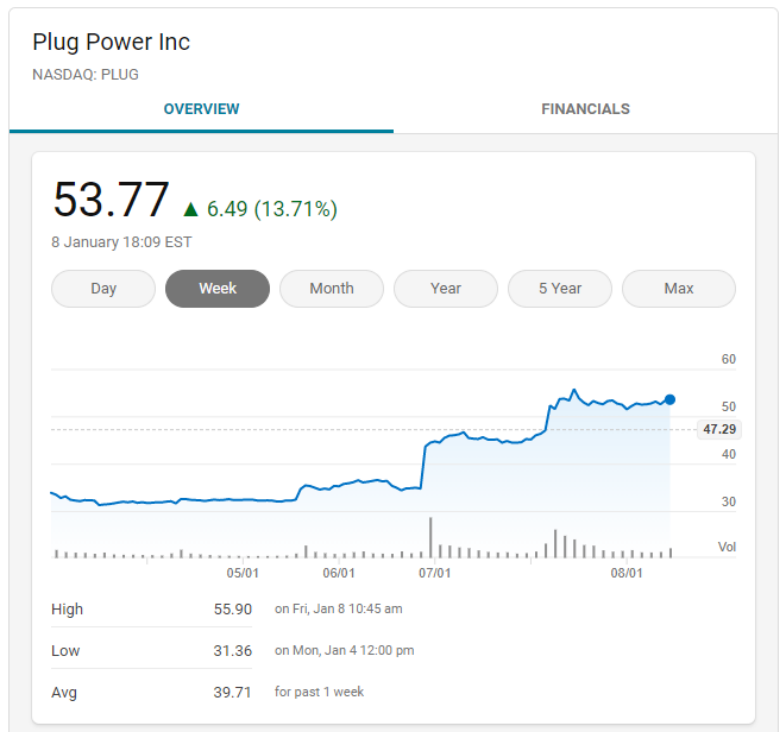
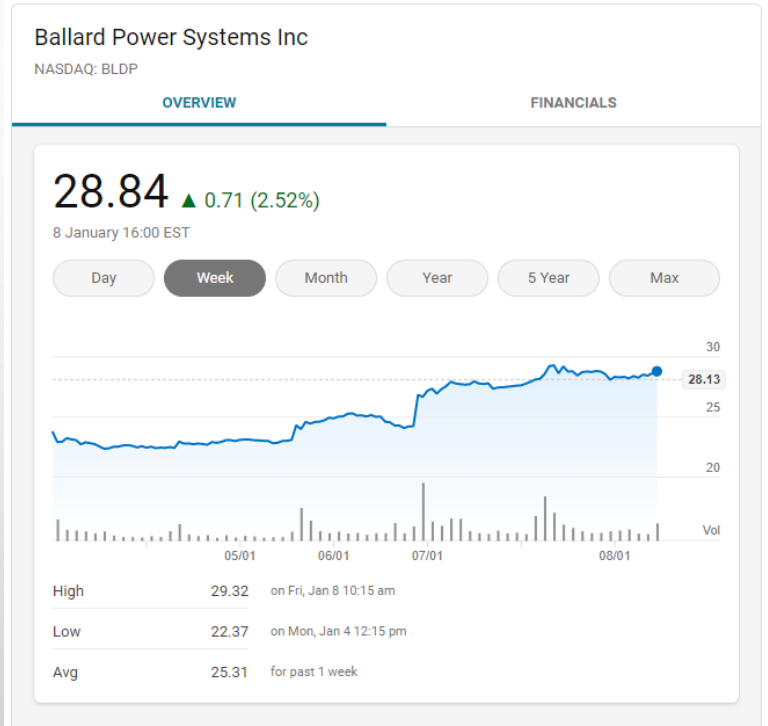
SESSION 5:

FUEL CELLS

THE GOLD RUSH





REI

6.54 USD

LON: 0A60

Follow

-11.16 (-63.06%) ↓ year to date

8 Oct, 15:11 BST · Disclaimer

1D | 5D | 1M | 6M | YTD | 1Y | 5Y | Max

13.94 USD

NASDAQ: BLDP

Follow

-8.60 (-38.17%) ↓ year to date

8 Oct, 10:15 GMT-4 · Disclaimer

1D | 5D | 1M | 6M | YTD | 1Y | 5Y | Max

27.20 USD

NASDAQ: PLUG

Follow

-5.02 (-15.60%) ↓ year to date

8 Oct, 10:14 GMT-4 · Disclaimer

1D | 5D | 1M | 6M | YTD | 1Y | 5Y | Max

REI

FUEL CELLS 101

BACK TO SCHOOL

VARIATIONS ON A THEME

Comparison of Fuel Cell Technologies

Fuel Cell Type	Common Electrolyte	Operating Temperature	Typical Stack Size	Electrical Efficiency (LHV)	Applications	Advantages	Challenges
Polymer Electrolyte Membrane (PEM)	Perfluorosulfonic acid	<120°C	<1 kW - 100 kW	60% direct H_2;[i] 40% reformed fuel[ii]	• Backup power • Portable power • Distributed generation • Transportation • Specialty vehicles	• Solid electrolyte reduces corrosion & electrolyte management problems • Low temperature • Quick start-up and load following	• Expensive catalysts • Sensitive to fuel impurities
Alkaline (AFC)	Aqueous potassium hydroxide soaked in a porous matrix, or alkaline polymer membrane	<100°C	1 - 100 kW	60%[iii]	• Military • Space • Backup power • Transportation	• Wider range of stable materials allows lower cost components • Low temperature • Quick start-up	• Sensitive to CO_2 in fuel and air • Electrolyte management (aqueous) • Electrolyte conductivity (polymer)
Phosphoric Acid (PAFC)	Phosphoric acid soaked in a porous matrix or imbibed in a polymer membrane	150 - 200°C	5 - 400 kW, 100 kW module (liquid PAFC); <10 kW (polymer membrane)	40%[iv]	• Distributed generation	• Suitable for CHP • Increased tolerance to fuel impurities	• Expensive catalysts • Long start-up time • Sulfur sensitivity
Molten Carbonate (MCFC)	Molten lithium, sodium, and/or potassium carbonates, soaked in a porous matrix	600 - 700°C	300 kW - 3 MW, 300 kW module	50%[v]	• Electric utility • Distributed generation	• High efficiency • Fuel flexibility • Suitable for CHP • Hybrid/gas turbine cycle	• High temperature corrosion and breakdown of cell components • Long start-up time • Low power density
Solid Oxide (SOFC)	Yttria stabilized zirconia	500 - 1000°C	1 kW - 2 MW	60%[vi]	• Auxiliary power • Electric utility • Distributed generation	• High efficiency • Fuel flexibility • Solid electrolyte • Suitable for CHP • Hybrid/gas turbine cycle	• High temperature corrosion and breakdown of cell components • Long start-up time • Limited number of shutdowns

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SUMMARY

- LOW-TO-ZERO EMISSIONS (BE CAREFUL)
- HIGH EFFICIENCY (BE CAREFUL)
- RELIABILITY
- ENERGY SECURITY
- DURABILITY
- SCALABILITY
- QUIET OPERATION
- FUEL FLEXIBILITY – FUEL AVAILABILITY IS IMPORTANT
- WIDE VARIETY OF APPLICATIONS
- OTHER SOLUTIONS MAY BE CHEAPER / MORE EFFICIENT
- FUEL CELLS SEEN AS A RAPIDLY EMERGING TECHNOLOGY

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FUEL CELL PROVIDERS

THERE ARE LOTS OUT THERE

Ballard	Plug Power	Doosan Babcock
Fuel Cell Energy	Proton	Nedstack
Hydrogenics	GenCell	Ceres Power
Bloom Energy	Adelan	Intelligent Energy
Hitachi	Mitsubishi	Elcogen
Powercell	Hyundai	Toyota

Other vendors are available

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ENE-FIELD – MICRO CHP PROJECT

ENE.FIELD

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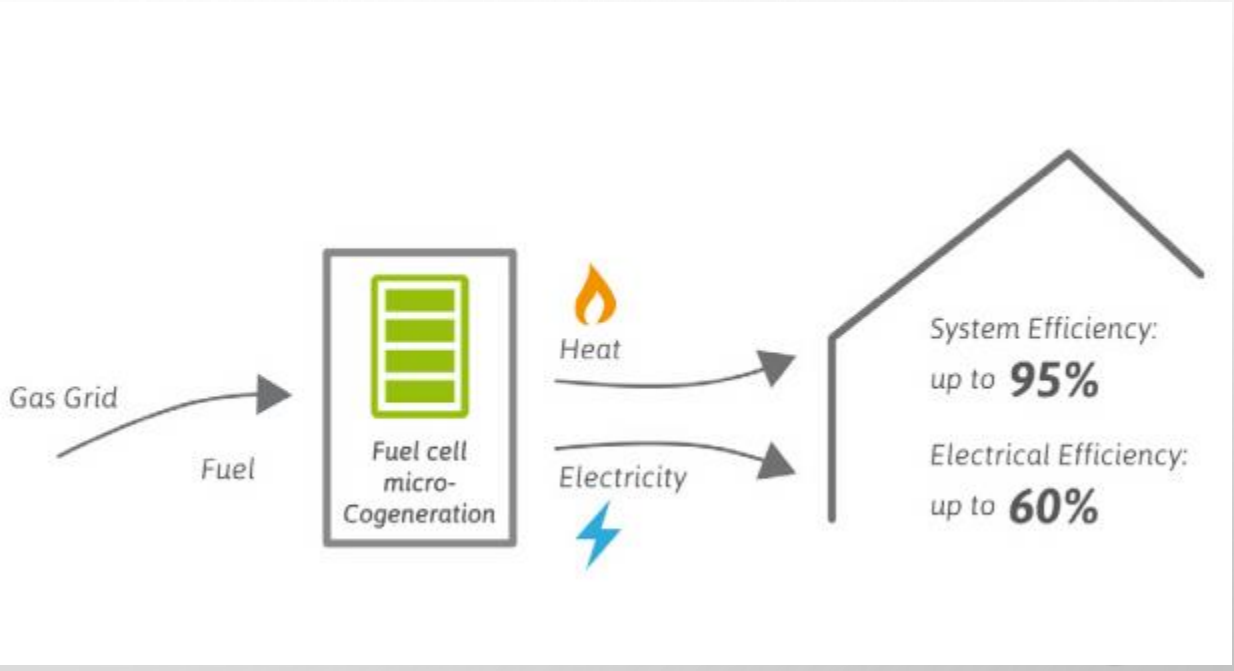
THE PROJECT

- DEPLOY > 1000 MICRO CHP (COMBINED HEAT AND POWER) UNITS ACROSS EUROPE
- DEVELOP DATASET TO UNDERSTAND CONSUMPTION AND APPLICABILITY
- PRE-CURSOR AND LEARNING PRIOR TO COMMERCIAL ROLL OUT
- RELATIONSHIPS BETWEEN UTILITIES / HOUSING PROVIDERS / TECHNOLOGY PROVIDERS / CUSTOMERS



KEY LEARNING

- CUSTOMERS 90% SATISFIED WITH NEW VALUE PROPOSITION
- UNDERSTANDING THAT MASS MARKET COMMERCIALISATION CAN PRODUCE A COMPETITIVE SOLUTION
- REDUCTION IN INFRASTRUCTURE COSTS POSSIBLE
- CO2 EMISSION REDUCTION POSSIBLE WITH SHIFT TO H2 FROM NATURAL GAS
- TRAINING / SKILLS

NOTE THE VALUE AND NEED FOR DEMONSTRATION PROJECTS

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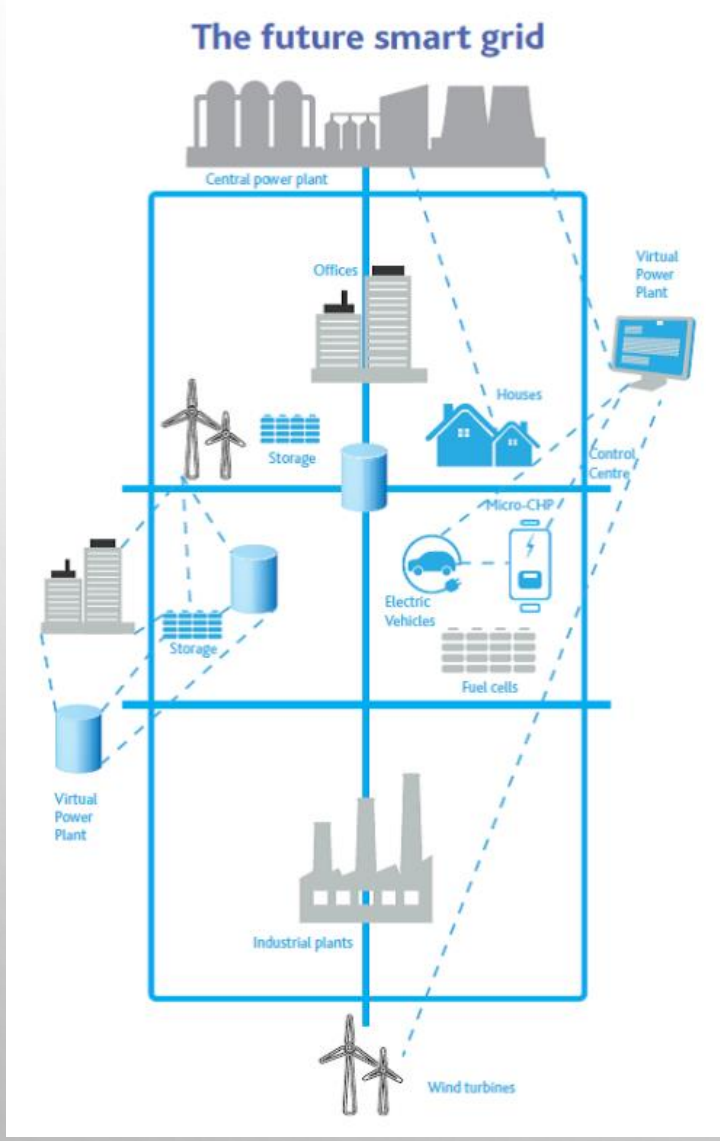

FURTHER IMPACTS

- ROLE OF MICRO CHP IN A DISTRIBUTED ENERGY SYSTEM (SEE SESSION 12)
- SUPPLY CHAIN DEVELOPMENT
- INVESTOR CONFIDENCE
- INFRASTRUCTURE CHANGE
- POLICY / REGULATIONS
- FOSSIL DISPLACEMENT

- **CUSTOMER FOCUSED**

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RESOURCES

FUEL CELLS FACT SHEET (ENERGY.GOV)

COMPARING FUEL CELL TECHNOLOGIES - GENCELL - FUEL CELL GENERATORS (GENCELLENERGY.COM)

FUEL CELLS (THEIET.ORG)

E4TECH FUEL CELL INDUSTRY REVIEW 2019

FUEL CELL FUNDAMENTALS | WILEY ONLINE BOOKS

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Q & A