



# 19th SOFC Annual Workshop LG Fuel Cell Systems Inc.

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# Outline

- **Business**
- **Technology**
- **Manufacturing**
- **Product Demonstration**



# LG Fuel Cell Systems Inc.

## Canton, Ohio



### Business Leadership

- Fuel Cell and Fuel Processor
- Power Electronics and Controls
- Prototype manufacturing
- Component and System Testing

## Derby, UK



### Design and Analysis Leadership

- IB / FCV design
- Generator module design
- TG/TGA design
- System modeling & analysis

## Seoul, Korea



### Manufacturing Leadership

- Fuel Cell Manufacturing
- Manufacturing development
- Supply-chain development
- TG/TGA mfg. and testing

## Global Resources



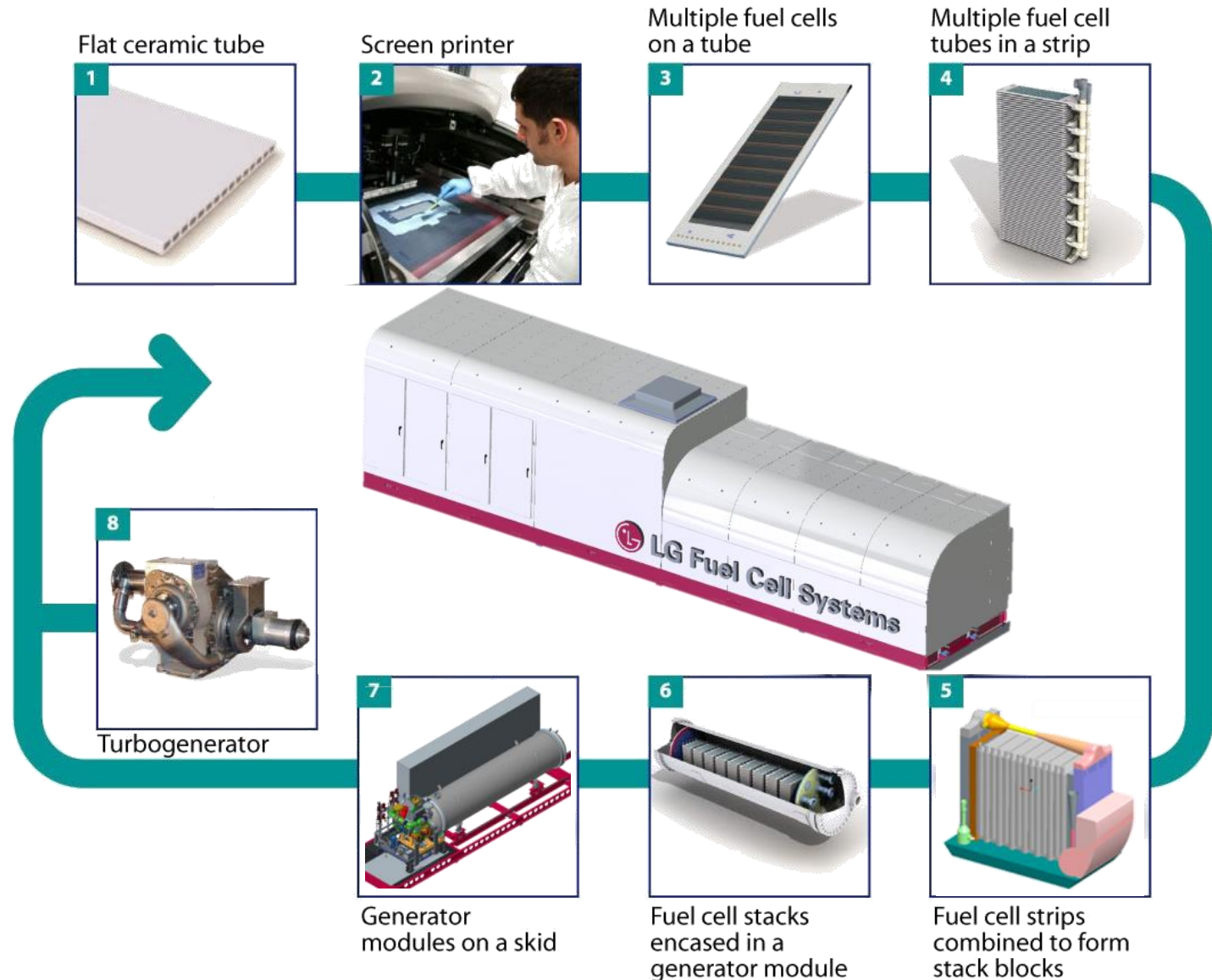
- Volume Manufacturing
- Design for Manufacturing
- Supply-Chain Development
- Electronics and Controls



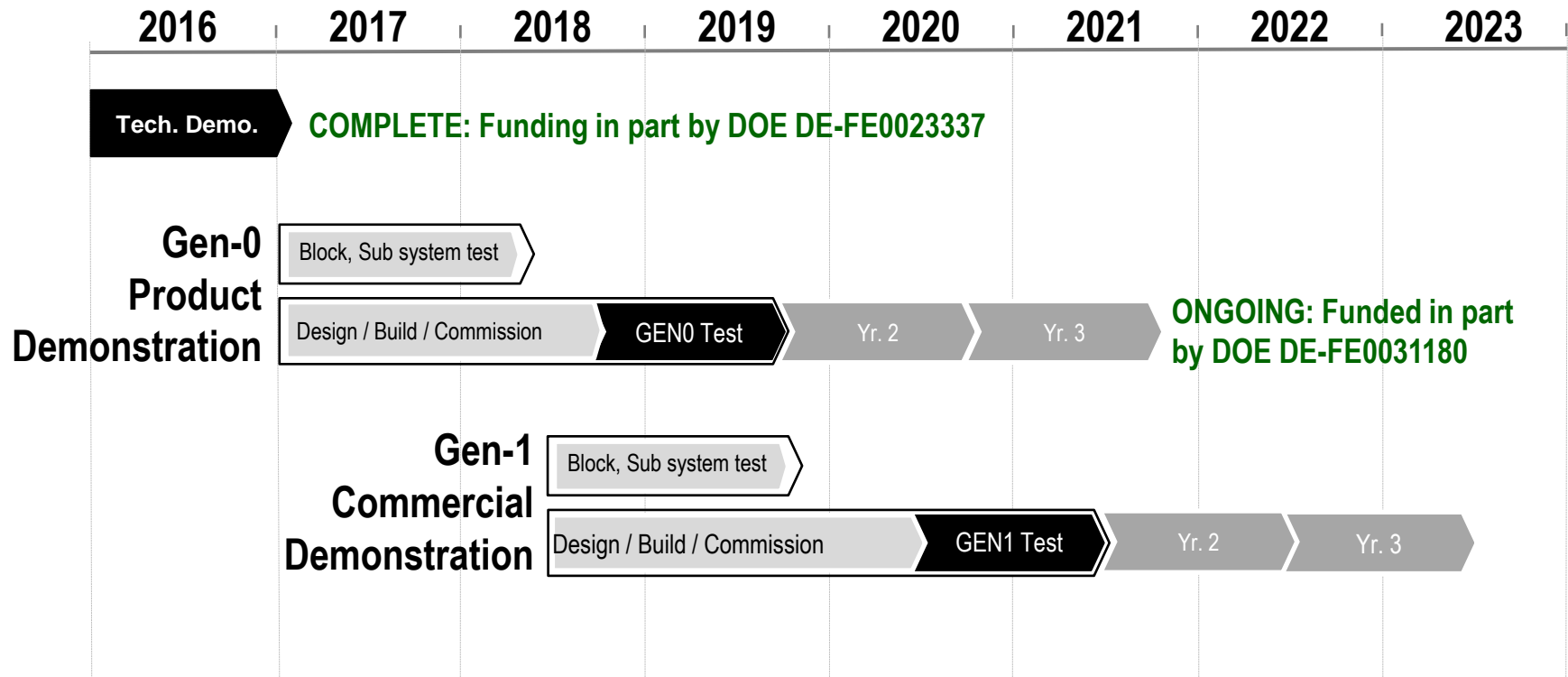
- Turbine & compressor
- Aero-thermal expertise
- High-temp Materials
- System Integration



# LGFCs SOFC Power Plant



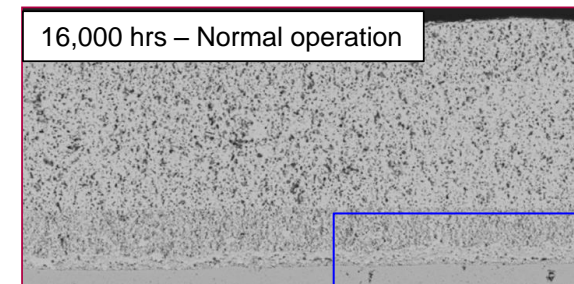
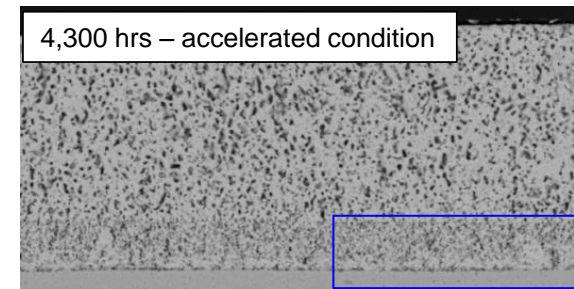
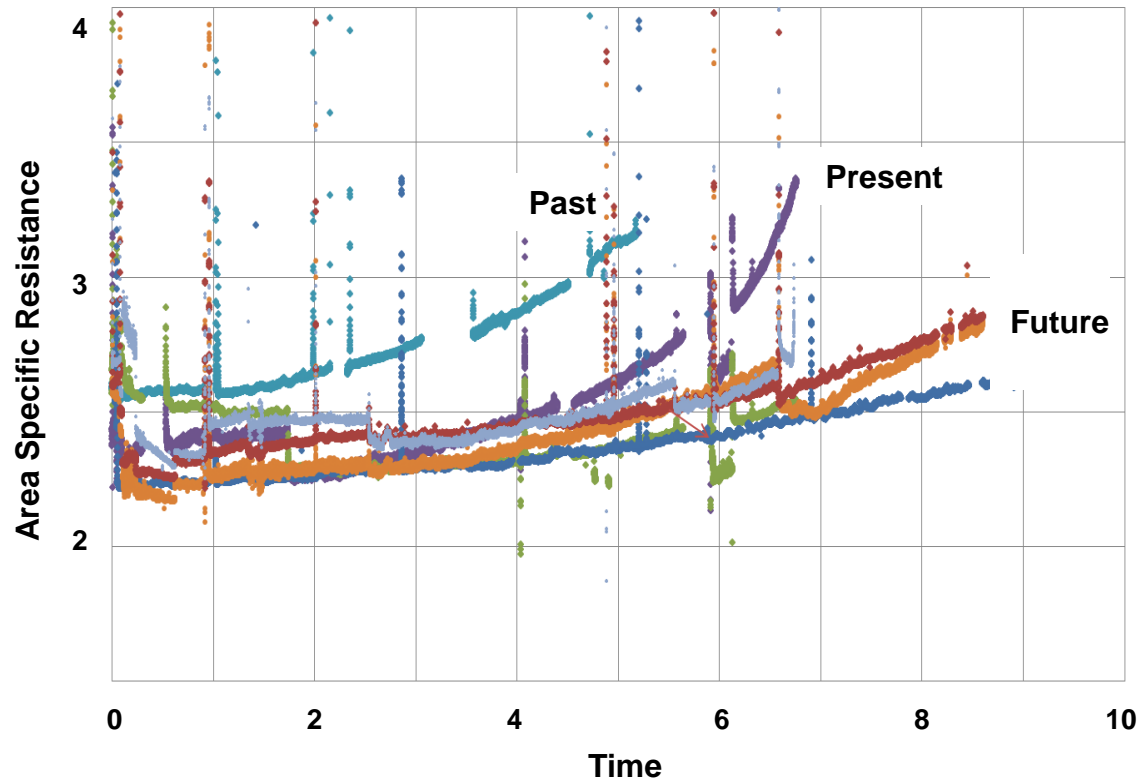
# LGFCs Entry Into Service Plan



# Fuel Cell Advances

- Continuously increasing durability and reliability drives down cost


## Accelerated screening tests



Similar cathode densification  
at electrolyte ~4:1 time factor

# Improved Fuel Cell Stacks

T  
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y


 **Reliability**  
Ceramic-to-Metal  
Joint



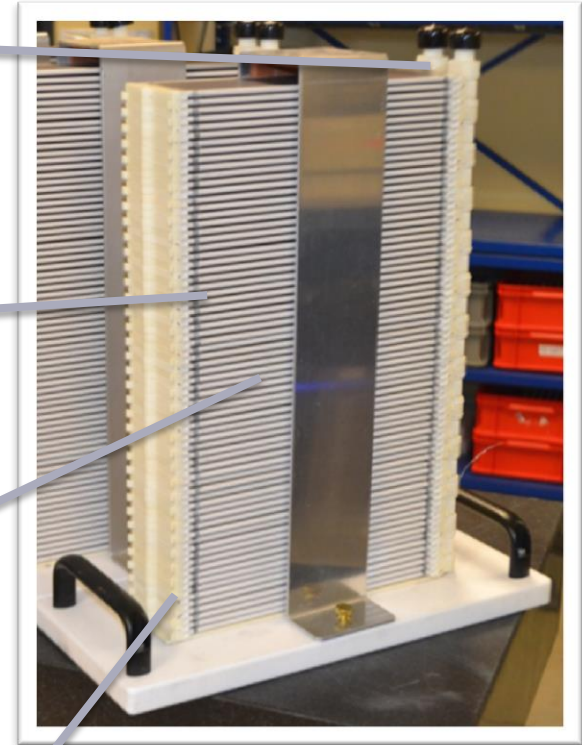
Dual-environment  
cyclic screening

 **Manufacturing**  
Connections  
Between Tubes

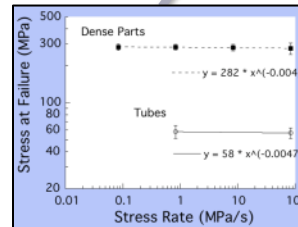


 **Cost**  
Longer/Wider  
Fuel Cell Tubes  
- 60% more power

Bundle Tests



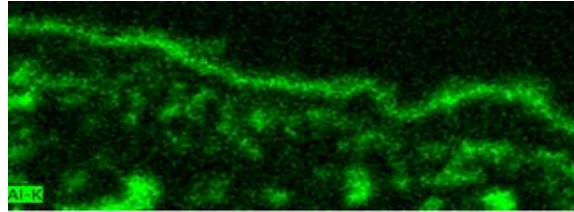
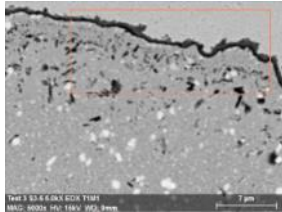
 **Durability**  
Improved Dense  
Parts



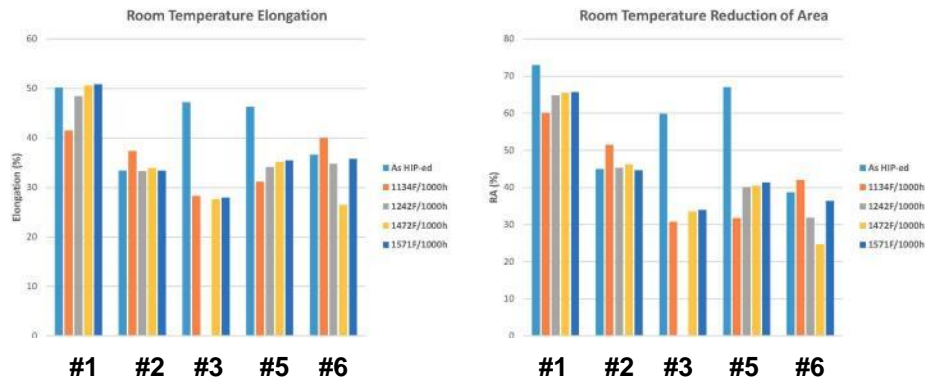
Slow Crack  
Growth in Use  
Environment

# Materials Selection

- High Temperature material selection crucial to cost competitiveness

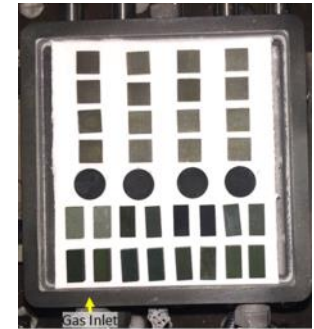


SEM: Alloy Microstructure - corrosion effects



## Mechanical Property Testing

- 1000 hours, 600 to 860 °C



## Corrosion Testing under fuel cell conditions

- 500-1500 hours
- At temperature and pressure
- Oxidizing, Reducing and Dual atmospheres
- Thermal cycling



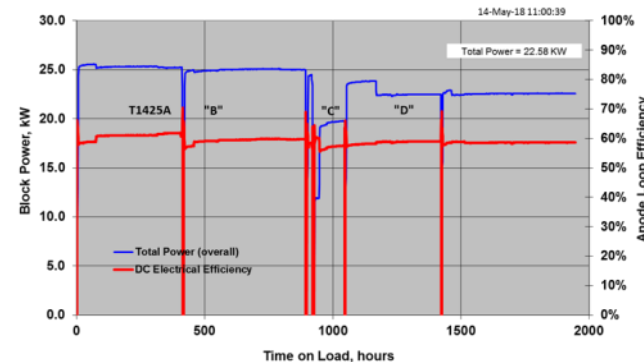
# Integrated Block Innovation

- Advanced cycle reduces chrome bearing materials
  - + Chrome getter
  - ↑ Longer life
- In Block Reforming (IBR)
  - ↓ Stack temperature
  - ↑ Current density
  - No carbon fouling
- Block testing at Technology Readiness Level 6 validates innovation
  - GEN-0 Pass Off Test



Integrated Block

Multi-Block Test Rig



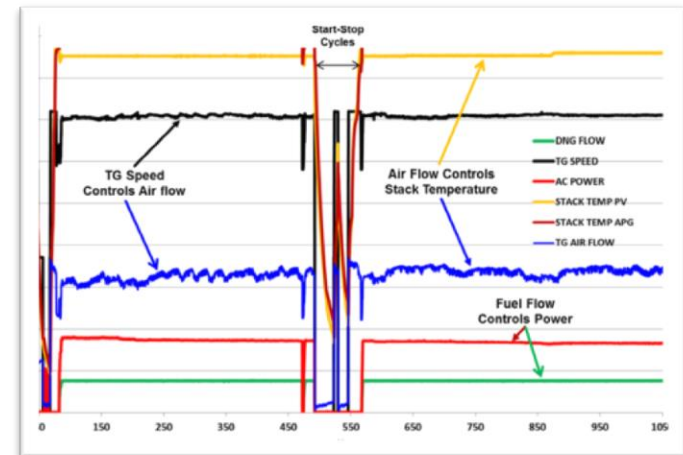
Block Power and Efficiency

# Technology Demonstration

- **200kW- class SOFC Power System (IST) in 2015-16**
  - Pressurized SOFC vessel
  - Turbo generator assembly
  - Power electronics
  - Fuel processing
  - Controls and safety system
- **Pipeline NG to grid AC Power**
- **Over 2000 hours of system operation**
  - Multiple starts, stops, loadings, and off design condition tests
- **Over 1300 hours on load**
  - AC efficiency of 56%



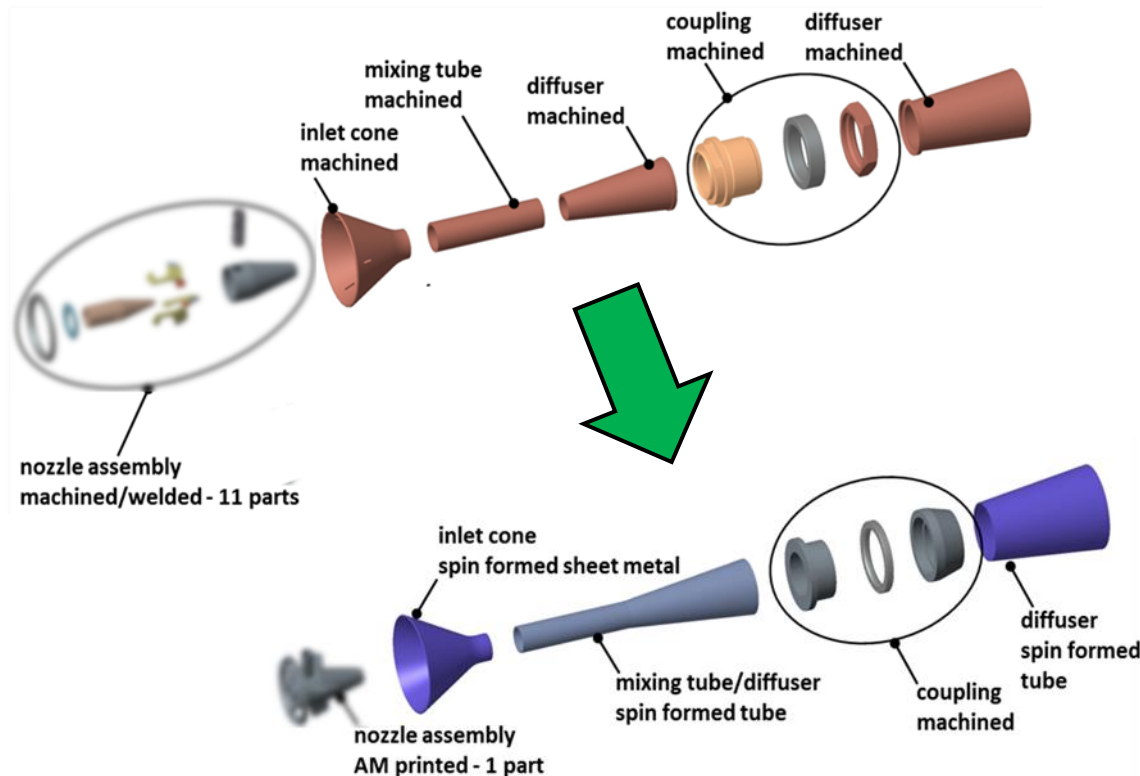
200 KW Fuel Cell Vessel



1000 Hour On Load Test

# Manufacturing and Supply Chain

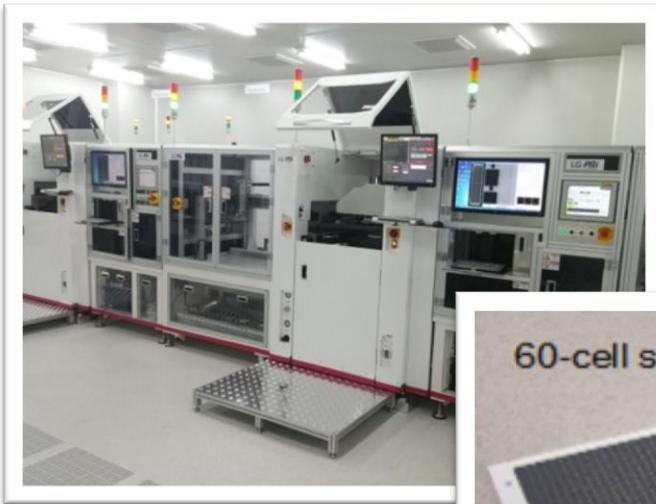
- Driving down component cost
  - DFM reduces ejector cost 60%



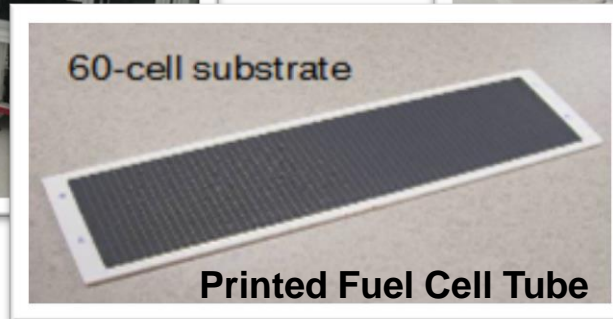
AM Printed parts

# Fuel Cell Factory

- Multi-MW / year printed tube line



Tube Printing Line



Printed Fuel Cell Tube

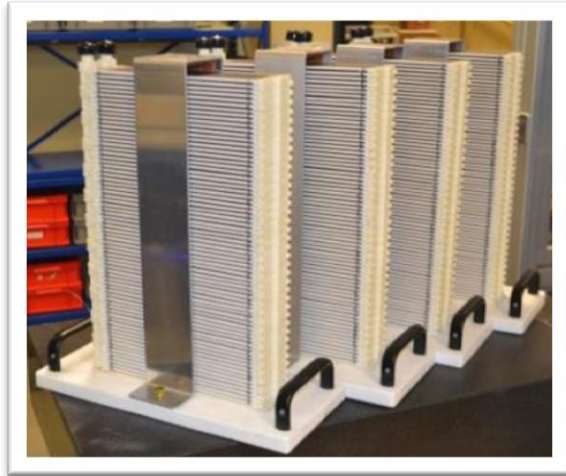


Edge Dispensing

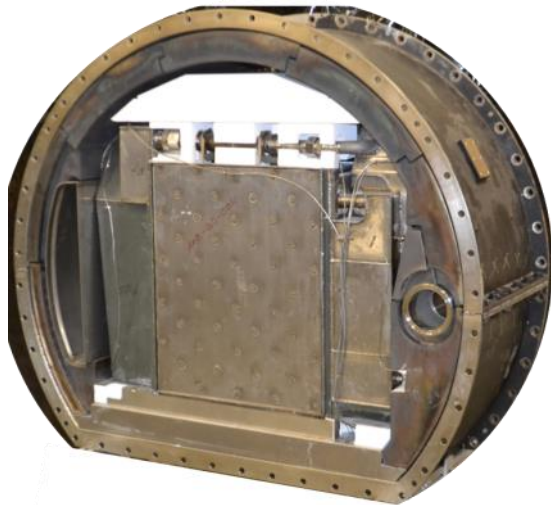
Firing



# Prototype System Manufacturing



Strips Ready to Install In Block



Inner Vessel Assembly



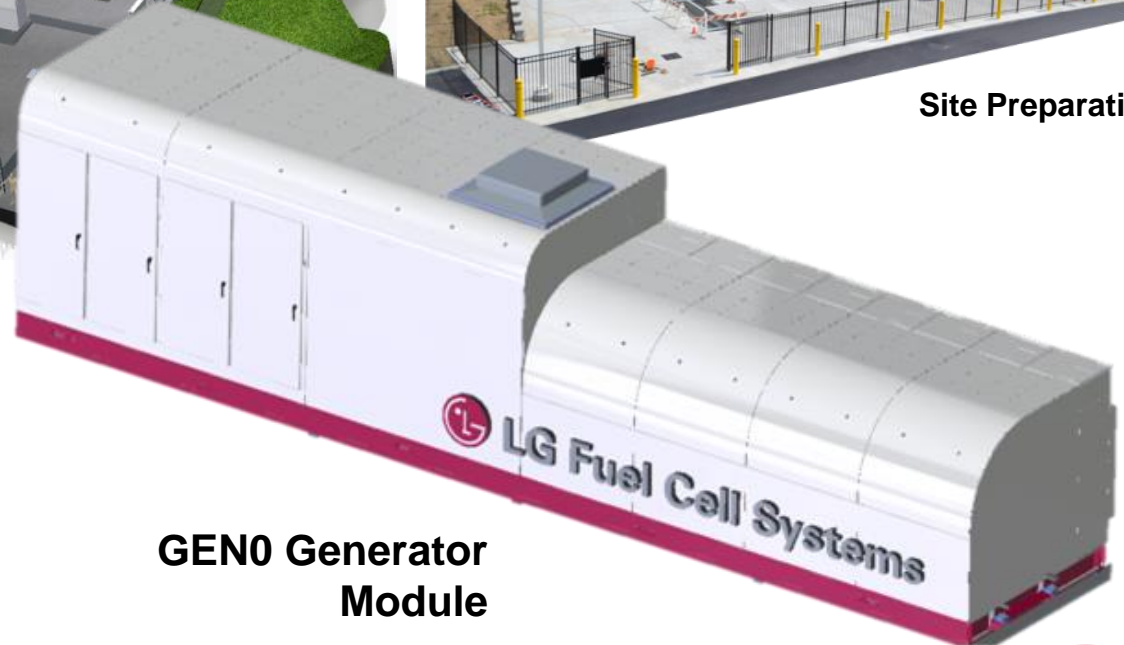
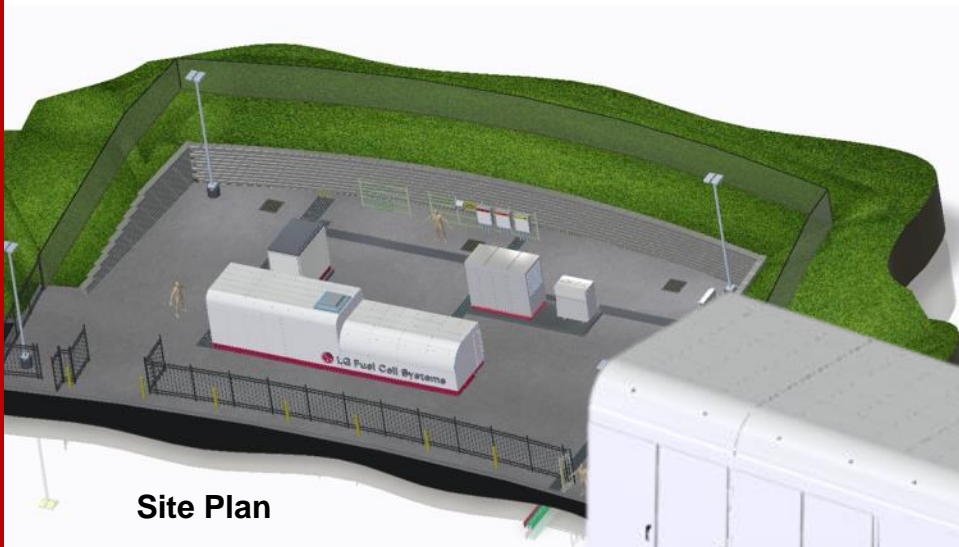
Blocks Assembled into Fuel Cell Vessel

# Product Features

- **Nominal 1MW scale SOFC Power System**
  - Scalable from 300kW to >20MW
- **Electrical efficiency >60% and conducive to combined heat and power**
  - Exhaust at >300°C at 13,000 lbs/hr per MW
- **Fuel flexibility with natural gas and biofuel**
- **Low Emissions**
  - Lower greenhouse gases due to higher efficiency
  - Meets air quantity regulations
- **Cost competitive with energy alternatives**
  - Efficiency, power density and materials
- **High availability for base load operation**
  - 5 year life for basic cell & stack components
  - >20 year life for BOP components

# 250 KW Product Demonstrator

- Operation in 4th Quarter 2018



# Acknowledgements

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