Characteristics of Nordic Power Systems 1kW Auxiliary Power Unit

NPS have demonstrated the feasibility of reformer based fuel cell systems that deliver electric power in the range of 1 kW with laboratory test units. A dedicated power generator will be available as a demonstrator in September 2009. This unit will be capable of delivering 1 kW electric power uninterrupted and will run self-sustaining and entirely disconnected from external controls or power grid. The generator is based on common autothermal reforming technology of Diesel fuels and a High Temperature PEM fuel cell. All components of the unit are contained within a suitable encasement which accounts for easy accessibility and mobility. Standard lead acid batteries are connected to the system externally to supply the required starting energy and allow peak power operation of up to 2,5 kW for a limited time according to battery size and performance.

Weight and dimensions

The unit weight is 55 kg which includes the sound and thermal insulated casing with fuel reserve tank, power electronics and embedded controls, DC/DC converter with battery management and user interface. Reduction in weight may be achieved by a more advanced lightweight production process. The dimensions of the encasement are: L x W x H = 110 x 40 x 37 cm. Batteries are not accounted for since the power generator can be integrated in existing battery infrastructure. Reduction in weight and size is possible especially as components can be accommodated in allocated cavities in an existing application structure. System modules such as reformer module, fuel cell module, auxiliary module, and power management module can therefore be arranged independently. Reduction in weight by increasing the output from the fuel processing system. An ATR reformer based gas processing requires water for operation. A water recirculation system is integrated and also accommodated within the casing. However the most significant size and weight reduction of the power generator can be achieved when water recirculation is not required and fresh water can be supplied to the unit. The impact on size and weight will then account for approximately 40% each.

Power performance and efficiency

Continuous power supply of the unit is 1 kW el. The hybrid concept (with batteries) however allows higher peak power output and also provides immediate availability of electric power when it is required. The integrated management starts the fuel cell power generation automatically once power load is detected.

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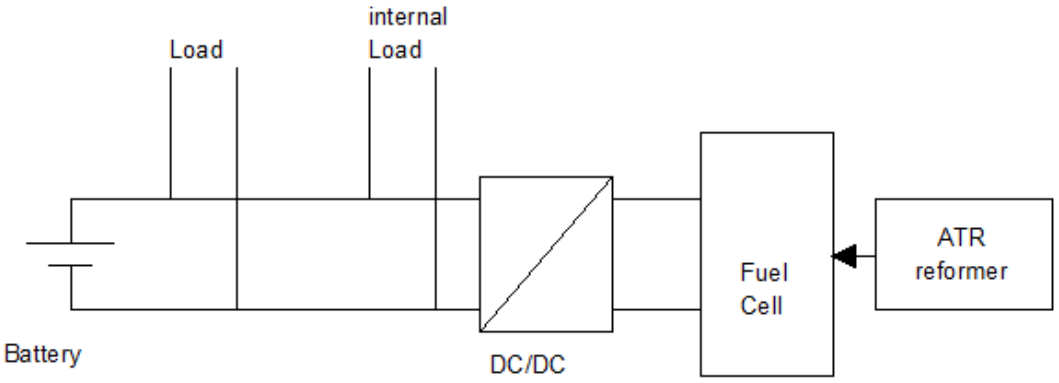
Power performance and efficiency



The figure above indicates the hybrid concept with batteries connected to the DC/DC conversion unit. This also means that power is always available on battery voltage level. If a regulated DC output is required a second DC/DC conversion unit must be connected between the load contacts and the battery line. General efficiency is affected by the ATR reformer efficiency and the efficiency of the High Temperature PEM fuel cell. The reformer efficiency is technically and physically limited to 65 %. The fuel cell efficiency can be adjusted by choosing a desired operation point and is therefore a balance between power density and efficiency. A typical achievable overall system efficiency is 28°% also accounting for internal use of electric energy.

Fuel flexibility

The demonstrator uses Diesel fuel. A wide range of liquid hydrocarbon fuels with a sulphur content of less than 10 (m)ppm are suitable for the application. When other fuels with higher sulphur contents such as AVTUR fuels have to be used a sulphur removal unit can be added onto the unit. This removal step requires thermal energy and affects the system efficiency.

Environmental conditions

Altitude	Estimated limit of 2000 meter at 100% of the power output, power reduction at higher altitudes
Operating temperature	Min: -30 °C / max: 35°C. Higher operating temperature when fresh water can be supplied
Storing temperature	Min: 0 °C not below dew point / max 55 °C
Shock	Not yet determined, no problems are expected
Dust	Needs clean air, in dusty environment supply air must be filtered
EMI / EMC	Not yet determined
Salt	Air should not be contaminated with salts
humidity	Unit should not be stored below the dew point, otherwise 95% rel.

Integration

Installation inside or operation outside any vehicle or application is possible. Access to ambient air must be provided and ventilation of the installing space must maintain the temperature operation limit. Integration into existing power infrastructure is easy since the unit can be directly connected to a battery. The unit does not deliver regulated DC current but will supply the electric energy on battery voltage level. Modularity is high and any number of units may be connected in parallel.
A connection to an external fuel tank or to existing fuel infrastructure is possible. A reserve tank is integrated in the demonstrator encasement.

Emissions

No hazardous or detectable emissions are discharged from the unit. Substantial emissions are limited to carbon dioxide exhaust at max. 40°C also containing water and air. Cooling air for the fuel cell will exit the unit at 160°C. Vibration is not emitted. The noise level during full load operation has not been determined yet but is expected to be very low and will be less than 59 dB(A), >1m.

Maintenance

There is no general interval maintenance cycle. All components are maintenance free and failure is subject to irreversible component wear down. The modularity allows easy exchange of single components or functional units when this is required. This service may be carried out by any instructed person.
If a sulfur removal is required the adsorptive cartridge has to be exchanged regarding to individual charge and load.

End of life and reliability

End of life limitations are expected to be predominantly governed by the fuel cell stack and catalytic converter performance. A lifetime cycle of more than 1000h has been proven for either component. Auxiliary components are mainly purchased off the shelf and are not expected to affect the operational lifetime. The modular gas processing unit has a very sturdy and reliable design and operates extremely predictable. The fuel cell stack is highly reliable and no unexpected events have occurred. Observed system failures have occurred due to single peripheral component liability caused by non industrial standard manufacture.

Modularity and availability

Since the electrical connection is made directly to an existing battery infrastructure or additional batteries several modules can be connected in parallel. However from a certain number of units the parasitic losses would be reduced if the power output of the system itself was increased.
Production of the device is not industrialized yet and each unit still comprises various custom made components. Manufacture of these components according to industrial standard would be feasible at high number unit production. A distribution network has not been established and each unit is produced manually on demand.