Sector coupling established by the technology partnership reFuels - rethinking fuels

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Summary

The use of regeneratively produced fuels (reFuels) is a promising path towards CO_2-neutral mobility, alongside other measures such as the expansion of electric mobility. These fuels can be produced from carbon-containing residues from agriculture and forestry, from industrial and municipal waste, as well as from CO_2 in combination with hydrogen obtained by electrolysis of water. These fuels together form the reFuels class.
In order to assess the potential of reFuels, a holistic evaluation is necessary, including the determination of efficiency potentials for their manufacture and application. Under the patronage of the state of Baden-Württemberg the technology partnership reFuels was initiated, in which companies of the energy and mineral oil industry, the automotive industry and the supplier industry together with the Karlsruhe Institute of Technology (KIT) are investigating efficiency potentials for the production and application of reFuels. Pilot facilities already in operation will be used to produce fuel components in a sufficient scale. The systemic and socio-economic aspects for the production and application of reFuels will be considered and put in an dialogue with civil society actors to consider the open communication into society..

Within the reFuels project started in 2019 for 2 years duration the consortium of industrial companies and KIT including companies as energy providers, fuels synthesis to suppliers, system developers to engine and car manufacturers. The Project shall achieve the following goals:
1. Provision of selected regenerative fuels ("reFuels") and holistic evaluation of the processes for their production including the determination of efficiency potentials for production and application
2. Evaluation of reFuels key properties, demonstration in the application and evaluation of the application properties
3. Involvement of civil society actors and communication in society.

1. The controversial introduction of E10 fuel

In the case of the E10 fuel introduction it became obvious that not only its environmental benefits are counting. The lack of acceptance by the general public has several reasons:

1. End customers were often not convinced this fuel will not damage their car.
2. The effect of the lower heating value (~3%) is small compared to the effects of personal driving but the public discussion on this topics led to the widespread opinion of increasing fuel consumption. The later adjustment of the E10 price did not lead to any major change in public opinion.

3. Beside the confusion of the customers, E10 has not really been pushed in public, neither by press media, by politics and the car manufacturers nor by the fuel suppliers.

When considering the future introduction of reFuels[1], these experiences need to be considered. As a consequence, the reFuels approach should take sufficient account of the different stakeholders.

Consideration of and communication with stakeholders is therefore a major task with several groups have to been taken into account:

- Manufacturer Motors
- Manufacturer Vehicles / Transport Equipment
- Fuel Suppliers (refinery, oil + gas industry)
- Community
    - politics
    - public
    - Non-governmental organizations (NGOs)
    - Press / Media
- Consumers
    - Transport companies Passenger transport (bus, rail, sea)
    - private persons

Each of these stakeholder groups will have its special perspective on evaluation factors towards reFuels:

- expenses and costs
- CO_2 balance in fuel synthesis
- CO_2 balance for availability of infrastructure
- CO_2 balance fleet
- Efficiency / feasibility up to 2030
- Public acceptance
- Robustness of the application

[1] reFuels summarize all types of fuels based on regenerative sources – energy and biomass

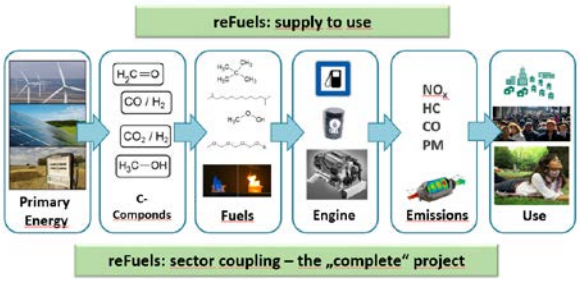

Figure 1: Holistic reFuels approach to ramp up a fuel change

As a result of this, we see

- ⇨ Different levels of mobility and different applications
- ⇨ A multidimensional task

And therefore a holistic approach is necessary.

Our approach led to a project structure of three columns: first, the energetic consideration and capability of reFuels synthesis, secondly the security in the reFuels use and thirdly the communication of the knowledge gained to all stakeholders.

2. The reFuels project approach

2.1 Bottom-up instead of top-down

Changing fuels is a general game changer in mobility. Usually such a task has to be addressed at the EU government level. Nevertheless, we decided to initiate a bottom-up approach for a demonstration project in the state of Baden-Württemberg, due to the unique project basis with all kind of relevant supply chain actors located in our state: business and industry of energy suppliers, refinery, automotive and industrial suppliers, system developers, engine and vehicle manufacturers as well as an established scientific community and a government driving transformation in mobility by the so called “Strategiedialog Automobilwirtschaft Baden-Württemberg”.

This small and compact project group allows short distances for discussions and decisions, a real advantage necessary to handle this complex change in mobility.

The two-year project is designed to demonstrate the feasibility of regenerative fuels in everyday life, taking into account sustainability from raw materials to synthesis and use. The range of engines extends from small cars to trucks and special vehicles, from diesel engines for rail and inland waterways to engines for decentralised energy supply. Communication as a key to the introduction of new fuels is a major focus of the project's activities and will be on the development of evidence-based facts for better cooperation towards stakeholder and the public

A key task for a future reFuels introduction will be that also vehicles currently in use can be operated with this new fuel. Therefore, the initial step in order to contribute to CO_2-neutral mobility are fuel test scenarios with blends, i.e. fuel blends that meet the existing fuel standards EN590 for diesel and EN228 for gasoline vehicles.

In our understanding, this project is the first to involve the entire value chain of mobility, from energy providers (ENBW), fuel synthesis (MiRO), suppliers, system developers to engines and vehicle manufacturers.

Figure 2: structure of project participants

2.2 Common alignment of project decisions

The diversity of project partners results in potentially complex decision processes. In order to keep a fast and efficient decision structure it is necessary to establish a multi-stage process for common alignment by building separate groups of responsibility. The first decision level must take place among the partners with core commitment and those coordinating the clusters A to C. The guidelines defined are then to be discussed between all partners to decide on concrete actions within the project.

3. reFuels structure

The project consists of a matrix-like structure to combine effective cooperation of the partners with the capability to take respect to the before mentioned constraints:

1. Steering Committee, Partner Committee, working groups
2. Clusters A to C

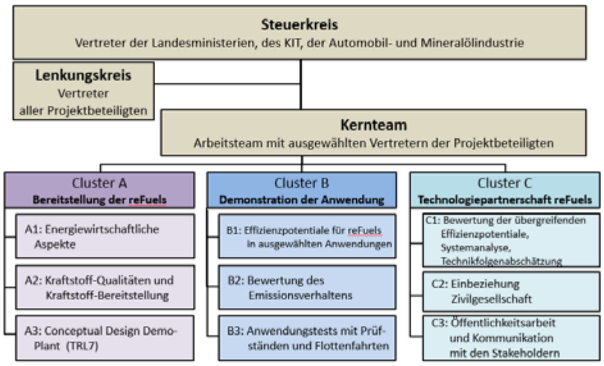

Figure 3: Organization and governance of the project

Figure 3 shows the organizational structure of the project, combining a hierarchical structure (strategic control and adjustment by the so-called Steuerkreis, operational control by the Lenkungskreis) and subject-of-work oriented structure in the specific tasks.

Every cluster will provide many project data but the project task will only be successful, if an intense information exchange takes place. By separating the detailed working packages within the clusters A to C we take into account, that that a constant loopback between fuel tests, fuel synthesis and holistic evaluation is ensured.

The complex interaction between the clusters is is visualized in Figure 4.

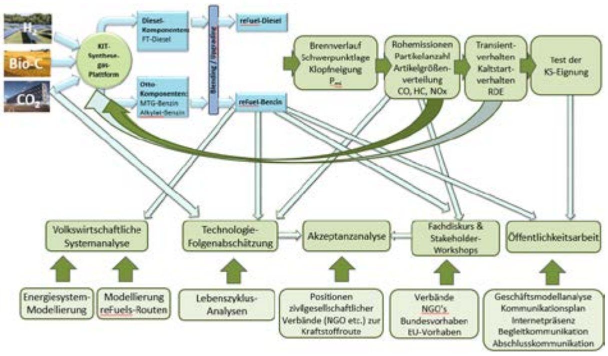

Figure 4: Interactions between project activities

Inside of each cluster the complexity stay

In every cluster the complexity is very high, especially if one takes into account that many technologies have to be considered in parallel today in order to contribute to success and thus a rapid reduction of CO_2 together and side by side. Since the change towards a CO_2-neutral mobility is not an exclusive or decision between the different powertrain approaches (electro-mobility, fuel cell mobility, regenerative gaseous mobility and regenerative fuel mobility) the different pathways of synthesizing regenerative energy must be considered in parallel and the respective efficiencies, availabilities and possibilities must be summarized in the ramp-up. Only the addition of different paths instead of competition with an either-or decision can ensure sufficient quantities of CO_2-neutral fuels.

This multi-pathway – approach for highest effects is shown in Figure 5.

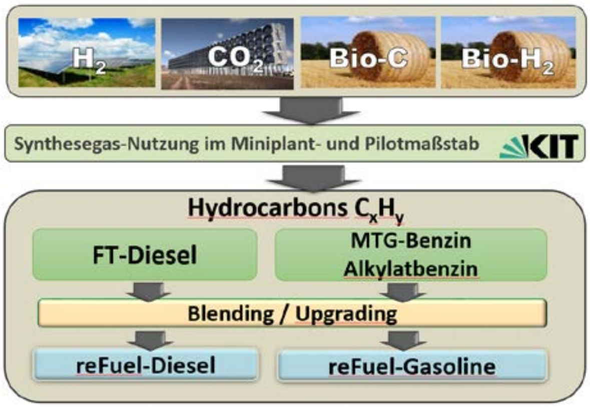

Figure 5: multi path approach in fuel synthesis

Initially, the fuel is provided in Cluster A by synthesis in the test facilities Bioliq® and EnergyLab2.0 at KIT. In order to effectively evaluate he limited volume of reFuels generated in these plants (each up to 2 t), we have chosen a step-by-step approach for the testing in Cluster B. This stepwise approach for fuel and fleet testing depends each step on decisions and results of the previous steps. In later working packages of the overall project planning for industrial equipment is scheduled based on the results of the synthesis in cluster A.

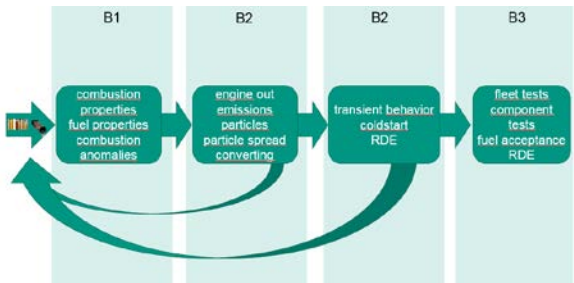

Figure 6: Testing plan for the regenerative fuels and their blends

The waterfall approach integration into the general approach, which is evaluated as the most efficient approach in this complex situation. The test phases are separated into three steps by its importance and its system complexity.

The standard combustion properties and the basic fuels properties are evaluated on a one-cylinder test stand by common measurement and testing approaches. These tests will show, that the fuel blends will have the necessary heating values, combustion behavior as well as its capability to be controlled by standard ECUs and standard application setups. Only when a blend can fulfill this “entrance door” the tests with higher complexity and higher fuel usage will follow. Implementation of testing is as usual by following the chain 1-cyl- → multi-cyl, → vehicles.

4. Communication Approach

To avoid unanswered worries and questions and unfinished discussions, all communication and discussion must be based on reliable and verifiable facts.

A technology assessment is a good basis for this approach and consists of the following components:

- Techno-economic and ecological evaluation of different process routes
- Fuel route in energy scenarios
- Acceptance analysis of positions of civil society associations
- Professional discourse with associations and stakeholder workshops

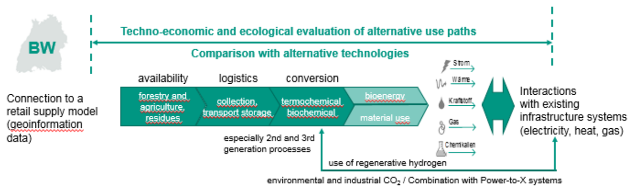

Figure 7: Lifecycle assessment for fuel evaluation

Figure 7 illustrates the general approach for a life cycle assessment according to DIN ISO 14040 and DIN ISO 14044.

Important from the view of the following communication is that all evaluation is based on facts instead of opinions. In this project it is a task to generate these facts by the test runs of the above described synthesis equipment.

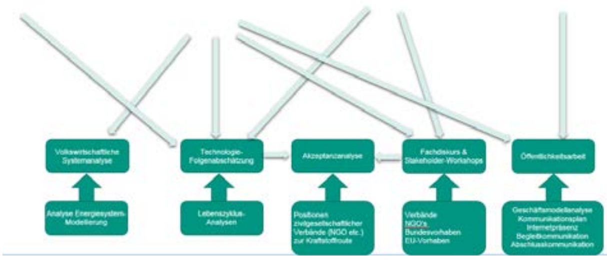

Figure 8: influencing communication and life cycle assessment by facts

Finally, all of these facts and evaluated assessments will be used in workshops with stakeholders and communication to public by multiple media pathways.

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