Summary
To reach the ambitious climate targets of the United Nations a systematic decarbonization of traffic is indispensable. As most countries focus on eMobility hydrogen technology offers in the long run a resource-saving alternative. By bonding the explosive hydrogen to an organic carrier substance one created a storage possibility and a transport possibility which allows the use of the existing gas station infrastructure in a nearly unchanged way. Also in national as well as international trade with this safely bonded hydrogen, existing structures in form of container ships or railway can be used with this safely bonded Hydrogen.

1. Initial position

The transfer to renewable energy use is the core element of climate policy as decided in the treaty of Paris in November 2015. One determined, that in order to reach the 1.5°target, one has to reduce the greenhouse gases to zero between the years 2045 and 2060.
While one succeeded to expand the renewable energies in the past as to production of electricity, the percentage of emission of green house gases in traffic didn't decrease but has even gone up. Thus the traffic sector has the responsibility to make a substantial contribution to reduce the greenhouse gases. This target can be reached by a massive conversion to battery driven vehicles as well as by fuel cell vehicles.
The pressure to work on environmentally friendly mobility does not only come from the Paris climate conference of November 2015 but recently from the decisions of the European Parliament, the European Council and the European commission of December 2018.
There demand are put on the car manufacturers to reduce their CO2 emissions massively namely by 15% by the year 2025 and even by 37.5% by the year 2030 respectively measured at the ambitious targets of 2021. In the current discussion about exceeding the nitrogen oxide limits in 90 German cities there is a strong call that within the framework of "mobility of the future" there should be more and more renewable energies applied.
For several years the topic e-mobility has strongly been propulsed by the federal government. As early as 2011 chancellor Angela Merkel demanded that by 2020 there should be one million e-cars on our roads. But in the beginning of the year 2018 there were not more than 100.000 vehicles, which means this target will not be reached.
So chancellor Merkel announced at the handing over of the management report of the national platform e-mobility (NPE) that the aimed target has to be postponed to the year 2022. Though scepticits of e-mobility ask at what mileage e-mobility is economically and ecologically reasonable. One has to take into account, that e-mobility is more economical and ecological, the higher the mileage is.
This fact also corresponds with the support policy "immediate program clean air" of the German federal government. By this the purchase of those electrically driven vehicles is supported, which are more or less all the time on the road such as busses, delivery vehicles and craftsmen vehicles and recently also municipal vehicles.
Unfortunately there is up to now not enough attention given to the use of fuel cell vehicles. It is obvious that the use of hydrogen could be an ideal link between "Energiewende" on the one hand and "Verkehrswende" on the other hand.

2. Using hydrogen as an alternative

Already to date there are times when more electricity is produced than actually needed due to the systematic expansion of wind energy and photovoltaics in Germany.
This is for example the case, when there is intensive sunshine and at the same time a strong wind blowing. In those cases many wind turbines have to be “taken out of the wind”, what is economically and ecologically unreasonable. Paradoxically, this fact is not at the expense of the wind turbine owners, because they get full compensation which is financed by the “energy supply law”(Energieeinspeisegesetz EEG) and has to be born by all consumers, thereby meaning increased electricity costs. It would be more reasonable do produce hydrogen with that surplus electricity which is not needed in the electrical net at that time. Though hydrogen has the inconvenient characteristic to be an explosive gas. And in fact hydrogen played a prominent, and at the same time tragic role as to the use of zeppelins which were in operation even for transatlantic flights, The skeptic attitude of many people results from a historic accident on March 4th, 1936 in American Lakehurst in the state of New Jersey. The hydrogen filling of the zeppelin LZ 129 “Hindenburg” caught fire and many people on board and numerous employees of the ground crew lost their lives. Up to today, the storage as well as the transport of hydrogen means increased costs. So, even with the latest transport facilities the Linde AG can only transport 1.1 ton of hydrogen under a pressure of 500 bar in a 40 ton truck..

3. Erlangens approach to the problem
In this case, a procedure which was developed at the Friedrich-Alexander University of Erlangen-Nuremberg could most likely help. Developed by the professors Wasserscheidt, Arlt and Schlücker this process makes it possible to bond hydrogen by a catalytic way to an organic hydrocarbon (liquid organic hydrogen carrier, L0HC). Togather with a manager of the company Hydrogenious, Daniel Teichmann, the mentioned team managed to get into the “top three” final group of the “future award” of the federal president Frank-Walther Steinmaier in December 2018 in Berlin. Essential element of the LOHC technology is the chemical bonding of hydrogen to an organic carrier liquid named dibenzyltoluol. The loading of the carrier medium is done by hydrogenation which releases heat and produces Perhydrodibenzyltoluol. The unloading of the carrier medium needs the input of heat and is an endothermic reaction in which dibenzytoluol is produced again. What is so interesting about this innovation is the fact, that the carrier substance can be loaded and unloaded continuously in a closed cycle. The hydrogen bonded to the carrier substance can be transported without any problems with conventional tankers and can be transported to the gas stations and stored in the existing gas station infrastructure. Depending on the demand quantity hydrogen can be separated in a reversible catalytic process from the hydrocarbon (L0HC). However at these hydrogen gas station it could be essential to create the possibility of compression of hydrogen gas. The highly compressed hydrogen can then be filled in the already existing gas station within minutes. In contrary to the long loading processes with eMobility the filling process does not take longer than the filling process for combustion engines with diesel or gasoline.
Similar to the use of hydrogen technology for automobiles there is also the possibility to use hydrogen technology for rail transport. So for example at the end of January 2019 the worldwide first by hydrogen driven train demonstrated its “mountain suitability” after beeing on tour in fall 2018 in the flat Elbe-Weser area in regular service. It bears mentioning that this train has a range of 1000 km and a maximum speed of 140 km/h and that the process of

filling does not last longer than the filling with diesel. The researchers at the Helmholtz-Institute at the Friedrich-Alexander-University Erlangen-Nuremberg are already working at a further developed technology: In this latest project hydrogen which is bonded at LOHC should be transported on board and should be released on board of the train only. There it delivers the electricity necessary for driving by a fuel cell during driving operation. The Bavarian government decided to support this technology with a large-scale financial support. The directors of the Helmholtz Institute Erlangen-Nuremberg for renewable energy, Prof. Mayrhofer and Prof. Wasserscheid were granted 29 million € which are meant to be used for the research and development of highly emission reduced propulsion systems following the example of rail traffic.
The fact that hydrogen technology has also - independent from the topic of mobility - fields off application was shown in 2016 when the first bonded L0HC hydrogen based electricity storage application was cimissioned. This system offers a long-term storage technology but can also be used as a short term store.
The above described technology can be used not only on a national level, but also across borders: hydrogen can be transported to Germany by tanker ships from those countries , where the production of hydrogen is quite inexpensive as for example Norway, which has extreme reserves of water power.
There electricity is extremely cheap and hydrogen can be produced at low costs in an electrolytical process.
Also on the national level the application of this technology can be used to bond hydrogen which is produced is the north German Laender like Schleswig-Holstein, Lower Saxony, Mecklenburg-Vorpommern, and Brandenburg at LOHC and transporting it on goods wagons or on ships on the waterway from the north of Germany to the industrial clusters in the south.
Already 20 years ago BMW, for example, applied the hydrogen technology in vehicles and as early as 1996 the city of Erlangen tested a bus with hydrogen propulsion for half a year without any problems in regular service.

4. Advantages of this technology

The enormous advantage of this technology is, that it is absolutely emission free and as only steam is produced as a combustion product. In contrast to e-Mobility where enormous financial costs arise for the production of the batteries - especially when extraction of Lithium is necessary - the production of fuel cells is far more affordable and one does not depend on scarce resources such as Lithium. In the light of this these current discussions in Germany have to be looked at in which one considers to establish a battery production with the expenditure of billions of euro. A further advantage of the application of hydrogen technology compared to e-mobility is the mileage of such driven vehicles can cover. As the weight of the transported hydrogen and the fuel cell which is necessary are significantly lighter than of current combustion engines. E-mobility needs a battery weight of nearly half a ton for a mileage of 400 up to 500 km which has to be transported as a “dead load”.
In the discussion about keeping to the nitrogen oxide limits of 40 µg per cubic meter based on the EU guideline 2008/50 EG (air quality guideline) the federal government published the “immediate program clean air” in fall 2017 which runs to nearly €2 billion euro after the 3rd municipal summit of December 3rd 2018.The federal government intends a quick and sustainable reduction of nitrogen dioxide by means of digitization of municipal traffic

systems, by electrification of traffic buses, taxis and delivery vehicles as well as retrofitting of diesel buses with this program.
Presumably these measures will not be sufficient to stick to the necessary limits in the 60 affected cities. For this reason it will be essential to further invest in new propulsion technologies and to incite the application of hydrogen technology with appropriate supporting measures. In this context hopes are set on the announcement at the coalition threaty of the coalition parties CDU/CSU and SPD of March 13th. 2018. It literally reads: “we want to continue the national innovation program hydrogen and fuel cell technology. We want to further develop the mobility and fuel strategy (MKS) technology open and increase the funds for its implementation. We want to promote the link between the energy sector and the traffic sector and amend the legal framework so, that “green hydrogen” and hydrogen as a product from industrial processes can be used as fuel or for the production of conventional fuels (e.g. natural gas). It is stated: “ we want to promote E-mobility in Germany (battery electric, hydrogen and fuel cell) and, wherever necessary, raise the funding by the year 2020.

5. summary
These statements in the coalition treaty give rise to hope that hydrogen technology will herald a totally new era of mobility. This era will not only contribute immensely to the compliance with the climate aims of the UN climate conference of Paris of November 2015, but it is also an important contribution to the implementation of the decisions of the European Parliament and the EU commission of December 2018 to reduce CO2 emissions.
Finally, the use of hydrogen technology makes us independent from the availability of strategic raw materials, as for example Lithium, which is needed in enormous amounts for the production of Lithium-ion-batteries.