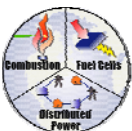


# REDUCTION OF ENERGY USE IN METHANOL DISTILLATION

**Gasification Technologies Council  
Annual Meeting  
Washington, DC  
October 5- 8, 2008**

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Valerie Francuz**

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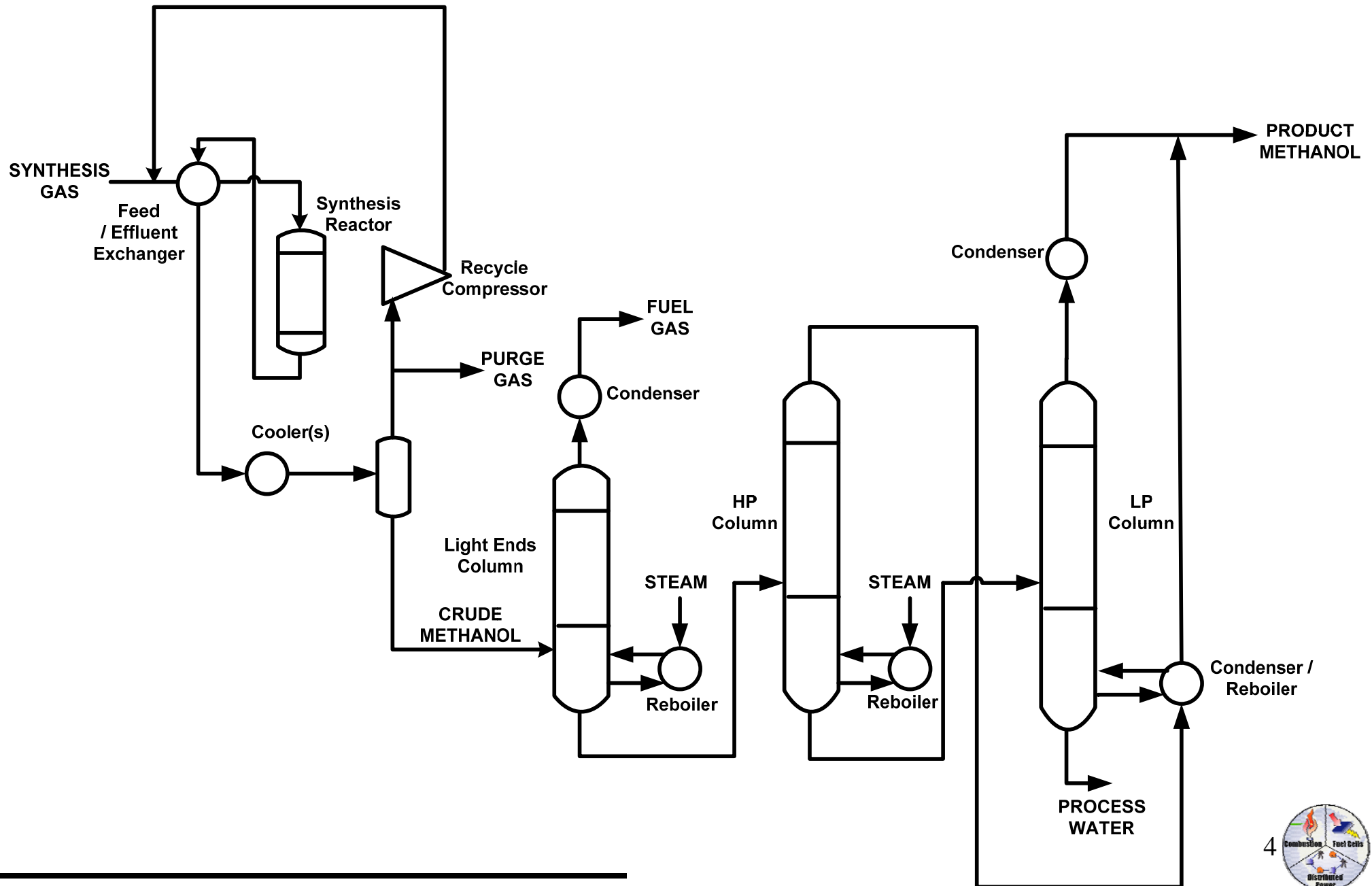
# Presentation Outline

- **Study Background**
  - Significance of Steam Use in MeOH Distillation
  - MeOH Synthesis & Distillation Process Description
  - Opportunity for Improvement
- **Design Basis for Study**
- **Design Approach**
  - Integrated Synloop & Distillation Process Description
  - Trade-offs
- **Results & Conclusions**

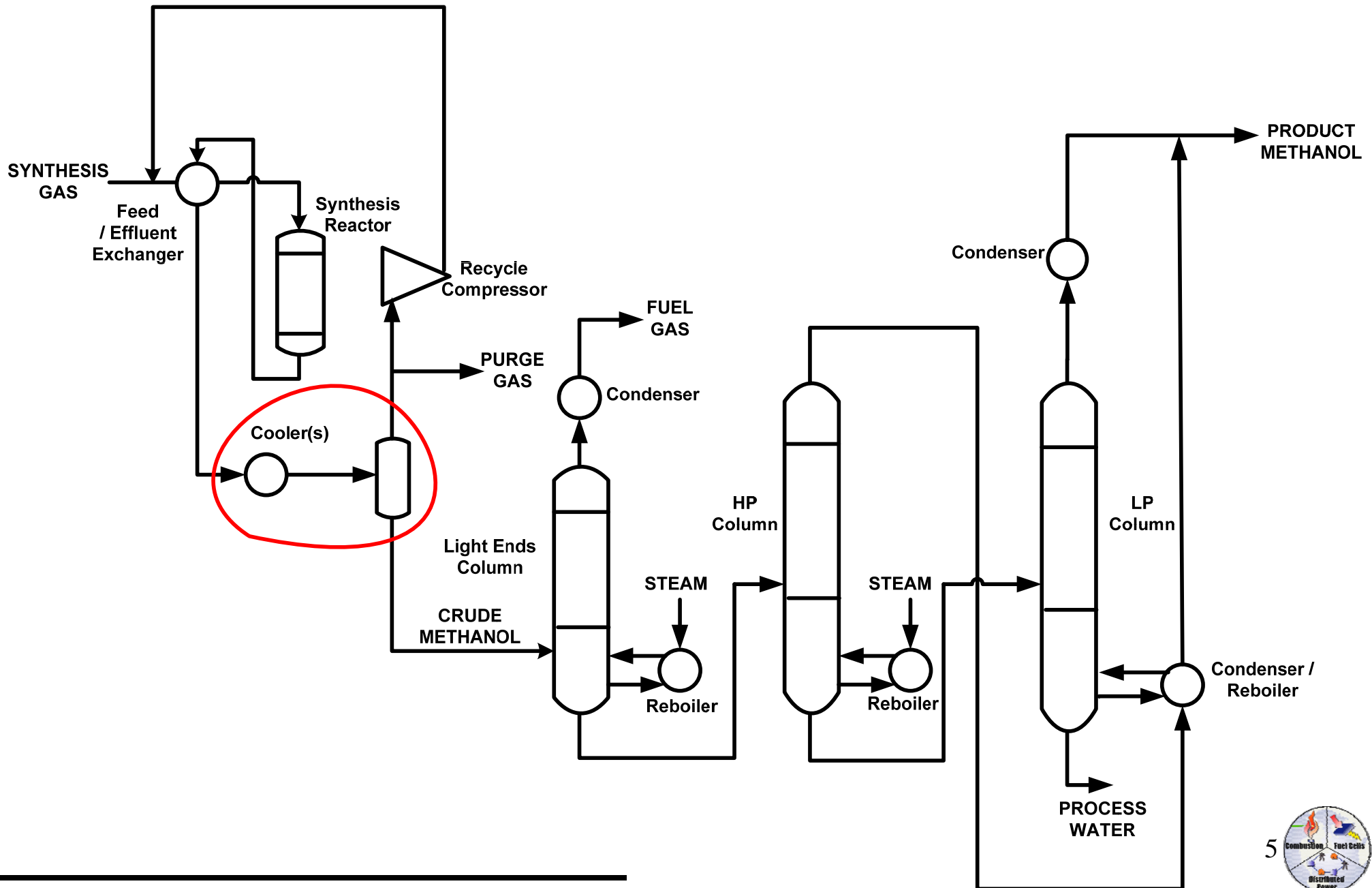
# Background

- **Significant Amount of Steam Utilized in MeOH Distillation**
  - Crude MeOH Contains  $< 15$  Wt % Water
  - But Steam Required set Primarily by Absolute Amount of MeOH
  - MeOH is Evaporated being Lighter Component
- **Impact on Plant Performance**
  - 3 to 4% Heat Rate Increase on Equivalent IGCC Basis (Same Coal Throughput as MeOH Plant)
  - Depending on MeOH Product Purity
  - & Number of Trays in Distillation Columns

# A Current Approach



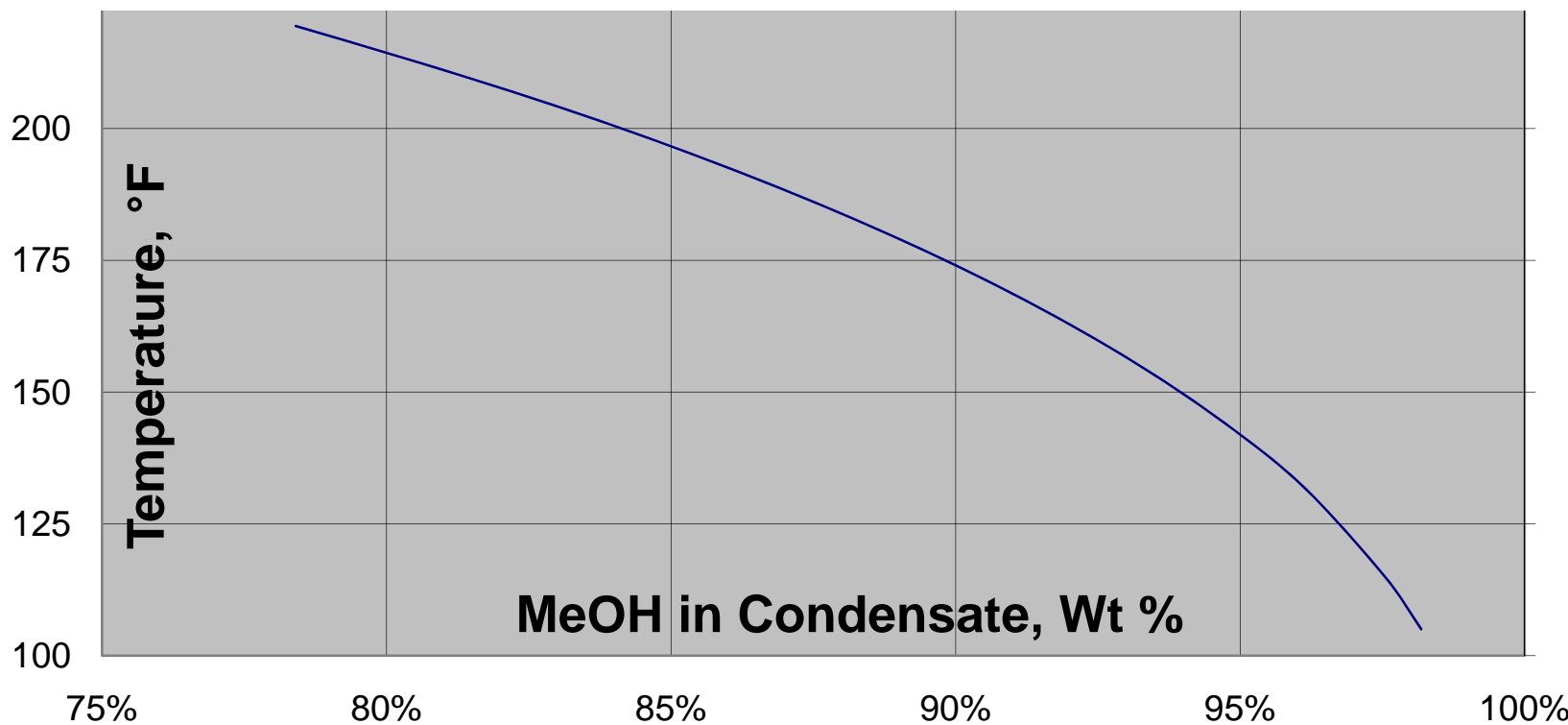
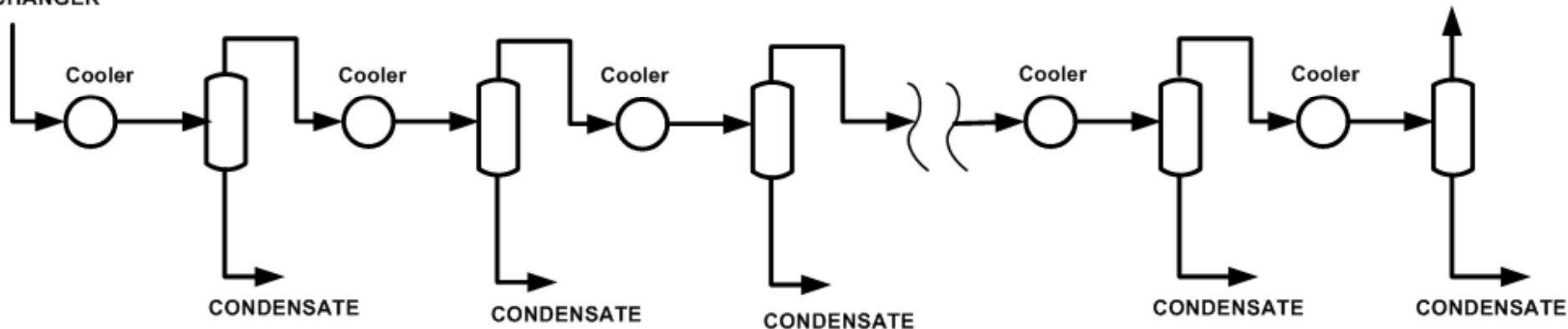
# Opportunity for Improvement



# Condensate Formation

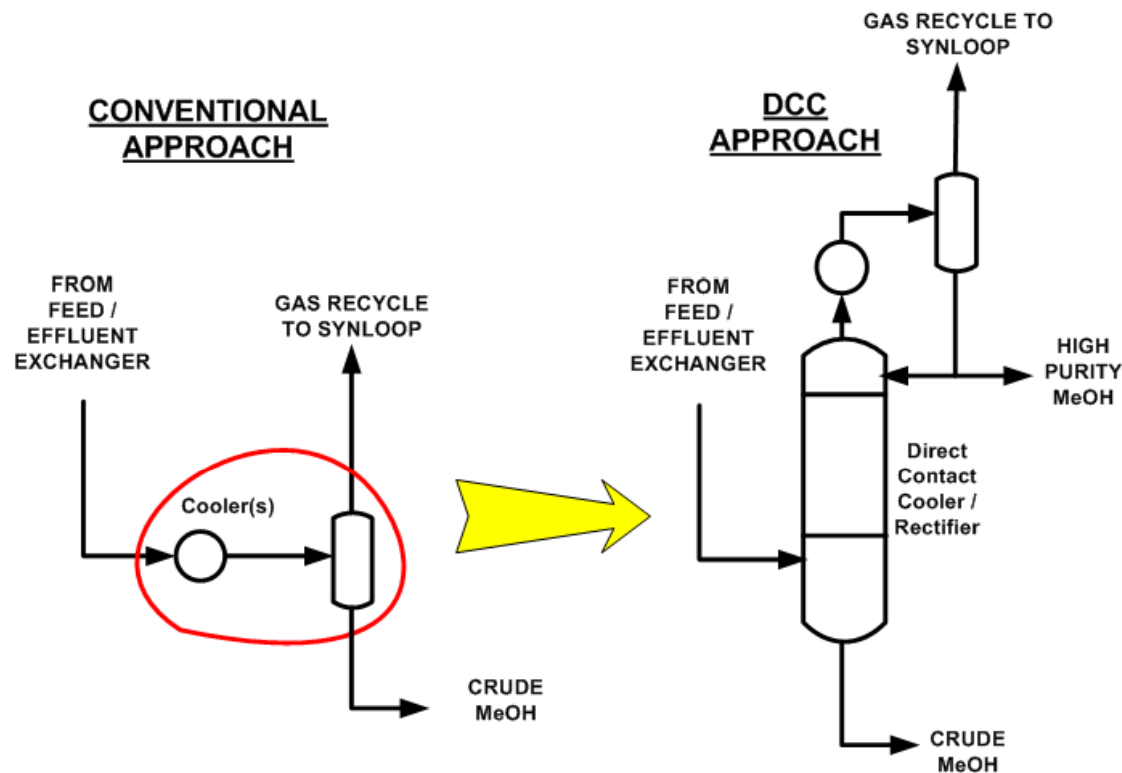
FROM FEED /  
EFFLUENT  
EXCHANGER

GAS RECYCLE  
TO SYNLOOP



# Design Approach

- **Take Advantage of Natural Separation during Cooling / Condensation**
  - Replace Coolers (Fin-Fan / Shell & Tube) with “Direct Contact Cooler” (DCC)
  - Functions also as a Rectification Column



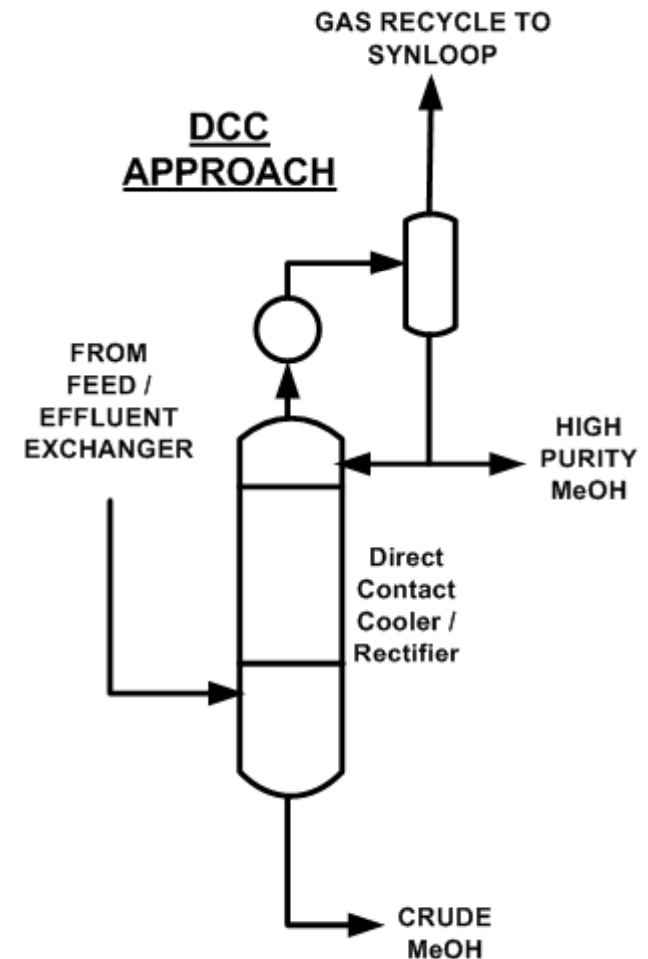
# Trade-off Analysis Necessary

- **Benefits**

- Pre-separates Significant Amount of MeOH
- Overall Steam Consumption & Size of Downstream Distillation Unit Reduced

- **Detriments**

- Additional Column Operating at Synloop Pressure Required
- Two (but Smaller) Light Ends Columns Required



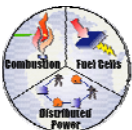
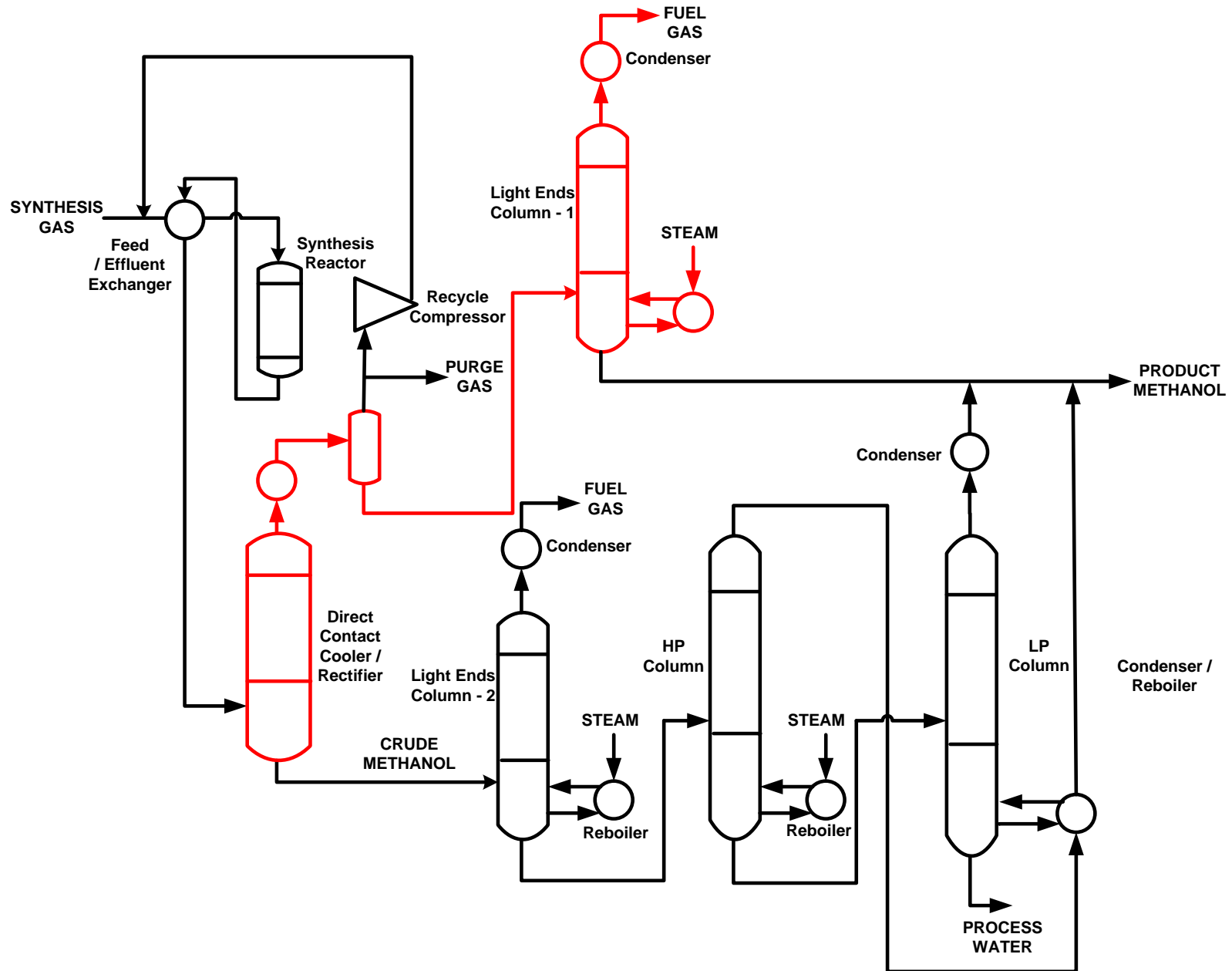
# Crude MeOH Constituents

- **H<sub>2</sub>O**
  - Varies with Syngas Composition (CO / CO<sub>2</sub> Ratio Used & Synthesis Process Design)
- **Dissolved Gases**
- **Trace Organic Components**
  - “Heavy Ends”
  - “Light Ends”
  - Type & Concentration dependent on
    - Operating Conditions
    - Type of Catalyst

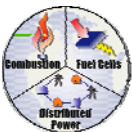
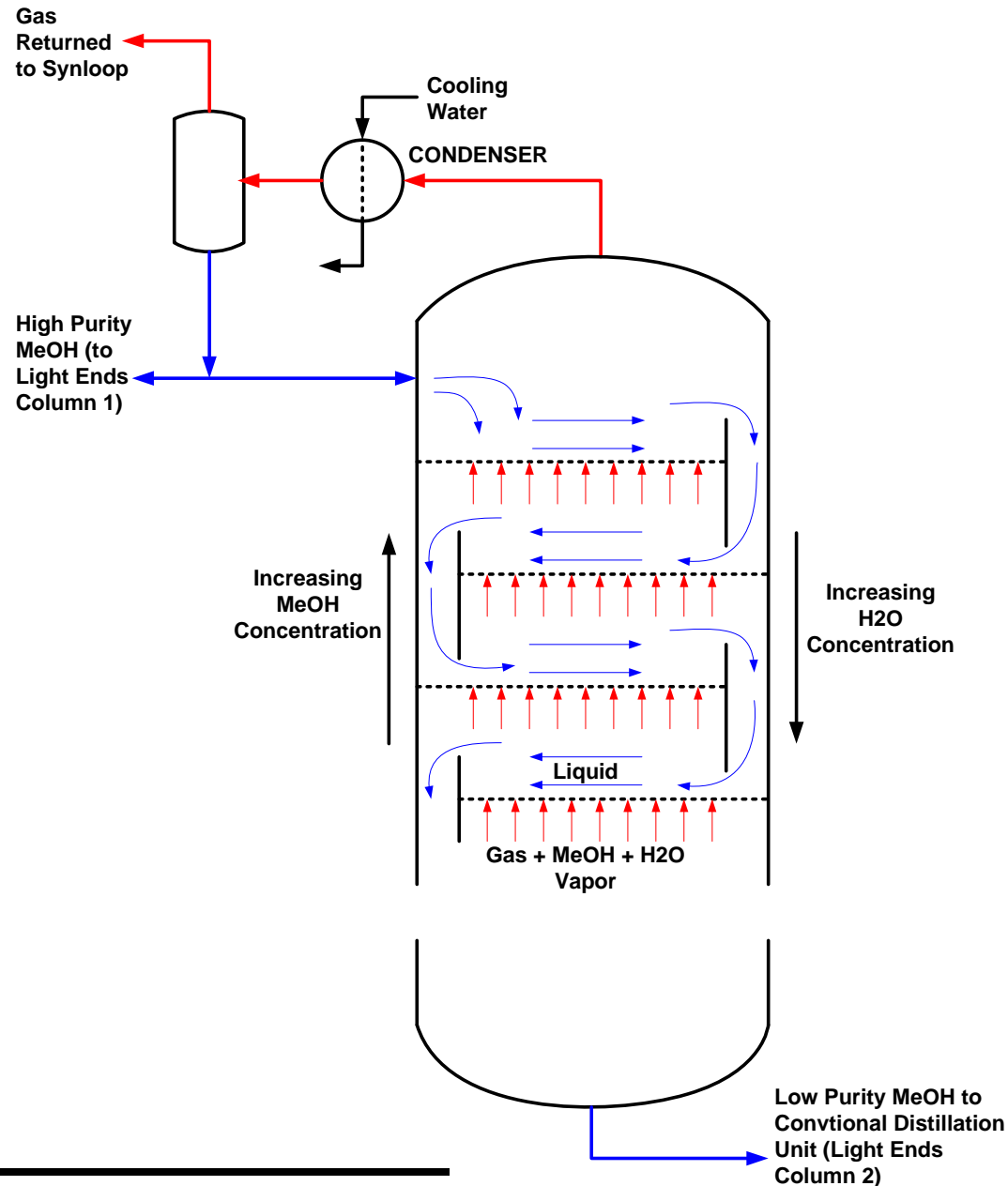
# Trace Components in Crude MeOH

- **Components that may be Present**
  - Hydrocarbons (Up to C<sub>12</sub>)
  - Higher Alcohols (C<sub>2</sub>-C<sub>5</sub>)
  - Esters
  - Ketones
  - Ethers
  - Amines
- **Concentrations**
  - Less than a PPM to Several Hundreds of PPM
- **Product MeOH Specs**
  - Fuel Grade (EPRI Report AP-1962)  $\geq$  99 Wt % MeOH
  - Chemical Grade (Grade AA)  $\geq$  99.85 Wt % MeOH
  - Stringent Individual Limits on Other Components

# Proposed DCC Design



# Heat & Mass Transfer in DCC (also a Rectifier)

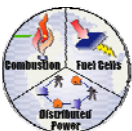


# Sources of Information & Acknowledgements

- **EPRI Report AP-1962 by Fluor Titled “Coal to Methanol”**
  - Syngas Composition
  - Synloop Design
  - Crude MeOH Composition
- **Simulations**
  - Aspen Plus for Synloop & Distillation
  - Thermoflex for Power Generation
- **Cost Estimation**
  - Icarus Software for Synloop & Distillation
  - PEACE for Power Generation

# Study Design Basis (EPRI Report AP-1962)

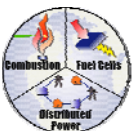
|                         |  |
|-------------------------|--|
| Feedstock               | Illinois No. 6 Coal  |
| Ambient Conditions      | 88°F Summer Dry Bulb   |
| Plant Make-up Water     | Fresh Water  |
| Plant Heat Rejection    | Mechanical Draft Cooling Towers  |
| Gasification Technology | “Texaco” with HT Syngas Cooler   |
| Plant Throughput        | Scaled Down to ¼ <sup>th</sup> of EPRI Study Capacity to Produce 2,700 ST/D MeOH |



# Column Sizes

**Basis: 2,700 ST/D of MeOH**

|                        | Base Case               | Case Study (DCC) Configuration |
|------------------------|-------------------------|--------------------------------|
| DCC / Rectifier        | None                    | 17 ft Dia X 76 ft T/T          |
| Light Ends Column 1    | 5.5 ft Dia X 119 ft T/T | 3.5 ft Dia X 120 ft T/T        |
| Light Ends Column 2    | None                    | 4.5 ft Dia X 111 ft T/T        |
| HP Distillation Column | 12 ft Dia X 121 ft T/T  | 9 ft Dia X 122 ft T/T          |
| LP Distillation Column | 14 ft Dia X 151 ft T/T  | 11 ft Dia X 149 ft T/T         |



# Results

- **MeOH Separated in DCC / Rectifier Column in Case Study Configuration = 40%**
- **Case Study Configuration over Base Case**
  - Decrease in Steam Required for Distillation = 35%
  - Additional Electric Power Generated via Steam Cycle = 3,940 kW
  - Increase in Plant Cost (Distillation + Power Generation) = \$9 million (Dec 2006 Basis)
  - Equivalent Specific Plant Cost = \$2,290/kW

# Conclusions

- **Case Study Configuration Economics Favorable at \$2,290/kW**
  - 3,940 kW Generated with Zero Fuel Costs
  - & Zero Plant Emissions
- **While IGCC Costs per DOE / NETL 2007/1281 Study**
  - \$2,390/kW to \$2,668/kW (Dec 2006 Basis) with 90% CO<sub>2</sub> Capture
- **Study Case Advantage Increases with Increasing Moist in Crude MeOH**
  - Above Results for EPRI Study Moist of 4.5% Wt H<sub>2</sub>O
  - Many Designs Produce Crude MeOH with 13 Wt%

# Recommendations

- **Results based on Computer Simulations**
- **High Pressure Experimental Data Required to Substantiate / Verify Results / Conclusions Reached**
  - VLE Data for MeOH / H<sub>2</sub>O System
  - Partitioning of Trace Components
- **Assess DCC Concept in other Synthesis Applications**
  - Ethanol & Mixed Alcohols
  - DME

# About the Principal Author / Presenter

- Dr. Ashok Rao is the Chief Scientist for Power Systems at the Advanced Power and Energy Program (APEP) of the University of California, Irvine. Prior to accepting the position at APEP in 2004, Dr. Rao was a director in Process Engineering at Fluor Inc. involved in gasification, syngas conversion and combined cycles, and a Senior Fellow. Prior to joining Fluor in 1979, he worked for a gasification technology developer, Allis Chalmers and a gasification licensor, McDowell Wellman. With more than 30 years of experience working in industry, Dr. Rao has been involved in all phases of project development starting from process conceptualization to R&D to techno-economic feasibility studies to detailed design. He is the recipient of several patent awards in the area of gasification technology. Dr. Rao can be reached at [adr@aep.uci.edu](mailto:adr@aep.uci.edu) or 949-824-4319.