

Biomass Powered Fuel Cells

Enabled by Metal-Supported SOFCs with Nanostructured Electrodes



**Affordable fuel cell systems
for people without access to
an electric grid.**

Craig Jacobson

Cofounder and CEO

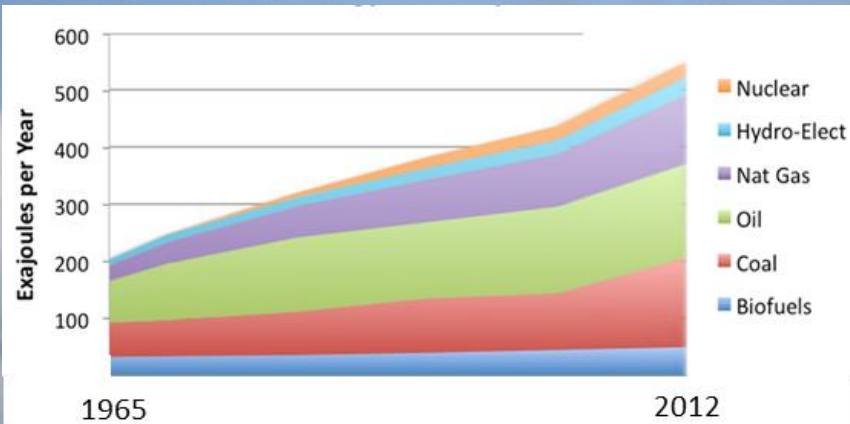
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Energy Challenge

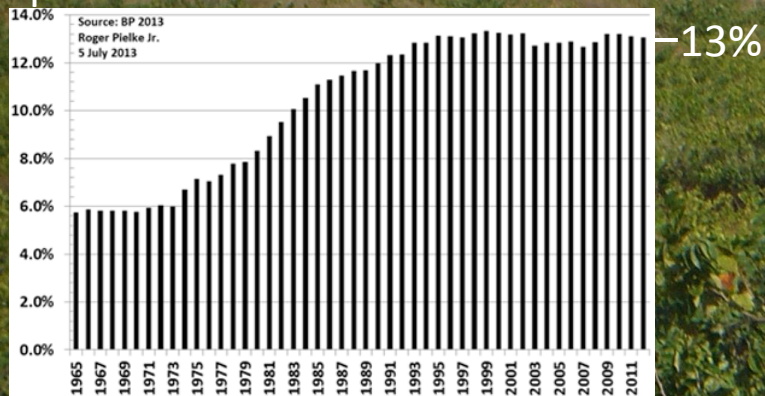
- Over 1.2 billion people - 20% of the world's population - are still without access to electricity. Another 1 billion people have intermittent access.
- About 2.8 billion people use solid fuels—wood, charcoal, coal, crop residue, and dung—for cooking and heating.

Energy Challenge

World Energy Consumption



Proportion from Carbon-Free Sources



PSP is developing biomass power systems for off-grid applications.

Most Advanced Form of Energy Storage?

charcoal



sticks



wood chips



pellets



peat



rice hulls

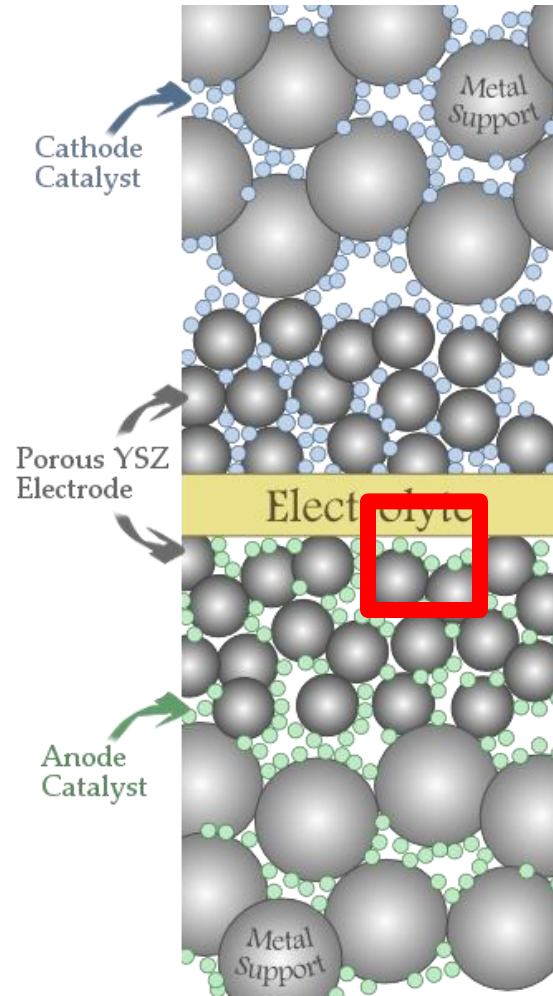


straw



*Over 450 million
years of
development!*

Metal-supported solid oxide fuel cells



Rugged fuel cell technology invented when at Berkeley Lab:

- rapid heat-up/cool-down
- redox stable anode
- tolerates fuel impurities (C, S, etc.)
- highly manufacturable
 - no clean room
 - sheets cut to size
 - weldable

Fuel Cells...

Technical success for 50 years!

3 barriers:

Cost

Cost

Cost



Nanostructured Coating on Pore Walls

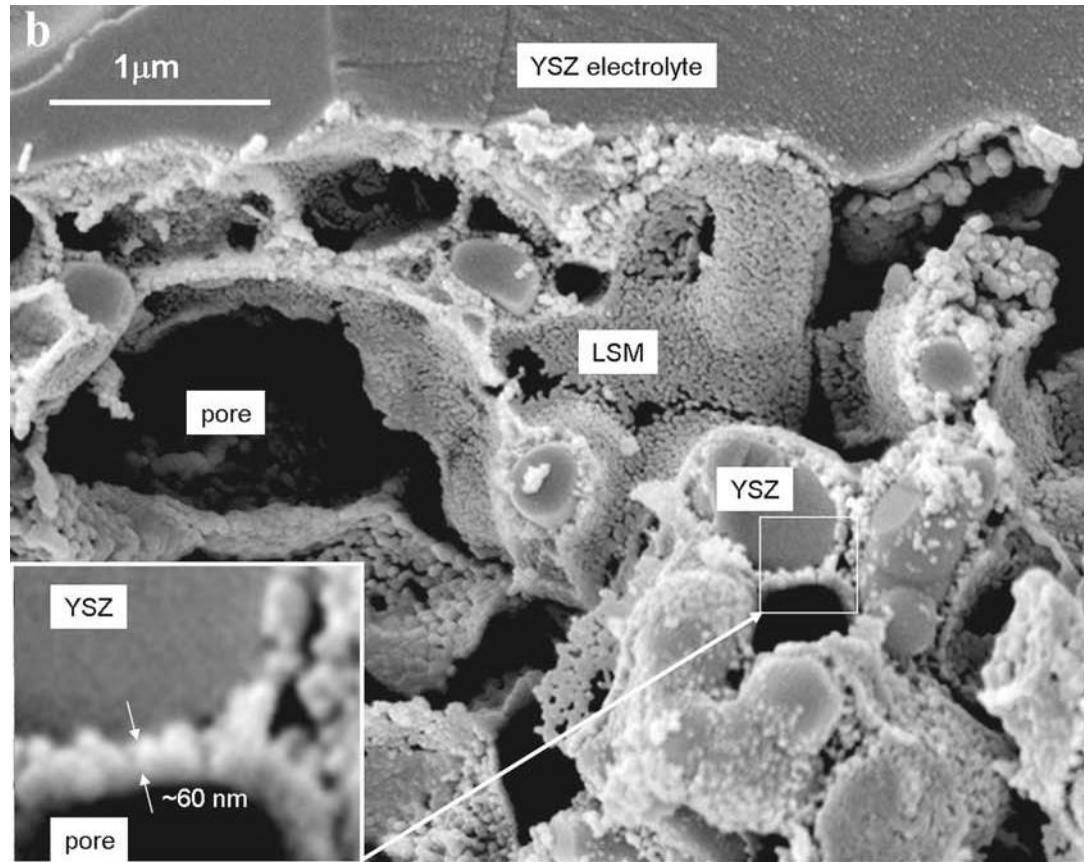
Challenge: How to produce a continuous, electrically conductive coating on the wall of a micron scale porous network...

that's stable to $>800^{\circ}\text{C}$

without filling the pores and blocking gas access in/out of the electrode...

in a low-cost scalable process?

20 – 100 nm connected network of almost any material!



Sholklapper et al., *Electrochemical and Solid-State Letters*, 9 (8) A376-A378 (2006).

VOTO

LED + Cellphone/battery charge



Status: Initial sales

Fuel: charcoal

Output: 1.5V (4W)

Weight: 0.5 lbs

Size: 1.5 x 3 x 8"

HALO

Charges smartphone, iPad, AA/AAA, etc



Status: Prototype

Fuel: propane/isobutane

Output: 5V (5W) USB

Weight: 1 lbs (including fuel)

Size: 4.5 x 4.5 x 5"

GEN3

Biomass generator/stove

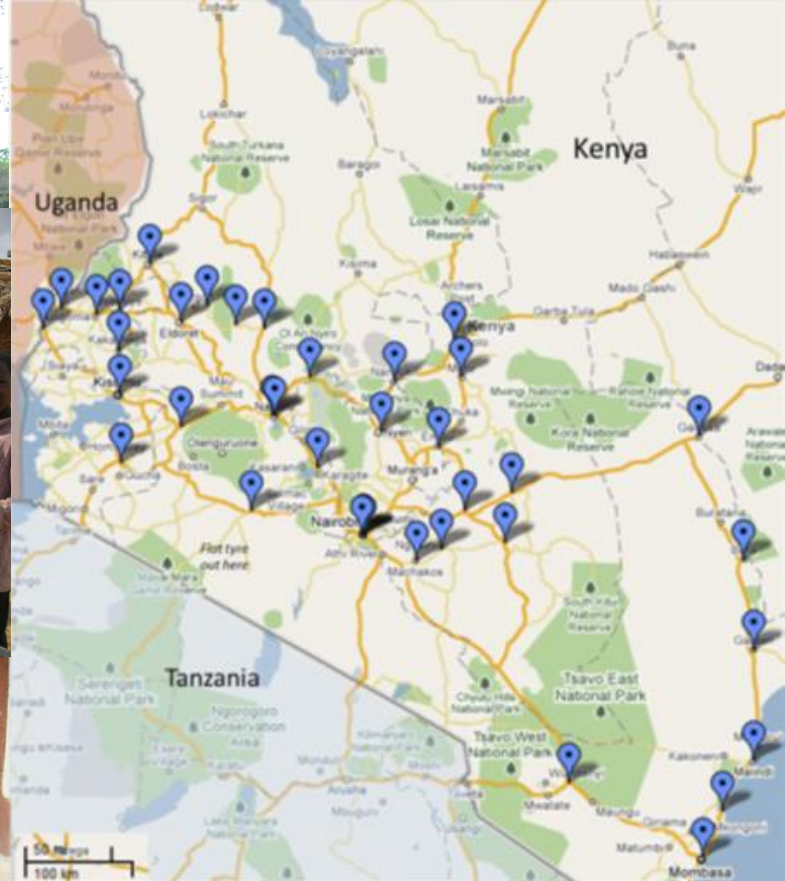


Status: Development

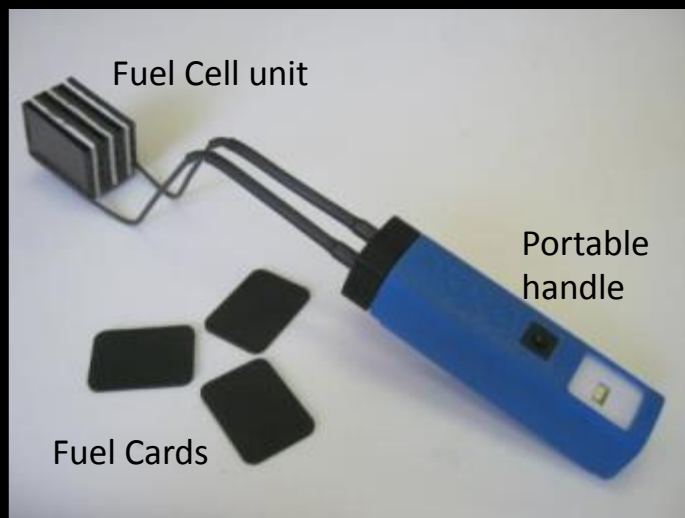
Fuel: wood/biomass waste

Output: 20-1000 W

How do you get this?



Cooking up some Electricity with the VOTO



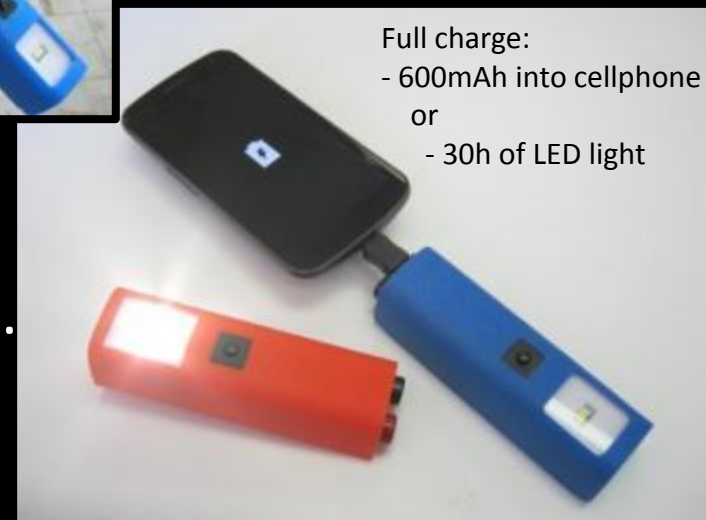
The fire supplies heat ($>700^{\circ}\text{C}$)



Designed for “jiko” stoves
found in East Africa

The fuel cell runs on $\text{CO} + \text{H}_2$
generated by the fuel card

No fuel clean up is needed



Not direct carbon, but *indirect* carbon fuel cell.

Transforms Lives

Replaces toxic, expensive kerosene with clean, bright LED.

Charging mobile phones at home saves time.

People produce their own power.

On-demand off-grid power.

Rain or shine.



Point Source Power

- 10 years metal-supported SOFC development while at Lawrence Berkeley Lab.
- For profit company spun out of LBNL October 2008 (do you remember what happened?).
- Started work in my garage (wife loved it).
- 2009 self-funded development for cookstoves and testing in India and Kenya.
- Series A from Khosla Ventures April 2010.
- We focus on small, biomass powered generators, often in combined heat and power applications (cooking).
- Licensing/partnerships for other applications (US/Europe, conventional fuels, gas separation, syngas production, etc.)

Point Source Power

R&D 100 winner, LAUNCH Energy Innovator

Over 130 issued and pending patents

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