Iowa State University
Utility Enterprise Fact Sheet

The utility enterprise employs 77 people and operates and maintains 2 central plants on the main campus and 2 satellite facilities at the Veterinary Medicine Complex and the Applied Science Center. The utility also operates and maintains systems to deliver utility services to campus buildings.

The utility operates as a rate-based auxiliary enterprise and has a $33.0 million annual budget including all wages, operating and maintenance costs, capital expenditures, debt service and depreciation charges.

Iowa State has operated a central co-generation facility since 1891. The current production facilities contain the following major equipment and have a replacement value of $282 million.

- 6 Boilers – total steam capacity of 900,000 pounds per hour
- 4 Turbine Generators – total electrical capacity 46 megawatts
- 5 Chillers – total cooling capacity of 21,000 tons
- 4 Air Compressors – total compressed air capacity of 3,750 cubic feet per minute
- Water Plant – rated at 1 million gallons per day

The main plant on the northeast corner of main campus combined with the north chilled water plant annually:

- Consumes 159,525 tons of coal
- Consumes 16,602 tons of limestone
- Generates 26,980 tons of ash
- Provides 203,017,000 kilowatt-hours of electricity
- Generates 2,763,420,000 pounds of steam
- Provides 34,089,000 ton-hours of cooling

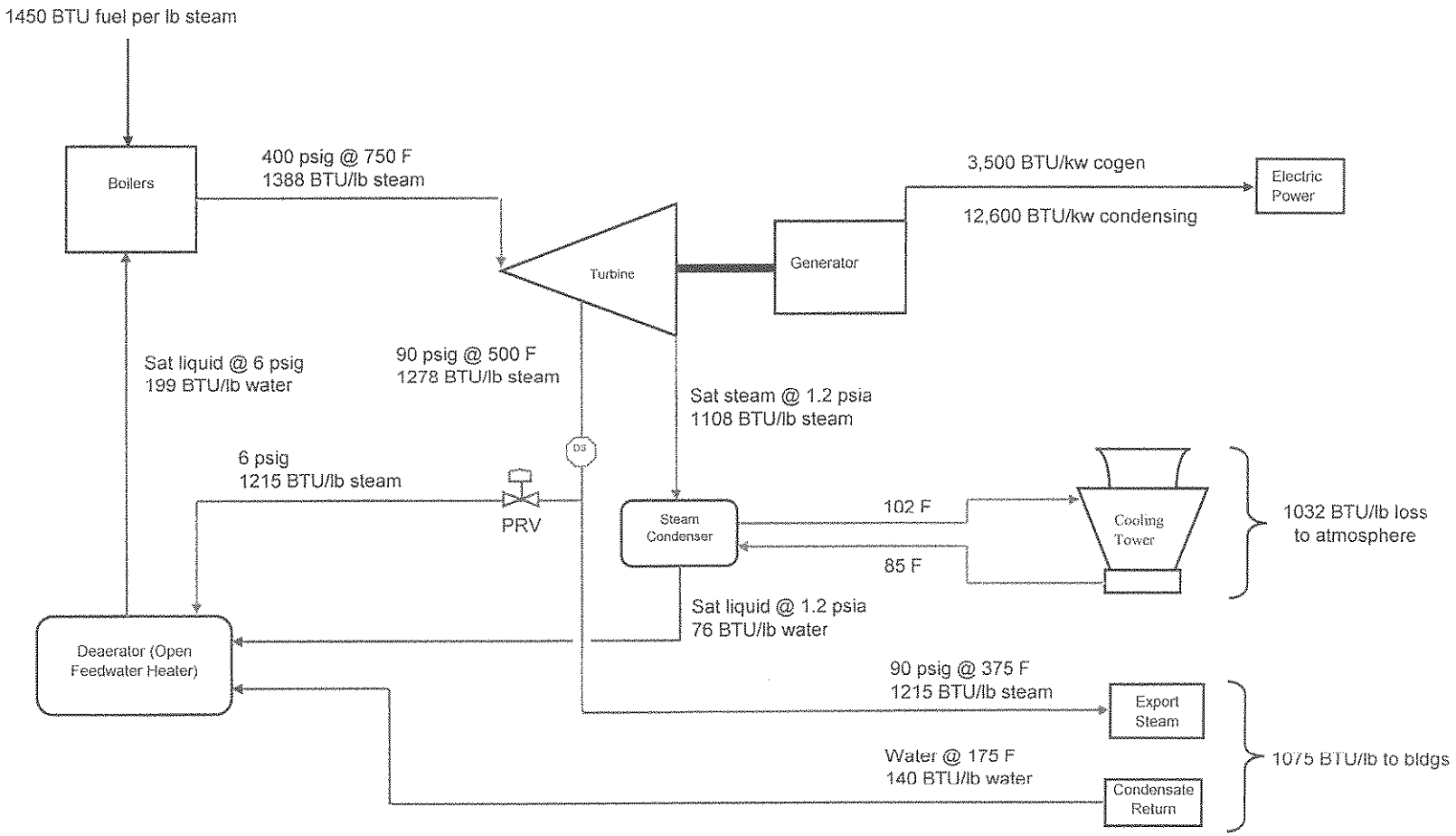
We also deliver or collect from campus buildings annually:

- 1,080,232,000 lbs of steam
- 22,581,000 cubic feet of natural gas
- 328,246,000 gallons of water
- 226,671,000 gallons of sewage

We also operate and maintain the following utility distribution systems with a replacement value of $157 million.

- Steam tunnels – 4.55 miles
- Direct-buried steam and condensate systems – 2.6 miles
- Chilled water systems – 5.3 miles
- Domestic water systems – 8.3 miles
- Natural gas systems – 4.5 miles
- Sanitary sewer systems – 10.3 miles
- Storm sewer systems – 25.2 miles
- Compressed air systems – 3.5 miles
- Traffic lights - 7
- Street, walkway and parking lot lights – 1,900
- Electrical substations – 7
- Electrical transformers – 515
- High voltage electrical cables – 16.7 miles
- Telecom distribution cables – 90 miles

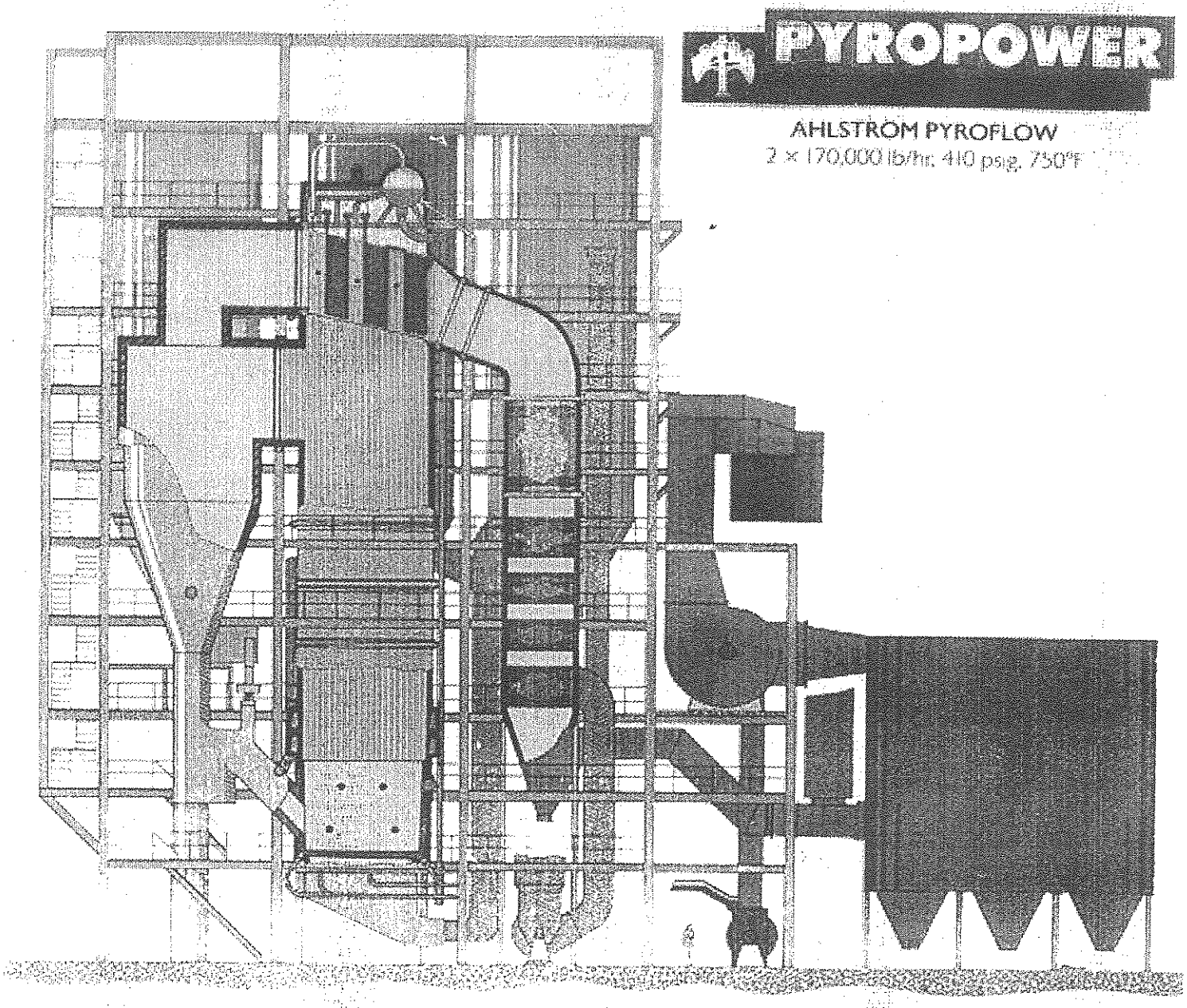
Iowa State University Power Plant
Steam Cycle



Iowa State University
Power Plant
Emissions Limits

	Limit	Normal Level	Reporting Period
Stoker Boilers			
Sulfur Dioxide	5.00 lb/mmBTU	3.87 lb/mmBTU	Monthly Average
Particulate	0.389 lb/mmBTU 40% Opacity	0.05-0.35 lb/mmBTU 15% Opacity	Performance Test 6 minute average
CFB Boilers			
Sulfur Dioxide	1.00 lb/mmBTU 1.42 lb/mmBTU 90% Removal	0.35 lb/mmBTU 0.35 lb/mmBTU 90.5% Removal	30 day rolling avg. 3 hour rolling avg. 30 day rolling avg.
Nitrogen Oxides	0.40 lb/mmBTU 0.40 lb/mmBTU	0.15 lb/mmBTU 0.15 lb/mmBTU	3 hour rolling avg. 30 day rolling avg.
Particulate	0.034 lb/mmBTU 10% Opacity	0.020 lb/mmBTU < 5% Opacity	Performance Test 6 minute average
Carbon Monoxide	200 ppm	<50 ppm	3 hour rolling avg.
Fluoride	0.039 lb/mmBTU	0.0085 lb/mmBTU	Performance Test
Lead	0.0015 lb/mmBTU	0.00011 lb/mmBTU	Performance Test
Beryllium	0.00063 lb/mmBTU	0.0000024 lb/mmBTU	Performance Test

lb/mmBTU is pounds of pollutant per million BTU of fuel input to the boiler



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Mechanical collectors

Mechanical dust collectors, often called cyclones or multiclones, have been used extensively to separate large particles from a flue gas stream. The cyclonic flow of gas within the collector and the centrifugal force on the particulate drive the particulate out of the flue gas (Fig. 10). Hoppers below the cyclones collect the particulate and feed an ash removal system. The mechanical collector is most effective on particles larger than 10 microns. For smaller particles, the collection efficiency drops considerably below 90%.

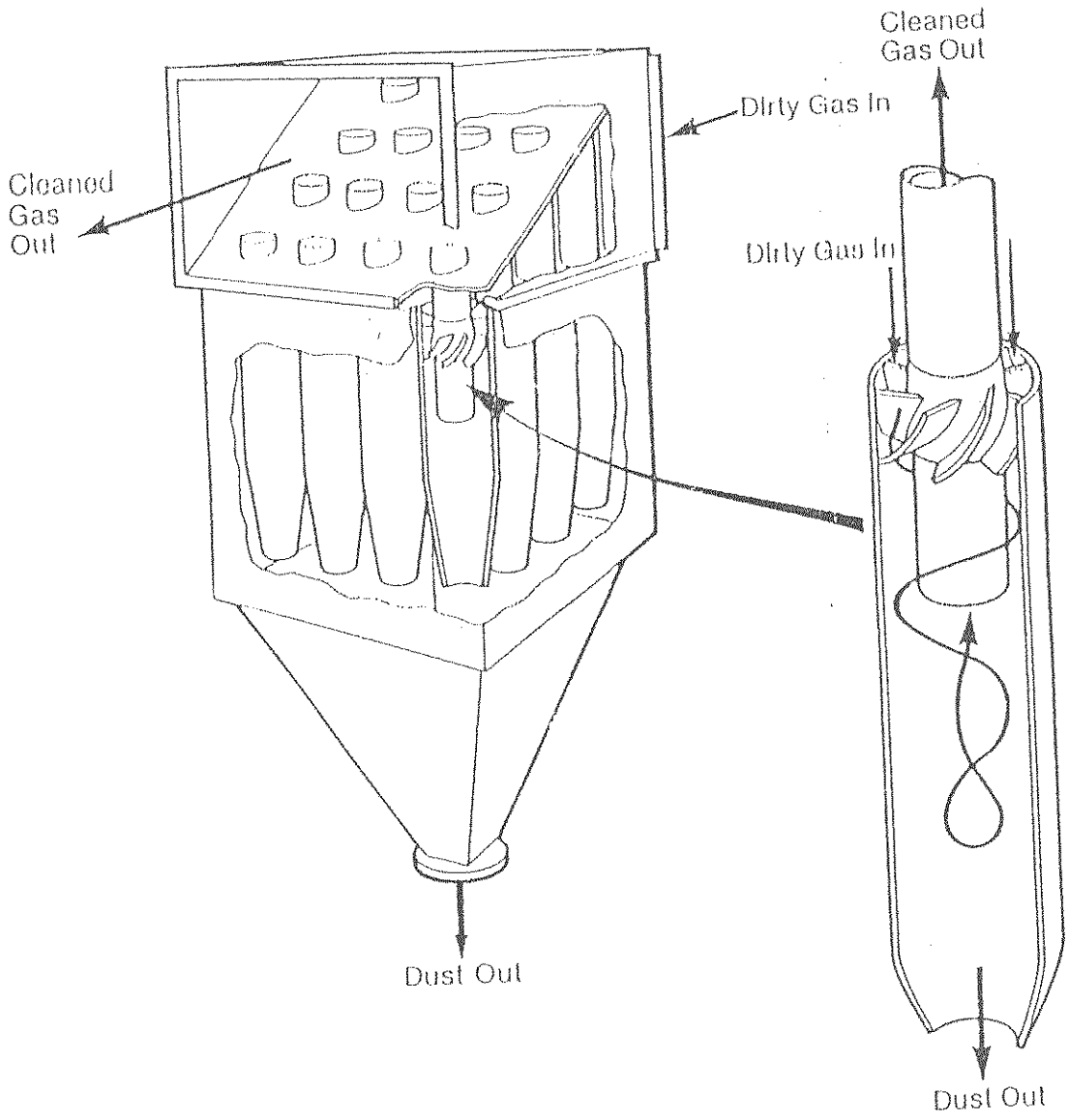


Fig. 10 Mechanical collector.

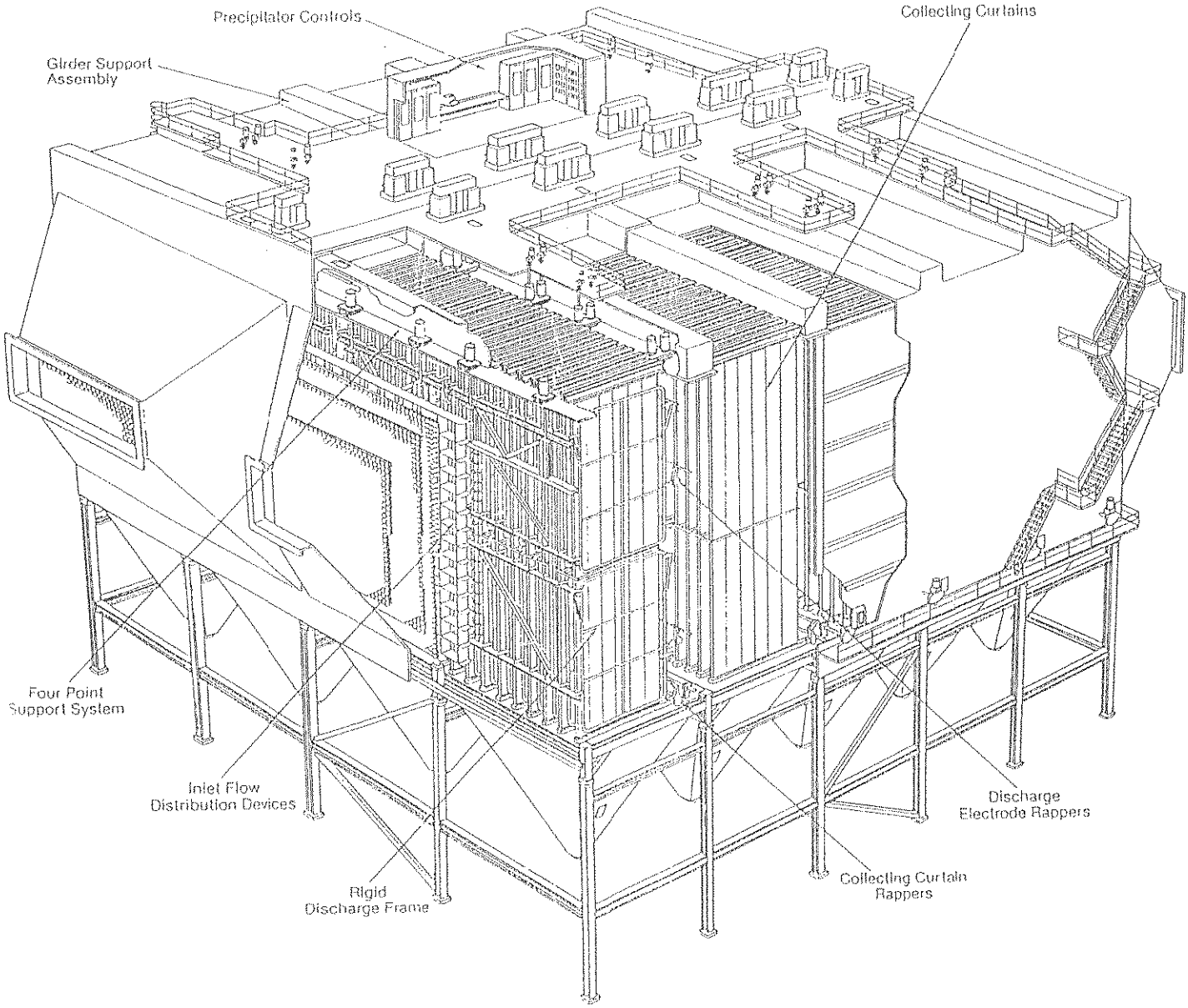


Fig. 6 B&W/Rothemuhle rigid frame electrostatic precipitator.

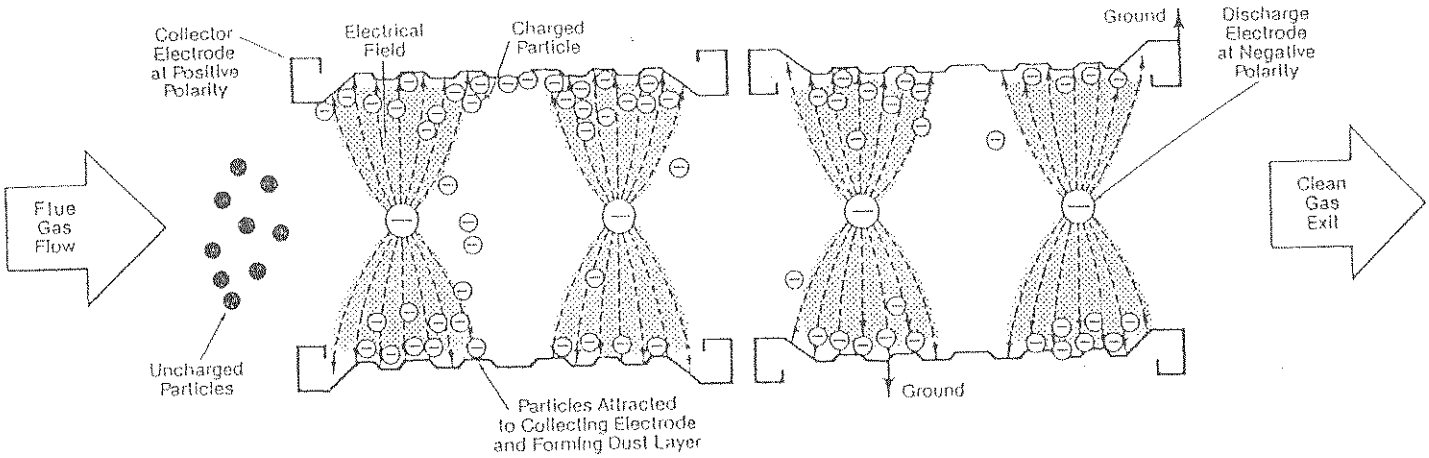


Fig. 3 Particle charging and collection within an ESP.

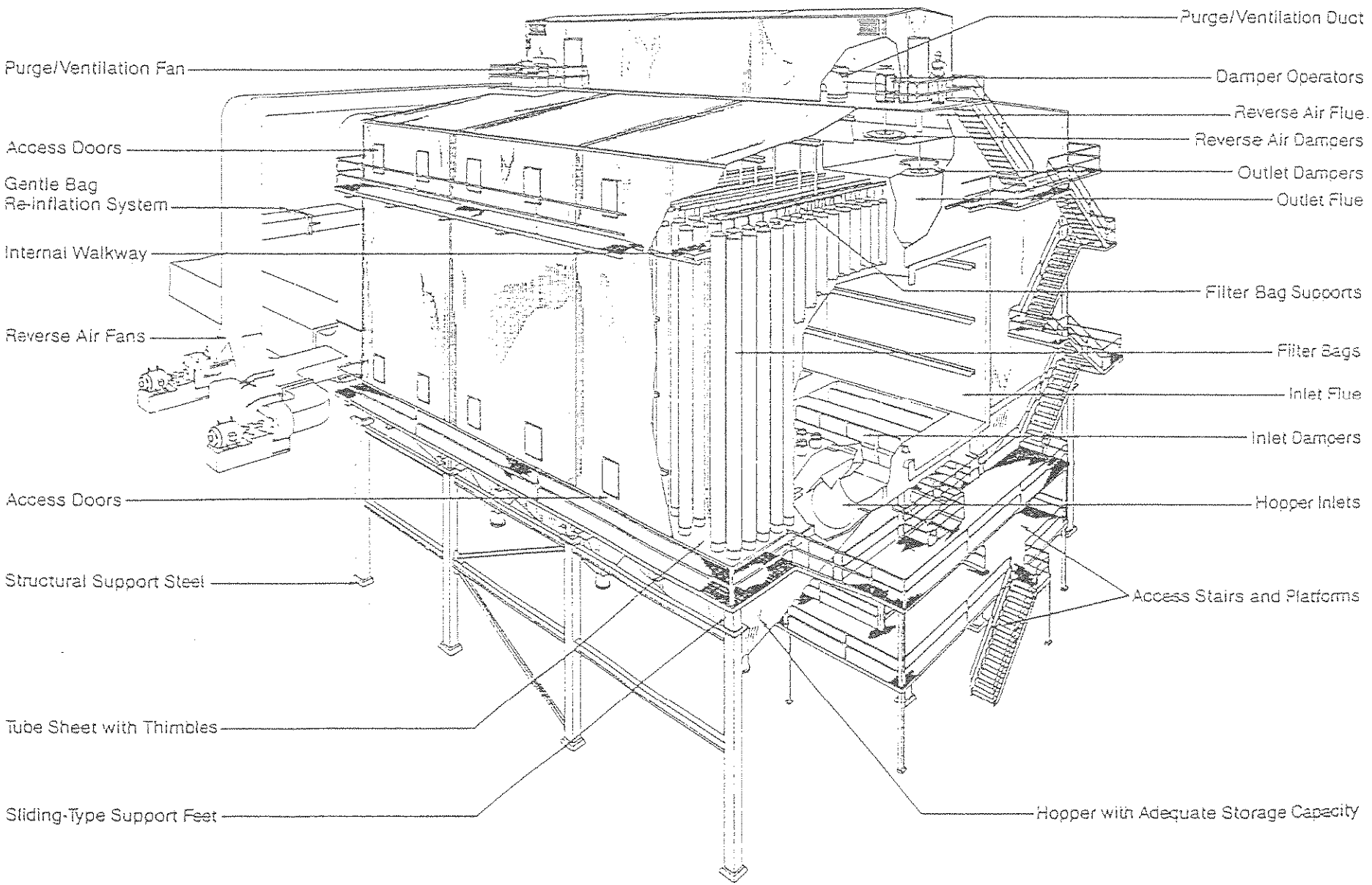


Fig. 8 Fabric filter or baghouse.

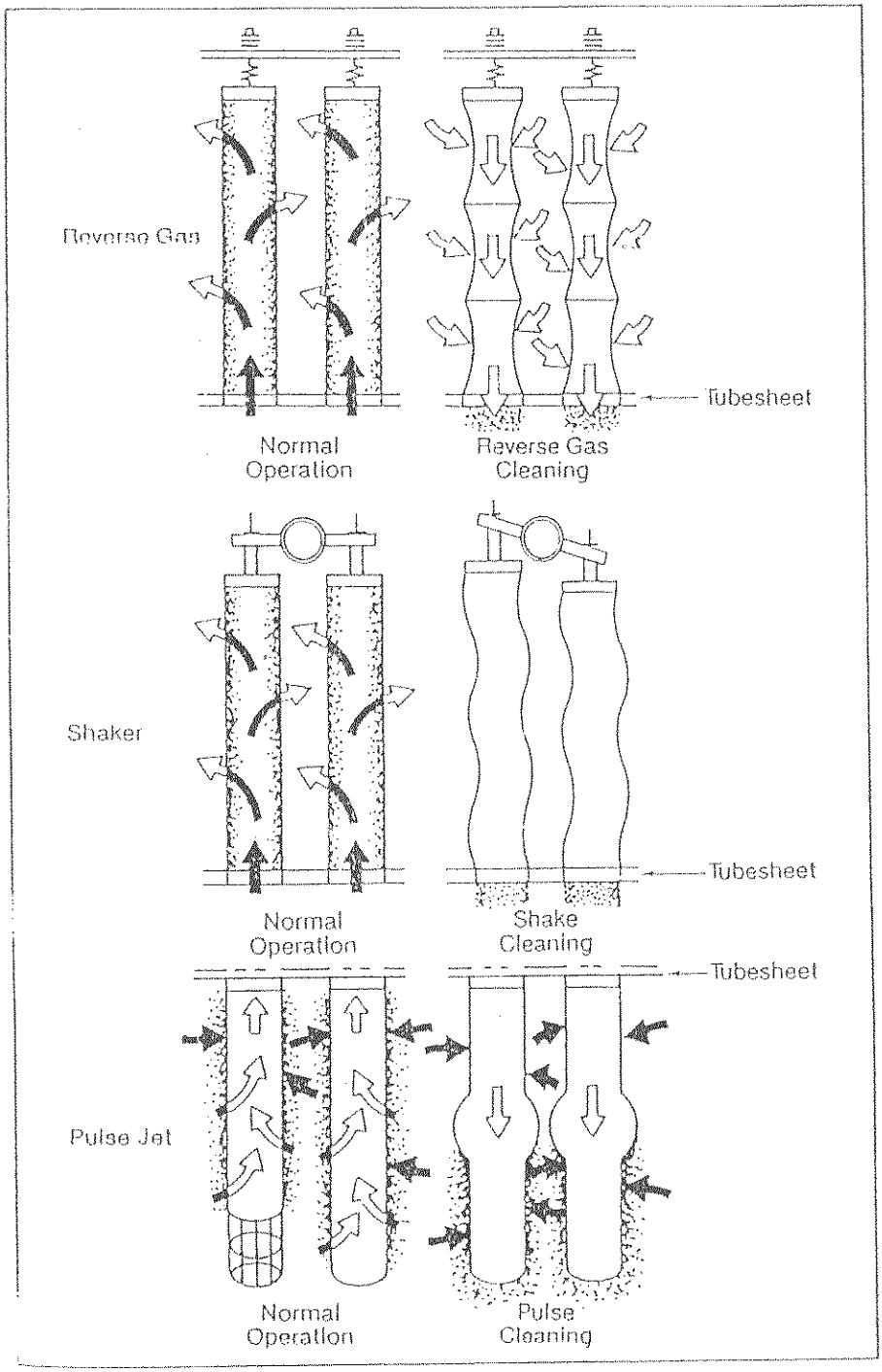


Fig. 9 Fabric filter types.

Emissions Comparison

Typical Emissions in tons for 200,000,000 kwh of electricity *

	Older Coal Plant	1980's Coal Plants	Today's Coal Plant	Today's gas plants	Nuclear plants	Wind Generator
Sulfur Dioxide (tons)	1,440	600	92	0	0	0
Nitrogen Oxides (tons)	720	150	64	64	0	0
Carbon Dioxide (tons)	275,000	291,667	180,000	86,667	0	0
High Level Waste (tons)	0	0	0	0	0.07	0

Energy Production Costs

Heat Rate (Btu/kwh)	12,000	10,000	9,200	8,000	NA	NA
Fuel Cost ($ per mmBTU)	$ 3.00	$ 2.20	$ 1.50	$ 8.00	NA	NA
Production Cost ($ per kwh)	$ 0.036	$ 0.022	$ 0.014	$ 0.064	$ 0.018	$ 0.040

* equivalent to recent ISU annual consumption

Iowa State University
Power Plant
Actual Emissions and Fees

Pollutant	2002 Actual Emissions Tons/Year	2003 Actual Emissions Tons/Year	2004 Actual Emissions Tons/Year	2005 Actual Emissions Tons/Year	2006 Actual Emissions Tons/Year
PM-10 (Boilers)	29.170	29.860	29.230	33.590	12.360
PM-10 (Non-boilers)	11.350	11.910	11.860	12.060	12.660
SOX	2060.420	2298.310	2260.460	2909.800	3238.100
NOX	451.850	442.590	458.500	457.010	519.500
Hydrogen Chloride	291.610	203.830	110.230	169.500	134.330
Lead	0.040	0.050	0.006	0.030	0.007
Beryllium	0.020	0.020	0.001	0.020	0.001
Mercury	0.004	0.004	0.004	0.004	0.005
Hydrogen Fluoride	6.340	3.870	8.284	4.260	2.190
Total	2850.80	2990.44	2878.58	3586.27	3919.15
Emissions Fee per ton	$ 30.75	$ 32.25	$ 31.60	$ 32.75	$ 32.42
Total Fees	$ 87,662.22	$ 96,441.82	$ 90,962.97	$ 117,450.47	$ 127,058.94

Iowa State University
Power Plant
Emissions Reduction Opportunities

Continue cogeneration

- 15,300 tons less coal consumed
- 1,600 tons less limestone consumed
- 2,585 tons less ash produced
- $1.24 million saved
- Emissions reductions
  - 37,000 tons less CO2
  - 310 tons less SO2
  - 50 tons less NOX

Do not consume energy

- Shut off things you don't need such as lights, A/V equipment, etc
- Improve efficiencies of operating equipment
- Adjust thermostats
- 100% efficient at reducing emissions
- Saves money for other things

Add pollution control equipment

- Effective but very expensive
  - Baghouse - $6.0 million
  - Scrubbers - $12-15 million
  - New coal boiler - $40 million plus

Iowa State University
Power Plant
Emissions Reduction Opportunities
(continued)

Switch Fuels

- Low sulfur eastern coals – cost is 25% greater than current fuel
- Low sulfur western coals – BTU content 25% lower, not suitable for ISU boilers, possible for blending with current fuel
- Biomass – Costs appear to be higher, BTU content 40% lower, possible for blending with current fuel
- Natural gas – Cost is 100+ % higher

Coal vs Biomass Comparison

Fuel Information				
	Midwestern Coal	Western Coal	Waste Wood	Oat Hulls
As Received				
Heating Value BTU/lb	11,707	8,838	6,435	6,934
% Moisture	10.07	26.05	20.22	10.43
% Ash	8.17	5.63	6.52	5.22
% Sulfur	2.43	0.21	0.44	0.04
Dry Basis				
% Carbon	72.23	71.09	47.83	48.58
% Hydrogen	4.99	4.80	5.74	5.26
% Nitrogen	1.46	1.00	0.54	0.73
% Oxygen	8.42	16.83	37.15	39.55
% Chlorine	0.15	0.00	0.06	0.17
Density lbs/cu ft	48	48	22	10
FY07 Fuel Requirements				
million BTU of fuel into plant	3,915,804	3,915,804	3,915,804	3,915,804
Fuel required - tons	167,242	221,532	304,258	282,363
Percent tonnage increase		132%	182%	169%
Fuel required - cubic feet	6,968,416	9,230,510	27,659,843	56,472,512
Percent fuel volume increase		132%	397%	810%
Truck capacity tons/truck	25	25	20	9
Trucks req'd per year	6,690	8,861	15,213	31,374

Economic Study of Coal Based Power Production & CO_2 Capture

Study Basis:

- 550 megawatts net output from plant
- Wet Scrubbers for SO_2 reduction
- SCR for NOx reduction
- Coal cost of $1.80 per mmBTU
- Natural gas cost of $6.75 per mmBTU

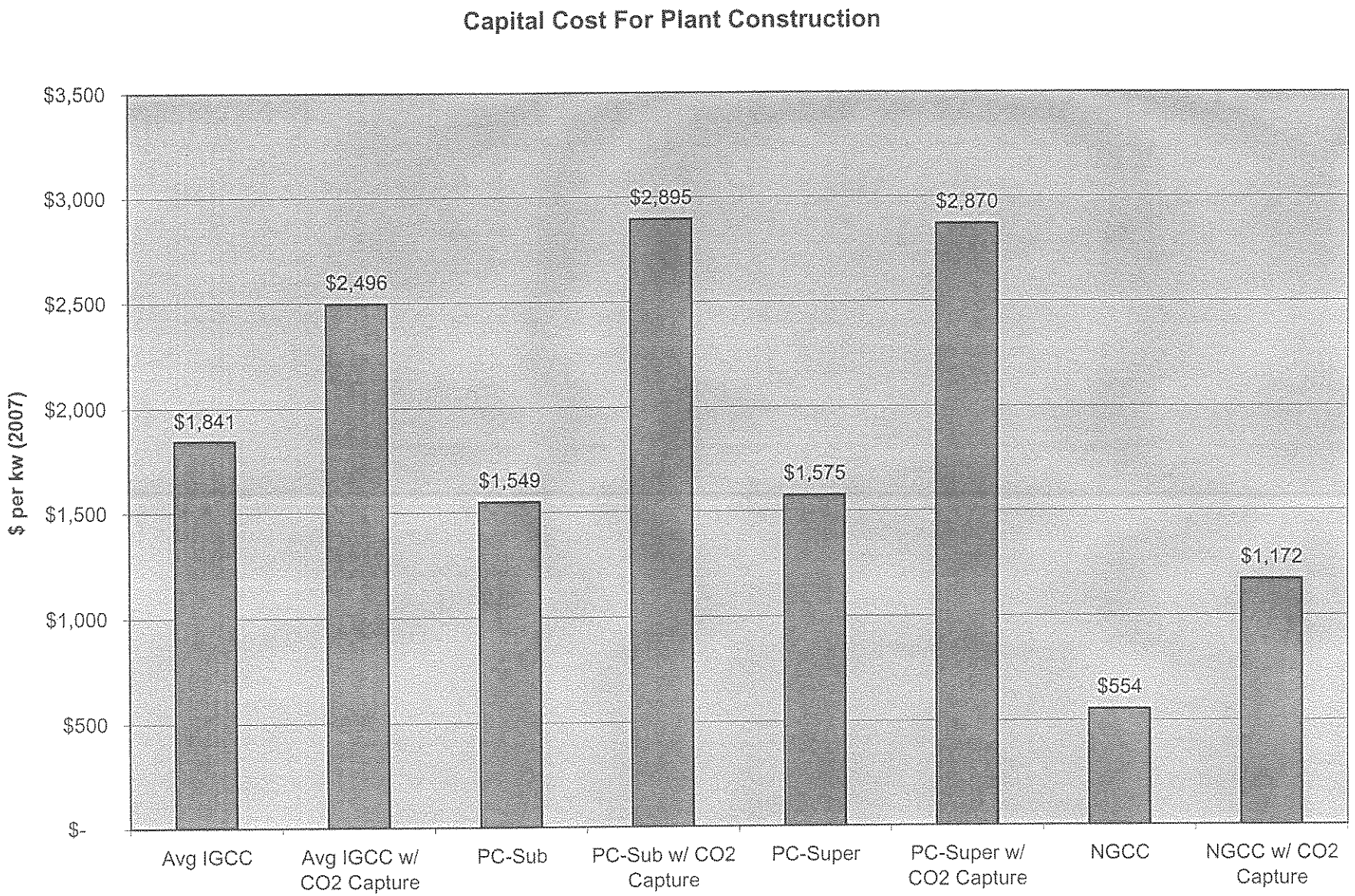
Plants Studied:

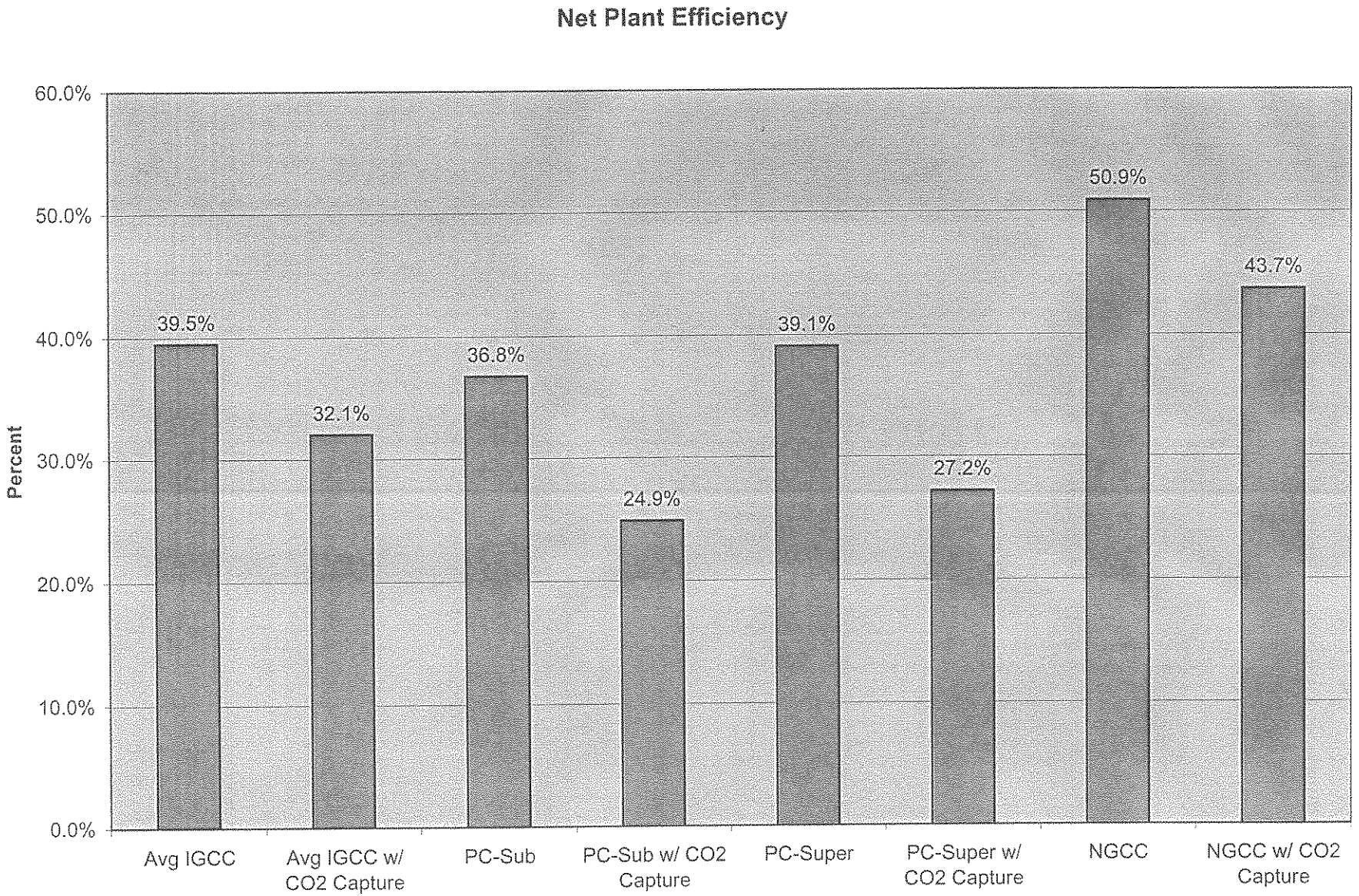
- Integrated Gasification Combined Cycle Coal Plant with and w/o CO_2 capture
- Subcritical Pulverized Coal Plant with & w/o CO_2 capture
- Supercritical Pulverized Coal Plant with & w/o CO_2 capture
- Natural Gas Combined Cycle Plant with and w/o CO_2 capture

Carbon Capture Assumptions:

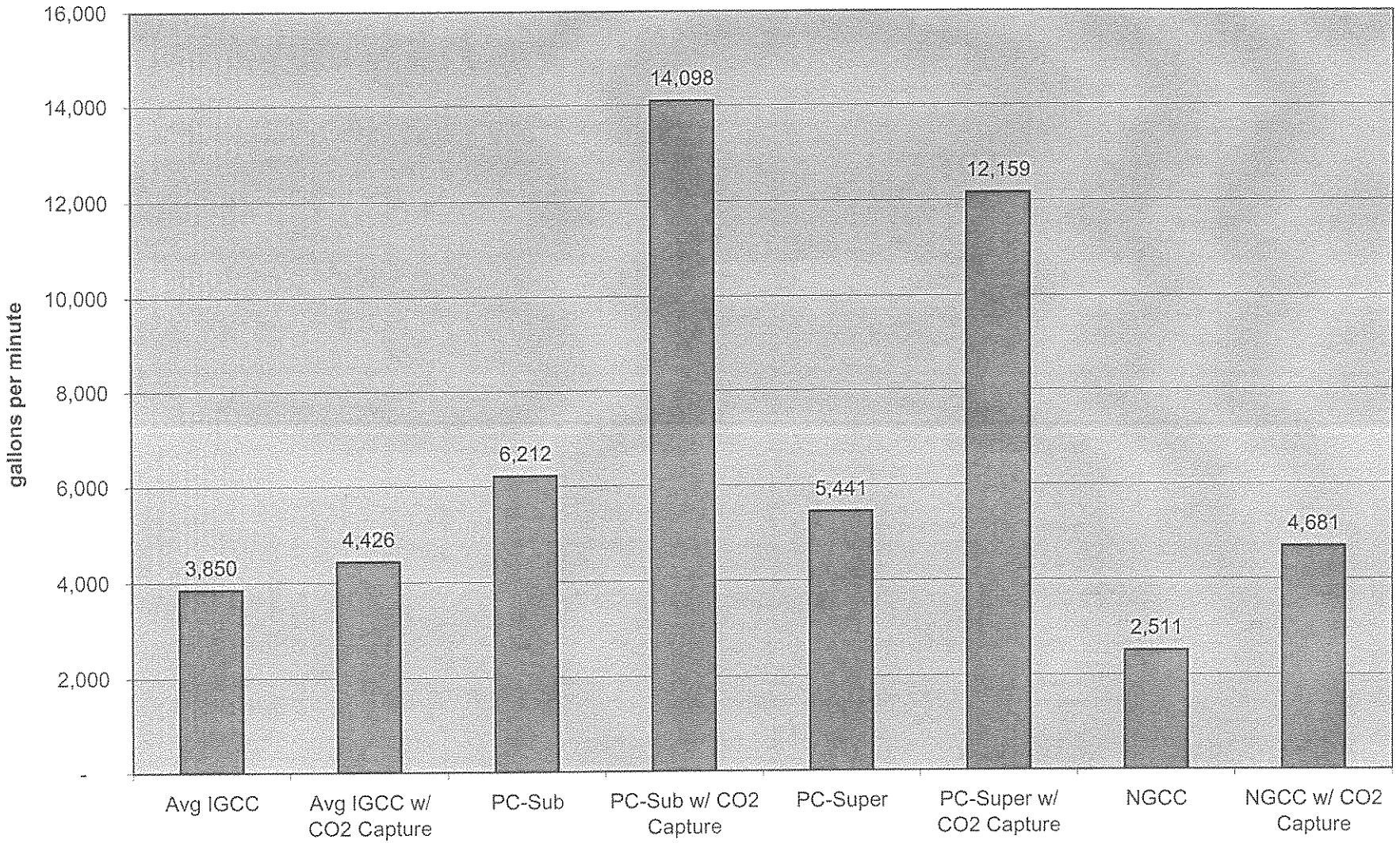
- Collect and compress CO_2 to 2200 psi
- 50 miles of pipeline to transport CO_2
- Injection of CO_2 to over 4,000 ft for sequestration
- Long term monitoring (80 years) of storage integrity

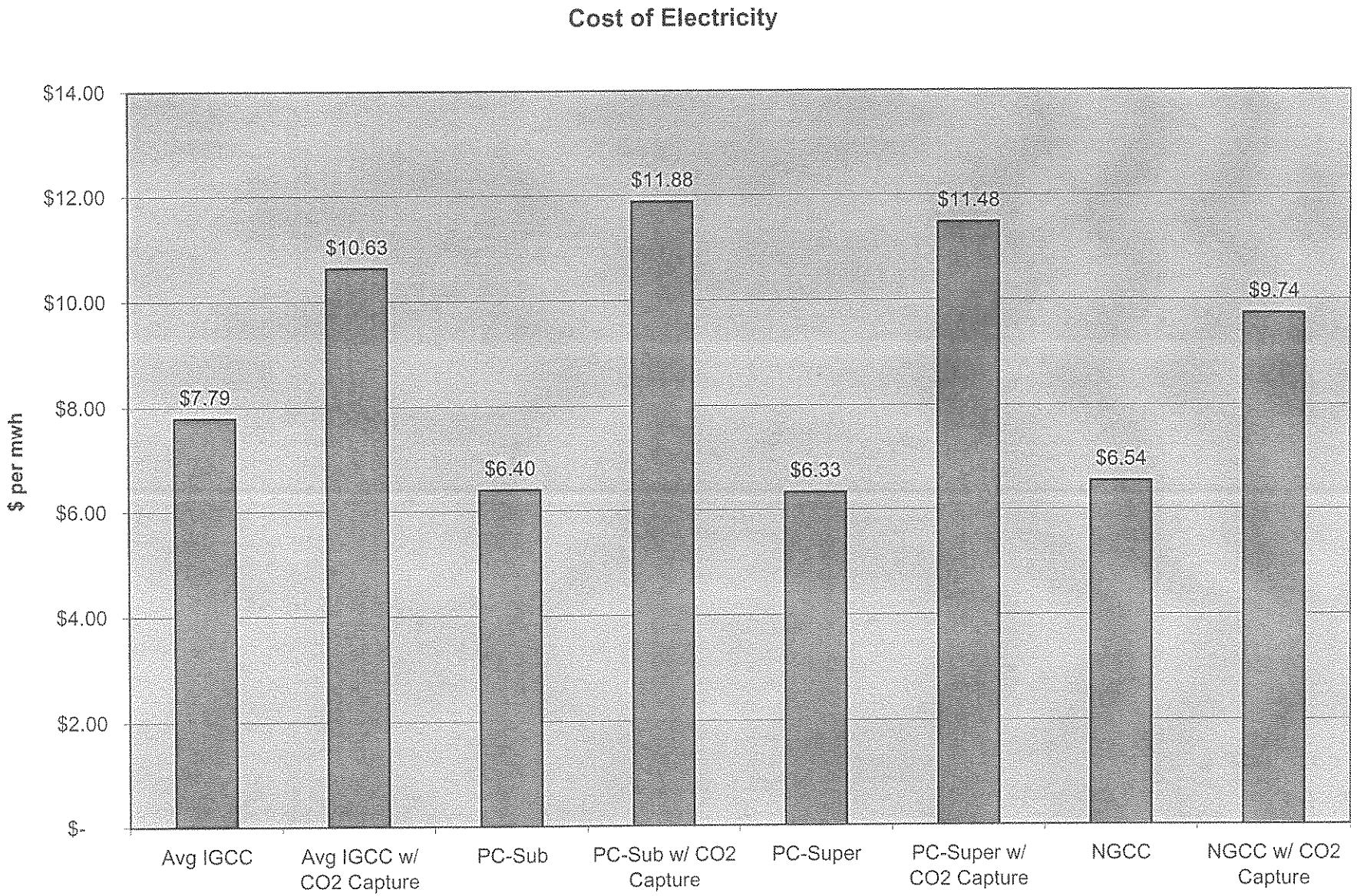
Source: Final Results of NTEL Baseline Study, May 2007


Capital Cost For Plant Construction
$ per kw (2007)
$3,500
$3,000
$2,500
$2,000
$1,500
$1,000
$500
$-
$1,841
$2,496
$1,549
$2,895
$1,575
$2,870
$554
$1,172
Avg IGCC
Avg IGCC w/ CO2 Capture
PC-Sub
PC-Sub w/ CO2 Capture
PC-Super
PC-Super w/ CO2 Capture
NGCC
NGCC w/ CO2 Capture


Net Plant Efficiency
Percent
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
39.5%
32.1%
36.8%
24.9%
39.1%
27.2%
50.9%
43.7%
Avg IGCC
Avg IGCC w/ CO2 Capture
PC-Sub
PC-Sub w/ CO2 Capture
PC-Super
PC-Super w/ CO2 Capture
NGCC
NGCC w/ CO2 Capture

Raw Water Consumption




Cost of Electricity
$ per mwh
$14.00
$12.00
$10.00
$8.00
$6.00
$4.00
$2.00
$-
$7.79
$10.63
$6.40
$11.88
$6.33
$11.48
$6.54
$9.74
Avg IGCC
Avg IGCC w/ CO2 Capture
PC-Sub
PC-Sub w/ CO2 Capture
PC-Super
PC-Super w/ CO2 Capture
NGCC
NGCC w/ CO2 Capture