FUTURE H2 POWERTRAINS – INSIGHT FROM IAV

In addition to all issues relating to the production and use of alternative energy sources from biological and synthetic origin, IAV as Engineering Pioneer and Tech Solution Provider for future safe and climate friendly mobility, is very intensively involved in the entire hydrogen value chain. In parallel to infrastructure and production, e.g., via electrolysis, intensive work is also being done on transport and storage solutions and, of course, the conversion of hydrogen into mechanical or electrical energy by means of combustion engines and fuel cells.

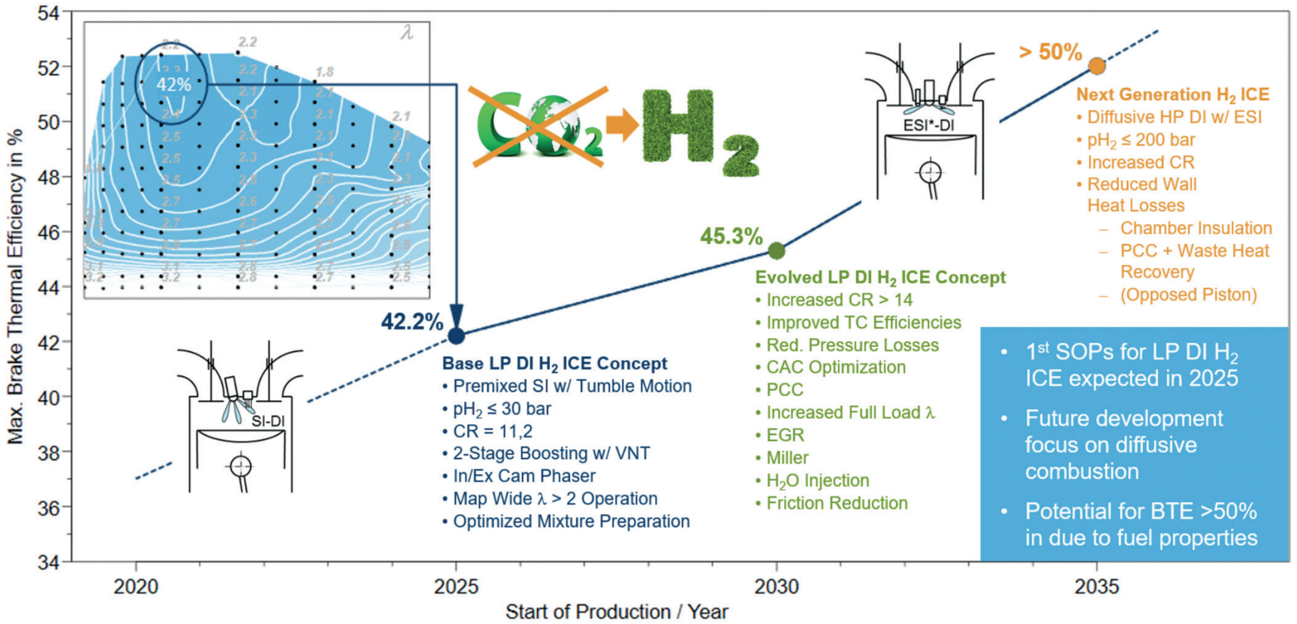
IAV's Engineering footprint over the H2 value-chain

Are the fuel cell and the hydrogen combustion engine in competition?

No, because both have advantages and disadvantages depending on the application. This will inevitably lead to a coexistence of both powertrain concepts. Where does this insight come from? From the results of a detailed techno-economic study which IAV conducted and published in 2021 on various hydrogen powertrain concepts in different vehicle classes. The study concludes that both fuel cell and hydrogen combustion engines powertrains are very comparable with purely electric powertrain from the point of view of CO_2 equivalents in the life cycle, and also from the point of view of TCO. IAV can prepare and tailor such studies on behalf of clients. For this purpose, large databases are available regarding a TCO calculation as well as for the assessment of environmental impacts such as CO_2e. Optimal sizing for each type of powertrain and operational constraints, are taken into account to have the most accurate assessment possible depending on the target applications.

Is a BTE of 50% realistic for Hydrogen fueled Internal Combustion Engines ?

At present, the development of hydrogen combustion engines is focused on concept with intake manifold injection and low-pressure direct injection. The latter work with injection pressures between 30 and 50 bar and allow higher power densities and efficiencies than engines with intake manifold injection. Depending on the engine concept, effective efficiencies of up to BTE 45% are achievable. IAV has developed its own combustion model to enable efficient, rapid and yet precise development of new hydrogen combustion systems, as well as to be able to map all relevant effects influencing efficiency, such as mixture inhomogeneities and self-ignition. This means, for example, that different injection systems and also technology combinations can be evaluated very quickly and yet reliably in terms of their potential on the basis of 1D simulations. This means that 3D simulations can be avoided in many places.



Insight on possible efficiency and technology Road Map for H2 ICE

Effective efficiencies greater than 45% and up to 50% are only achievable with hydrogen if the rather complex high-pressure direct injection with pressures of up to 200 bar is used, (see below on the figure). This in turn enables very late injection, so that the transition from premixed to diffusive combustion can take place, which allows the avoidance of self-ignition or knocking in conjunction with high compression ratios. Here too, IAV develops its own combustion models to enable effective development of new highly efficient combustion concepts.

In this way, IAV is once again underlining its high level of expertise in the field of combustion process development, especially for new energy carriers.

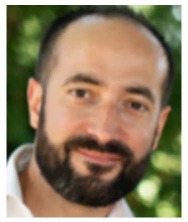
What are the technologies and steps to help fuel cells become more competitive?

Compared to combustion engines, fuel cell systems already achieve efficiency levels of well over 50%, often up to approx. 55%. In addition to a further increase in efficiency, other points are also the focus of development activities, decisively also at IAV. On the one hand, costs must be reduced and, on the other, the durability or service life of the stack must be improved. Both points can be influenced, for example, by monitoring ageing and degradation during operation. IAV can offer a solution to this problem because the degradation and ageing models developed in-house at IAV, which are already used in basic development, are developed with the intention of real-time capability right from the start. This makes it possible to use these models on control units as well, which means that during operation of the fuel cell, the operating scenarios can be set in such a way that the degradation or ageing behavior can be prevented or delayed.

The aforementioned ageing and degradation models are validated using measurements from IAV's own single-cell test rig. With the help of this test bench, MEAs can be exposed to any harmful operation or even poisoning scenarios.

If operating scenarios of the entire fuel cell system are to be evaluated or developed, IAV can draw on its own 150 kW fuel cell system test rig which, in addition to a wide range of applications, also allows extreme conditions to be represented, such as conditioning of ambient conditions down to -40°C.

IAV is therefore equipped to provide support in all main areas of fuel cell development.



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