Implications of the energy transition for the European storage, fuel supply and distribution infrastructure

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Agenda

- Introduction (5’)
  - Policy Context
  - Aim of the study
  - Methodology
- Case studies of Supply Chains: FAME and SAF (2 * 10’)
- Main findings, conclusions & takeaways (20’)

Introduction

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Policy Context

- December 2019 European Green Deal
  - Commitment to tackle climate challenges – climate neutrality by 2050
  - EU's commitment to climate action following the Paris Agreement
- European Commission is preparing the "Fit-for-55" Package
  - Due this summer
  - Committing EU to 55% reduction in greenhouses gas emission by 2030
- Decarbonisation will lead to fundamental changes to all aspects of European activities, including energy storage, energy transportation and end use
- These issues present challenges and opportunities to European storage, fuel supply and distribution infrastructure

Aim of the study

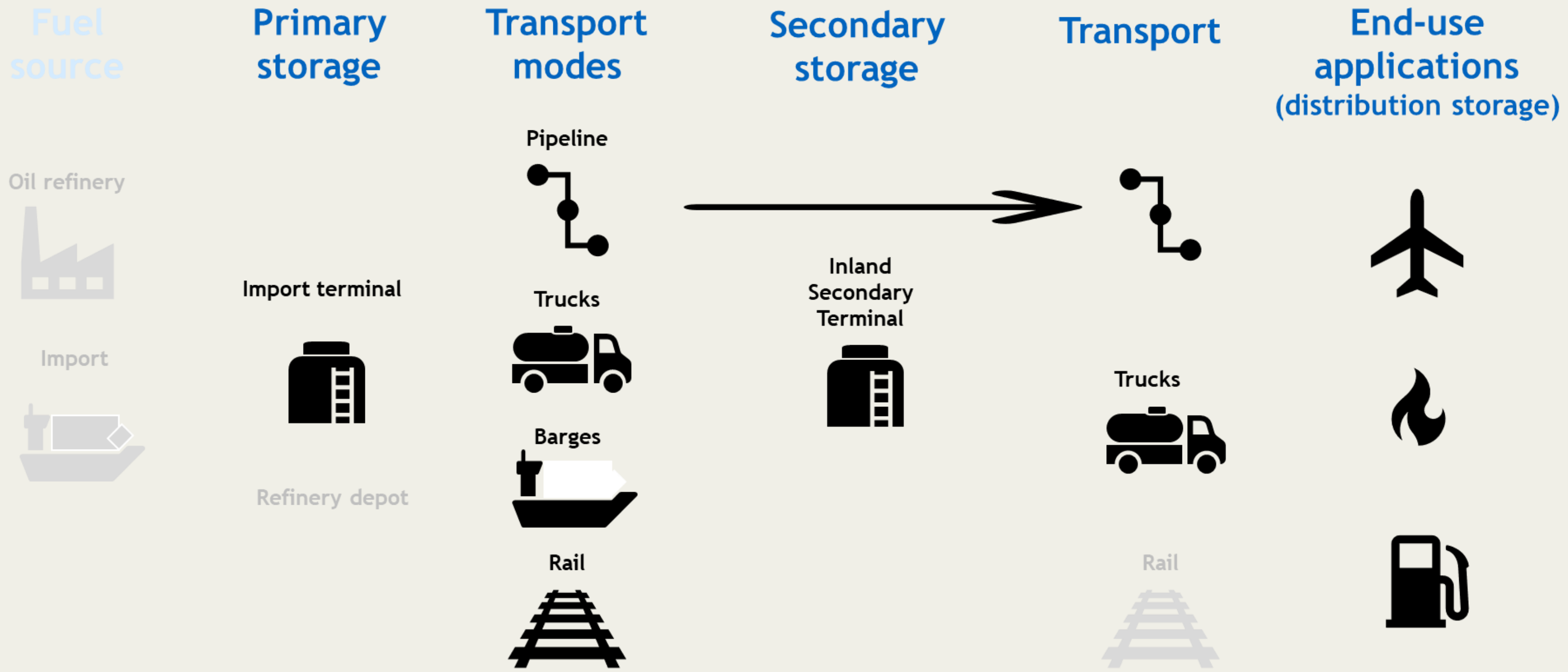
The purpose of the study is to explore the implications of replacing conventional fossil fuels with low carbon alternatives on the bulk liquid storage sector and the entire supply chain. The scope of conventional fossil fuels includes:

- Liquid fuels: diesel, gasoline, kerosene, marine fuels, gas oil;
- Gaseous fuels: LPG, natural gas (covering only for the use as transport fuel).

Many of these fuels have various end-uses and also alternative-fuel substitutes. However, for the purpose of exploring fuel infrastructure adaptations, the short list of renewable alternatives was designed with the widest possible range of applications, and cover: biodiesel (FAME & HVO); bioethanol; compressed/liquid hydrogen; e-fuels like methanol; e-kerosene; e-gasoline; e-diesel; bio-LPG.

Methodology

Long list of supply chains, to concentrate efforts and assess cost implications, we proposed a case study approach, on 5-steps SCs (via literature & stakeholders survey)



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Chains Examined

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- Diesel to FAME biodiesel
- Gas oil to HVO biodiesel
- Gasoline to Bioethanol
- Methane/LNG to Hydrogen
- Ship (marine) fuel to Methanol
- Kerosene to SAF
- Gasoline to e-gasoline
- Diesel to e-diesel
- LPG to BioLPG

- Each chain step analysed
- Role for flexibility is the energy transition
- Consideration of whether infrastructure is fit for purpose or needs repurposing or replacement
- Assessment of locational issues
- Cost implications and identification of stranded costs

Cost Methodology

- Cost estimates have been undertaken using the following methodology:
  - Where available, data from studies have been used (for example: hydrogen pipeline adaptation; hydrogen fuelling station);
  - For civils, electrical works, and labour costs from cost estimating handbooks have been used, which are price estimating books and guides for the mechanical, electrical and construction industries;
  - For equipment and soft costs (planning, permitting etc) quantitative survey methodology has been used, based on quotes from suppliers, web research, as well as data from similar projects.
- For the calculation of levelised costs, WACC (Weighted Average Cost of Capital) rate used is 5% and the project lifetime is 20 years.

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Adaptation of diesel supply chain for FAME biodiesel

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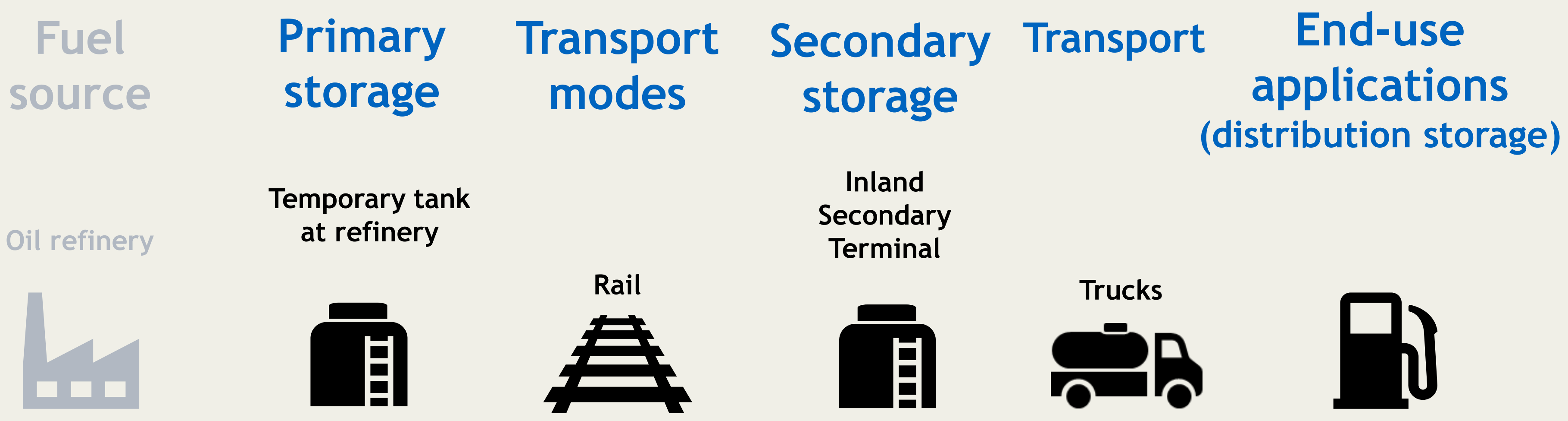
Model supply chain for diesel fuel



Main components of Diesel supply chain
Primary storage
On-site temporary storage tank at the refinery
Piping from the refinery tank to the oil rail wagons
Rail loading facility
Pump devices
Meters
Fuel filtration
Rail transport
Rail wagons
Secondary storage
Piping from the oil rail wagons to the secondary storage tanks
Rail unloading facility
Pump devices
Meters
Tanks
Transport to final users
Tank truck loading rack
Tank trucks to distribute to final consumers' on site storage
Delivery to final users
Distributor depots
Fill in devices into truck as end-users

FAME Biodiesel - intro

- FAME = Fatty acid methyl esters
- Produced from animal fats and plant oils, in standalone facilities
- Already blended with standard diesel up to 7% (Renewable Energy Directive)

Scenario: diesel replaced by 100% FAME biodiesel or high-volume blend, transported via existing infrastructure

Main FAME biodiesel properties

Fuel property	Impact on infrastructure
FAME is a good solvent	➢ Sediments from previous infrastructure use might ger dissolved in FAME
FAME degrades certain materials	➢ certain (older) types of rubber compounds used for hoses and gaskets can degrade
Quality of FAME fuel degrades with time	➢ Fuel ageing and oxidisation degrade the stored fuel over time ➢ Some metals, especially copper can accelerate the process of degradation and contribute to the creation of additional sediments
Microbial contamination possible	➢ Especially when fuel is contaminated with water
FAME has higher freezing point than conventional diesel	➢ Impacts for example above-ground tank storage in certain climates

Implications for diesel fuel infrastructure

Adaptation challenge	Proposed measures
Adaptation of equipment to prevent fuel contamination	➢ Storage design features for easier removing of sediments and water ➢ Specific filtering activities
Adaptation of tanks and storage facilities to prevent material degradation	➢ Epoxy coating of tank interiors
Additional filtering of the fuel	➢ Installing dedicated filtering equipment
Additional insulation or heating to prevent fuel freezing	➢ Depending on location ➢ Depending on fuel properties (cold filter plugging point)
Reconfiguration of supply chain infrastructure to connect the biodiesel production facilities	➢ Additional transport step between biodiesel production facility and diesel infrastructure

Conclusions

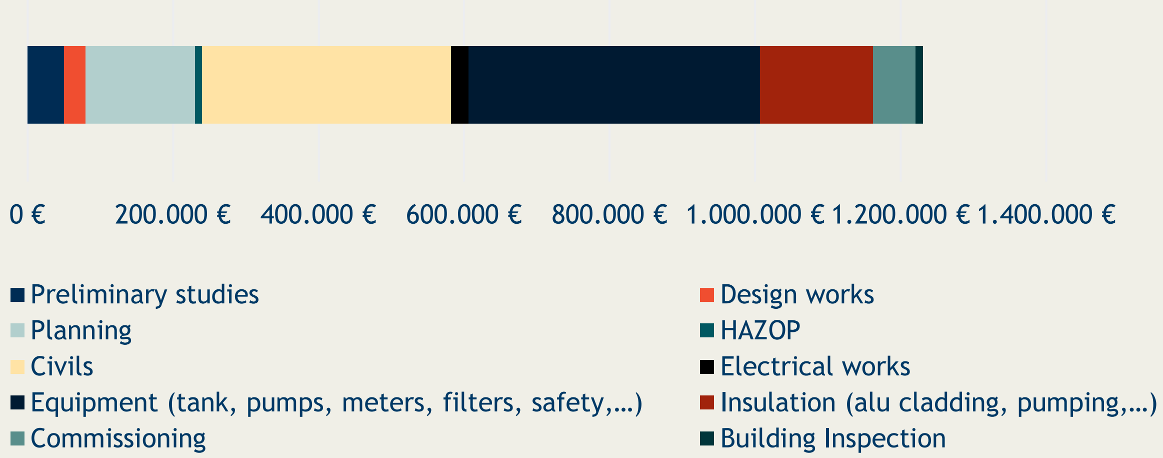
	Geographic/spatial reconfiguration of supply chain	Primary storage	Fuel transport	Secondary storage	Fuel transport	Fuel distribution
	No	Import terminal	Rail	Inland terminal	Tank trucks	Fuel station - heavy duty trucks

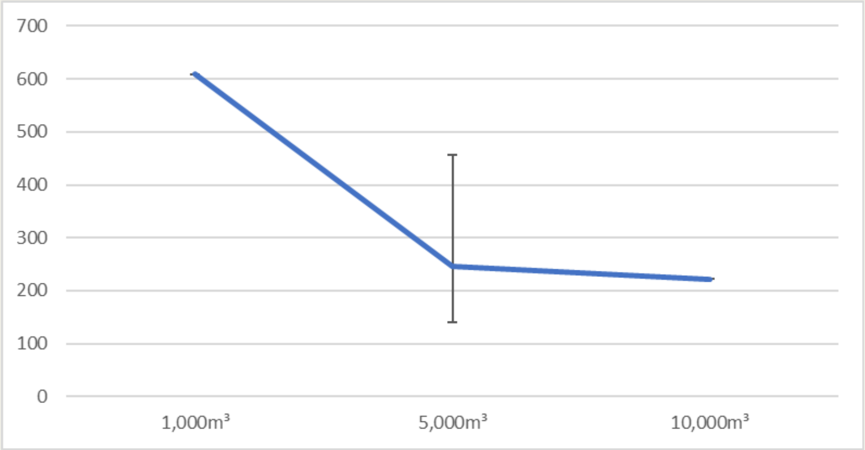
No changes required — Limited changes required — Important changes required

- Limited impacts of geographical reconfiguration
- Some materials need to be replaced but this process has been already going on for some time
- Proper cleaning of existing assets and proper handling of the fuel can prevent many issues

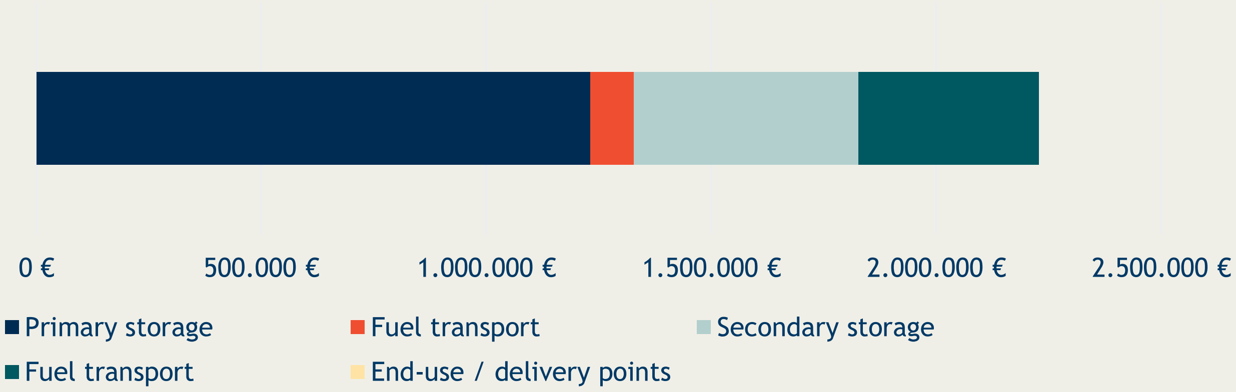
Cost assessment

- **Price components of primary storage**





- **Adaptation cost per supply chain element**



Adaptation of aviation fuels supply chain for Sustainable Aviation Fuels (SAF)

Model supply chain for jet fuel

Fuel source	Primary storage	Transport modes	Secondary Storage (central tank)	Transport	End-use applications (distribution storage)
Oil refinery	Temporary tank at refinery	Pipeline		Pipeline	

Sustainable Aviation fuels - intro

- Diverse group of products, resulting implications may vary
  - There are 7 groups of SAF recognised by the norms, blended with jet fuel up to 50% in most cases
- SAF blends currently available on the market are designed to be compatible with existing transport infrastructure
  - The situation is unlikely to change in the 2030 timeframe

Scenario: SAF accepted in the secondary storage as prepared blend or blended on-site; transported via existing infrastructure to airports

Main SAF properties

Impacted equipment	Possible impacts
Fuel blending at the central terminal	
SAF storage tank	• Specific materials additional maintenance might be necessary for SAF storage, depending on concrete physical qualities
Blending equipment	• Additional mixing equipment might be necessary
Fuel quality testing	• Adjustment of certification process might be necessary
SAF transport to central terminal	
Tank truck and rail wagon	• Additional supply chain step to be established; • Specific materials additional maintenance might be necessary for SAF storage, depending on concrete physical qualities.

Implications for jet fuel infrastructure

Adaptation challenge	Proposed measures
Adaptation in central terminal	• Dedicated storage tanks with specific materials and maintenance procedures might be needed
Establishing SAF transport to distribution storage	• Specific tanks might be needed for rail/road transport

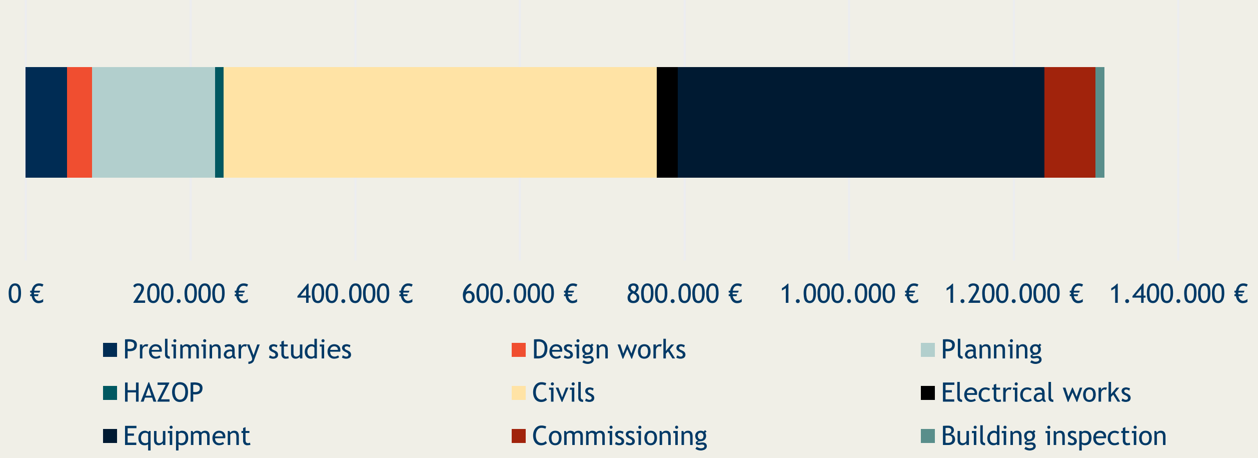
Conclusions

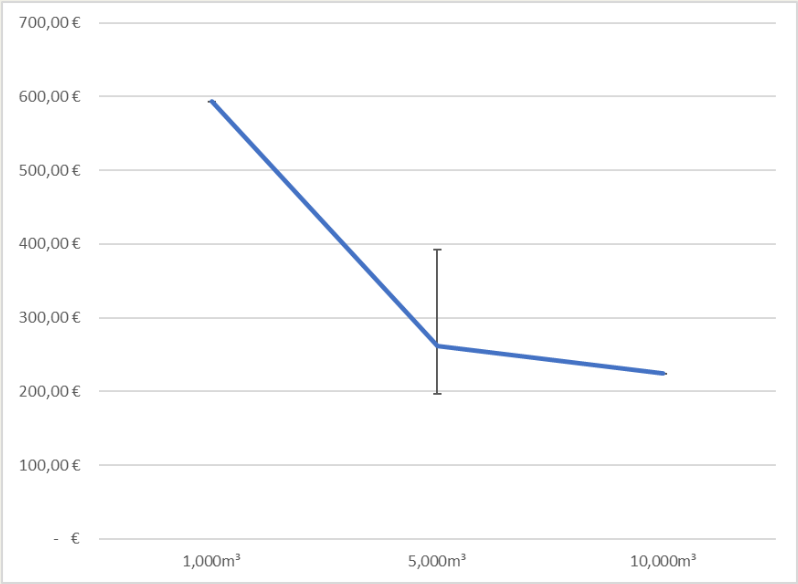
Geographic/spatial reconfiguration of supply chain	Primary storage	Fuel transport	Secondary storage	Fuel transport	Fuel distribution
Partial	Import terminal	Pipeline	Airport storage	NA	Filling planes - aviation turbines

- Investment in storage tanks in primary storage and airport storage might be necessary depending on the fuel type
- Partial geographical reconfiguration of supply chain might be necessary, as production facilities might not match refinery locations

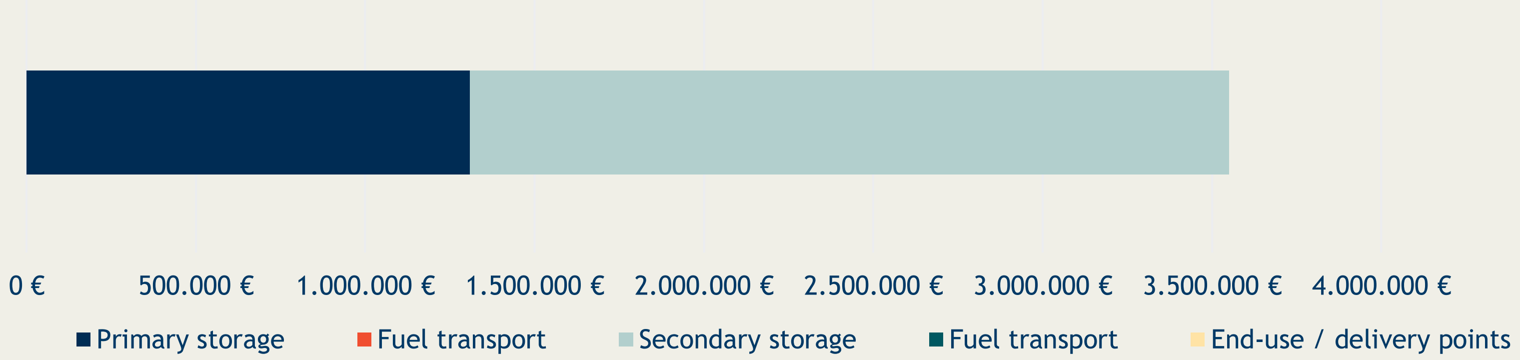
Cost assessment

- **Price components of primary terminal (5 000m3)**





- **Adaptation cost per supply chain element (secondary storage 10 000m3)**
  (assuming no adaptation needed for pipeline transport)



Main findings, conclusions & takeaways

Main findings

Summary results

		Geographic/spatial reconfiguration of supply chain	Primary storage	Fuel transport	Secondary storage	Fuel transport	Fuel distribution
1	FAME biodiesel 100%	No	Import terminal	Rail	Inland terminal	Tank trucks	Fuel station - heavy duty trucks
2	FAME biodiesel 100%	Yes	Import terminal	Tank trucks	Inland terminal	Tank trucks	Fuel station - passenger cars; heavy duty trucks
2.a	FAME biodiesel <100%						
3	HVO biodiesel	No	Import terminal	Barge (inland)	bunkered stock / distributor depot	Tank trucks	Domestic heating fuel (domestic tanks)
4	bioethanol	Yes	storage at bioethanol plant	Tank trucks	Inland terminal	Tank trucks	Fuel station - passenger cars
5	hydrogen	No	Import terminal	Pipeline	NA	NA	Fuel station - trucks
6	Methanol		Import terminal (from large H2 prod)	Pipeline	Port fuel depot	NA	Bunkering tankers - ships
7	SAF	Partial	Import terminal	Pipeline	Airport storage	NA	Filling planes - aviation turbines
8	liquefied biomethane	No	Import terminal			Tank trucks	Fuel station - heavy duty trucks
9	e-gasoline	No	(small stand-alone prod facility)	Pipeline	Depot	Tank trucks	Fuel station - passenger cars
10	e-diesel	No	(small stand-alone prod facility)	Tank trucks	Depot	Tank trucks	Fuel station - trucks
11	bioLPG	Yes	BioLPG tank at biorefinery	Tank trucks	LPG cylinder filling plant	Tank trucks	household heating (cylinder tanks)

Rem: blended FAME (2.a) biodiesel blends are largely used and require limited changes to the existing infrastructure, and were therefore not addressed in the frame of this study

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Main findings

	Short description	Primary storage	Fuel transport	Secondary storage	Fuel transport	End-use / delivery points	Levelised cost of primary terminal	Levelised cost (unit)
FAME 100% biodiesel	5000m3 storage, 4 rail wagons (cleaning of wagons, epoxy coating, insulation+cladding), adaptation secondary terminal (cleaning of existing storage tanks, insulation and cladding, epoxy coating), tank trucks	1.230.689	98.080	499.202	400.000	-	0,016	eur/m3
FAME 100% biodiesel	5000m3 storage, tank trucks, adaptation secondary terminal (cleaning of existing storage tanks, insulation and cladding, epoxy coating), tank trucks	1.230.689	400.000	499.202	400.000	-	0,016	eur/m3
HVO biodiesel								
bioethanol	5000m3 storage, tank trucks, adaptation secondary terminal (10000m3 new tanks for blending + all necessary equipment (meters, filters etc) + civils to install the new tank), tank trucks	1.279.163	400.000	2.132.821	400.000	100.000	0,016	eur/m3
hydrogen	10000m3 tanks, pipeline 100km, fuel station	8.733.401	30.079.100	-	-	1.451.363	0,002	eur/kg
Methanol	2*5000m3 storage, pipeline adaptation 100km + equipment, adaptation secondary storage (incl. cleaning of storage tanks, floating roof, old thermal insulation removal, new equipment (pumps, meters, filters)), tank trucks	2.789.499	5.350.958	411.625	-	-	0,036	eur/m3
SAF	5000m3 storage, pipeline (existing infrastructure is compatible for SAF), 10 000m3 secondary terminal (incl. new blending tank+all necessary equipment (meter, filter, pump)+civils work)	1.309.508	-	2.240.813	-	-	0,017	eur/m3
liquefied biomethane								
e-gasoline								
e-diesel								
bioLPG	3*300m3, tank trucks to secondary storage, then the existing infrastructure can be used without adaptation	1.171.774	400.000	-	-	-	0,126	eur/m3

Conclusions and takeaways

Main conclusions

- Oil infrastructure is more widely spread and distributed, offering flexibility & adaptability to supply alternative conventional fuels
- Depending on product, most existing infra can be used, without changes or minimal modifications (e-fuels, same characteristics)
- Surrounding facilities can be used to minimise the necessary investment
- Limited supply of sustainable biofuels (resource availability), necessary to find specialized applications (most viable decarbonisation option)
- Alternative fuel production may become decentralised & more geographically dispersed (e.g closer to biological feedstock, large offshore wind-H2). Spatial distribution of existing SCs to be adjusted + new local infrastructure
- In some cases, alternative fuels are not direct substitute used by the same end-users without any adaptations (e.g. bioethanol vs gasoline in high-percentage blends or H2 vs CH4)

Conclusions and takeaways

Opportunities

- Large part conventional fossil fuels infra already usable for alternative fuels transport, storage and distribution
- Oil infra is more spread and less dense, therefore provide important and actual opportunities given its flexibility to adapt to fast and important changes (decentralised production, smaller storage, increasing number of products…)

Challenges

- Demand for fossil-based fuels will decrease (EVs, EE, RES shift) & associated fuel infra to be re-purposed accordingly, with oversize, leading to stranded assets
- Spatial distribution of existing fuel supply chains will have to be adjusted (decentralised and more geographically dispersed)
- Disruptions along SCs may occur, given the above-mentioned threats, with consequences in supplying
- Ensure vulnerable consumers without resources for fuel switch are not left behind
- Still early stage of development (except biofuels) with limited experience in handling and use. Further research required
- Fuels diversification have implications along SC, incl. at fuel stations becoming multi-fuels (wider range of products), adaptations required

Conclusions and takeaways

Main takeaways

To address the above-mentioned challenges, policy makers should address the following main areas:

- Building clear pathway & trajectory for RES and low-carbon fuels is needed
- Involve the oil infrastructure and supply chain sector in the design of the pathway to carbon neutrality
- Increasing awareness about above challenges, opportunities & infra to adapt
- Differences between in regulated & non-regulated markets, possibly leading to discrepancies in fast moving markets, while large investments may be required & face lack of level playing field
- Assessing risks of disruption and stranded assets due to major changes
- Taking appropriate measures to secure supply and provide a stable framework
- In the frame of the Oil Stocks Directive, anticipate evolution of fuel consumption
- Ensuring a level playing field for all types of energies & energy carriers (comply with low carbon)
- Accompanying industrial operators and investors to adapt existing assets
- Removing existing alternative fuels deployment barriers (e.g blending walls in FQD)
- Mandating European Standardization body for development of missing standards
- Policies addressed better at national, also key setting up unified regulatory approach (European)

Conclusions and takeaways

Main takeaways

Existing EU policy instruments and gaps covering the entire oil supply chain

- The Directive on the deployment of Alternative Fuels Infrastructure (AFID)
- The Council Directive imposing an obligation on MS to maintain minimum stocks of crude oil and/or petroleum products
- The Fuel Quality Directive (FQD), with regard to alternative fuels: reduce GHG emission, minimum share FAME (7%)
- The Renewable Energy Directive (RED II)

Other policy frameworks and planning should or could also address the supply of oil

- All instruments supporting the shift to low carbon and renewable fuels (e.g. ETS, support schemes, taxation, …)
- NECP including a section on SoS, should include the evolution of fossil-based consumption
- The Tran-European Transport Network (TEN-T), with the goal to close gaps, remove bottlenecks & technical barriers, to strengthen social & economic cohesion

Globally, the oil supply chains are more or less included in all planning and measures expected to address security of supply. However, in practice, some elements along the chain are not fully considered.

Conclusions and takeaways

Main takeaways

Europe should build clear view or pathway for RES & Low-C fuels by 2050 with trajectory;

Europe should include assessment of existing oil infrastructure of transition scenarios (such as CTP), & factor in cost & benefit impacts of repurposing existing infrastructure (vs new infra);

For the NECP revision, MS could

- be more precise alternative liquid fuels complementing other carriers
- include all infrastructure elements in IA, including storage

In the frame of the Oil Stocks Directive, MS could anticipate evolution of fossil-based liquids consumption & emergency storage needs to adapt legal framework. Close coordination would be required between MS;

In the frame of the FQD, assess the impact of going beyond existing threshold (FAME);

Some MS may require providing support to investments in new storage and transport assets and equipment to investors, infrastructure operators, and other concerned market actors. Revise State Aid guidelines accordingly;

Europe could play a role supporting RD&I, to further explore emerging fuels impacts on equipment.

Conclusions and takeaways

Main takeaways

MS determine own energy mix ➔ not EU to define what alternative fuels in which sectors. Mainly in the hands of **national governments** to indicate to industry what role alternative fuels expected to play for cost effective transition to low carbon economy. This will give infra operators a more precise picture on demand, for a more qualified investment decisions (conversion, phase out, new).

However, EU/EC could provide coordination with MSs ensure compatibility within framework of Internal Market.

Policy framework differ from country to country, but EU regulation sets at least two basic instruments: NECPs (define target) & AFID (include all infra).

In the frame of these instruments, MSs should plan decarbonisation of liquid fuel, by consulting the sector, based on IA considering

- Geographic coverage of the different fuel uses, and the related infrastructure
- Loss of value & stranded assets where dismantling is required
- New specific threats and risks of disruption
- Permitting delivery or renewal for existing assets

Such planning should be transparent and provide visibility to all concerned stakeholders.

Conclusions and takeaways

Main takeaways

Infrastructure owners & operators should/could also anticipate these global trends, by considering:

- Prepare business continuity plans based on realistic scenarios, to avoid new stranded assets
- Most cost-effective way is replacing equipment at end of lifetime, consider using suitable materials and equipment
- Consider spatial differences of alternative fuels to existing fossil fuels SC
- Support research for equipment for new fuels compatibility (e.g. valves, pumps, pipes, ….)
- Support development of standards for the use of (neat) alternative fuels or hi-percentage blends
- Take all required measures to work with national regulators in developing guidance, standards and plans to meet emerging safety requirements
- Assess the needed skills and knowledge in handling alternative fuels and infrastructure;
- Consider creating partnerships along the whole supply chain to construct resilient energy SC

Thank you for your attention, please contact us for more information

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