

Research and Development Initiatives of WRI

Presented at

COAL GASIFICATION:

WHAT DOES IT MEAN FOR WYOMING?

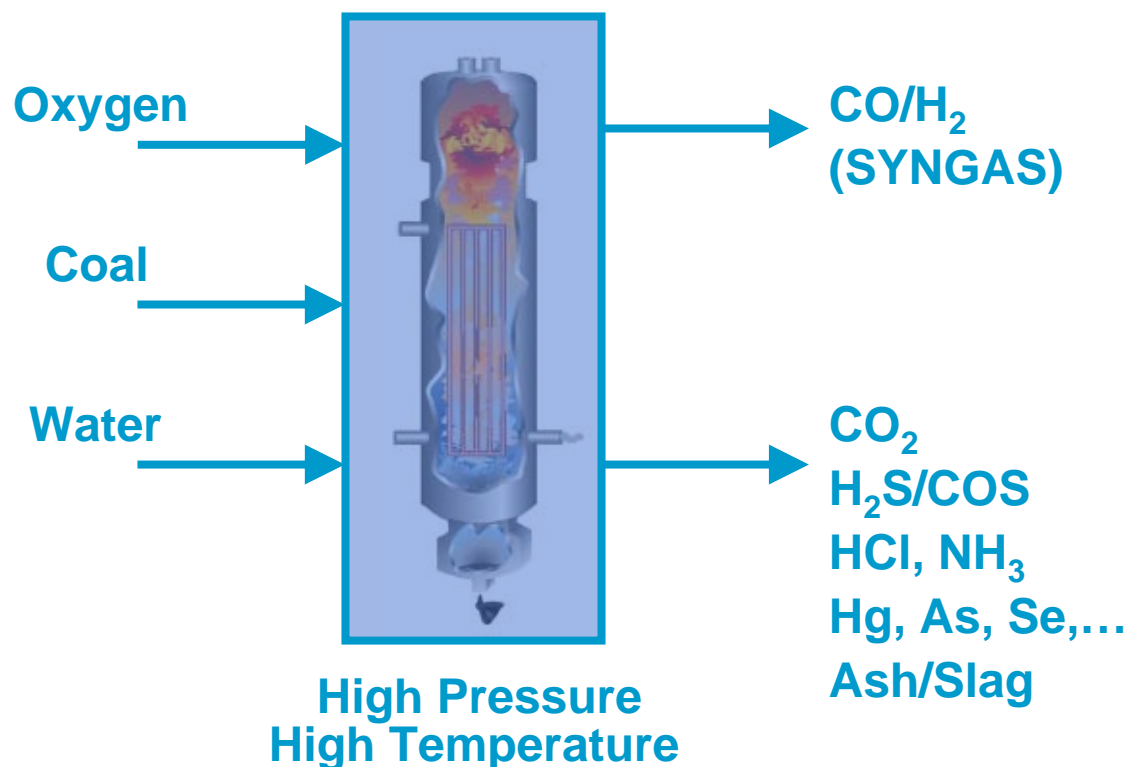
February 28, 2007

www.westernresearch.org

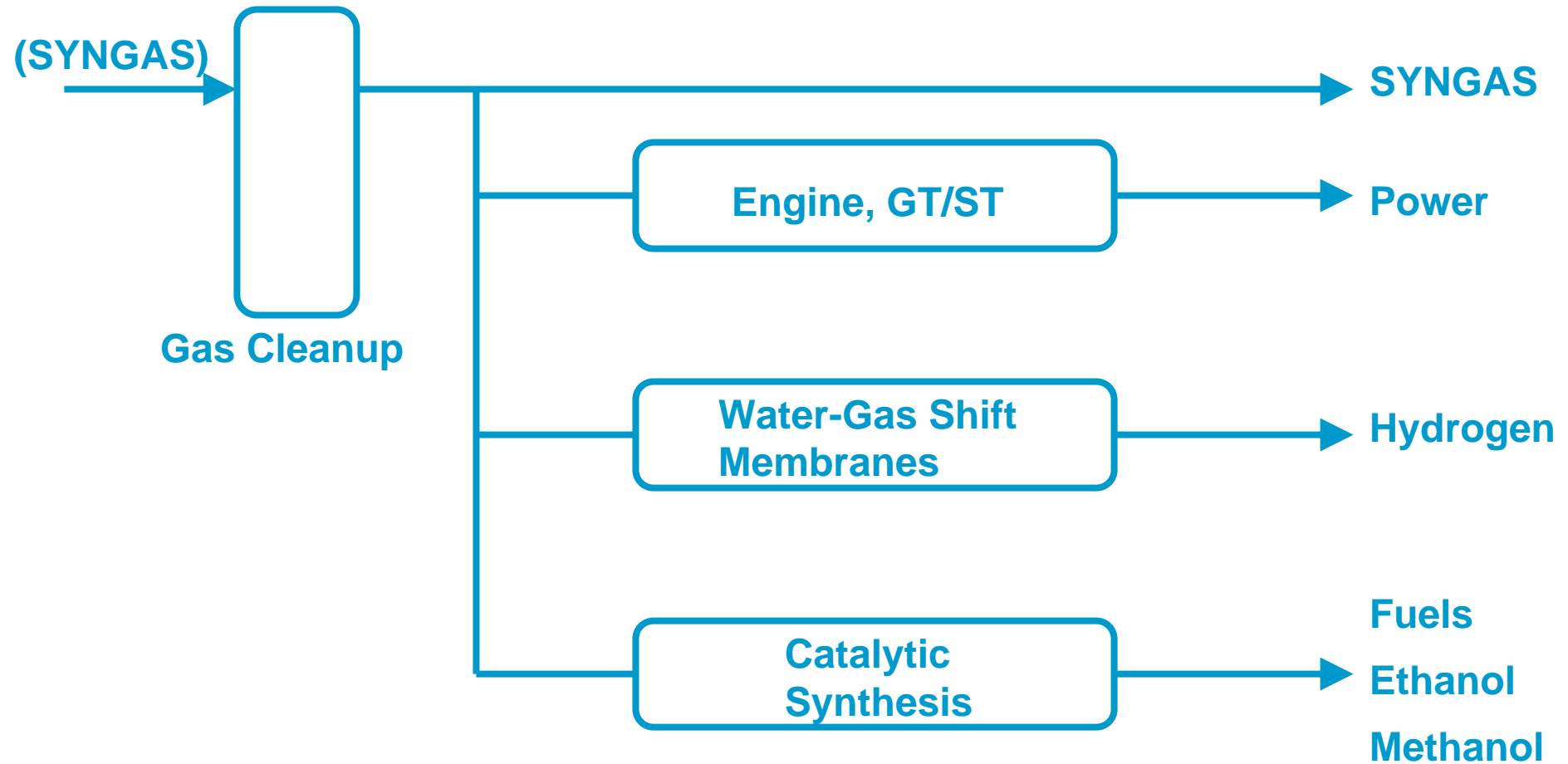
Western Research
I N S T I T U T E

-
- * WRI is a 501 (c) 3 research, technology development and contract services organization serving the energy and highway materials industries.
 - * WRI is a former U.S. DOE Energy Technology Center (LETC). In 1983, LETC was privatized and WRI came into existence.
 - * Currently, WRI is a \$8+ million per year company employing about 70 highly skilled scientists, engineers and support personnel.
 - * WRI has two major Federal contracts:
 - A contract with the FHWA to apply asphalt chemistry to specifications for better highway performance
 - A Cooperative Agreement with the U.S. DOE wherein we work jointly with industry to support the needs of the coal and power industries.

Gasification is a “Btu Conversion” scheme whereby an inexpensive feedstock such as coal, is converted into a value-added product



Gasification Products

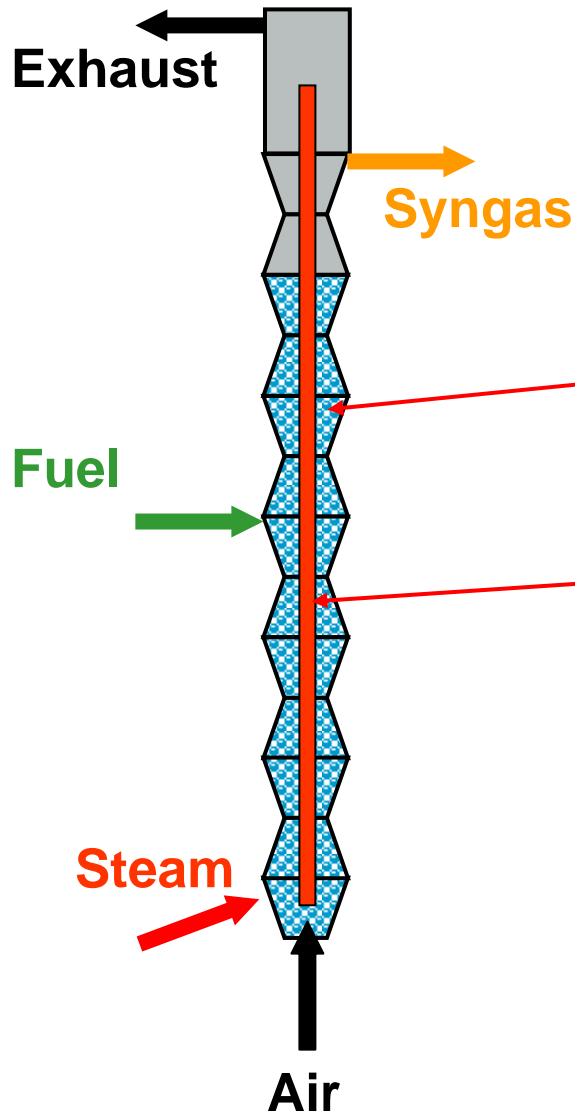


- * **Existing technologies are >20 yrs old and amenable only to large-scale applications**
 - Gasifier, typically a pressure vessel where oxidant, water, and fuel react
 - How the reactions are carried out has an impact on the process economics and conversion efficiency
 - Most not suitable for low-rank coals or small size
 - Require air separation plant

- * **Innovative technologies are being developed such as transport gasifier, chemical and thermal looping concepts, catalytic gasifiers to ensure that technology indeed meets the efficiency and fuel flexibility goals**

- * WRI is developing and testing dual bed-based thermal-looping gasifier designs that do not require expensive oxygen plant to produce medium-Btu syngas for distributed power generation**

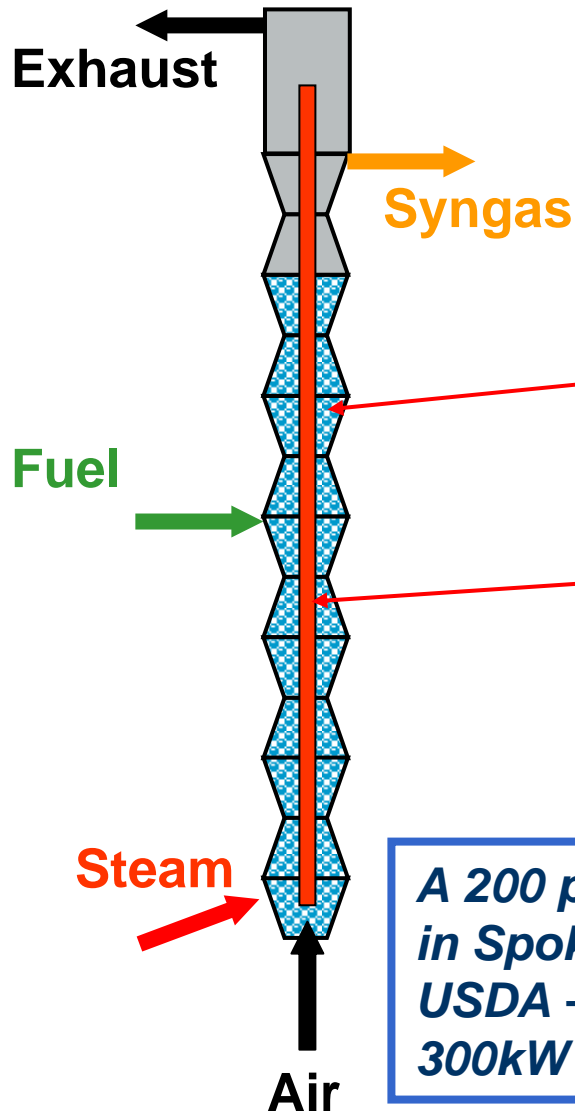
Technology Description



- **Dual-Bed Gasification Concept**

- Inert solids (heat carrier) conveyed up oxidizer tube and cascade down hourglass sections
- Reduction side: Fuel gasified with steam and hot inert solids. Syngas extracted from top
- Oxidation side: Residual carbon combusted with air, heating inert solids
- Separation of oxidizing & reducing zones produces a high quality syngas

Technology Description

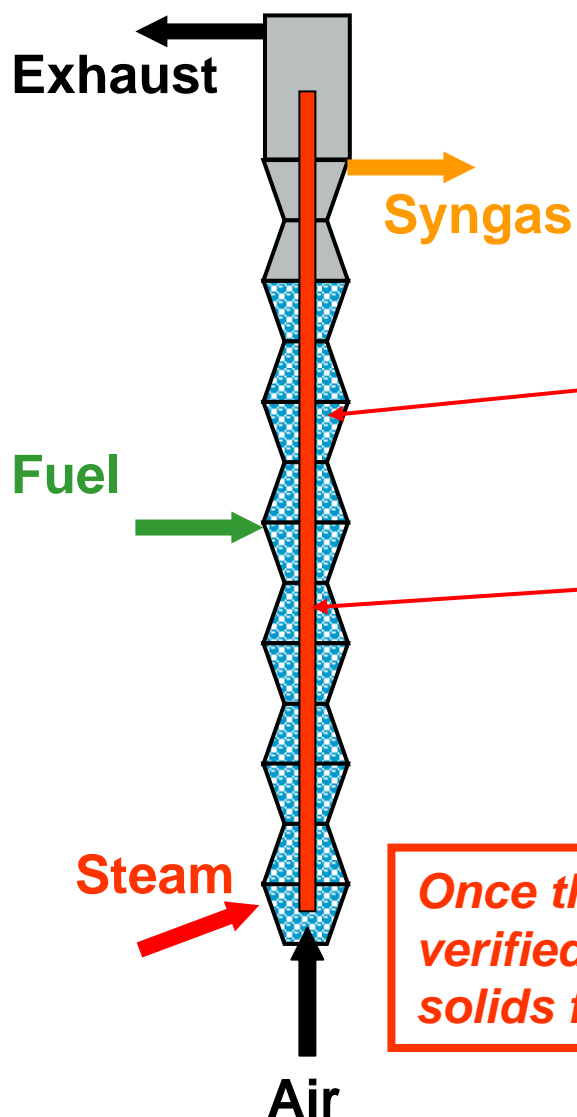


- **Dual-Bed Gasification Concept**

- Inert solids (heat carrier) conveyed up oxidizer tube and cascade down hourglass sections
- Reduction side: Fuel gasified with steam and hot inert solids. Syngas extracted from top
- Oxidation side: Residual carbon combusted with air, heating inert solids
- Separation of oxidizing & reducing zones produces a high quality syngas

A 200 pph gasifier is being assembled at a demonstration site in Spokane County, Washington under the supervision of the USDA – ARS Corvallis. The gasifier will be integrated with a 300kW reciprocating engine to produce power.

Technology Description



- **Dual-Bed Gasification Concept**

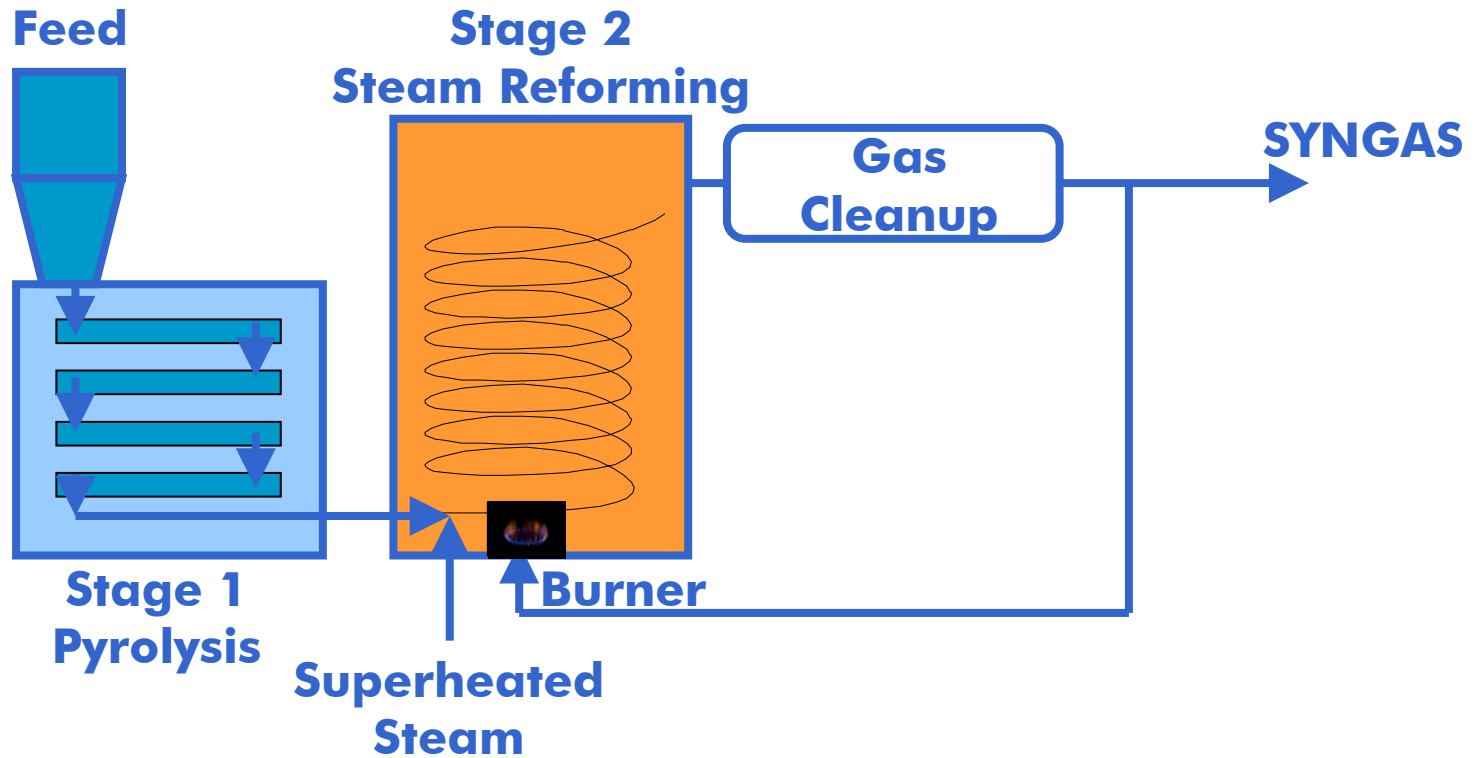
- Inert solids (heat carrier) conveyed up oxidizer tube and cascade down hourglass sections
- Reduction side: Fuel gasified with steam and hot inert solids. Syngas extracted from top
- Oxidation side: Residual carbon combusted with air, heating inert solids
- Separation of oxidizing & reducing zones produces a high quality syngas

Once the mechanical aspects of the technology have been verified, future version might include reactive and/or catalytic solids for low-rank coal gasification applications

- * WRI is developing and testing dual bed-based thermal-looping gasifier designs that do not require expensive oxygen plant to produce medium-Btu syngas for distributed power generation**
- * WRI is developing an indirectly-heated steam pyrolysis system for coal-based F-T synthesis applications**

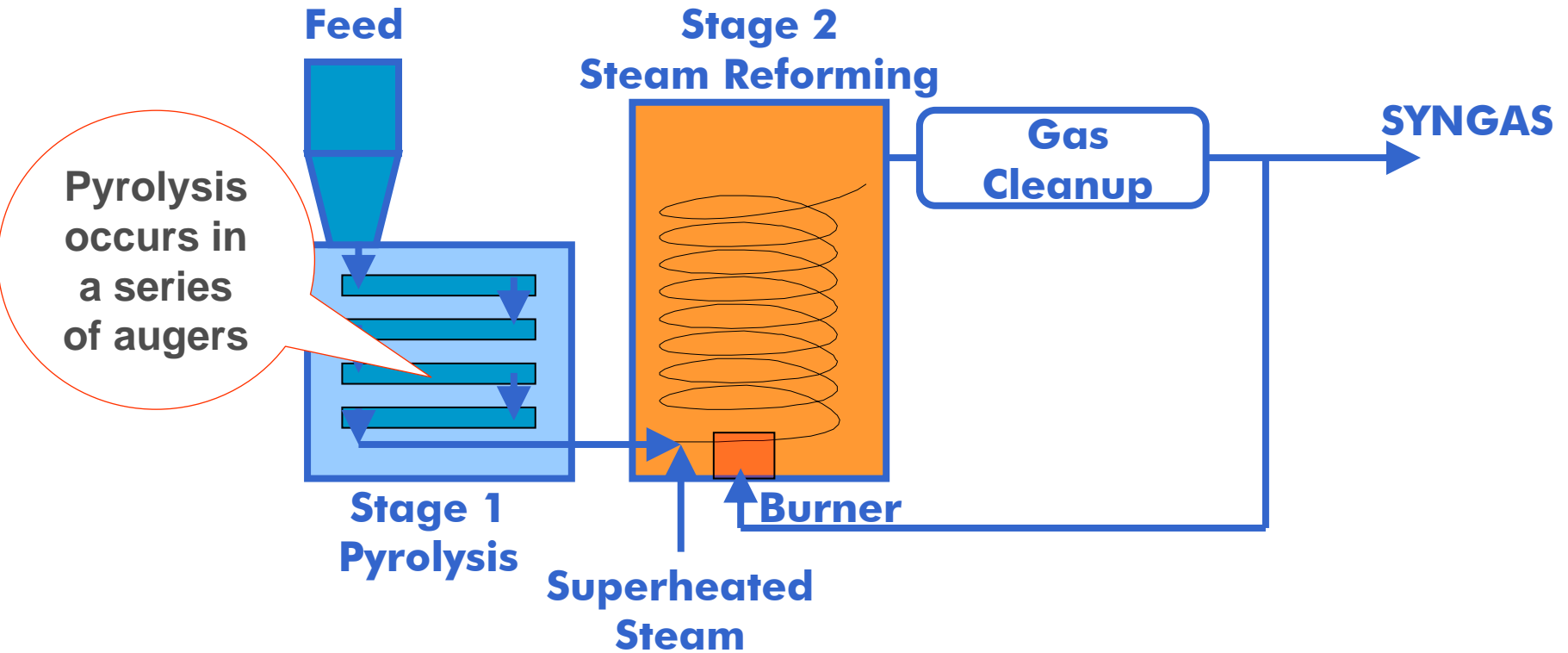
Technology Description

- * A staged, indirectly heated steam pyrolysis-based gasifier which does not require either air or oxygen to produce high quality synthesis gas



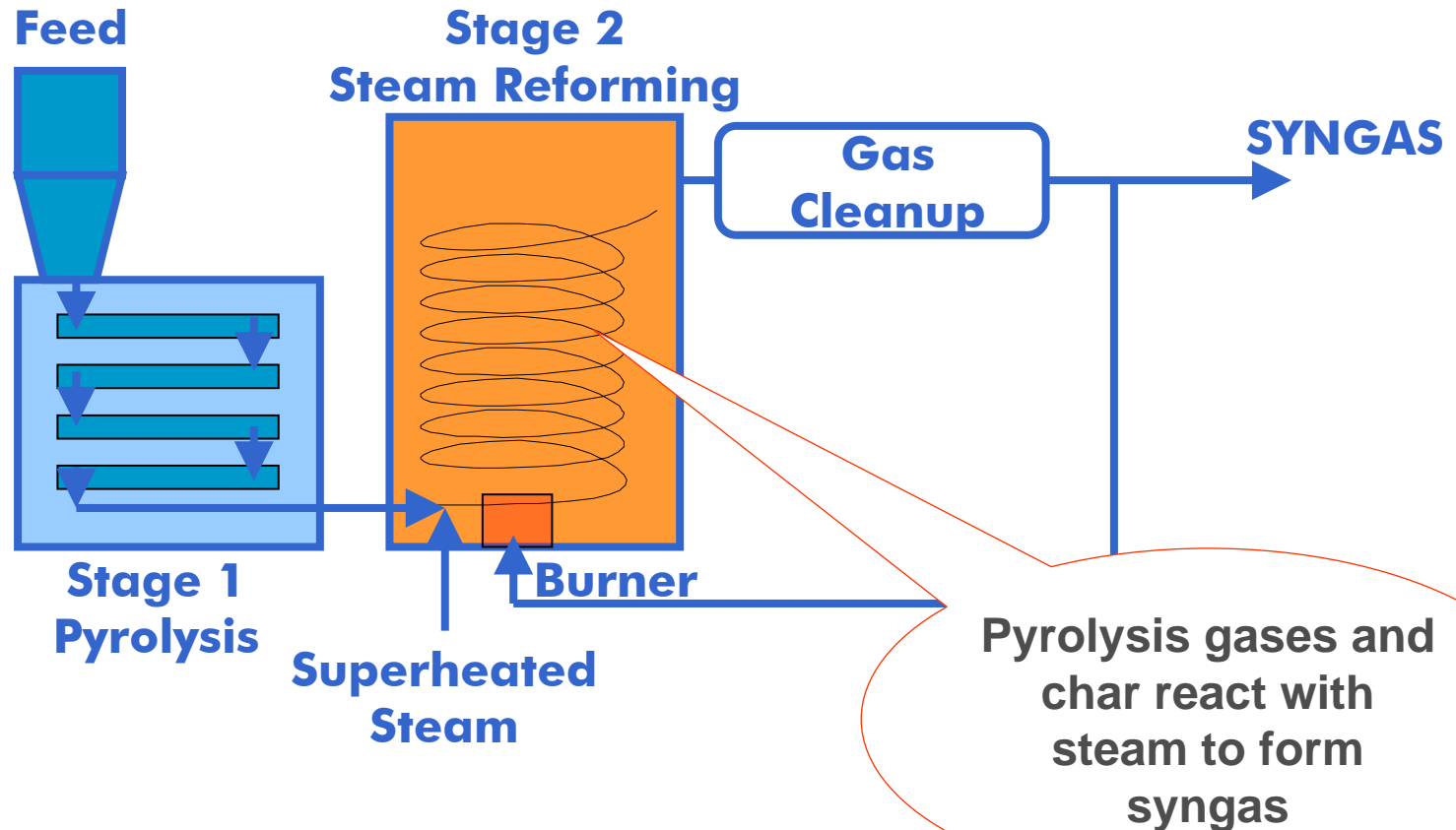
Technology Description

- * A staged, indirectly heated steam pyrolysis-based gasifier which does not require either air or oxygen to produce high quality synthesis gas



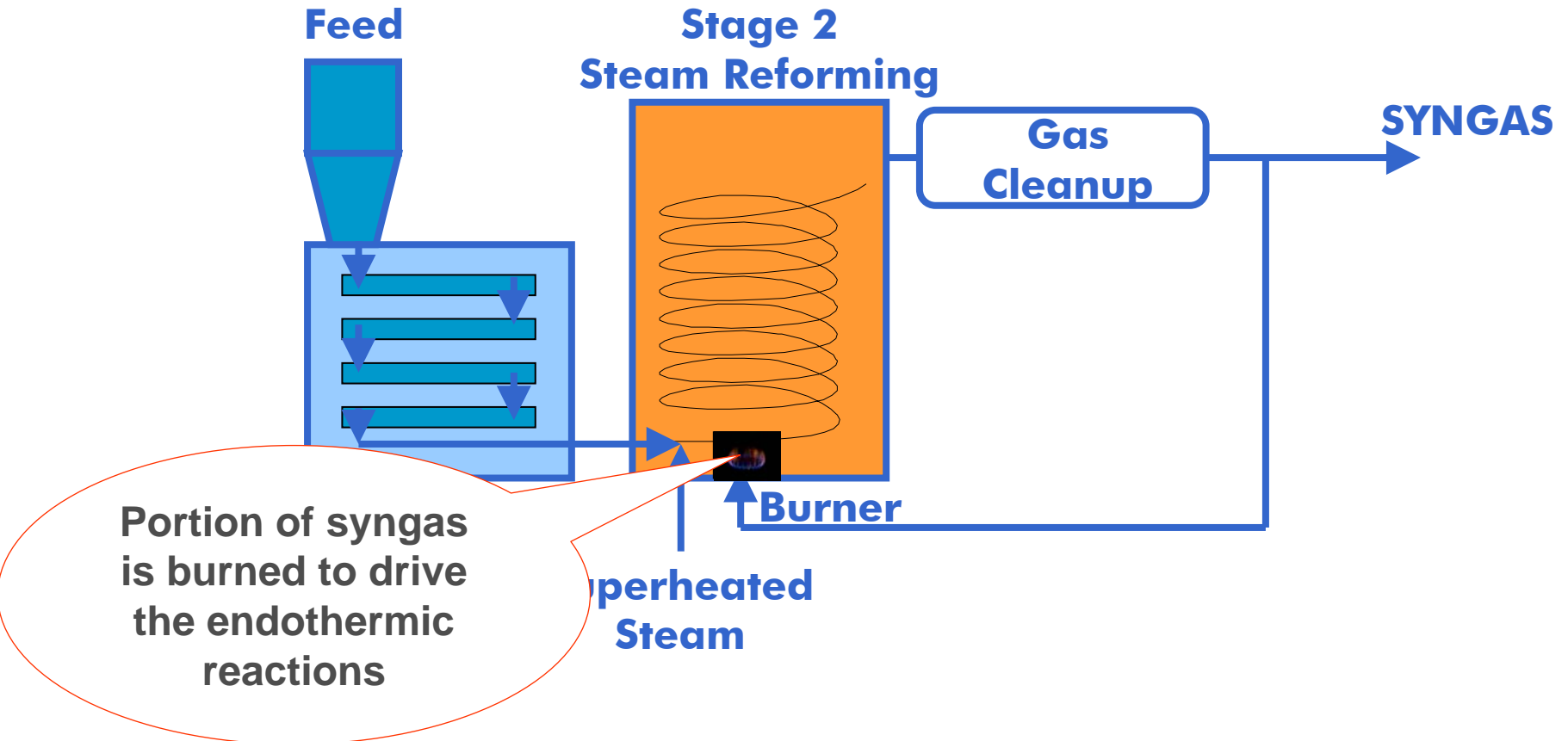
Technology Description

- * A staged, indirectly heated steam pyrolysis-based gasifier which does not require either air or oxygen to produce high quality synthesis gas



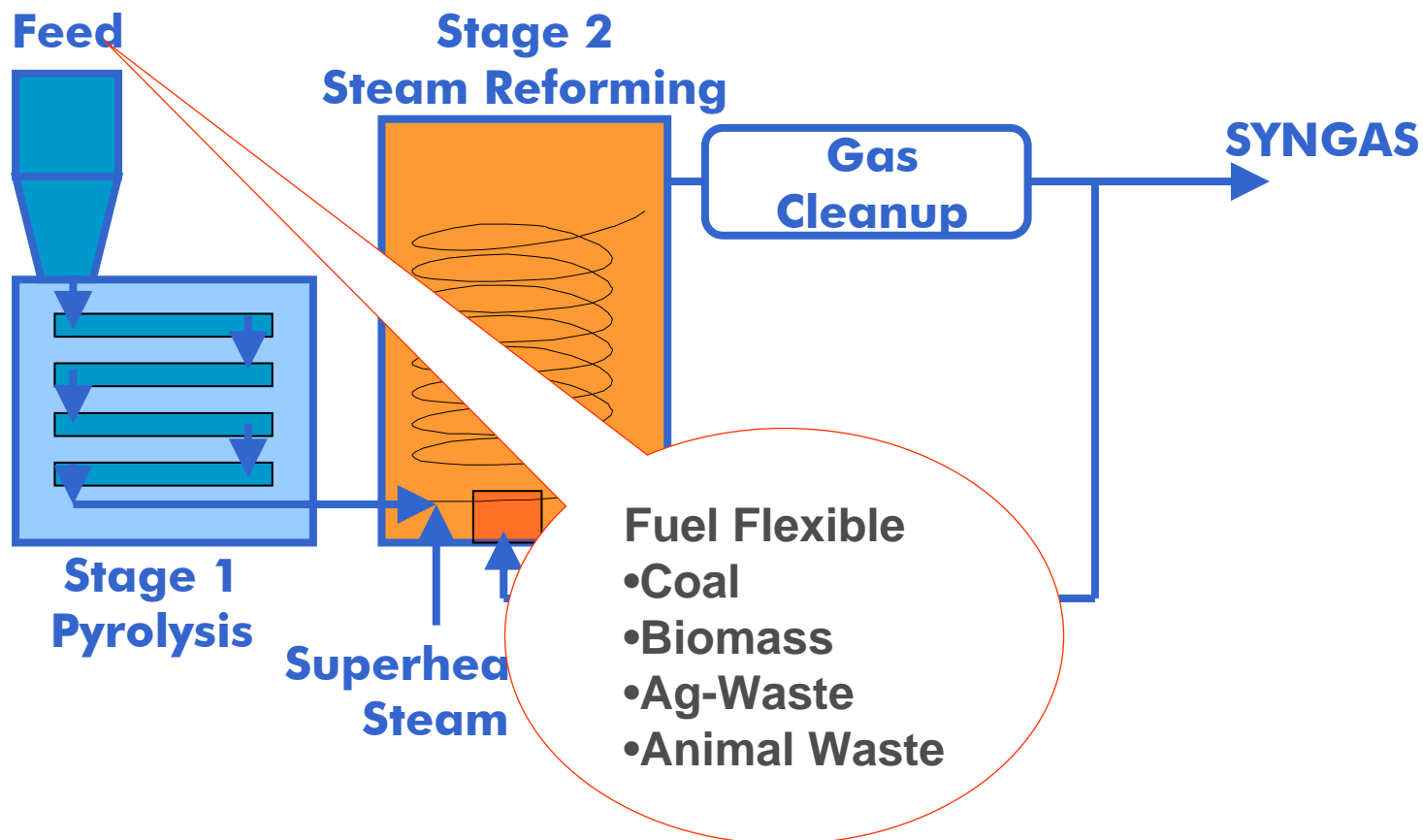
Technology Description

- * A staged, indirectly heated steam pyrolysis-based gasifier which does not require either air or oxygen to produce high quality synthesis gas



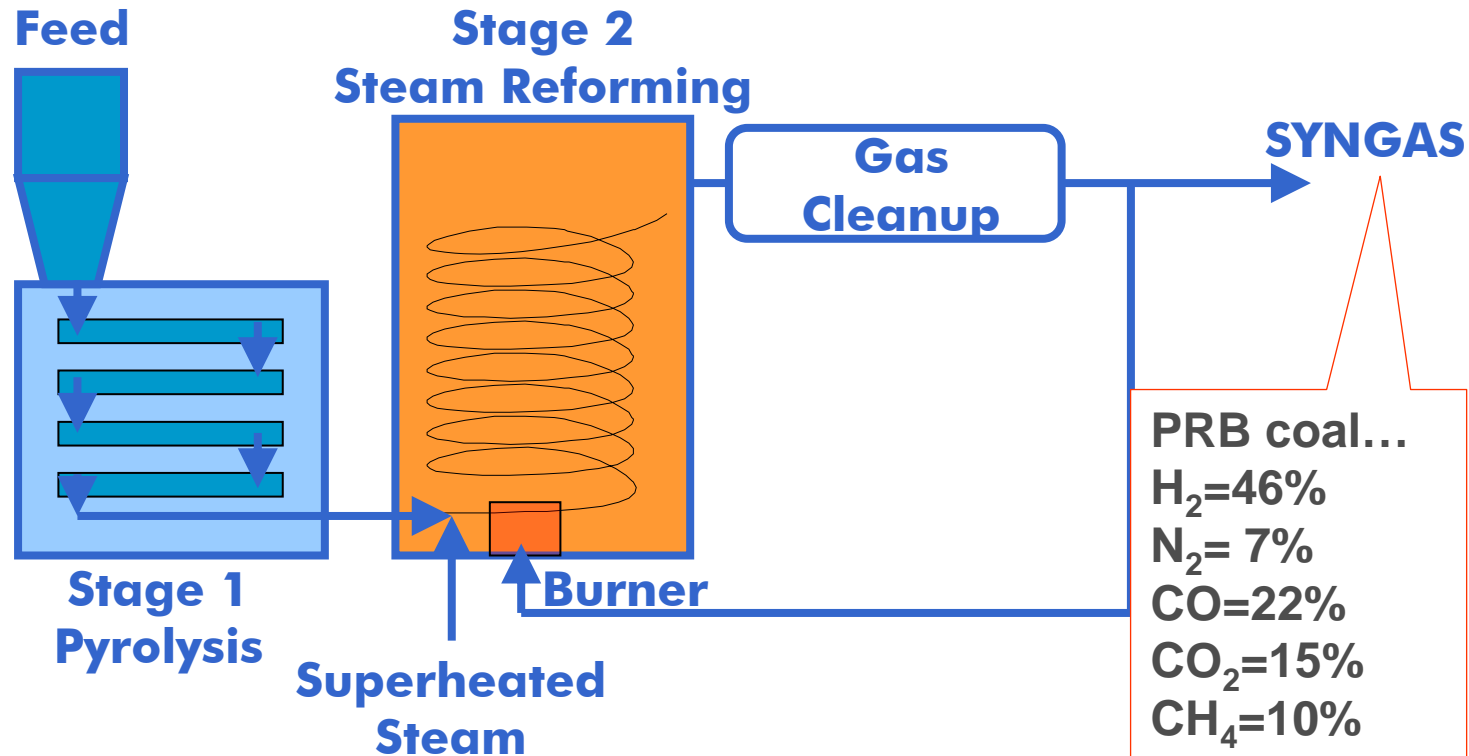
Technology Description

- * A staged, indirectly heated steam pyrolysis-based gasifier which does not require either air or oxygen to produce high quality synthesis gas



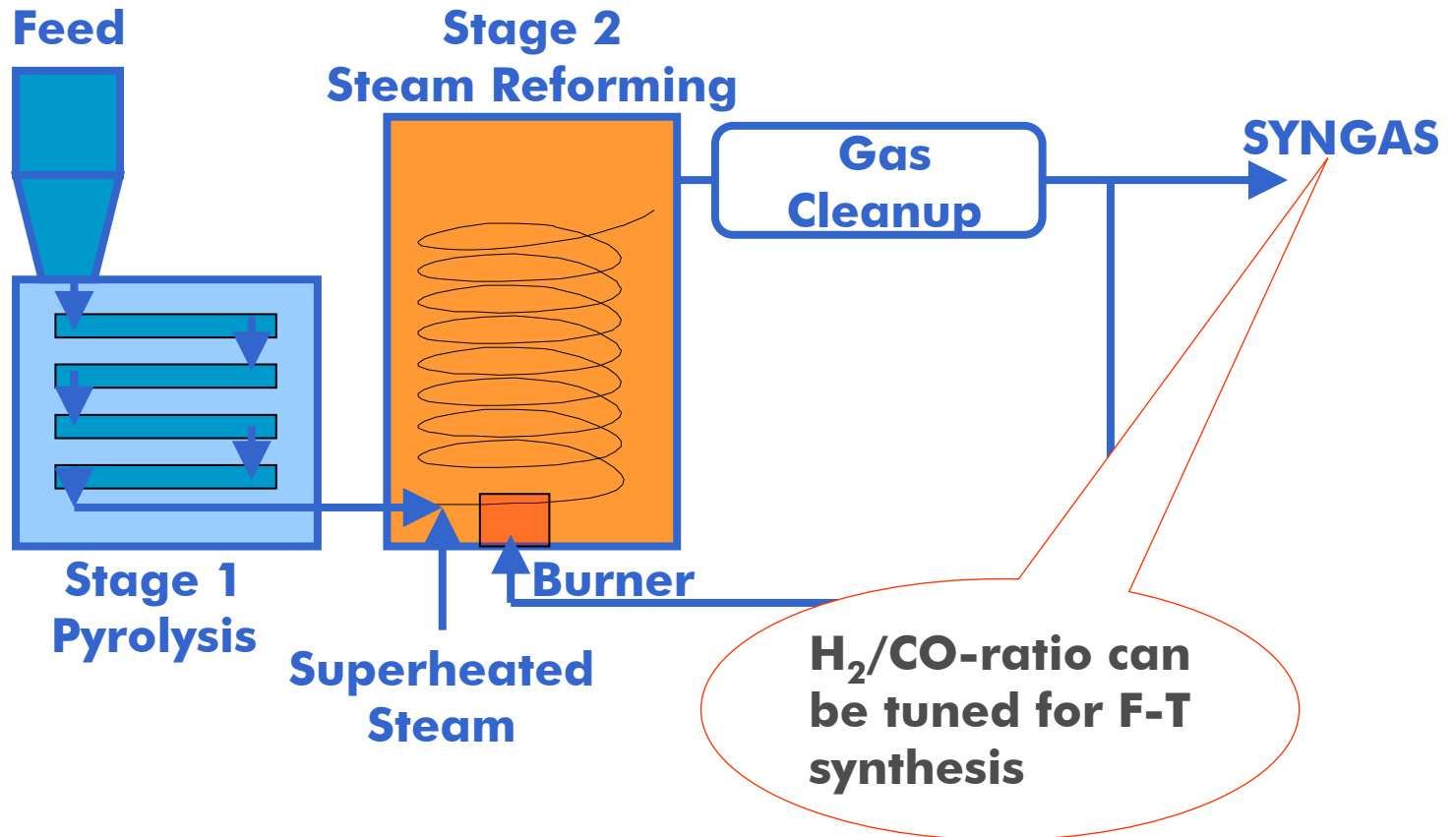
Technology Description

- * A staged, indirectly heated steam pyrolysis-based gasifier which does not require either air or oxygen to produce high quality synthesis gas



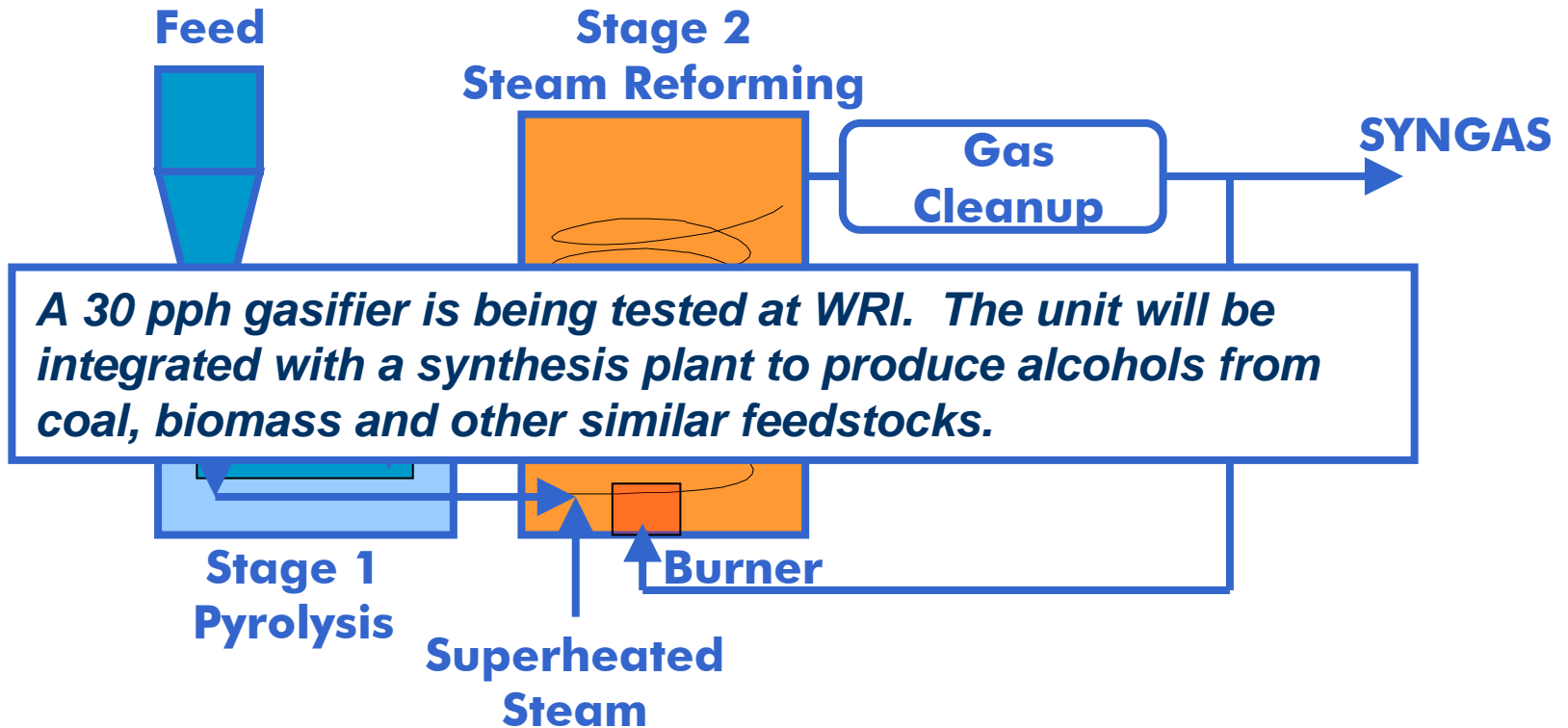
Technology Description

- * A staged, indirectly heated steam pyrolysis-based gasifier which does not require either air or oxygen to produce high quality synthesis gas



Technology Description

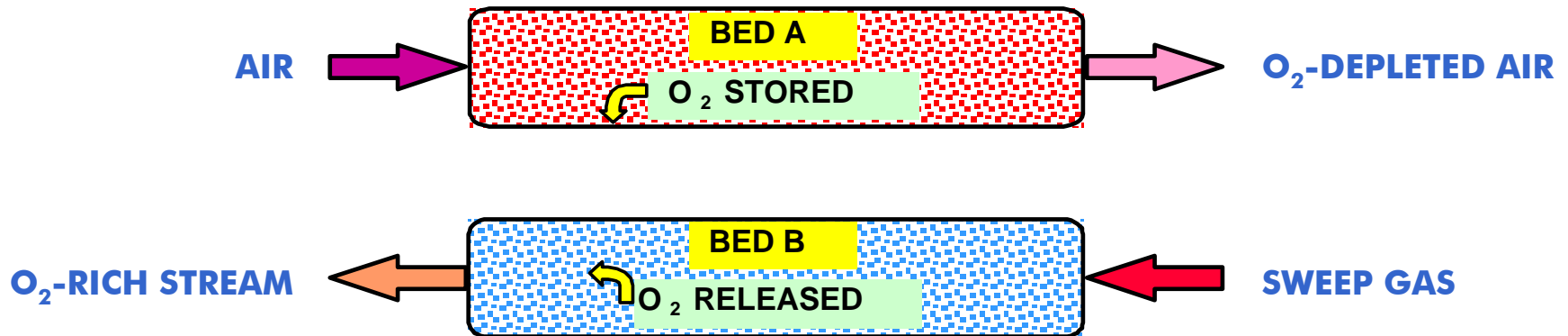
- * A staged, indirectly heated steam pyrolysis-based gasifier which does not require either air or oxygen to produce high quality synthesis gas



- * WRI is developing and testing dual bed-based thermal-looping gasifier designs that do not require expensive oxygen plant to produce medium-Btu syngas for distributed power generation**
- * WRI is developing an indirectly-heated steam pyrolysis system for coal-based F-T synthesis applications**
- * WRI is also developing alternative systems for cheaper oxygen production**

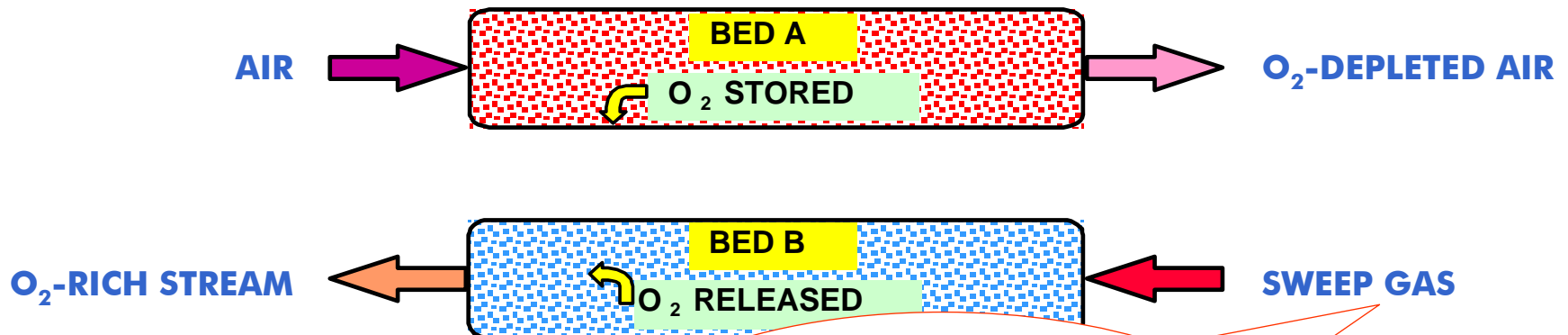
Technology Description

- * Ceramic Autothermal Recovery (CAR) oxygen production process
 - * Uses oxygen “storage” property of perovskites (ABO_{3-x}) at high temperatures



Technology Description

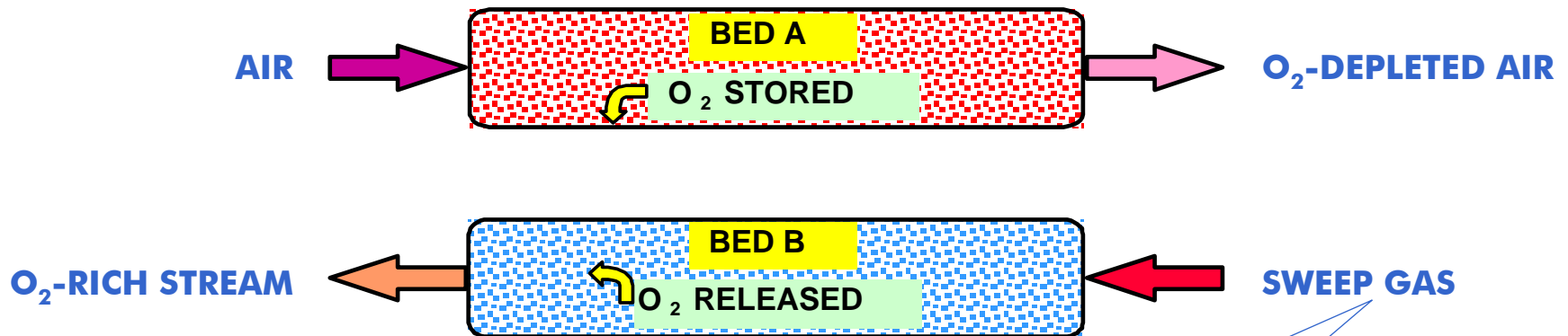
- * Ceramic Autothermal Recovery (CAR) oxygen production process
 - * Uses oxygen “storage” property of perovskites (ABO_{3-x}) at high temperatures



For Oxy-Combustion
sweep gas can be flue
gas replacing N₂ in
air with CO₂

Technology Description

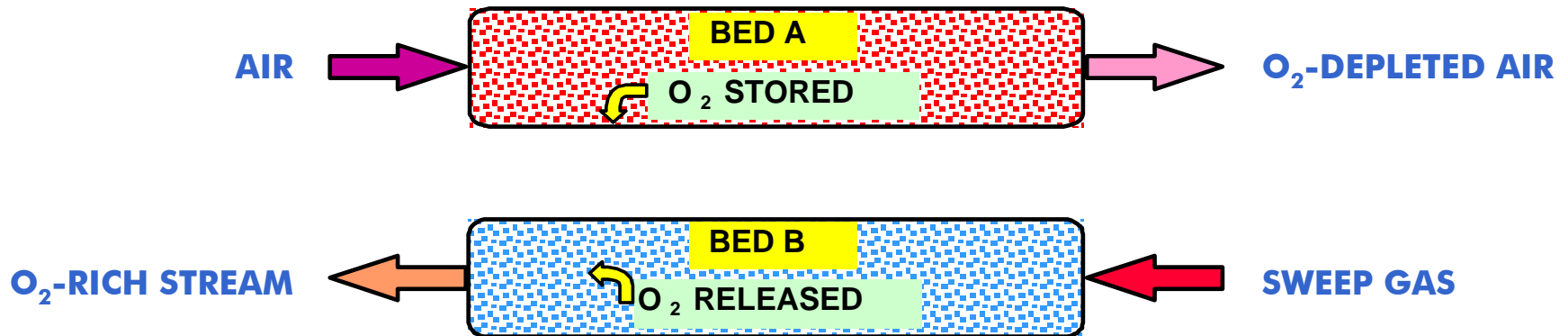
- * Ceramic Autothermal Recovery (CAR) oxygen production process
 - * Uses oxygen “storage” property of perovskites (ABO_{3-x}) at high temperatures



For Gasification sweep gas can be steam

Technology Description

- * **Ceramic Autothermal Recovery (CAR) oxygen production process**
 - * Uses oxygen “storage” property of perovskites (ABO_{3-x}) at high temperatures
 - * Cost of oxygen from CAR is expected to be 30-40% lower than from cryogenic air separation



A two-bed, 60-pph CAR unit is being tested at WRI. The unit will be integrated with an existing 250,000 Btu/h Combustion Test Facility to demonstrate oxy-fuel combustion concepts.

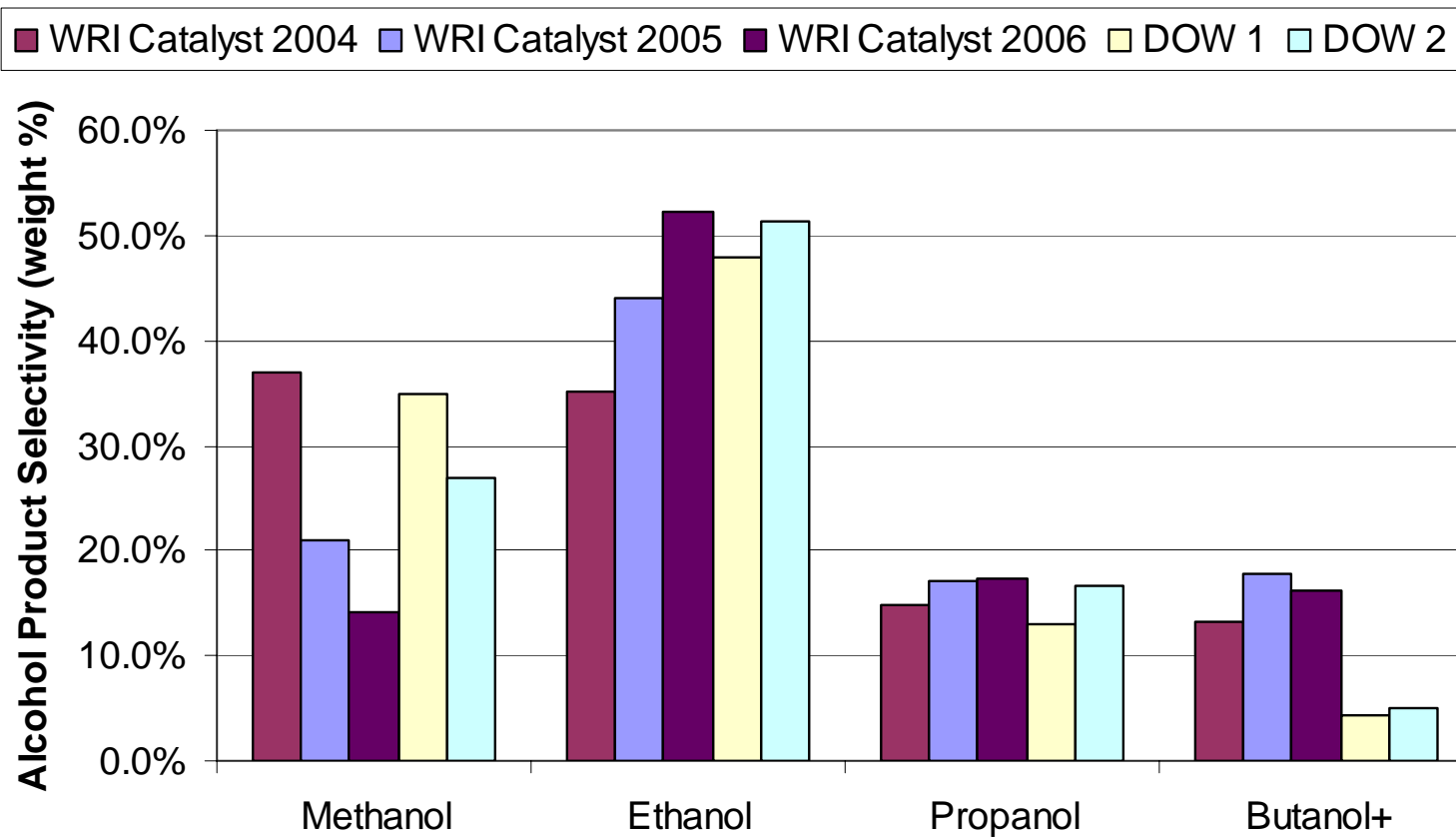
- * About six years ago, WRI began the development of indirect coal conversion technologies with the ultimate goal of producing transportation grade fuel for automotive applications.**
- * We elected to pursue synthesis of mixed alcohols over conventional F-T because alcohols as a gasoline additive offer a quicker way to get coal into the fuel tanks.**

WRI has developed a new catalyst formulation for the synthesis of alcohols

- **New catalyst is cheaper than Rh-based formulations**
- **New catalyst exhibits superior activity and product selectivity when compared to the Co-promoted MoS₂-based formulations**
- **New catalyst does not contribute to sulfur contaminants in the product**



Improved Catalysts for Alcohol Synthesis



WRI has developed a new catalyst formulation for the synthesis of alcohols

- **New catalyst is cheaper than Rh-based formulations**
- **New catalyst exhibits superior activity and product selectivity when compared to the Co-promoted MoS₂-based formulations**
- **New catalyst does not contribute to sulfur contaminants in the product**
- **Licensing and co-development negotiations for biogas and biomass applications are underway**

A 50-gpd pilot plant is in its final design phase. The unit will be first operated with NG and then integrated with a coal gasifier to demonstrate the integrated alcohol synthesis technology.



- * Emissions of hazardous air pollutants such as mercury from syngas can easily be controlled provided we cool the gases for cleanup**
- * Cooling however means loss in overall efficiency**

For warm-gas cleanup, there are two scenarios...

- * Pre- gasification removal from the coal**
- * Post-gasification capture from the syngas**

WRI is developing technology for both scenarios.

WRI is developing and testing coal upgrading technologies which remove mercury before coal is combusted or gasified

- * WRI's patented two-stage mercury removal technology was recently selected by DOE for further development
- * WRI is also working with clients in testing their technologies that upgrade low-rank coals while concomitantly remove trace contaminants

For warm-gas capture from syngas, WRI is pursuing development and testing of low-cost non-carbon sorbents.

Gasification Residue Management

- * Solid residue from gasifiers must be managed to protect the environment and preferably qualified for beneficial uses.**
- * Prior work has demonstrated that the slag from certain gasifiers can be used as lightweight aggregate.**



Photo of gasifier residue in concrete

WRI and UW are working with an IGCC developer to ensure that the residue if disposed in a landfill will be compatible with both the clay and geo-synthetic liners.

Testing at WRI also indicates that residue can be used in construction applications, such as structural fills

Meaning and Current Status:

Gasification offers...

- ✓ **Fuel and product flexibility**
- ✓ **Environmentally superior**
- ✓ **High efficiency**
- ✓ **Sequestration ready**
- ✓ **Uses less water**

Yet,

- ✗ **Utilities are not sold on the idea of operating chemical plants**
- ✗ **Public does not appear to be in favor of increased coal use**
- ✗ **Technology developers have little or no experience with Wyoming low-rank coals, and**
- ✗ **Our advantage of having a “less-dirty” coal is lost!**

Means, we have a lot of work to do...

Questions?

Western Research
I N S T I T U T E