PureCell Model® 400: A versatile product line enabling transition to a full Hydrogen Economy

Introduction:

In this paper we explore the role of HyAxiom PureCell® Model 400 in enabling the transition to a Hydrogen economy. Hydrogen is a clean energy carrier that can be used for a variety of applications as we move away from fossil fuels. It can be used to store renewable energy from Solar and Wind and then reused in fuel cells to balance electrical grid and provide uninterrupted power to customers. It can also be used as transportation fuel, feedstock for a variety of uses such as Ammonia, steel production, semi-conductor manufacturing etc. and serve as feedstock for using captured Carbon to make a variety of petrochemical products.

PureCell Model 400 is a versatile product that and can run on Natural gas, Natural gas plus Hydrogen or Pure Hydrogen. This is particularly important as we transition power generation from a Natural gas to mixing Hydrogen into Natural gas pipelines and then eventually pure Hydrogen flowing in those pipelines.

PureCell® Model 400 product description:

PureCell Model 400 baseline product runs on Natural gas. Natural gas enters the powerplant into the fuel processing section. Fuel processing section has two key functions. First is to remove the Sulfur in Natural gas and second is to reform the natural gas into Hydrogen rich gas. In PureCell® Model 400 Sulfur is removed from Natural gas via Hydro desulfurization. Hydro Desulfurizer breaks down Sulfur compounds into Hydrogen Sulfide. Hydrogen Sulfide then reacts with Zinc Oxide in the reactor bed and is stored as Zinc Sulfide[1] inside the powerplant until it is decommissioned. Methane in Natural gas then goes to reformer where it is converted to Hydrogen rich gas via steam methane reforming. Hydrogen then goes thru cell stacks where an electrochemical reaction occurs to create DC electric power and heat. Electrical system module in the powerplant converts DC power generated by fuel cell stacks to AC power. Coolant flowing thru the stacks removes heat generated from the cell stacks and it is exchanged with customer via heat exchangers. This unit can achieve up to 90% Combined heat and Power (CHP) efficiency.

The baseline model in this configuration can operate with up to 30% Hydrogen in the Natural gas stream. This is especially important in the near term as Hydrogen produced via clean energy such as hydro, wind, solar etc. is injected into Natural gas pipelines to evaluate the feasibility of such an operation and reduce emissions. Not all generation equipment has been proven to handle such high levels of Hydrogen in Natural gas and PureCell Model 400 clearly stands out in its ability to handle such a mix.

As more and more Hydrogen becomes available from clean energy sources, PureCell® Model 400 can be easily transitioned to handle 100% Hydrogen mix by removing the above-mentioned fuel processing system. Since the powerplant is assembled in modules it makes the removal of fuel processing system a relatively easy activity that can be accomplished in a matter of days.

Furthermore, operation on pure Hydrogen enhances the capabilities of the existing product by offering ~ 7 points increase in electrical efficiency. In addition, the unit also is able to respond faster to customer load changes by improving load following capability of 10 kW/sec to ~ 20 kW/sec.

1. Note that Zinc Sulfide is considered a non-hazardous waste per Globally Harmonized System (GHS) classifications for the Hazard Communication Standard.

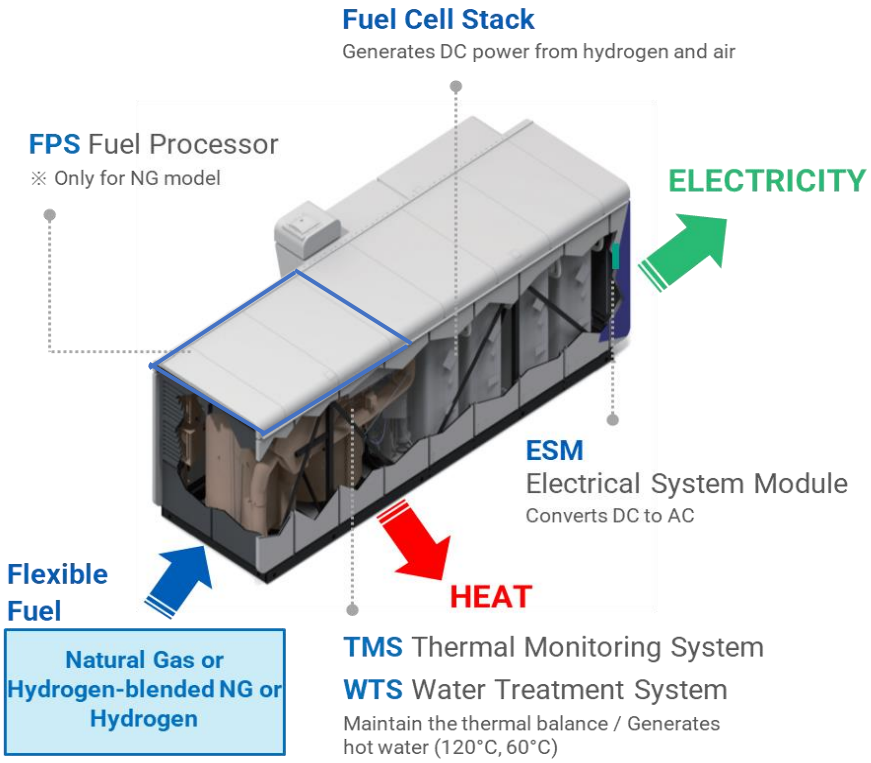

Figure 1: PureCell Model 400 Key Powerplant Modules

Figure 2: 50 MW PureCell® Model 400 Hydrogen fuel cell plant

Key performance metrics between 3 operating modes are provided in the table below.

	Natural Gas (NG)	**NG + H2 (up to 30%) blend**	**H2**
Electric Power, kW	440	440	440
Electrical Efficiency, %	44%	> 44% (depends on mix)	~50%
High Grade Heat (@ 250 F), kW	341	Depends on H2 mix, reduces proportionally to the increase in overall electrical efficiency compared to NG operation.	350
Low Grade Heat, kW	111	Depends on H2 mix, reduces proportionally to the increase in overall electrical efficiency compared to NG operation.	35
CHP Efficiency, %	90%	90%	90%
CO2 emmissions, lb/MWhr	496	Depends on H2 mix but less than 100% Natural gas	0
NOx emissions, lb/MWhr	0.02	0.02	0
SOx emissions, lb/MWhr	0	0	0
CO emissions, lb/MWhr	0.01	0.01	0
VOC emissions, lb/MWhr	0.01	0.01	0
Load Following Ramp Rate, kW/s	10	10	~ 20 kW/sec
Noise, dB @ 10 m	60	60	60
Max Ambient Temp w/o Make-up Water	30 C	Depends on H2 Mix but > 30 C	No Make-Up Water needed
Power Density, kW/m3	6.3	6.3	6.8
Power Density, W/kg	18.0	18.0	16.1
Product Life, yr	20, w/ stack & FPS overhaul at 10 yr	20, w/ stack & FPS overhaul at 10 yr	20, w/ stack overhaul at 10 yr
Capacity Factor, %	95	95	95
Operating modes	Grid Connect and Islanding, MULS	Grid Connect and Islanding, MULS	Grid Connect and Islanding, MULS

Table 1: Key performance metrics on various NG, NG+H_2 mix, 100% H_2

Conclusions: As countries around the globe become more environmentally aware, Hydrogen will play a major role in reducing global emissions. PureCell Model 400 can enable transition to a Hydrogen economy with a technology that is proven, reliable and clean with zero NOX, SOX and Carbon emissions while operating on pure Hydrogen.