Split Fuel Stream System

A Breakthrough in Hybrid Fuel Cell/Turbine Energy Generation Systems

EnergYield LLC
Carlsbad, CA

Executive Summary

What is the Split Fuel Stream Energy System (SFS)?

A new and patented design for hybrid fuel cell/turbine power systems

What are the benefits of the SFS?

We estimate the SFS can achieve 80% to 90% energy conversion efficiency for the life of the plant

Extend the life of fuel cell-based systems to 5-7 years of 24/7 operation between stack replacements

Potential to become the dominant technology for power generation for the coming 30 to 50 years

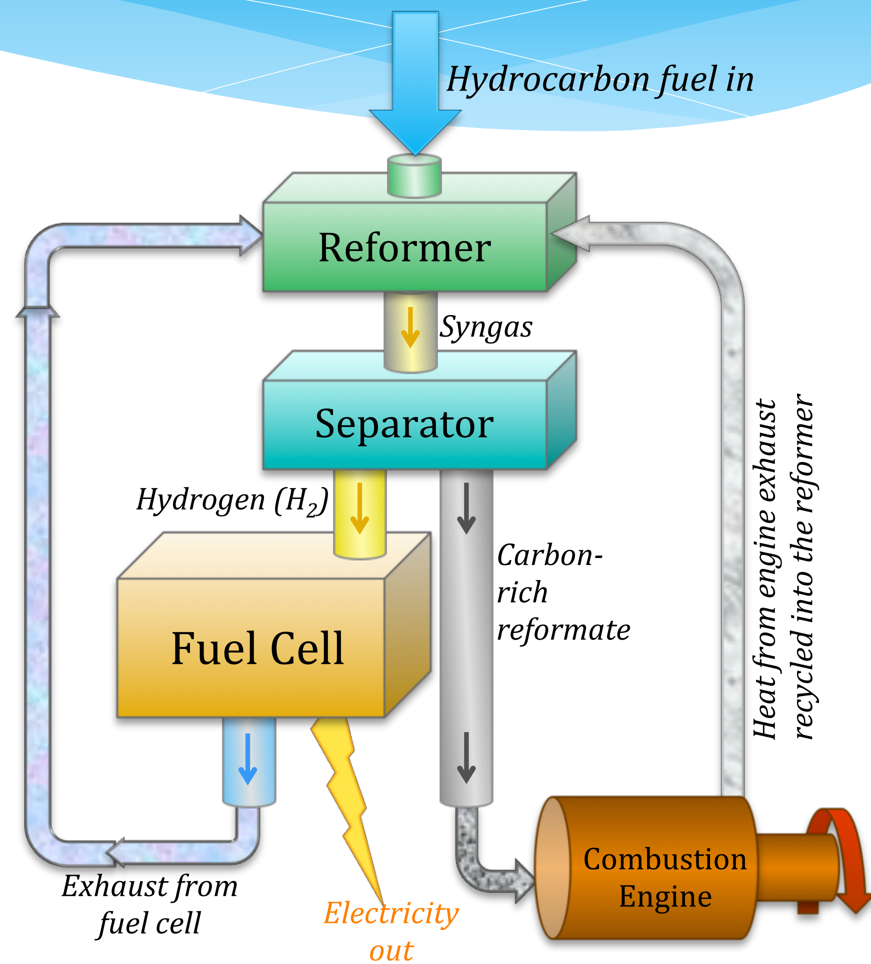
Very low technical risk – the SFS is based on existing, proven technology

Block Diagram of Split Fuel Stream System

Features of the SFS:

* Reformed fuel (syngas) is separated into two fuel streams.
* H_2 is sent to the fuel cell.
* The carbon-rich fuel stream is sent to a combustion engine (a turbine or piston engine).
* The exhaust from the fuel cell is fed back into the reformer.
* Exhaust from the engine is fed into a heat exchanger at the reformer.

How is this different from existing fuel cell/ turbine systems? *See next slide…*



Simplified block diagram of the Split Fuel Stream System

Current State of Hybrid Turbine/Fuel Cell Systems

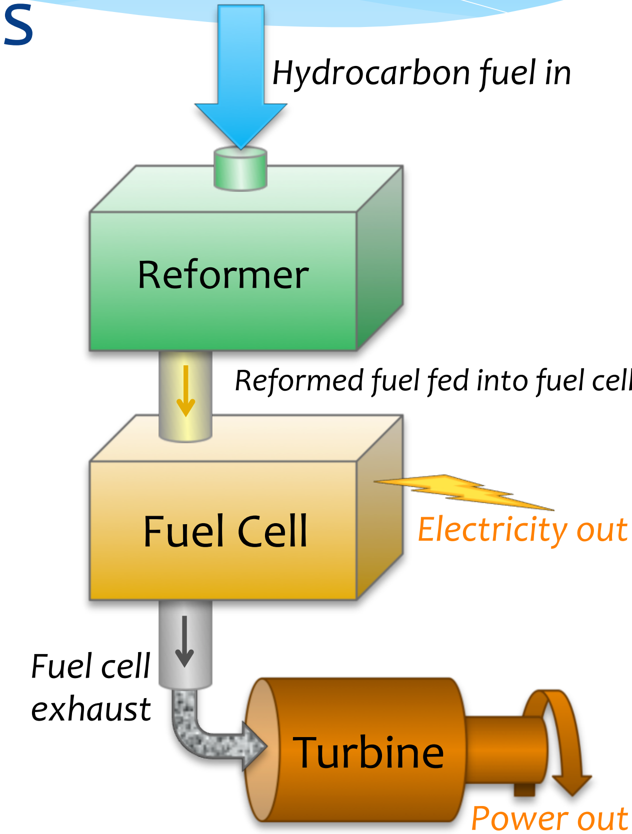
A highly-efficient, long-lived hybrid turbine/fuel cell system is the Holy Grail of energy generation. But these systems have never lived up to their potential.

Here is the current state-of-the-art:

* Fuel is fed into a reformer
* The output from the reformer is fed into the fuel cell.
* Exhaust from the fuel cell is fed to a turbine to extract residual energy from the exhaust gases
* This design relies on the fuel cell as the primary tool for extracting energy from the fuel, because fuel cells (theoretically) have the highest energy conversion rate

In real world operation, this design has problems.

See next slide…

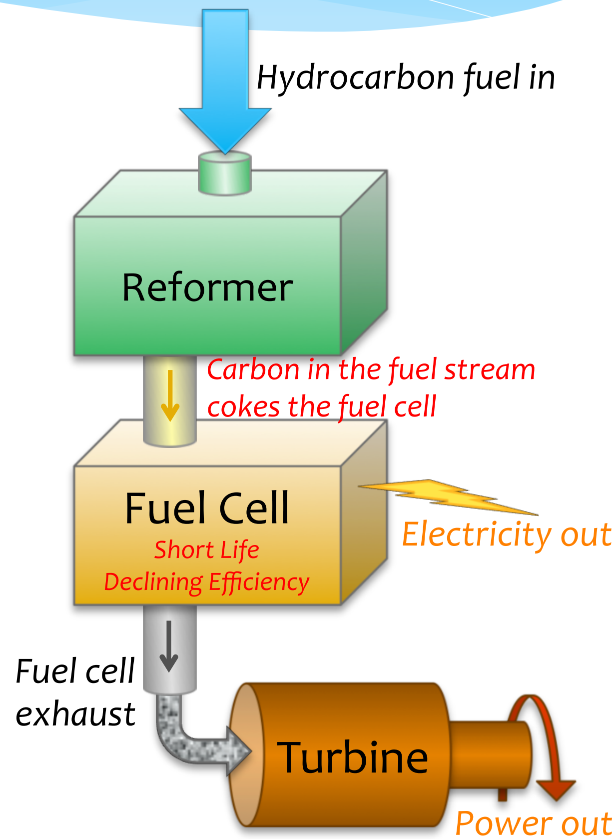


Simplified block diagram of prior designs of hybrid fuel cell/turbine systems

Problems with Current Hybrid Turbine/Fuel Cell Systems

* For the first few hours of operation this is a fuel efficient system, but efficiency degrades over time.
* Carbon-rich fuel fouls the fuel cell, causing rapid declines in efficiency and early failure.
* Requires high temperature operation (with SOFCs). This shortens the life of the fuel cell, which increases system cost and operating cost.

How can we get longer life and higher efficiency from a turbine/fuel cell system?



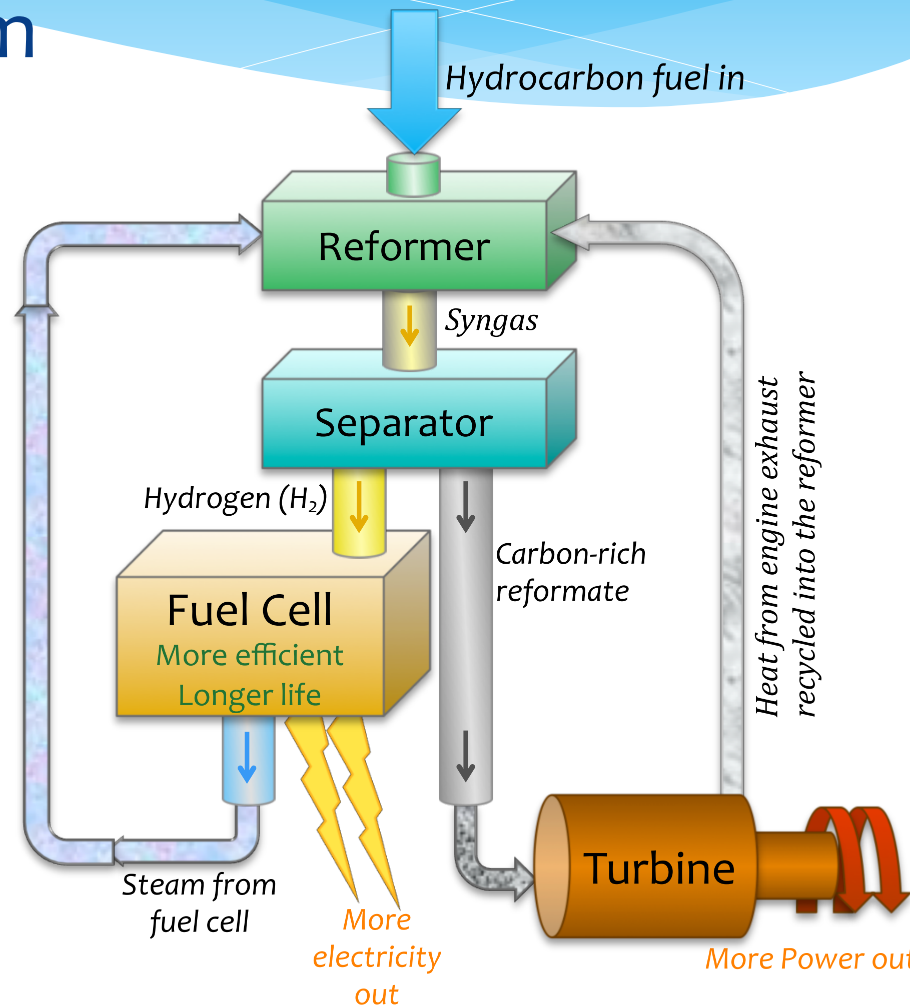
Advantages of the

Split Fuel Stream System

* No carbon-fouling of the fuel cell → Higher efficiency and longer life
* Fuel cell can run at lower temperature → Longer life and faster start-up
* The fuel stream into the turbine has higher energy content → More power output
* Feeding fuel cell exhaust into the reformer → Increases system efficiency even further
* Minimizes pollutants in the exhaust → The cleanest possible use of hydrocarbon fuels.

Will this work in the real world?

See next slide…



Split Fuel Stream System
In the Real World

* The SFS can work with existing reformers, fuel cells and engines. No new technology needs to be developed.
* Fuel Flexibility – can work with almost any kind of hydrocarbon fuel
* Allows SOFCs to operate at lower temperatures – which increases fuel cell life and decreases system cost
* Estimated life of 40,000-60,000 operating hours (5-7 years in the field) between stack replacement
* Extremely scalable – can be used for:
  * Large regional power generating plants
  * Peaker plants
  * Power generation from coal gasification
  * Local power generation for industrial parks, server farms, and business parks
  * Can be scaled down to provide power for individual homes or vehicles

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Example: **Peaker Plants**

- "Peakers" are electricity generating plants that are brought online during peak power demand
- Traditional fuel cell/turbine systems *<u>could</u>* be good candidates for peakers, but they have a problem of long start-up times (to get up to temperature and to stabilize) – which is not acceptable for a peak demand plant
- <u>Start-up time for the SFS is measured in minutes – not hours</u>
- During periods of peak demand, an SFS peaker could be powered up quickly and provide efficient, reliable power

Sweltering summer day

Fire up an SFS peaker

Efficient power to your customers within a half hour

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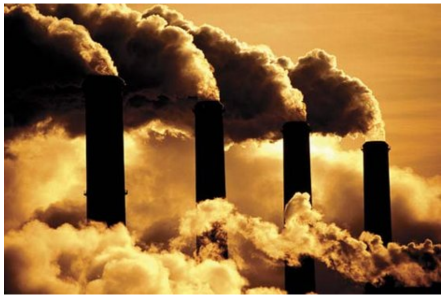
Example: **Coal Gasification**

- The Split Fuel Stream System is a natural fit with coal gasification.
- Coal gasification is a reforming process. The primary outputs are H_2 and carbon monoxide.
- The H_2 can be fed into the fuel cell, and CO is a great fuel for turbines.
- This eliminates the need for a water-gas shift reaction of the CO. The CO is combusted in a turbine to create energy
- <u>This could be the technology that leads to truly "clean coal"</u>

Change coal power from this…



…to this…

…with a highly efficient SFS coal gasification system

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Example: **Distributed Power Systems**

- The SFS can provide clean, efficient power to industrial parks, server farms or residences.
- Localized power systems are less susceptible to power outages due to hurricanes and similar natural disasters. As long as there is a natural gas supply, an SFS would continue to provide power.
- All that is needed is a supply of natural gas, and a Split Fuel Stream System can generate power locally <u>at nearly double the efficiency of electricity from the grid</u>

In a citywide blackout…

…you can still have power

Generate power locally at about half the cost of the grid

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Example: **On-board Vehicle Power**

- The SFS can be designed to power cars, trucks and buses.
- Increase fuel efficiency by a factor of 2 to 3 over internal combustion engines.
- Catalytic converters could be eliminated
- Any hydrocarbon fuel could be used – gasoline, diesel, LNG.

Significant increase in MPG

Can use existing fuels. Don't need to create a new fuel infrastructure.

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Current Status

* Patents have been issued in the US, Canada and Japan
* Additional patent applications pending
* PCT filings in the United Kingdom and Germany
* Seeking industry partners to develop and test prototype systems

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More Info for Techies

* EnergYield has published a white paper with more details about the Split Fuel Stream System.
* The white paper has a full description of theory of operation and references to relevant research
* Available at www.energyield.com or by contacting Bob Hotto or Clint O’Conner – see next slide.

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SUMMARY

* Breakthrough technology in energy generation
* Protected by strong, blocking patents
* This is industry-changing technology. We expect this will be the dominant form of energy generation for the next 30 to 50 years
* Short-term goal: Develop and test working prototypes
* Long-term goal: Commercialization of the technology
* Contacts:
  * Bob Hotto – bob@energyield.com
  * Clint O'Conner – clint@energyield.com