

CASE STUDY OF A STAND- ALONE SOLID OXIDE FUEL CELL

THE FUEL CELL PROJECT AT EXIT
GLACIER

KENAI FJORDS NATIONAL PARK

KENAI FJORDS

EXIT GLACIER

NATURE CENTER

FUEL CELL

PROJECT DESCRIPTION

- COMPLETES CURRENT EXIT GLACIER DEVELOPMENT
- PROVIDES A YEAR-ROUND NATURE CENTER AT EXIT GLACIER
- FIRST WHOLE DEVELOPED AREA IN ALASKA TO BE POWERED BY A FUEL CELL
- UTILIZES HEAT FROM THE FUEL CELL TO HEAT THE NATURE CENTER

FUEL CELL

- 5 KW SOLID OXIDE FUEL CELL
- PROPANE IS THE HYDROGEN SOURCE
- CO-GENERATED HEAT TO BE USED IN THE NATURE CENTER
- RUNS CONTINUOUSLY – NOT A STANDBY UNIT

WHY A FUEL CELL?

- EDUCATE THE PUBLIC ON HYDROGEN AS AN ENERGY SOURCE (Besides the Hindenburg)
- SHOW A FUEL CELL USING A HYDROGEN SOURCE THAT HAS AN EXISTING INFRASTRUCTURE IN ALASKA AND OTHER RURAL AREAS
- SHOW AN OFF-GRID POWER GENERATOR WITH REDUCED NOISE AND POLLUTION
- UTILIZE THE WASTE HEAT FOR THE BUILDING
- LEARN FROM A FUEL CELL IN ACTUAL OPERATING CONDITIONS



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PROJECT SCHEDULE

- START-UP IN THE FALL OF 2002
- CONSTRUCTION OF THE BUILDING COMPLETED IN AUGUST 2003
- FUEL CELL TESTED IN LAB – SEPTEMBER 2003
- FUEL CELL WAS INSTALLED AT EXIT GLACIER– SEPTEMBER 2003
- INITIAL ON-SITE TESTS – SEPTEMBER 2003
- FINAL INSTALLATION – MAY 2004

COMPLETED NATURE CENTER



COMPLETED NATURE CENTER



FUNDING SOURCES

- PUBLIC LANDS DISCRETIONARY
- PROPANE EDUCATION AND RESEARCH COUNCIL
- FEE DEMO
- ALASKA ENERGY AUTHORITY (DENALI COMMISSION)
- UAF (AEDTL) – GRANT PENDING

HOW DOES A FUEL CELL WORK?

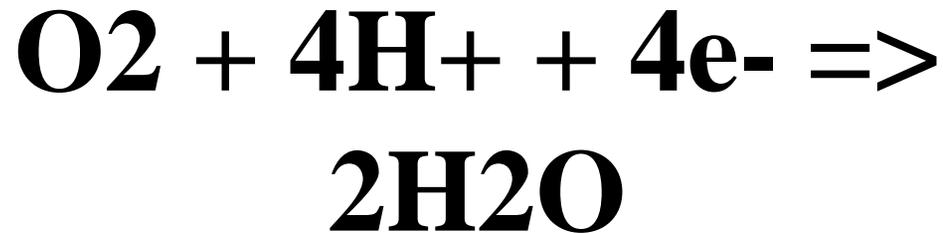
- BASICALLY A SERIES OF BATTERIES
- ALL FUEL CELLS RUN ON HYDROGEN (Some are not exclusive)
- THE MAIN BYPRODUCTS OF A FUEL CELL ARE ELECTRICITY, WATER, HEAT and CARBON DIOXIDE
- HARMFUL EMISSIONS ARE GREATLY REDUCED

Chemistry of a Fuel Cell

Anode side:

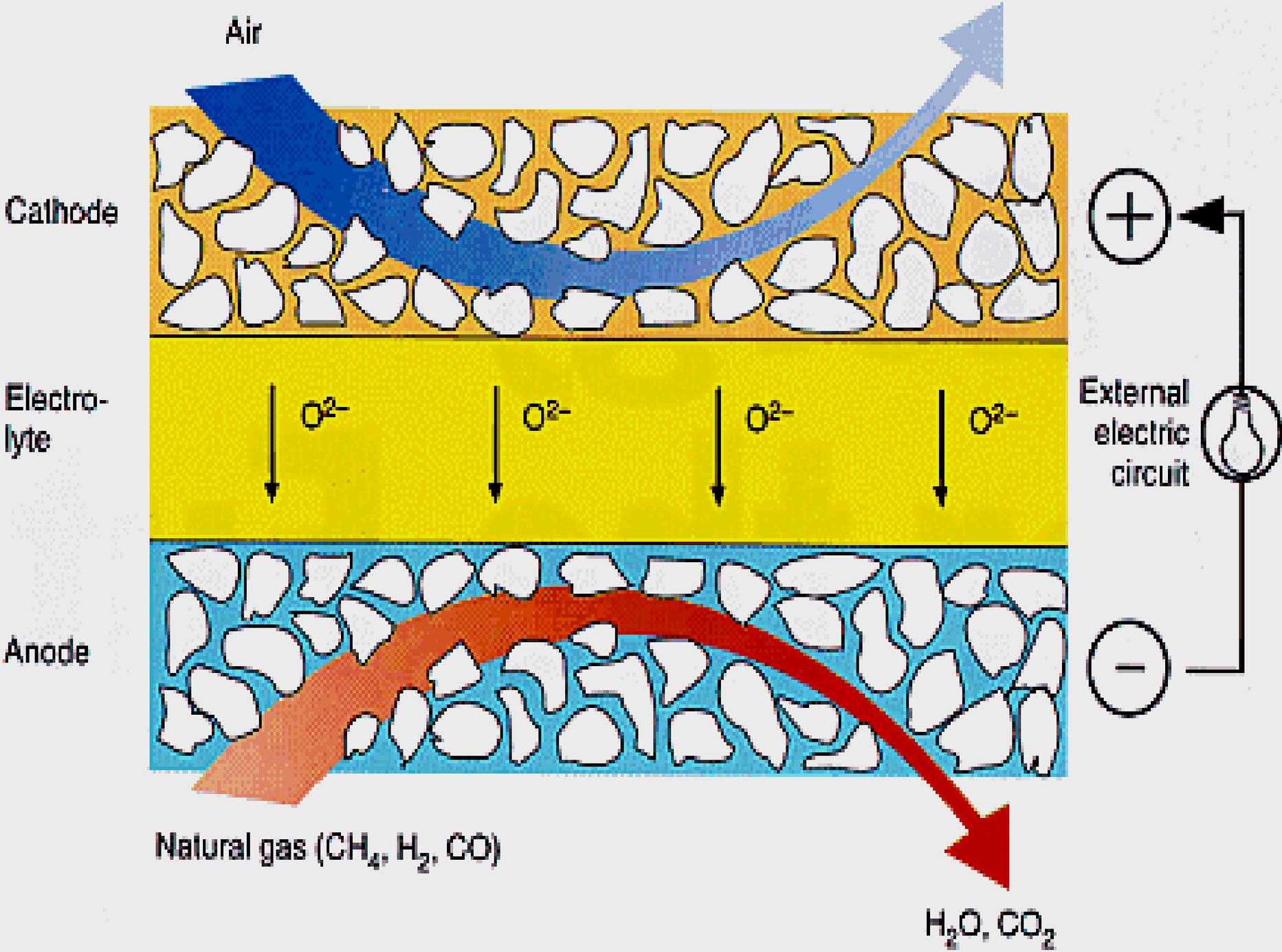


Cathode side:



Net reaction:





THE STACK

- THE SERIES OF BATTERIES ARE CALLED “THE STACK”
- THE MEDIUM OF TRANSFERRING THE ELECTRICAL CHARGES THROUGH THE STACK (THE TYPE OF ELECTROLYTE) IS THE MAIN DIFFERENCE IN THE TYPES OF FUEL CELLS

WHERE DOES THE HYDROGEN COME FROM?

- BOTTLED HYDROGEN GAS
- PRODUCE IT ON-SITE – SUCH AS ELECTROLYZING WATER
- REFORM IT FROM SOMETHING WITH HYDROGEN IN IT
- OPERATING FUEL CELLS REFORM IT FROM NATURAL GAS, METHANE, ETHANE, PROPANE, DIESEL, ETC

WHAT IS A REFORMER?

- SEPARATES THE HYDROGEN FROM THE CARBON CHAIN
- ONCE THE PROCESS STARTS IT IS SELF-SUSTAINING BY UTILIZING SOME OF THE HYDROGEN TO KEEP THE HEAT UP

FUEL CELL POISONS

- SULFUR – Removal of sulfur is required
- CARBON MONOXIDE (Most fuel cells)
- TEMPERATURE DIFFERENTIAL
ACROSS THE STACK
- There are others

TYPES OF FUEL CELLS

- MOLTEN CARBONATE
- PEM (PROTON EXCHANGE MEMBRANE)
- PHOSPHORIC ACID
- ALKALINE
- SOLID OXIDE

MOLTEN CARBONATE FUEL CELL

- IN THE TESTING STAGE (AT LEAST 1 OPERATING)
- 200+ KILOWATT UNITS
- 1200 DEGREES FAHRENHEIT
- 60% EFFICIENT (85% WITH CO-GENERATION)
- INTERNAL REFORMER
- TYPICALLY REQUIRES AND DISCHARGES WATER IN THE 4 liter/minute RANGE

PEM FUEL CELLS

- IN LIMITED PRODUCTION
- SMALL UNITS – TYPICALLY 5 TO 10 KILOWATTS
- CO-GENERATION TEMPERATURES OF 140 DEGREES FAHRENHEIT
- EFFICIENCIES OF 40%
- EXTERNAL REFORMER
- SMALL WATER OUTPUT
- THIS IS THE FUEL CELL IN MOST VEHICLES THAT YOU READ ABOUT



PHOSPHORIC ACID FUEL CELL

- 200+ KILOWATT UNITS – LIMITED COMMERCIAL AVAILABILITY
- CO-GENERATION TEMPERATURES OF 300 TO 400 DEGREES FAHRENHEIT
- 40% EFFICIENCY – 80% WITH CO-GENERATION
- EXTERNAL REFORMER
- TYPICALLY DISCHARGES QUITE A BIT OF WATER



1MW Fuel Cell Project
US Post Office, Anchorage, Alaska

ALKALINE FUEL CELLS

- USED IN THE SPACE SHUTTLE
- NOT COMMERICALLY AVAILABLE OR VIABLE
- EFFICIENCY OF 70%
- REQUIRES VERY PURE HYDROGEN AND A PLATINUM CATALYST
- PRODUCES POTABLE WATER

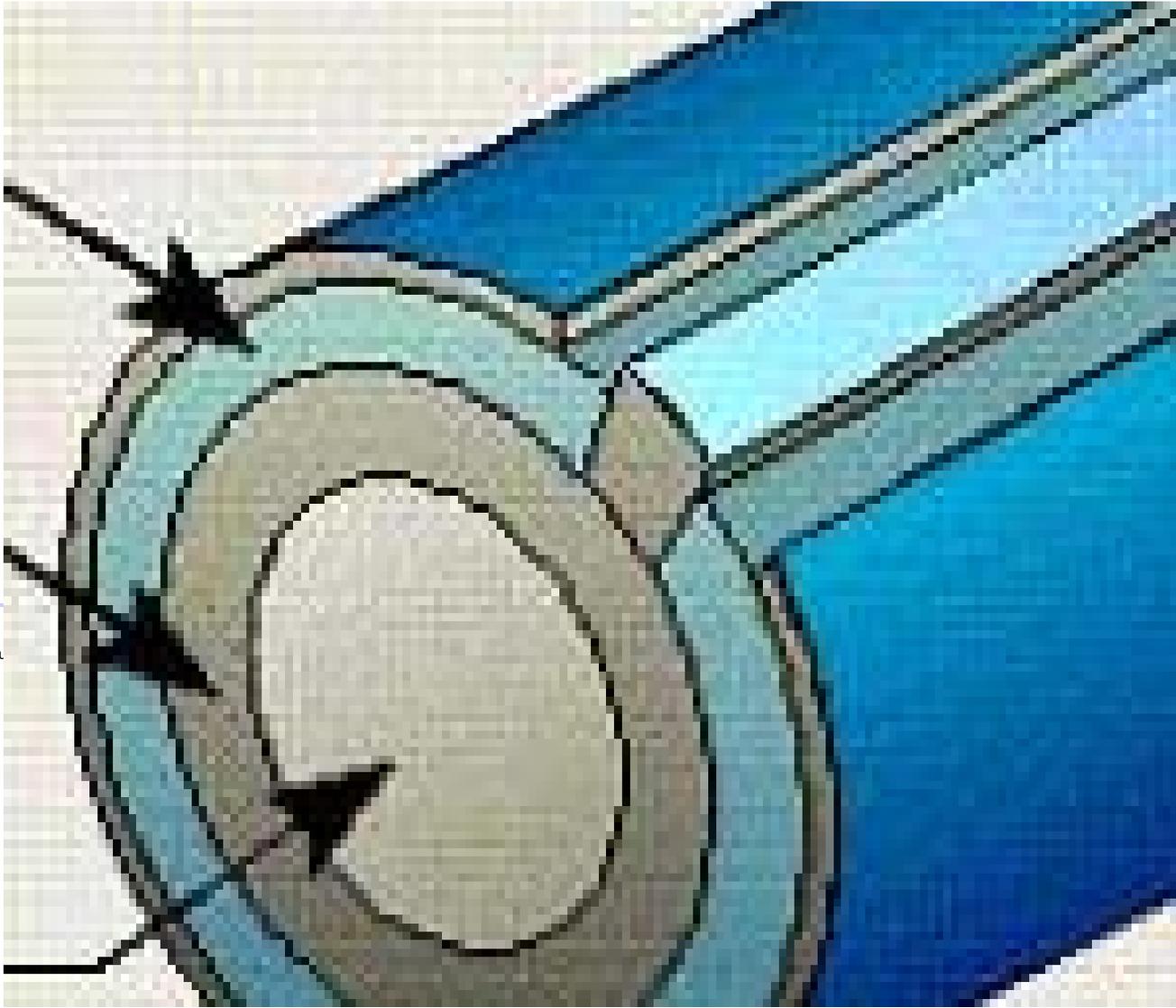
SOLID OXIDE FUEL CELL

- 25 KILOWATT UNITS IN EXISTENCE – 5 KILOWATT UNITS IN 2003
- CO-GENERATION TEMPERATURES OF 1800 DEGREES FAHRENHEIT
- 50% EFFICIENCY (80 TO 85% WITH CO-GENERATION)
- INTERNAL REFORMER
- NORMALLY DOES NOT REQUIRE WATER INPUT



“1.5-meter solid oxide fuel cells bundle, Westinghouse”

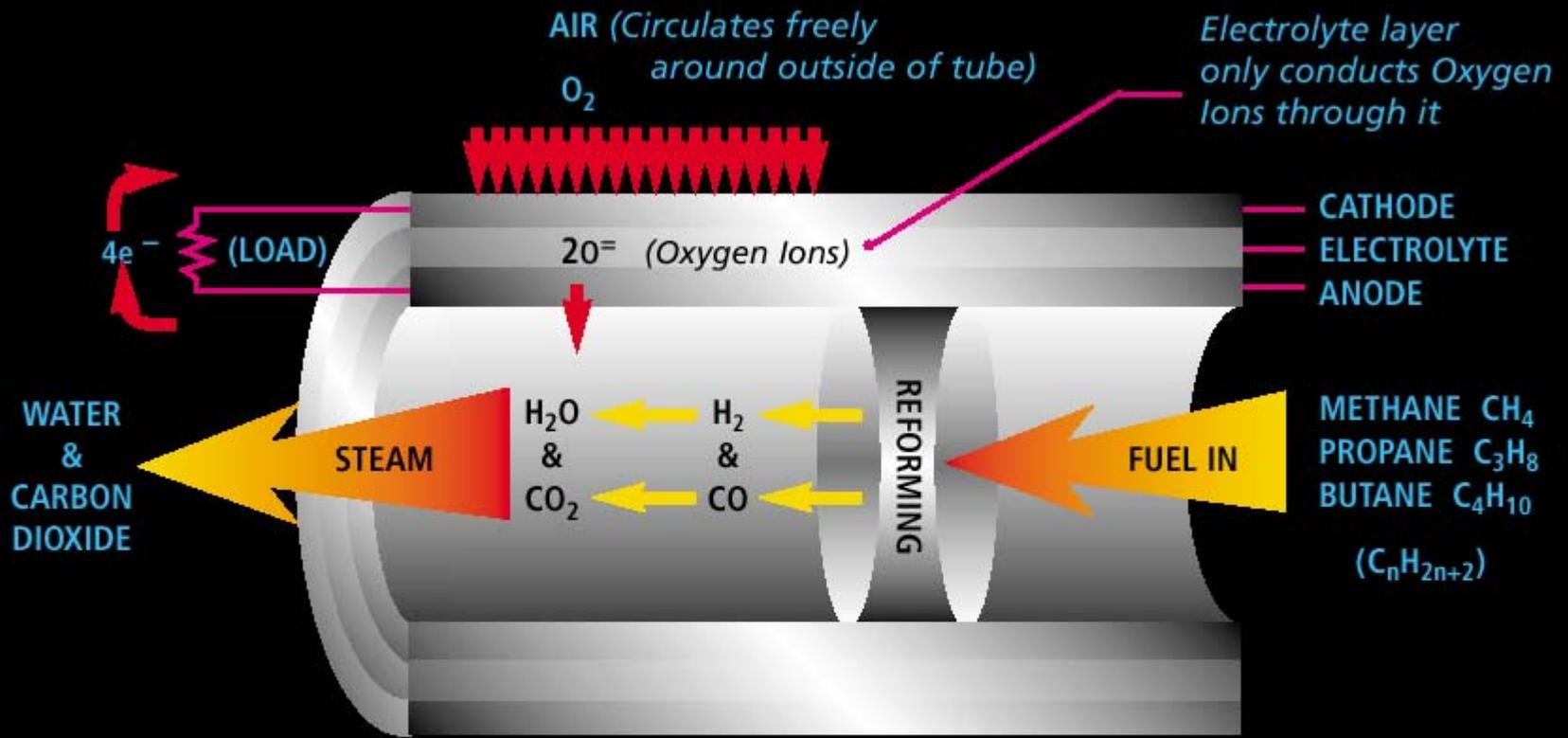
Image from the National Energy Technology Laboratory



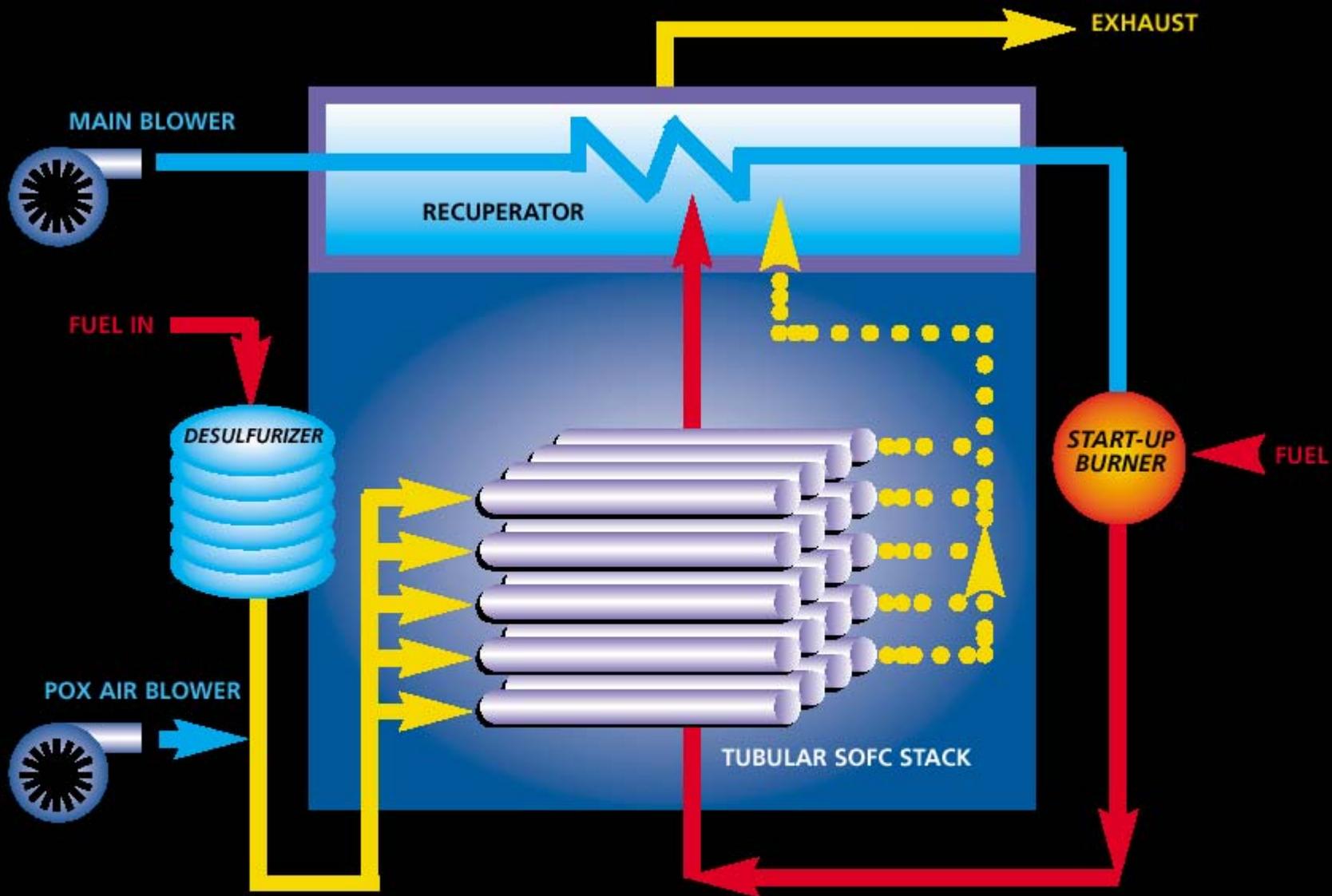
Solid Oxide –
cross-section of
one part of the
“stack” or
“bundle”.
The fuel flows
over the cell
and air flows
around or
through it.

Acumentrics Cells





Acumentrics Tubular Solid Oxide Fuel Cell Process



Acumentrics SOFC System Overview

5 KW FUEL CELL AT EXIT GLACIER



WHY DID WE CHOSE A SOLID OXIDE FUEL CELL?

- AVAILABLE IN 5 KW
- CO-GENERATION
- RAN ON A DELIVERABLE FUEL
(PROPANE)
- DID NOT REQUIRE A WATER SUPPLY
- POTENTIAL STACK LIFE WAS
LONGER



5 KW FUEL CELL AT EXIT GLACIER



Exit Glacier



Exit Glacier



Exit Glacier



5 KW FUEL CELL AT EXIT GLACIER



FUEL CELL EXHAUST



DESULFURIZER



EDUCATIONAL PANEL



The image shows an educational panel titled "What is a Fuel Cell?" mounted on a wall. The panel is blue and features text and several small images. To the left of the panel is a dark green metal vent cover. To the right is a wooden door with a silver handle. A red date stamp "SEP 26 2003" is visible in the bottom right corner of the panel.

What is a Fuel Cell?

A fuel cell is an electrochemical energy conversion device that converts hydrogen and oxygen into water, producing electricity and heat in the process. It is very much like a battery that can be recharged while you are drawing power from it. Instead of recharging using electricity, however, a fuel cell uses readily available hydrocarbon fuels and air.



The fuel cell will compete with many other types of energy conversion devices, including the gas turbine in your city's power plant, the gasoline engine in your car and the battery in your laptop. Combustion engines like the turbine and the gasoline engine burn fuels and use the pressure created by the expansion of the gases to do mechanical work. Batteries store electrical energy by converting it into chemical energy, which can be converted back into electrical energy when needed.

A fuel cell provides a DC (direct current) voltage that can be used to power motors, lights or any number of electrical appliances. There are several different types of fuel cells, each using a different chemistry. Fuel cells are usually classified by the type of electrolyte they use. Some types of fuel cells show promise for use in power generation plants. Others may be useful for small portable applications or for powering cars.

SEP 26 2003

WHAT DID WE LEARN?

- CHALLENGES OF REFORMING A MORE COMPLEX HYDROGEN SOURCE
- BALANCE OF WATER IS NOT EASY
- BATTERIES WILL TAKE A LOAD OVER THE RATING OF THE FUEL CELL
- RECOVERY OF THE BATTERIES IS QUITE RAPID
- START-UP AND SHUT DOWN IS ABOUT 4 HOURS

PROJECT CLOSEOUT

- THE FUEL CELL WILL GENERATE A LOT OF INTEREST AND PUBLICITY
- SHOWCASES OFF-GRID POWER GENERATION USING A KNOWN COMMODITY (PROPANE) AS THE HYDROGEN SOURCE
- A FORMAL MEDIA EVENT IN THE SPRING OF 2004 IS PLANNED

QUESTIONS??

- CAN WE MAKE HYDROGEN (YES)?
- IS IT COST EFFECTIVE (TODAY OR LATER)?
- CAN WE GET RESULTS ON HOW IT IS OPERATING (YES – UAF GRANT)?
- WHO IS THE MANUFACTURER?
- CAN IT RUN ALL WINTER (YES – IF YOU WANT IT TO AND IT HAS A LOAD)?

THANK YOU

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