Carbon Capture - Distributed Generation

Cost Neutral Path to Zero Net Energy Campus

- Wean campus off of Centralized Steam System
  - Combined Heat and Power
    - Stoichiometric Exhaust
      - Carbon Sequestration
- DC Based Microgrid
  - Electrical sustainable w CHP
  - Integration of Renewable Generation
    - Alleviate problems w/non-firm electric generation

UC's Existing Co-Gen Steam System

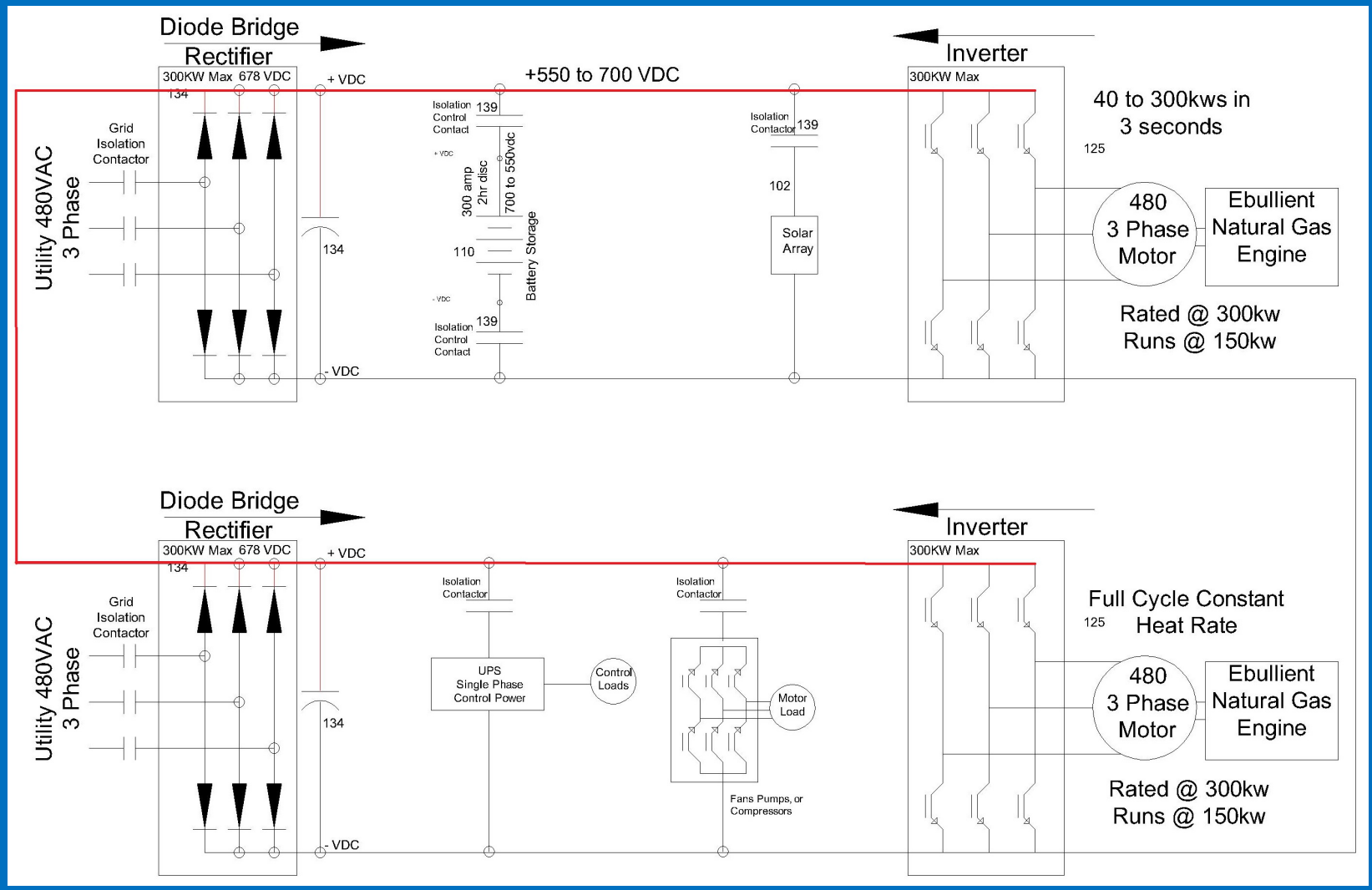
- Equipment
  - Co-Generation System
    - LM2500 Gas Turbine (22mw)
    - HRSG
      - 600psig and 125psig
    - 600-125psig BP Steam Turb(5mw)
  - Auxilary Boilers
    - 3x100klb/hour

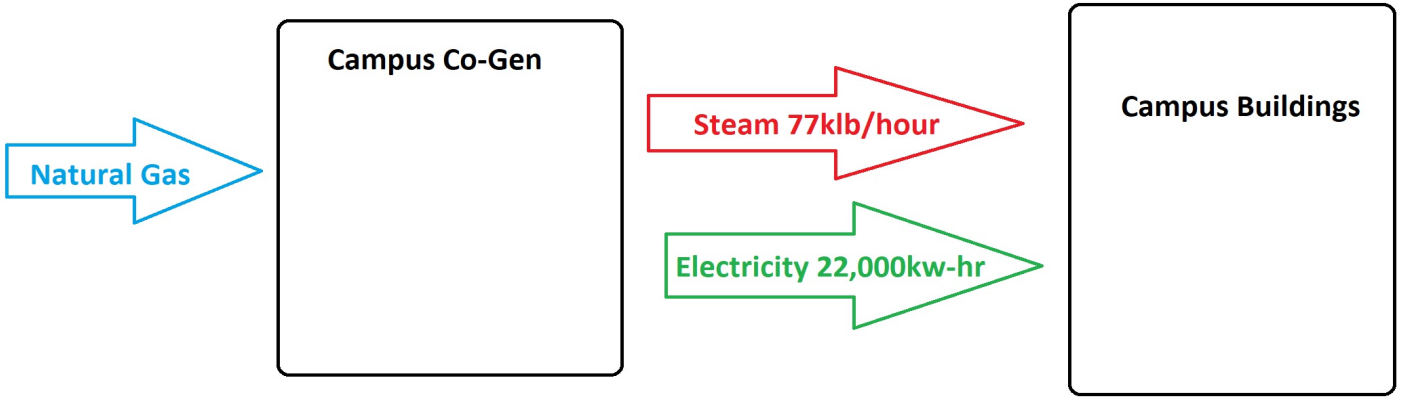
- Production
  - 530,533 Kw-hr/day
    - 22,106 kw-hr/hour
  - 1860 kLbm/day (125psi steam)
    - 77klb/hr

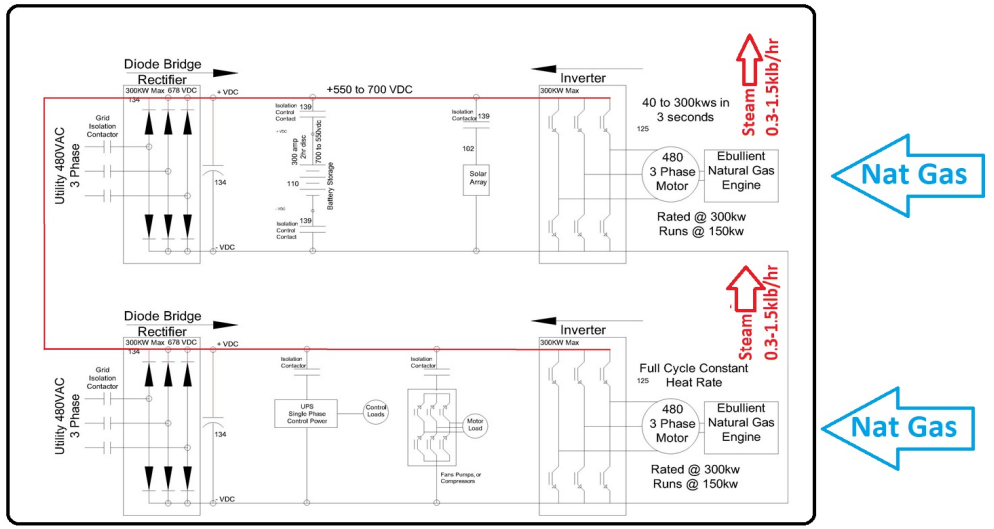
Proposed University Microgrid

- 150 ea X 300kw Gensets
  - Otto Cycle Engine Modules
    - Exhaust & Jacket Steam
      - 1500 lb/hour 75psig steam each
    - Stoichiometric Exhaust
      - 3 way catalyst <2ppm Nox
      - Zero Oxygen
    - Heat Recovery to 100F
      - Condensing Heat Exchange
    - Carbon Sequestration
      - MEA CCS

- DC Bus Microgrid
  - 540 to 825VDC.
    - Cogen
    - Solar Photovoltaic
    - Wind


Diode Bridge
Rectifier
300KW Max 678 VDC
134
+ VDC
- VDC
+550 to 700 VDC
Inverter
300KW Max
40 to 300kws in
3 seconds
125
Grid
Isolation
Contactor
Utility 480VAC
3 Phase
Isolation
Control
Contact
139
300 amp
2hr disc
700 to 550vdc
Battery Storage
110
Isolation
Contactor
139
102
Solar
Array
480
3 Phase
Motor
Ebullient
Natural Gas
Engine
Rated @ 300kw
Runs @ 150kw
Diode Bridge
Rectifier
300KW Max 678 VDC
134
+ VDC
- VDC
Inverter
300KW Max
Full Cycle Constant
Heat Rate
125
Grid
Isolation
Contactor
Utility 480VAC
3 Phase
Isolation
Contactor
UPS
Single Phase
Control Power
Control
Loads
Isolation
Contactor
Motor
Load
Fans Pumps, or
Compressors
480
3 Phase
Motor
Ebullient
Natural Gas
Engine
Rated @ 300kw
Runs @ 150kw


Natural Gas
Campus Co-Gen
Steam 77klb/hour
Electricity 22,000kw-hr
Campus Buildings


Diode Bridge Rectifier
300KW Max 678 VDC
+550 to 700 VDC
Inverter
300KW Max
40 to 300kws in 3 seconds
Steam 0.3-1.5klb/hr
480 3 Phase Motor
Ebullient Natural Gas Engine
Rated @ 300kw
Runs @ 150kw
Nat Gas
Utility 480VAC 3 Phase
Grid Isolation Contactor
Solar Array
Battery Storage
Diode Bridge Rectifier
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Full Cycle Constant Heat Rate
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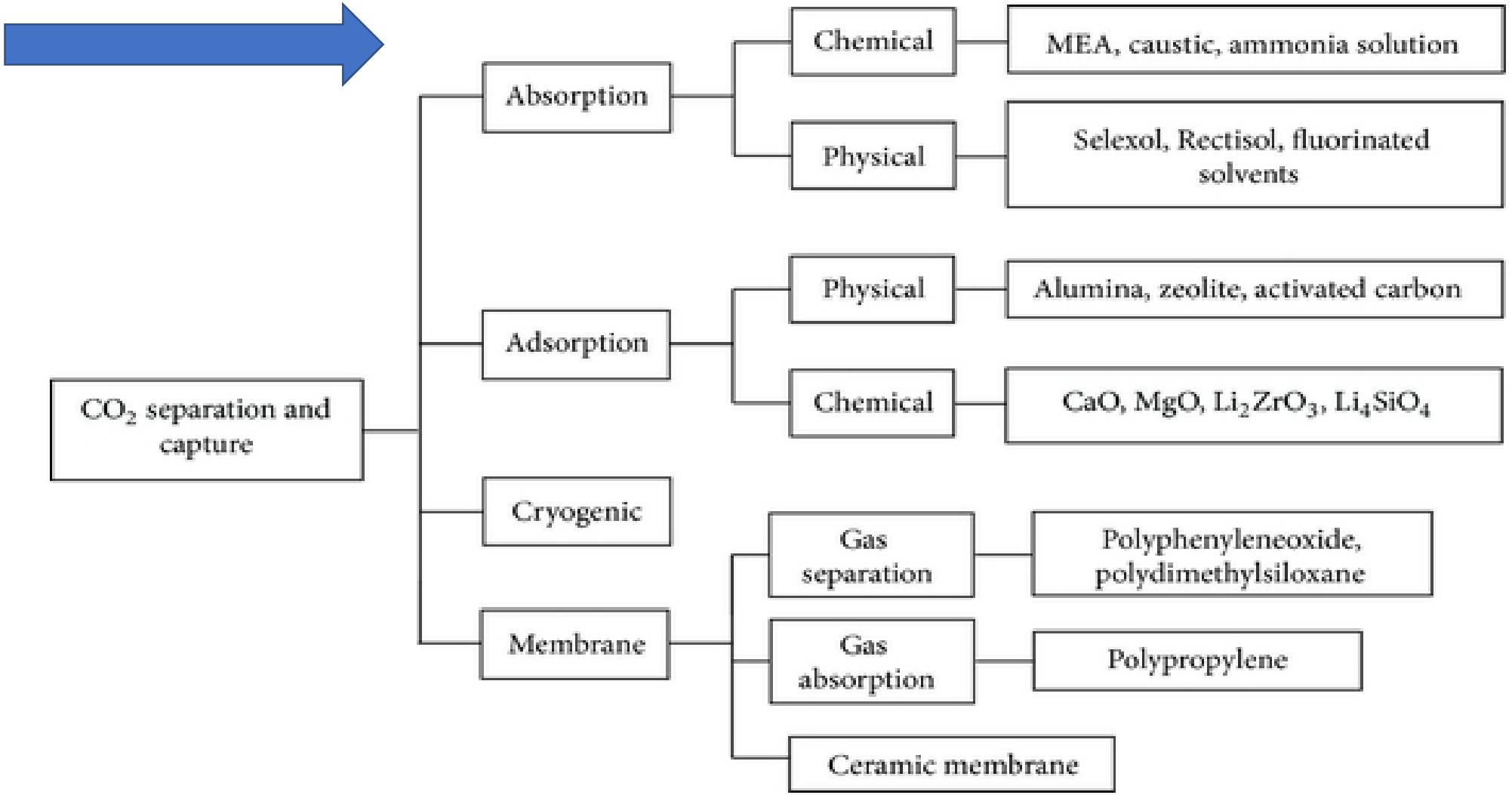
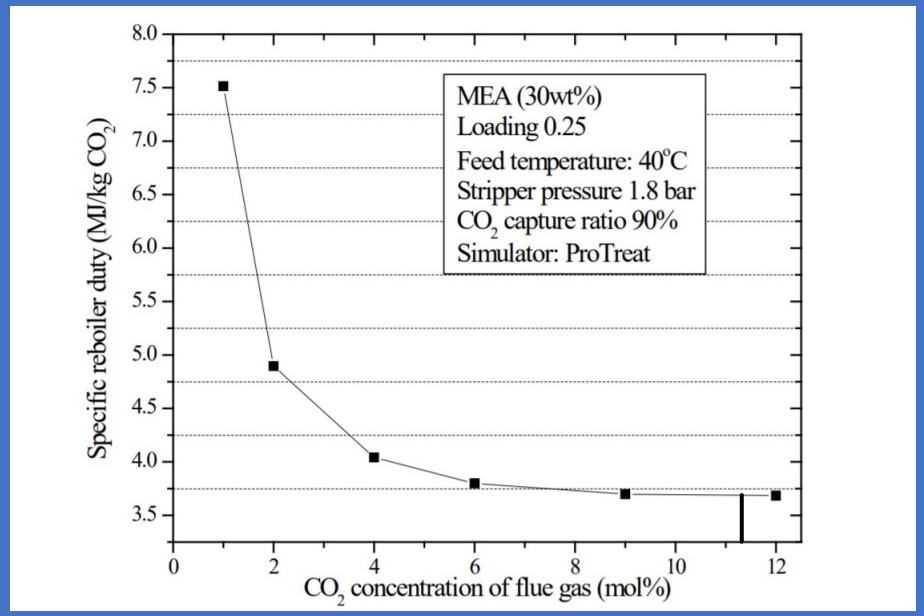
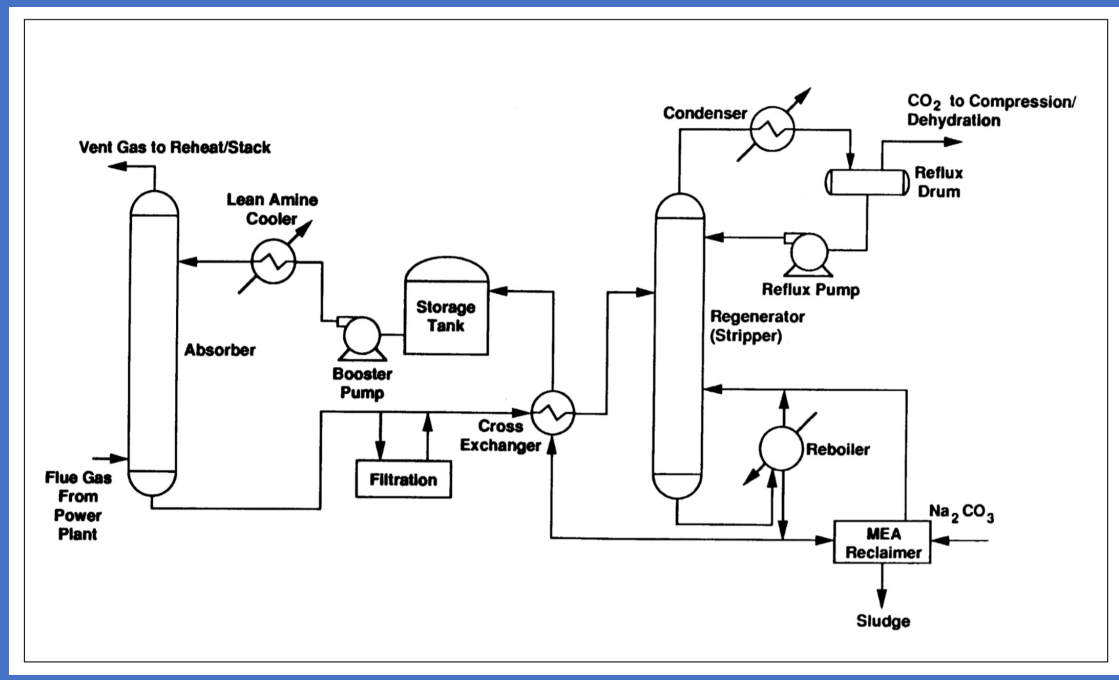

CO_2 separation and capture
Absorption
Chemical
MEA, caustic, ammonia solution
Physical
Selexol, Rectisol, fluorinated solvents
Adsorption
Physical
Alumina, zeolite, activated carbon
Chemical
CaO, MgO, Li_2ZrO_3, Li_4SiO_4
Cryogenic
Membrane
Gas separation
Polyphenyleneoxide, polydimethylsiloxane
Gas absorption
Polypropylene
Ceramic membrane

Carbon Capture and Storage (CCS)

- Monoethanolamine (MEA) solvent
  - Scrubber pack tower



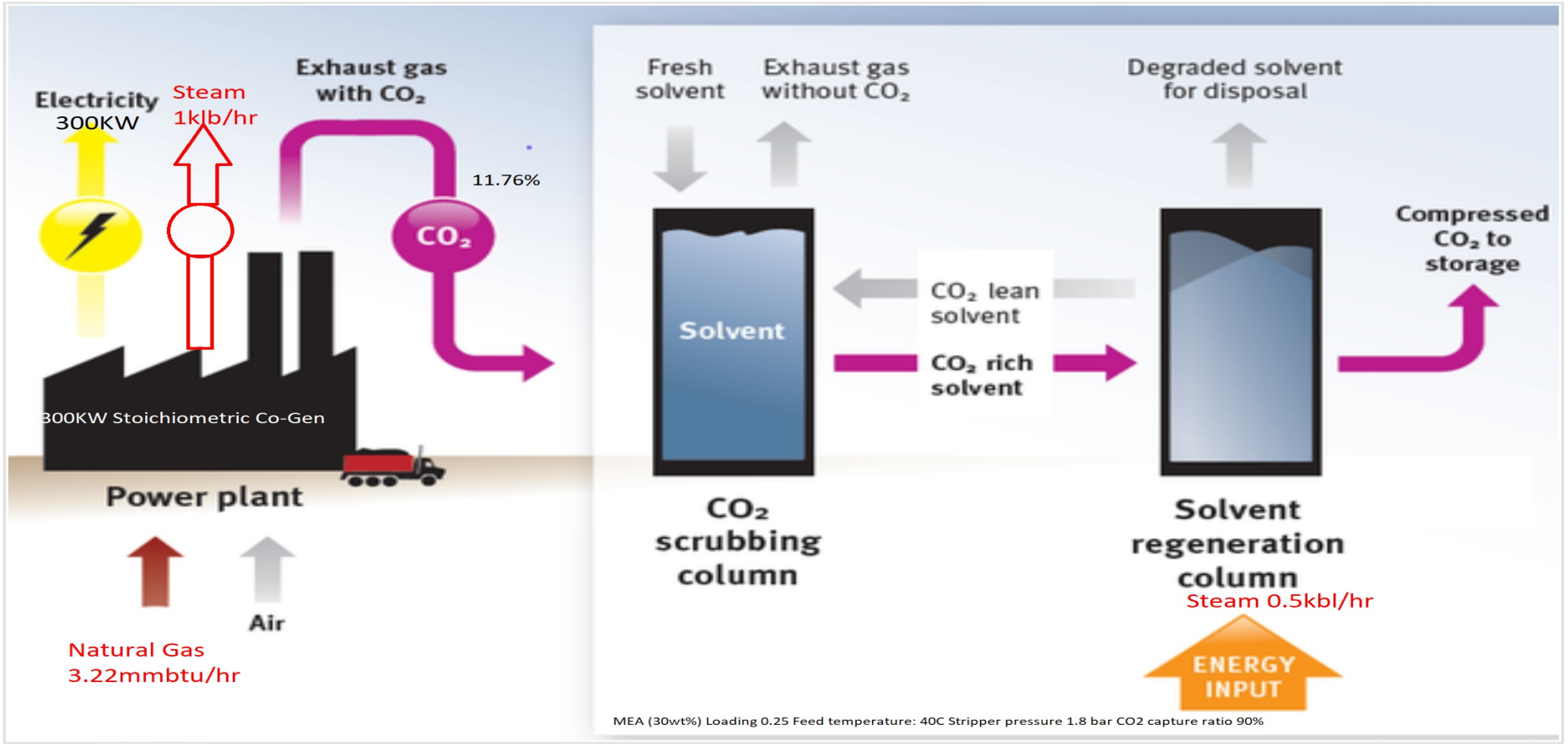


Complications Problems MEA-CCS

- Low Partial Pressure
  - The lower the concentration the higher the energy penalty
    - Stoich Recip w/3-way 12.5% CO2 – GT Exhaust 2.67% CO2
      - Water gas shift = 1.5% increase CO2
- Oxygen
  - Amine oxidative degradation
    - Stoichiometric Recip 0% O2 – GT Exhaust 15% O2

Stoichiometric Recip Ideal for MEA-CCS

CCS Distributed Generation Heat Balance



Questions?

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