

The case(s) for hydrogen:

Motivations for Oil and Gas Producers' increasing focus on hydrogen

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IEA Workshop on Hydrogen

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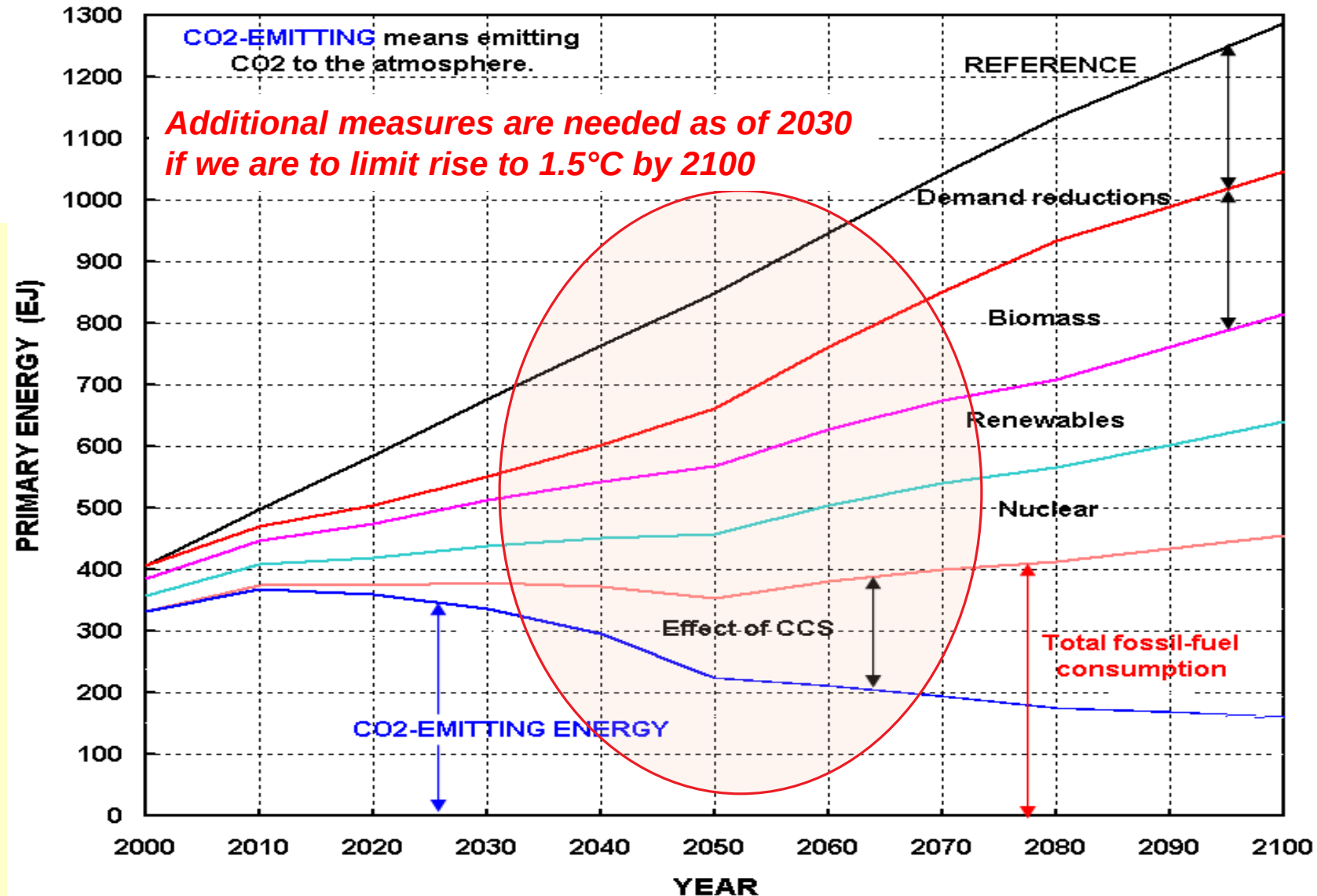
According to recent UN (IPCC), more action is needed quickly to limit T rise from GW to 1.5°C by 2100 rather than 2°C



All plausible scenarios to meet the 2°C target show that all sources and technologies must contribute and more is needed if we aim at 1.5°C limit.

- Efficiency & Re is low hanging fruit; contribute most 2050
- Room to double engine efficiency, introduce EV/Re.
- Biomass, nuclear and clean fossil fuels (with CCUS, DAC, CDR) contribute increasingly, but development & investment needed for all on equal footing.
- Planes and trucks powered by hydrogen will be a crucial part of efforts to cut carbon emissions to required levels consistent with the desired limit of 1.5 °C to 2 °C.

A Typical Scenario that would meet the 2°C Target



Source: Tom Wigley, IAEA 2018 Scientific Forum.

Climate Change and O&G Exporting Countries

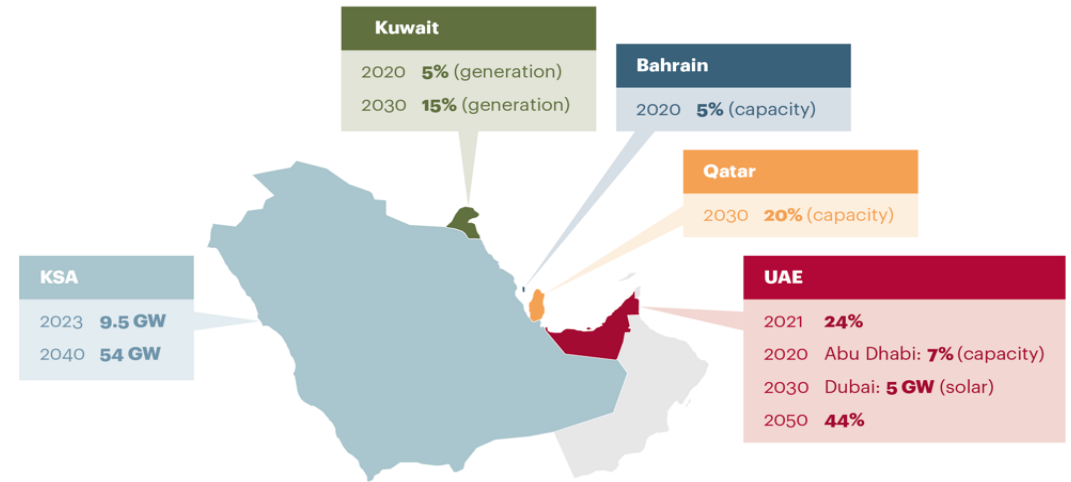


- Oil and Gas (O&G) Exporting Countries, including the GCC, have joined the international consensus and have already taken measures towards addressing the Climate change challenge (Paris Agreement).
- Low hanging fruit for decarbonizing energy systems:
 - Energy conservation
 - Improving Energy Efficient
 - Subsidies reform (reduce waste)
 - Renewables (mainly solar)
- Producers **need to optimize** economic value from their large O&G **reserves** (with P/R lifetime (**>50 years**)), while pursuing **diversification of** their economies. **=>** must continue to **mitigate** potential of major reduction in demand for O&G (e.g. SDS scenario).
- Need to address how to decrease their carbon footprint of domestic energy systems & decarbonize O&G exports.**
- One opportunity receiving increased attention beyond shifting to gas for domestic use and export: to convert O&G to carbon free hydrogen.**

2/12/2019

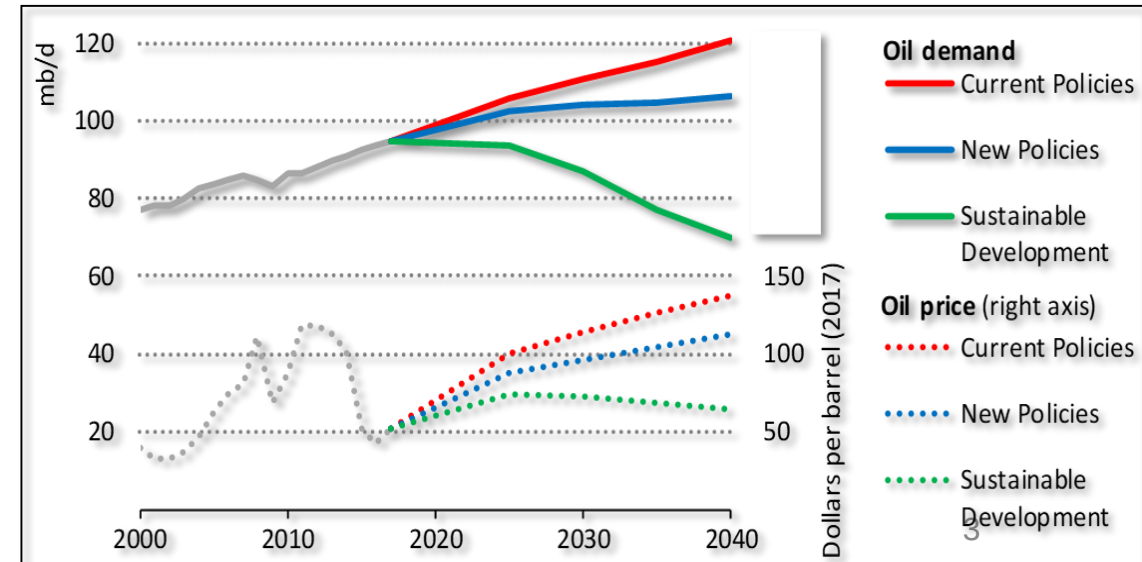
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GCC renewable targets



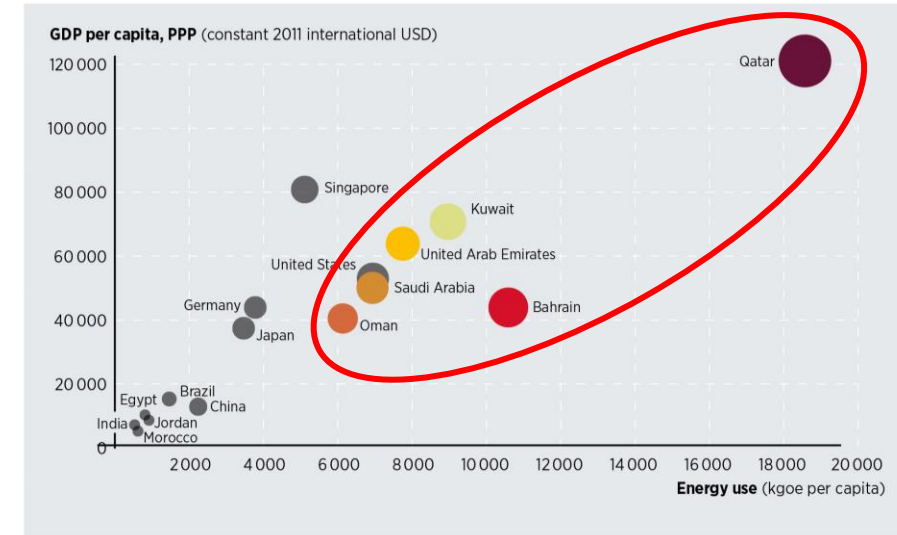
IRENA RENEWABLE ENERGY MARKET ANALYSIS: GCC 2019

In 2040, oil demand in the Current Policies Scenario is 51 mb/d higher than in the Sustainable Development Scenario (WEO; 2018)



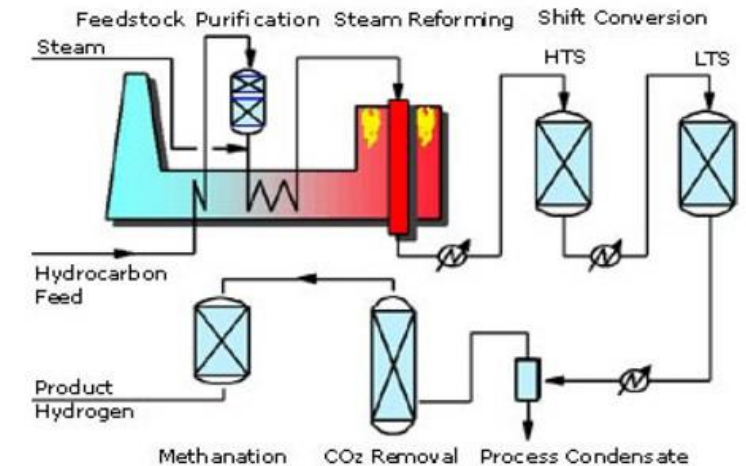
O&G Producers' Strategies to Address Emissions for Domestic & Export Markets

- **Short-term:**
 - Reduce excessive high p/c energy demand and limit growth rates: Continue/accelerate subsidy reforms.
 - Continue decarbonization of energy systems through **more Re** and increased investments in E&P for natural gas as a cleaner substitute for domestic power
- **Long term (2040 and beyond):** CDR technologies, including DAC, to offset CO₂ (blockchain verified) from exported O&G, need to be developed.
- **Medium to long-term, aim for deeper decarbonization:**
 - Focus on reducing CO₂ emissions from power using **CCS** (with **EOR** first).
 - Develop and deploy O&G sourced hydrogen with **CCS**.
 - Removing the **carbon from molecules of natural gas produces clean hydrogen gas**, for use in generating electricity, transportation (FCV) and heat.
 - Remaining carbon captured and sequestered underground: **reducing more than 90% of CO₂ emissions**.
 - Lead the way to the scale-up of **carbon free oil made using carbon-free sources of electricity to convert water and CO₂ to hydrocarbons for use in equipment that is difficult to electrify**.



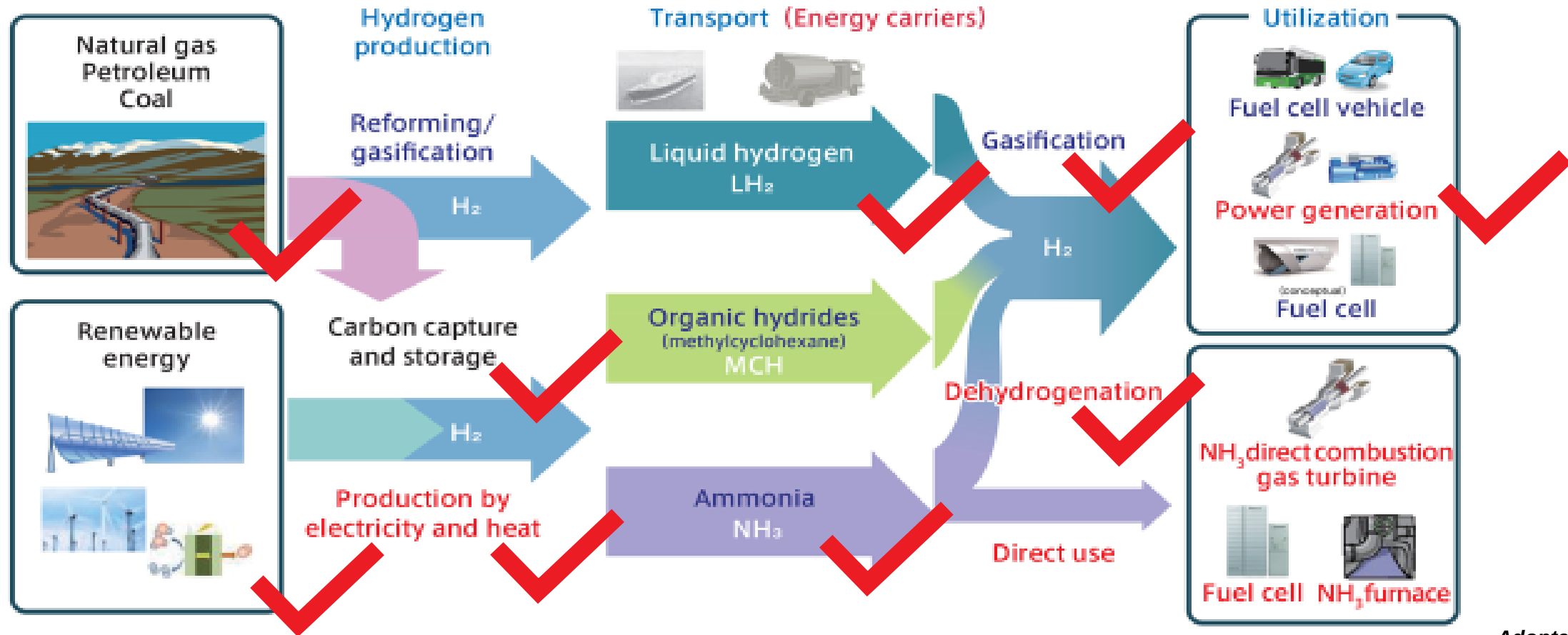
Source: IRENA based on World Bank (2018).

Note: PPP = Purchasing power parity; USD = United States Dollar; kgoe = kilograms of oil equivalent



<http://www.making-hydrogen.com/steam-reforming-hydrogen.html>

Strategy of Energy Carriers ~Development of CO₂ free hydrogen value chain~

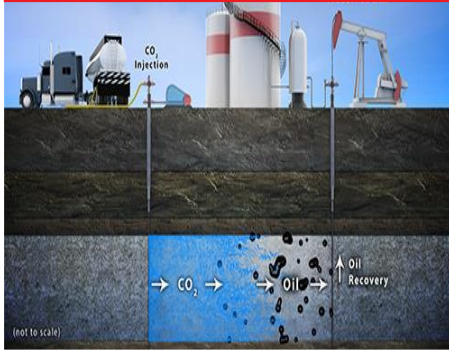


- Hydrogen can be produced from various energy sources and can be utilized for electricity as well as fuel (Potential to reduce CO₂ emission significantly)
- Hydrogen has a difficulty in transportation, because it is low Btu gaseous form. It is essential to develop viable mass-transportation methods and related technologies (energy carrier) and make hydrogen to be affordable energy source.

Adopted from Cross-ministerial Strategic Innovation Promotion Program (SIP)_Energy Carriers_2016

The Hydrogen Economy, from a Hydrocarbon Producer's Perspective

Carbon Management and Potential in EOR



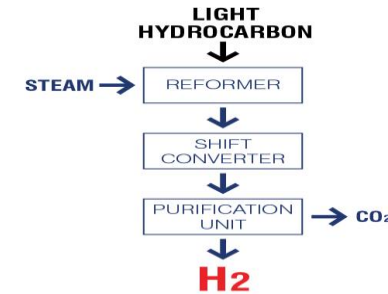
- Global environmental concerns
- Adding CO2 EOR to oil production equation actually allows for a net negative CO2 emission of up to 100kg/bbl,
- Offset emissions in the production of hydrogen

Energy Abundance and Diversity of Energy Sources to Product Hydrogen



- Entire energy system is important; reducing liquids use in power generation, for example, frees up more crude for export and creates more local demand for gas and other alternatives
- Access to all the options for hydrogen production is a competitive advantage as industry evolves

Industrial and Technology Infrastructure In Place for an Added Advantage



- Infrastructure already in place: hydrogen is produced through steam in the refining process
- Petrochemical Industry produces ammonia
- Producing hydrogen from methane (or other hc after partial oxidation) requires the majority of energy to be supplied by pressurized steam
- Transportation technology for hydrogen energy carrier has been handled by O&G industry

Unified nature of government & industry/ Governance of Investments (Public and Industry)



- Unified nature of government and industry in the GCC nations and many other energy producers
- Allows for quick response to the sweeping changes and coordination required to transform the global energy landscape

Other Examples of Hydrogen Production & Use in Oil Producing Countries



Saudi Arabia

- Built world-scale hydrogen production and purification units for Air Liquide Arabia's site at Yanbu, Saudi Arabia. The plant supplies hydrogen "over the fence" to the nearby oil refinery, which has a capacity of 400,000 barrels per day.
- **Aramco and Air Products: signing of an agreement to jointly-build the first hydrogen fuel cell vehicle fueling station in Saudi Arabia**
 - Air Products' proprietary Smart Fuel hydrogen fueling technology will be incorporated into the new station to supply the vehicles with compressed hydrogen
- **These steps can provide leverage for a grand role for hydrogen as proposed in the collaboration between Saudi and Japan**



UAE

- Toyota Mirai, a zero-emission FCEV (electric vehicle with on-board fuel cell), being tested on the UAE roads as part of a pilot to explore the potential of hydrogen energy use in the UAE for the creation of a sustainable, low-carbon society
- **Abu Dhabi's sole carbon capture company Al Reyadah exploring plans to bring carbon dioxide (CO2) emitted from industrial facilities, power plants and refineries to be deployed into enhanced oil recovery (EOR)**
- Joint venture Abu Dhabi National Oil Company (Adnoc) and Masdar
- **Expected to divert around 13.3 million ton of CO2 emitted from UAE-based industries towards oil and gas production**



Kuwait

- Discussions on CCUS and hydrogen production by the Kuwait Petroleum Company as part of the newly revised strategy moving forward
- **KISR experimenting with nono-produced Metal Hydride fueled FCVs**

<https://www.khaleejtimes.com/business/energy/aramco-air-products-to-build-first-saudi-hydrogen-fuel-cell-vehicle-fuelling-station>;
<https://gulfnews.com/uae/environment/se-cond-hydrogen-station-in-uae-to-open-in-abu-dhabi-1.2155940>;
<http://www.ammoniaenergy.org/japan-saudi-arabia-explore-trade-in-hydrogen-ammonia/>

Example of Preparation for Hydrogen Strategy in Producing Country: Saudi Collaboration with Japan



Demonstration projects to produce and transport Saudi hydrogen to Japan under discussion between Delegation of Saudi and Japanese companies & public officials

present

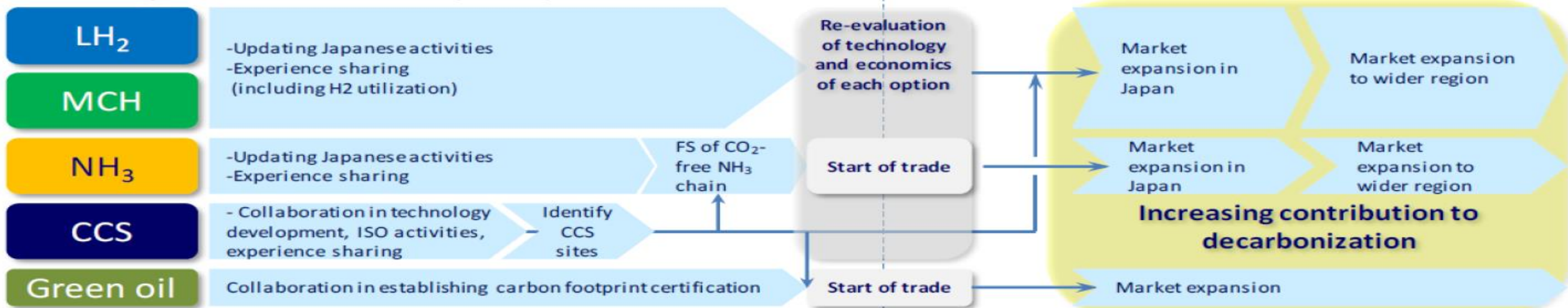
2020

2030

2040

2050

Saudi-Japan collaboration (draft)



- Saudi Arabia expressed interest in ammonia due to the cost advantage over other hydrogen carriers
 - Ammonia able to combust directly in power generation without regasification or dehydrogenation
 - With reduced costs for CCS, carbon- free ammonia can be achieved at \$300-\$350/t-NH₃, well within target for cost competitive power
- They will continue to explore CCUS & EOR technologies, making a wider assessment of the hydrogen economy & the carbon footprint certification scheme and links to climate change (Monica Nagashima "Japan's Hydrogen Strategy and its economic and geopolitical Implications"_Oct 2018)
- Aramco's CEO stated recently: "we must deal with carbon emissions in line with the Paris Agreement on Climate Change. This is where hydrogen and Carbon Capture Utilization and Storage could be game-changers for Saudi Arabia and China,". Although hydrogen mostly comes from gas, it could also increasingly come from oil and coal, Nasser explained. "If carbon capture, utilization, and storage (CCUS) and hydrocarbons can be made to work together, then green hydrogen is within our reach" he said

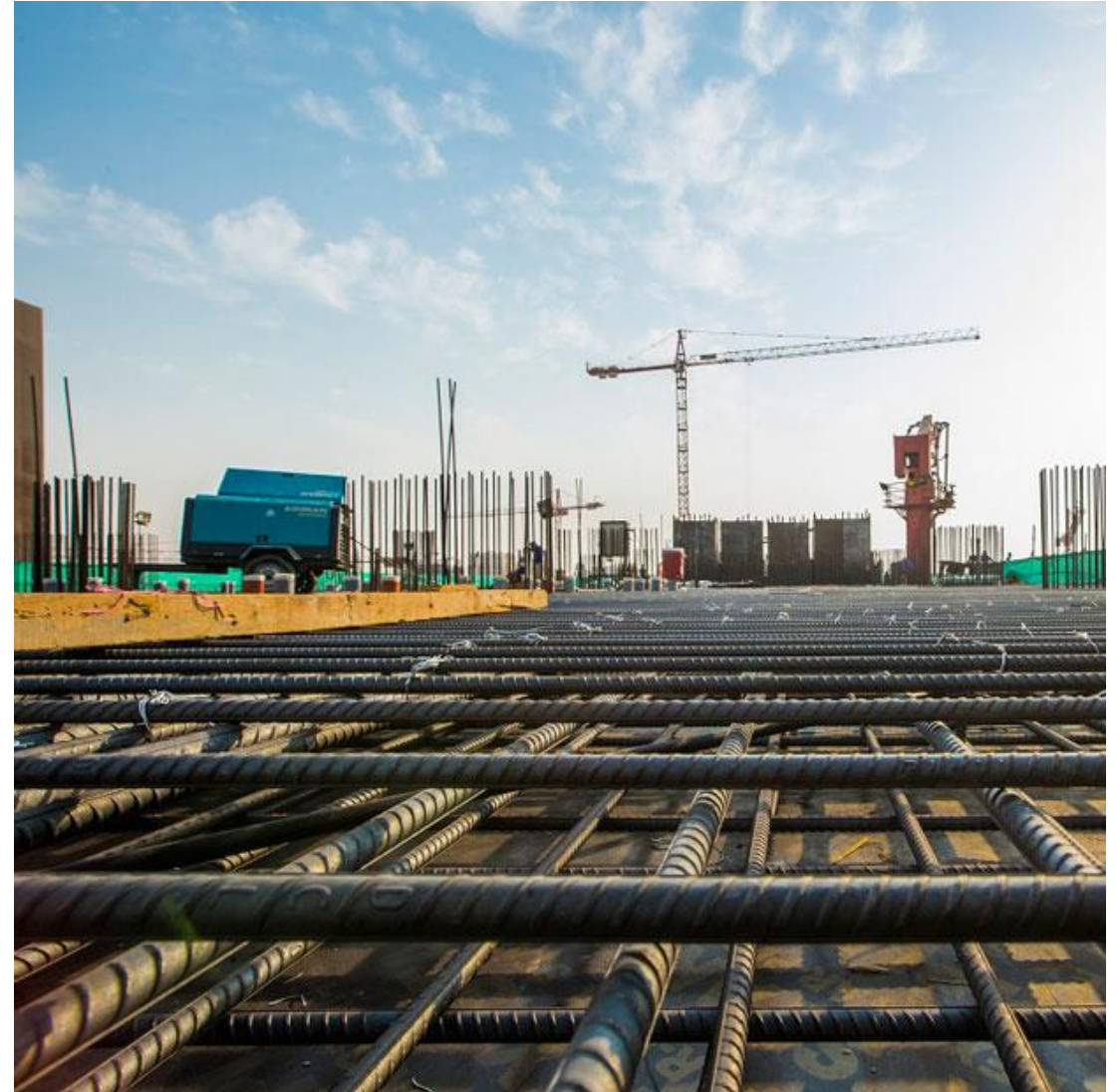
<http://tradedarabia.com/touch/article/IND/322139>

Example of Preparation for Hydrogen Strategy in Producing Country: Green Hydrogen Project in Dubai, UAE



Development of the Green Hydrogen Facility:

- An area of 10,000 square meters.
- Will test and showcase an integrated megawatt-scale plant to produce green hydrogen using renewable energy, in this case solar energy.
- Gas will be stored and then delivered for re-electrification, transportation or other industrial uses.
- Collaboration between Dubai Electricity and Water Authority (Dewa) with Siemens.
- Considered a first-of-its-kind project in MENA.



<https://www.constructionweekonline.com/projects-tenders/169116-expo-2020-dewa-siemens-launch-green-hydrogen-energy-plant-at-dubais-mbr-solar-park>;
<https://gulfnews.com/uae/first-green-hydrogen-project-breaks-ground-in-dubai-1.1549175502065>

Concluding Remarks



- **Hydrogen can be a major player in achieving climate change targets**, in collaboration with other efforts. It can play a major role in **preserving value from large hydrocarbon resources** in producing countries while they pursue diversification of their economies
- **Deployment of hydrogen-based transport solutions has begun**, with Japan, South Korea, California, China and Germany leading the way. Japan has set itself the target of having 40,000 FCEVs on the road by 2020 and 800,000 by 2030; China plans 1 million FCEVs by 2030 and is already investing in growing its manufacturing capabilities.
- **Some of the GCC countries have developed or starting to develop a strategy for hydrogen production and export** as means to address energy transition and move away from conventional CO2 emitting fossil fuels to clean oil and gas& renewables, for both domestic & export markets
- **While energy producers have more incentives than IOCs to invest in hydrogen/renewables due to potential to free up oil& gas for export**, NOCs & IOCs would both benefit from working jointly to develop their competitive advantage within the evolving hydrogen value chain at an early phase of its development (e.g. leveraging NOCs/IOCs downstream knowhow in refining & petroleum fuels)
- G20 should encourage, facilitate and incentivize collaboration between producers and consumers on clean hydrogen economy
- **Sending HCs and converting to H2 at the consumer side** and returning the tanker filled with CO2 **has been discussed** as a possibly cheaper option, as it cuts transport costs.

Thank you