



***Future of Coal:
Emissions, Energy, Fuels,
and Chemicals***

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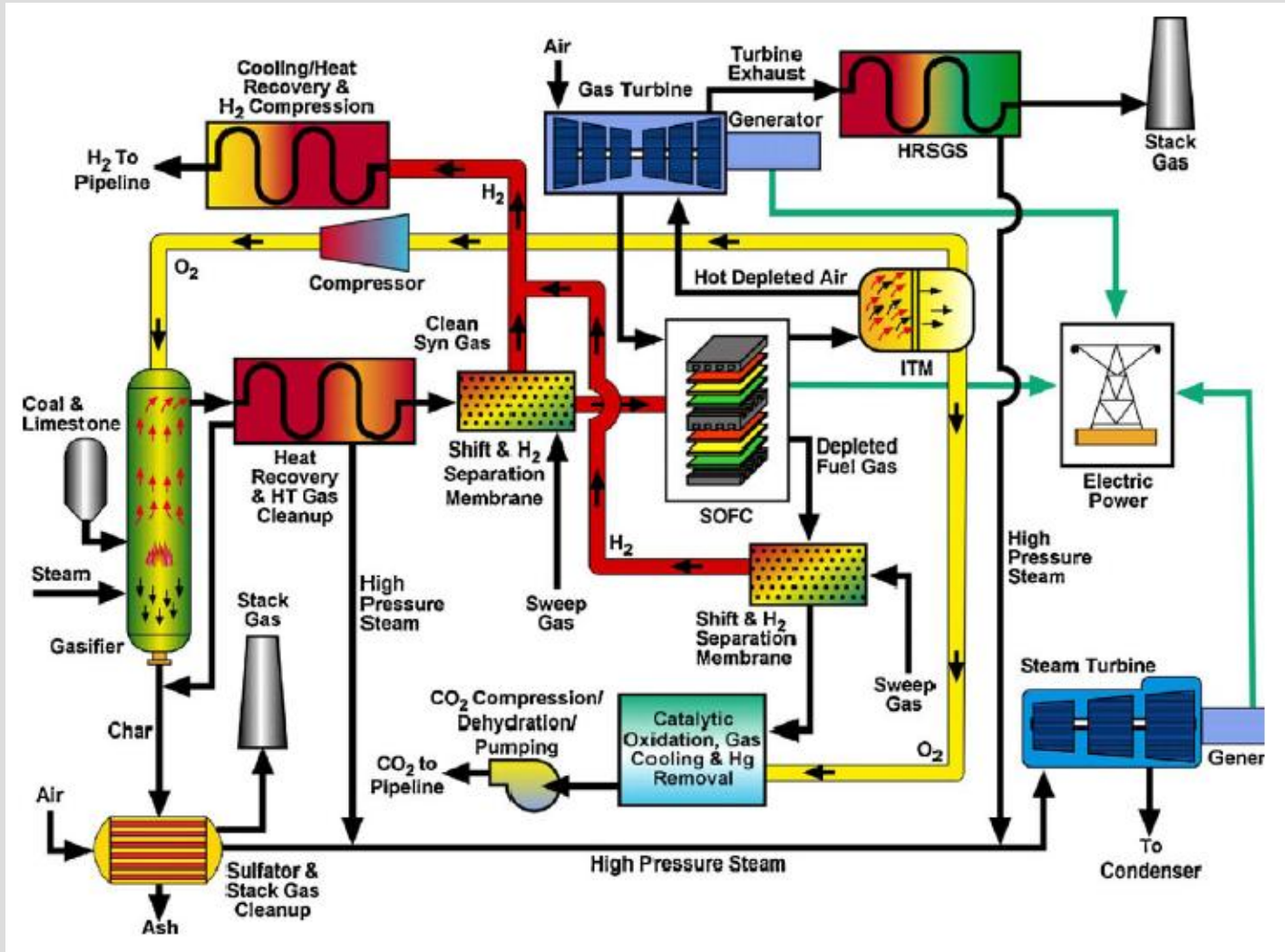
Background

Coal – Uses and Concerns

- Coal is cheap and abundant
- Energy security issues will influence use
- Price differential with alternatives will drive use
- Carbon management is already limiting
- Future applications
 - Pulverized coal combustion
 - Oxycombustion
 - Integrated gasification combined cycle
 - Fuel Cells
 - Fischer-Tropsch fuel production

Future of Coal

U.S. DOE FutureGen [USDOE/NETL]



Carbon Management – Coal's biggest challenge

CM – It is not just carbon sequestration

Elements of Carbon Management

- Carbon separation
- Carbon sequestration
- Carbon avoidance
- Carbon recycling

Carbon Management – Coal's biggest challenge

Carbon Separation

Just how do you get CO₂ from flue gas?

Amine scrubbing

Chilled ammonia scrubbing

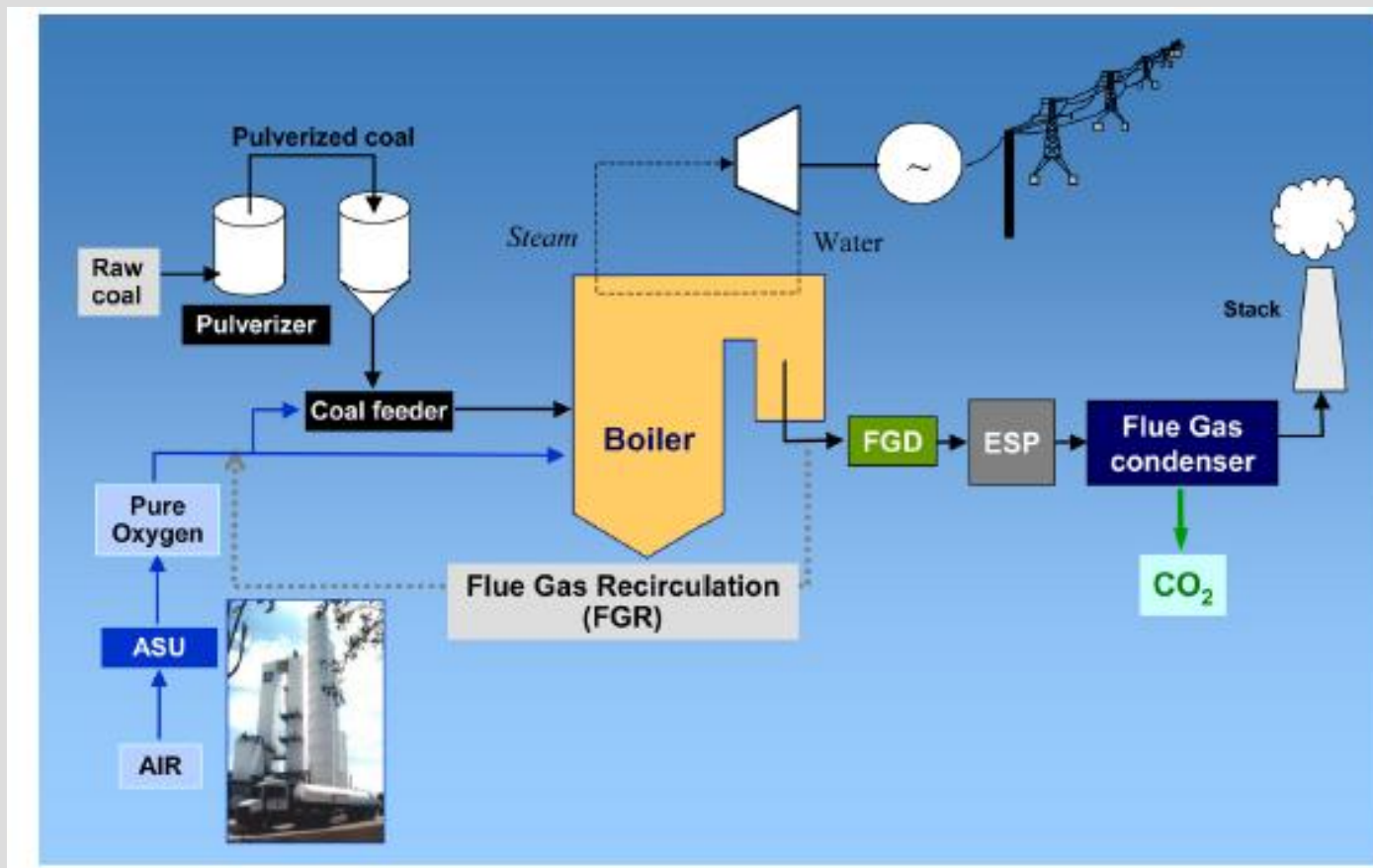
Sodium carbonate-bicarbonate exchange

Or

Use O₂ combustion to produce CO₂ and H₂O

Oxycombustion – Alternative to Gasification?

All the fun of P.C.C. with none of the nitrogen



Courtesy U.S. DOE

Carbon Management – Coal's biggest challenge

Carbon Sequestration

What do you do with the CO₂?

- Enhanced Oil Recovery
- Enhanced Gas Recovery

Once that fills up or runs out

- Deep saline aquifer injection (supercritical)
- Deep ocean storage (supercritical)

Carbon Management – Coal's biggest challenge

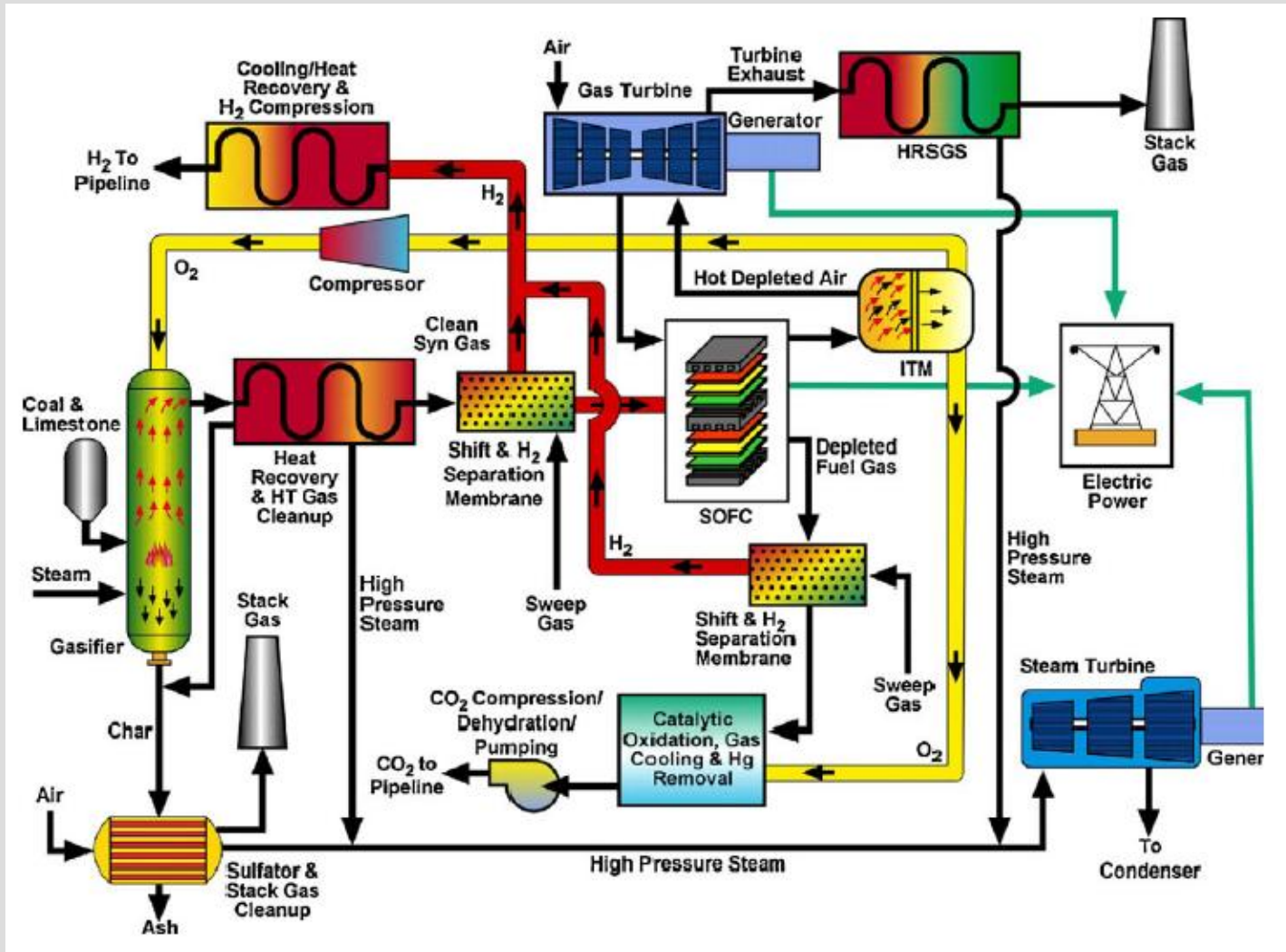
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- Carbon recycling

IGCC – Carbon Reduction and Capture

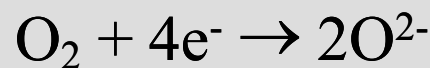
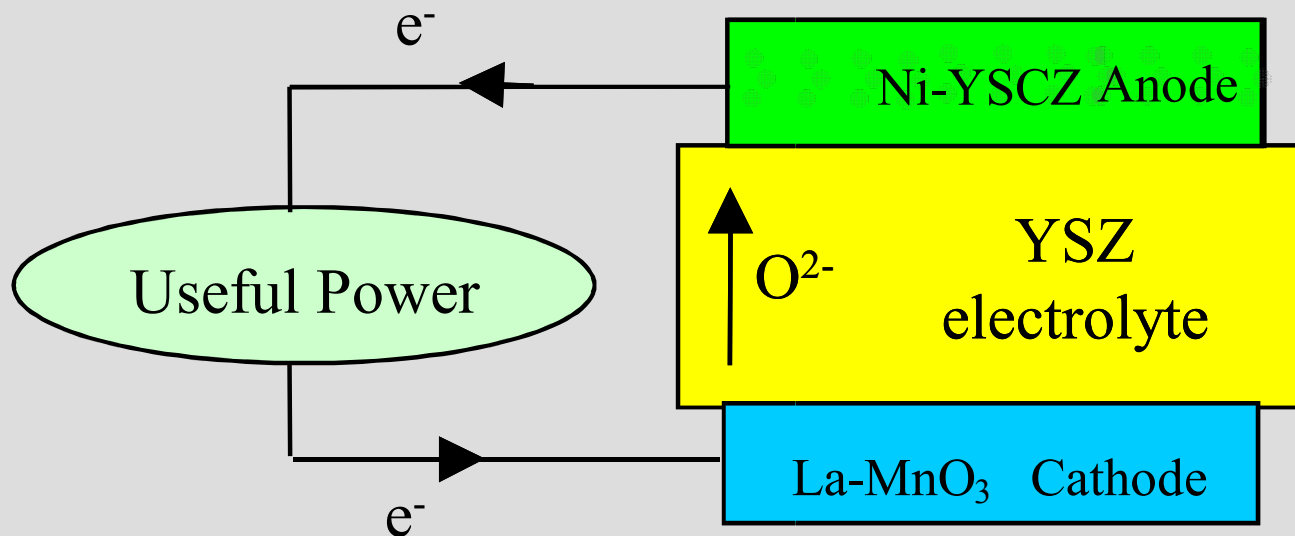
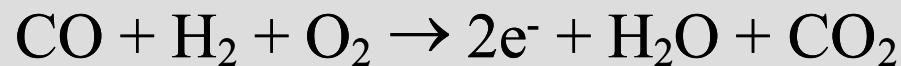
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Electrochemical Energy Conversion

Planar Solid Oxide Fuel Cells

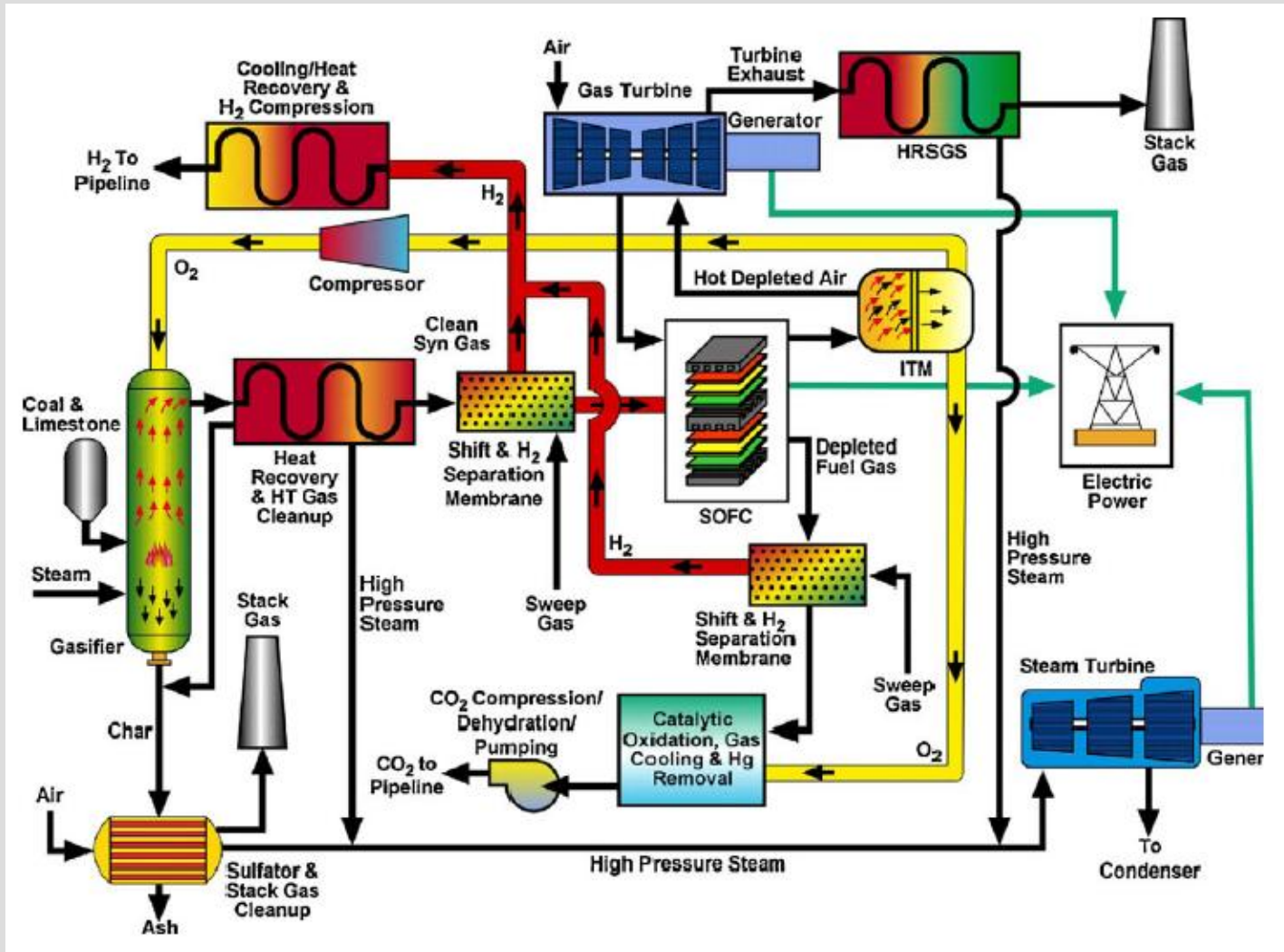
Fuel: CO and H₂



Air

Future of Coal

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Fischer-Tropsch for Fuels Production

What is Fischer Tropsch?



- Syngas (CO and H₂) are passed over a catalyst forming longer hydrocarbon chains
- The wax can then be hydro-cracked (like petroleum) to make gasoline, diesel or JP8
- A serious problem is CO₂ – FT synthesis produces nearly twice the CO₂ of just using petroleum
(Coal=CH_{0.8}, Diesel = CH₂)

Carbon Management – Coal's biggest challenge

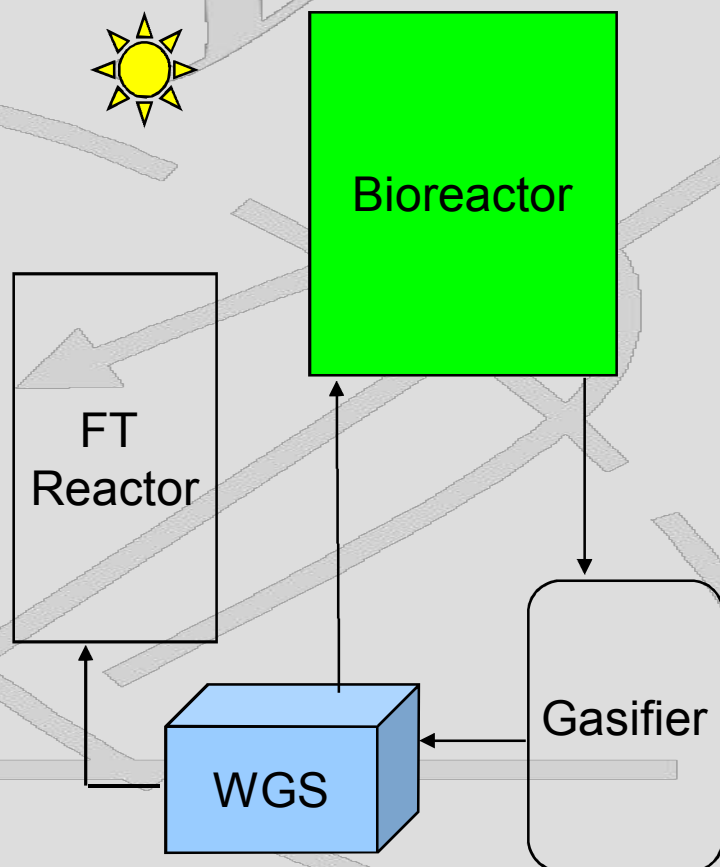
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Algal-based Carbon Recycling

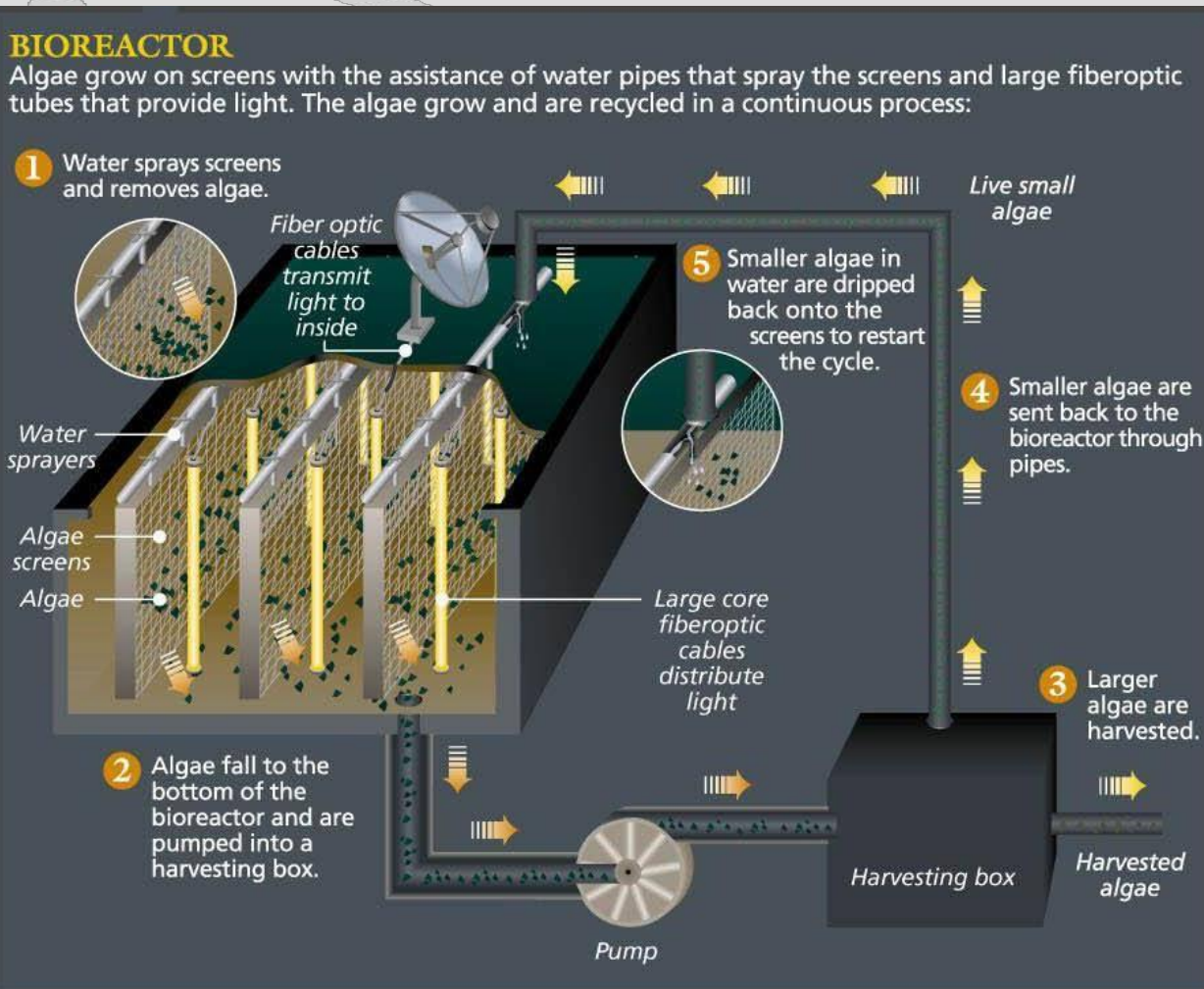
Fischer Tropsch for Coal/Biomass to Transportation Fuels



- One possible answer – use bioreactors to mitigate CO₂
- CO₂ from water-gas shift can be throttled and used in bioreactor
- Controlled photosynthesis produces significant biomass
- Biomass can be dried, processed and fed to the gasifier
- CO₂ is recycled into fuel

Algal-based Carbon Recycling

An Engineered Option for CO₂ Mitigation



Algal-based Carbon Recycling

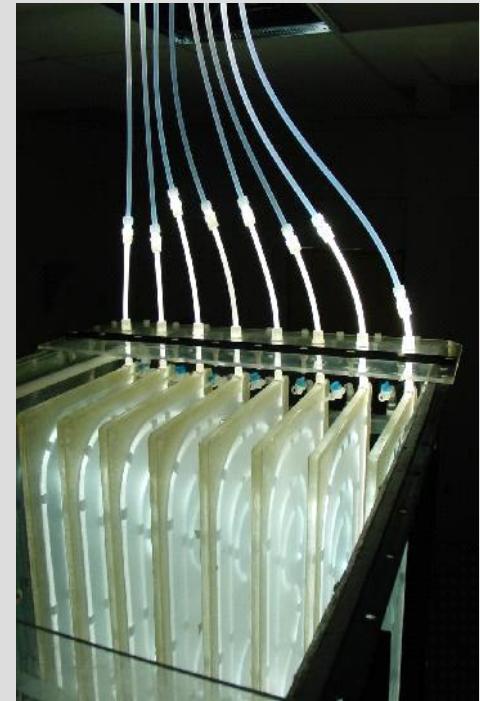
Delivery of Visible Photons for Photosynthesis



Solar collector



Lighting panels viewed from direction of gas flow



Top of lighting panels

Algal-based Carbon Recycling

Membranes after five full days





Further questions?

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