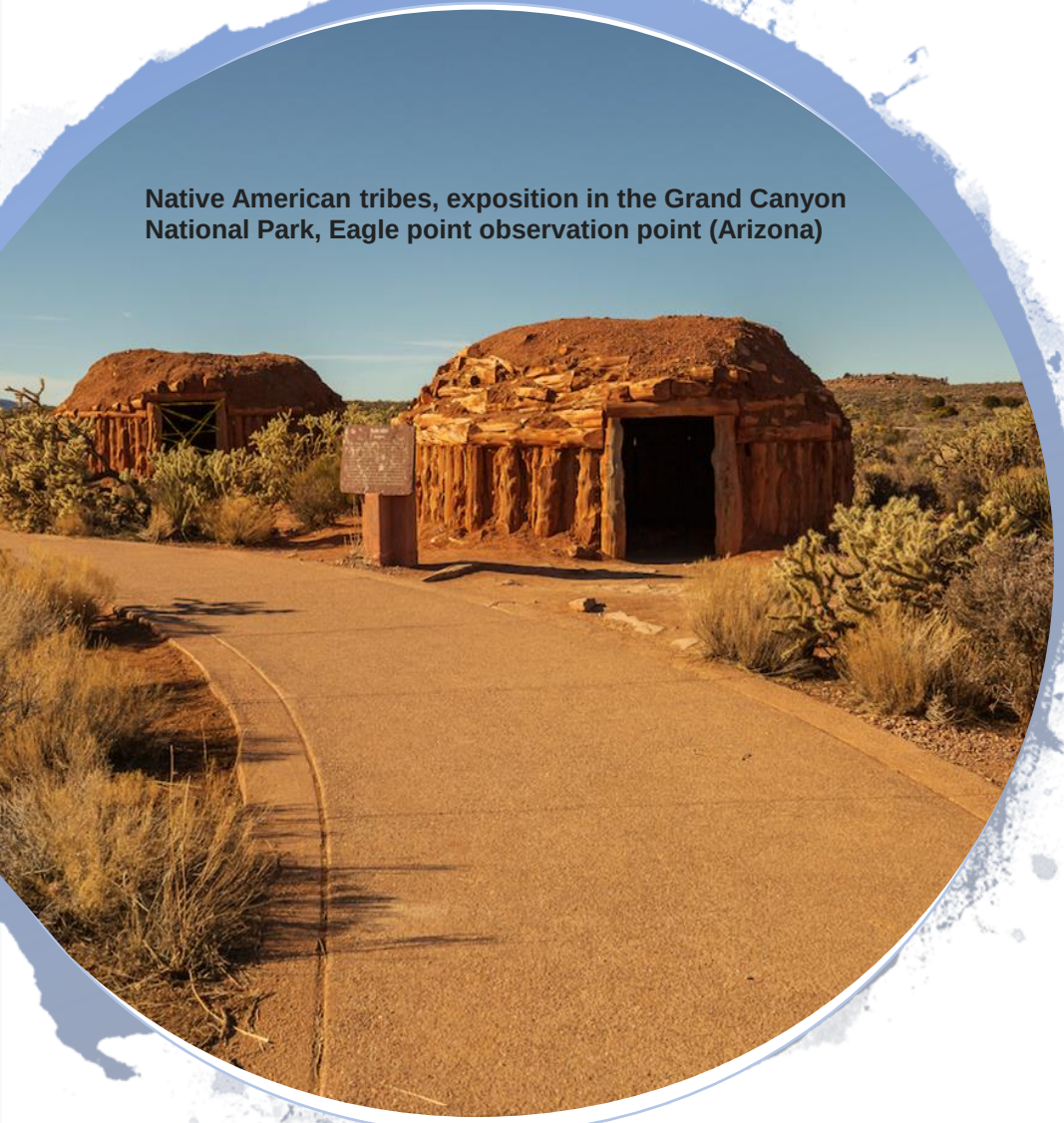
The Future of Clean Energy Resiliency


Native American tribes, exposition in the Grand Canyon National Park, Eagle point observation point (Arizona)

Fuel Cell Technology for Micro-Grids & Green Hydrogen Generation integrated for improved comfort for homes or farms

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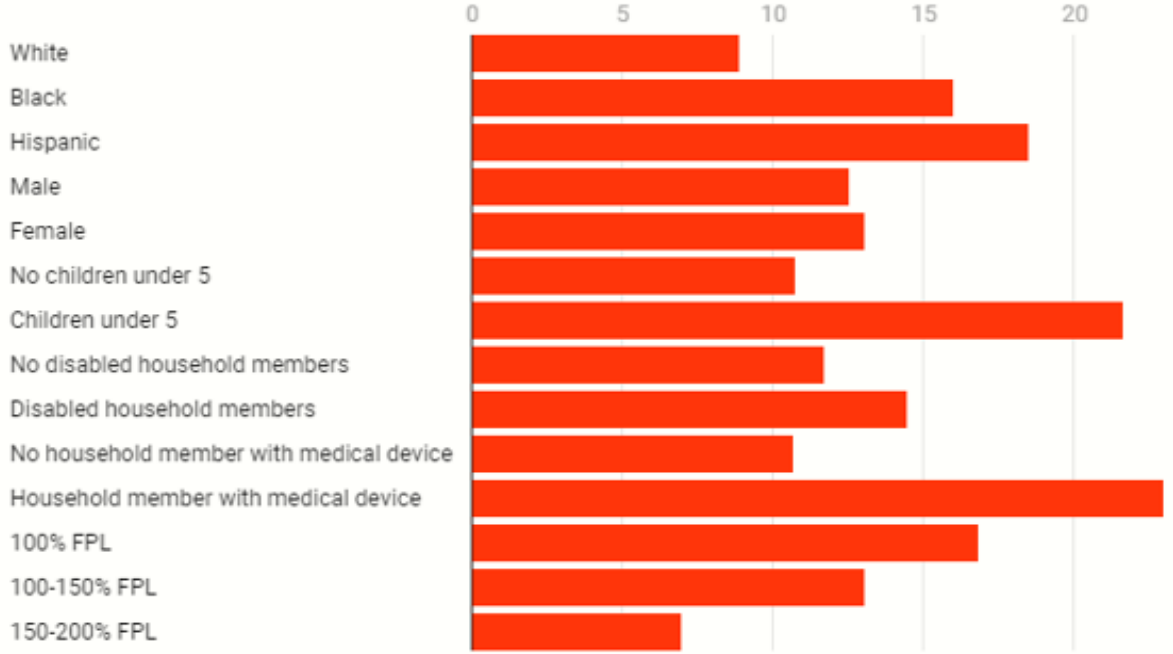
Market Problem

- United States has aggressive goals to be net-zero carbon emissions by 2050
- Increased consumptions of NG by 12.8% (2017-19) & electrical power increased 6.9% (2018-2019)
- Electricity prices are higher because of PTC and hardship on Americans who cannot pay their utility bills
- Electrical grid is overburdened
- Farms' runoff creates issues with the watershed

Many U.S. households are struggling with energy bills during the COVID-19 pandemic

Percentage of respondents who reported being unable to pay an energy bill from late April through late May of 2020, by demographic group. (FPL = Federal poverty level)

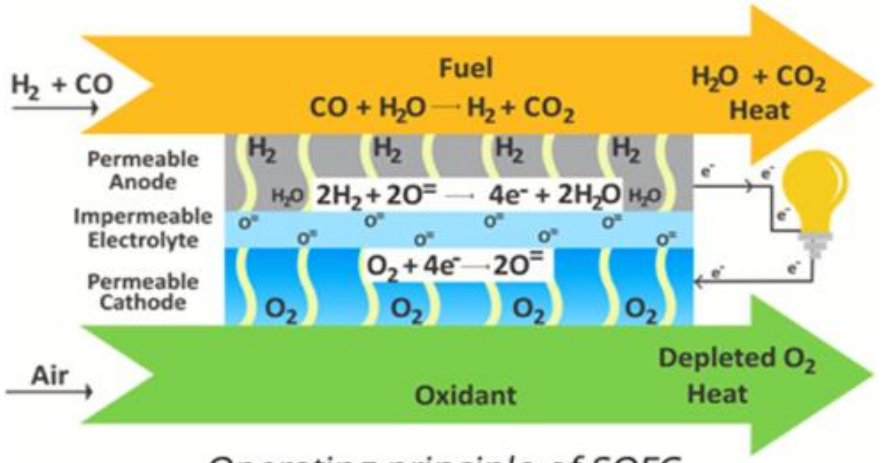


Carley, S., & Konisky, D. (2020, July 30). *Energy is a basic need, and many Americans are struggling to afford it in the COVID-19 recession*. The Conversation.

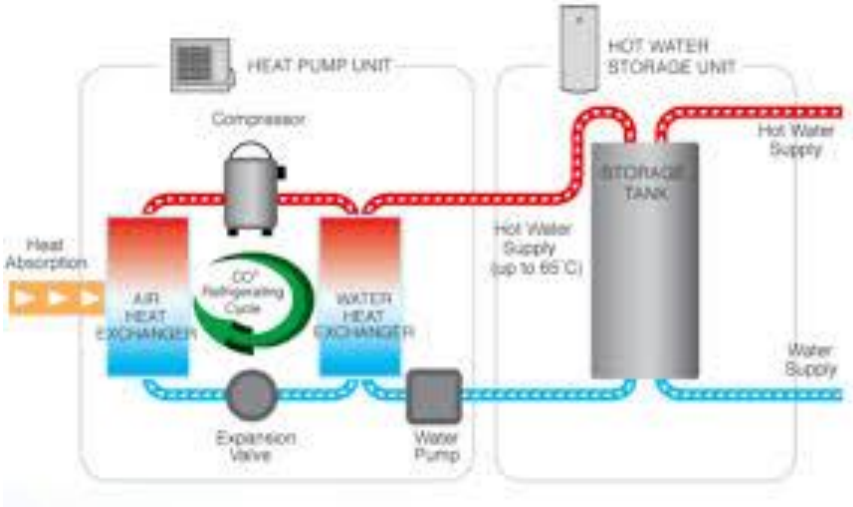
Market Solution

h2e/Hexis:
1.5kW SOFC

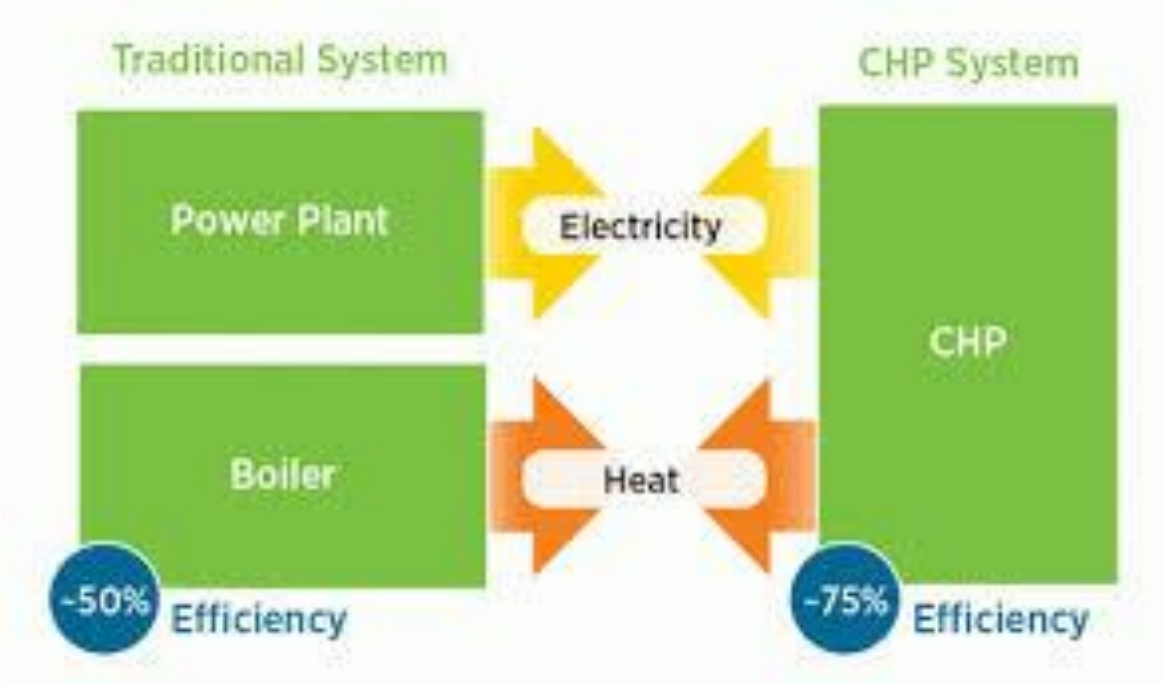
ICHP
Integrated Cooling, Heat, & Power



Operating principle of SOFC



What is CHP (Combined Heat & Power)?



Combined Heat and Power (CHP) is a process in which heat engines are used to generate electricity and useful heat simultaneously. The conventional method of producing usable heat and power separately has a typical combined efficiency of 45 percent; CHP systems can operate at levels as high as 85 percent.

SOFC Value Proposition

- Multi-fuel capabilities with utilization of conventional fuels and/or alternate fuels such as biogas. Technology is fuel flexible & not dependent on 99.9% pure hydrogen.
- Silent operation and zero to negligible emissions based on type of fuel used.
- Highest possible conversion efficiencies compared to incumbent technologies.
- Reduced lifecycle costs.
- Capability to integrate with other renewable technologies and create a multi-energy platform.
- 45% to 60% electrical efficiency and 85% to 90% CHP efficiency.
- Reformation capabilities being extended to liquid fuels covering entire spectrum of hydrocarbons from natural gas to biodiesel.
- ***Easily Scalable technology from 100 Watts to MW.***

Technical: Mini or Micro Grids

Transportation

- Renewable Hydrogen at highest efficiency
- Power to Fuels (liquid fuels)

-95,000kg CO_2 savings per gas station per year
- $68,800 / year savings in energy imports per gas station
- Equivalent to planting 4,270 trees per gas station
- Potential in India: 65,000 gas stations

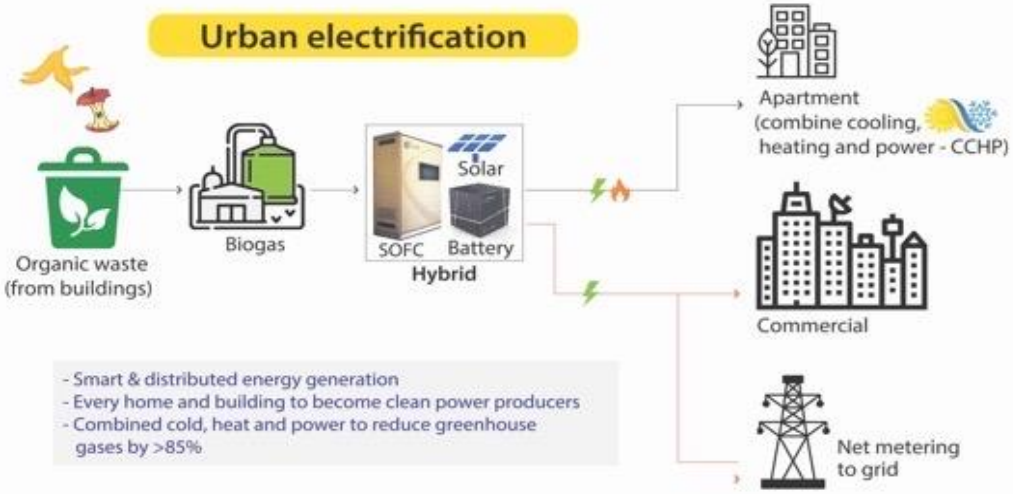
Agriculture

Village micro & mini grids
- 20% (about 15,000 liters/hectare/month) savings in water & 30% increase in productivity per hectare
- 24x7 power and heat to help food storage - increases yield, shelf life and profits
- Energy independence for every home in a village
- Schools, medical facilities, small industries to get uninterrupted and inexpensive power
- CO_2 and greenhouse gases reduction >75%

Manufacturing

- Energy security
- Combined heat and power solutions to save cost
- CO_2 reduction >70%

Urban electrification

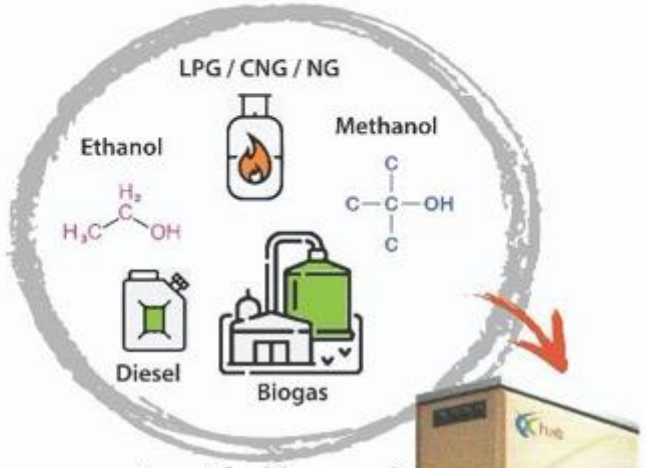


- Smart & distributed energy generation
- Every home and building to become clean power producers
- Combined cold, heat and power to reduce greenhouse gases by >85%

Technical: Fuel Cell Technology

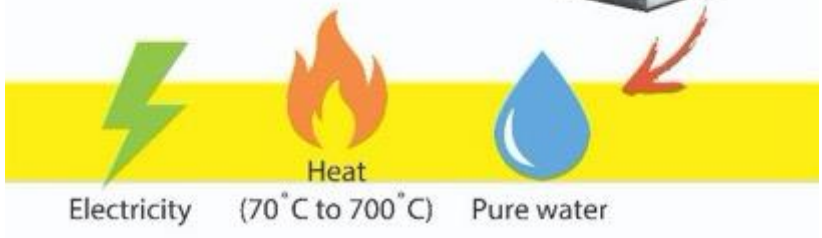
From Fuel to Power

Multi Fuel Capability



Input fuel (any one)

45% - 60% Electrical efficiency
90% CHP efficiency
>50, 000 hours life
Near zero emission & maintenance



From Powder to Power

Commercially proven SOFC/SOEC stack

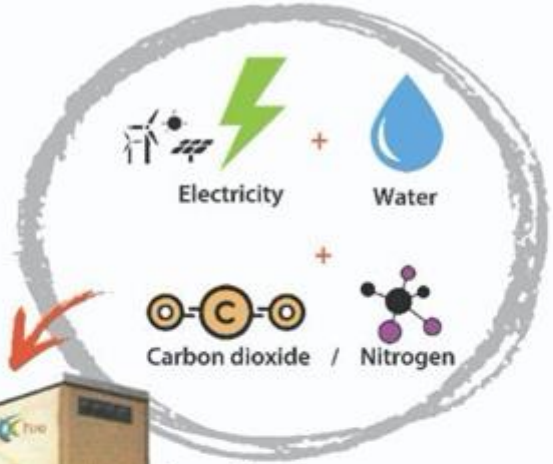
100% recyclable & reusable

Robust & long life

Inexpensive raw material (no precious or rare earth material used)

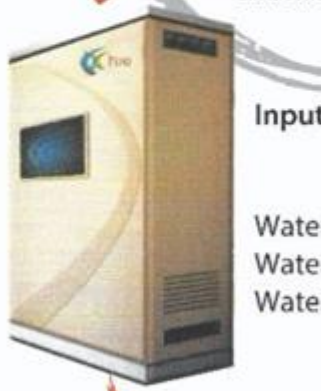
From Power to Fuel

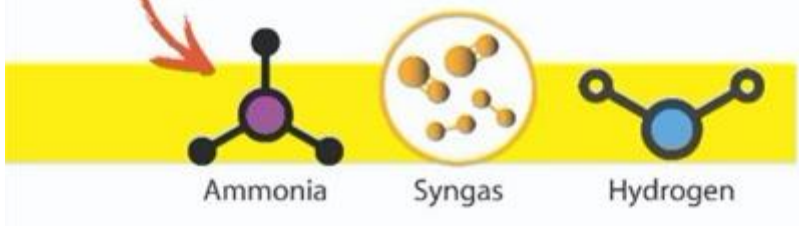
Reversible Technology



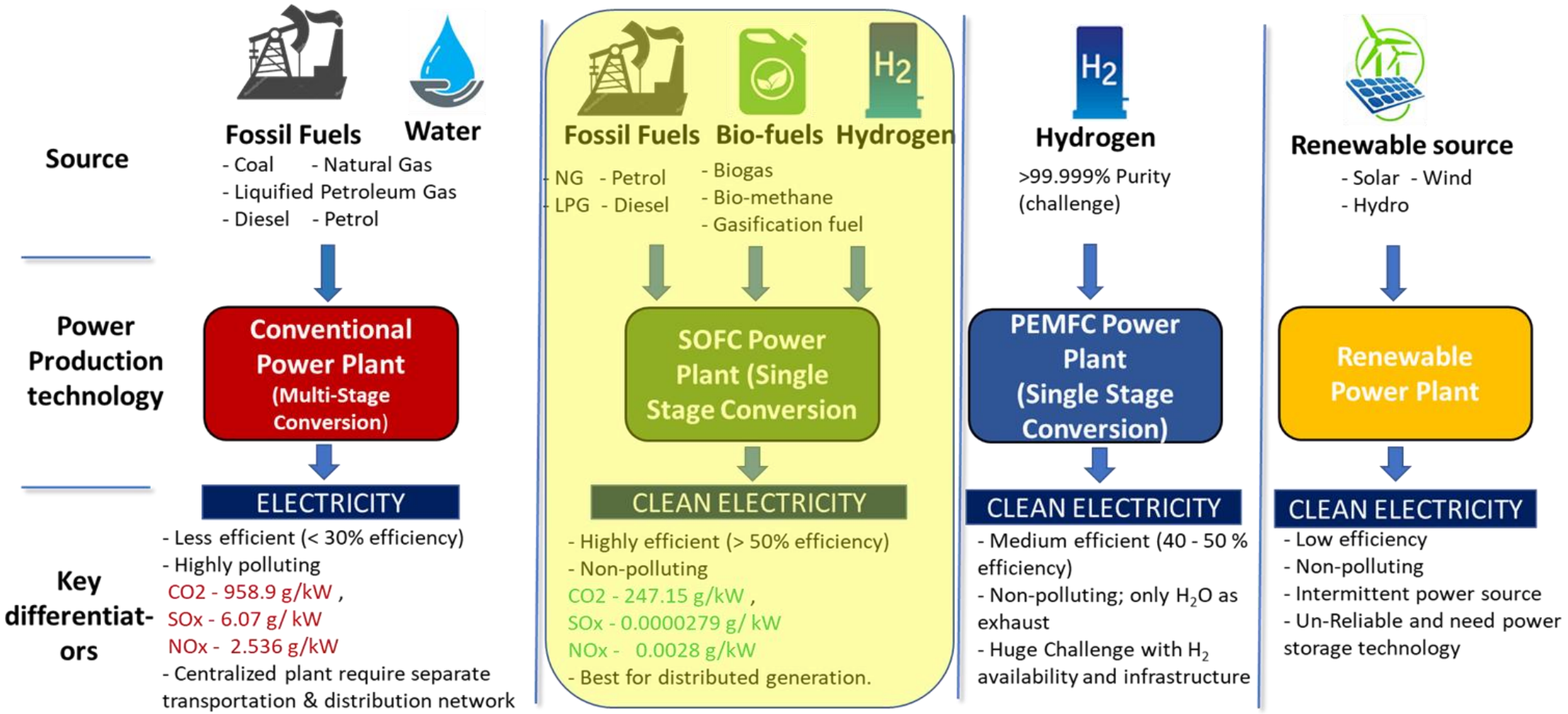
Input fuel

Water + Electricity → Hydrogen
Water + Electricity + CO_2 → Syngas
Water + Electricity + Nitrogen → Ammonia



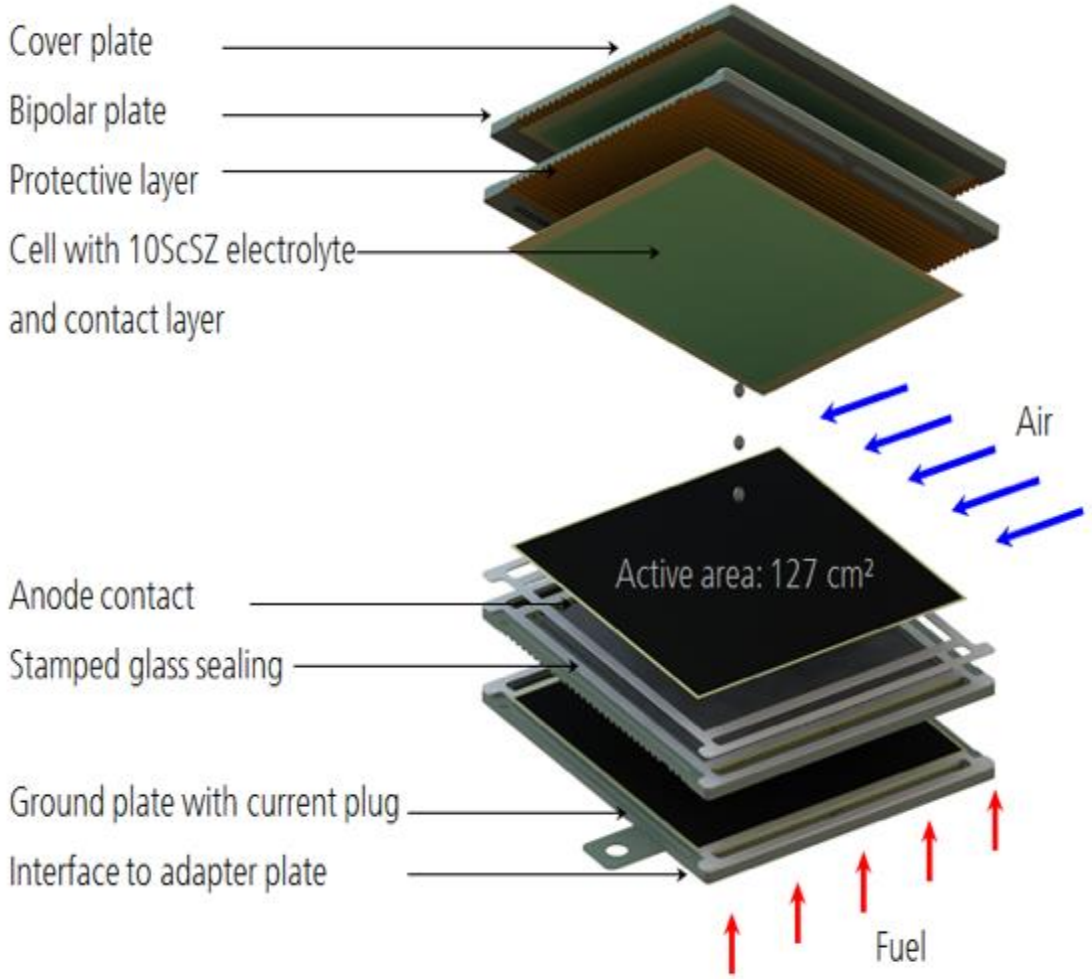


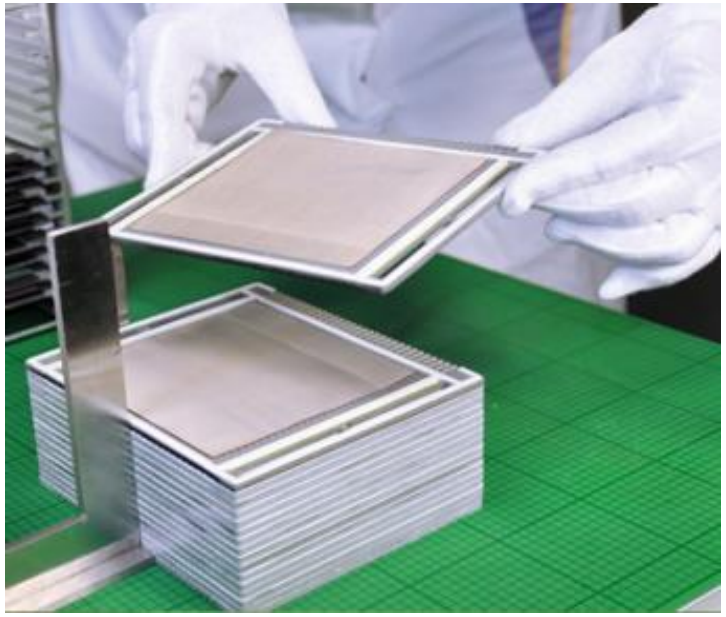
Technical: Differentiators



Technical: Partner's SOFC/SOEC Stack

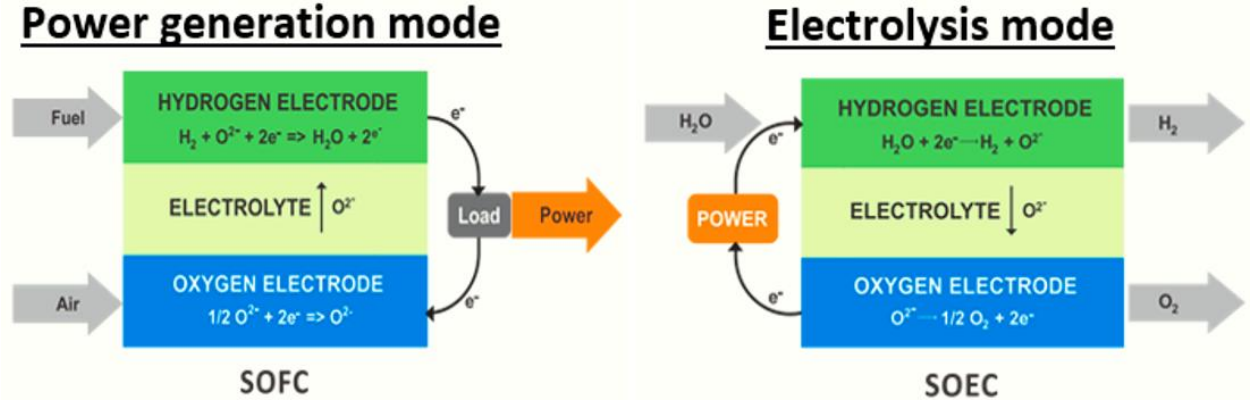
h2e develops and manufactures the reversible stack for **ELECTROLYSER AND FUEL CELL**





Technical: Stack Technology

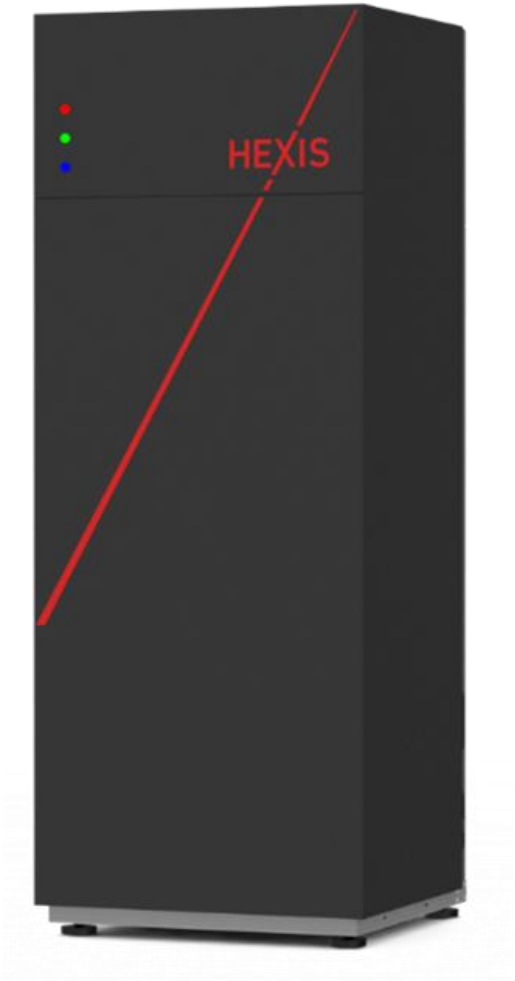
High temperature Solid Oxide Fuel Cell capable of operating in reverse mode



Advantages

- High power density: > 30 W/cell (SOFC)
- Multiple Operating modes: SOFC, SOEC, rSOC
- Electrical efficiency of > 50% and CHP Efficiency upwards of 95%
- Multi-fuel capable (gaseous fuels like biogas, LPG, NG, & liquid fuels like methanol, diesel, gasoline)
- Non-polluting & highly reliable
- No precious metals used

SOFC: Heat, Hot Water, & Power



- Local
- Efficient (95%)
- Independent
- Environmentally Friendly
- Resilient
- Saves money
- Backup, in case of a power outage

Shovel-ready Hexis Fuel Cell Unit

- Electrical power output - 1.5 kWel (AC, net)
- Thermal power output ca. 2 kWth
- Fuel - Natural gas (also with hydrogen additions)
- Modulation range - 100 % – 30 %
  all-year operation possible with warm water generation
- Electrical efficiency - 40% AC, net (CPOx)
- Total efficiency - 95% (LHV, Return= 30°C)
- Lifetime unit ≥ 15 years

FCU designed for easy integration in a heating appliance by OEMs

- Fits to single & small multi-family houses and small commercial applications
- Can work as stand-alone CHP or can be combined with auxiliary burner
- In contrast to PEFC system: no limitations on heating systems (return temperature fitting to all houses)
- Combination with battery energy storage system to increase self consumption and autonomy in combination with E-mobility running in field test; island grid capability planned

Strategic Partners

HEXIS

- Winterthur (CH) and Konstanz (D)
- SOFC CHP systems for Europe
  HEXIS-Stacks
- SOC Cells and Electrochemistry
  SOC Fundamentals
- 50 employees
- Ca. 30 years of SOFC
  100 % owned by mPower – h2e
  till 06/2020 owned by Viessmann

h2e

- Pune (IN), New York (USA)
- Hybrid solutions: Combining Solar, Biogas, Battery, and SOFC
- Production hub for emerging countries

mPower GmbH

- Dresden (D)
- SOFC Stacks and SOEC Stacks
- Empowering others

PACE

- $225M Invested
- 3m Operating Hours
- Over 100 years of experience
- Certification Europe UL/CSA Standard
- 6th PACE Partner

Demonstration: Lab in Lucas County OH

- **Fuel Cell Stack**
- **Electric Hook-up Double Pull 30 Amp**
- **Natural Gas Hook-up with Regulator**
- **Water System**
- **Radiator Heat Reduction System**

Ohio Market Target

- Farms
- Tribal Partnership
- Micro homes

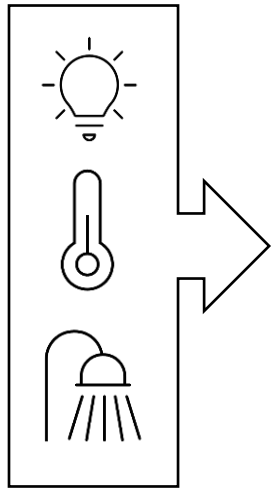
Acoma Indian Reservation, also known as Sky City, outside Albuquerque, New Mexico

Technical: Solar + Battery NG/Biomass + SOFC + Heat/Cooling Pump

ICHP
Integrated Cooling, Heat, & Power

Bio

FUEL



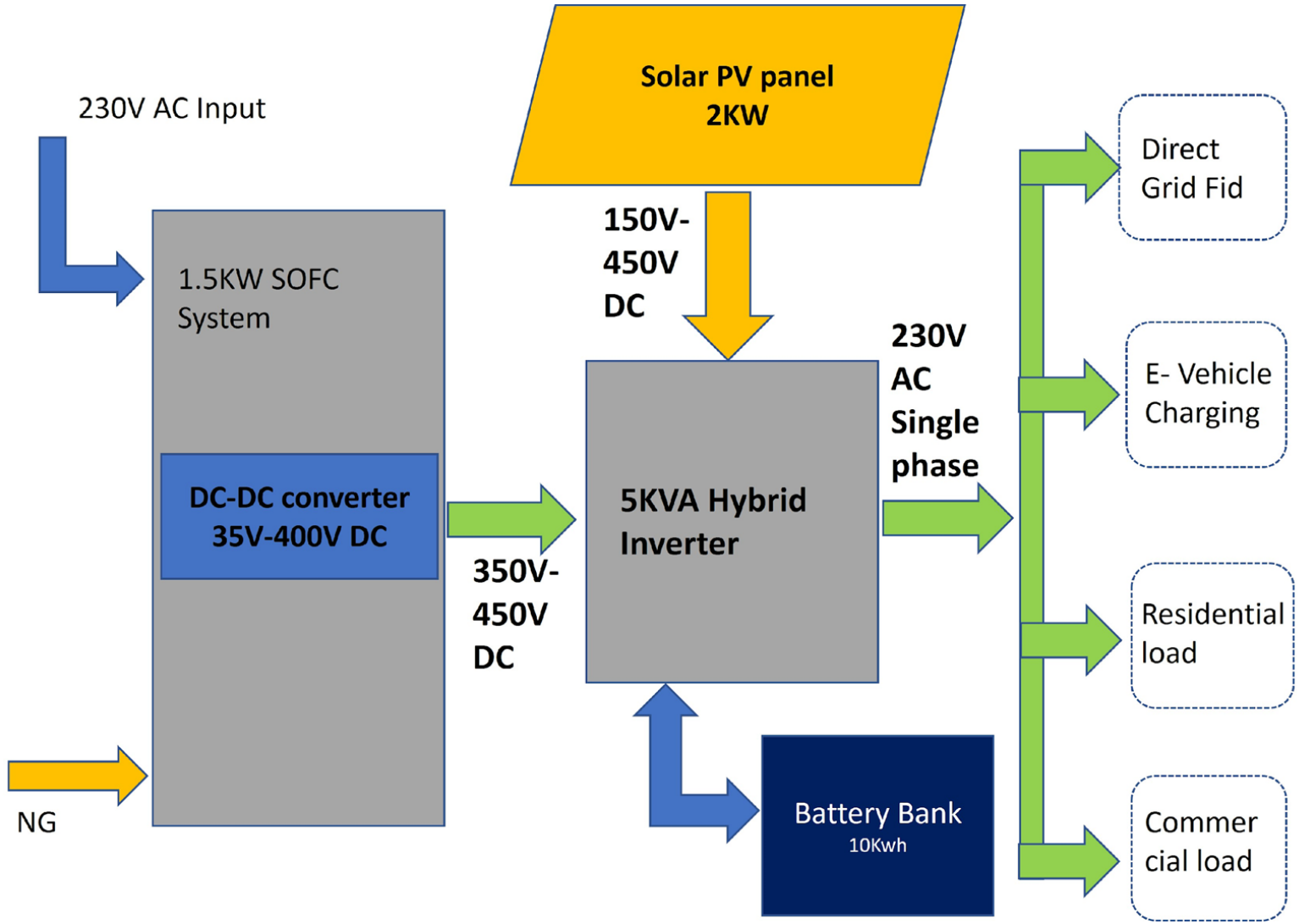
Acoma Pueblo Sky City Indian Reservation outside Albuquerque, New Mexico

Heat/Cooling Mode

Community Benefits

- Higher Efficiency up to 95%
- Reduce CO2 Emissions along with a decline in air and sound pollution
  - ✓ 30-50% reduction in CHP or 80% with Biogas
- Fuel Flexibility
  - ✓ Clean fuels biogas or methane
- 7|24|365 operational
- DI Water & usable heat
  - ✓ Bi product with usable heat and DI (Deionized) water
- Ag waste use as fuel
- Lower Nitrogen, Phosphate, and Sulfate runoff to watershed
- Only technology that can lower air, sound, and water pollution

Technical: Structure



System is flexible to connect and support micro grid structure.

Lab Plan

2023 Lab

Lucas County, OHIO

- 8100 kWs produced

Questions?
Thank You!

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