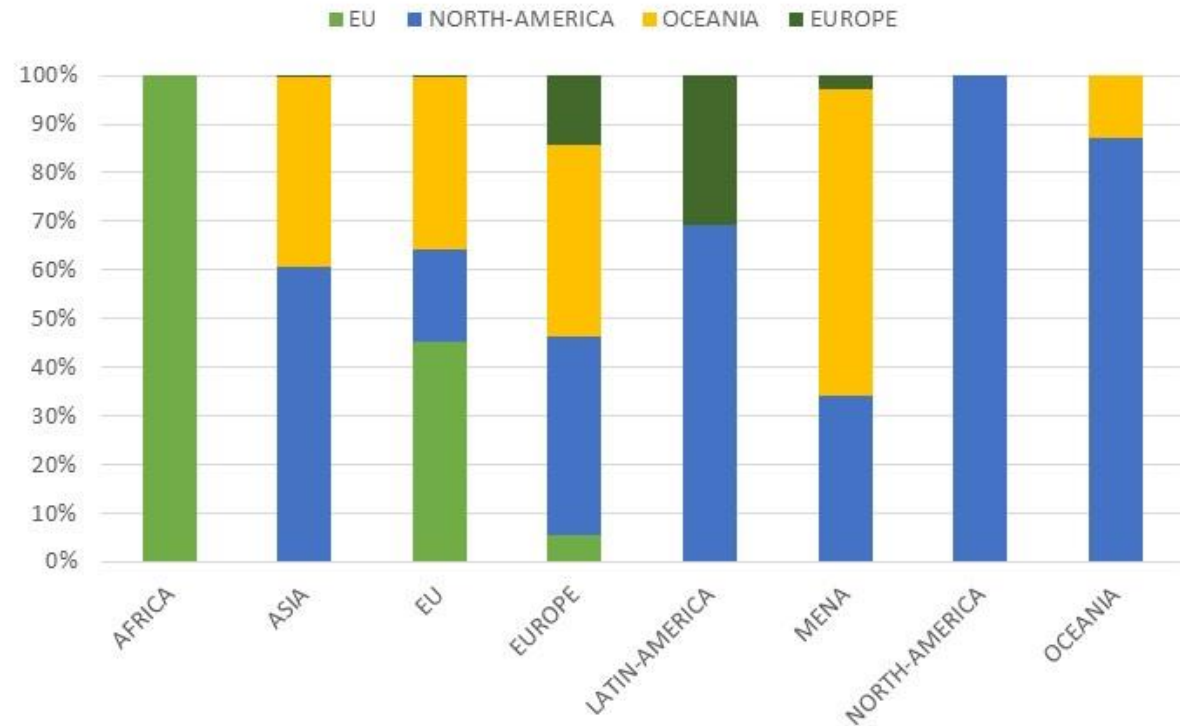
Global Trade Model

- Island supply, only RE supply determines load factor
- Individual economic consideration with the goal of profit maximisation
- Consideration of country-specific interest rates and customs duties
- Trade is done until the demand is satisfied or there are no potentials left
- Merit order for each import country
- Continuation in the next year
- For insufficient potentials the program is stopped



Import of synthetic Fuels

- Production cost within a country determines willingness to pay for imports
- Scenario EL: Fuels mainly for aviation and shipping
- Business as usual scenario: Interest rates similar to today
- Trade is dominated by interest
- EU will produce about 50% of its own fuels
- The other half will be imported



Green hydrocarbons, 2050, Scenario-Variant EL_bau

Conclusions



- Long distance aviation and shipping in particular will need green fuels for defossilisation
 - Main fuel demand in aviation for intercontinental flights
 - Fuel options for shipping are still open, but there is a tendency to a multi-fuel world
- Agriculture, construction, military, will need green fuels in the future
- Production of fuel should focus on fuels required in the long term (for aviation and shipping), avoid stranded investments
- Imports of green fuels will depend on the prices that emerge on the global market in comparison to own production potentials.
 - But: Political priorities, country-specific risks and the enormous need to cover growing domestic demand for renewable energy in potential export countries raise questions about the desired level of imports

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