Flue-Gas Water as a Resource for Carbon-Capturing Power-Plants

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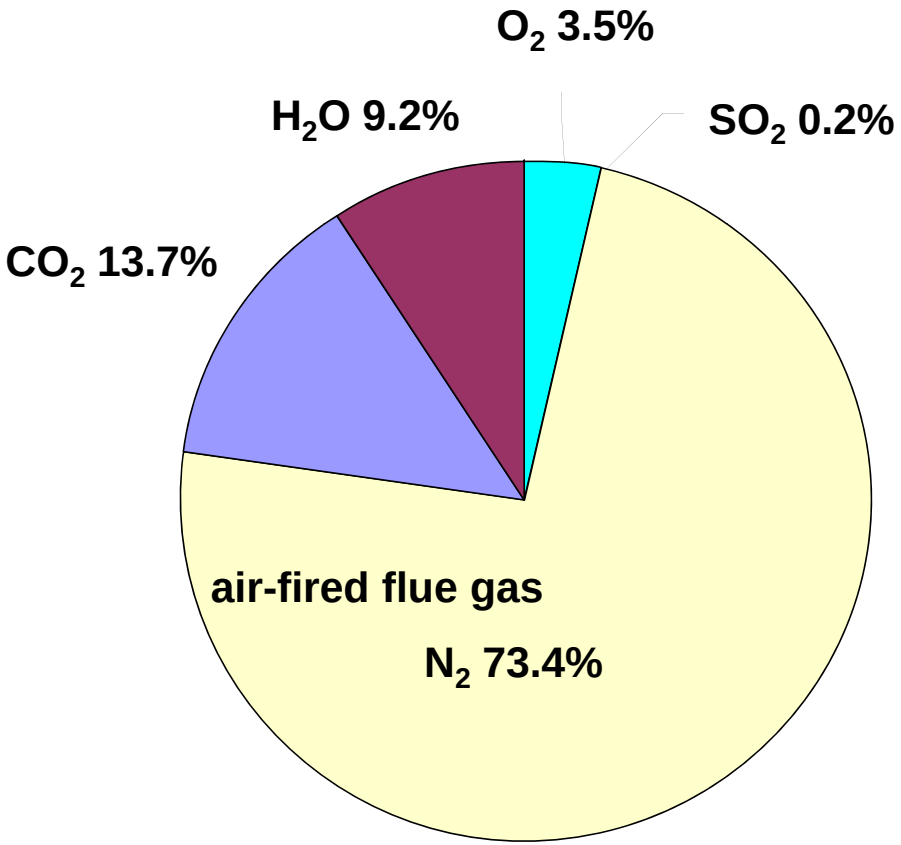
Basic Process Outline

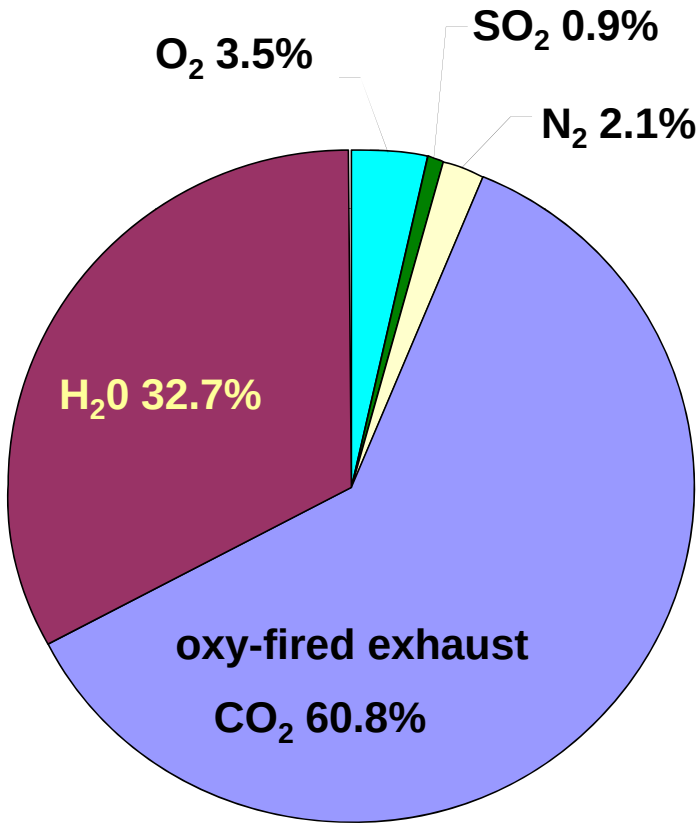
- Combust fuel in directly-supplied (not air-carried) oxygen.
  - Undiluted products of combustion
- Capture combustion products to capture the CO_2 component
- Cooling and compression (part of the capture process) produce condensed flue-gas water

Combustion Products

air-firing



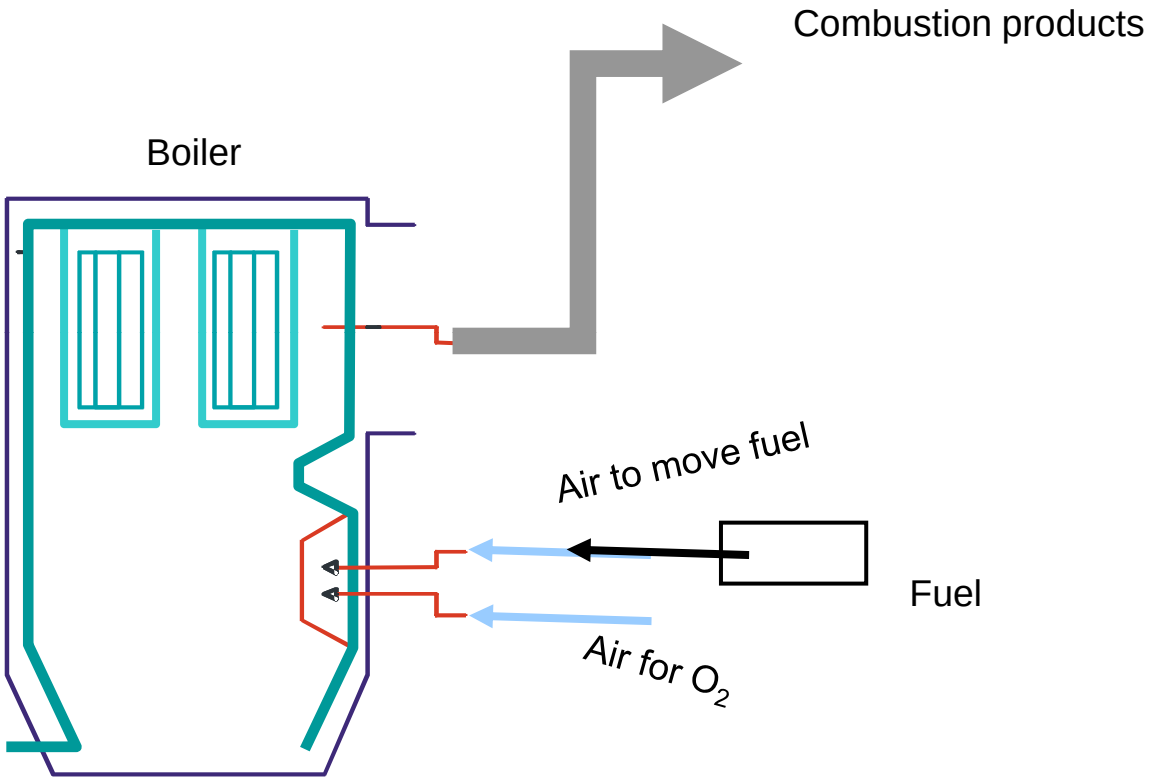
oxy-firing



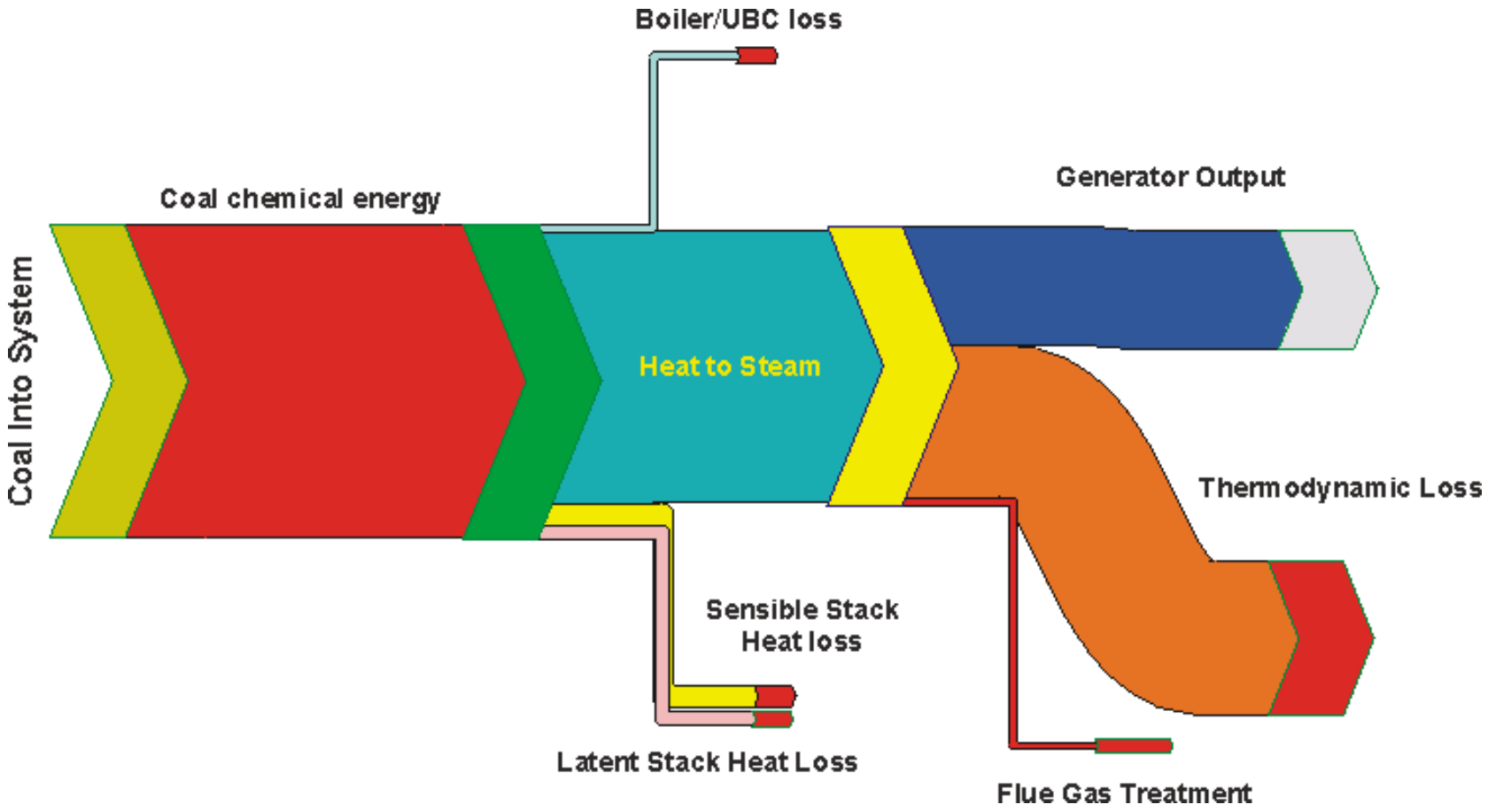
Water/energy: The Oxy-Combustion with **I**ntegrated **P**ollutant **R**emoval (IPR) effort

- Water previously released to the atmosphere now presents a resource
  - Energy (heat recovery)
  - Heat-exchange medium
  - Combustion-optimization (completion of combustion)

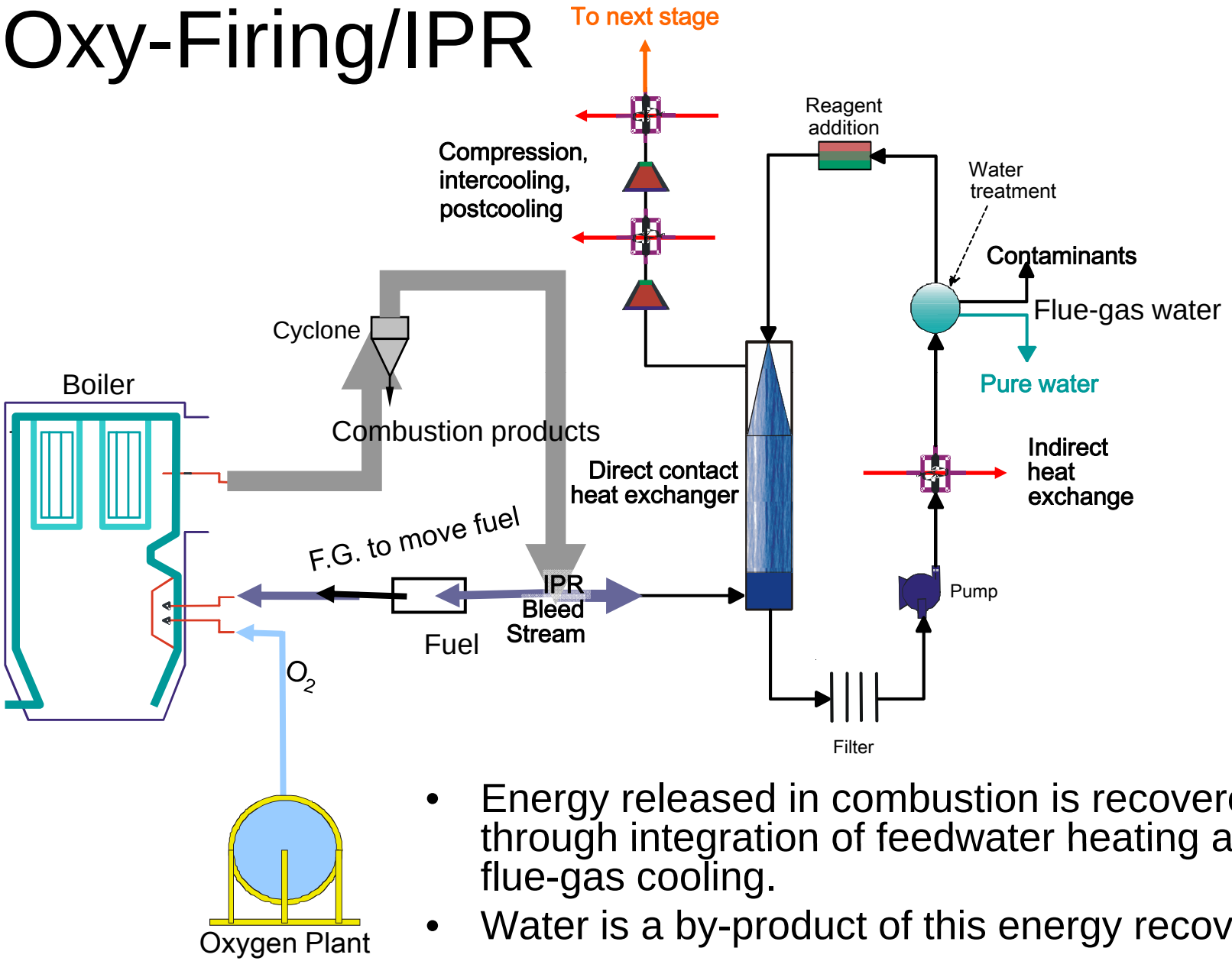
Air-Firing



Air-Firing

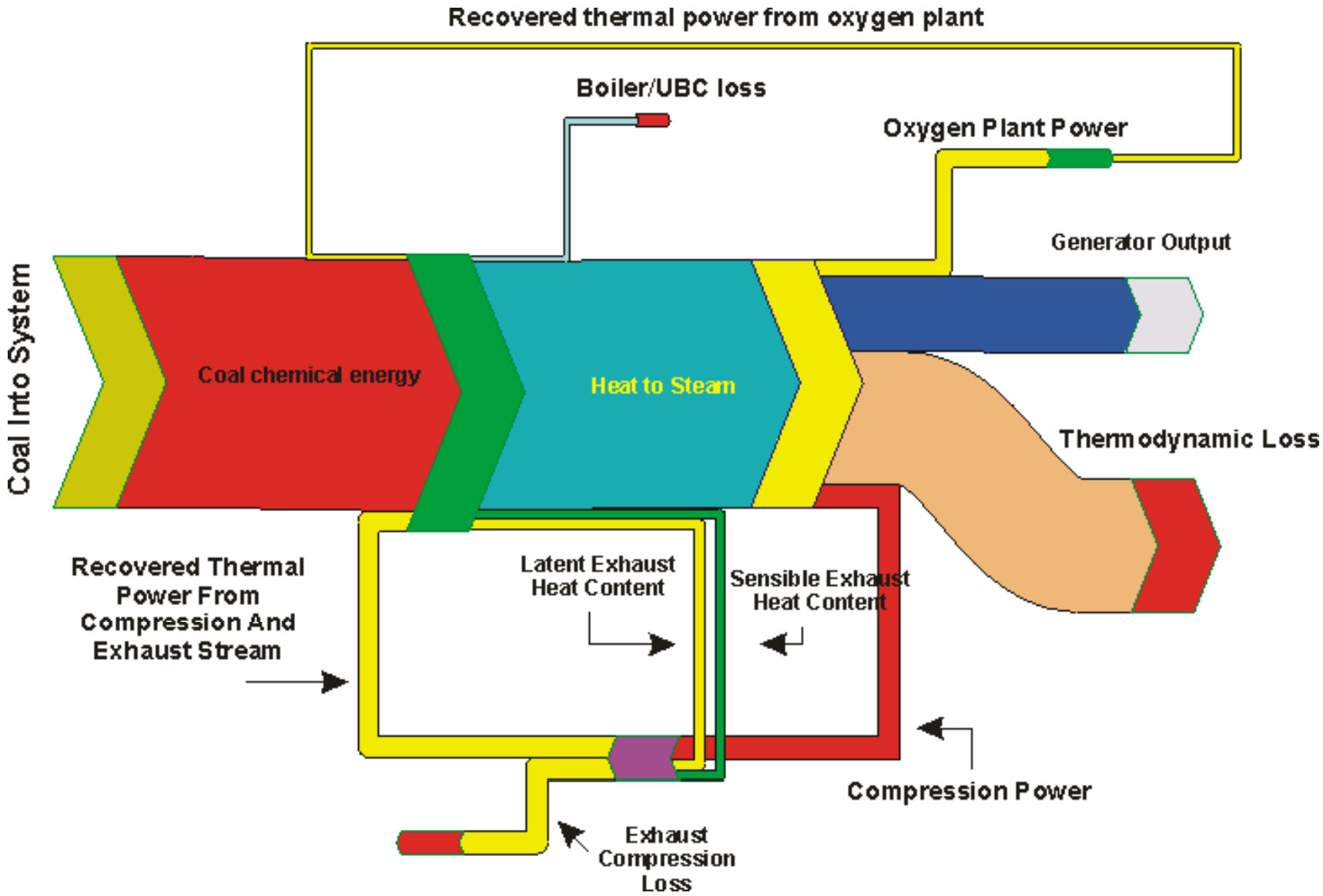

Boiler/UBC loss
Coal chemical energy
Generator Output
Coal Into System
Heat to Steam
Thermodynamic Loss
Sensible Stack
Heat loss
Latent Stack Heat Loss
Flue Gas Treatment

Oxy-Firing/IPR

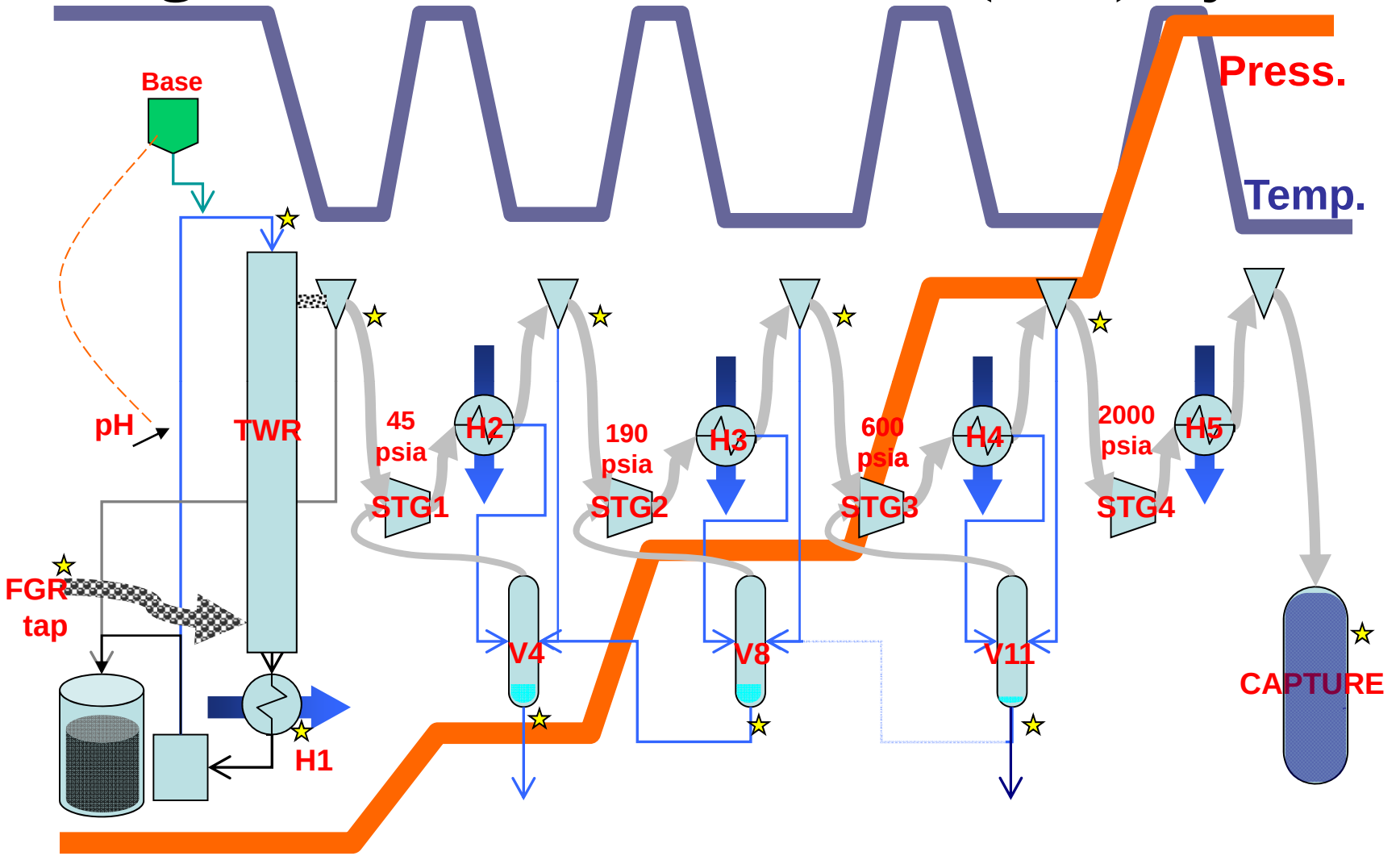


- Energy released in combustion is recovered through integration of feedwater heating and flue-gas cooling.
- Water is a by-product of this energy recovery.

Oxy-Firing/IPR



Integrated Pollutant Removal (IPR) System



Water Opportunities

- Pollutants that now interact with atmospheric water are capturable from point-source liquid water
- Correctly applying recovered energy and water within the thermal cycle can maximize fuel efficiency (more fully using the energy entering with the fuel)
- Flue-gas water massflow offsets massflow of water required for thermal power production

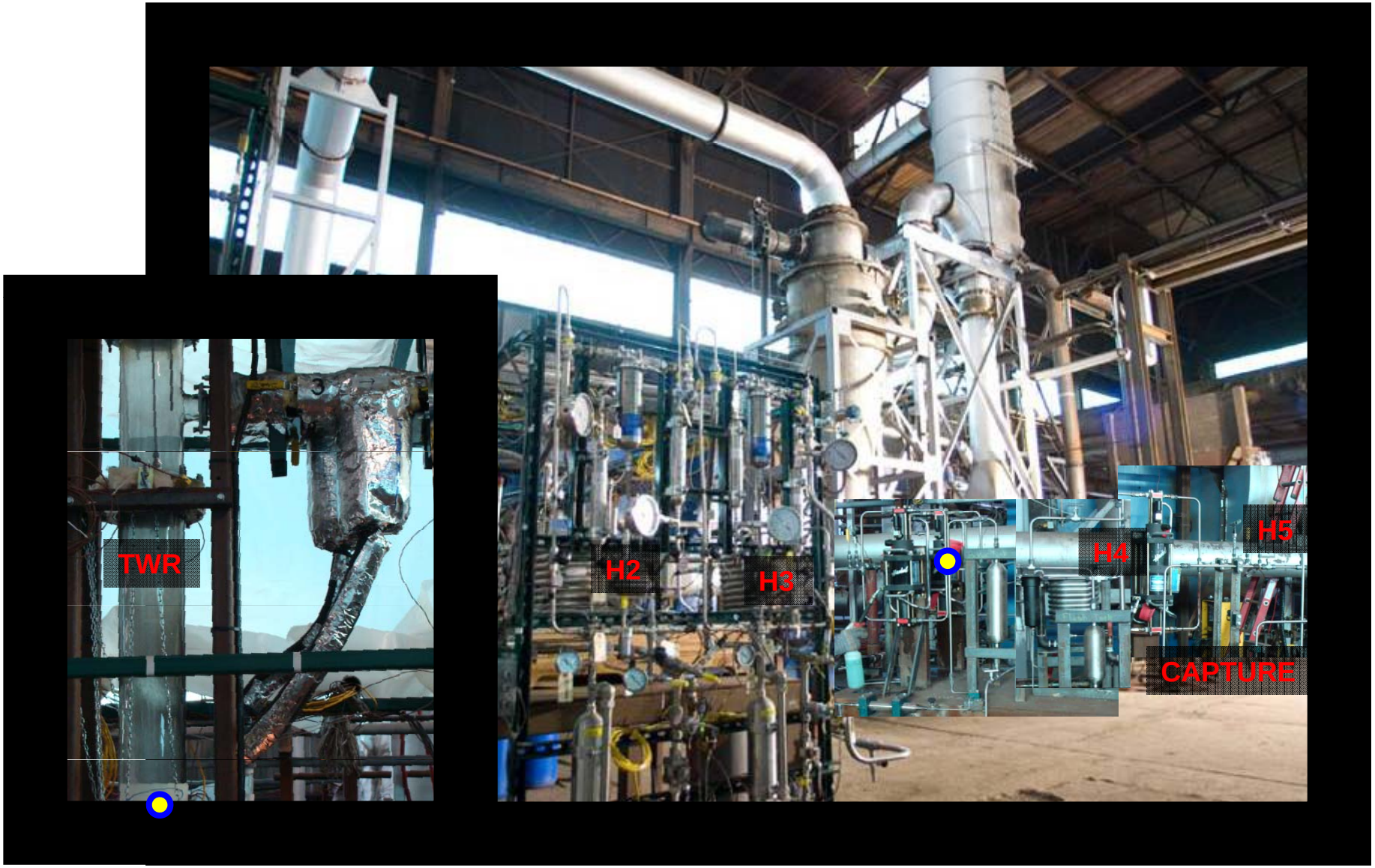
Questions for research

- Highly-efficient purification processes for released water
- Optimal full-use applications for recovered water
- Economic opportunities for material recovered during water purification

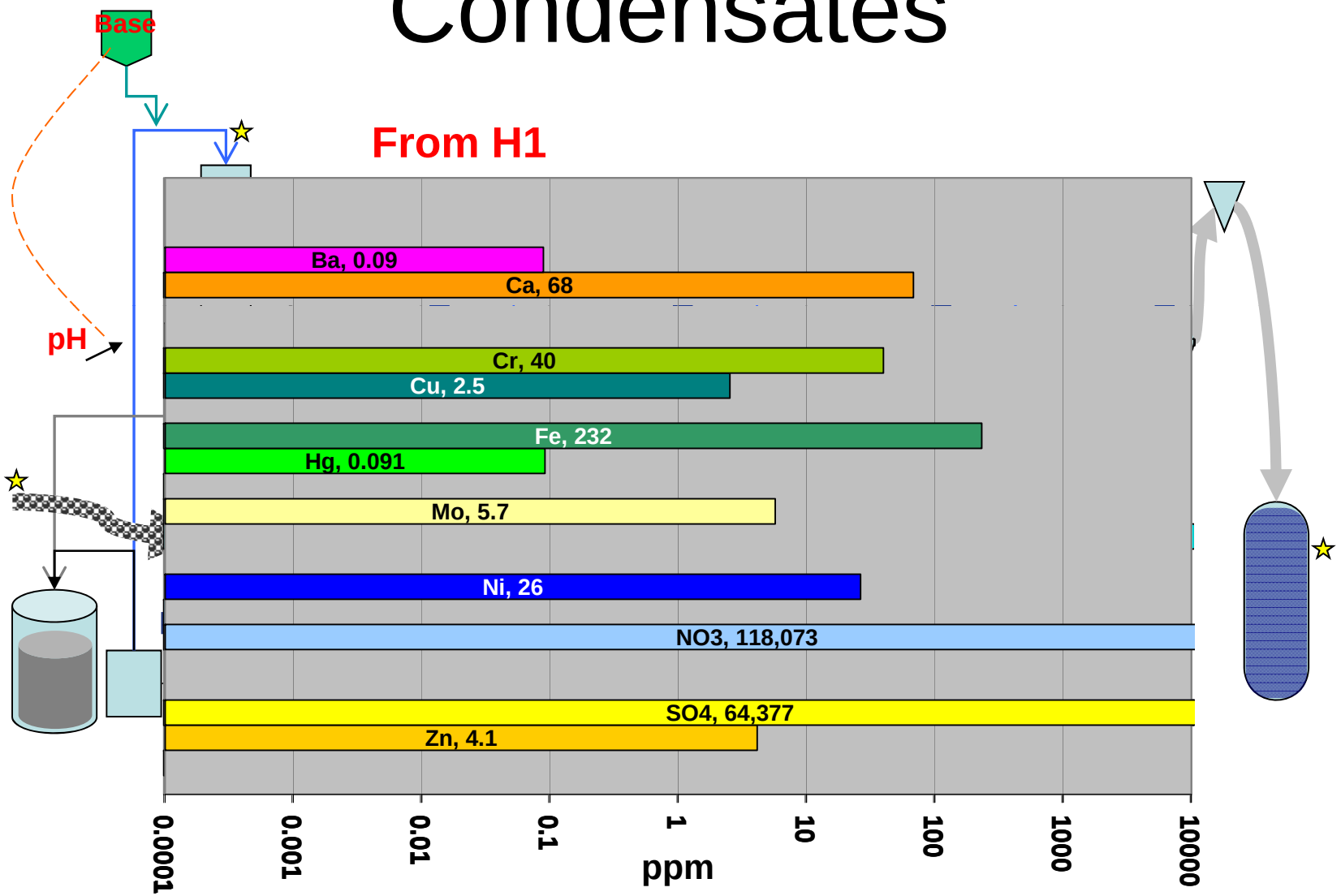
What we are finding in IPR

- May be able to use less water in Flue-Gas Desulphurization (FGD)
  - Sulfur capture effective at pressure
- Species reporting at intercooler locations

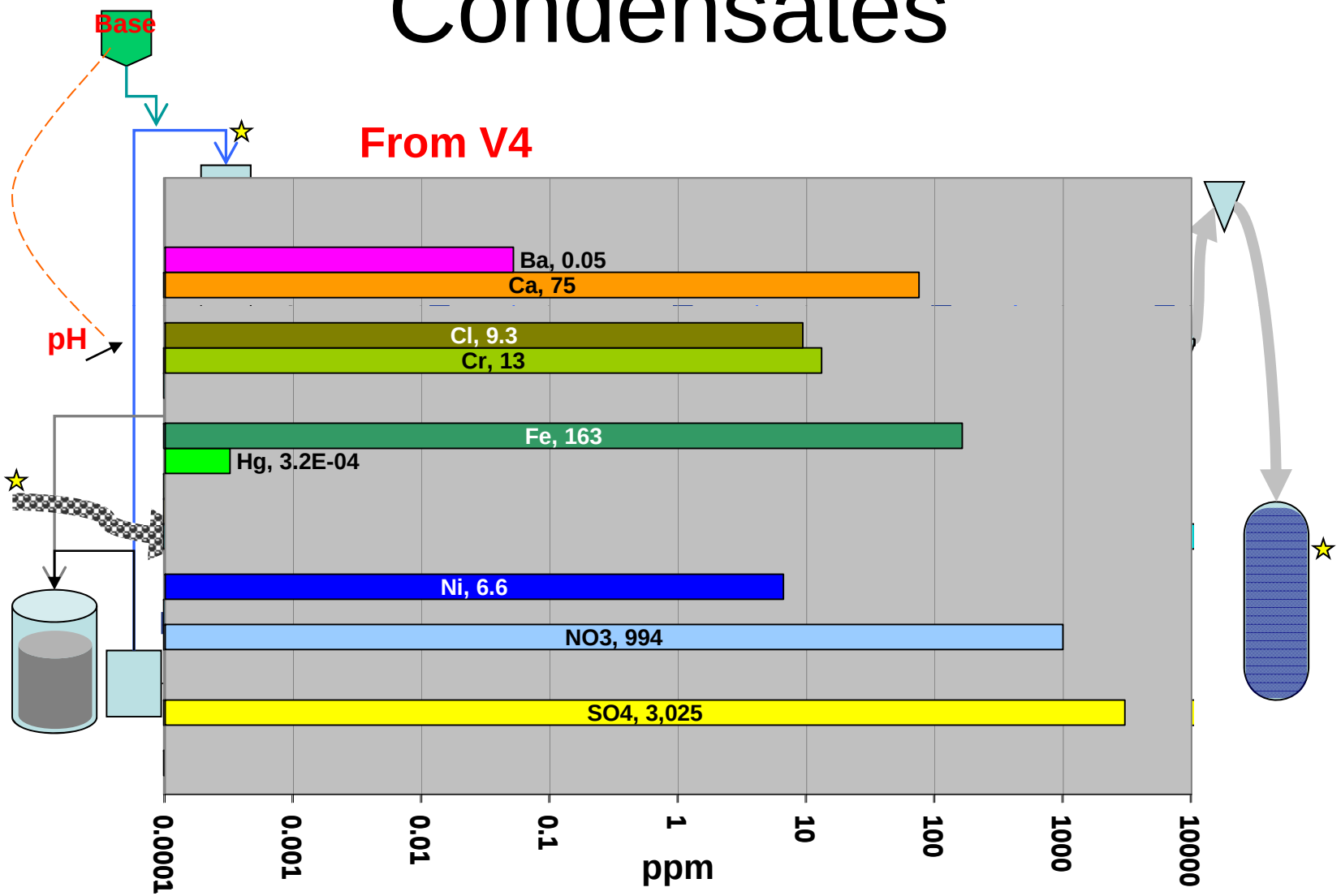
Installation in the Field



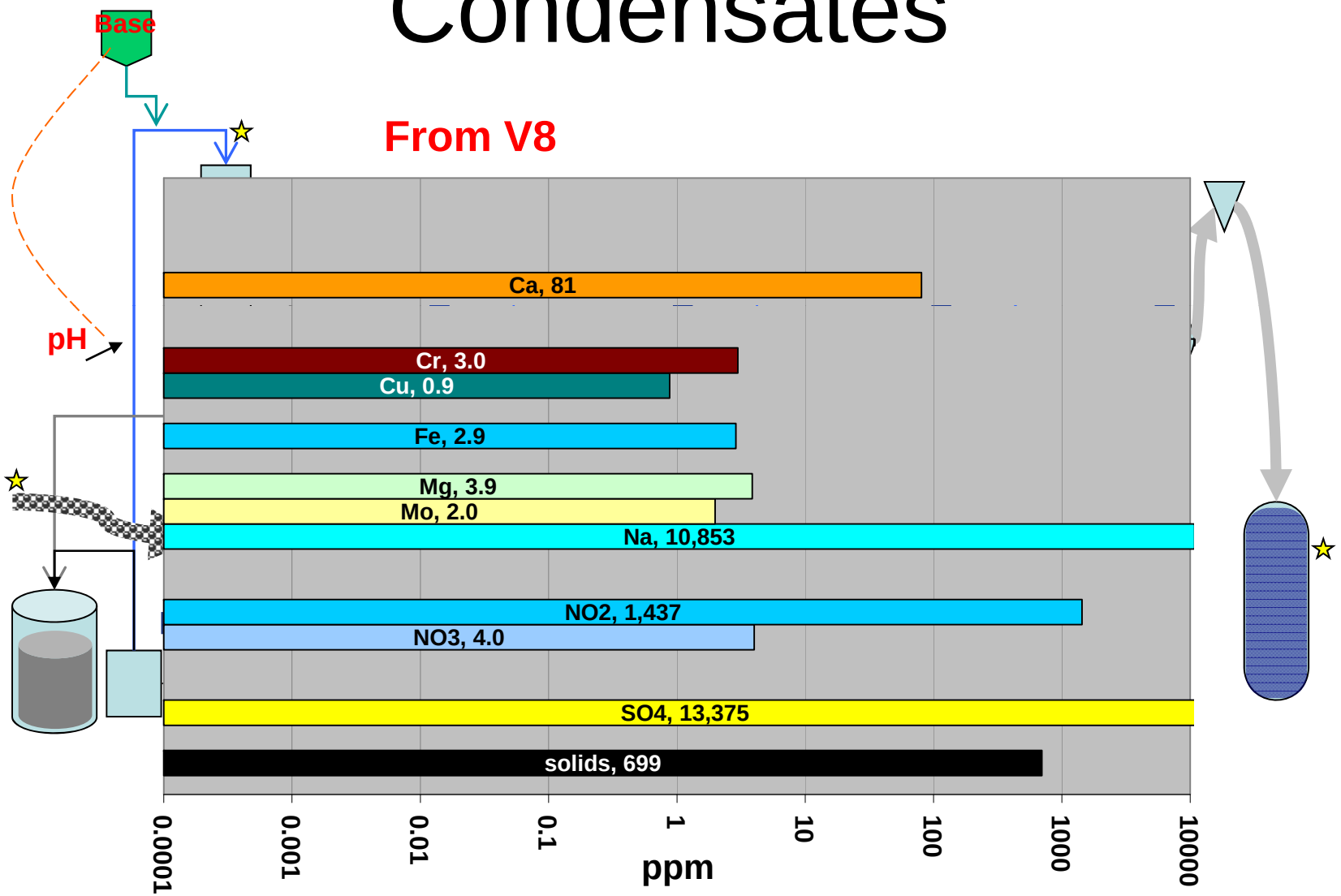
Recovering Water – Process Condensates



Recovering Water – Process Condensates



Recovering Water – Process Condensates



One Possible Approach

- Combustion products, entraining fine particulate (not caught in cyclone) sent counter-current to flue-gas-water spray to remove the bulk of the particles left.
  - Scrubber may employ bases to react with the SOx if needed.

One Possible Approach

- The scrubber traps gas constituents that are water soluble as well as chemicals that leach out of the particles trapped in the scrubber.
  - Particles trapped by the scrubber are filtered out.
  - Scrubber water → Treat for reuse as spray

One Possible Approach

- Treatment for water-offset applications
  - pH-swing precipitation and filtration
  - Demineralization (using ion exchange resins)
  - Testing for usage
  - Reuse in the cooling loop (IPR, or Plant at large)
  - Release

Summary

- Recovering energy leads to recovering water
- Water removes pollutants from CO_2
- Chemically adjusting water for thermal-cycle application
- Preventing release of those pollutants with returned water

Thank you for your attention.

Exhaust Composition

	Conventional after economizer	Oxyfuel exhaust after splitter	After 1st compression	After 2nd compression	After 3rd compression
Gas Flow (kg/hr)	**1,716,395**	**409,083**	**364,367**	**354,854**	**353,630**
Vol flow (m^3/hr)	**1,932,442**	**483,092**	**72,623**	**15,944**	**661**
Inlet Pressure (psia)	**14.62**	**15.51**	**62**	**264**	**1,500**
Inlet Temperature (°F)	**270**	**500**	**342**	**323**	**88.2**
Density (kg/m^3)	**0.8882**	**0.8468**	**5.017**	**22.26**	**534.6**
H_2O (fraction)	**0.0832**	**0.3322**	**0.0695**	**0.00994**	**0.0004**
Ar (fraction)	**0.0088**	**0.0115**	**0.0163**	**0.01730**	**0.0175**
CO_2 (fraction)	**0.1368**	**0.6131**	**0.8662**	**0.92161**	**0.9305**
N_2 (fraction)	**0.7342**	**0.0090**	**0.0128**	**0.01359**	**0.0137**
O_2 (fraction)	**0.0350**	**0.0250**	**0.0353**	**0.03755**	**0.0379**
SO_2 (fraction)	**0.0020**	**0.0091**	**0.0000**	**0.00000**	**0.0000**