PEM Electrolyzer Types

Mars Workshop and ISRU tag-up
July 31 - August 2, 2017
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Overview

Basic Electrolyzer Types and System Components
- Anode liquid feed
- Cathode liquid feed
- Cathode vapor feed

Applications

Challenges

Anode Liquid Feed

Cell characteristics:

Liquid water fed to oxygen side (anode)

Product O_2 and H_2 contain liquid water
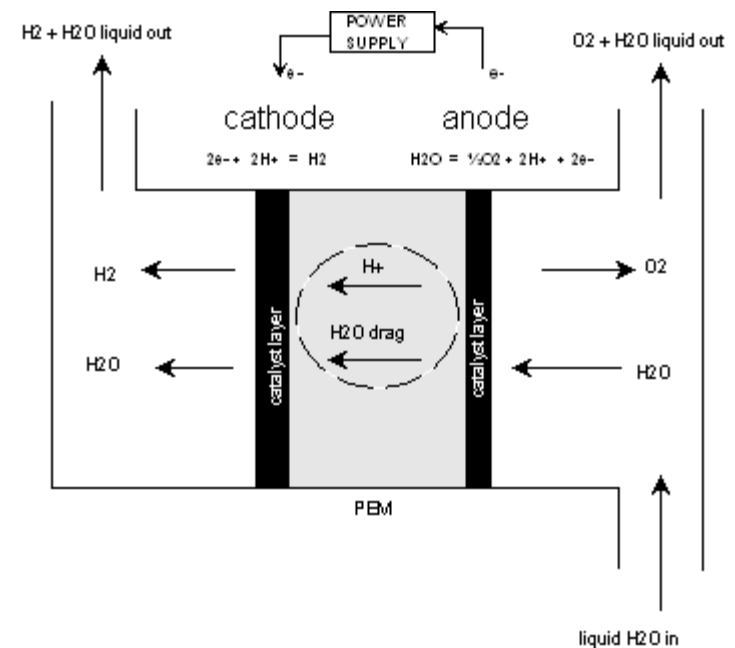
Proton drag carries substantial water to H_2 side

- ~2 moles H_2O per mole of H_2 (or more)
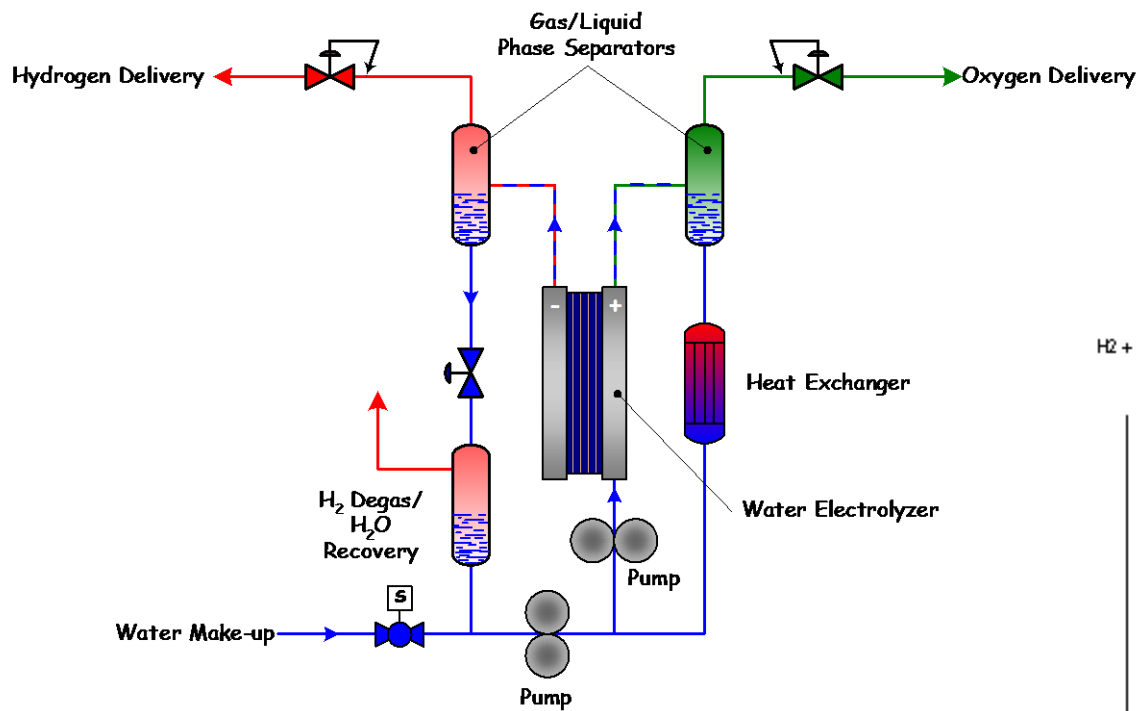
Protonic water is saturated with H_2

System characteristics:

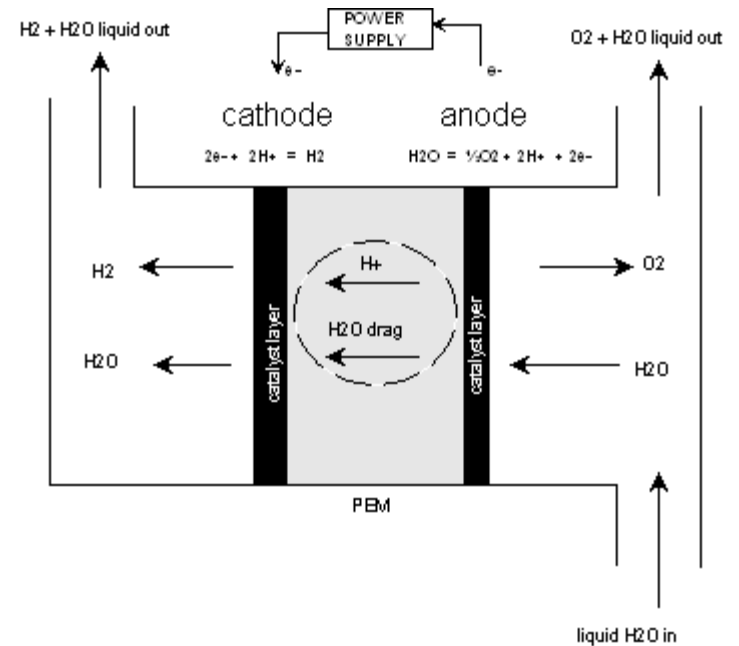Greatest rate capability

Most complicated system

Anode Liquid Feed

Gas/Liquid Phase Separators

Hydrogen Delivery

Oxygen Delivery

Heat Exchanger

Water Electrolyzer

H_2 Degas/ H_2O Recovery

Water Make-up

Pump

Pump

Most complicated system

- 2 Pumps
- 2 phase separators
- H_2 degas / H_2O recovery

H2 + H2O liquid out

O2 + H2O liquid out

POWER SUPPLY

cathode

anode

$2e^- + 2H^+ = H_2$

$H_2O = \frac{1}{2}O_2 + 2H^+ + 2e^-$

H2

O2

H+

H2O drag

H2O

H2O

catalyst layer

catalyst layer

PEM

liquid H2O in

Cathode Liquid Feed

Cell characteristics:

Liquid water fed to hydrogen side (cathode)

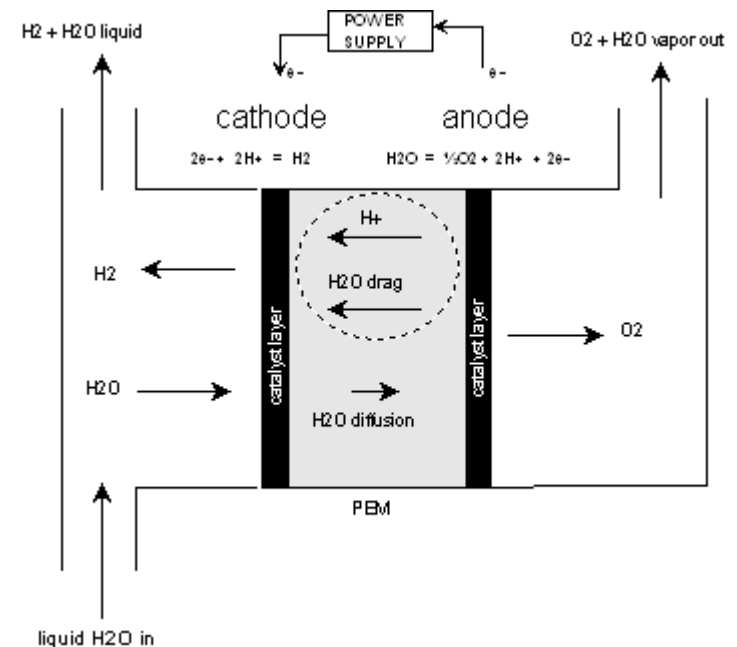Water diffuses to O_2 side through PEM

- H^+ drag limits rate capability

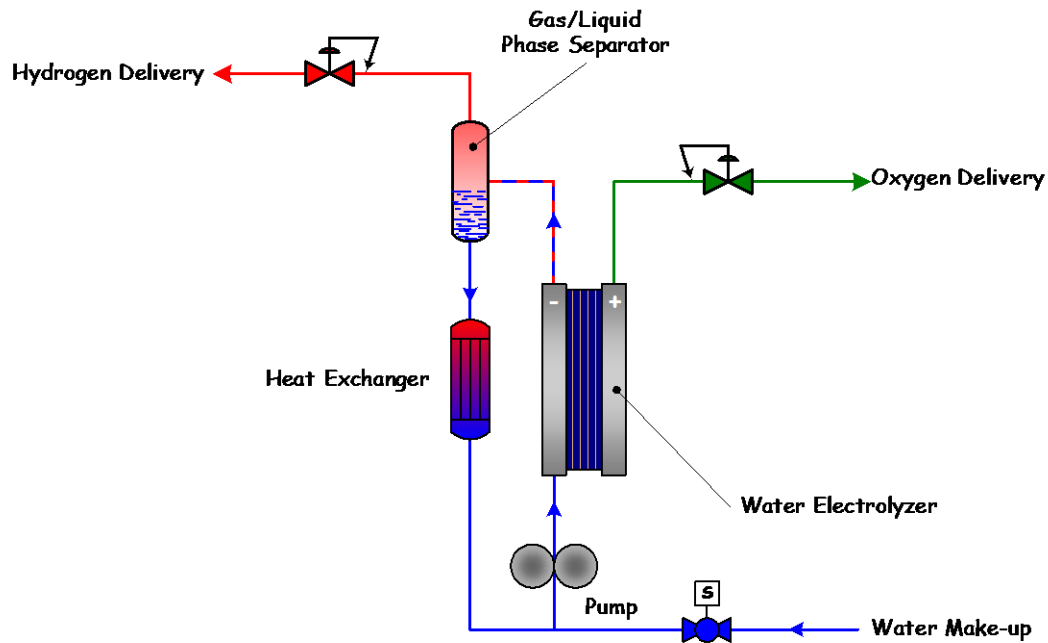- Keeps O_2 free of <u>liquid</u> water

H_2 contains liquid water

System characteristics:

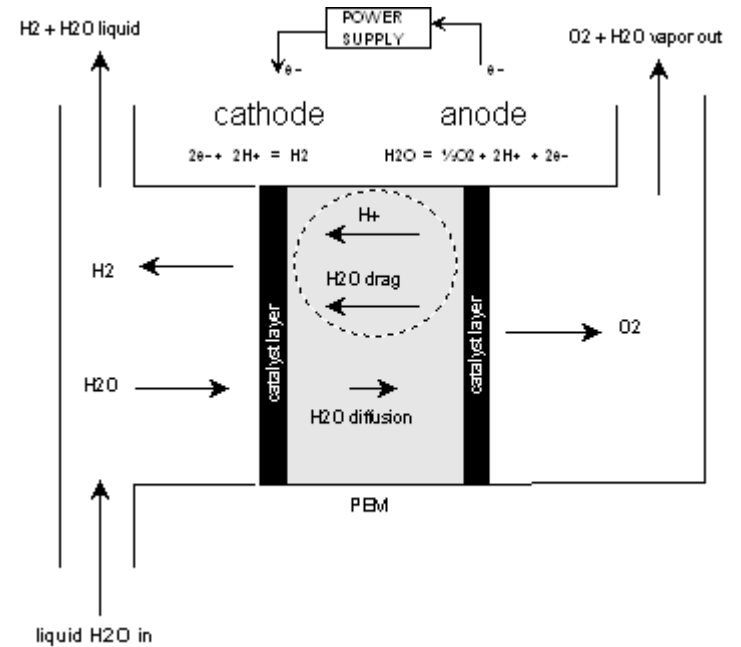Moderate rate capability

Less complicated system

Cathode Liquid Feed

Less complicated system
- 1 Pump
- 1 phase separator

Cathode Vapor Feed

Cell characteristics:

Liquid water fed to water chamber (cathode side)

Water diffuses to O_2 side through H_2 cavity <u>and</u> PEM
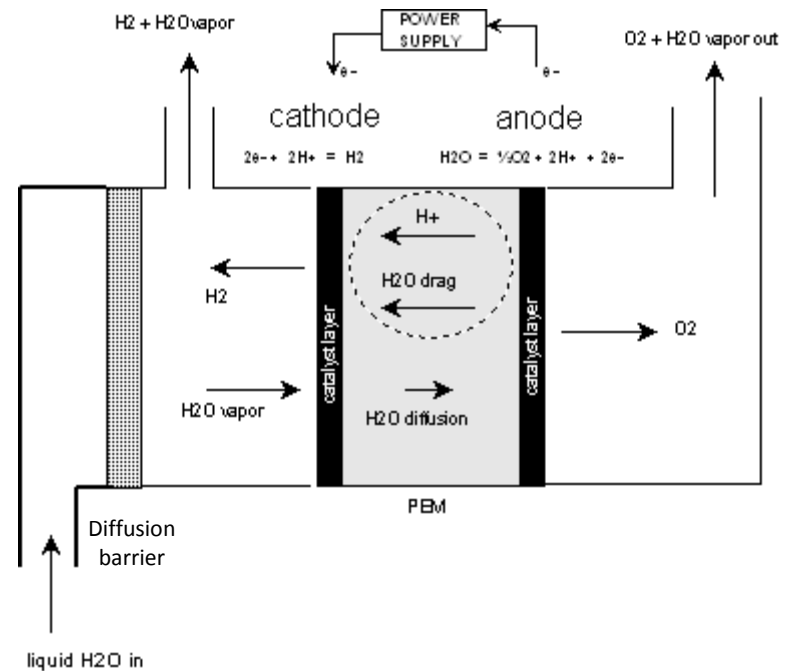
- H^+ drag limits rate capability

- Keeps O_2 free of liquid water
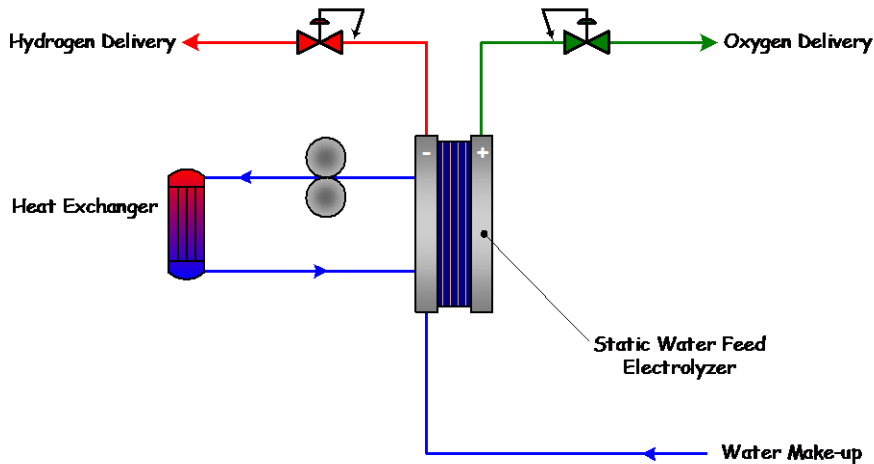
H_2 contains no liquid water

System characteristics:

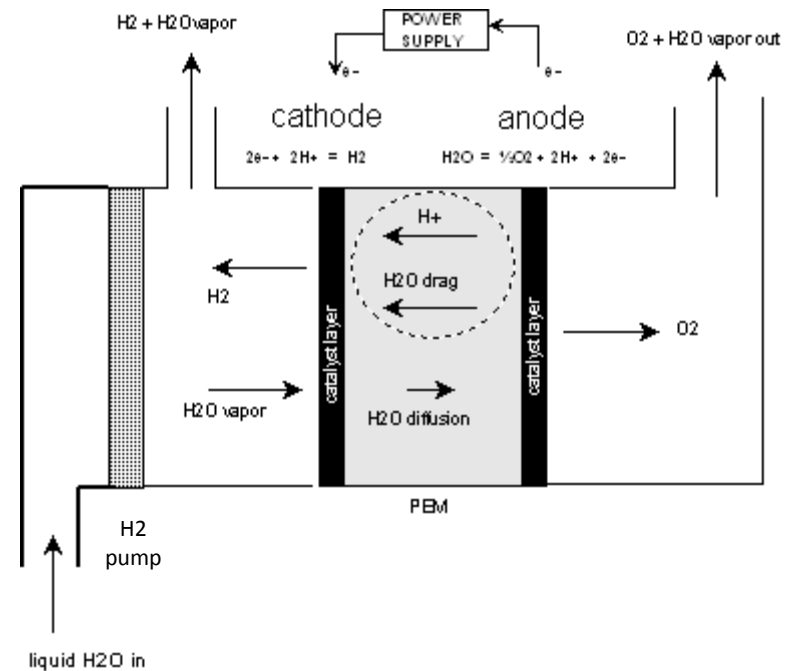Lowest rate capability

Simplest system

Cathode Vapor Feed

Simplest system
- 1 Pump (for cooling)
- no phase separators

Hydrogen Delivery

Oxygen Delivery

Heat Exchanger

Static Water Feed
Electrolyzer

Water Make-up

H2 + H2O vapor

O2 + H2O vapor out

POWER
SUPPLY

e-

e-

cathode

anode

$2e- + 2H+ = H2$

$H2O = \frac{1}{2}O2 + 2H+ + 2e-$

H+

H2O drag

H2

catalyst layer

O2

catalyst layer

H2O vapor

H2O diffusion

PEM

H2
pump

liquid H2O in

Electrolysis Applications

Hydrogen Generation for Electric Vehicles

Oxygen Generation for Life Support
- Navy Submarines
- International Space Station

Regenerative Fuel Cells
- High-Altitude Long-Endurance (HALE) Unmanned Aerial Vehicles
- Surface Power Systems

ISRU

System-Level Challenges

Accumulation of impurities feed water

MEA degradation

Corrosion/shunt currents

Drying of product gases

Degassing (in anode feed systems)

Gas/liquid separation

Gas crossover/purity

Complexity