Uptake of Drop-in Fuels/Low Carbon Energy Observatory

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The European Commission's science and knowledge service

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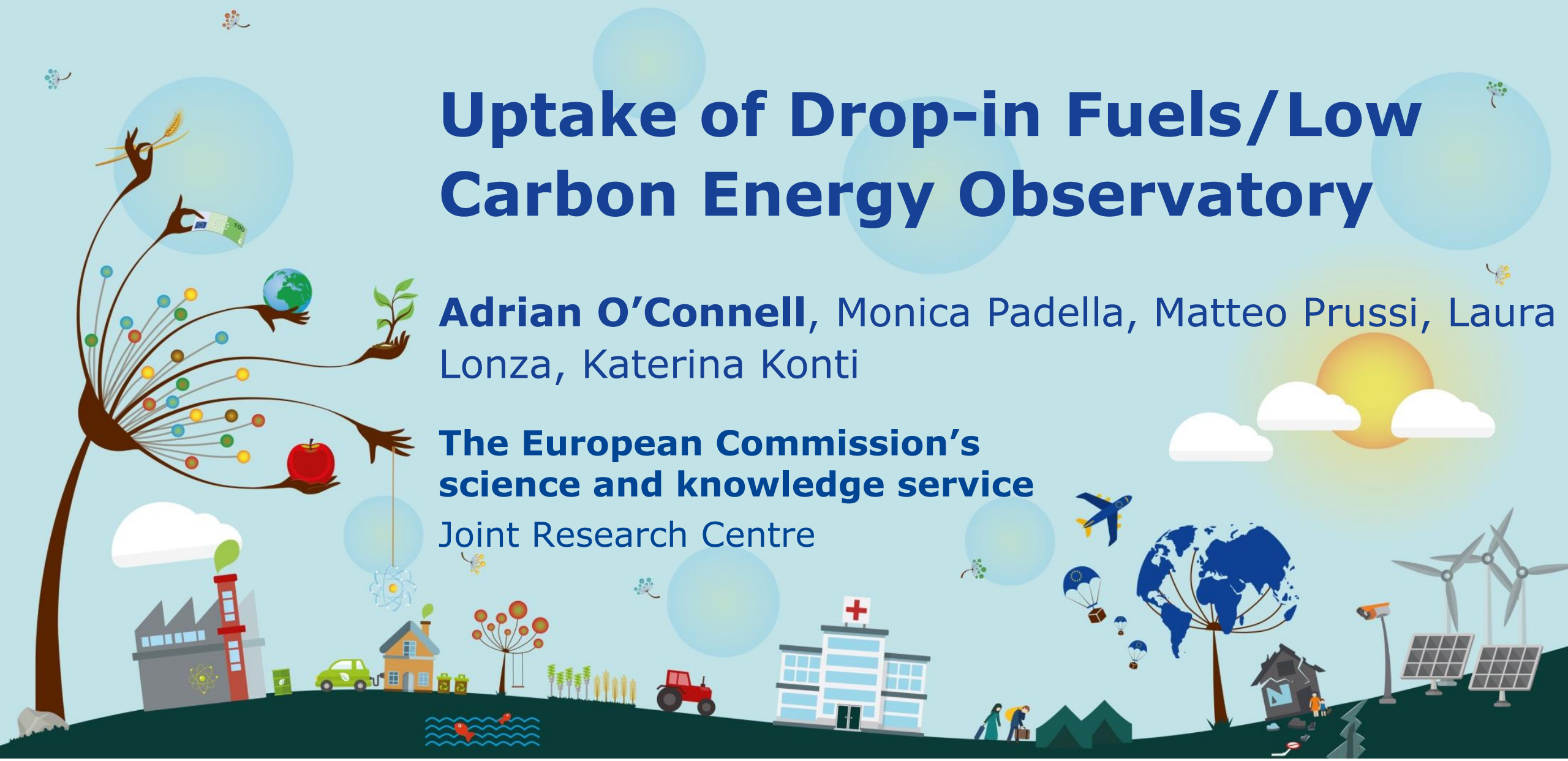

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Outline

- Low Carbon Energy Observatory overview
- Definition of advanced biofuels
- Advanced biofuel R&D in the EU – status and perspectives
- Definition of advanced alternative fuels
- Advanced alternative fuel R&D in the EU – status and perspectives

Low Carbon Energy Observatory

- In-house Commission project by JRC for DG-RTD, in the context of the Strategic Energy Technology (SET) Plan
- Runs 2015 to 2020
- Provides world-class data, analysis and intelligence on developments in low carbon energy technologies

LCEO Technologies

- Wind Energy
- Photovoltaics
- Solar Thermal Electricity
- Solar Thermal Heating and Cooling
- Ocean Energy
- Geothermal Energy
- Hydropower
- Biomass for Heat and Power
- Carbon Capture, Utilisation and Storage
- Unconventional Fossil Fuels
- Sustainable Advanced Biofuels
- Hydrogen and Fuel Cells
- Advanced Alternative Fuels

+ related "Future Emerging Technologies" (FET)

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(1) Advanced biofuels; definition

- Advanced biofuels **definition** varies, as advanced can refer to various attributes of the value chain
- We consider advanced, technologies capable of converting:
  - lignocellulosic feedstocks (i.e. agricultural and forestry residues)
  - non-food and non-feed biomass (i.e. grasses, miscanthus, algae) and
  - biogenic waste and residues (e.g. biogenic fraction of municipal solid waste and animal manure)
- ..into transportation fuels* with high GHG emissions savings, and no or low indirect land use change (ILUC) impact

*** For this discussion the focus is on drop-in type advanced biofuels**

BtL and SNG; challenges and next steps

- For the time being, **no large-scale** gasification plants producing BtL biofuels in operation. A number of opportunities for improving gasification, syngas cleaning and FT synthesis identified in IRENA 2016 to decrease production costs (up to 15% of current costs) and result in process efficiency gains.
- Possible future improvements on which R&D activities may concentrate efforts include:
  - Optimization of the process at **smaller scales**, developing new concepts suitable to smaller size range resulting in lower capital and operational costs.
  - **Process integration** within the whole plant in order to improve the overall energy balance of the plant reducing need for external energy imports.
  - Development of **biomass handling** and reliable gasification systems with greater feedstocks tolerance also able to produce a high-quality syngas.
  - Development of **novel clean-up systems** to reduce impurities from syngas and to limit the energy requirements for its upgrading.
  - Development of **new catalysts** less susceptible to impurities with longer lifetimes.
- Co-processing of FT products at existing crude oil refinery sites in order to achieve greater economies of scale and efficiencies as well as tailoring the product portfolio according to the market needs.
- For **SNG**, with the exception of the AMBIGO initiative, the sector is showing a lack of confidence about the possibility to profitably produce SNG via biomass gasification

Fast Pyrolysis; challenges and next steps

- There are opportunities to improve pyrolysis through development of processes able to **maximise bio-oil yields**, and the use of **catalysts able to promote higher selectivity** and productivity of desirable products.
    - Catalyst improvements are an opportunity in upgrading. More dedicated research is required to reduce hydrogen consumption during hydro-treatment. Past projects such as the FP7-CASCATBEL as well as on-going project such as 4REFINERY have already published or are investigating several technical developments using catalytic fast pyrolysis and up-grading via refining processes but they need to be scaled up.
- **Co-feeding** pyrolysis oil in oil refinery units using existing infrastructure and commercial technologies is another promising opportunity investigated by current H2020 projects.
- According to IRENA, the majority of cost reductions are expected to occur in **upgrading**, and innovations could ultimately lead to a 10%-30% fuel cost reduction.
- Another important area of investigation is to produce pyrolysis liquids from **cheaper residual resources**, while maintaining a product quality meeting the specifications for bio-liquid.
- Investigations on other processes combining different routes, such as Thermo-Catalytic Reforming that combines intermediate pyrolysis with post catalytic reforming of the pyrolysis products

HTL; challenges and next steps

- HTL, proven at laboratory and/or pilot units, appears promising for the production of bio-crude oil that can be blended with traditional fossil crude with a view to being **upgraded** at oil refineries.
- The challenge of ongoing projects led by Steeper Energy Aps (SEA) industry in Denmark and by Licella Pty Ltd company in Australia is to **move TRL** from 5-6 (pilot) to 7-8 (nearly commercial) via testing, scale-up and demonstration.
- In both cases, R&D involves testing feedstock types to determine optimal operating parameters for development and demonstration of HTL platform and upgrading reactor configuration.
- The key objective is to validate current process assumptions, on large-scale, outdoor, year-round operation. Most recently, Licella appear to be moving closer to this point through the integration of their technology into a paper mill
- Better understanding of HTL technology needed to identify specific challenges and promote cost-effective conversion pathways. Techno-economic analyses will have to be conducted as research and development progresses over the next few years.
- An interesting development which may be a solution to the relatively limited progress on upgrading of bio-oils are initiatives of NesteOil (Neste Oil-2, 2018) and Repsol (REPSOL, 2016) are now performing tests at scale to **co-process HTL with crude** oil, but at very low blend levels.

(2) Advanced alternative fuels; definition

- Two new types of Advanced alternative fuels which Member States can promote are described in the new Renewable Energy Directive (RED) published December 2018 (EU 2018/2001), namely:
  - **Renewable fuels of non-biological origin**; are liquid or gaseous fuels, used in transport whose energy content comes from renewable energy sources other than biomass (generally expected to be renewable electricity, producing so-called electrofuels)
  - **Recycled carbon fuels**; are defined as being 'produced from liquid or solid waste streams of non-renewable origin which are not suitable for material recovery, or from waste processing gas and exhaust gas of non-renewable origin produced as an unavoidable and unintentional consequence of the production process in industrial installations'

Electrofuels; challenges and next steps

- Individual steps of the production chain available at high TRL, complete chain appears not yet to be in existence
- Such fuels can be a method for converting excess renewable electricity into liquid fuels, and become an energy storage medium. **Costs** appear a considerable drawback, thus work to alleviate this could prove useful in increasing the TRL of a production chain.
- Schmidt et al (2018) note the main requirement to large-scale implementation is a continued cost reduction - in particular of renewable hydrogen production from water electrolysis powered by solar and wind energy. Important secondary considerations would be ensuring the electrical grid can supply enough power to production units.
- In the medium-term, there is a strong need for alternative fuels, in particular in **aviation**, while for the other transport modes, an important further aspect would be to look at the direct use of the renewable electricity in transport, which appears currently to be more energy efficient

Electrofuels; challenges and next steps

- Regarding the fuel synthesis part of electrofuels, it has been seen that a number of options are available, which utilise Fischer-Tropsch technology, or methanolysis (to produce hydrocarbon fuels or alcohol fuel respectively).

- Power-to-Gas (**PtG**) has overall chain efficiencies approaching that of large thermal power plants, but costs remain a large inhibiting factor, while Power-to-Liquid (**PtL**) - employing FT which has worked at large scale, but now attempts are being made to ensure it succeeds at a lower scale more suitable to match the likely available volumes of the most favourable CO_2 sources.

- Whereas for PtL, methanol synthesis is also largely functional, but work is on-going to try and reduce the operating pressures of such systems (though the methanol would require further processing to make a drop-in fuel).

Recycled carbon fuel; challenges and next steps

- **Microbial fermentation**, in which microorganisms are fed by carbon containing gases, have gained a lot of attention and coverage. One company are the dominant party in this area, and it is of interest to note they announced during the middle of 2018 their production chain is going into industrial scale production (with a c.45 000 ton/annum facility) in China.

- The same company have been involved in a large EU (H2020) project; the results of this work will be interesting. The carbon gas sources may be fossil based, but the technology is likely to be transferrable to bio-carbon sources also. From a **sustainability/LCA perspective**, if the feedstock gases are already being used as a fuel (to provide heat or power), this would need to be taken into account.

Recycled carbon fuel..

- Finally, if a fuel can (and in a verifiable manner such as via a robust life cycle analysis which takes into account the existing uses of feedstock materials) **save GHG emissions**, compared to the regular predominant fuels, it would seem a rational approach to include such fuels in future analyses of advanced alternative fuels, even if the pathway is not entirely renewable.

Any questions?

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