

EPRI

ELECTRIC POWER
RESEARCH INSTITUTE

IGCC 101

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Outline

- What is Coal Gasification?
 - How does it differ from coal combustion?
- What is a Combined Cycle?
- Gasification + Combined Cycle = IGCC
- IGCC Experience
- IGCC with CO₂ Capture
- Your Questions

What is coal???



- Carbon
- Ash (rock)
- Sulfur
- Nitrogen
- Hydrogen
- Mercury
- Water

What happens when coal burns?

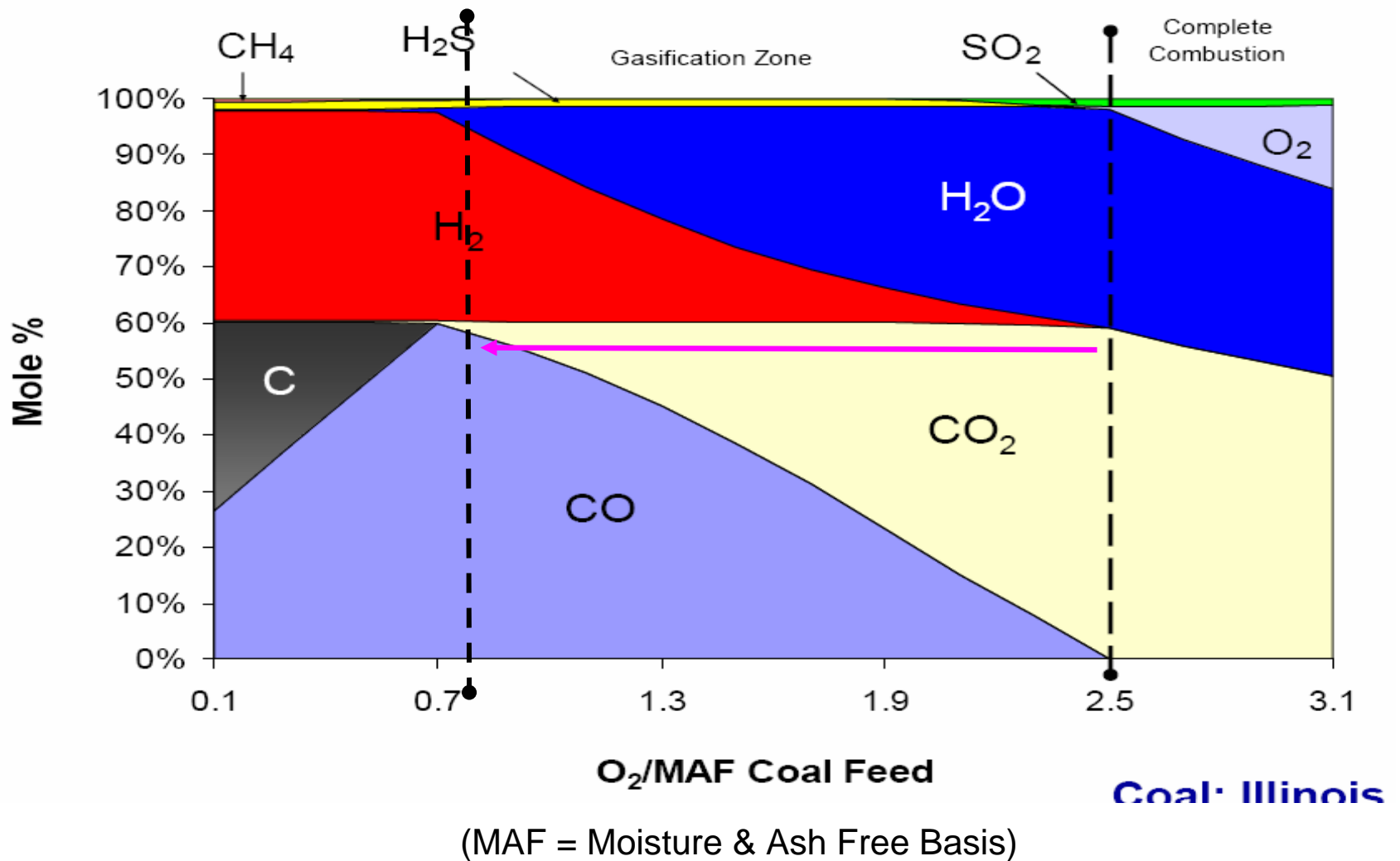
- Carbon => CO₂ (carbon dioxide)
- Ash => flyash
- Sulfur => SO₂, SO₃ (SO_x)
- Nitrogen => N₂ and NO_x
- Hydrogen => H₂O
- Mercury => Hg, HgCl₂
- Water => water vapor (H₂O)

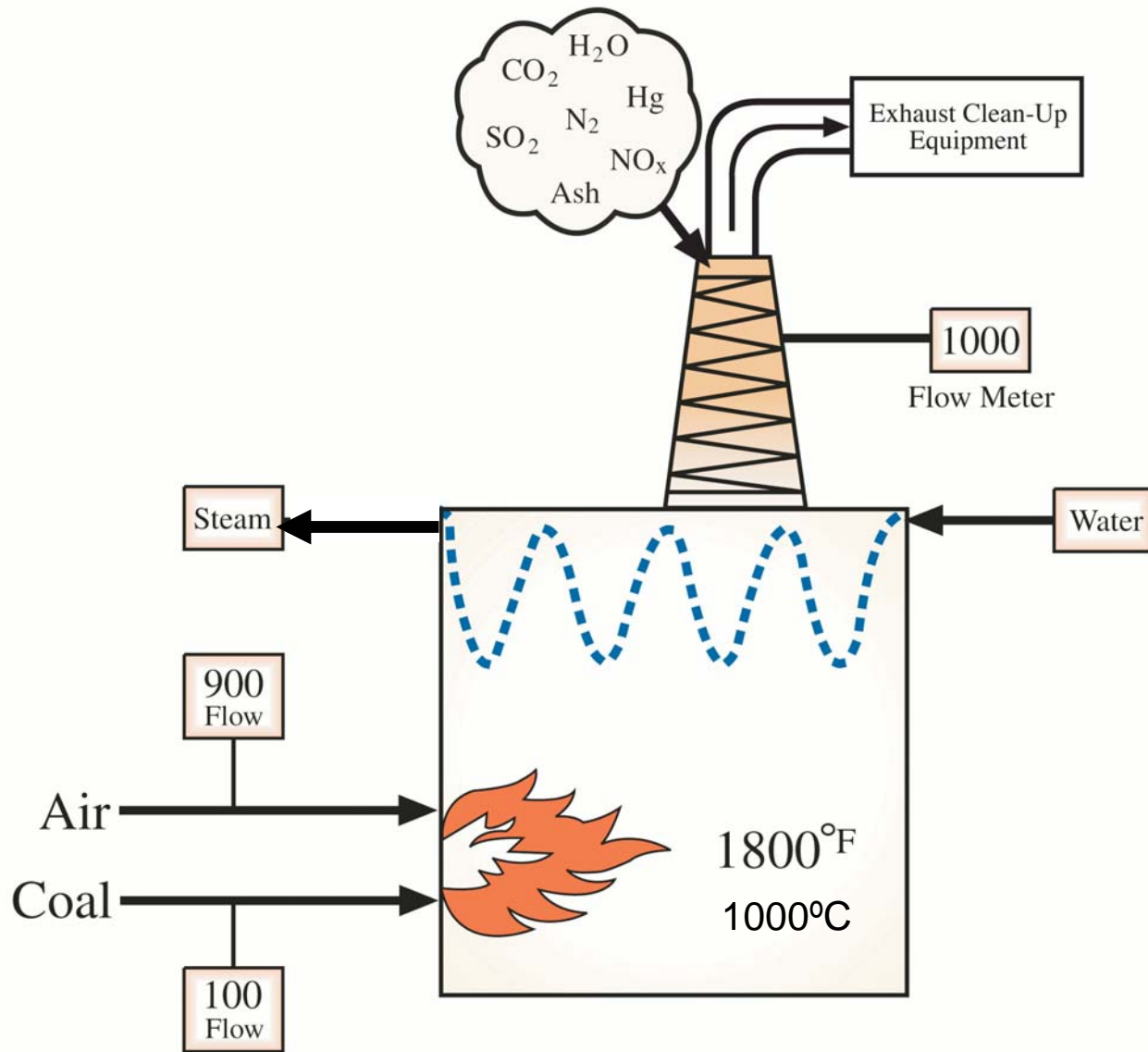
- And you release a lot of heat!

What is gasification?

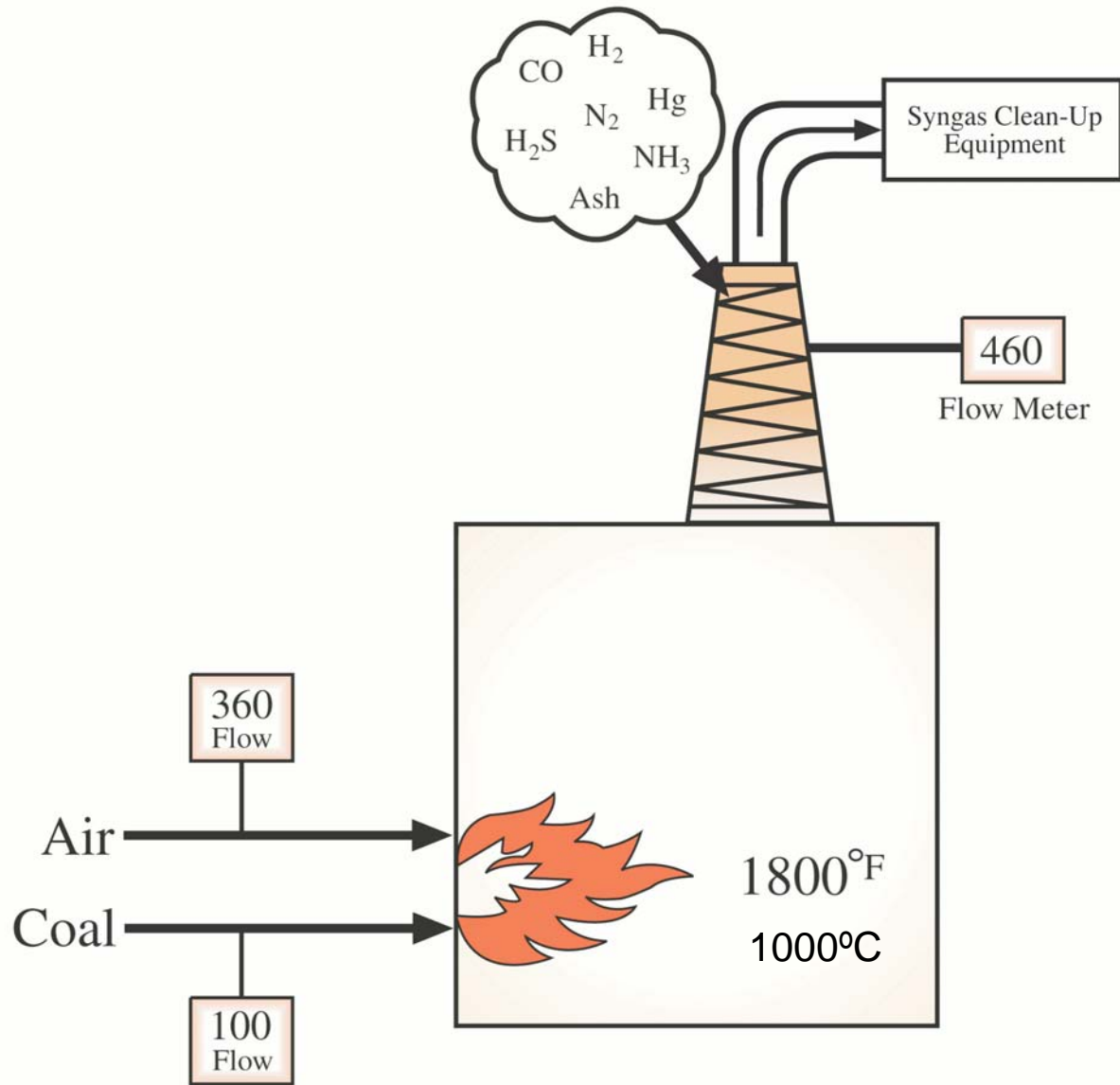
- Similar to combustion (burning) but with less than half the amount of oxygen needed to fully burn the coal
- Combustion: excess air
- Gasification: excess fuel (by a lot!!)

Combustion & Gasification Products

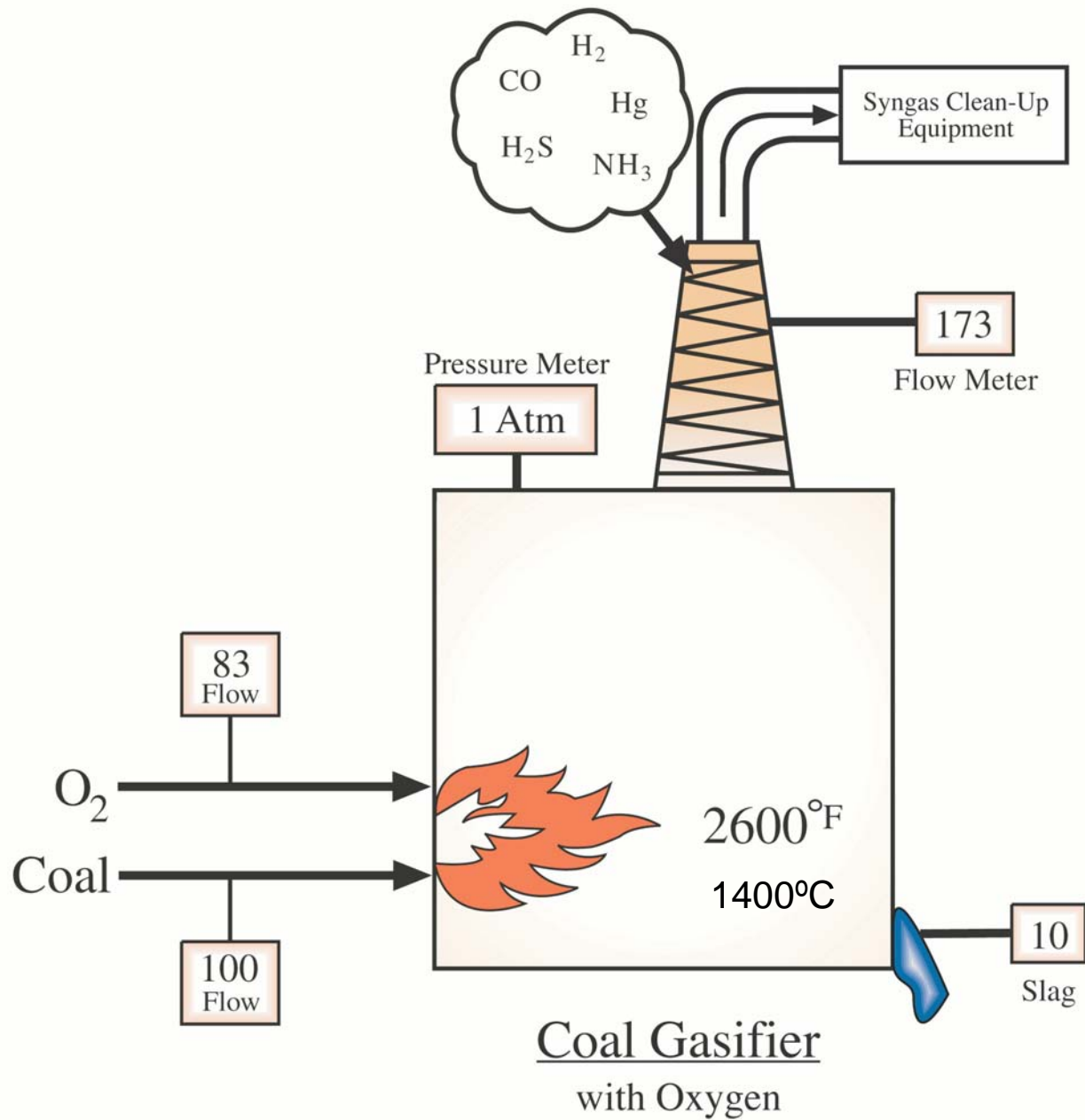


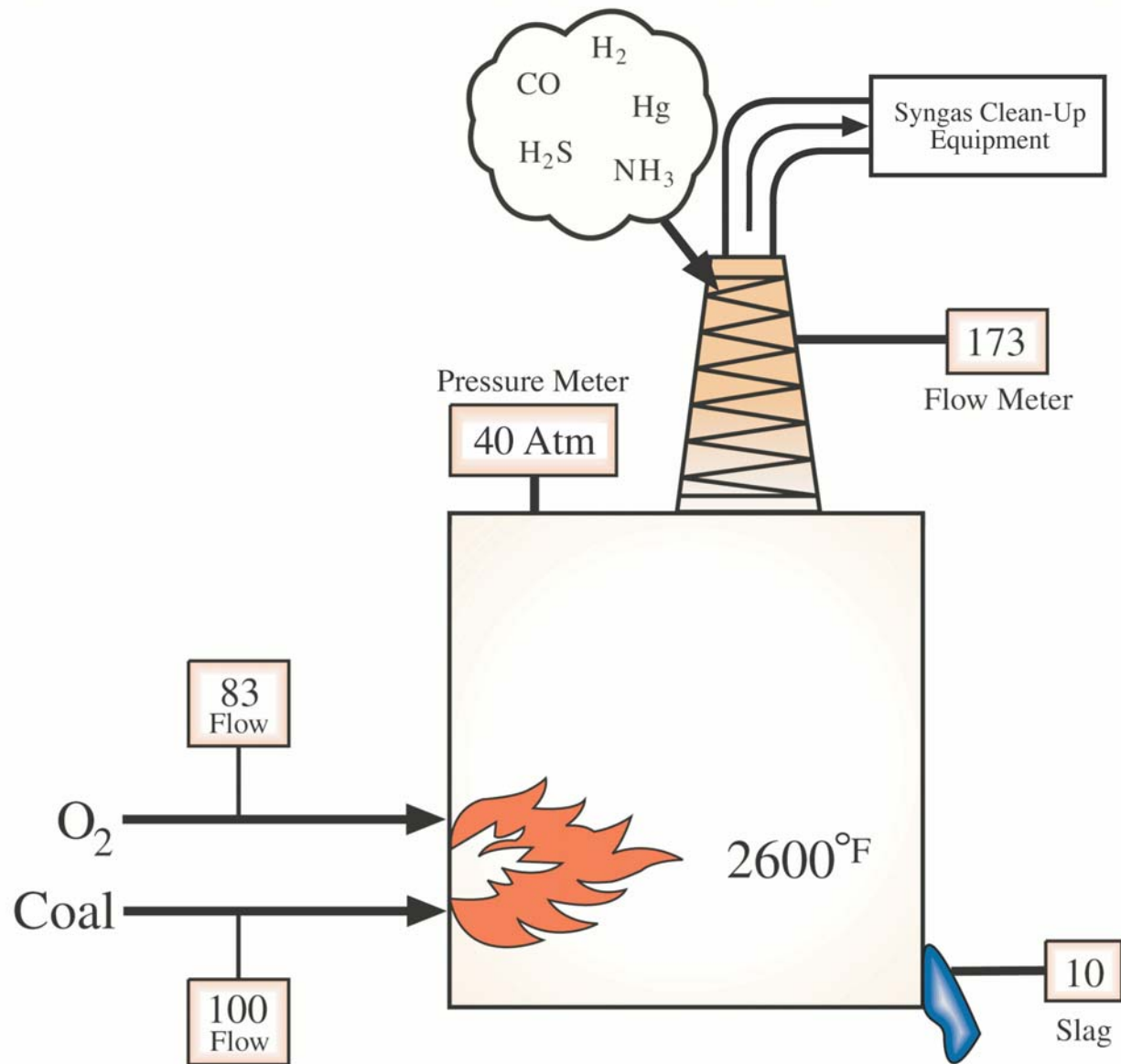


Coal Boiler



Coal Gasifier with Air





High Pressure Coal Gasifier
with Oxygen

Gasification Emission Control Strategies

- SO_x control
 - H₂S & COS are easily removed from syngas using mature technologies used in the oil and gas industry
 - Captured “acid gas” is converted to solid sulfur or sulfuric acid
 - >99% removal is feasible
- NO_x control
 - Minimize “fuel nitrogen”: NH₃ washes out of syngas with water
 - Minimize “thermal NO_x”: moderate flame temperature in CT with diluent injection (N₂ from air separation unit or steam from turbine)
 - Optional SCR for deeper NO_x removal – levels close to an NGCC
- PM control
 - Ash is converted to glassy slag which is inert and usable – quenched in water bath and sluiced out of gasifier
 - Secondary removal of fine solids from syngas with barrier filters and water scrubbers
- Hg control
 - >90% of Hg removed by passing high pressure syngas through activated carbon bed



Vapor-Phase Mercury Removal

>94% Removal



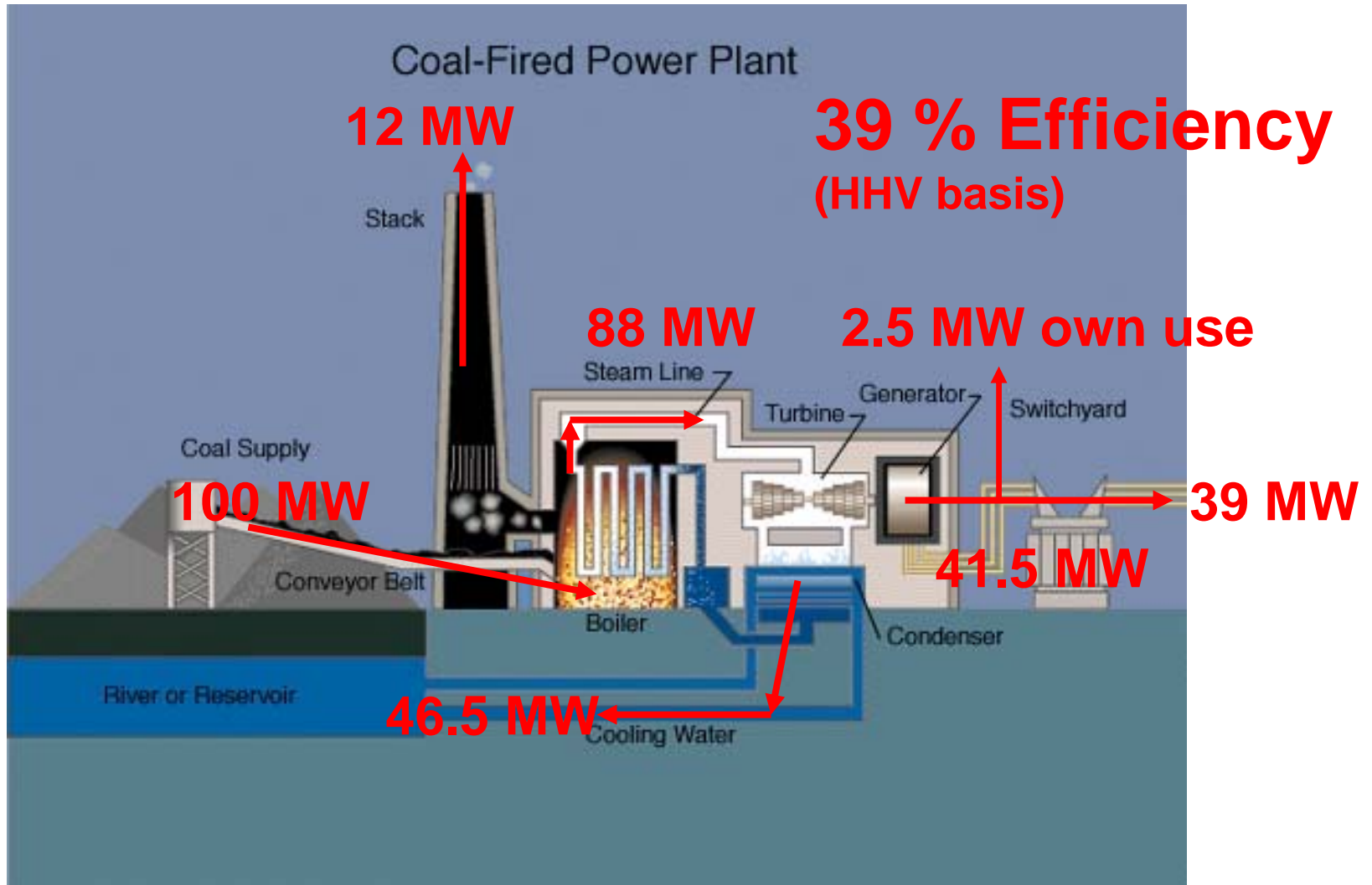
Demonstrated for 21 years at Eastman !

The cost of volatile mercury removal by IGCC is estimated to be < \$0.25/MWh, almost an order of magnitude lower than for PC technologies using activated carbon, according to a 2002 DOE report by Parsons (DOE Report, "The Cost of Mercury Removal in an IGCC Plant", September, 2002).

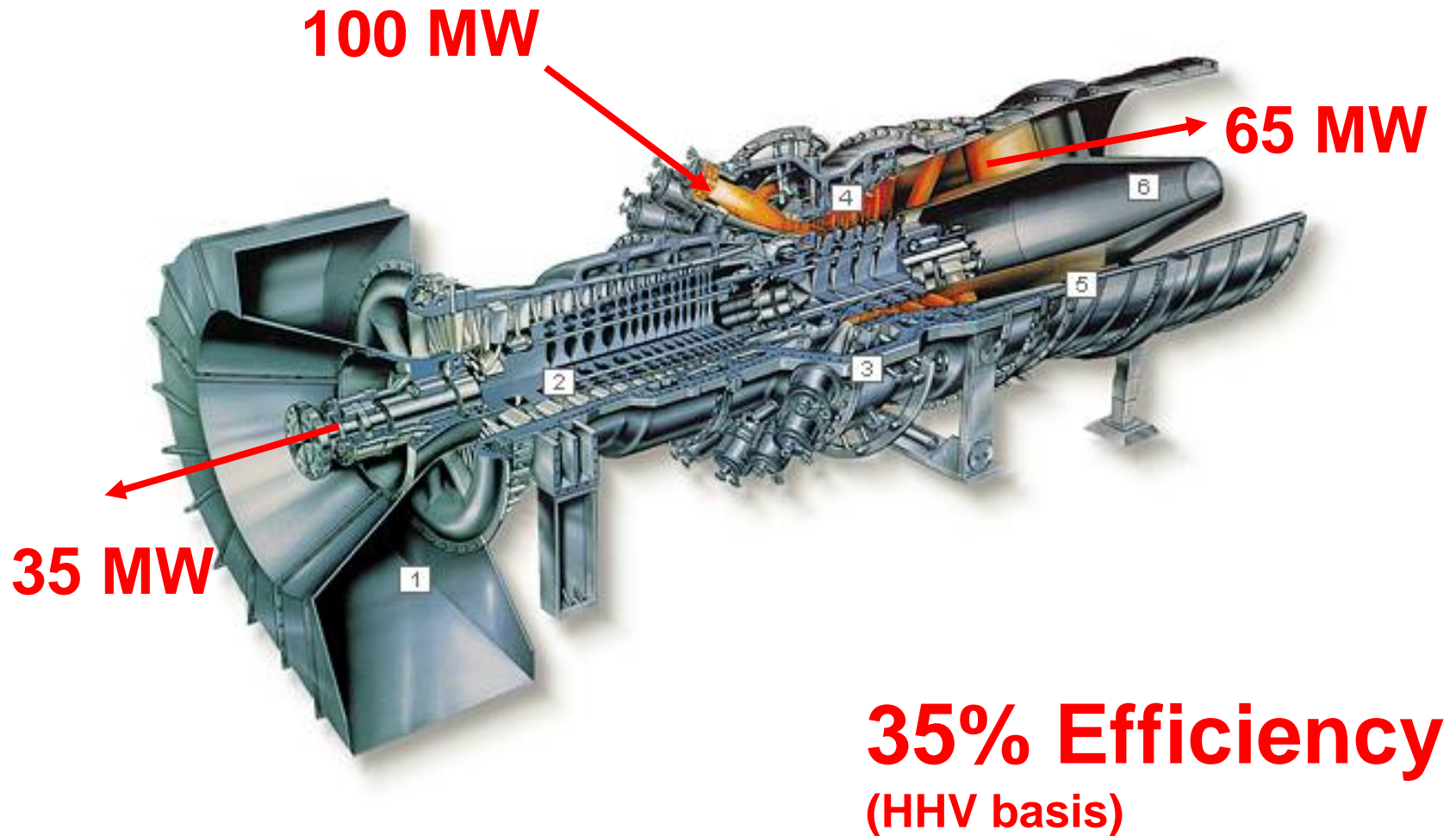
Steam Cycles vs “Combined” Cycles

- Steam Cycles have
 - a boiler
 - a steam turbine
 - Referred to as “Rankine” cycle, fossil boiler, “fossil steam” plant, “conventional coal” plant
- Combined Cycles (the “CC” in IGCC) have
 - a Gas Turbine
 - a “heat recovery steam generator” (HRSG)
 - a steam turbine

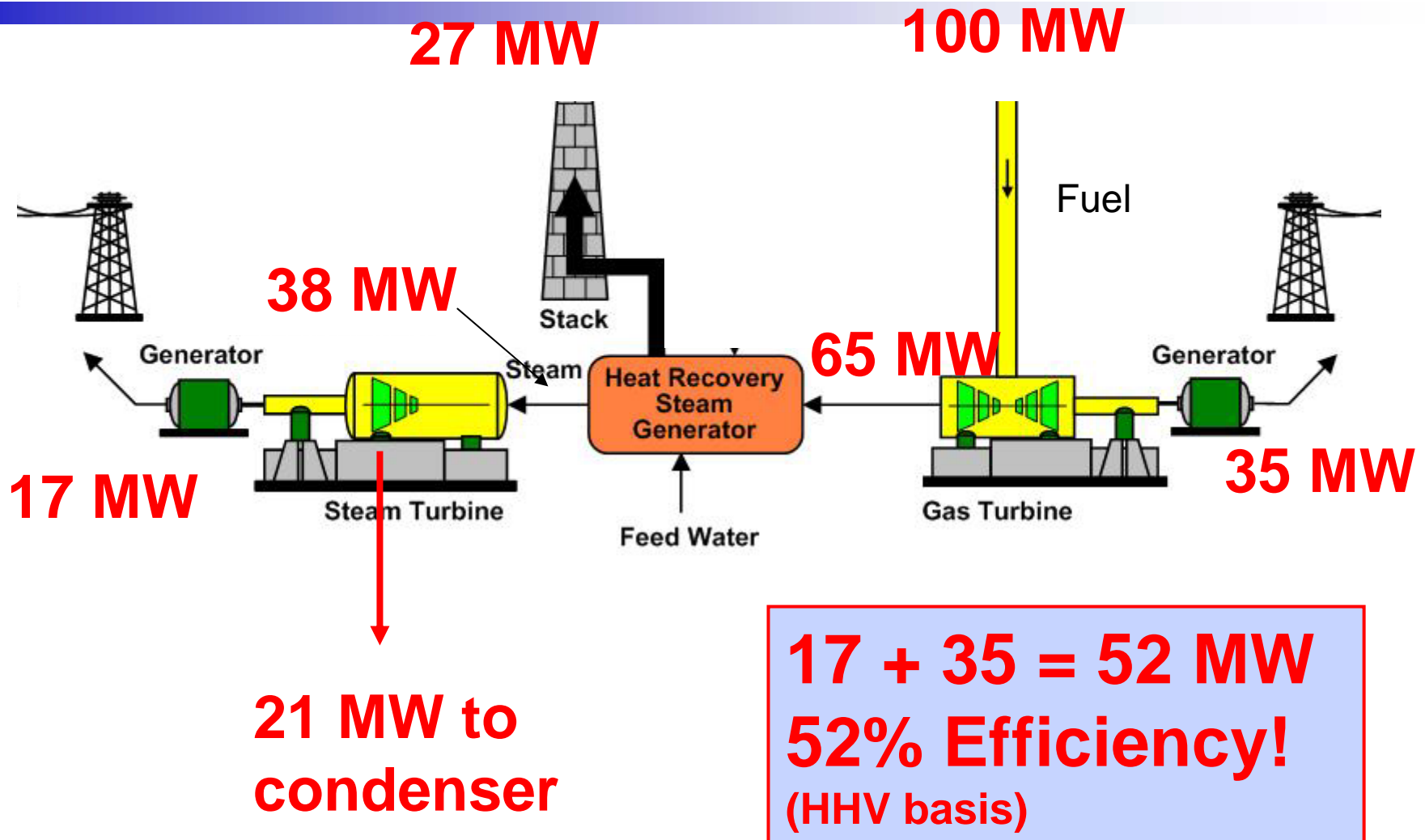
Conventional Coal Plant

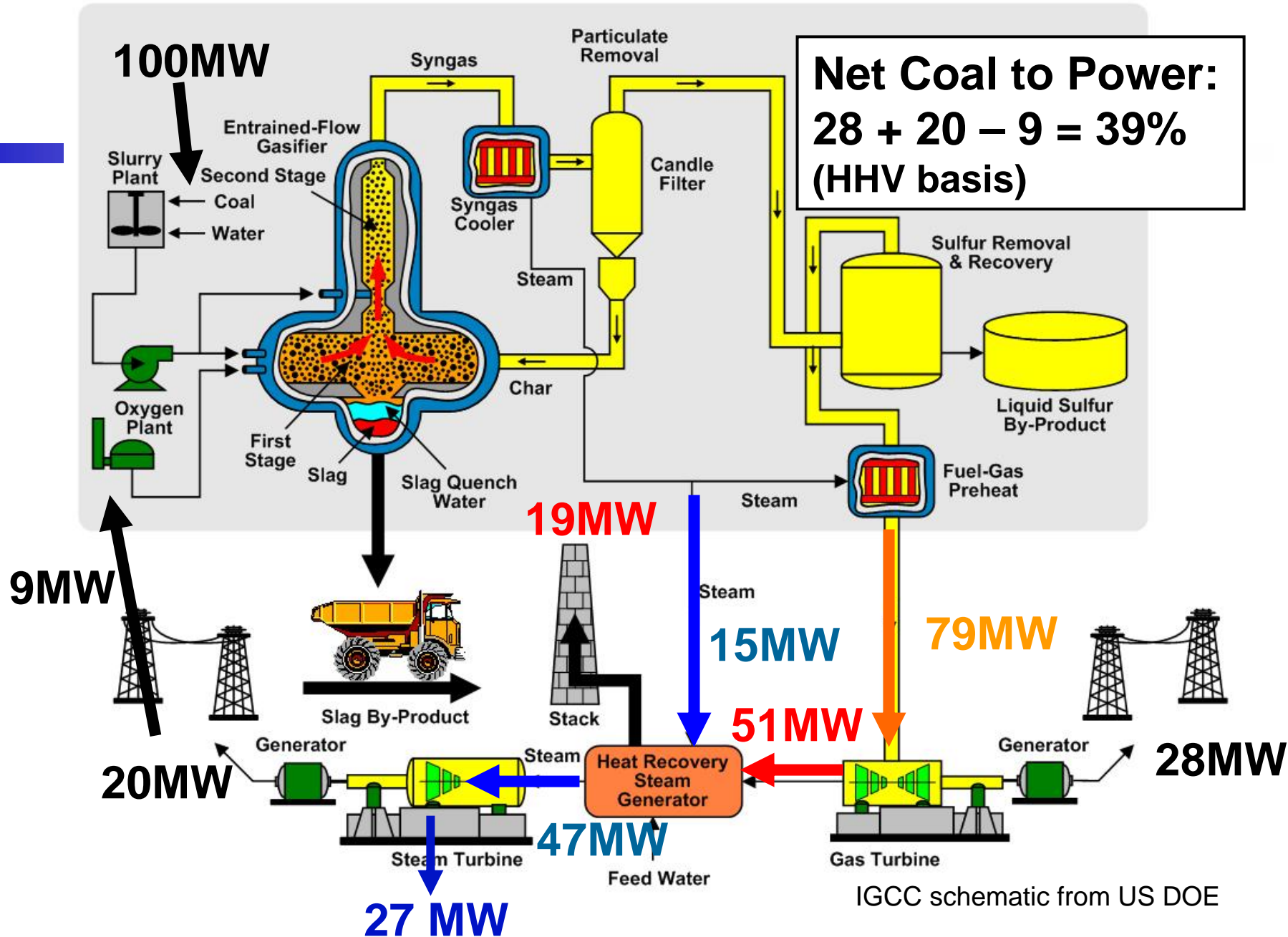


Gas Turbine “simple cycle”



Combined Cycle





Existing Coal-based IGCCs



Puertollano (Spain)



Wabash (Indiana)



Polk (Florida)



Buggenum (Netherlands)

Other Solid Fuel IGCCs

- The first IGCC was built in Lunen, Germany in 1972
 - 170 MW (no longer in service)
- EPRI helped fund the 125 MW Cool Water project in the 1980s – moved to Kansas in 1990s for pet coke-to-fertilizer project
- Dow built a 165 MW demo unit in the 1980s
 - Plaquemine, LA (no longer in service)
- Texaco built two small IGCCs at refineries in the 1990s
- Another small IGCC operates in eastern Germany (Schwarzepumpe)
- A 350 MW IGCC was built in the Czech Republic in the 1990s
 - Uses 26 Lurgi gasifiers and one GE gas turbine
- A Japanese consortium is building a 250 MW IGCC which will start-up later this year

Liquid Feedstock IGCCs

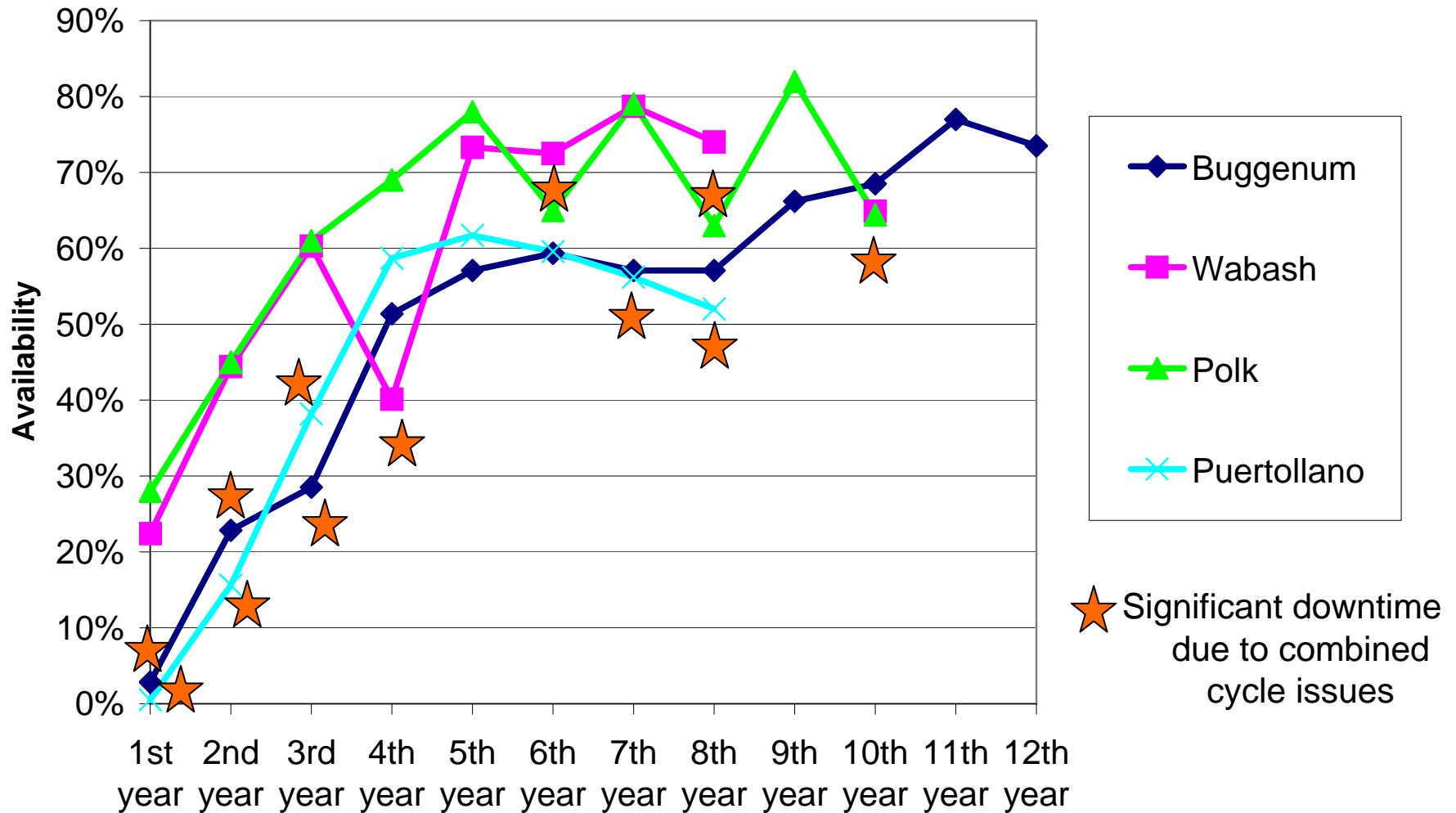
- Several IGCCs have been built that use petroleum-derived liquids as feedstock
 - Four are in Italy with the largest rated at 550 MW
- In total, 4900 MW of IGCC will have been built by the end of 2007
 - 2400 MW with solid feedstock
 - 2500 MW with liquid feedstock



Negishi IGCC, Yokohama, Japan

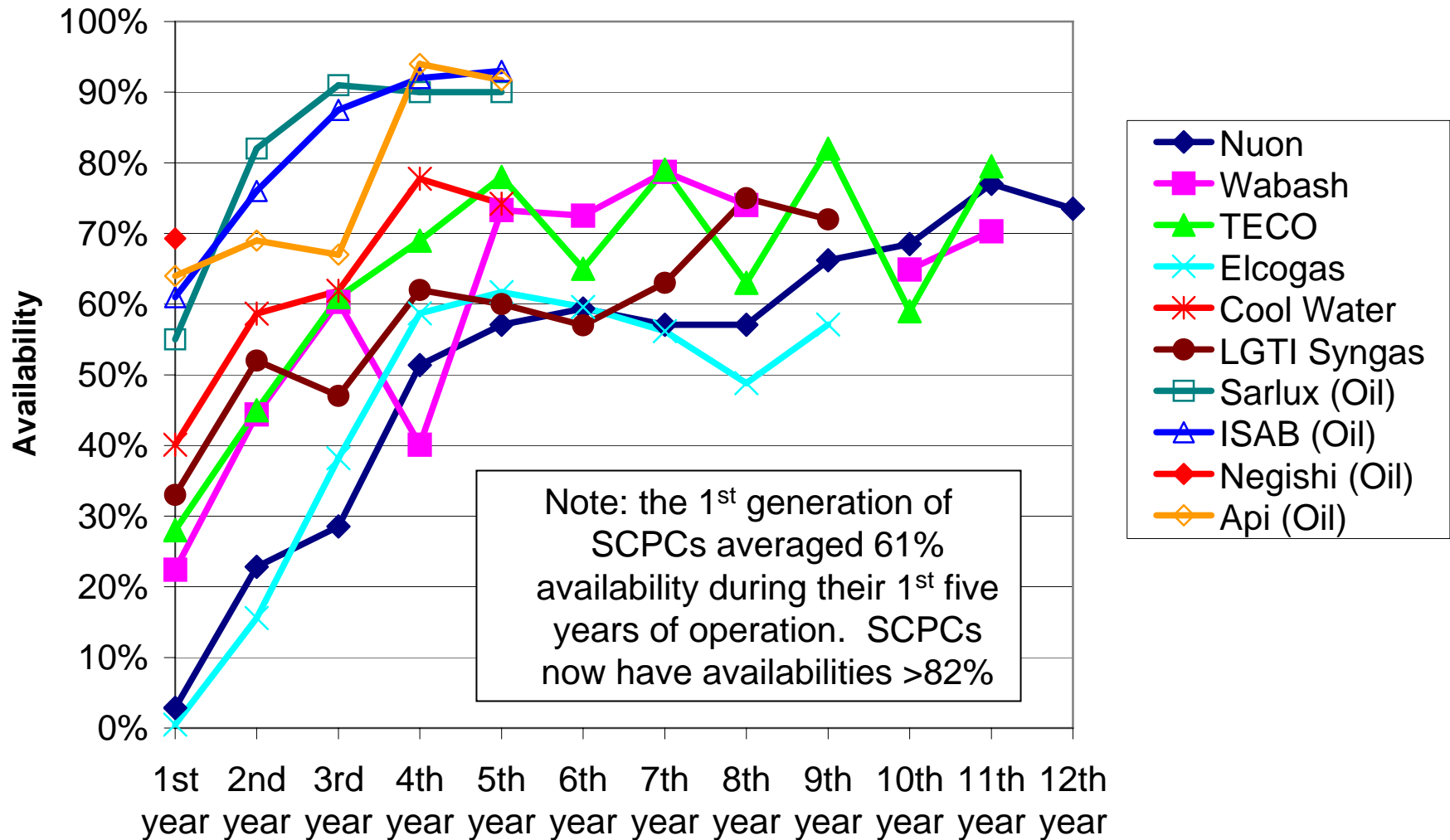
Coal IGCC Availability

(Excludes impact of operation on back-up fuel)

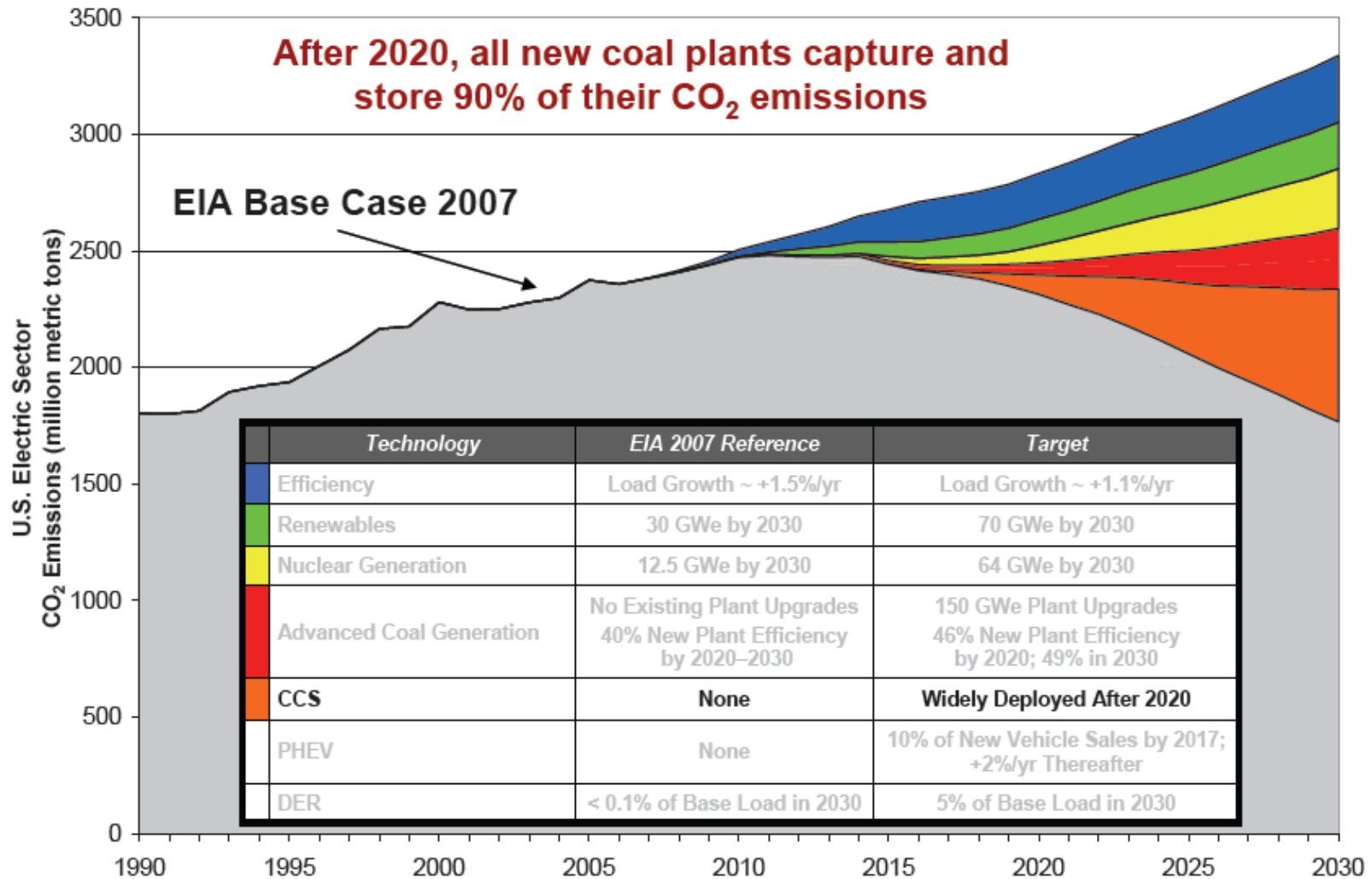


IGCC Availability

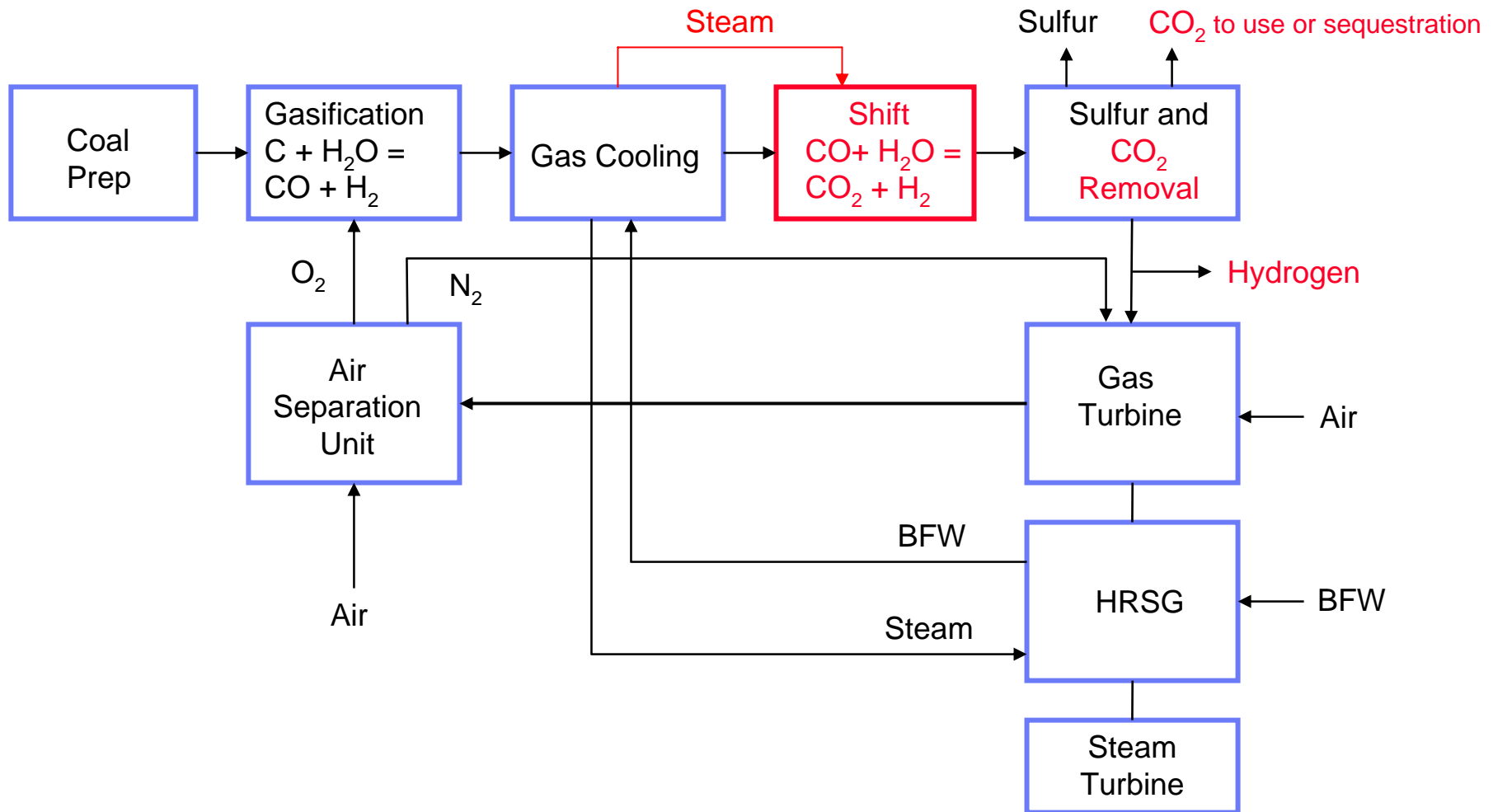
Excludes impact of back-up fuel operation



Carbon Capture & Storage with IGCCs



IGCC with CO₂ Removal and Optional Hydrogen Co-Production



CO₂ Capture from Gasification-Based Plants - US

No coal gasification-based power plant (IGCC) currently recovers CO₂ from the process

Three non-power facilities in the US recover CO₂

CO₂ from the Great Plains plant used for enhanced oil recovery

–2.7 Million tons per year (~ 340 MWe if it were an IGCC Plant)



The Great Plains Synfuels Plant
<http://www.dakotagas.com/Companyinfo/index.html>

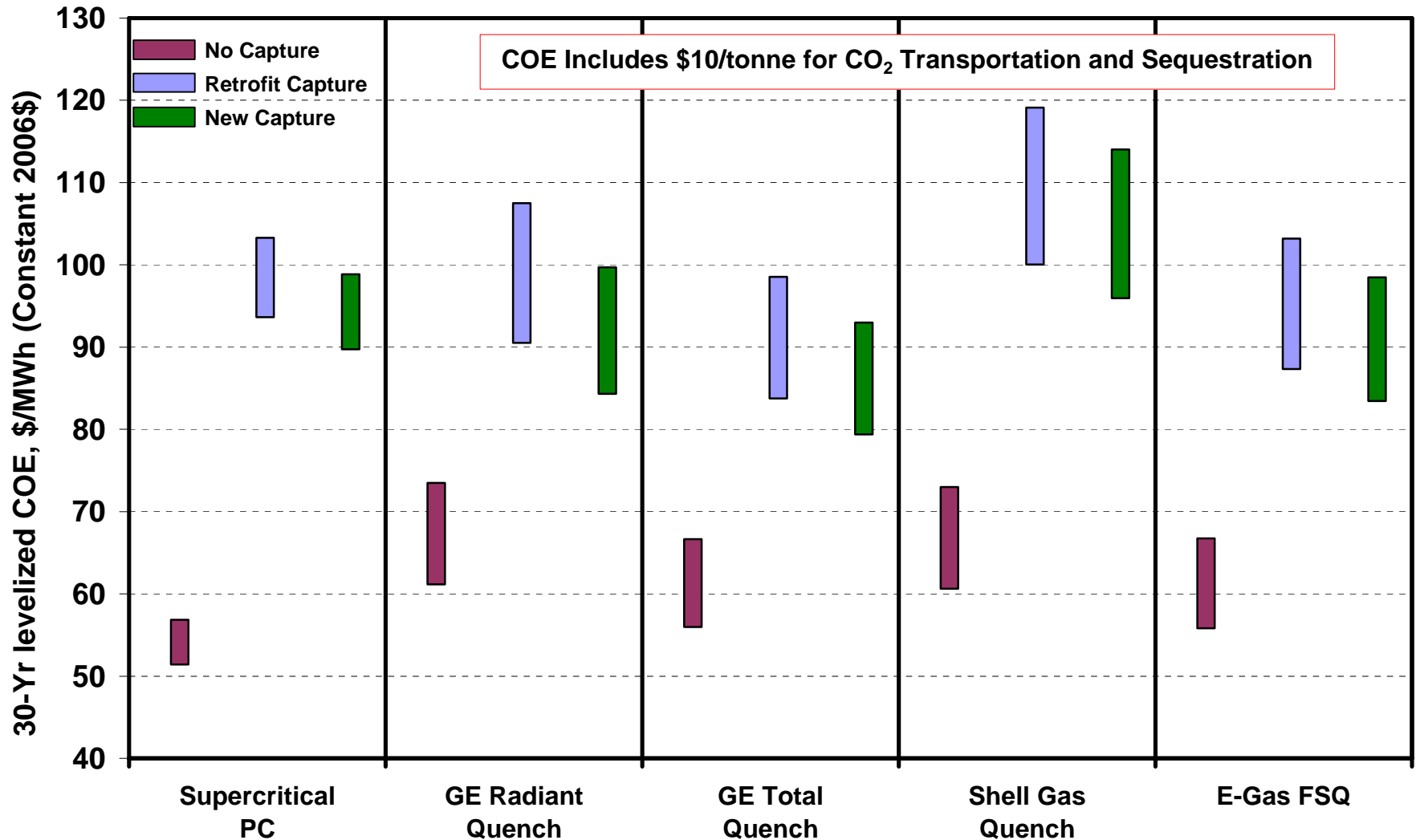


Weyburn pipeline
<http://www.ptrc.ca/access/DesktopDefault.aspx>

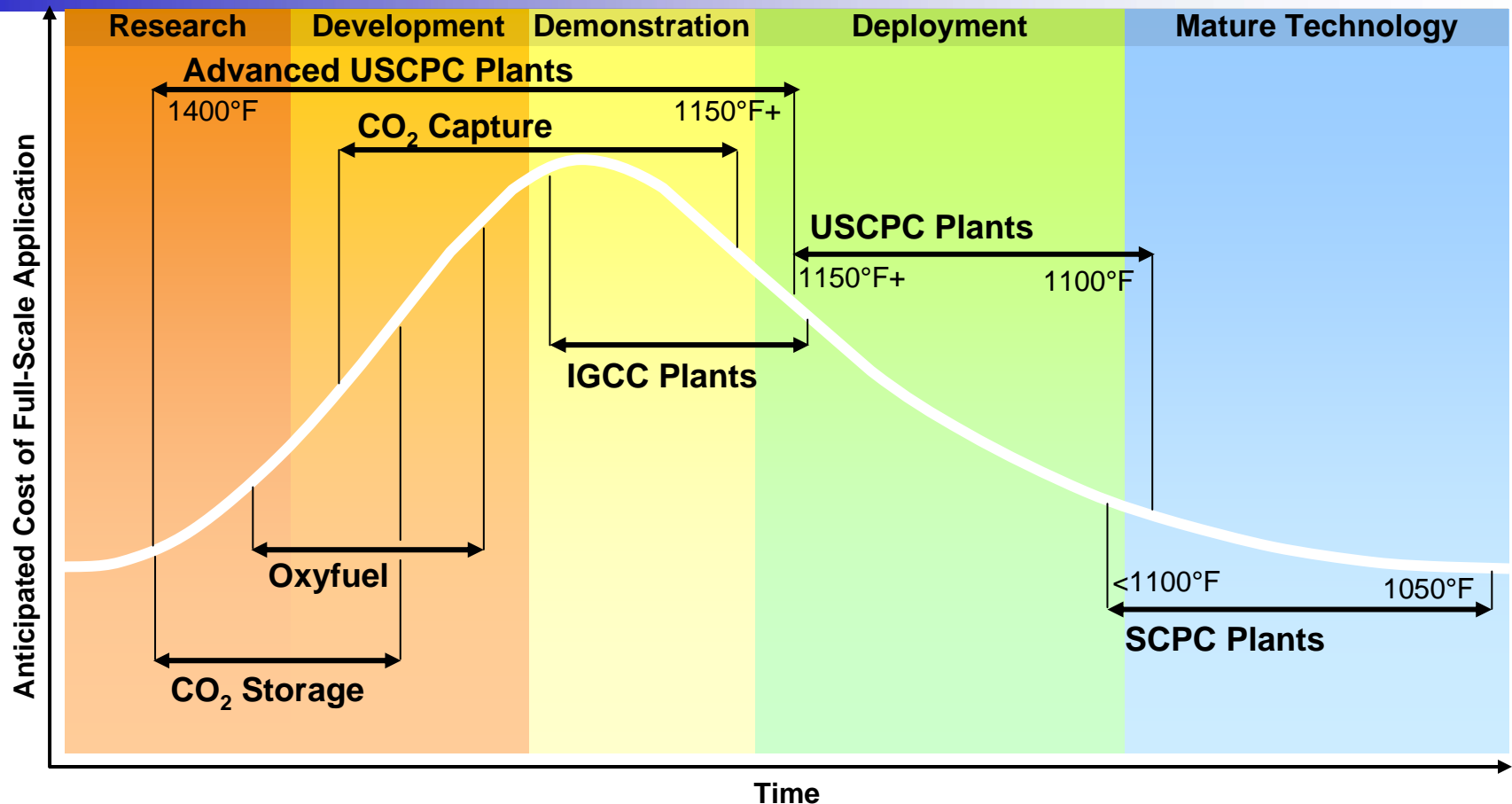
CO₂ Capture Comparison

	Exhaust or Syngas Pressure	CO ₂ Volumetric Concentration	CO ₂ Partial Pressure
Natural Gas Combined Cycle Exhaust	14.7 psia 1.01 bar	4%	0.6 psia 0.04 bar
Supercritical Coal Boiler Exhaust	14.7 psia 1.01 bar	13%	1.9 psia 0.13 bar
IGCC Syngas	825 psia 57 bar	40%	330 psia 22.8 bar

EPRI PC and IGCC Cost of Electricity With and Without CO₂ Capture (Illinois #6 Coal) (All IGCC and CCS cases have +10% TPC Contingency for FOAK)



New Technology Deployment Curve for Coal Power Generation Options



IGCC is at the top of the cost curve – additional deployment should bring cost reductions

Questions and Discussion

