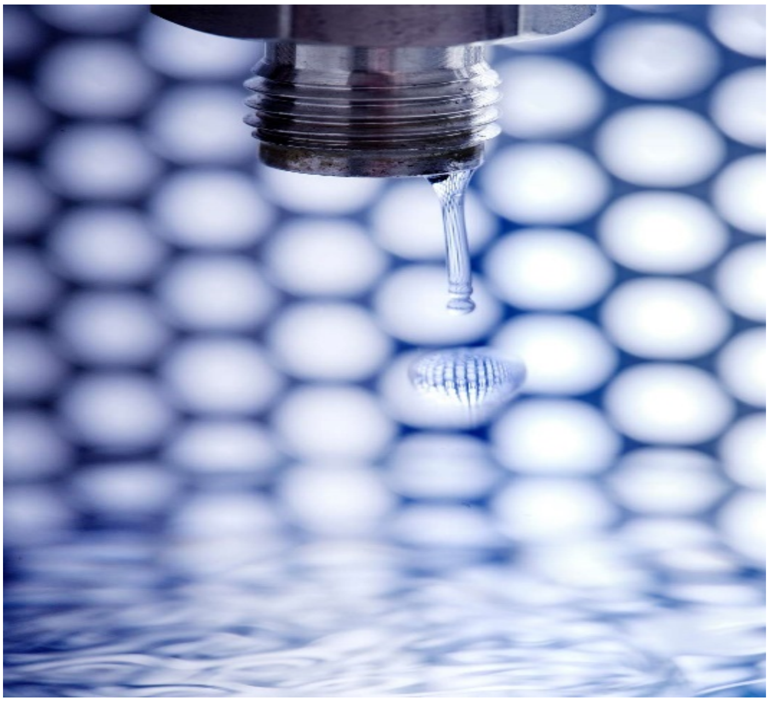
GREEN FUELS

Executive Summary



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Introduction

Uncertainty and concern about the future of fossil fuels continues with the agreed climate targets of the Paris Agreement driving a need for deep carbonization of the economy. The impact on the oil and gas sector is intensifying, leading industry and investors to avoid overinvestment in potentially unnecessary projects. But dependency on fossil fuels in the transport sector is high due to its high energy density, easy handling and existing infrastructure and cost-competiveness compared to alternatives, which leads to the question which role liquid and gaseous energy carriers play in the future energy system.

Alternative fuels and technologies are promising complements to unabated fossil fuels[1] in the near term and likely substitutes in the long term. Alternative fuels, also known as non-conventional or advanced fuels, are any materials or substances that can be used as fuels.

In the longer term, new technologies in generation, storage and smart demand, together with electric cars and the shift towards digitalization, will increase demand for electricity, and not fuels. While the full decarbonization of the power system may be manageable, for some usages, the direct shift to electricity may be difficult or very costly for example in waterborne and air transport or high heat industrial processes. But electricity may be used to generate different energy carriers, including synthetic gas and liquid fuels. Therefore, power-to-x (gas and liquids) solutions appear to be promising solutions to decarbonize the whole energy sector, in line with the development of low-carbon electricity generation capacities.

Other promising low-carbon fuels are advanced bio-fuels, provided that production does not lead to increased emissions from direct or indirect land-use changes. Biofuels may be a preferable replacement for fossil fuels in transport as it can be converted to high density fuels and can be used in current infrastructure and with all types of ICEs installed in light duty vehicles, heavy duty vehicles, waterborne craft and aircraft. This includes renewable methanol, which is an ultra-low carbon chemical produced from sustainable biomass, often called bio-methanol, or from carbon dioxide and hydrogen produced from renewable electricity. Different technology routes for converting electrons or photons to molecules exist, including electrochemical, photochemical processes. Thermochemical processes are also used. These processes can be coupled as hybrid processes. Some are in commercial use (TRL 9) while others need further development.

The experts workshop addressed three overall questions:

1. What is the global outlook for alternative fuels in a low-carbon energy system and what are the drivers?
2. What are the challenges and opportunities for alternative fuels?
3. How can RD&D policies accelerate affordable, effective and environmentally friendly alternative fuels?

The global outlook for alternative fuels is closely related to the decarbonisation of the energy system, first and foremost those parts of the transport system where direct electrification appears difficult or too costly, but also the need to build flexibility options into the power system with high amounts of renewable energy sources and to make use of existing infrastructure. National CO_2 reduction targets and regulatory frameworks will impact the development and use of alternative fuels. Therefore it is difficult to to foresee when which alternative fuels will prevail and when they will be competitive in the markets (end-use sectors of transport, building and industry).

The decarbonisation of the transport sector is a major challenge. It accounts for almost one-third of final energy consumption, produces approximately one-third of global energy-related CO_2 emissions and is primarily responsible for urban air pollution. Alternative fuels are important options for aircraft, waterborne vessels, long-haul heavy trucks. Which alternative fuel to choose will depend on the required infrastructure and its adaptation and competing alternatives.

[1] These are fossil fuel conversion technologies not using carbon dioxide capture and storage technologies.

In the medium-term drop-in-fuels (e.g. from biomass) may provide an important contribution due to its lower transaction costs. Resources for power-to-x fuels are closely linked to the large scale-up of renewable energy and should be considered as a global commodity, which can be traded and transported. The engagement of all relevant stakeholders (including also for example refineries) will be needed in order to accelerate the transformation towards a low carbon economy.

Challenges and opportunities

The overall guiding principle for alternative fuels rests of the 3 'S' – Sustainable, Scalable and Storable, being power-to-fuels, power-to-liquids or advanced biofuels.

The overall timeframe for developing and introducing alternative fuels puts enormous pressure on developing a proper market design that covers all aspects of the transformation and transition period. Conflicting and competing interests from incumbents, lobbyists and lack of long-term policy framework will characterise the transition period which will add to the challenges and costs.

When it comes to biofuels, the challenges are closely related to the competition between fuel, food and fibre. The biodiversity and the carbon mitigation potentials add to the complexity of developing advanced biofuels.

For both power-to-x and advanced biofuels, key challenges are to keep production costs low and competitive. Comparative, prospective analysis of the pros and cons of different alternative fuels and energy carriers need to be done for each sector. For example what are the prospects of biofuels, LNG, hydrogen, methanol, ammonia or batteries in the maritime sector? Much will depend on a possible carbon tax on competing energy carriers, but it will also depend on different uses with differentiated qualities and prices.

Whether production facilities should be large, centralised units or smaller decentralised units is not straightforward but associated with trade-offs between economics of scale, the trend towards a distributed energy system, infrastructure planning and also the request to adapt to specific sector needs. Also a reliable supply of advanced fuels should be considered which may be a challenge when integrated into a coupled energy system with multiple uses. However, large scale power-to-X is much more than curtailment. Huge investment in technology development is needed, but as demonstrated by the SUNFIRE case, it is possible to raise the necessary venture capital from strategic investors and private equity to scale up production capacity of power-to-x fuels and gases for future markets of transport, steel and chemicals.

Existing infrastructure may be adapted to advanced fuels and thereby overcome the challenges of stranded assets. Alternative fuels in the transport sector may need new infrastructure, which further will require new safety standards and regulation. The challenge can be compared to the built up of infrastructure of gas-pipes for heating. What comes first the egg or the chicken.

Interesing opportunities are closely related to infrastructure planning. When scaling up offshore wind power in the North Sea, energy clusters can – if properly designed – balance power supply, large scale electrolysis of hydrogen (2.2 capacity of current the power consumption) and integrated infrastructure planning with less transmission lines and more gas lines.

The roll-out of advanced fuels will very much depend on public perceptions. FridaysforFuture as promoted by young people around the globe has huge impact and demonstrates that the next generation is ready to act. It depends also on stakeholder outreach and dialogue and in general educating the general public about the pros and cons of alternative fuels.

Recommendations for enhanced RD&D efforts

Integrate alternative fuels in the energy system

The development and market introduction of alternative fuels should be considered as an integrated part of the long-term goals of reducing CO_2 emissions (i.e. carbon neutrality). This will require a holistic approach/ comprehensive energy system analysis and planning, which takes into consideration life-cycle-assessment of competing options of alternative fuels, the overall system efficiency, feedstock analysis, integration and sector coupling. Without a carbon tax, it may be difficult to remove the implicit and explicit bias in the current fuel market.

Be ware of consumer needs and acceptance

Decisive to the further development of alternative fuels is to keep the consumer in the centre of the energy system. This includes the overall acceptability of such fuels, how they are produced, at which production and infrastructure costs, the fuel efficiency and quality and the environmental impacts.

Learn from others and develop sound decision-support and monitoring tools

The German BEniVer project illustrates how an accompanying project supports a larger alternative fuels R&D programme and provides a sound decision support. It establishes consistent methods to compare different technologies and fuels, conducts a comprehensive evaluation of research results and develops a roadmap for synthetic fuels. Such approach will allow for learning from others, what has been successful and what not and thereby build in the necessary technology push and market pull incentives to advance further. Also the energy system analysis of the Danish transmission and gas infrastructure as well as the future gas study are good examples of analysing the potentials of alternative fuels taking into consideration of renewable energy sources, infrastructure, sector coupling and storage.

The Austrian energy model region WIVA P&G is a good example of how to scale and position a transregional, thematically focused cluster of more than 30 sectorally integrated projects. It has a multidisciplinary innovation structure, demonstrates and tests intelligent system solutions in practice, and provides applicable systems for users.

Ensure financial support to the whole value chain

RD&D support/policies should not exclude technologies or new ideas, but rather differentiate necessary financial support across different TRLs. Some technologies such as bio-fuels from algae production is still at an early stage, industrial scale SOEC still at pilot scale and alkaline electrolysis a mature technology. It takes time to develop and mature new technologies as it is demonstrated in the development of the Fischer-Tropsch synthesis of fuels and chemicals. In addition, it is of utmost importance to support demonstrations and flagship projects to create confidence and tangibility among technology producers and users as well as the general public. Both public and private funding is needed to accelerate the technology innovation, not least demostrations and flagship projects.

Promote public-private partnerships to drive the knowledge devleopment

Partnership is a major driver of developing alternative fuels. It takes time and resources to develop the technologies and design well-functioning markets. This will require close cooperation across different sectors such as regulators, infrastructure partners (TSOs, GSOs), fuel technology providers, utilities, the transport sector, agriculture and of course research institutions. Lessons learned from different transport sectors across different countries are also valuable for the futher advancement of alternative fuels.

Promote international cooperation to avoid overlapping R&D activites and fill gaps

Finally, international cooperation is needed regarding R&D strategies in order to avoid overlapping R&D activities and filling R&D gaps. Such cooperation also includes making available lessons learned from successful demonstrations, market introduction mechanisms and regulatory frameworks.