Emergency Backup Power

Group G
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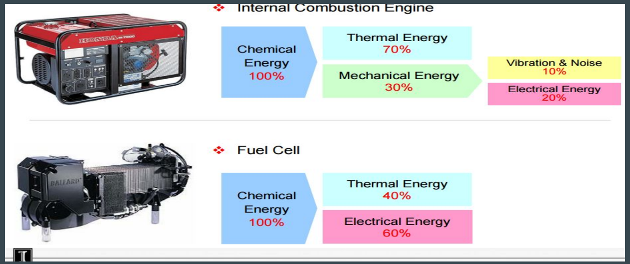
Field of Application: Commercial Buildings

- Applies when the main power grid shuts down for commercial buildings resulting in the need of backup power generation.
- Commercial buildings such as hospitals, schools, emergency shelters, offices, and more

Background/Problem Statement

- "Blackouts during the last ten years in Europe and Northern America have demonstrated an increasing likelihood of supra-regional blackouts with accompanying large economic losses. The earthquake, tsunami damage and power shortages that idled thousands of Japan's factories in 2011 highlighted its role as a key." Allianz
- Problem: Due to harsh climate conditions current power systems in use tend to fail and the current backup power systems can better be replaced from a relativistic standpoint.
- Harsh conditions: Lightning, gales, tornadoes, hurricanes, flooding, earthquakes, and other natural disasters are some examples which cause power failure.
- Reciprocating Generators are currently in use, but can there be an alternative solution-one which has an equivalent efficiency while reducing the harsh climate conditions(later explained)
- Alternative Solution: Use an alternate backup energy supply such as high temperature fuel cells or mobile low temperature fuel cells which can provide the electrical power necessary to run operations all-while not wasting most of their energy on sound due to moving parts as opposed to generators.

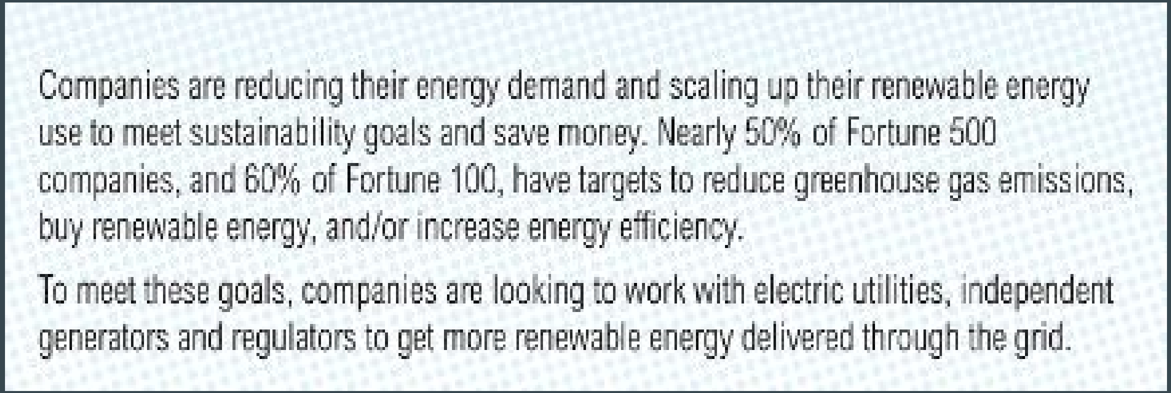


Background/Terminology

- Emergency Power Systems: **Required**, provide backup power to main components such as lighting, smoke alarms, elevators, etc… → 10 second engage, This has to be completely separate from buildings→ has own space
- **Legally required** standby power systems: Same as top, but not completely separate from main components- not necessary for living heating, ventilation
- Optional standby power systems: not required by code, but are purposefully picked to supply power to a certain component. Example to save financial or data loss.
- Primary interest is Emergency power systems.

Problem Statement

- Each year, power outages in the US cost an estimated $80 billion. Nine years later, in their 2013 report, forecasting experts at Hartford Steam Boiler placed the estimated annual losses from power failure in the US at $100 billion.
- Big business not switching emergency power systems because lack of incentive from government to update-past ideals→ satisfied with reciprocating pumps(diesel, petro..)
- Climate change
- New ideals: **Musk Foundation.**
- **World Wild Life ------>**



Companies are reducing their energy demand and scaling up their renewable energy use to meet sustainability goals and save money. Nearly 50% of Fortune 500 companies, and 60% of Fortune 100, have targets to reduce greenhouse gas emissions, buy renewable energy, and/or increase energy efficiency.

To meet these goals, companies are looking to work with electric utilities, independent generators and regulators to get more renewable energy delivered through the grid.

Problem Statement cont.

- Harsh weather conditions and private foundation incentives incentivize big businesses to consider updating their emergency power systems to reliable energy sources and away from motors, which use combustion
- Reduce reliance on fossil fuel usage and help make the environment better.
- According to WWF article in 2014 it explains how companies are making this change already and are receiving fair compensation for doing so.


WWF

OUR WORK SPECIES PLACES ABOUT US HOW TO HELP Search DONATE

PRESS RELEASES

New Analysis: America's Largest Companies are Jumping on Clean Energy Bandwagon and Saving More Than $1 Billion a Year

Recent corporate renewable energy and greenhouse gas reduction efforts equivalent to retiring 15 coal-fired power plants

Engineering Requirements - Constraints

- Large Fuel Cell necessary for emergency power systems-commercial building
- High Temperature Fuel cell needed to supply power
- Need DC to AC converter for fuel cell, increase power → cost
- High initial foundation cost
- Power output- Area of stack plates, type of fuel, type of catalyst,...
- Fuel type is dependent on local fuel cost efficiency.
- Large backup power systems require significant initial investments to create fuel and energy transportation pathways.
- Operating Temperature: 100 - 200℃

Selection of Fuel - Logistics

- Due to maintenance and durability the polymer electrolyte membrane was chosen.
- Only maintenance is water as opposed to circulating pump generator
- Natural gas reformation or small scale water electrolysis into pure hydrogen
  - Does not cause carbon dioxide waste
  - More costly to buy and store
- Less maintenance because of this fuel-->convenience
- Exhibits highest power density of all fuel cells
- Best fast-start and on-off cycling characteristics(response time).
- The fuel processor then converts the fuel supply (e.g. natural gas and biogas) into a hydrogen-rich stream, which is purified to an acceptable purity level for the fuel cell stack.

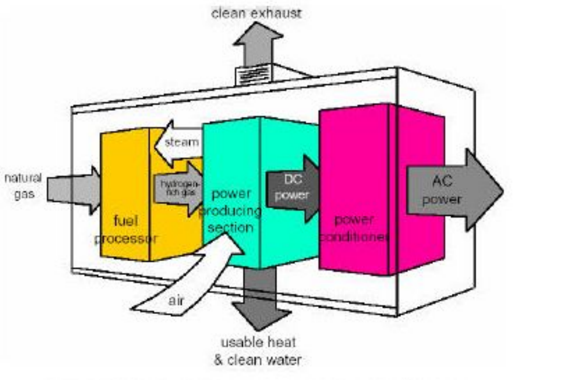


Figure 8-6 Block diagram of a fuel cell power system

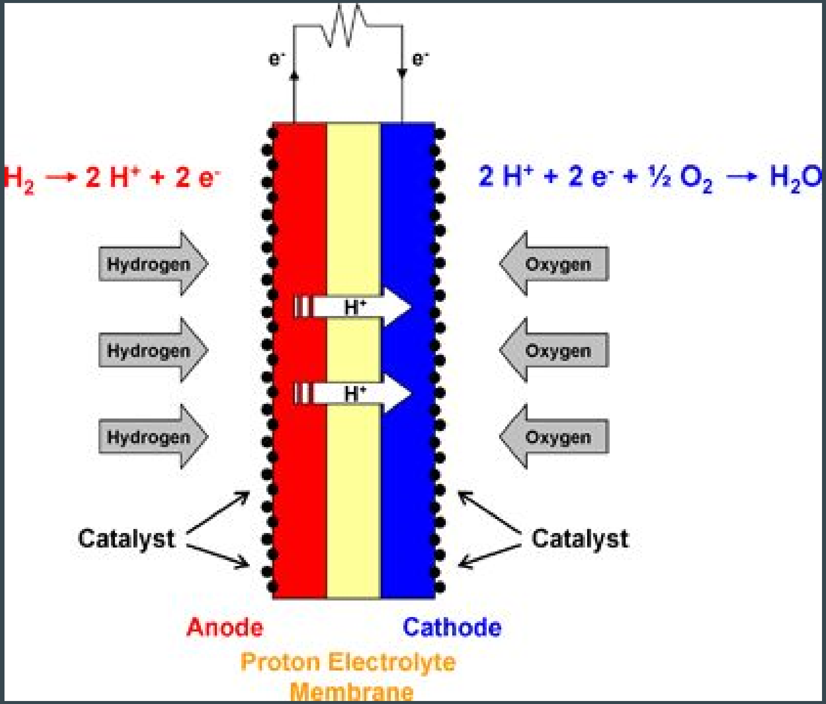
Electrochemical Reaction

Anode: $H_2 \rightarrow 2H^+ + 2e^-$
Cathode: $(^1/_2)O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$
Overall: $H_2 + (^1/_2)O_2 \rightarrow H_2O$
Real Thermo dynamic potential

$$E_{cell} = E^0{}_{cell} - \frac{RT}{2F} \ln \left(\frac{1}{p_{H_2} p_{O_2}{}^{1/2}} \right)$$

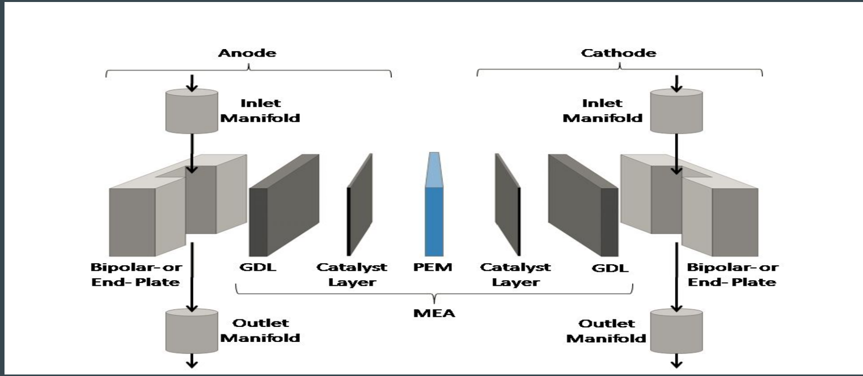
$E_o = 1.23$ V-ideal
$E_{cell} = 0.73$ V-real
$\Delta G_o = -237\ ^{kJ}/_{mol}$

Note this value is for per cell if stack can add plate values in series and taking consideration of energy loss due to leaking



Description of Design and Structure

- Standard PEMFC Fuel Cell System
- Electrolyte membrane: Perfluorinated sulfonic acid polymer
- Electrodes: Porous carbon electrodes on outside and insides coated with a Pt catalyst mixture(TPB).
- Will use steam reformation rxn to achieve higher intake of Hydrogen
- Use cogeneration as well due to enthalpy lost



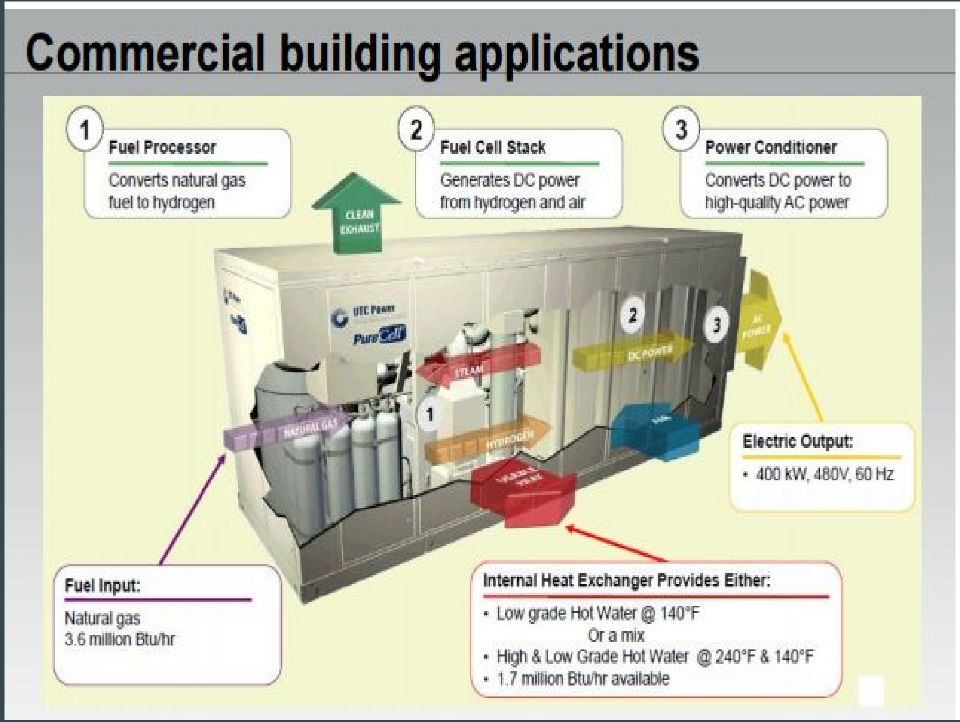
$$CH_4 + H_2O \leftrightarrow CO + 3H_2 \qquad \Delta H_{295} = -206 \text{ kJ/mol}$$

$$CO + H_2O \leftrightarrow CO_2 + H_2 \qquad \Delta H_{298} = -41 \text{ kJ/mol}$$

$$CH_4 + 2H_2O \leftrightarrow CO_2 + 4H_2 \qquad \Delta H_{298} = 165 \text{ kJ/mol}$$

Description of Design and Structure X2

- 1) a fuel processor that converts natural gas into a hydrogen-rich fuel gas for the fuel cell,
- 2) a proton exchange membrane fuel cell (PEMFC) stack (and integrated air blower) that generates DC electricity from the hydrogen,
- 3) power conditioning electronics that convert the DC electricity into grid-quality AC power,
- 4) an optional battery subsystem to increase the peak power of the system, and
- 5) optional cogeneration for hot water production and/or space heating.

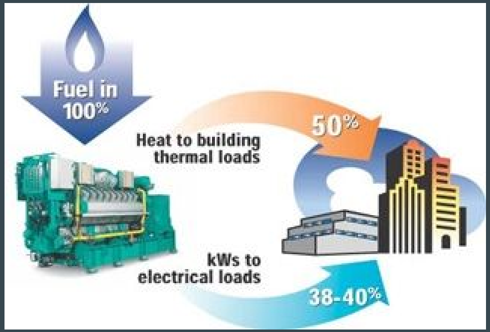


Comparison of systems - Qualitative

Machine 1:

Reciprocating Energy generators:

- Use petro fuels
- Waste energy to sound
- CHP system gives high efficiency
- Moving parts->shaft work lead to maintenance
- Cold weather, causing diesel to solidify into a partially crystalline state.
- high temperatures, the systems must be kept cool in order to prevent overheating during start-up.



Machine 2:

Polymer-Fuel Cell

- Use surroundings for fuel and water
- Small in size
- Has co-generation
- Quick start Capability
- No moving parts no wear out and fail
- Not affected by extreme heat proven to operate between minus 40-46 degree celsius
- Can place anywhere around world withstand harsh conditions

Comparison of Systems-Quantitative

Factors	Reciprocating Generator	Polymer Electrolyte Fuel Cell
Cost ($/kw)	1,000-2,000	3,500-4,500
Durability	Need consistent check ups by technician	>11,000 hours
Maintenance	High/moving parts-need trained technician	low/no moving parts/monitored online
Efficiency(%)	~80(CHP)	~75--steam methane reformer
Start up time	10 minutes(computer data)	<30 sec
Emissions	High/vary with HP	~0

Comparison of Systems-Quantitative

Decibel level	~100->require permit	~50
Placement	Outdoors only	Indoors or outdoors

-each year, power outages in the US cost an estimated **$80 billion**.2 Nine years later, in their 2013 report, forecasting experts at Hartford Steam Boiler placed the estimated annual losses from power failure in the US at **$100 billion**.

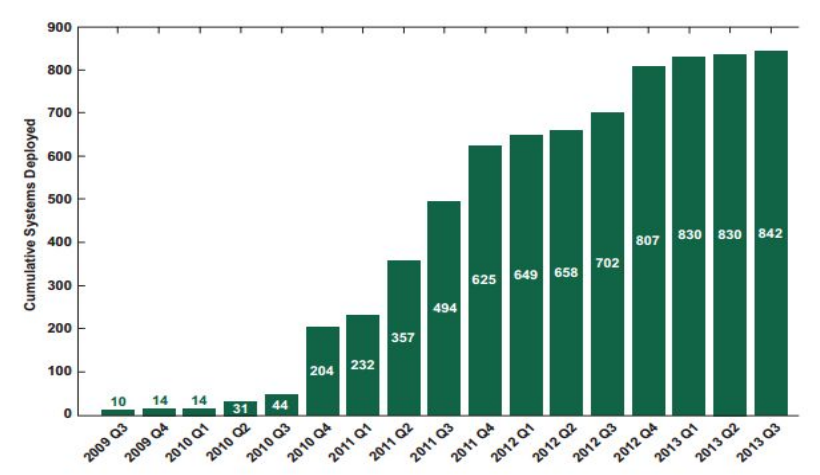
-"Generators are a huge cost up front. They are very expensive to maintain and run, and you only use them in emergencies. When they don't work, it's frustrating."8 —Bloomberg Businessweek

Benefits of using selected system

- Near zero emissions at the point of operation
- Reduction in current and future electricity costs **long term** through the efficient use of renewable energy technologies
- A high-quality, reliable, and consistent power supply as long as fuel is supplied
- Higher electrical efficiency than traditional combustion power supplies
- Can be placed indoors or outdoors
- Less maintenance-status of fuel cell can be viewed online
- Fuel-flexibility, enabling the use of a variety of domestic energy sources (e.g. hydrogen, natural gas, and methanol)
- Silent operation 24 hours per day, 7 days per week -->financially prosperous don’t need to apply for permit due to noise constraints.

Conclusions

- It has been proven that the PEM fuel cell costs more to replace than the reciprocating generator
- 15 % failure due to maintenance of reciprocating diesel generator systems costs 100 billion dollars in the U.S.
- Old ideals- government not provide enough incentives to promote green change
- New ideals: Foundations like Musk foundation and many more provides funding to any businesses making this greener energy change



Citations

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