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AIR LIQUIDE™
Engineering & Construction

CO_2 Purification Units Futuregen 2.0

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Air Liquide Engineering & Construction

2011 NETL CO2 Capture Technology meeting

Agenda

- Air Liquide CO_2 CPU roadmap
- FutureGen 2.0 CPU

A comprehensive roadmap for the CPU

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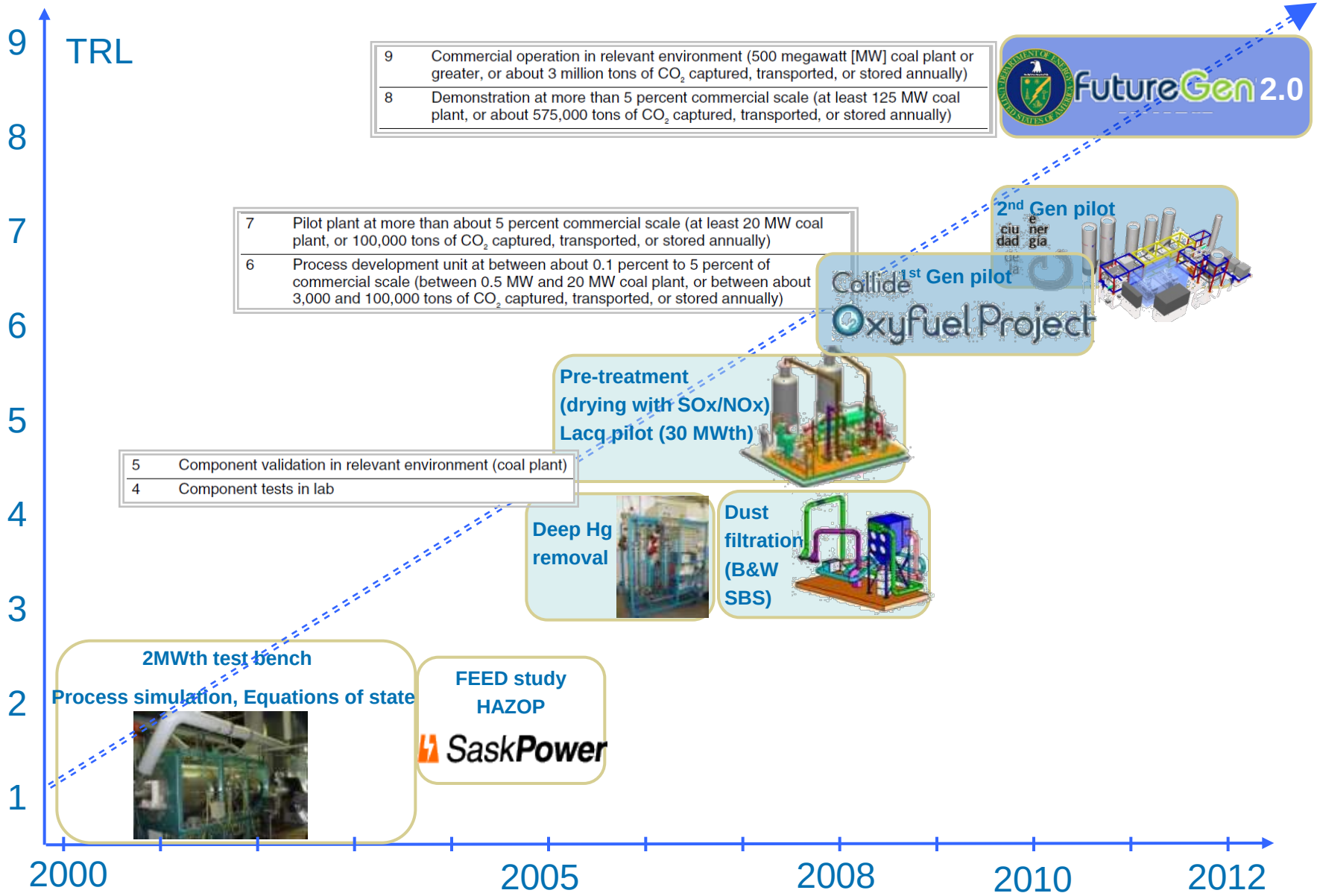

Critical components validation

- SaskPower studies helped to identify critical components that require specific testing

- High efficiency filter
  - Dust entering the CPU will accumulate there (most of it in the compressor)
  - 250,000 Nm^3/h with 100mg/Nm^3 dust equals 600kg/day
  - A filter is required to reduce the dust level to a few µg/Nm^3
  - Test performed mid 2009 at B&W's SBS

- Mercury
  - Is a poison for the cold box and shall be removed to a very low level
  - Efficient and economical method did not exist for flue gas
  - Test at a lab scale performed in France end 2009

- Pre-treatment (drying with SOx/NOx abatement)
  - Dryers were not proven in presence acidic gases (corrosion, formation of potentially dangerous compounds…)

Project summary

Objectives

- Achieve TRL 5 for the lower criticality components (centrifugal compressor, cold box) in a relevant environment (retrofit of PC boiler)
- Achieve TRL 6 for the 1st generation CPU design (FutureGen)

Features

- 100MWth PC boiler
- CO_2 capacity: 75 tpd
- Instrumented for R&D
- Project started in September 2008
- Operational in December 2011

- CPU performance
  - 68% CO_2 in flue gas
  - Produces 75 tpd of high purity (99.9%vol) CO_2
    - 1 ppm vol of NO_2
    - 1 ppm vol of SO_2
    - 1 ppm vol of O_2
    - 10 ppm vol of Argon
  - CO_2 capture rate 74%
  - Near Zero emissions ➔

	Oxyfuel (AL)	Air	IGCC
NOx	≤ 0.015	0.08	0.047
Particulate	≤ 0.0000003	0.012	0.007
SO2/SO3	≤ 0.00045	0.06	0.01
Hg	≤ 0.000000003	0.82	0.571

lb/MBtu (HHV)

- R&D testing:
  - 4 years of testing in real operating condition
  - Specific instrumentation has been installed
  - Test objectives:
    - Actual process performance, mainly: dust filtration, Flue Gas drying and cryogenic distillation
    - Fate of various impurities (NOx/SOx and mercury)
    - Understand corrosion and ageing over 4 years

Callide Oxyfuel Project

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June 2010

May 2006

Callide Oxyfuel Project

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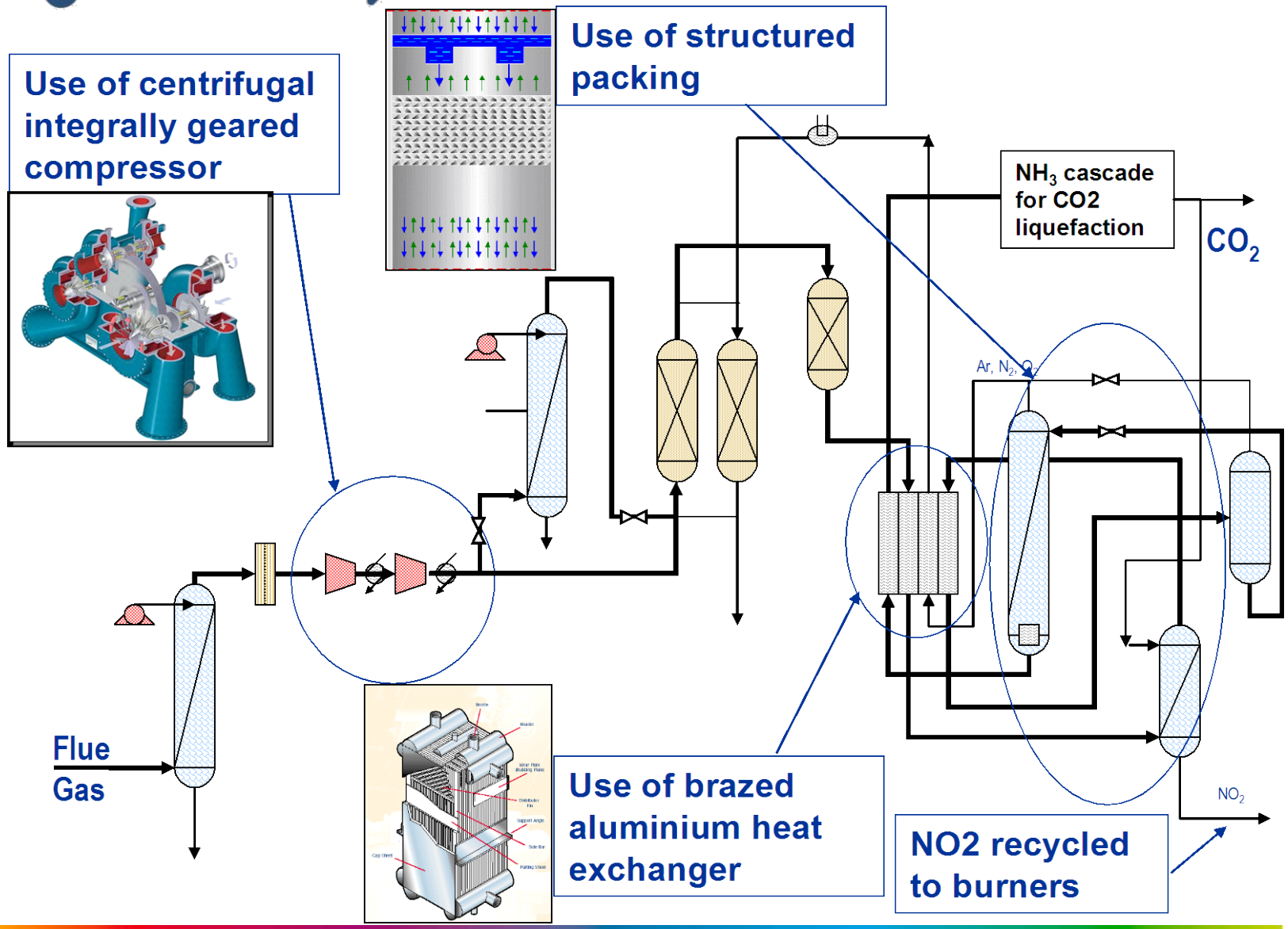


Project summary

Objectives

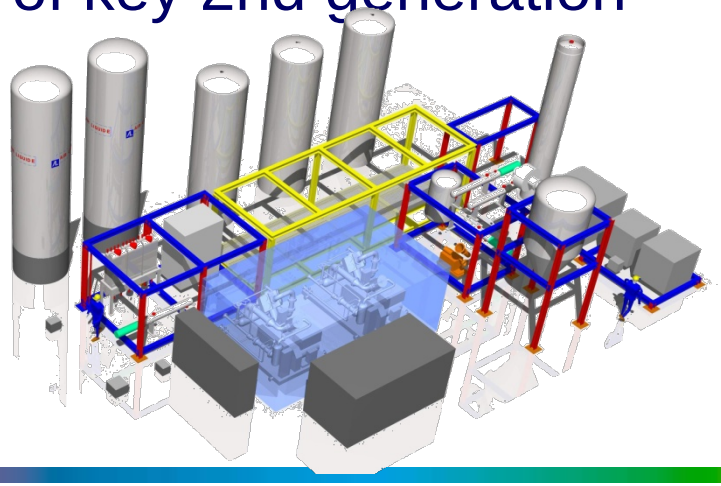
- Achieve TRL 6 for the 2nd generation CPU design

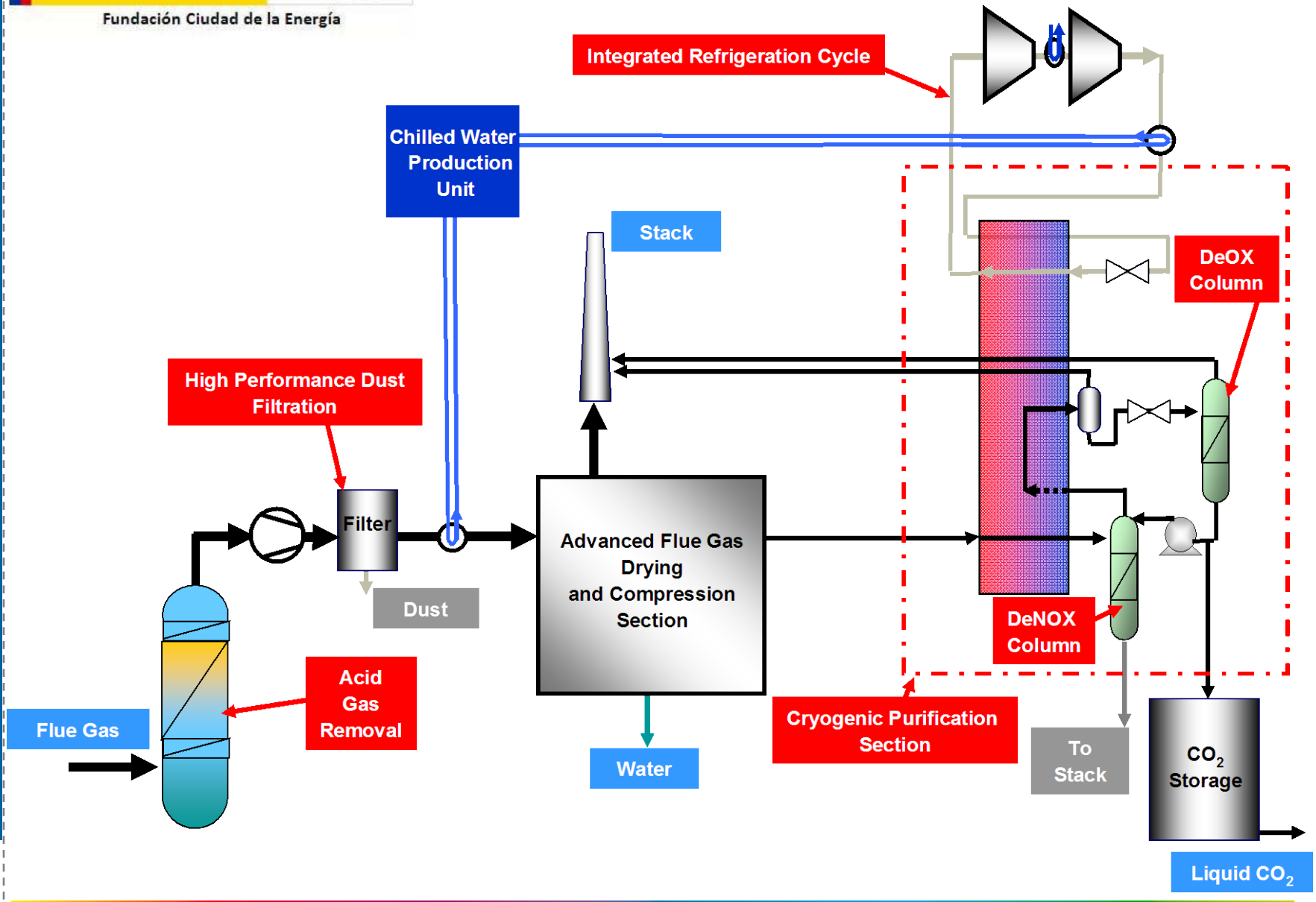
Features

- 30MWth CFB boiler
- 20MWth PC boiler
- CO_2 capacity:
  - Pre-treatment: 200 tpd
  - Cold box: 10 tpd
- Instrumented for R&D
- Project started in January 2011
- Operational in end 2012

ing

- R&D testing:
  - several years of testing in real operating condition
  - Specific instrumentation will been installed
  - Test objectives:
    - Impact of different coals and boiler technology (CFB/PC)
    - Actual performance of key 2nd generation components




Integrated Refrigeration Cycle
Chilled Water Production Unit
Stack
DeOX Column
High Performance Dust Filtration
Filter
Dust
Advanced Flue Gas Drying and Compression Section
DeNOX Column
Acid Gas Removal
Flue Gas
Water
Cryogenic Purification Section
To Stack
CO_2 Storage
Liquid CO_2

Agenda

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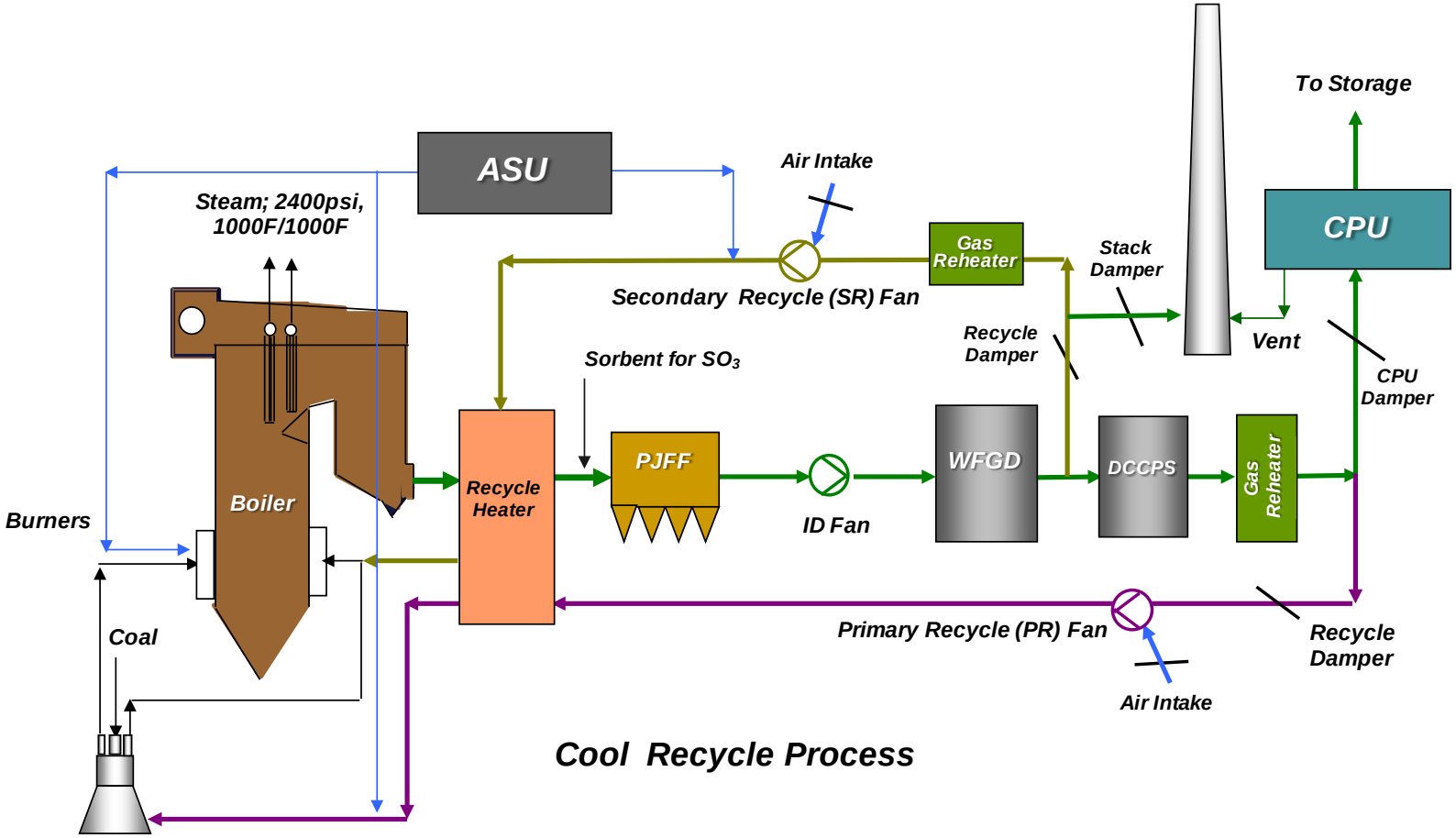
- FutureGen 2.0 CPU

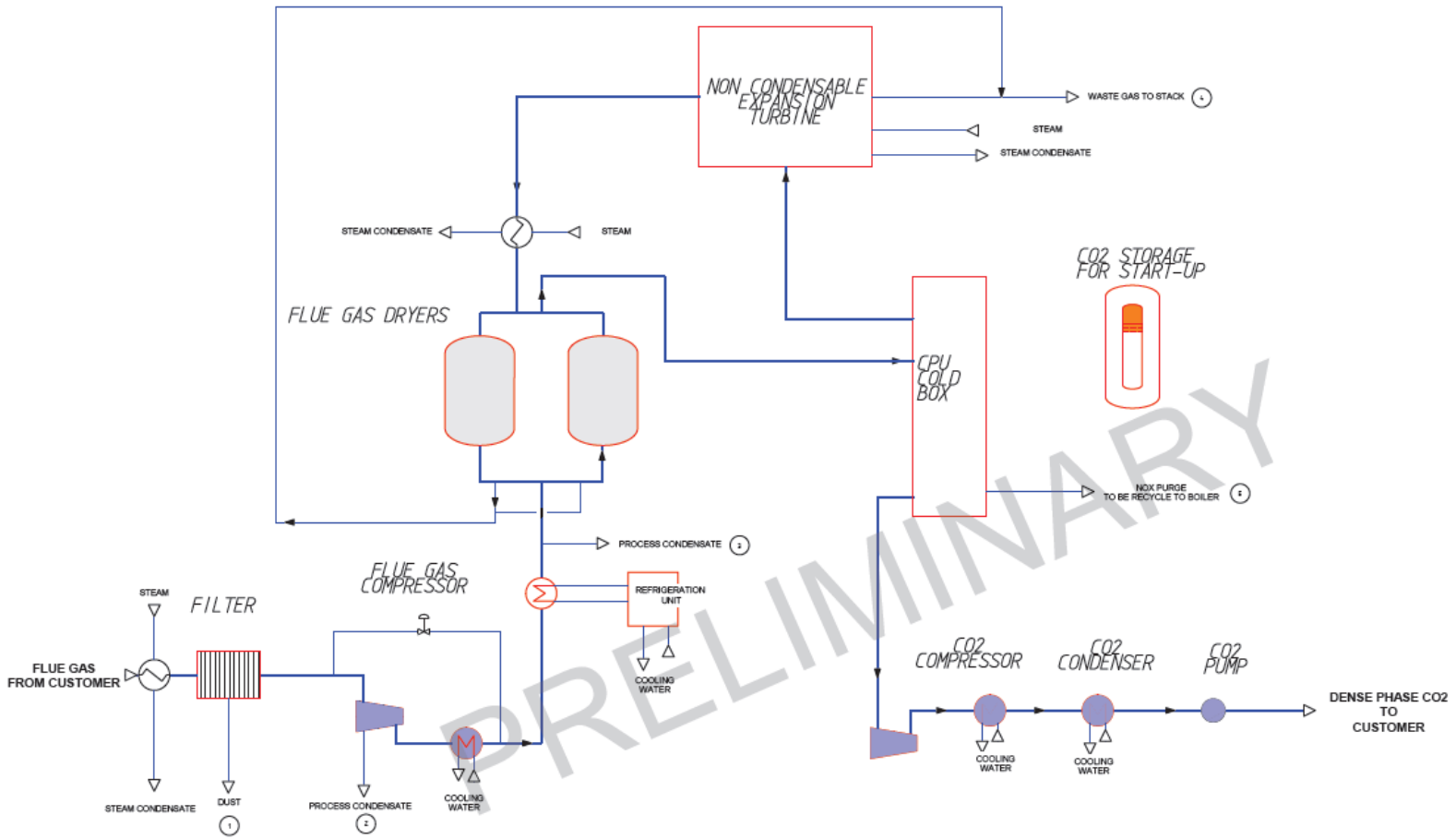
This material is based upon work supported by the US Department of Energy under Award DE-FE0005054

Oxyfuel process



CPU block flow diagram

- 1st generation, yet innovative design!
  - No SCR: NOx are removed in the cold box
  - CO_2 compressed/pumped



Plant performance

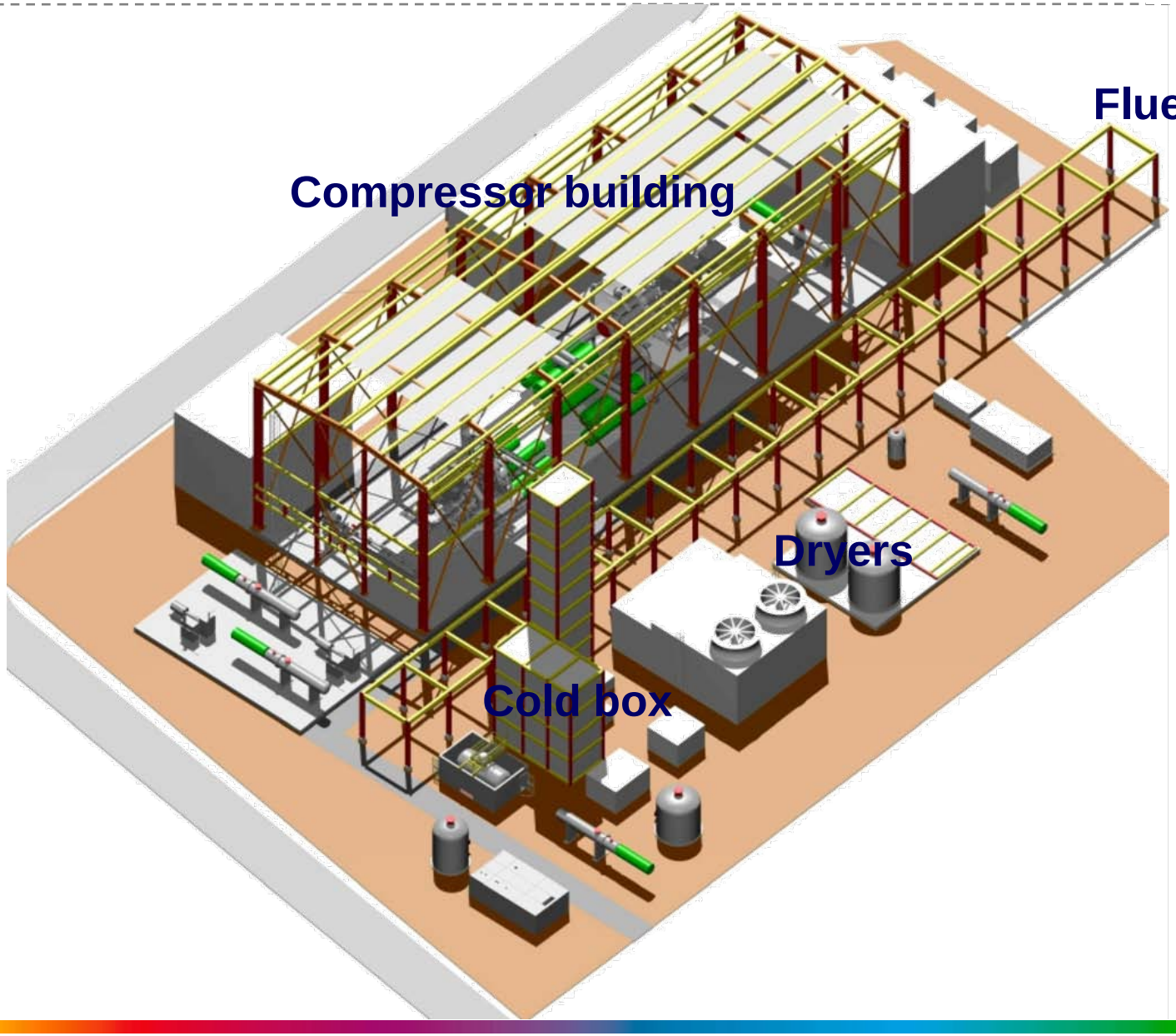
Near-Zero emissions plant

Emissions Constituent	lb/hr	lb/MBtu (HHV)
CO	286.90	0.15
NO_x	≤ 28.21	≤ 0.0147
VOM	≤ 6.89	≤ 0.0036
Particulate (Total)	≤ 0.0006	≤ 0.00000031
SO_2	≤ 0.774	≤ 0.0004
SO_3	≤ 1.660	≤ 0.00087
HCl	≤ 0.092	≤ 0.000048
HF	≤ 0.00065	≤ 0.00000034
Hg	≤ 0.0000059	≤ 0.0000000031

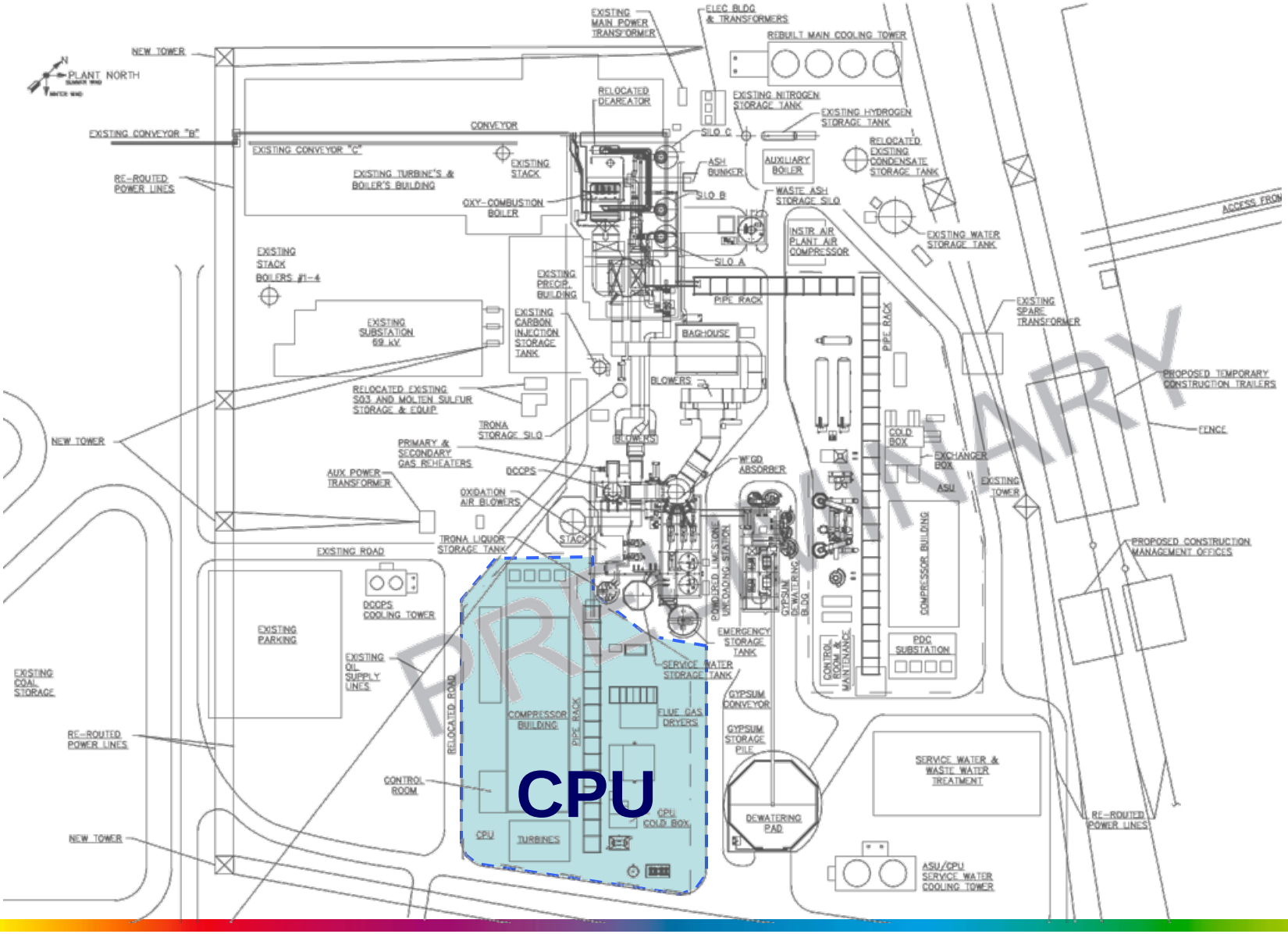
CO_2 quality

CO_2 Recovery	90% (mass basis)
Mass flow (CO_2)	351 klbs/hr (4210 tpd or 3820 metric tons / day)
Pressure	2100 psig *
Temperature	71°F
CO_2 content	≥ 99.7% (by mass, dry basis)
Inerts (Ar, N_2)	≤ 0.04% (by mass, dry basis)
Water (H_2O)	≤ 1 ppmw (dry basis)
Oxygen (O_2)	≤ 110 ppmw (dry basis)
Total Sulfur (SO_x)	≤ 1 ppmw (dry basis)
Hydrogen Sulfide (H_2S)	Negligible
Nitrous Oxides (NO_x)	≤ 1700 ppmw (dry basis)
Mercury (Hg)	≤ 2 ppbw (dry basis)

CPU details



Plot plan


NEW TOWER
PLANT NORTH
EXISTING CONVEYOR "B"
EXISTING CONVEYOR "C"
CONVEYOR
RE-ROUTED POWER LINES
EXISTING TURBINE'S & BOILER'S BUILDING
EXISTING STACK
OXY-COMBUSTION BOILER
EXISTING STACK BOILERS #1-4
EXISTING SUBSTATION 69 kV
EXISTING CARBON INJECTION STORAGE TANK
EXISTING PRECIP. BUILDING
RELOCATED EXISTING SO3 AND MOLTEN SULFUR STORAGE & EQUIP
TRONA STORAGE SILO
PRIMARY & SECONDARY GAS REHEATERS
AUX POWER TRANSFORMER
DCCPS
OXIDATION AIR BLOWERS
TRONA LIQUOR STORAGE TANK
EXISTING ROAD
DCCPS COOLING TOWER
EXISTING PARKING
EXISTING OIL SUPPLY LINES
EXISTING COAL STORAGE
RE-ROUTED POWER LINES
CONTROL ROOM
NEW TOWER
RELOCATED ROAD
COMPRESSOR BUILDING
PIPE RACK
CPU
TURBINES
CPU COLD BOX
FLUE GAS DRYERS
EXISTING MAIN POWER TRANSFORMER
ELEC BLDG & TRANSFORMERS
REBUILT MAIN COOLING TOWER
RELOCATED DEAERATOR
EXISTING NITROGEN STORAGE TANK
EXISTING HYDROGEN STORAGE TANK
SILO C
ASH BUNKER
AUXILIARY BOILER
RELOCATED EXISTING CONDENSATE STORAGE TANK
SILO B
WASTE ASH STORAGE SILO
INSTR. AIR PLANT AIR COMPRESSOR
EXISTING WATER STORAGE TANK
SILO A
PIPE RACK
BAGHOUSE
BLOWERS
STACK
WFGD ABSORBER
POWDERED LIMESTONE UNLOADING STATION
GYPSUM DEWATERING BLDG
EMERGENCY STORAGE TANK
SERVICE WATER STORAGE TANK
GYPSUM CONVEYOR
GYPSUM STORAGE PILE
DEWATERING PAD
COLD BOX
EXCHANGER BOX
ASU
COMPRESSOR BUILDING
CONTROL ROOM & MAINTENANCE
PDC SUBSTATION
EXISTING SPARE TRANSFORMER
EXISTING TOWER
ACCESS FROM
PROPOSED TEMPORARY CONSTRUCTION TRAILERS
FENCE
PROPOSED CONSTRUCTION MANAGEMENT OFFICES
SERVICE WATER & WASTE WATER TREATMENT
ASU/CPU SERVICE WATER COOLING TOWER
RE-ROUTED POWER LINES
PRELIMINARY