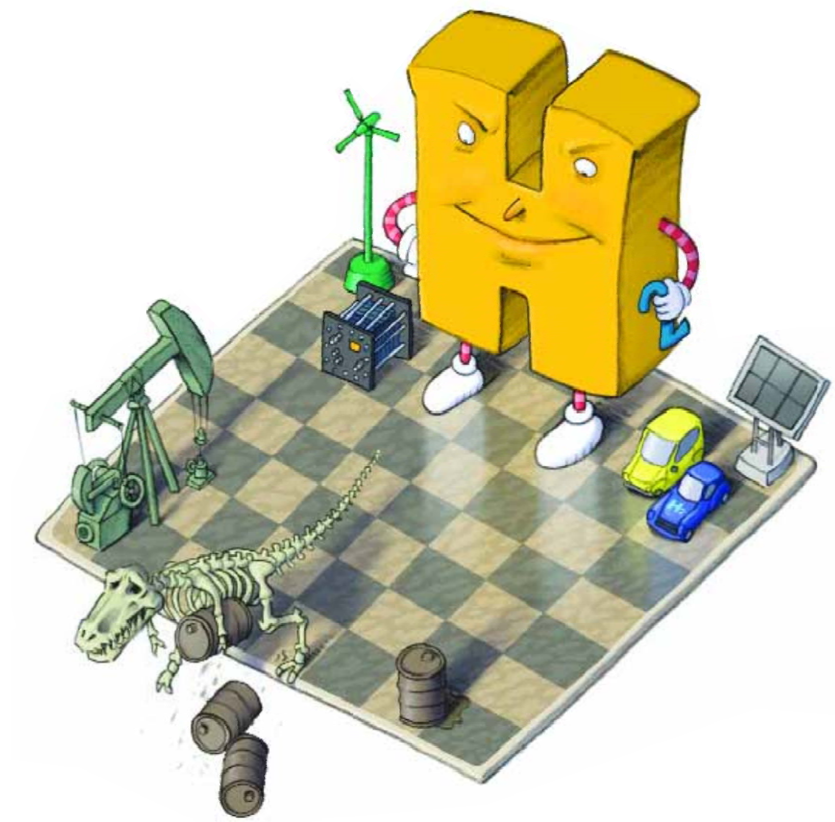
FUTURE IS HERE -- HYDROGEN ECONOMY

One-Megawatt Hydrogen Fuel Cell Power Plant



Project Description

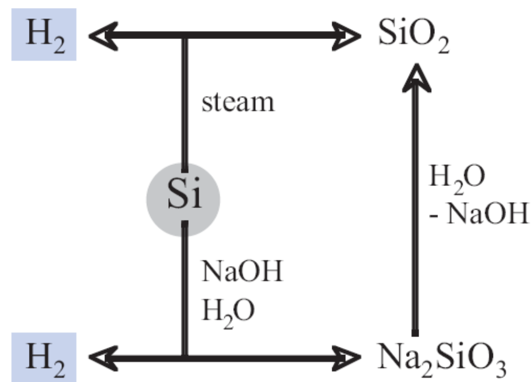
This document details the technical specifications of a 1-MW PEM Fuel Cell power plant for generation of electricity using silicon as the primary fuel. The document is prepared as pilot project with the understanding that many of the details are to be determined as a result of pre-contract negotiations and decisions. Many of the cost issues will greatly depend on the local labor costs, permits, codes, and resource availability.

The PEM FC power plant described herein will generate a peak power of 1.02 MW using silicon to produce purified hydrogen to enhance the life of the fuel cell stacks. In this project, silicon will be reacted with water and other catalysts to produce high purity hydrogen for use in the PEM fuel cell stacks.

Even though the DC power produced by the fuel cells can be converted to any desired voltage using appropriate transformers, we will describe the EBOP system that provides line voltages suitable for internal use of any complex.

Silicon System

In this project, silicon will be used as the primary fuel source for the 1-MW power plant. Silicon through very efficient proprietary process is converted to hydrogen with high purity suitable for PEM fuel cells. The balance of the chemical reactions in this technique is the reaction of silicon with water to yields hydrogen and silicon dioxide.



Since 1 kg of hydrogen is obtained from 3.5 kg of silicon, silicon at a rate of about 208 kg/h or 5,000 kg per day or 5 metric ton per day will be required to operate the 1-MW at its rated power on a 100% duty cycle at a nominal overall efficiency of 50%. Silicon storage size will be a strong function of the delivery frequency. On the assumption of a 10-day delivery charge frequency, the storage capacity of silicon will be designed for 50, 000 kg, which will occupy a volume of 21 cubic meters. This amount of silicon can be stored in two hoppers, 2 meters in diameters and 3.3 meters in height. The summary of fuel usage rate is given below;

Required Silicon and Hydrogen rates for a 1-MW Power Plant

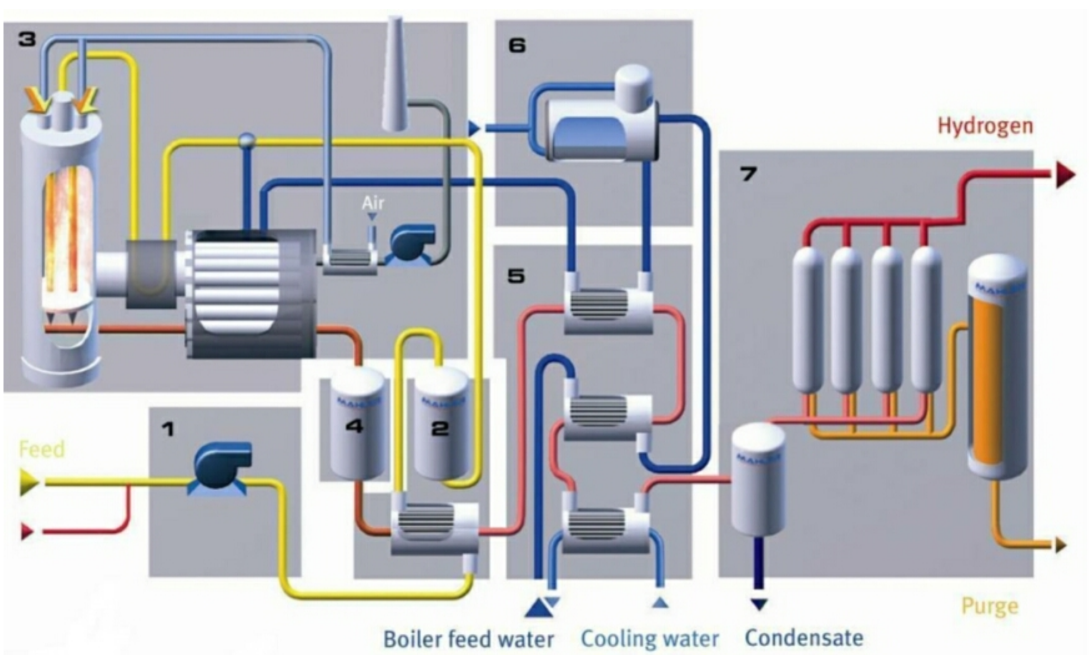
Hydrogen	**Kg***	**m^3* @5000 psi**
Consumption per hour	**60**	**2**
Consumption per day	**1440**	**48**
Consumption per year	**525,000**	**17,520**
Silicon		
Consumption per hour	**208**	
Consumption per day	**5000**	
Consumption per year	**1825 ton**	
**Note: a 50% operational efficiency is assumed*		

Hydrogen Fuel System

This system is designed to operate on pure hydrogen and air or air enriched with oxygen. The fuel cell requires humidified gases a relative humidity up to 100%. For the usage of this system a hydrogen storage system holding approximately 10 days worth of hydrogen should be sufficient to withstand any shortages or other primary power. The hydrogen storage vessel will store pressurized hydrogen at approximately 5-6,000 psi in 40 ft cylinders. The hydrogen storage equipment will have to be chosen to match the available location and local regulations. Proper equipment can potentially be leased from major gas suppliers or can be purchased and integrated into a permanent system if location permits.

This system will use 675 m^3 (at standard pressures) or 2 m^3 (at 5000 psi) of hydrogen per hour when producing 1-MW of electrical energy.

PowerAvenue will partner with leaders in gas storage industry to provide a safe, compact, reliable gas storage unit. Mahler AGS has provided such services in the past for similar projects.



1: Feed compression unit
2: Feed pretreatment
3: Reforming and steam generation
4: High temperature conversion
5: Heat exchanger unit
6: Pretreatment of boiler feed water
7: Purification unit – HYDROSWING® system

1- MW Power Fuel Cell System Descriptions

This system will be designed for reliable extended operation over many years as a stationary power generation device. The fuel cell will provide high quality power for up to 10 days (intermediary hydrogen storage system capacity) at an average power level of 750 kW with a peak of 1.02 MW. The fuel cell system will be comprised of 30 parallel fuel cell stack modules each producing 34 kW of nominal power. This configuration allows for the maximum efficiency of the fuel cell while matching the voltage to commonly available power inverters. The fuel cell modules can run independently from one another and therefore the likelihood of a full power outage is greatly reduced. In addition to electrical power generation the fuel cell system will provide up to 1 MW of heat for water or space heating or other process heating applications.

Technical Data

1 MW Power System, 30 parallel 34 kW Fuel Cell Modules. Ten Systems of 102 kW each, with following typical specifications for each 102 kW system:

Number of cells	**1,650 total (550/FC system)**
Active Area	**155 cm^2**
Power	**102 kW at 360 VDC, 118 kW at 330 VDC**
Reactants	**H2, Air**
Temperature	**50- 80 degrees C**
Pressure	**~ 40 psi**
Humidification	**100%**
Cooling	**40 psi de-ionized water**
Stack Weight (combined)	**<750 pounds/system**
Dimension (combined)	**1 m x 0.6 m x 0.5m/system**
Type of fuel cell	**PEM**
Flow rate at max output	**3 gpm / 10 gpm during back flush**
Start up time	**10 sec, full power in 2 min**