Hydrogen membrane reactors are being studied for power production with pre-combustion decarbonisation. The membrane reactor produces hydrogen from natural gas at a low pressure and a steam and CO_{2} rich stream at high pressure. Condensation of the steam leaves a concentrated CO_{2} stream at high pressure for disposal. The hydrogen separated will be used as fuel in a gas-turbine combined-cycle plant to generate electricity at high efficiency. Due to the in situ removal of reaction products, the reaction equilibriums of the reforming and shift reactions are shifted to higher conversions in the membrane reactor. Therefore, relatively low temperatures can be used. The need for multiple shift reaction stages is avoided, CO_{2} scrubbing becomes much easier and the compression requirement for the captured CO_{2} is minimized.

Unlike conventional reforming, membrane reforming benefits from high operation pressure due to the increased H_{2} partial pressure differential across the membrane, which acts as the driving force for hydrogen permeation. Membranes exist that selectively permeate hydrogen between 773 and 873 K with high flux. Higher temperatures should be avoided due to membrane or membrane-support disintegration problems. The catalyst used in membrane reactors should be: 1) sufficiently active for both the reforming and water-gas shift at relatively low temperatures, 2) resistant to deactivation under the hydrogen-lean conditions in separation-enhanced reformers. The present study aims at obtaining insight in the potential of Nickel-based catalysts for steam reforming of methane in membrane reactors (SRMR). A modeling study was carried out to compare catalyst activity of Ni and precious metal (PM) based catalysts together with hydrogen permeance in a palladium membrane reformer. Several ECN-made and pre-commercial or commercial catalysts based on Nickel and Rhodium have been studied for their methane conversion stability under conditions that approach the conditions in the membrane reactor. From this catalyst evaluation study a promising catalyst was selected and tested in an experimental membrane reactor test rig at high pressure.

Materials and Methods

The system is modeled in a 1-D rectangular geometry, consisting of six coupled differential equations solved in Matlab. Hydrogen permeation is calculated from the eq. 1 below with n=1

\[ J_{\text{HHV}} = k_{\text{m,HHV}} (p_{\text{H2,reaction}} - p_{\text{H2,permeate}}) \text{ [mol/m}^2\text{s]} \]  

where \( k_{\text{m,HHV}} \) is the membrane permeability. Hydrogen membrane reactors are being studied for power production with pre-combustion decarbonisation, which is an important technological approach to meet CO_{2} capture and sequestration targets. The use of relative cheap Ni-catalysts in membrane reformers may boost the general acceptance of this pre-combustion CO_{2} capture technology.