

Update on Oxy-fuel Combustion System Design for Natural Gas-fired Power Plants

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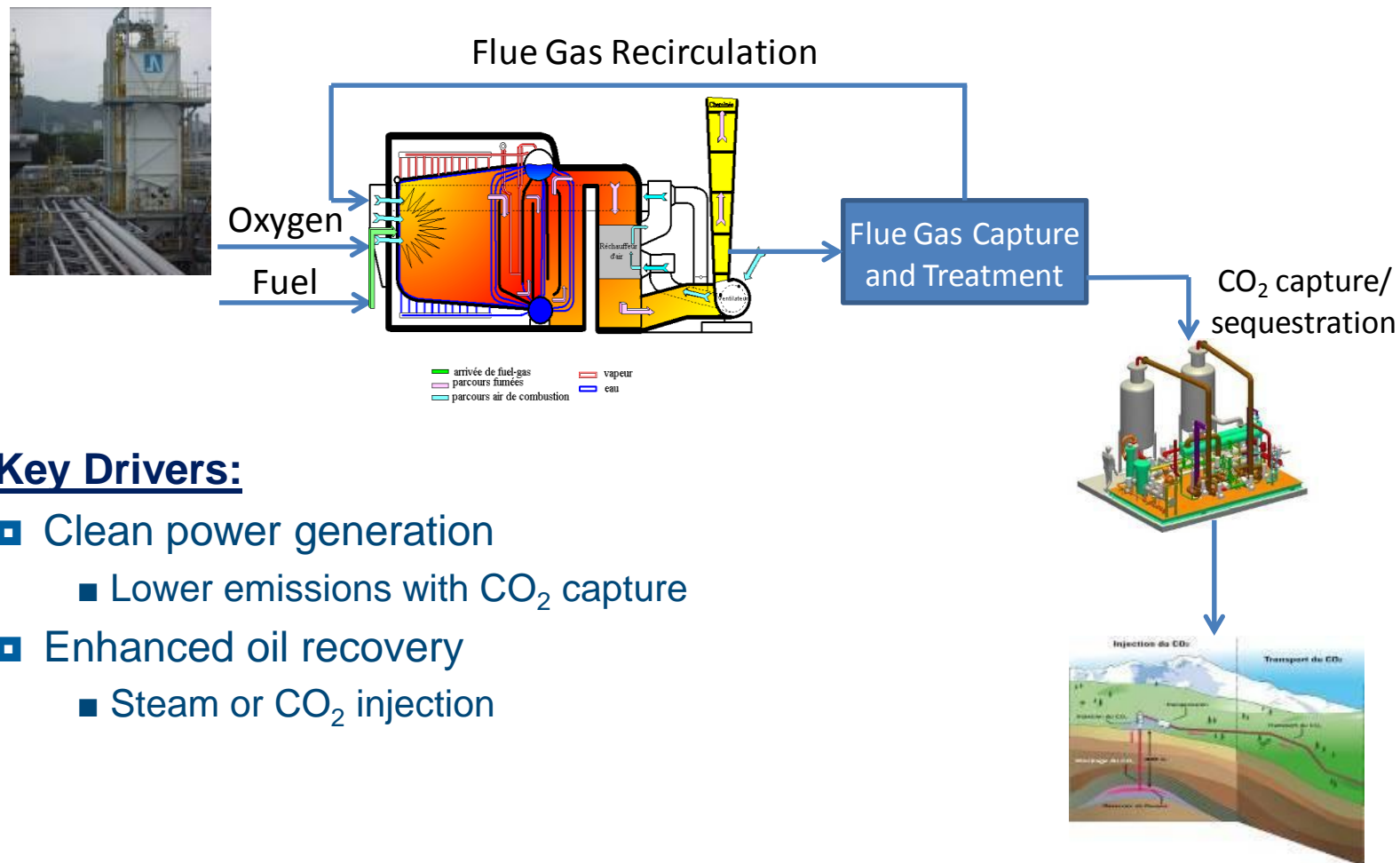
McIlvaine Company Hot Topic Hour
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Overview

- Oxy-fuel Combustion Process with FGR
- Current Activities at Air Liquide
- Recent Developments
 - Burner Design
 - Combustion System Optimization
- Challenges Ahead

Oxy-fuel Combustion Process Overview

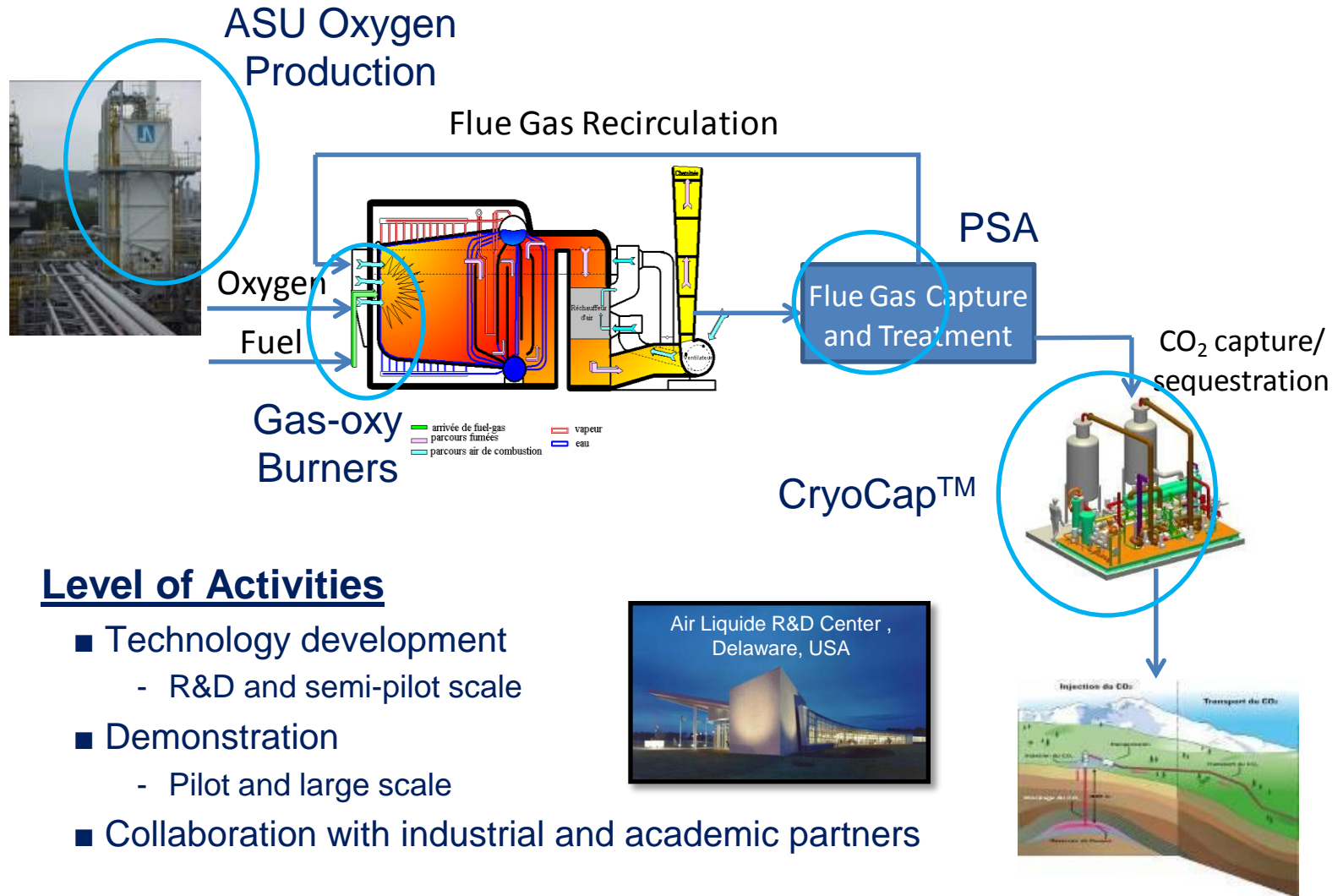
- Oxy-fuel combustion process with flue gas recirculation



Key Drivers:

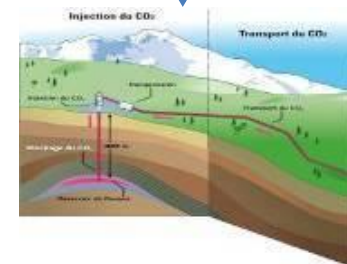
- Clean power generation
 - Lower emissions with CO₂ capture
- Enhanced oil recovery
 - Steam or CO₂ injection

Activities at Air Liquide



Level of Activities

- Technology development
 - R&D and semi-pilot scale
- Demonstration
 - Pilot and large scale
- Collaboration with industrial and academic partners



Oxy-fuel Combustion – Key Challenges

- Design considerations
 - Operational requirement
 - Oxy only or Oxy with air back up
 - Emission levels
- Burner design
 - Flame stability
 - Control of heat flux distributions
 - Optimization of pollutant emission levels
- Combustion system operation
 - Air, oxygen, or any combination
 - Optimization of flue gas recirculation
 - Integration with other components



Large-scale oxy flame, Farzan et al. (2008)



Pilot-scale oxy flames (air mode), Marcano et al. (2011)

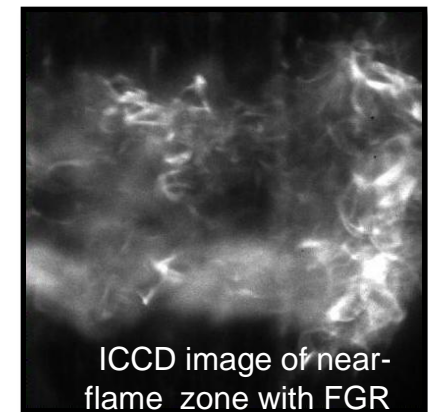
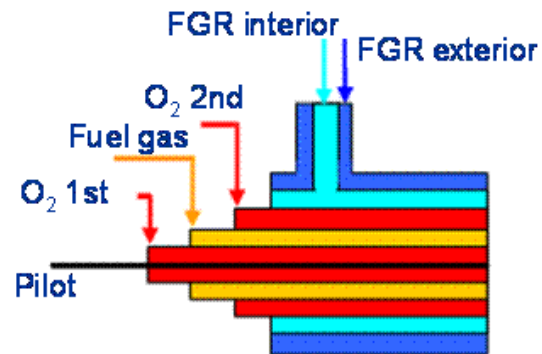
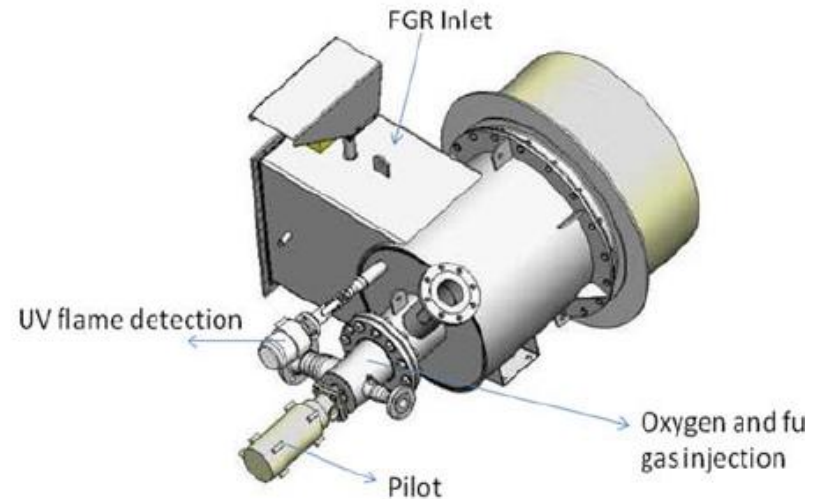
Experimental Test Facilities



- Major R&D Centers for Combustion:
 - CRCD – France, DRTC – USA
 - 1 MW and 6 MW test boilers
- Burner operations up to 6 MW with closed-loop heat extraction
- Flue gas capture, treatment and recirculation
- Flexible fuel options with full oxy to any level oxy-enrichment tests
- Fully integrated, automated test facility

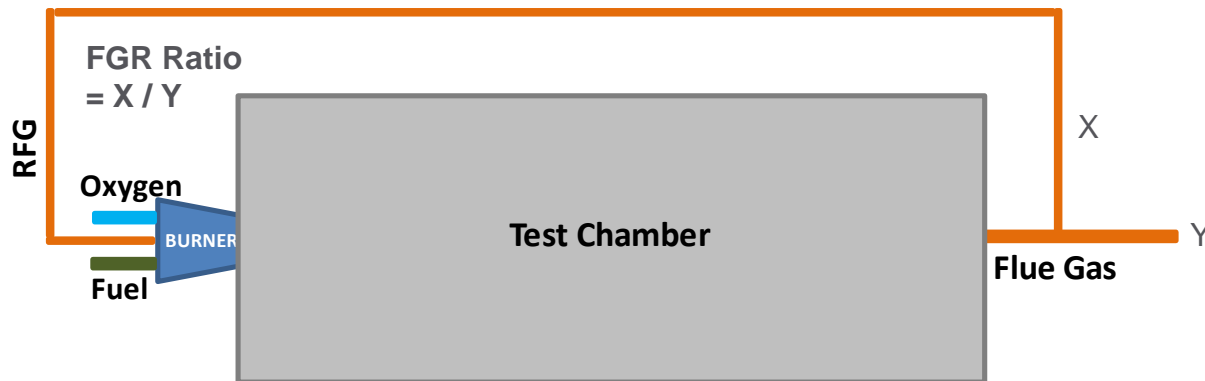
Developments in Gas Oxy Burner

- No Oxygen-FGR premixing
- Control of FGR and oxygen injection to burner
- Flexible start-up in oxygen or air mode
- Ultra-low NOx design
- Matched heat transfer profile



Combustion System Operation

- Start-up in oxy or air mode; Heat-up FGR lines
- Initiate flue gas recirculation to burner and attain stable flame
- Adjust FGR ratio by controlling:
 - Flame stability
 - O₂ content in flue gas
 - CO level



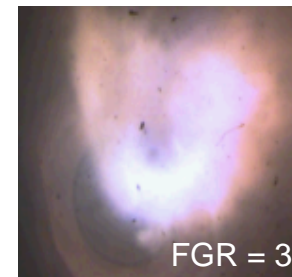
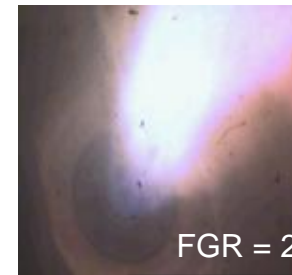
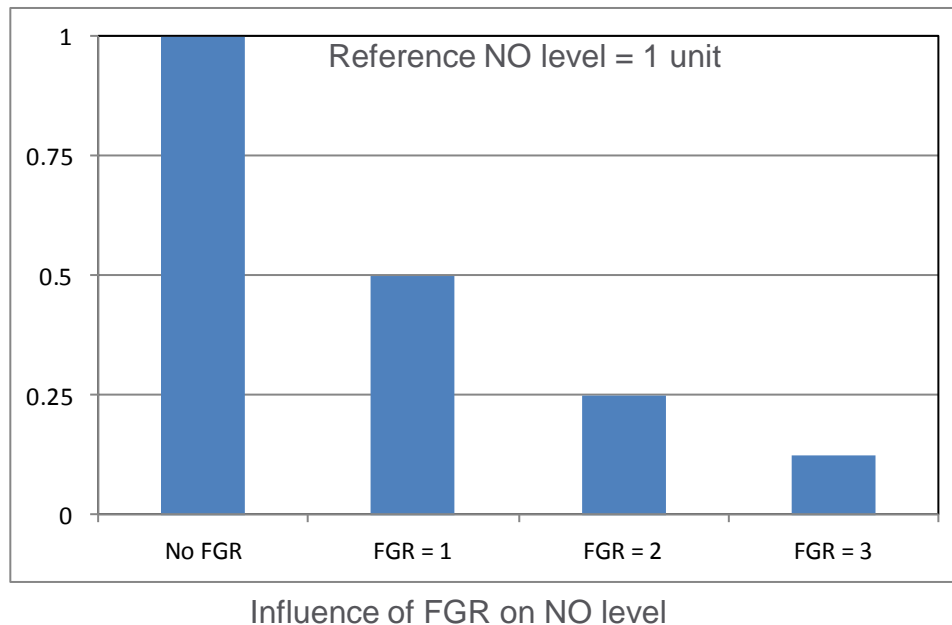
Influence of Flue Gas Recirculation Ratio

■ FGR impacts:

- Flame stability
- NO emission level
- Load on related systems

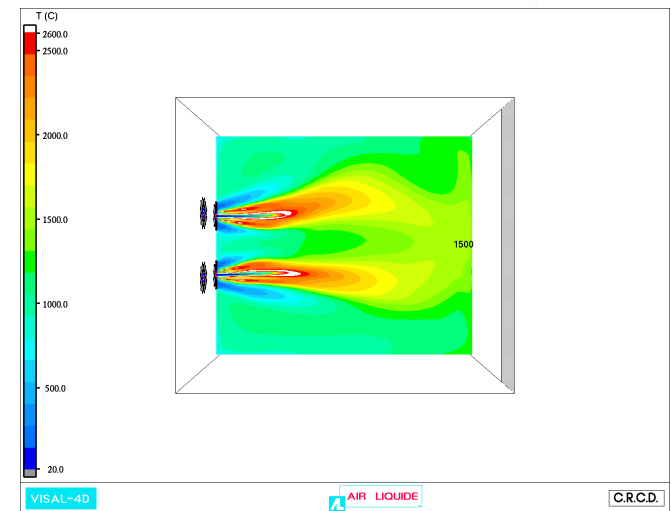
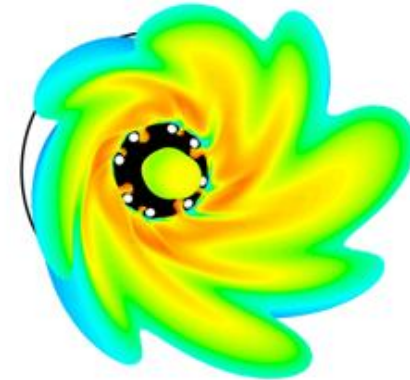
Air or Oxy mode also influences the selection of FGR ratio!

■ Significant decrease noticed in NO at higher FGR



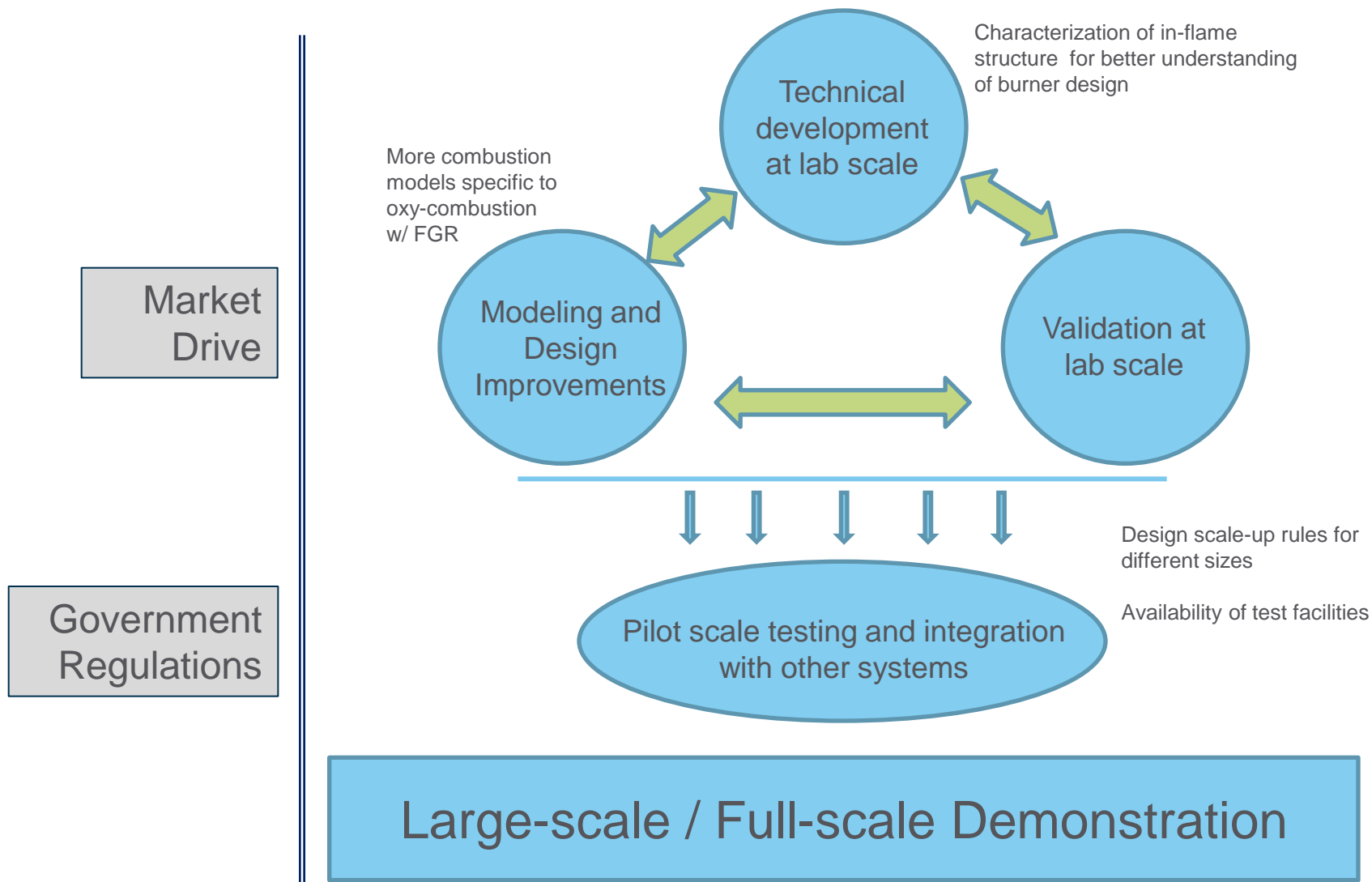
Developments in Computer Modeling

- Specific to oxy-combustion
- Fine-tuned with experimental data
- Our approach:
 - Develop and validate models at lab scale and intermediate scale
 - Use the model for scale-up to pilot scale and full scale designs
 - Provides confidence to our design



Simulation results of gas-oxy burners for Lacq pilot

Challenges Ahead





Thank you for your attention