Our **second HYDROGEN Seminar** on September 13 at KAUST reviewed current hydrogen production technologies from both hydrocarbon sources and water. Dr. Joe Powell addressed the topic of hydrogen production via reforming and gasification. He highlighted that hydrogen is an energy vector and can be considered as the *diesel* or liquefied natural gas in the future. He emphasized that these vectors allow the movement of energy from resource-rich regions to those that don't have quite that resource availability, whether that be natural gas or renewable energy.

Dr. Joe pointed out that while today blue hydrogen is cheaper compared to green hydrogen, the development of the efficient and cost effective electrolyzers and the reduction in the cost of solar and wind power, will see green hydrogen become cost competitive in the near future. He noted that 228 hydrogen projects were announced in the year 2021. On hydrogen from natural gas, Dr. Joe noted the reduced energy needed when compared to water electrolysis. In addition, hydrogen production through the Auto-Thermal Reforming (ATR) or partial oxidation, where oxygen is added in the process, have an added advantage of producing heat and electricity in addition to the hydrogen. The ATR and the partial oxidation are advanced technologies relative to the steam methane reforming, which is the most commonly used these days. He warned that with the scaling of the hydrogen industry and the need for transport and pipelines, the issue of hydrogen leakage is regarded as a major concern. He said if the entire fossil economy is replaced, a 1% leakage rate in hydrogen, would reduce the decarbonization value by about 2%. And if the leakage rate is higher than that, with these newer global warming potentials, then that can be up to 10% which means that there's a move to consider more distributed production of hydrogen. Looking into the future, Dr Joe noted that methane pyrolysis has been gaining attention lately especially since instead of converting the carbon in methane into CO2, it can be split into solid carbon and hydrogen. Such technology can be valuable in locations where CO2 storage is not available.

Mr. Christopher Capuano highlighted two technologies, namely: Alkaline electrolyzers using liquid KOH and Proton Exchange Membranes (PEM). The liquid KOH technology is a well-established, old (the installation dates back in the 1950s) and robust technology. It is cost-competitive due to the economy of scale, with systems in the range of 100-200 MW. He noted that despite that there is still an opportunity to reduce cost through further research and automation of the manufacturing process. One drawback is that large scale is needed to reduce cost of hydrogen production and that results in very large footprint. On the other hand, the Proton Exchange Membranes technology can run at much higher current densities, increasing the potential of significant capital expense reduction, for the same rate of hydrogen production. One drawback of PEM is that it requires expensive metals, such as platinum and iridium, although there's significant research effort to replace those with cheaper more abundant materials. Mr. Christopher concluded his talk by highlighting Nel's largest PEM electrolyzer system to date, a 20 MW

installation, which makes about 8,495 kg/day. He also highlighted that Nel's energy has the longest history in the world in producing and installing hydrogen electrolyzer equipment, and that plans are underway to scale their technology further in the near future.