Development of PSA System for the Recovery of CO_2 from Blast Furnace Gas

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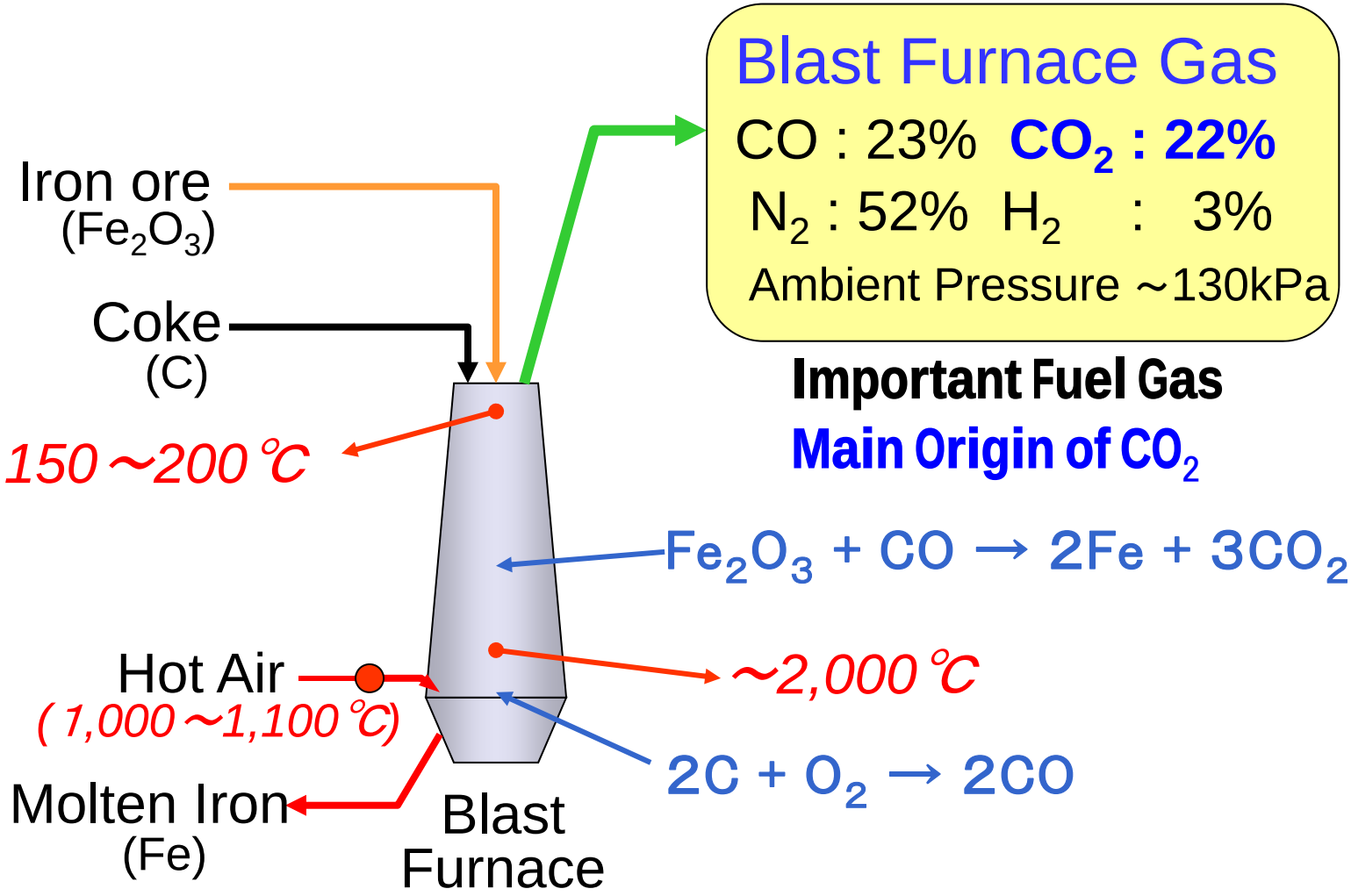
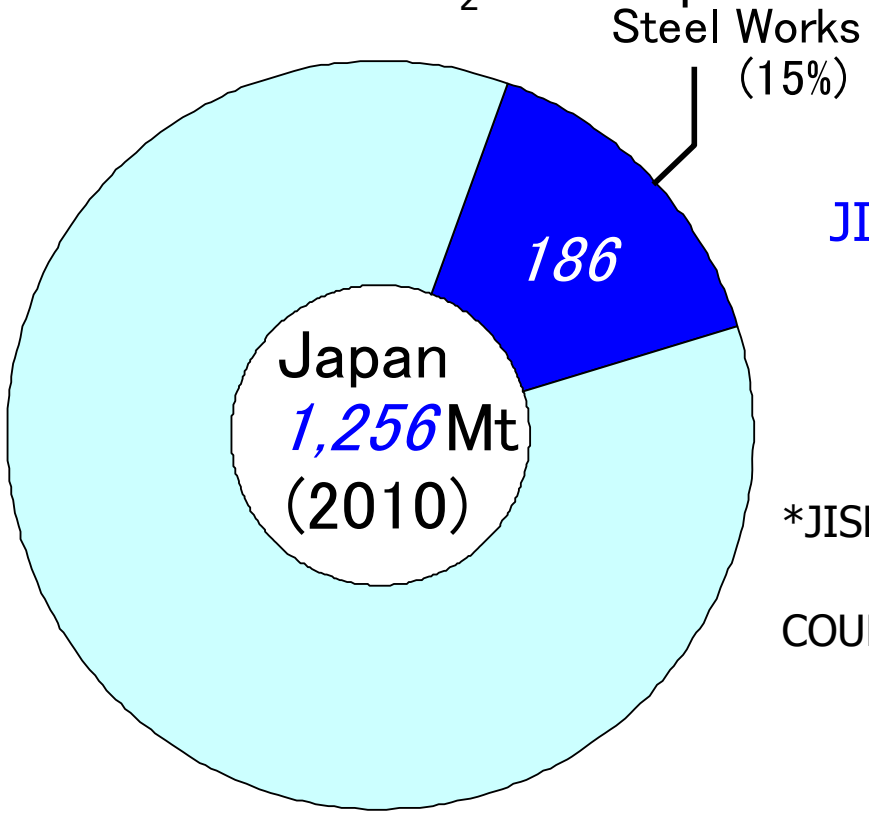
Blast Furnace



CO_2 Emission in Japan

CO_2 emission in Japan lies around 1.0-1.3 billion tons per year
CO_2 emission from Steel Works is around 15%
Reduction of CO_2 is an important subject for Steel Makers



JISF* starts COURSE 50** Project
(STEP 1 2008-2012)
(STEP 2 2013-2017)

*JISF : Japan Iron and Steel Federation

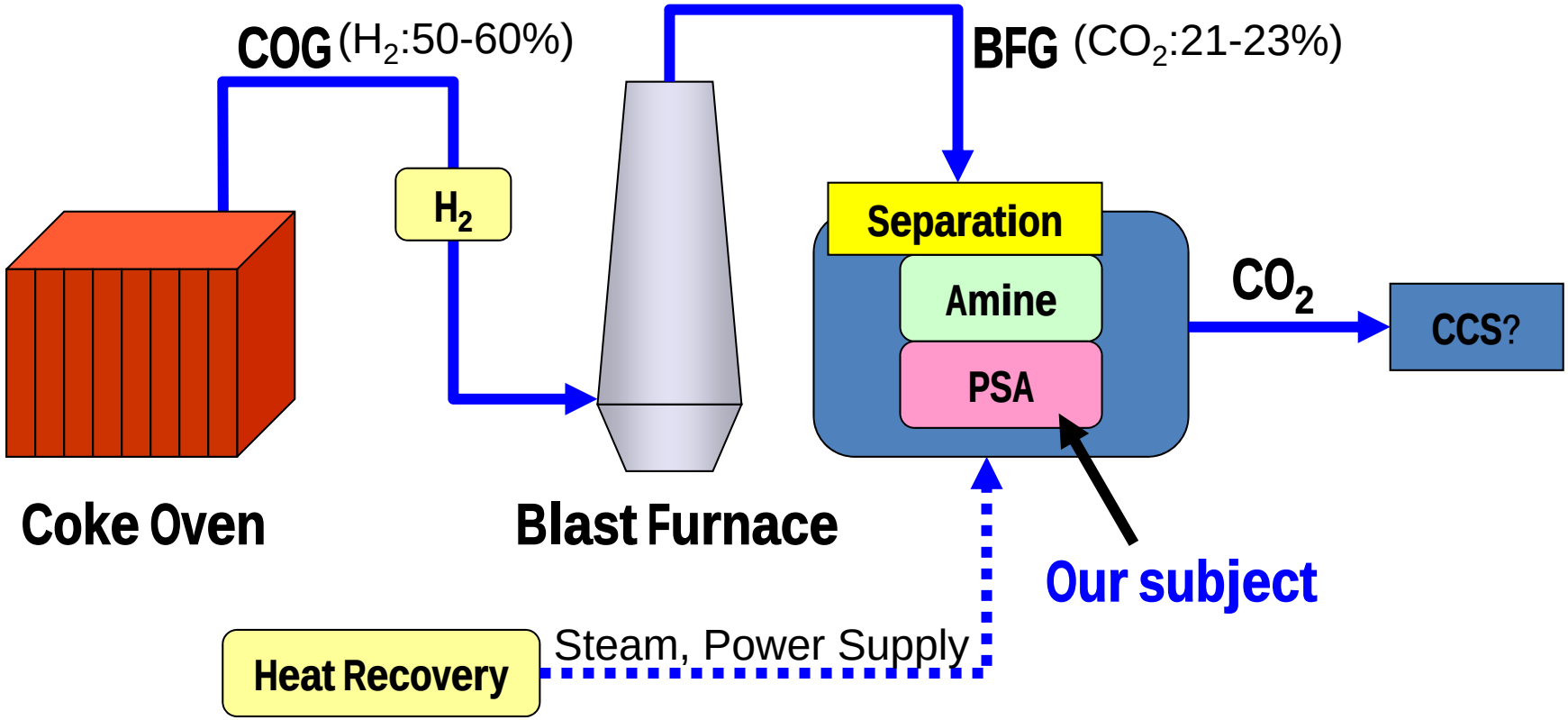
COURSE 50 : CO_2 Ultimate Reduction of Steel-making Process by Innovative Technology for Cool Earth 50

Subjects in COURSE 50

Use of H_2 at Blast Furnace for Iron Ore Reduction

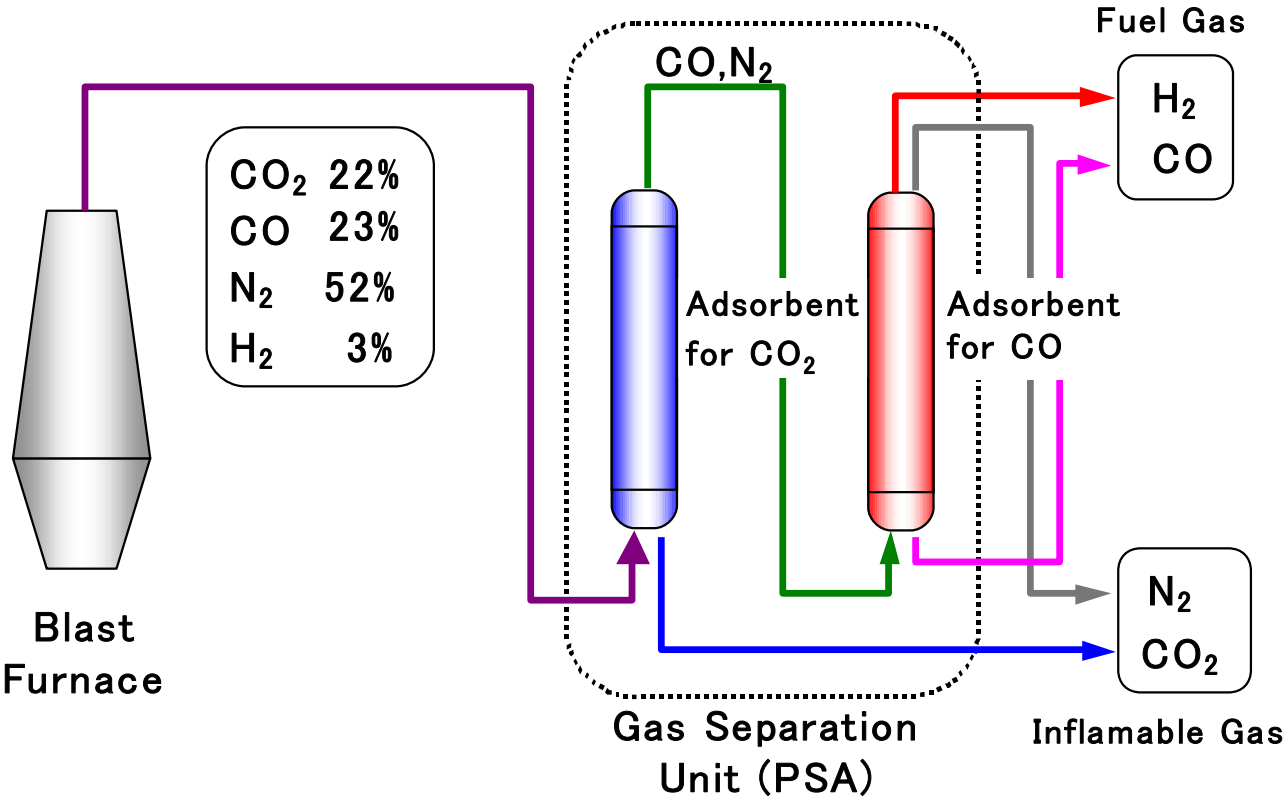
Separation of CO_2 from BFG with amine or PSA

Recovery of Wasted Heat to supply separation energy

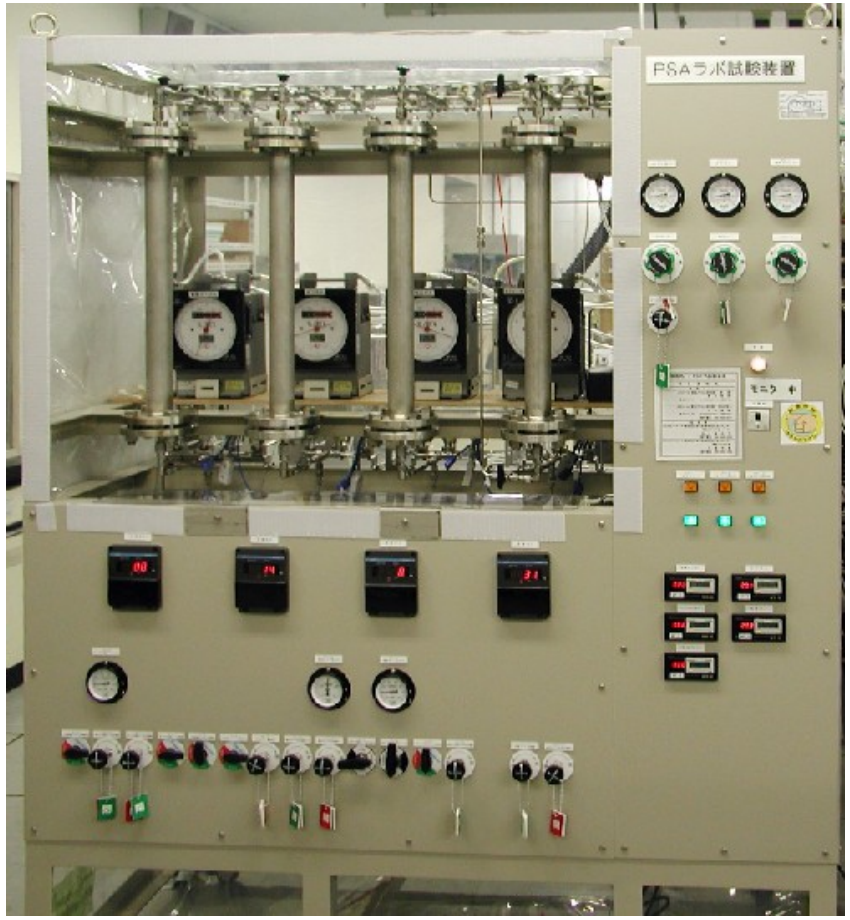


Outline of PSA Project

Target
- CO_2 Recovery ≧80% or CO_2 Purity ≧90%
- Flamable Gas Recovery ≧90%
- Reduction of CO_2 Recovery Cost >50% (≦2,000yen/t)



Laboratory PSA Apparatus

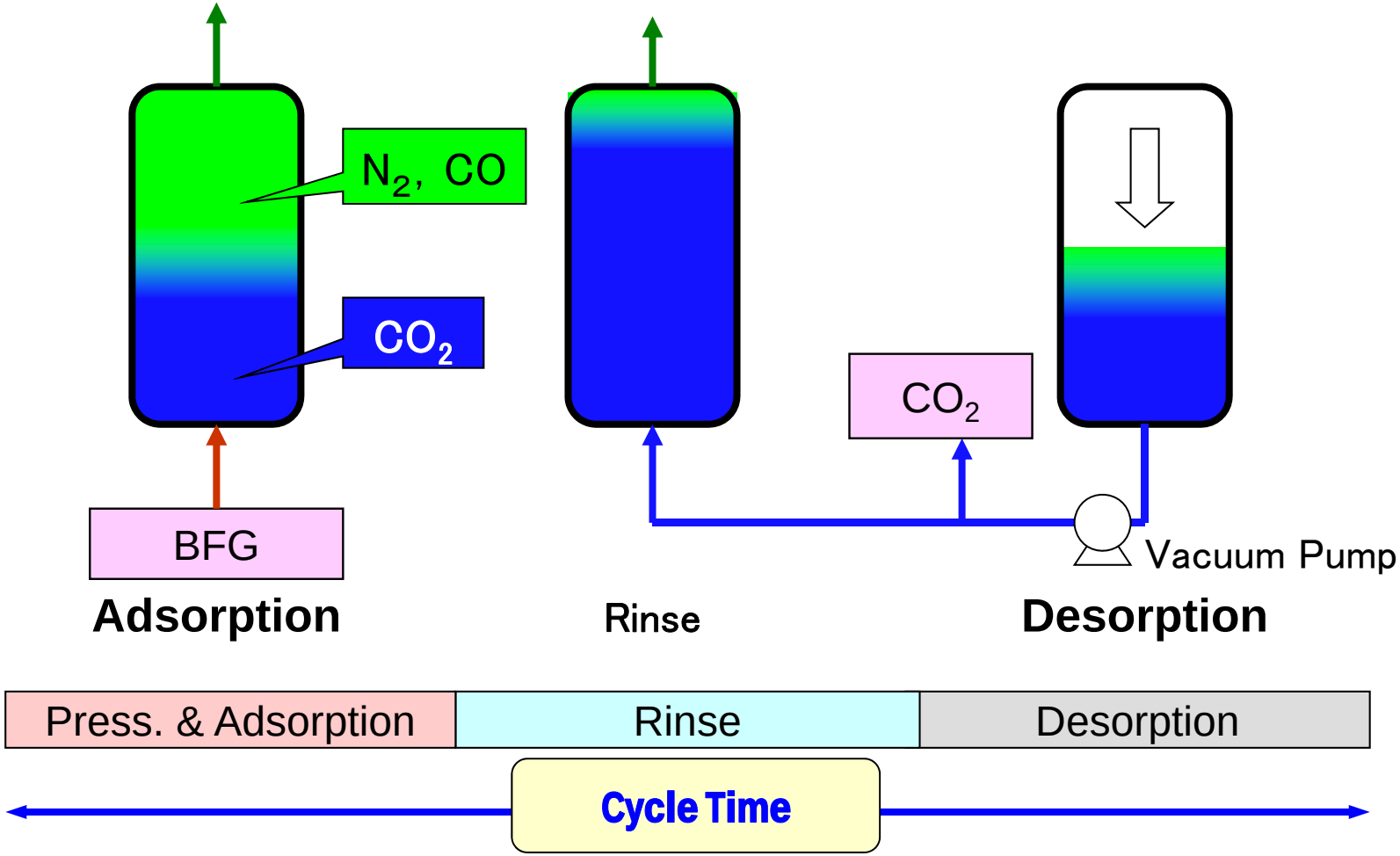


PSA Tower : ID.40mm x 500mmH x 4 Towers system
(Usually use 3towers]

Feed Gas : CO_2, CO, N_2, H_2

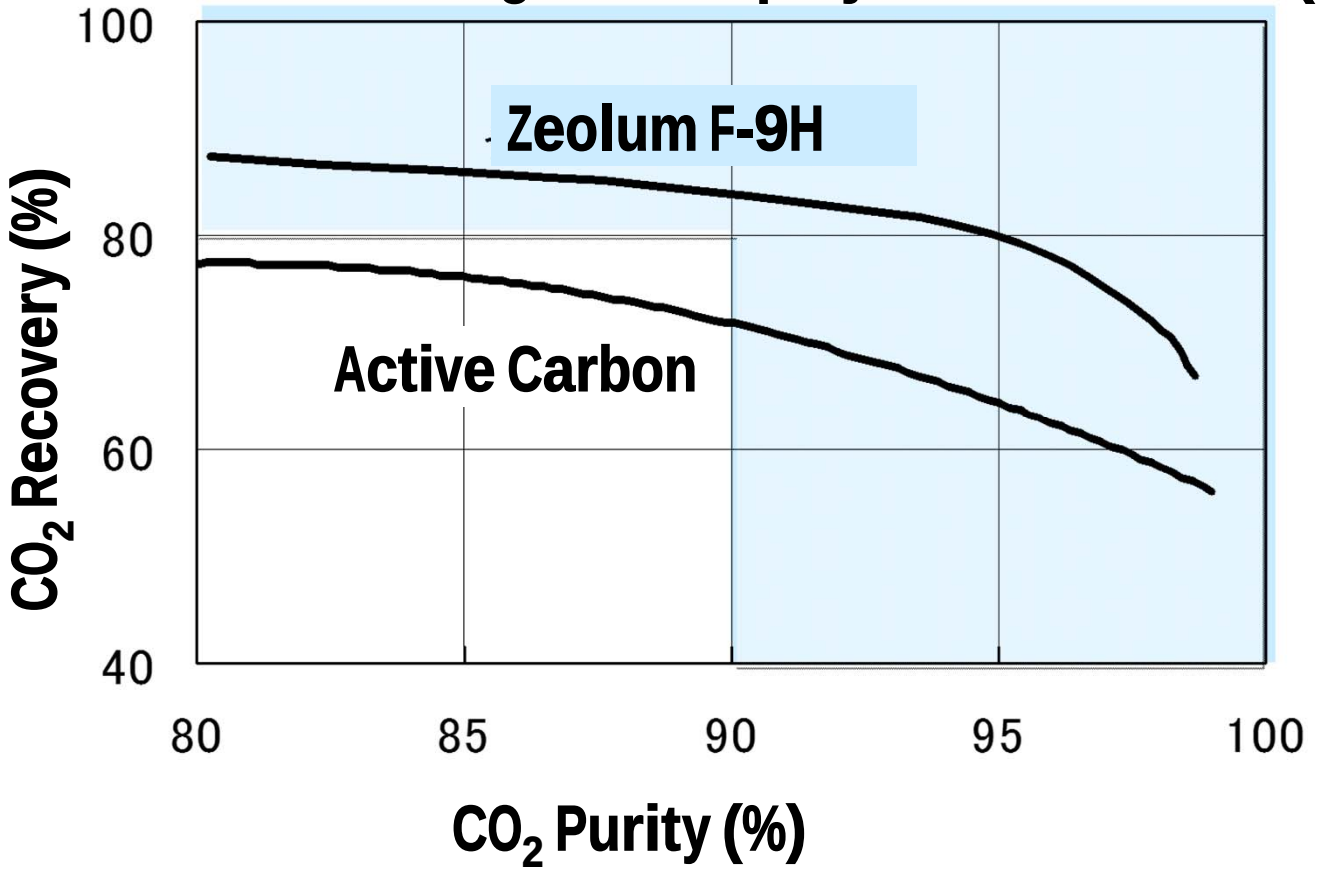
Each flow rate is controlled independently and mixed.

3 Steps 3 Towers PSA System



Evaluation by Laboratory PSA

Zeolum F-9H shows high performance in PSA system.
Technical target of the project is achieved. (blue area)

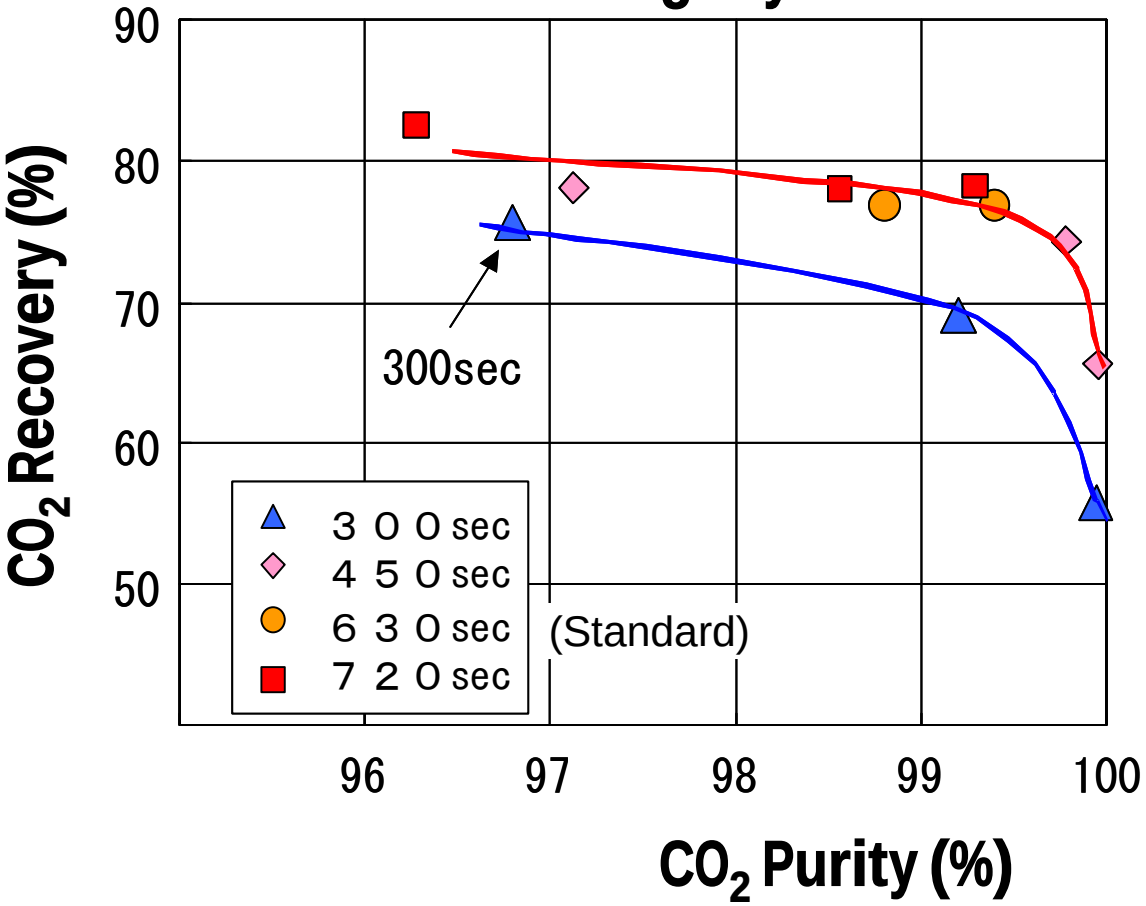


Adsorption 200kPa*
Desorption 7kPa*
Cycle Time 630sec

***absolute pressure**

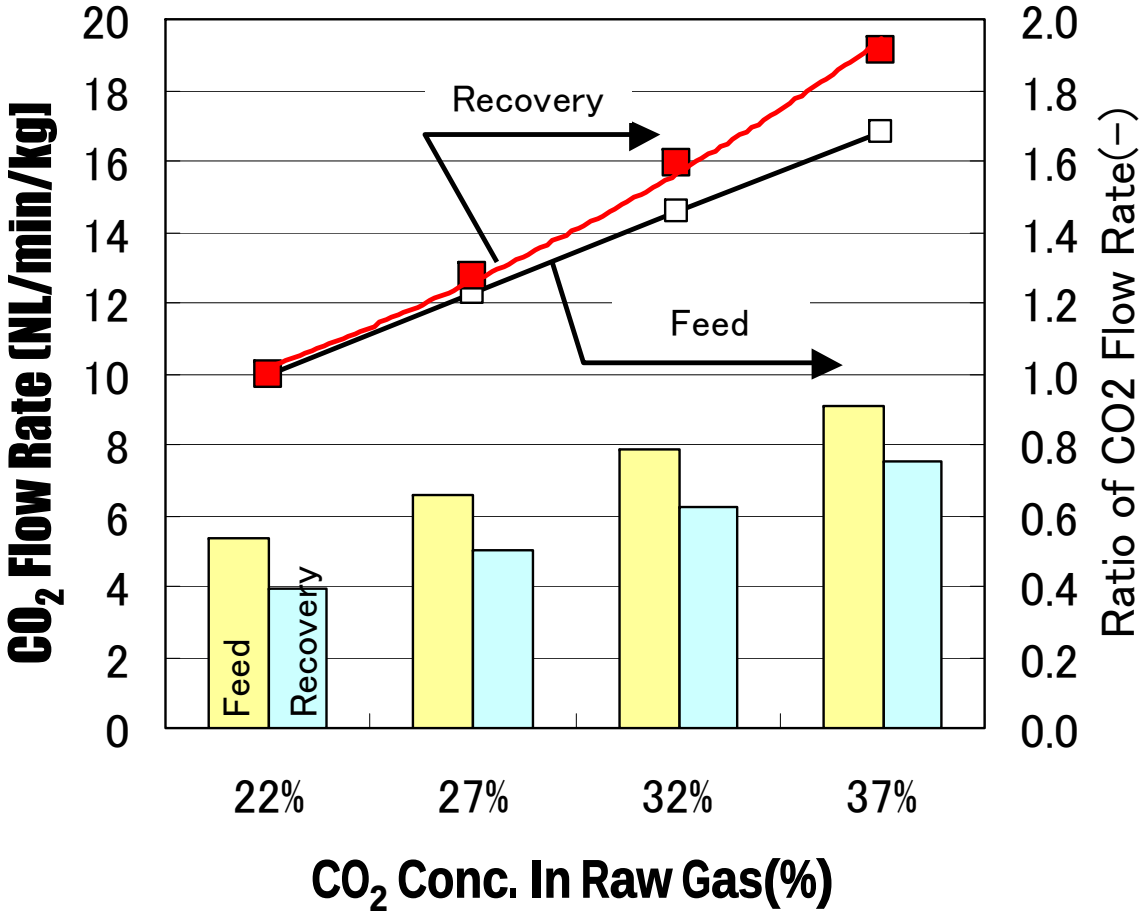
Effect of Cycle Time

No change in performance when cycle time lager than 450 sec.
Performance at 300sec is slightly lower but still acceptable.



Effects of CO_2 Concentration in Feed Gas

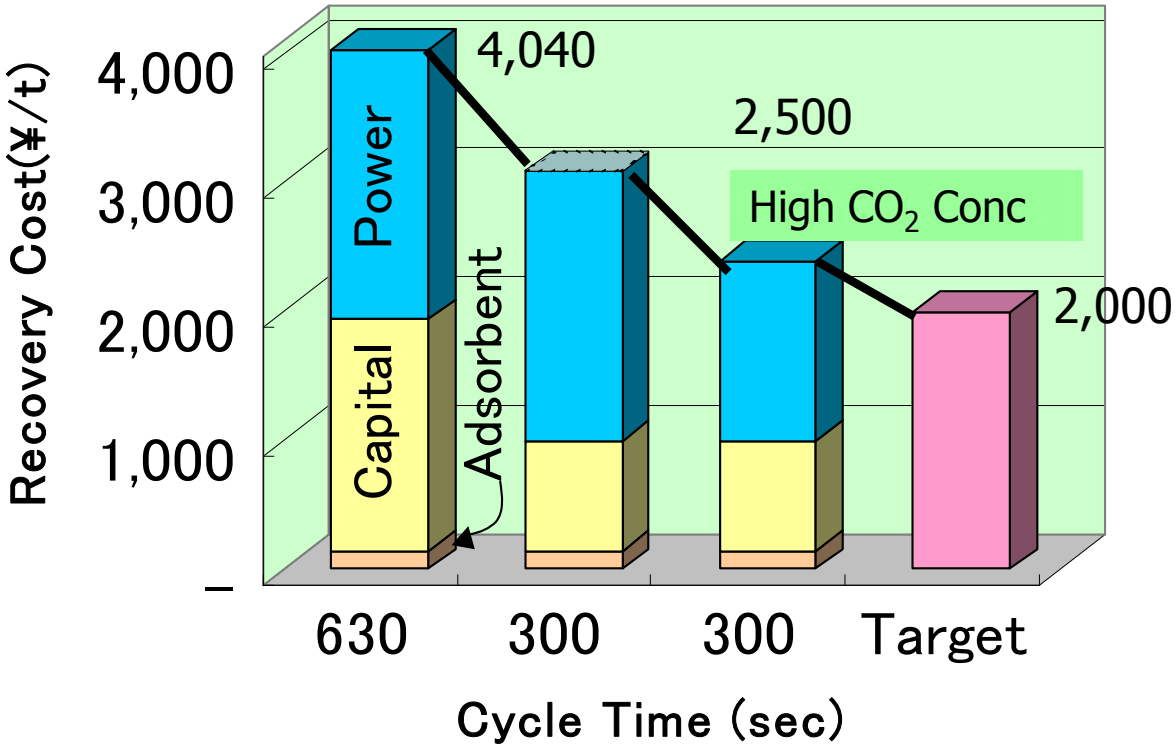
Higher CO_2 concentration leads higher recovery rate.



Gas Feed Rate: Constant

Recovery Cost Estimated from Laboratory Results

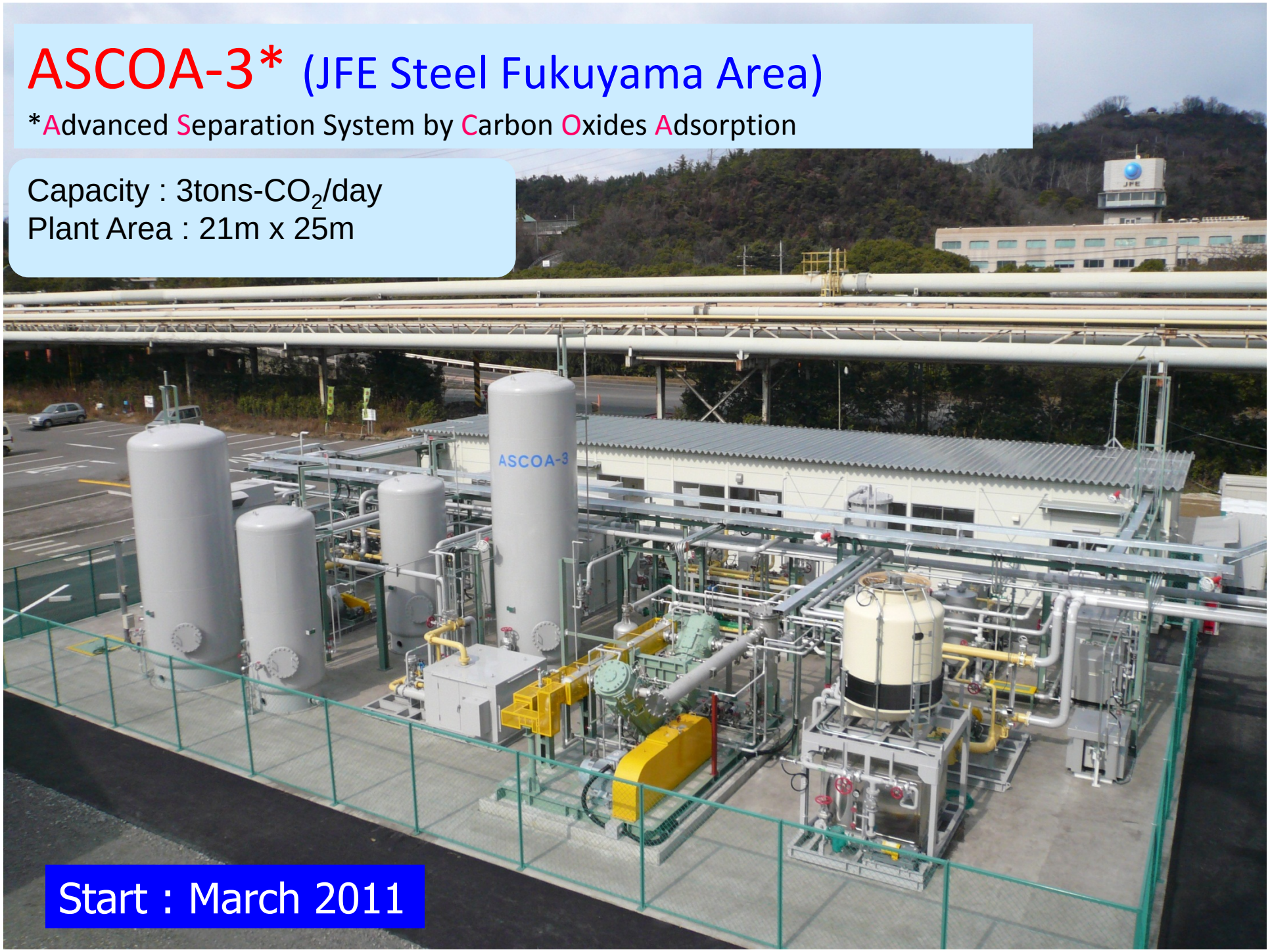
Total cost is reduced at shorter cycle time because of lower capital cost and higher CO_2 concentration leads more advantage.



ASCOA-3* (JFE Steel Fukuyama Area)

*Advanced Separation System by Carbon Oxides Adsorption

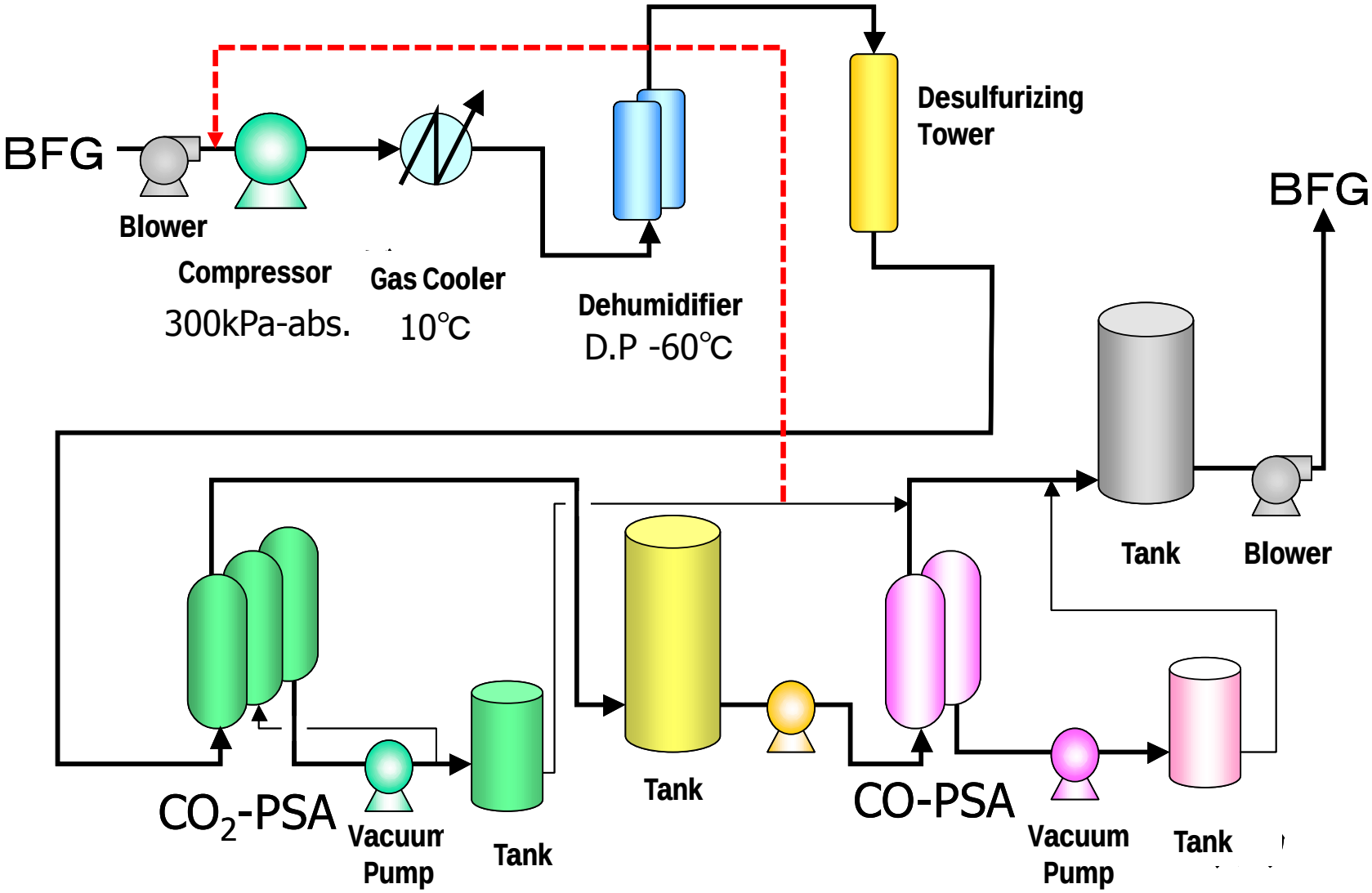
Capacity : 3tons-CO_2/day
Plant Area : 21m x 25m



Start : March 2011

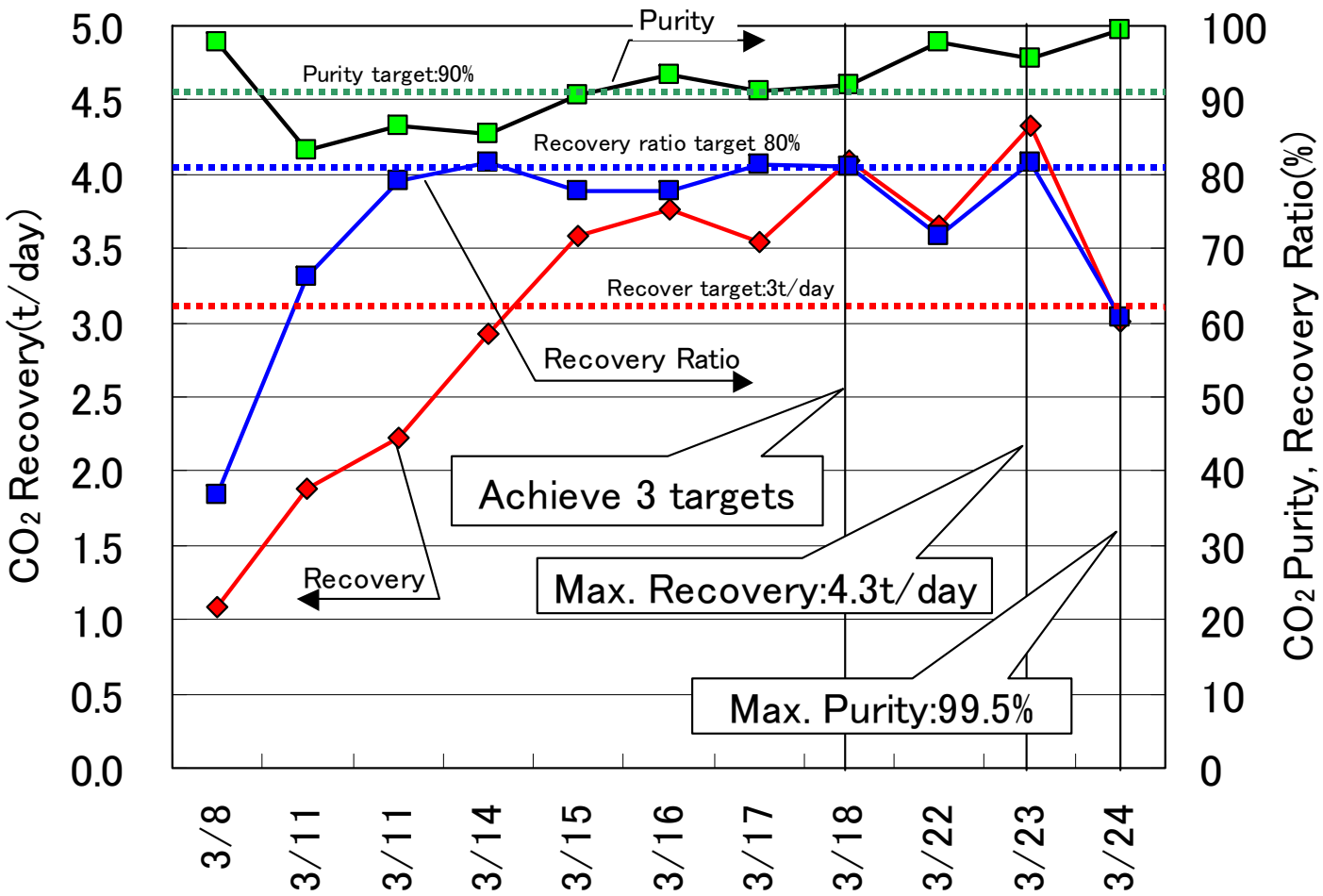
CO_2 Adsorption Towers ID : 750mm,
Height : 1,200mm

ASCOA-3 Flow Diagram



General Test Operation

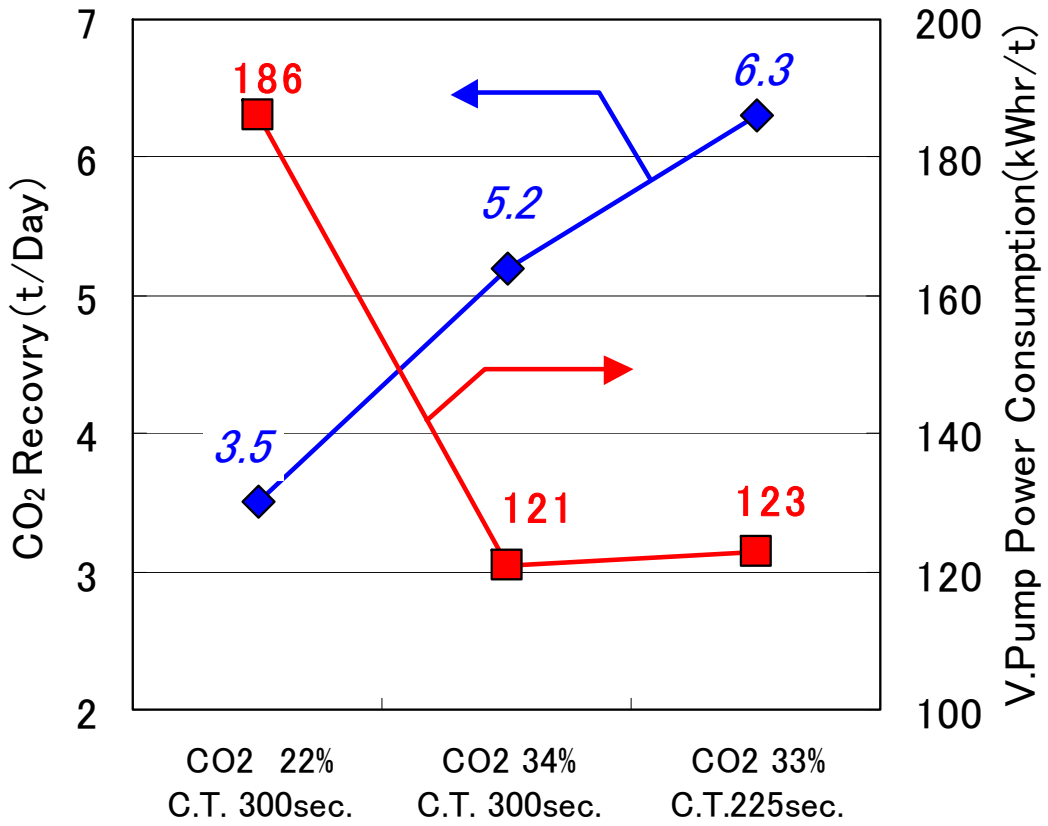
All technical targets were cleared during test operation period.



Cost Reduction

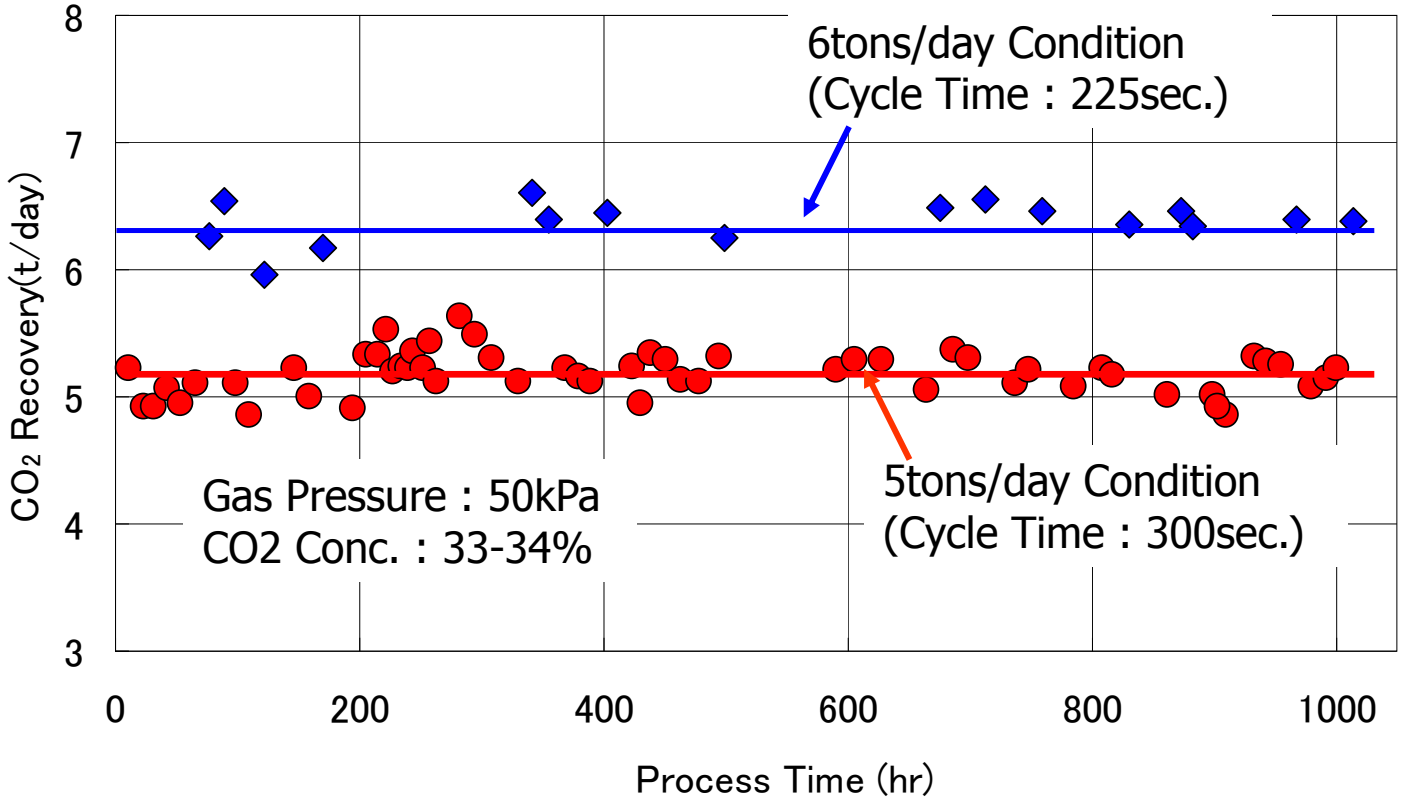
-Power Consumption of Vacuum Pump-

Higher CO_2 recovery leads lower power consumption



Further Cost Reduction (Higher Dew Point)

Operation is stable even at a higher dew point.
(Dew point of raw gas:-60→-30℃)

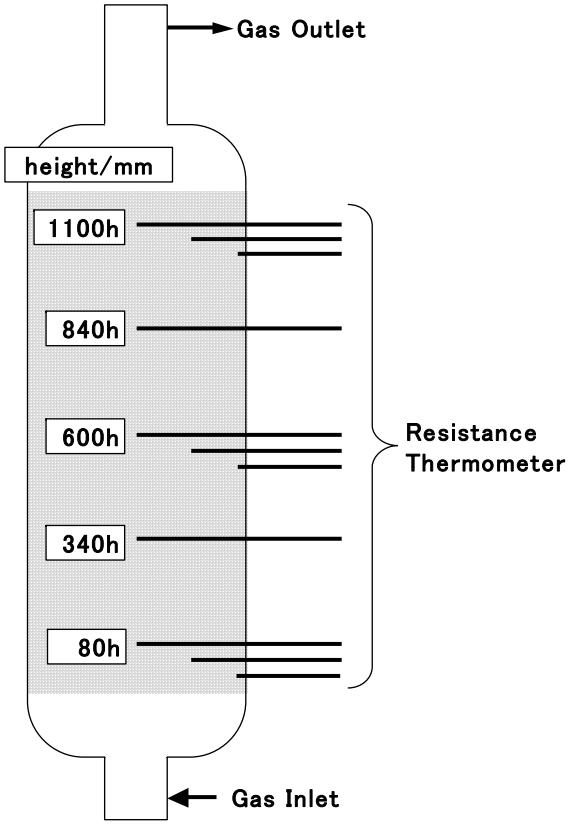


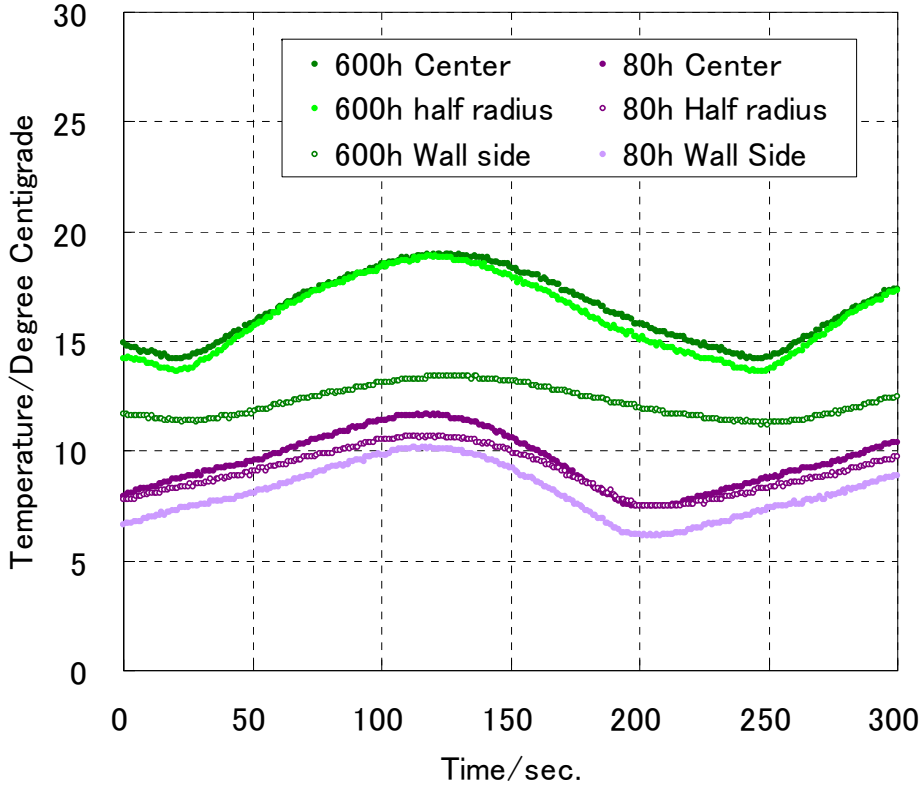
CO_2 Adsorption Towers

11 Resistance Thermometers

Temperature Distribution(Horizontal Direction)

Temperatures at center and half radius move simultaneously





Temperature Distribution

☆ Temperature change indicates adsorption-desorption behavior of CO_2

☆ Adsorption-Desorption behaviors at center and half radius are the same.

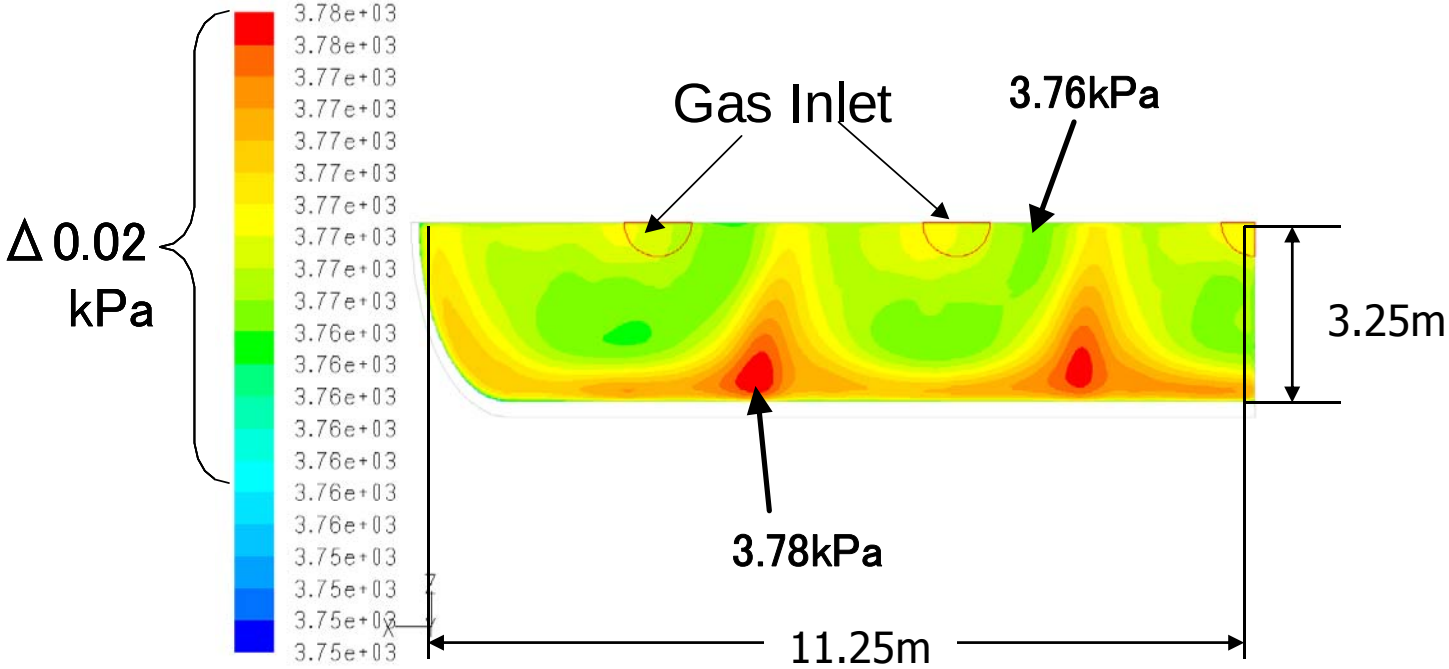
⇨ It is easy to scale-up the adsorption tower to the horizontal direction.

☆ Homogeneity of gas flow in enormous adsorption tower?

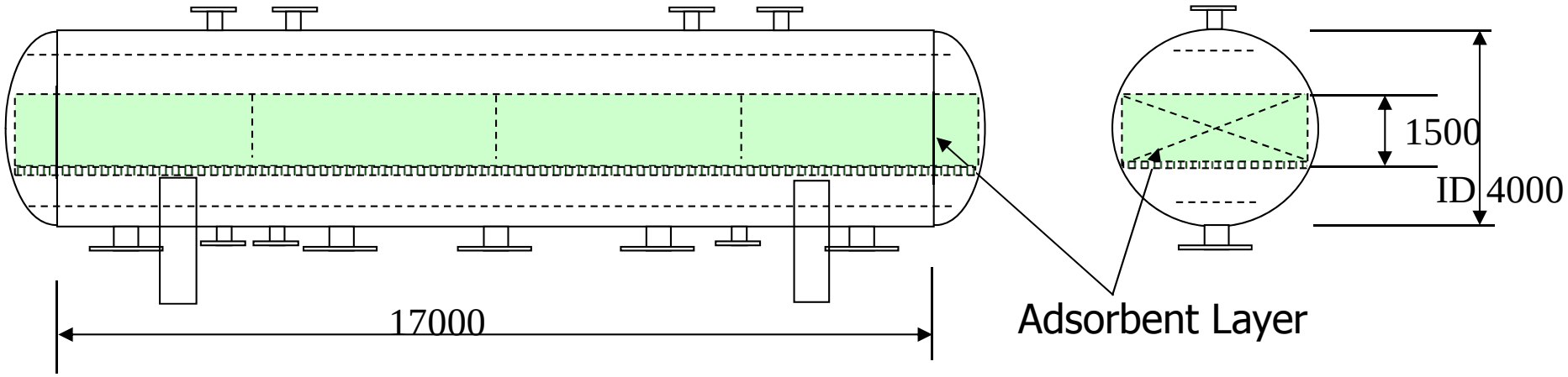
Pressure Distribution in Commercial Scale Tower

☆Pressure difference of lower side of adsorbent layer is only 0.02kPa in a commercial scale adsorption tower.

⇨ There are no problems in pressure distribution.



Design of Adsorption Tower



Adsorption Tower

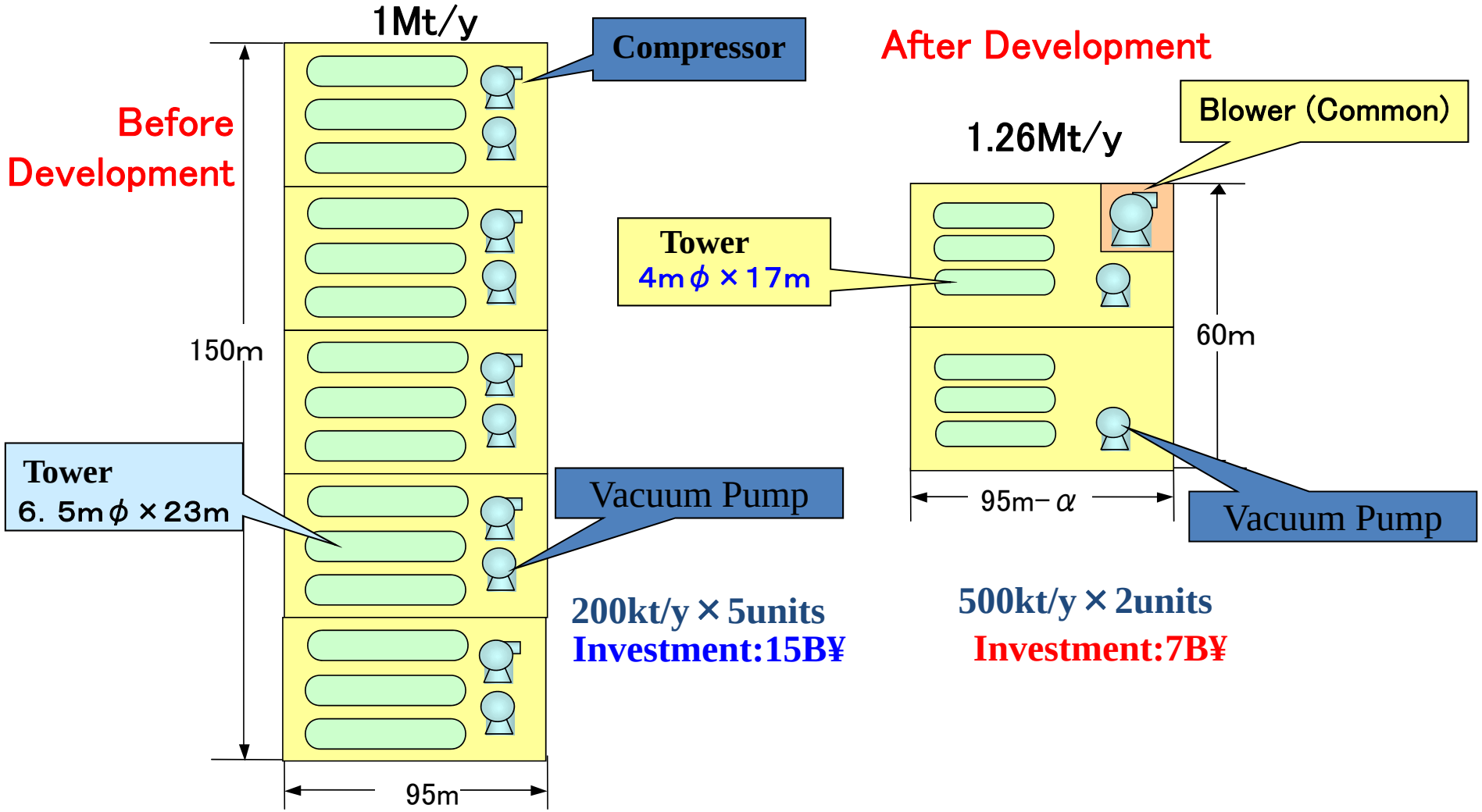
Size : 4,000mmΦ×17,000mm
Thickness : 12mm
Weight : 50tons
Material : SM490B
Designed Pressure : 190kPa/FV

Adsorbent : Zeolum F-9H

Apparent Density : 0.65kg/L
Weight : 65tons

Commercial Plant Image

(Capacity : 1Mt-CO_2/y)

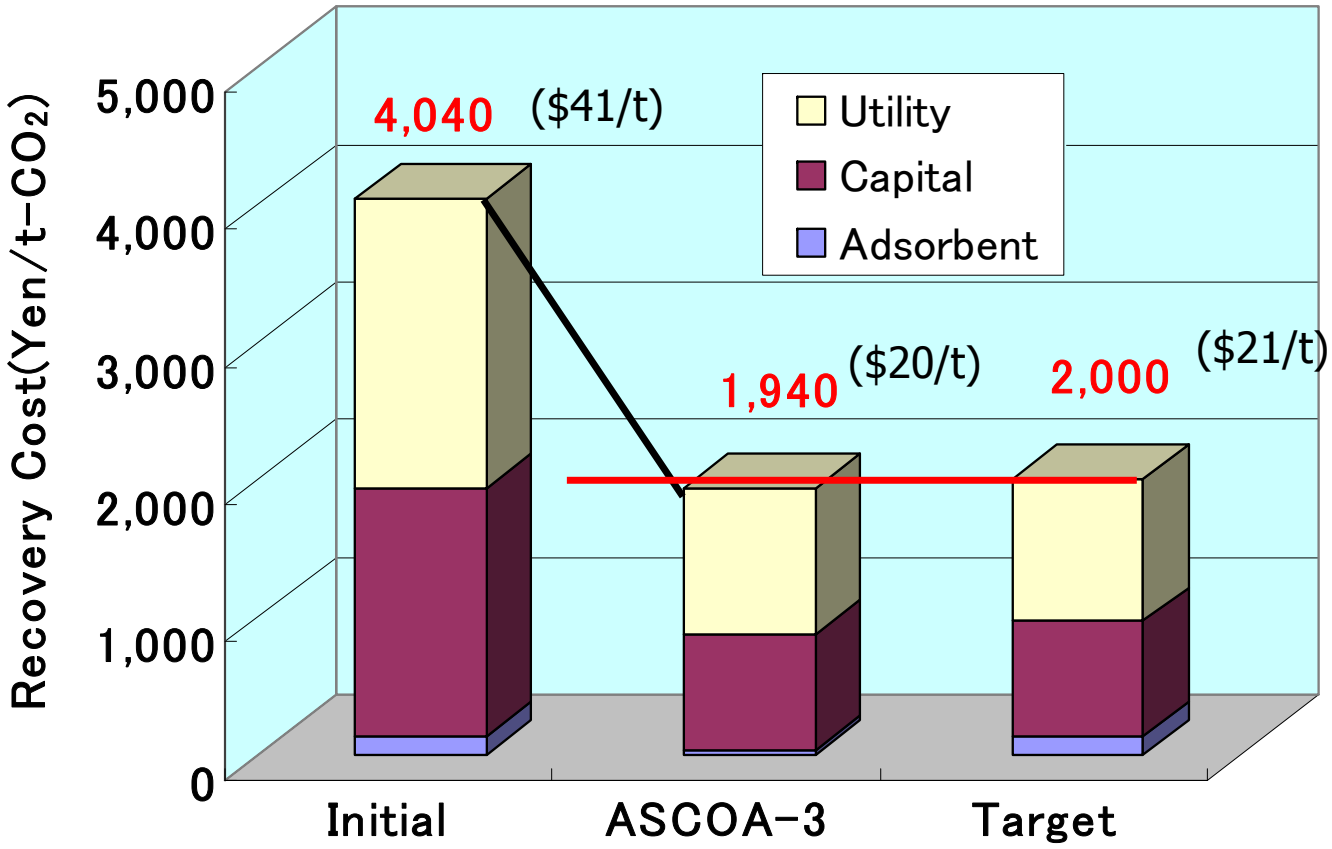


Recovery Cost Estimation

Recovery cost was achieved the target! (≦2,000yen/t)

Item	Cost	
Capital	7,000	Million ¥
Unit Cost	840	¥/t-CO_2
Power	145	kWh/t-CO_2
Steam	0.05	t/t-CO_2
Utility Cost	1,060	¥/t-CO_2
Adsorbent	390	tons
Unit Cost	40	¥/t-CO_2
Total Unit Cost	1,940	¥/t-CO_2

Cost Estimation from ASCOA-3 Operation Results



Summery

1. Zeolite type adsorbent has a good performance in Laboratory PSA and ASCOA-3
2. Shorter cycle time and higher CO_2 concentration in BFG reduce the cost for CO_2 separation
3. The size of commercial adsorption tower was reduced to 1/3～1/4 as the fruit of development
4. CO_2 recovery cost achieved the target through the operation result with ASCOA-3 and imaging the design of commercial plant

Acknowledgement

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Thank you for your attention!