FLEDGED

Socio-economic analysis of biomass based DME production and use

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maîtriser le risque pour un développement durable

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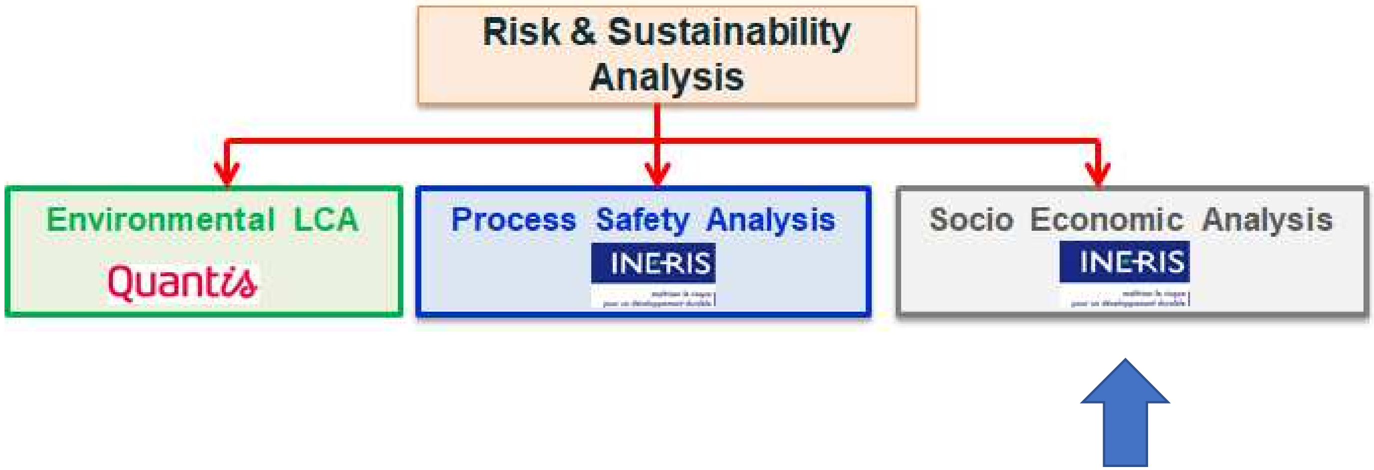
Outline of presentation



1. **Overall approach to Socio-Economic Analysis (SEA)**
2. **Cost-benefit analysis for the FLEDGED process for DME based fuel production**
3. **Overall risk & sustainability scoring of Fledged process configurations**
4. **Cost-benefit analysis for the use of DME based fuels in road transport replacing diesel**

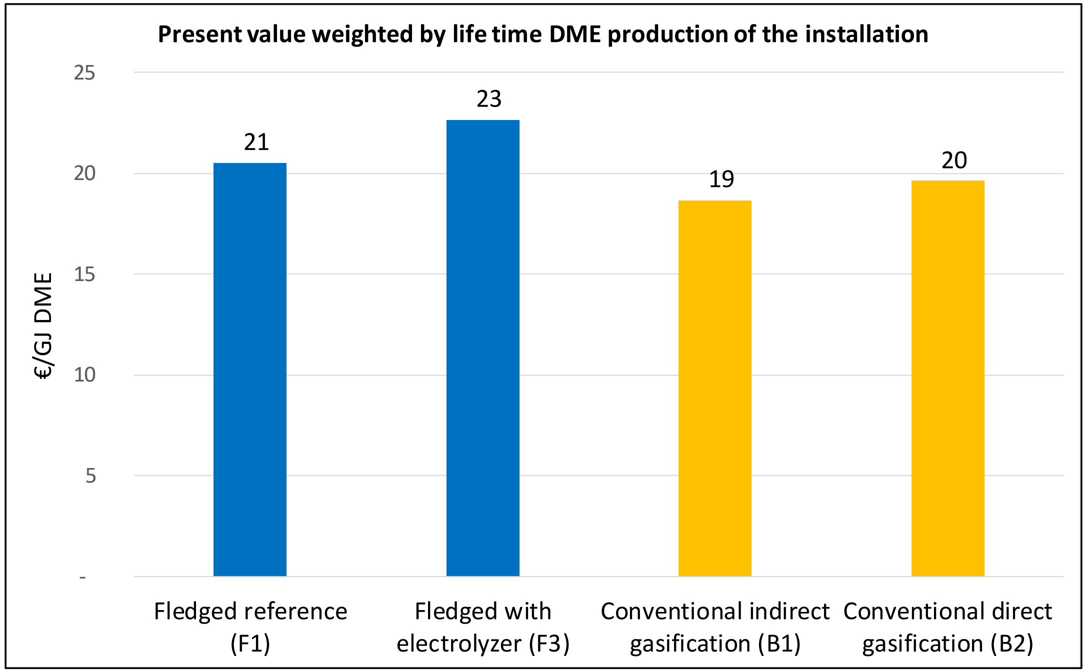
1 - Overall approach to Socio-Economic Analysis (SEA)

- Assess advantages and drawbacks of the FLEDGED scenarios relative to benchmark scenarios
  - Taking an integrated view of environmental, health & economic impacts by monetizing impact indicators
  - Expressing results as today's value of costs and benefits incurred over the period (=> Present Value (PV))
- For the FLEDGED process for biomass based **DME fuel production**
  - Monetization of LCA health & environment results and extrapolation to plant level over life-time
  - CAPEX & OPEX data over plant life-time
- For the **use of DME fuel** in road transport replacing diesel (*)
  - Modelling of vehicle park to assess impacts on air pollutant emissions and GHGs up to 2040
  - Air quality modelling and health impact assessment
  - Benefits assessed are avoided health impacts and CO_2 emissions
  - Additional costs of DME: distribution network, truck retrofit, fuel price differential ….
- Integrating results with those from process risk & safety assessment

(*) Use of GAINS integrated assessment model, Copert transport model, Chimere chemistry-transport model, ARP health impact assessment model

2 - Cost-benefit analysis for the FLEDGED process for DME based fuel production

- PV calculated over life time (20 years) with a social discount rate (4%)
- Including health & environment and investment and O&M costs
- Weighted by plant life-time DME production to account for varying process efficiencies



– F1 and F3 are more costly than the baseline configurations (although orders of magnitude are similar)
– Higher investment and O&M costs over-compensate lower health & environmental damage
– In this view no apparent social benefit of F-configurations
– But: costs of technology (under development) might decrease due to learning effects and economies of scale

LCA steps covered (aggregated): Biomass production and transport, DME production process, Co-production of electricity potentially replacing electricity from the grid

Monetization of Impact 2002+ midpoint indicators based on CE Delft, 2018; Stiglitz & Stern, 2017

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3 – SEA: overall risk & sustainability scoring of Fledged process configurations

- Integration of results from the industrial process safety and cost-benefit analyses
- For a more comprehensive view on advantages and disadvantages of implementing the FLEDGED DME process configurations

Decision matrix – Fledged relative to baseline configurations

	F1	F3
Process safety	🟢	🟡
Environment & health damage	🟢	🟢
Investment and O&M costs	🟡	🟡

– F1: preferred option in terms of environment, health and safety

– F1 & F3: less favourable in terms of costs, but it is a technology under development, costs might decrease over time (economies of scale, learning)

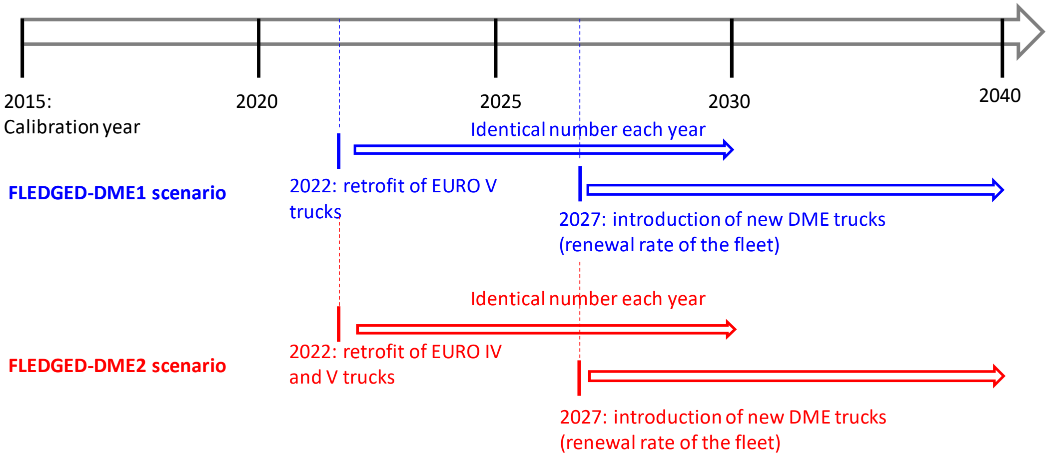
– F3: would be an interesting option if intermittent and renewable electricity was available at a competitive price, or if the initial development would be politically supported through subsidies or policies

4 - Fledged DME use scenarios: replacement of diesel use in heavy-duty trucks

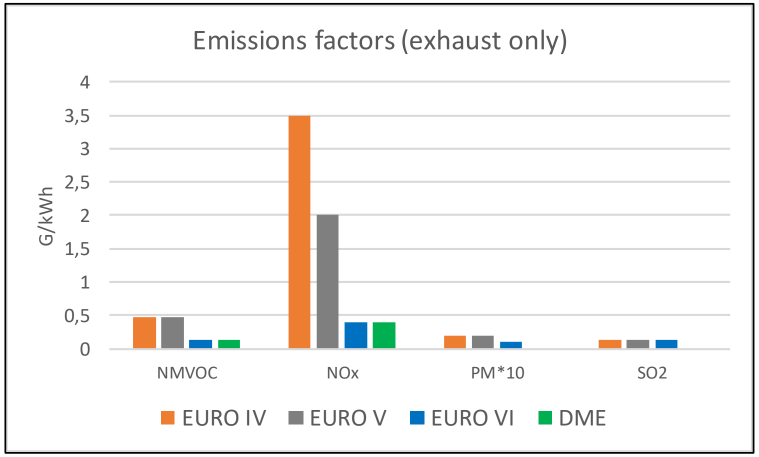
Comparison of a reference scenario (no DME use)

- GAINS model (IIASA) current air quality legislation scenario up to 2030 with PRIMES REF activity projections (climate policy adopted up until 2016)
- Projection of vehicle park, activity and abatement measures up to 2030, estimation of evolution between 2030 and 2040 (replacement of old vehicles, but no changes in emission factors or vehicle activity)

With 2 Fledged DME use scenarios:



Emission factors for DME trucks compared to diesel trucks



CO_2 emissions: 10% reduction compared to diesel for new DME trucks

Models used: integrated assessment model GAINS, transport model COPERT, chemistry transport model CHIMERE , health impact assessment model ARP

4 - Cost assumptions

Additional costs for adapting trucks for DME use	Existing diesel trucks	≈ 4 k€/truck	Low-level retrofit: tank system replaced for on board blending
		≈ 7 k€/truck	High-level retrofit: replacement also of injection system & modification of the air path
	New DME trucks	0	DME vehicles require more expensive tank systems but less demanding after treatment
Development of DME distribution network	Investment costs ≈ 250 k€/service station	Estimation of number of DME fuel stations	Low estimate based on minimum distances between fuel stations on motorways
			High estimate based on the existing service station network of big specialized fuel distributor
Additional fuel costs	Difference DME – diesel price	≈ 17 €/GJ DME	LCOF for DME : F1 = 28.26 €/GJ; F3 = 31.35 €/GJ; Diesel without taxes: 12.96 €/GJ

4 – Net present values of costs and benefits

EU27+UK, million € (€2019)	Whole period (2021-2040)			
	High benefit & low cost	Low benefit & high cost	High benefit & high cost	Low benefit & low cost
Net present value covering health and climate benefits, and retrofit and distribution network costs				
Scenario 1	47 881	8 209	43 969	12 121
Scenario 2	74 132	11 445	68 835	16 742
Net present value covering health and climate benefits, and retrofit, distribution network costs and additional fuel costs				
Scenario 1	-125 055	-164 726	-128 967	-160 814
Scenario 2	-110 166	-172 853	-115 463	-167 556

Czechia, million € (€2019)	Retrofit phase (2021-2030)			
	High benefit & low cost	Low benefit & high cost	High benefit & high cost	Low benefit & low cost
Net present value covering health and climate benefits, and retrofit and distribution network costs				
Scenario 1	1 893	257	1 822	328
Scenario 2	3 065	365	2 921	509
Net present value covering health and climate benefits, and retrofit, distribution network costs and additional fuel costs				
Scenario 1	564	-1 072	493	-1 001
Scenario 2	1 157	-1 543	1 013	-1 399

- EU27+UK: Benefits exceed additional retrofit & distribution network but not fuel costs
- Czechia: Benefits exceed all additional costs in retrofit phase for high benefit assumptions

Benefits:
- avoided health impacts
- avoided greenhouse gas emissions

Costs:
- retrofit cost
- investment in distribution network
- additional fuel costs

NPV > 0 ⇔ Benefits > costs

High and low assumptions for benefits differ in the value for the monetisation of mortality

4 - Conclusions

- **Assumed emission factors imply that air pollutant emission reductions relative to diesel vehicles are more important for retrofitted DME vehicles than for new DME vehicles**
- **For the introduction of new DME vehicles, from an environmental point of view, CO_2 might be the crucial argument**
- **On an EU27+UK average benefits exceed retrofit and distribution network costs for all assumptions, but are insufficient to cover the additional fuel costs**
- **In countries where the truck park is older than for the European average, health benefits from retrofit may outweigh additional fuel costs => DME as a fuel might be a better choice for some regions than for others**
- **These results depend strongly on our hypotheses**
  - Rhythm of DME introduction (retrofit & new vehicles); unit cost factors for mortality; diesel-DME price differential …
- **To make DME a viable fuel alternative, its price would need to be brought down at least to the level of the diesel price**
  - By decreasing production costs
  - By subsidising DME production or DME prices which might be justified by additional health & environment benefits from the production step of DME compared to diesel
- **A future CBA should cover the entire life cycle of DME and diesel**

Thank you!