Greening of fossil-fuel infrastructures through biomass: The case of liquid biofuels

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Objectives

- Liquid, renewable and advanced transport fuels (RESFuels), can be integrated in existing infrastructures and thereby serve as a relatively short-term CO_2 mitigation strategy
- Co-processing of biomass towards RESFuels is possible in existing infrastructures such as power plants, gasifiers, refineries and chemical plants

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- Aim of the study is to:
  - *Present possibilities* for greening existing fossil fuel infrastructures as driver for the development of advanced biofuels
  - *Identify barriers* for commercialization of the technologies required for greening

Integration options of RESFuels into fossil infrastructures

- The main integration options maybe direct and indirect as shown in Figure 1.
- *Direct options:*
  - Blending of biogenic feedstock with a fossil-based process stream followed by co-processing in a downstream conventional unit
  - Substitution of a conventional part of a liquid fuel production chain by a bio-based one
- *Indirect options:*
  - Indirectly contribute to enable the development of biomass market and infrastructures
    - *Biomass co-firing* in power plants
    - Combined heat and power in *District Heating networks (DH)*

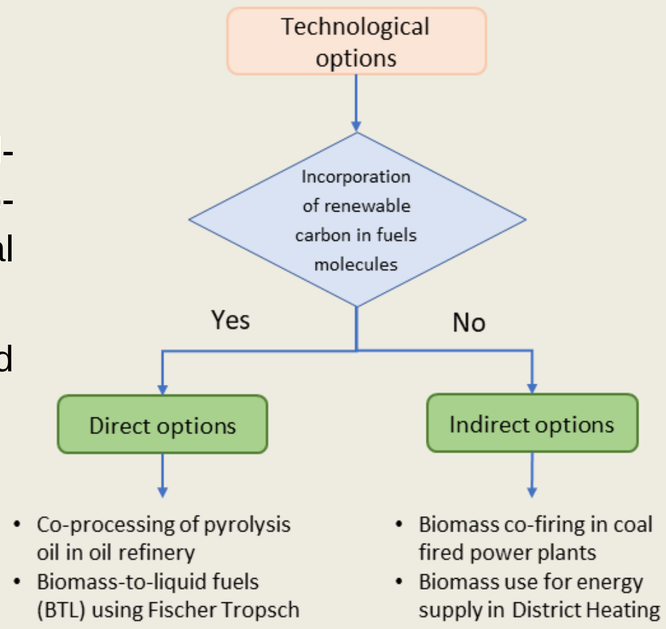
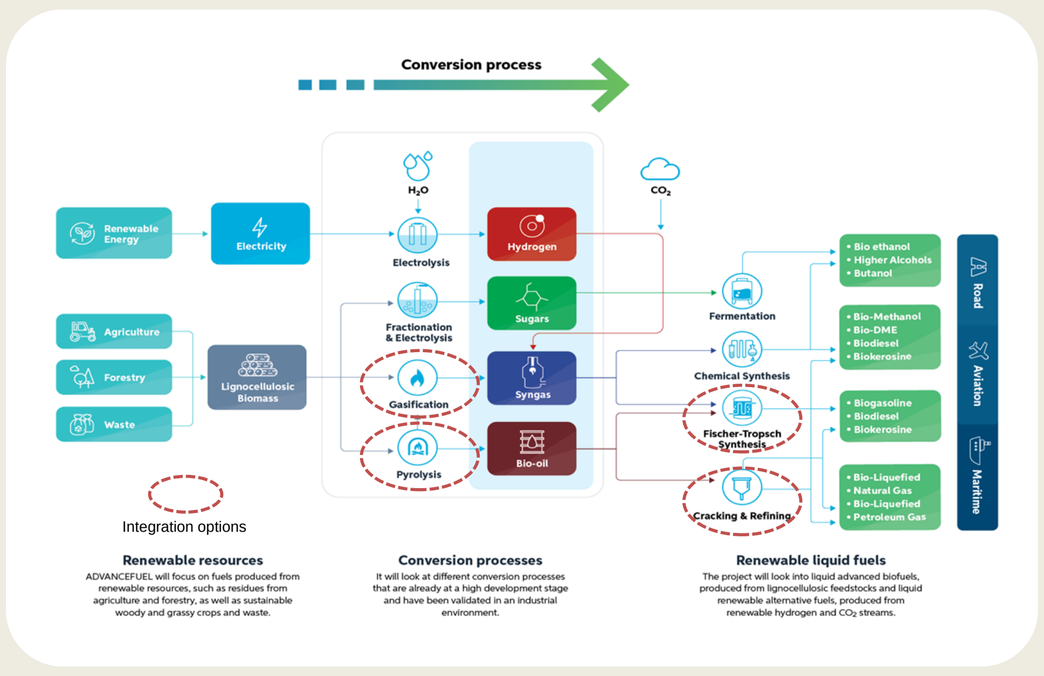


Figure 1 Technological options which can facilitate biomass use and green fossil fuel infrastructures

Methodology

Step 1. Identification of potential integration points from a variety of conversion processes for the production of advanced transport fuels



Step 2. Mapping of relevant European fossil-based facilities indicating integration points of biomass into existing fossil-based infrastructures

Direct option: The potential of greening oil refineries in EU

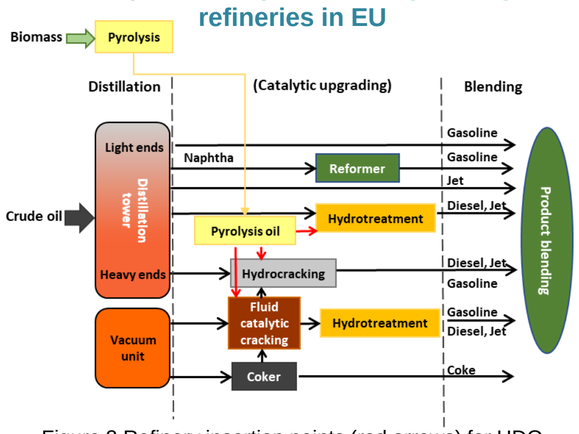


Figure 2 Refinery insertion points (red arrows) for HDO Bio-oils (Karatzos et al., 2014)

Table 1 Refinery capacity in EU 27, including mineral oil refining and for FCC units (Barthe et al., 2015)

	Charge capacity in Mm³/yr				
Country	No of oil refineries	Crude	Catalytic cracking	Catalytic hydrocracking	Catalytic hydrotreating
Austria	1	12.1	1.5		8.1
Belgium	4	42.9	7.8		39.9
Bulgaria	1	6.7	1.4		3.7
Cyprus	0				
Czech Republic	4	10.6		2	6
Denmark	2	10.1			2.5
Estonia	0				
Finland	2	15.1	3.3	5.2	17.3
France	11	86.9	18.1	4.2	68.4
Germany	13	140.3	20.3	11.8	116.74
Greece	4	24.5	4.4	2.5	21
Hungary	1	9.3	1.4		7
Ireland	1	4.1			2.6
Italy	15	135.6	18.7	17.6	72.58
Latvia	0				
Lithuania	1	11	2.5		8.9
Luxembourg	0				
Malta	0				
Netherlands	5	68.9	5.9	11.5	59
Poland	5	28.6	1.9	8.5	15.1
Portugal	2	17.7	2.4	0.5	11.7
Romania	9	31.2	6.4	0.1	13.8
Slovakia	1	6.7	1	2.4	5.1
Slovenia	0	0.8			
Spain	10	73.8	11.1	7.6	47.9
Sweden	5	25.4	1.7	2.8	15.6
United Kingdom	9	102.5	25.8	2.1	73.8
EU-27	106	864.8	135.4	78.9	616.7

Indirect option: The potential of greening coal-fired plants in EU

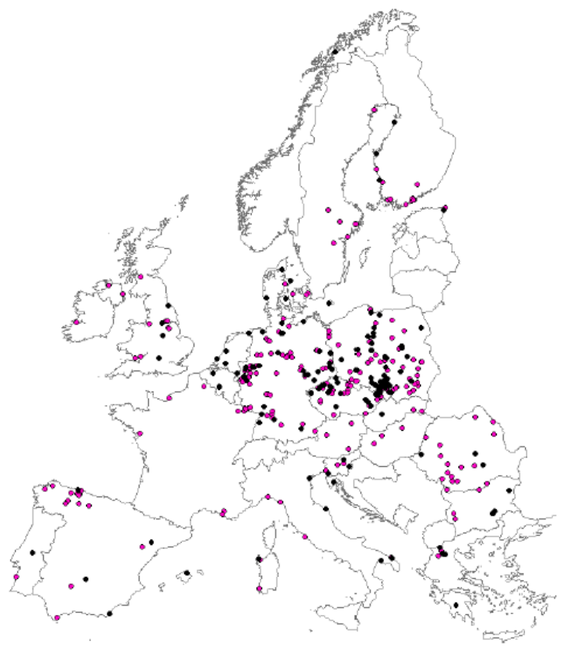


Figure 3 Data corresponding to coal-fired power plants, taken from the Chalmers Power Plant Database for Europe (Cintas et al. 2019)

- Black dots: coal fired plants constructed after 1990 and considered economically feasible for retrofitting for biomass co-firing
- Purple dots: plants not available for retrofitting (constructed before 1991)

Step 3. identification of *Opportunities* and *Barriers* for commercialization of the technologies required for greening the fossil fuel infrastructure. Example:

Direct option	Opportunities	Barriers
Bio-oil co-processing within an oil refinery	**Technological** ▪ TRL of biomass pyrolysis: 6 or higher **Economic** ▪ Co-processing bio renewable feeds and fuels in existing refinery units, more profitable than the stand-alone case **Supply chain** ▪ Established infrastructure of refineries for long-distance sea transport ▪ Bio-oil imports can be facilitated together with oil imports	**Technological** ▪ Current blending ratios of 2-10% lead to rather low scale-up feasibility ▪ Presence of water and oxygenated organic compounds o affects yields and conversion rates o need for stainless steel piping ▪ Alkali metals deactivate catalysts ▪ Differences in yields between pilot and commercial scale projects **Economic** ▪ Co-processing highly sensitive to the crude prices and refinery feed rates **Supply chain** ▪ Discontinuous production, variety and storage of biomass feedstock transportation chains, required pretreatments to accomplish energy densification ▪ Challenge of the decentralized production of pyrolysis oil and its transfer to the oil refineries

Indirect option	Opportunities	Barriers
Biomass co-firing with coal	**Technological** ▪ Exploiting existing infrastructures to establish biomass-supply infrastructure where lacking. ▪ Large number of coal-fired power plants makes biomass co-firing an option in many EU countries ▪ Roughly two-thirds of about 150 coal-fired power plants in Europe presently use biomass either as pilot tests or in commercial use **Economic** ▪ Co-firing in existing boilers costs about 2–5 times less to implement than other bio-electricity generating options ▪ It costs less than range compared to other renewable energy based electricity options ▪ Cost of retrofitting a coal-based plant is lower than a dedicated 100% biomass plant **Supply chain** ▪ Start-up biomass supply chains, also suitable as feedstock for 2nd generation biofuels ▪ Uncertain biomass supplies do not jeopardize the fuel supply for power plant	**Technological** ▪ Risk of delaying the phase-out of fossil-fuel power plants ▪ A steady growing biomass demand for co-firing may be considered a lock-in risk ▪ Local availability of large amounts of quality biomass **Economic** ▪ Cost of collection, handling, preparation and transportation of biomass, in comparison with the relatively low cost of coal **Supply chain** ▪ Cost of co-firing sensitive to the plant location and the key cost element is the biomass feedstock ▪ A substantial increase in biomass co-firing poses the question of the sustainability and availability of the feedstock supply, which could also be used for the production of biofuels

Conclusions

- Using existing fossil fuel infrastructures to incorporate biomass constitutes a low-risk option for ramping up renewable fuels in the EU
- Biofuels production processes to be part of a long-term climate strategy, require incentives and overcoming of technological barriers in order to be ramped up over time, eventually phasing out fossil-based infrastructures (e.g. coal-fired plants)
- Biomass to Liquid (BTL) production is mainly constrained by the biomass gasification technology
- Bio-oil integration into refineries suffers from scale-up issues
- District heating (DH) systems in EU represent a large heat sink
- Co-firing and DH are secondary technological options which prepare the conditions for regions where biomass infrastructures are missing, avoiding however lock-in situations.

References
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