vantedge+

Blue Paper

Technology overview and suitability for hydrogen in India

Part -7 (Hdyrogen ecosystem development and identification of key future market growth clusters in India)

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Technology overview – hydrogen production by reformer technology

Process	Overview
Syngas generation	• Steam Methane Reformation (SMR) • Autothermal reforming (ATR) and Partial Oxidation (POx) – ✓ Lower number of references for hydrogen production, but technologies are mature ✓ Preferentially used in large scale industries e.g. synthetic fuels and commodity chemicals ✓ SMR + ATR Combined Reforming (as used in ammonia and methanol production) • Gas Heated Reformer (GHR). GHR is not a self-sufficient reforming technology. An external heat source is required to meet/supplement the reforming needs of the GHR. This is typically provided by combining a GHR unit with a high temperature heat source (reformed gas) from an ATR or SMR.
CO_2 removal	• Amine based systems – ✓ Amine based CO_2 removal systems are mature technologies. Selexol is also competitive at large capacities and where the cost of power is high ✓ Technological improvements include better heat integration, reduced fouling of solvents and improved corrosion efficiencies
H_2 extraction	• Pressure Swing Adsorption (PSA) – ✓ Mature technology available at large capacities and high purity requirements ✓ Technological improvements include increased reliability and longer absorbent lives • Membranes – ✓ Technology is maturing, however is associated with lower purity H_2 product and increased operating costs

Hydrogen production – steam methane reforming (SMR)

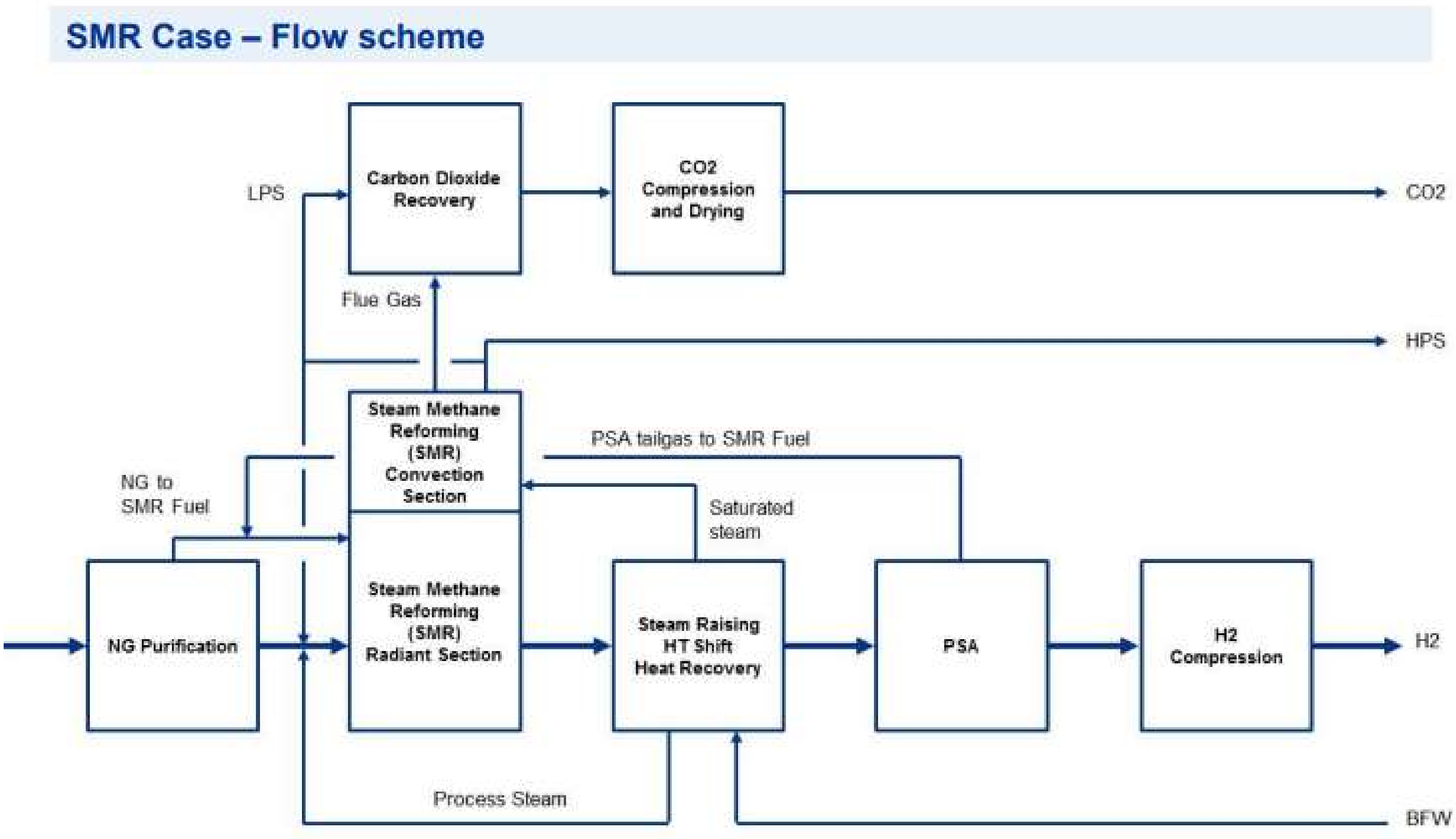
Technology Overview

- Mature technology and widely used across the refining and petrochemical industries
- Improvements have included higher performing materials, improved heat recovery, lower pressure drop and higher conversion catalysts
- Typical capacities ~20 MMSCFD (22 kNm3 /h or 74 MW H2 HHV) to world scale capacities of 150 - 200 MMSCFD (168 - 224 kNm3 /h or 564 – 739 MW H2 HHV)
- Example large scale proven single train SMR plants:
- ✓ Grayville, USA: 120 MMSCFD (134 kNm3 /h or 450 MW H2 HHV)
- ✓ Baton Rouge, USA: 120 MMSCFD (134 kNm3 /h or 450 MW H2 HHV)

Carbon capture from SMR hydrogen production

- Two main sources of CO2 production:
- ✓ CO2 produced from the chemical reactions of the process
- ✓ CO2 production from the combustion of the fuel that is required to provide heat for the endothermic process reactions
- Source 1) relatively easy to capture as a high purity stream, especially using an amine solvent
- Source 2) relatively difficult (i.e. expensive) to capture, due to diluted concentration of CO2 and pressure at atmospheric condition
- Carbon capture solutions that aim to recover both sources are much more capital intensive than those that focus just on Source 1)
- The AFW Case 3 captures the CO2 from the Flue gas

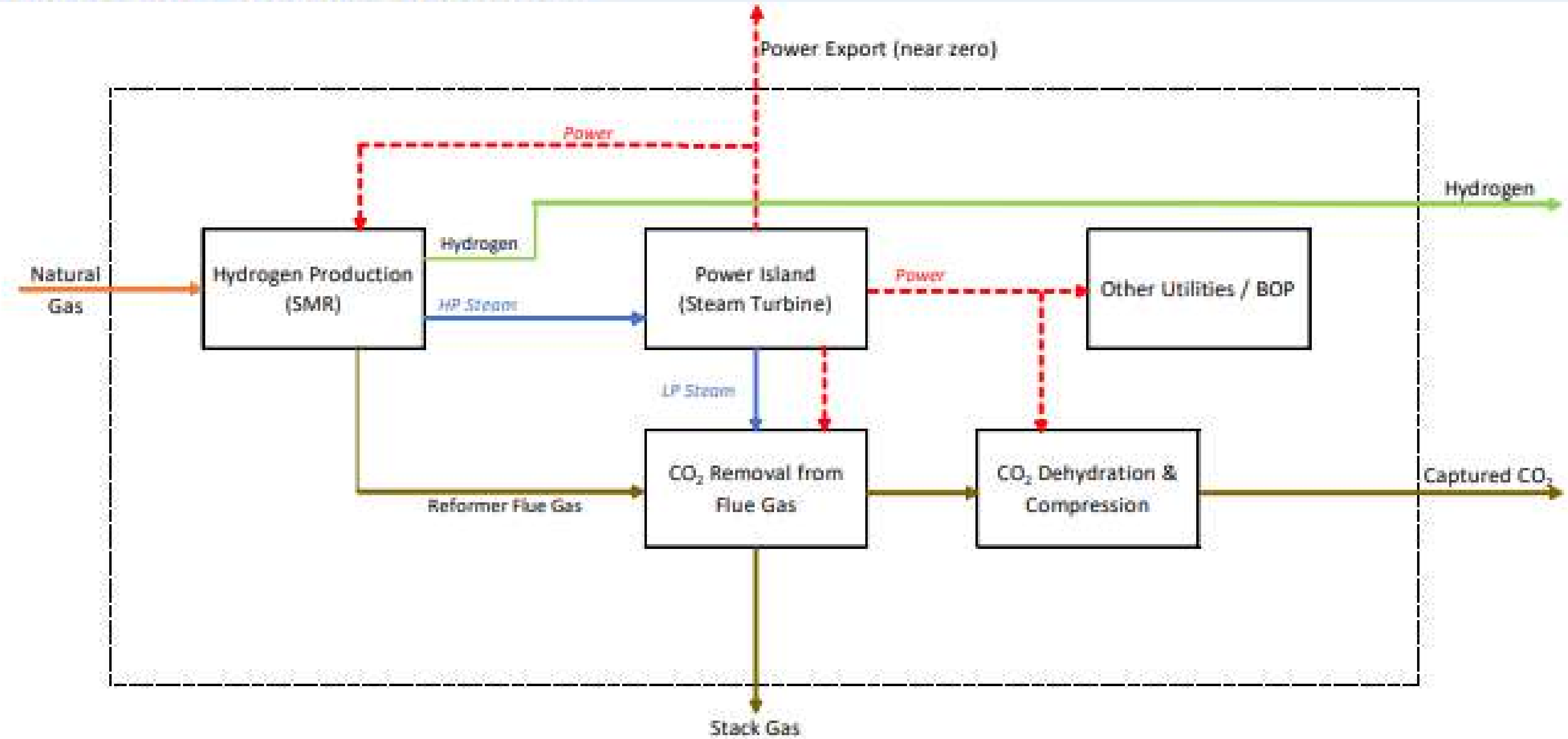
Hydrogen production – steam methane reforming (SMR) ,(Contd.)



Source: Eninrac research, Element Energy

Hydrogen production – steam methane reforming (SMR) ,(Contd.)

SMR Case – Plant Boundaries



Source: Eninrac research, Element Energy

Hydrogen production – Auto thermal reforming (ATR) , more attractive for blue hydrogen

Technology Overview

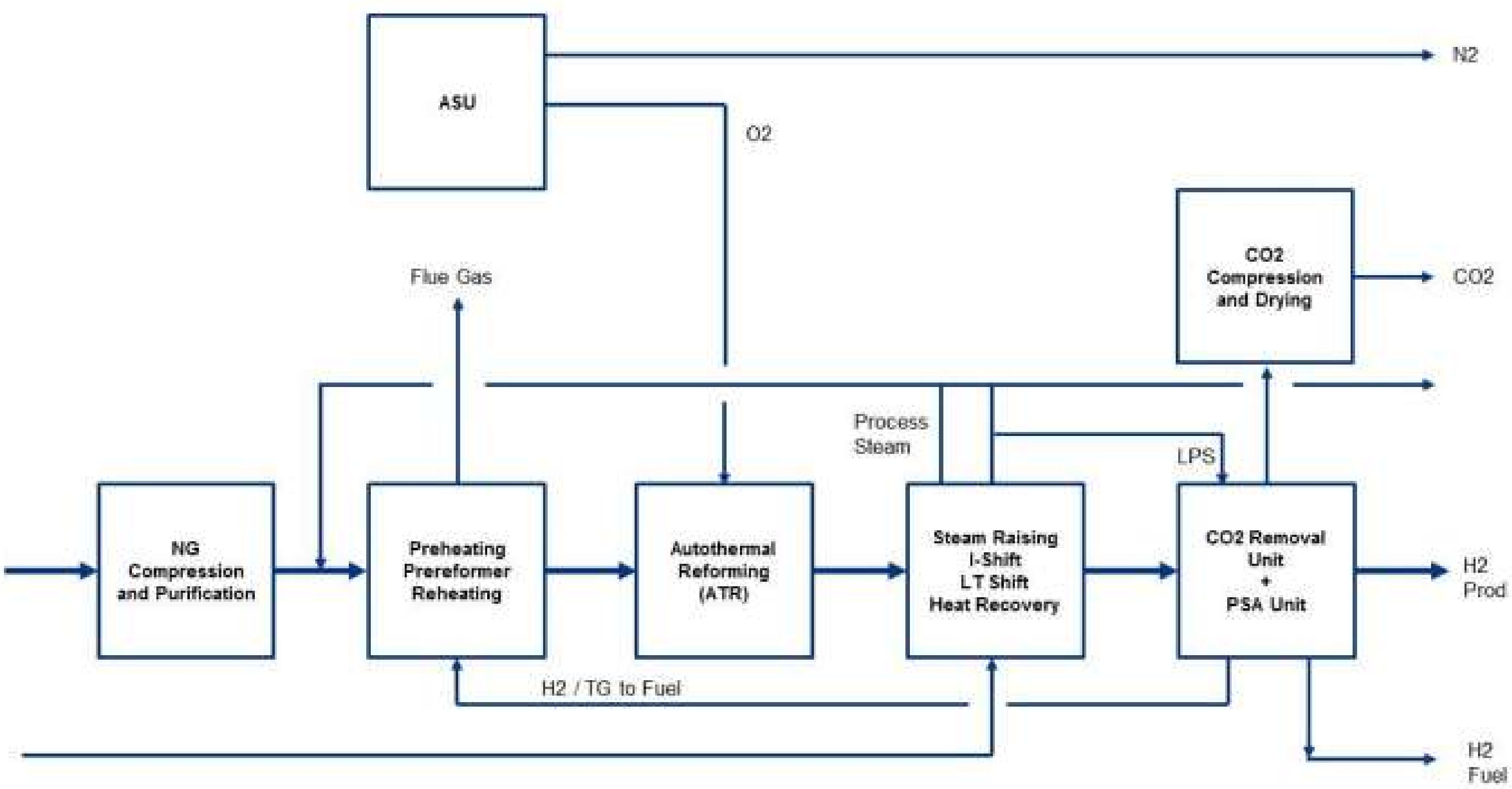
- In the ATR technology, part of the natural gas feed is partially combusted to generate heat for the endothermic reforming reaction. This self-heating ('auto-thermal') mechanism largely eliminates the need for any external heating, which can be met with supplemental hydrogen firing
- The H2 /CO ratio from ATR technology is less suited to hydrogen production than SMR, more suited to Fischer–Tropsch processes, so technology has to be "re-optimized" for hydrogen production
- Numerous ATRs are in operation worldwide, but most operate as secondary reformers in ammonia plants in collaboration with SMR technology. For ammonia plants, stand-alone ATR technology has so far been considered uneconomical. For methanol plants, only a few true stand alone ATRs have been realized up to now, but ATR technologies are maturing steadily
- The high CAPEX cost of capturing CO2 from SMR flue gas makes the use of **ATR more attractive for "blue" hydrogen production, especially if CO2 capture rates >90% required**

Carbon capture from ATR hydrogen production

- On the positive side, use of oxygen instead of air for natural gas combustion avoids the need for expensive post-combustion separation of CO2 from nitrogen
- On the negative side, the ATR technology requires an Air Separation Unit (ASU) which commands high CAPEX as well as OPEX due to associated additional power demand
- If a portion of the hydrogen produced is used as fuel to generate power to meet the plant's power requirement, CO2 capture rates of 95% can be achieved with ATR technology (versus 90% maximum for SMR technology)
- This makes ATR particularly attractive where there is low carbon grid factor electricity available. Where internal power demand has to be self-generated, higher CO2 capture rates can only be maintained by using hydrogen as combined cycle gas turbine fuel

Hydrogen production – Auto thermal reforming (ATR), (Contd.)

ATR Case – Flow scheme



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