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Cost Evaluation of CCS Technology and Deployment Scenarios in Japan

Masato Takagi
RITE

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Q5. How much can we reduce the CCS cost in future? What should we do?

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Q1. How much will we pay as an additional cost for CO2 reduction?

Q2. How important is CCS as a CO2 mitigation option?

Additional Cost for CO2 Reduction

IEA Energy Technology Perspective 2006

Incentive of CO2 reduction: 25 US$/t-CO2

- The maximum additional cost that the market would be willing to pay for low-carbon technologies.
- Less than the average price for CO2 permits under the European trading scheme over the first four months of 2006
- A price of USD 25 per tonne of CO2 would add about USD 0.02 per kWh to the cost of coal-fired electricity and about USD 0.07/litre (USD 0.28/gallon) to the cost of gasoline.

IEA Six Scenarios

Table 2.1 ▶ Overview of scenario assumptions for ACT and TECH Plus scenarios

	Technologies					
	Renewables	Nuclear	CCS	H_2 fuel cells	Advanced biofuels	End-use efficiency
Scenario						
Map						
Low Renewables	Pessimistic					
Low Nuclear		Pessimistic				
No CCS			No CCS			
Low Efficiency						Pessimistic
TECH Plus	Optimistic	Optimistic		Optimistic	Optimistic	

IEA Energy Technology Perspective 2006

Position of CCS

- In the Baseline Scenario, CO2 emissions will be almost two and a half times current level by 2050.
- CCS is the second effective option (next to Energy Efficiency).
- CCS can significantly reduce CO2 emissions from power generation, industry and transport sectors. In the ACT scenarios, CCT technologies contribute between 20 and 28% of total CO2 emission reductions below the Baseline Scenario by 2050.
- The cost of CCS is high, but it could fall below 25 USD 25 per tonne of CO2 by 2030.

IEA Energy Technology Perspective 2006

Answers to **Q1, 2**

According to IEA,

- Marginal cost of CO2 reduction in 2050 is estimated to be 25US$/t-CO2
- CCS will play an important role to reduce enough CO2 and decrease a mitigation cost.

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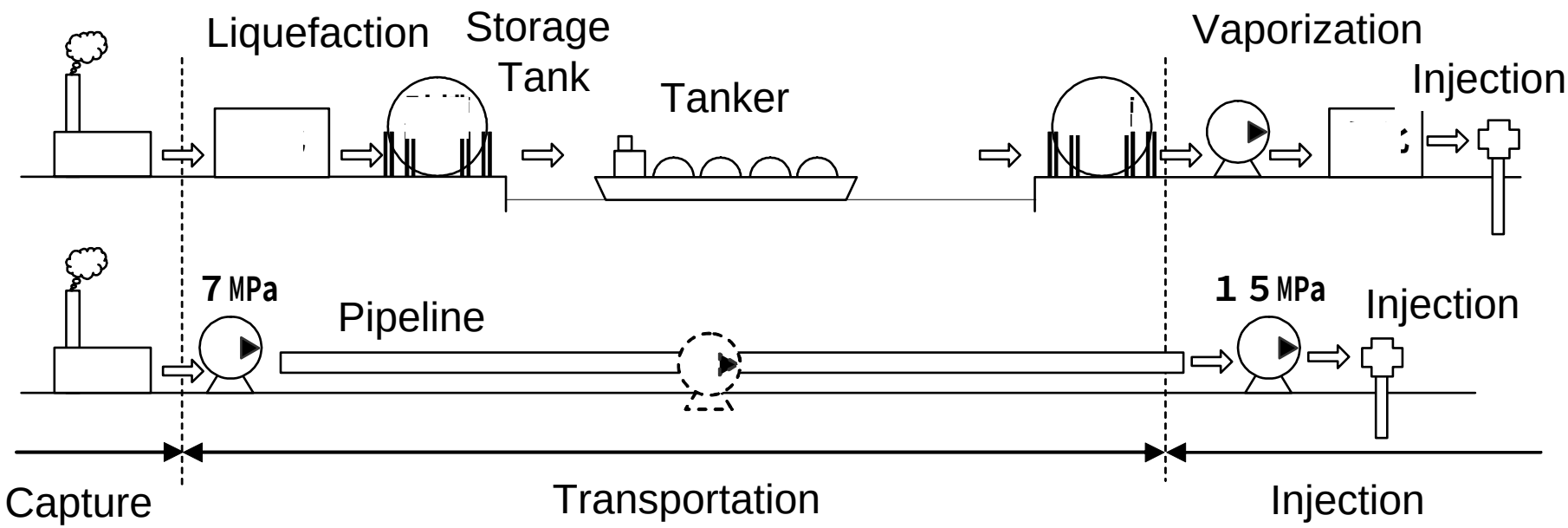
Q3. How much is the present cost of CCS in Japan?

Q4. Is it high or low when comparing to costs in overseas?

System of CCS

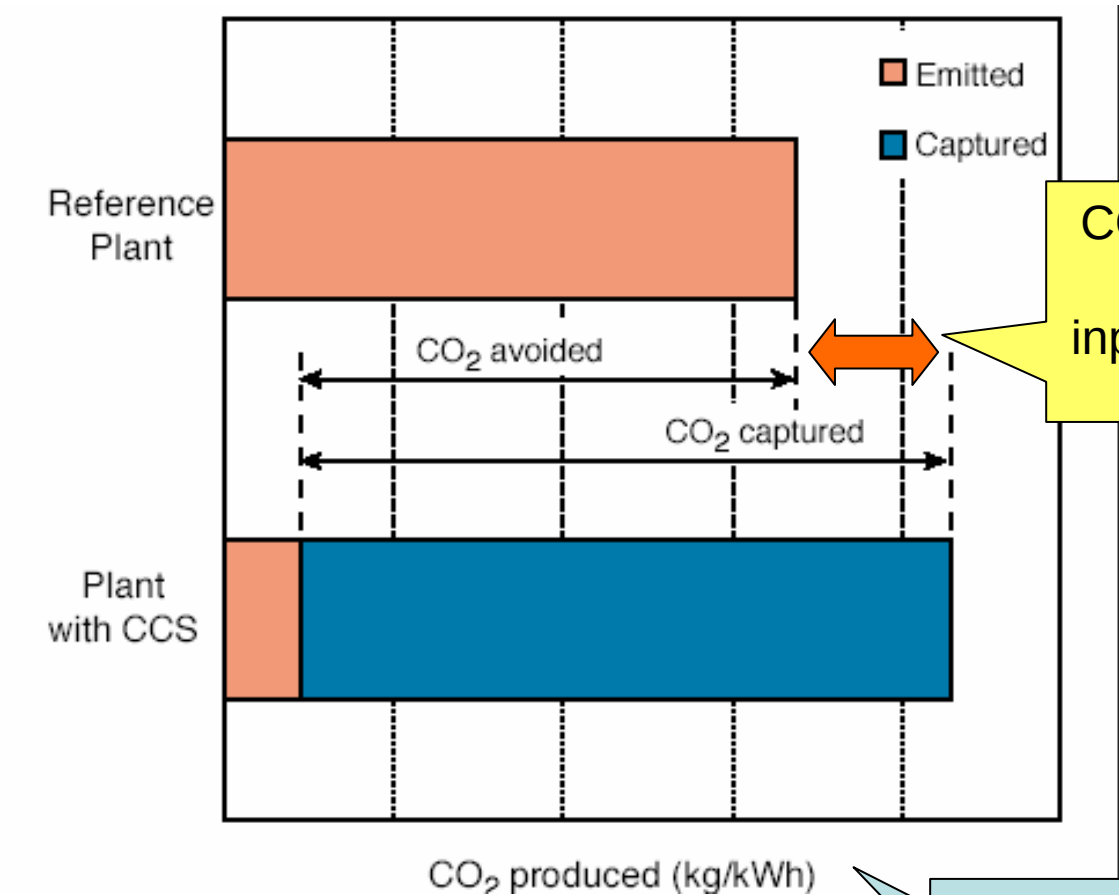


- **Capture cost**
- **Compression cost**

- **Transportation cost**

- **Injection & Storage cost**
  - **Pre-exploration**
  - **Injection**
  - **Monitoring**

Cost of CO2 Avoided



CO2 equivalent to an additional energy input for CO2 Capture & Storage

Comparison of emission rate

IPCC SRCCS

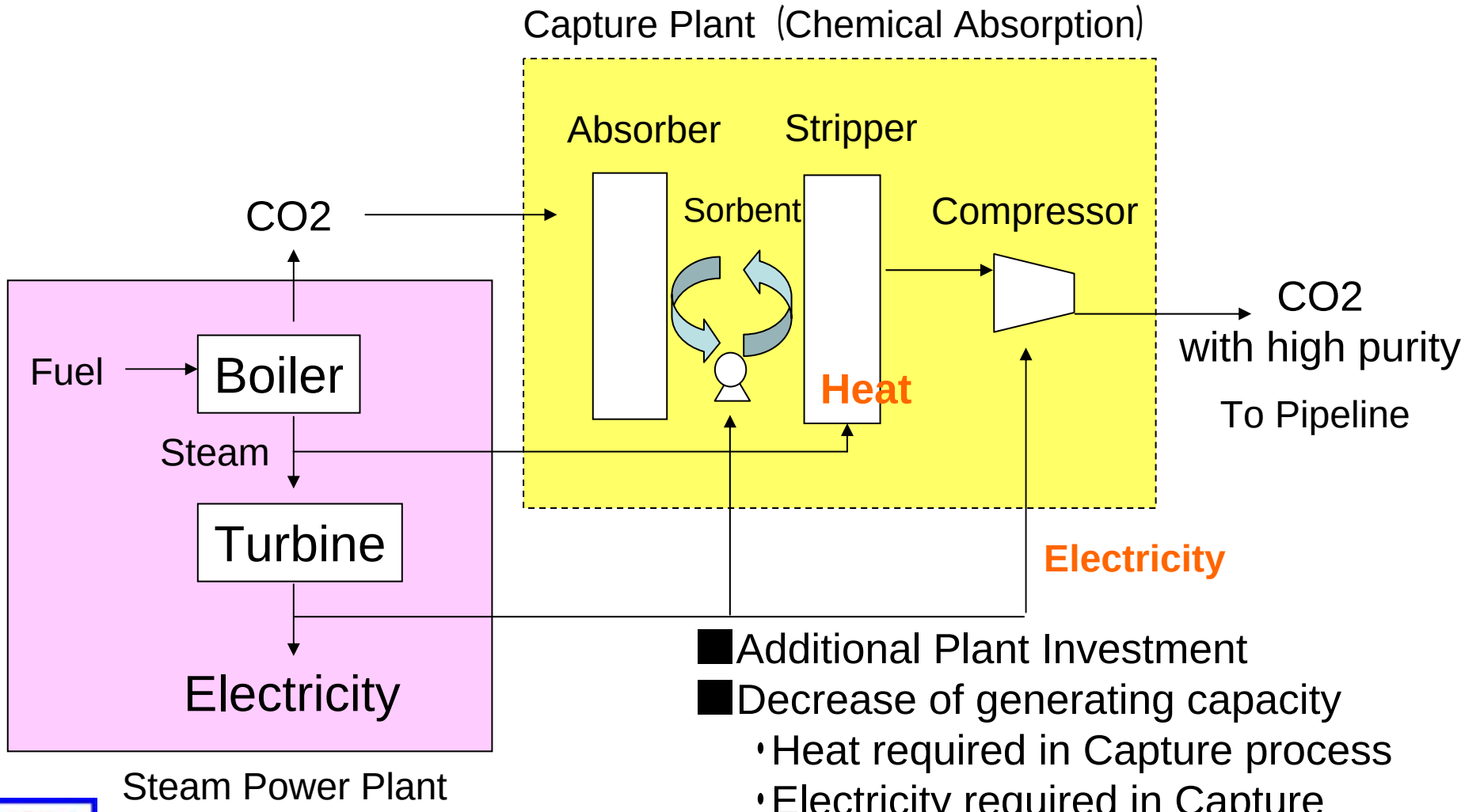
Cost of CO2 Avoided (Power Plant)

IPCC SRCCS

Cost of CO2 Avoided
= [(COE)capture – (COE)ref] / [(CO2/kWh)ref –(CO2/kWh)capture]

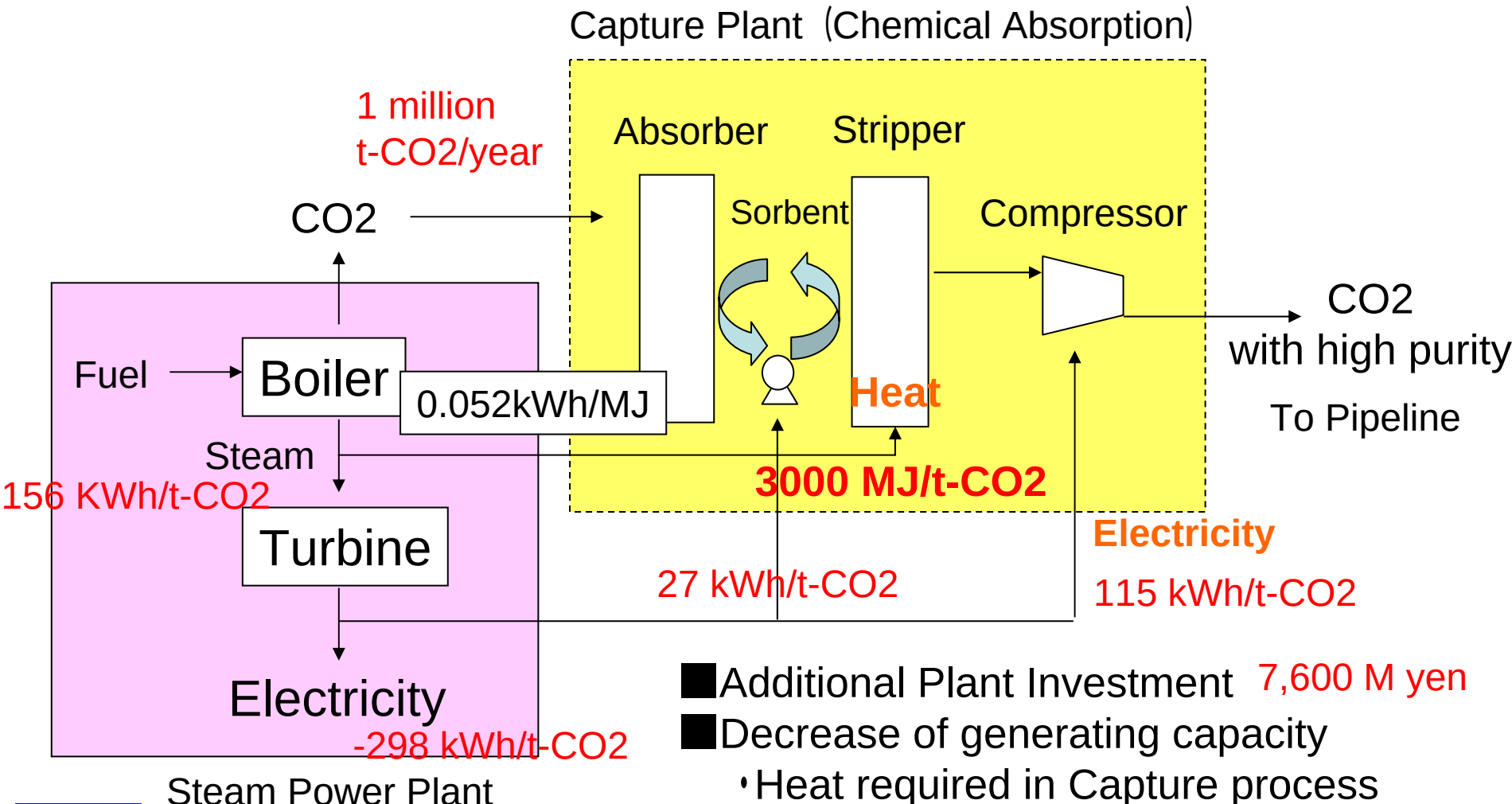
COE (cost of electricity)= (Expense)/(Net Power)

Capture (Steam Power Plant)



- Additional Plant Investment
- Decrease of generating capacity
  - Heat required in Capture process
  - Electricity required in Capture process

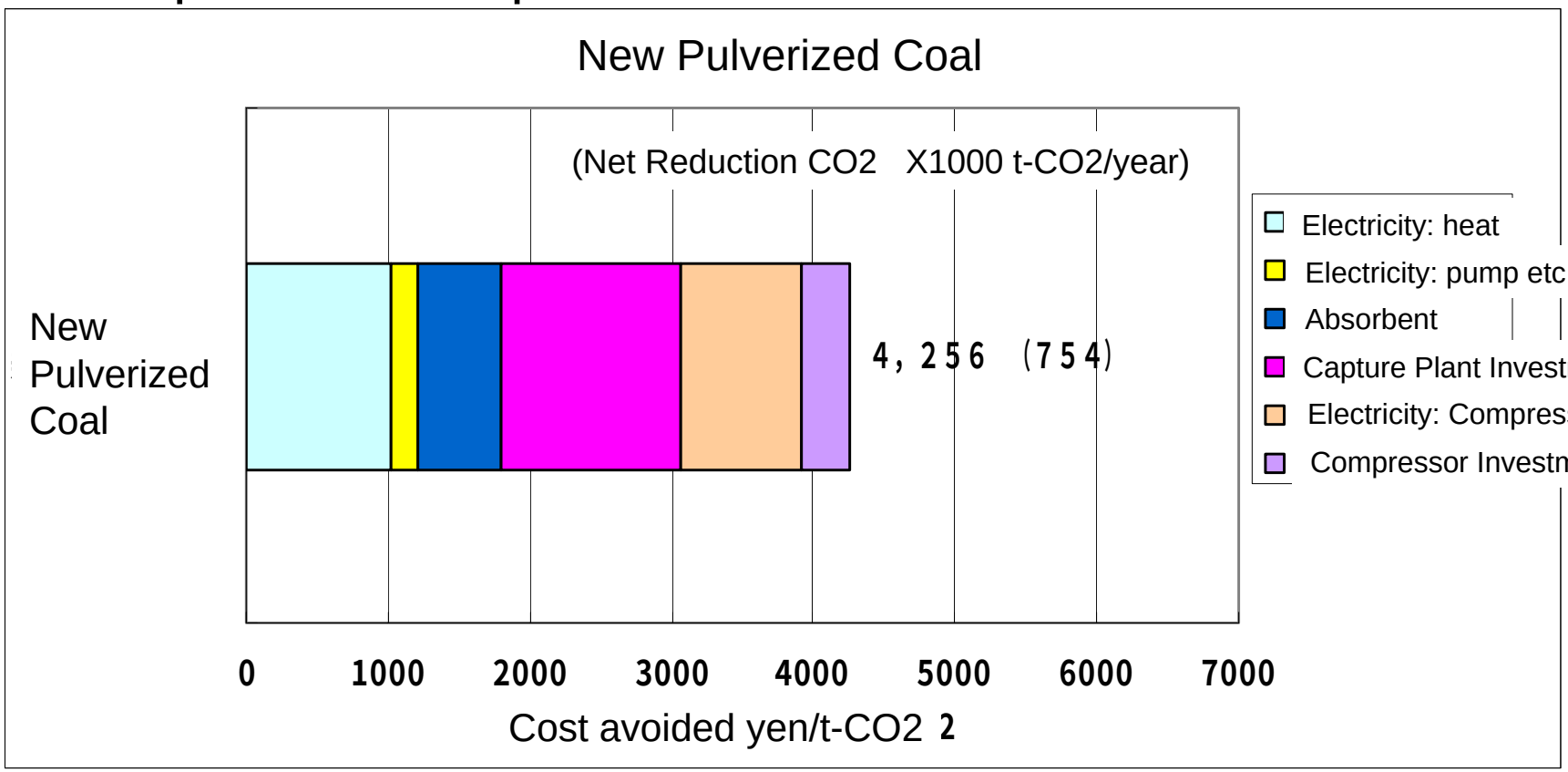
Capture (Steam Power Plant)



- Additional Plant Investment 7,600 M yen
- Decrease of generating capacity
  - Heat required in Capture process
  - Electricity required in Capture process

Capture Cost
-New Pulverized Coal Power Plant

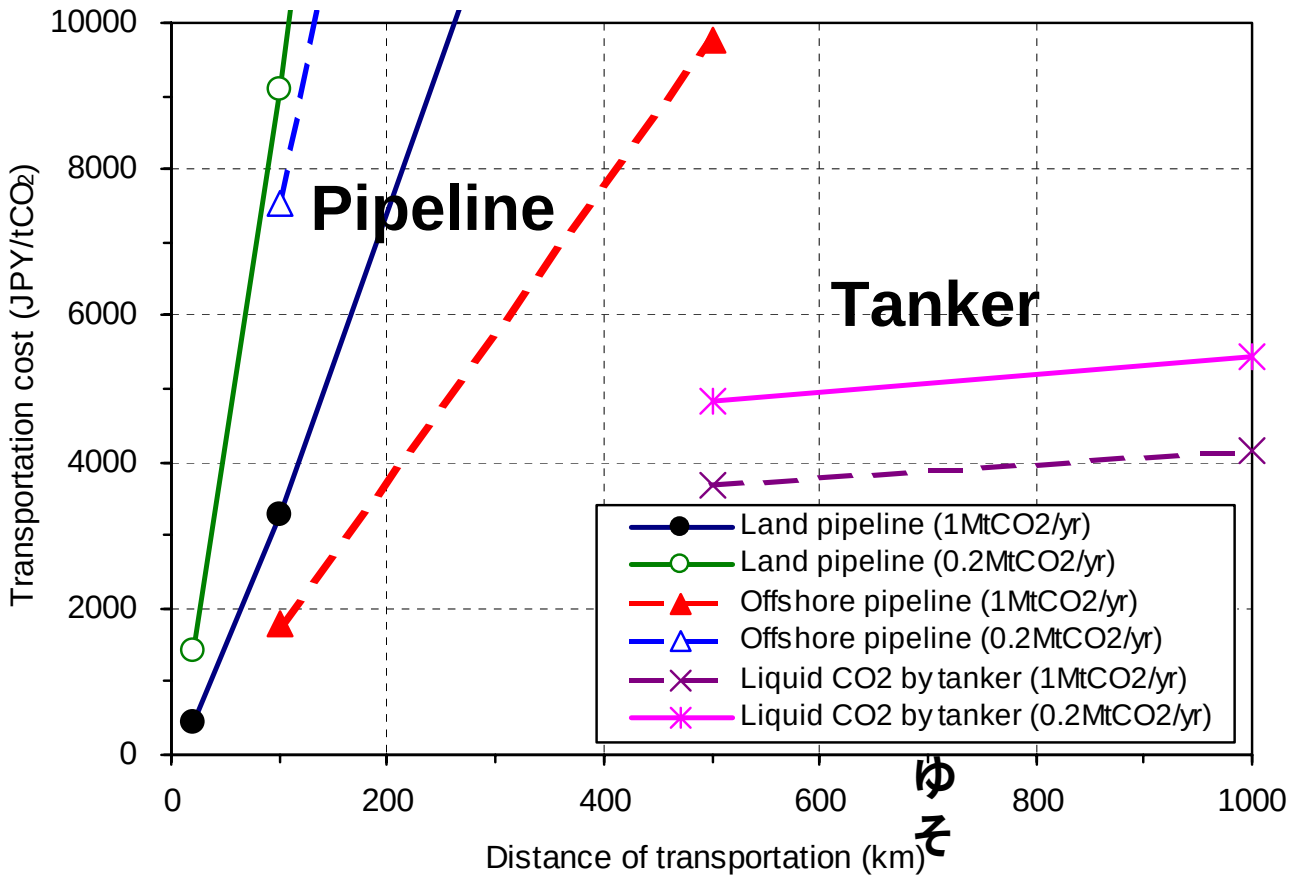
Investment of capture plant, heat at stripper, and electricity in compression are predominant.



- Capture: 1 million t-CO2/year
- Coal 7000 yen/t, 0.09542kg-CO2/MJ-LHV
- Capture Plant：7,600 million yen, Compressor: 2,000 million yen

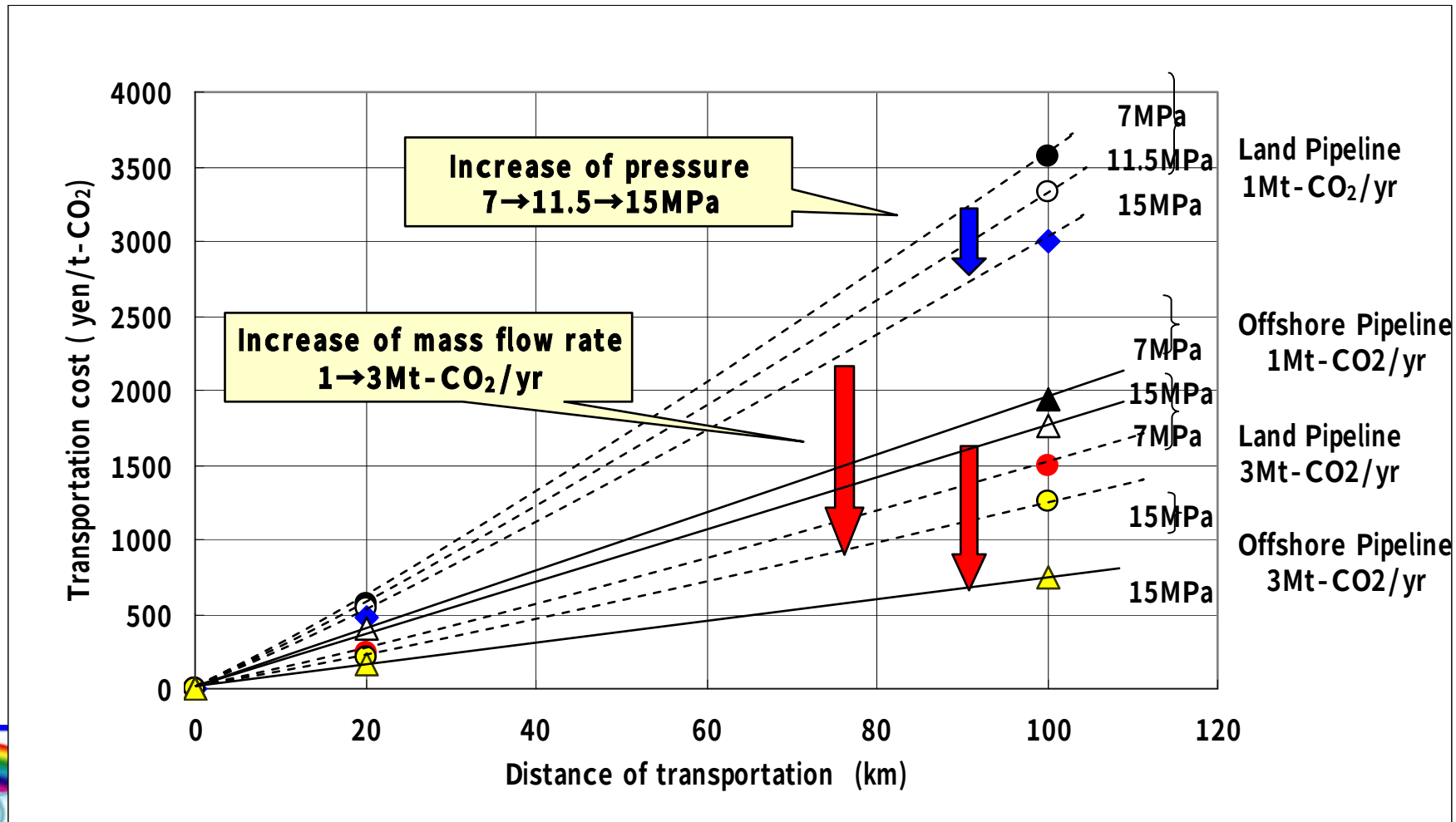
Transportation Cost

- Tanker is effective for long distance transportation but rather expensive.
- Short distance transportation using pipeline is most effective to low the transportation cost.



Transportation Cost

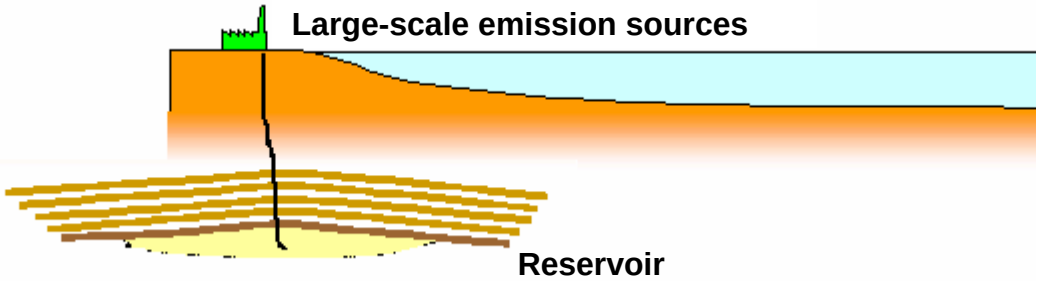
Long distance transportation is rather expensive and unrealistic.



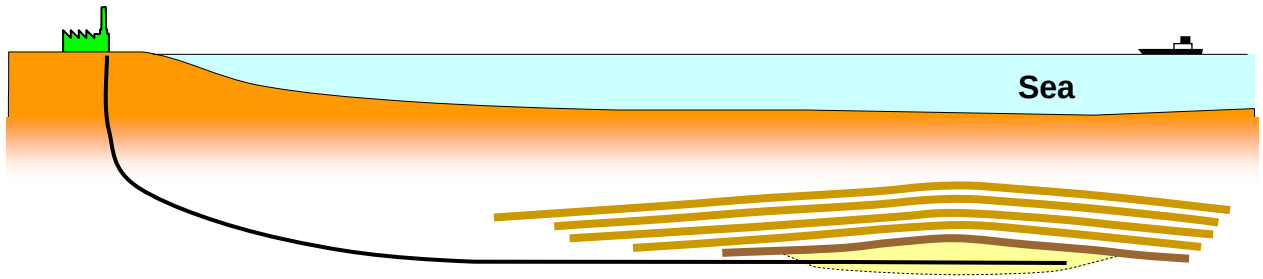
Injection and Storage

- Well
- Platform
- Pipeline
- Compressor
- Pre-exploration
- Monitoring

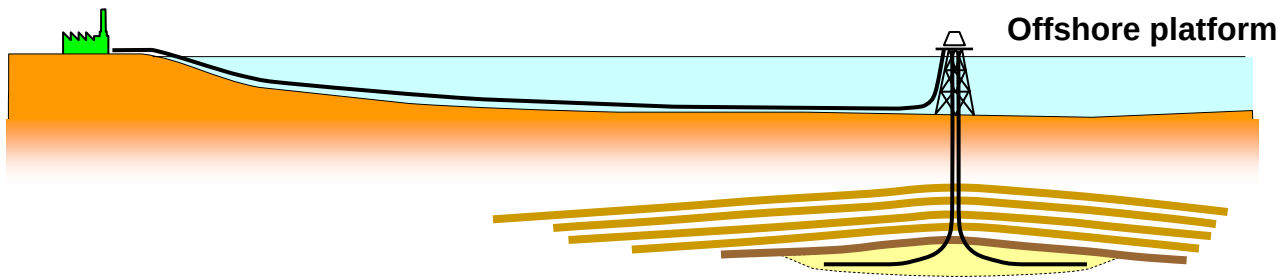
Land area



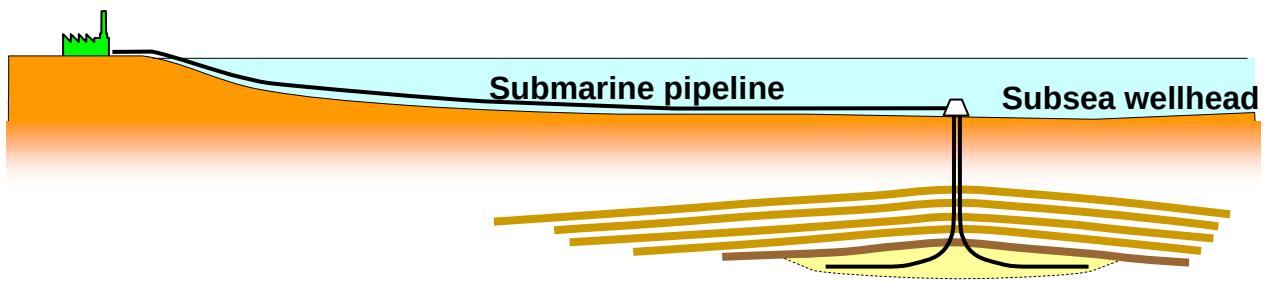
Offshore
(ERD (extended reach drilling))



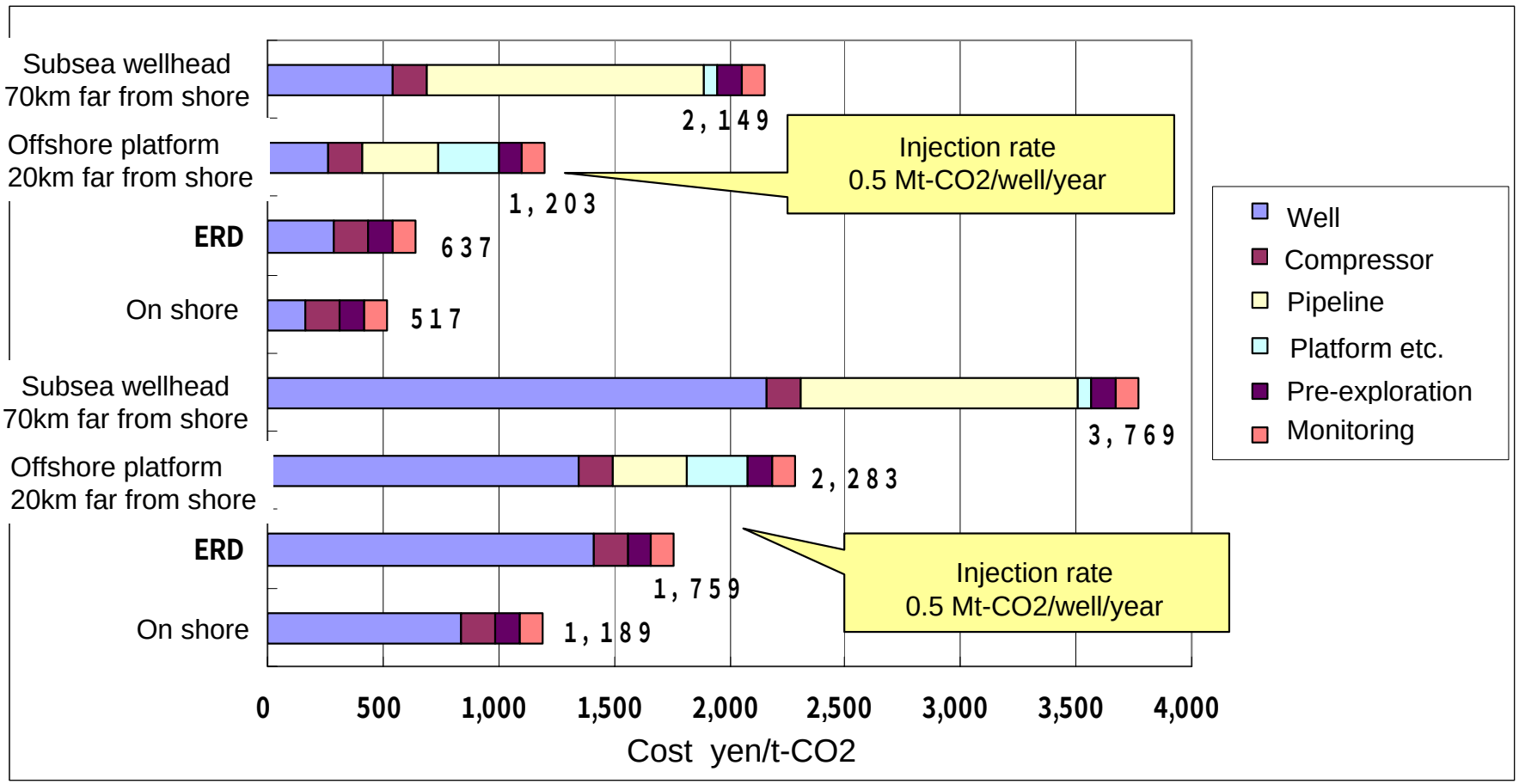
Offshore
(Offshore platform)



Offshore
(Subsea wellhead)



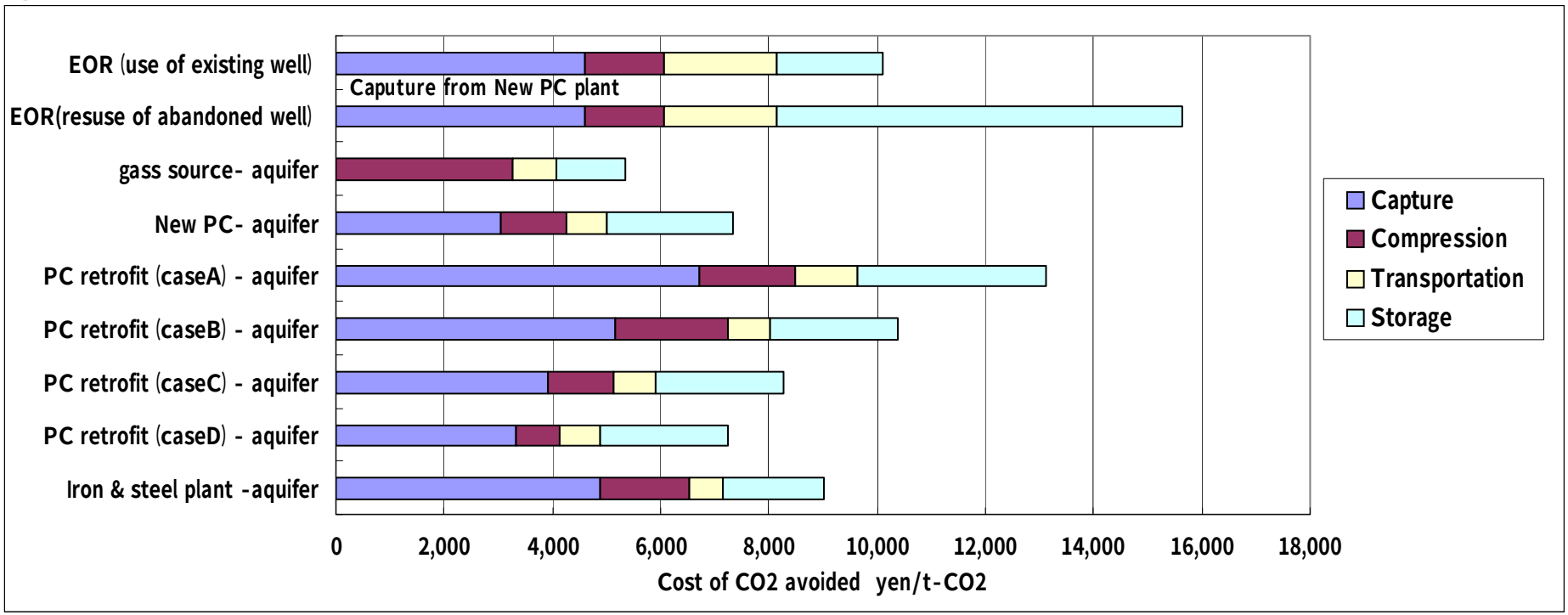
Cost of CO2 Storage



- Cost becomes high when reservoirs being far from shore.
- Storage cost is heavily dependent on Injection rate per well.

Current Cost of Capture and Storage in Japan

Current CCS cost was estimated to be 5,000 – 10,000 yen/t-CO2 avoided.



* Baseline assumption: amount of CCS 1Mt-CO2/yr、Transportation distance 20 km、Injection pressure 10 MPa, ERD, Potential injection rate per well：0.1 Mt-CO2/yr
* New pulverized coal power plant：cost of electricity 5 yen/kWh
* Pulverized coal power plant retrofit: (case A) auxiliary coal boiler、cost of electricity 5 yen/kWh
  (case B-D) steam extract from steam cycle of power plant, cost of electricity B: 10 yen/kWh, C: 5 yen/kWh, D 2.6 yen/kWh
* Iron & steel Industry：steam 2,500 yen/t-steam, electricity 10 yen/kWh
* EOR：0.2 Mt-CO2/yr of CO2 is captured. Transportation distance 20km.
* Gas source：storage 0.1 Mt-CO2/yr, transportation distance 9km

Comparison with Cost in IPCC SRCCS

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Transportation and storage cost in Japan is higher than that in IPCC SRCCS.

	Japan **yen/t-CO_2**	IPCC SRCCS US$/t-$CO_2$		
Case	New PC plant -Aquifer storage	New PC plant -Aquifer storage	New NGCC plant -Aquifer storage	New PC plant -EOR
Capture & Compression	**4,200**	**29－51**	**37－74**	**29－51**
Transportation	**800** 1Mt-CO2/y **20km**	**1－8** 5-40Mt-CO2t/y- **250km**		
Storage	**2,300** 0.1Mt/well/yr, ERD	**0.5～8**		**△10～16**
Total	**7,300** 1Mt-CO2/yr-20km-ERD	**30－70**	**40－90**	**9－44**

Answer to Q3, Q4

CCS cost

- High Capture Cost：a common issue in the world
- High Transportation Cost
- High Storage Cost

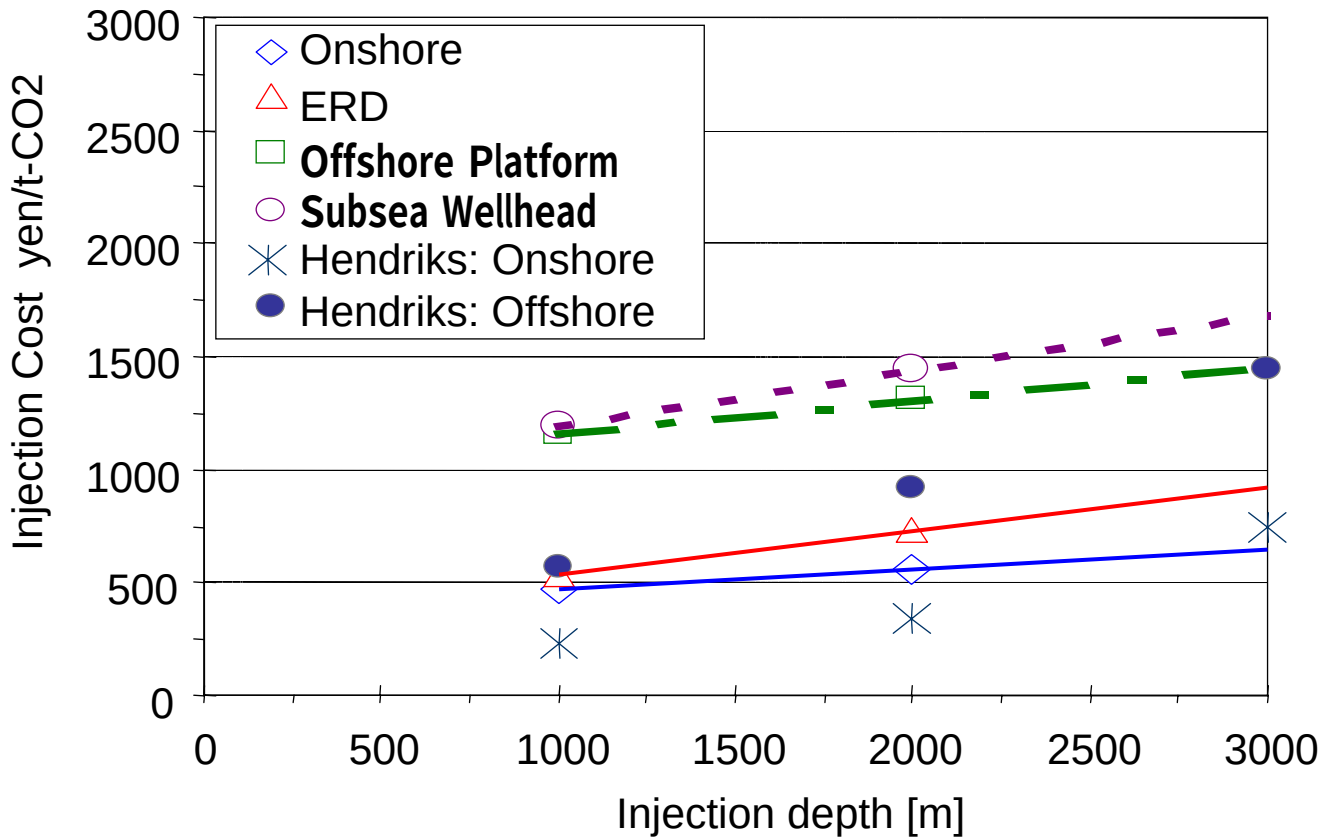
} Special issues in Japan

Pipeline
(Reasons for the high cost in Japan)

- In overseas construction of pipelines is done in ROW (Right of Way: a way having possessory right).
- In contrast, pipelines must run under public roads in Japan. Therefore, big construction limitations (a short working hour, a short execution distance per day, and frequent test digging and siphon culvert) and necessity of restoration of paving occur. These make construction period longer.

Storage
(Reasons for the high cost in Japan)

A cost when extrapolated to 1Mt-CO2/well/year is almost the same as foreign studies. A low injection rate per well (because of a low penetrate rate) is a reason for the high injection cost in Japan



Hendriks: IPCC SRCCS, 1US$=120JPY

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Q5. How much can we reduce the CCS cost in future? What should we do?

Issues for Cost Reduction in Capture process

- Reduction in calories required for CO2 stripping.
- Reduction in capture plant cost.
- Thermal integration of capture process with power plant.
- Increase in effectiveness of compressor.

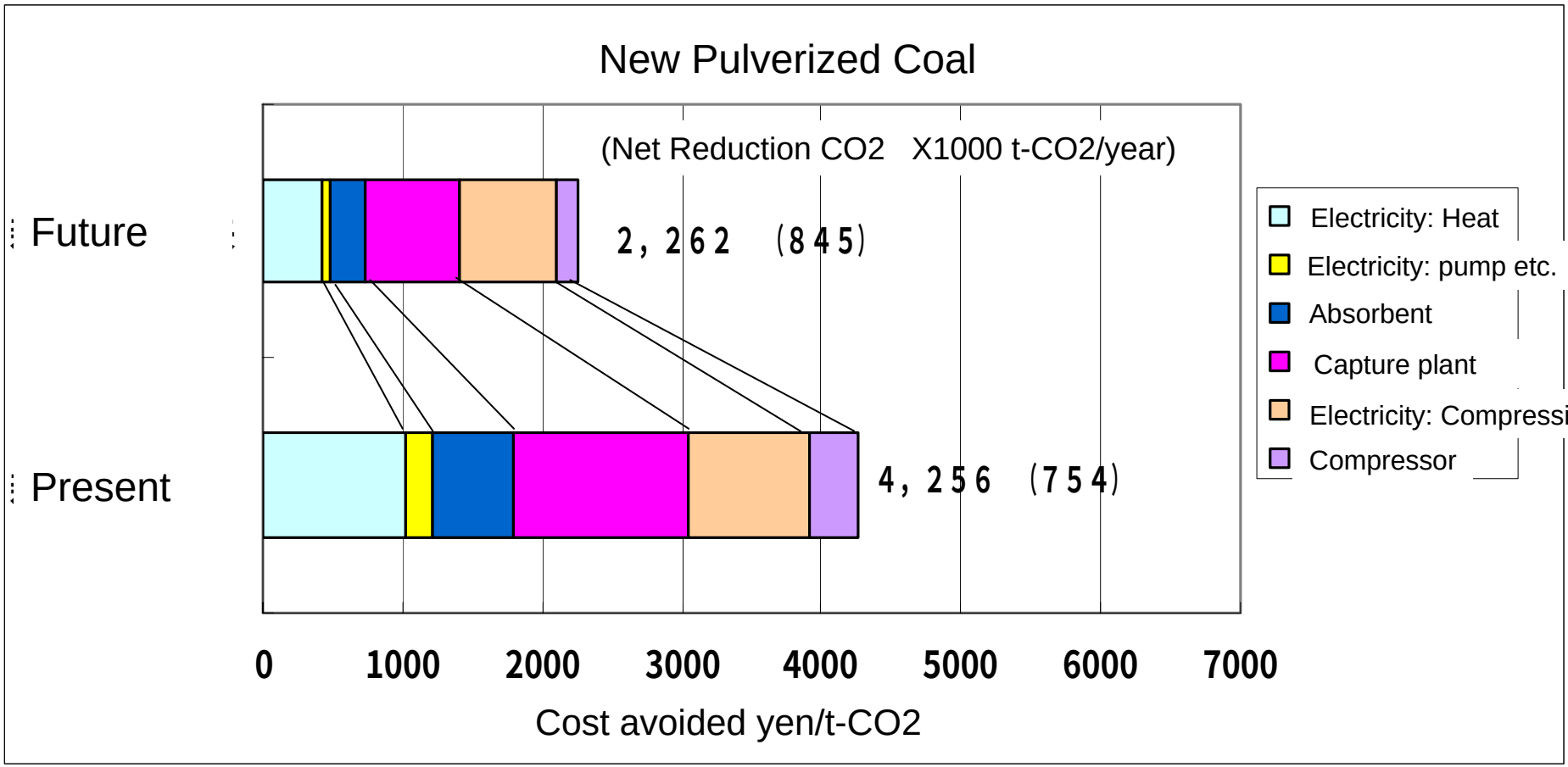
Capture Cost in future

●Variable Factors

Items			2005	2015	(ref) Feron
Common factors	Capture: Heat	MJ/t-CO_2	3,000	1,800	2,000
	Capture: Electricity	kWh/t-CO_2	26.8	10	10
	Capture: Absorbent	index	1	0.5	
	Capture: Plant	index	1	0.6	
	Compression: Electricity	kWh/t-CO_2	115	100	103
	Compression: Compressor	index	1	0.5	
New PC	Electricity loss factor	kWh/MJ	0.052	0.04	0.042

※Paul H. M. Feron (TNO, Netherlands) Reduction of emission and Geological storage of CO2, Paris (2005)

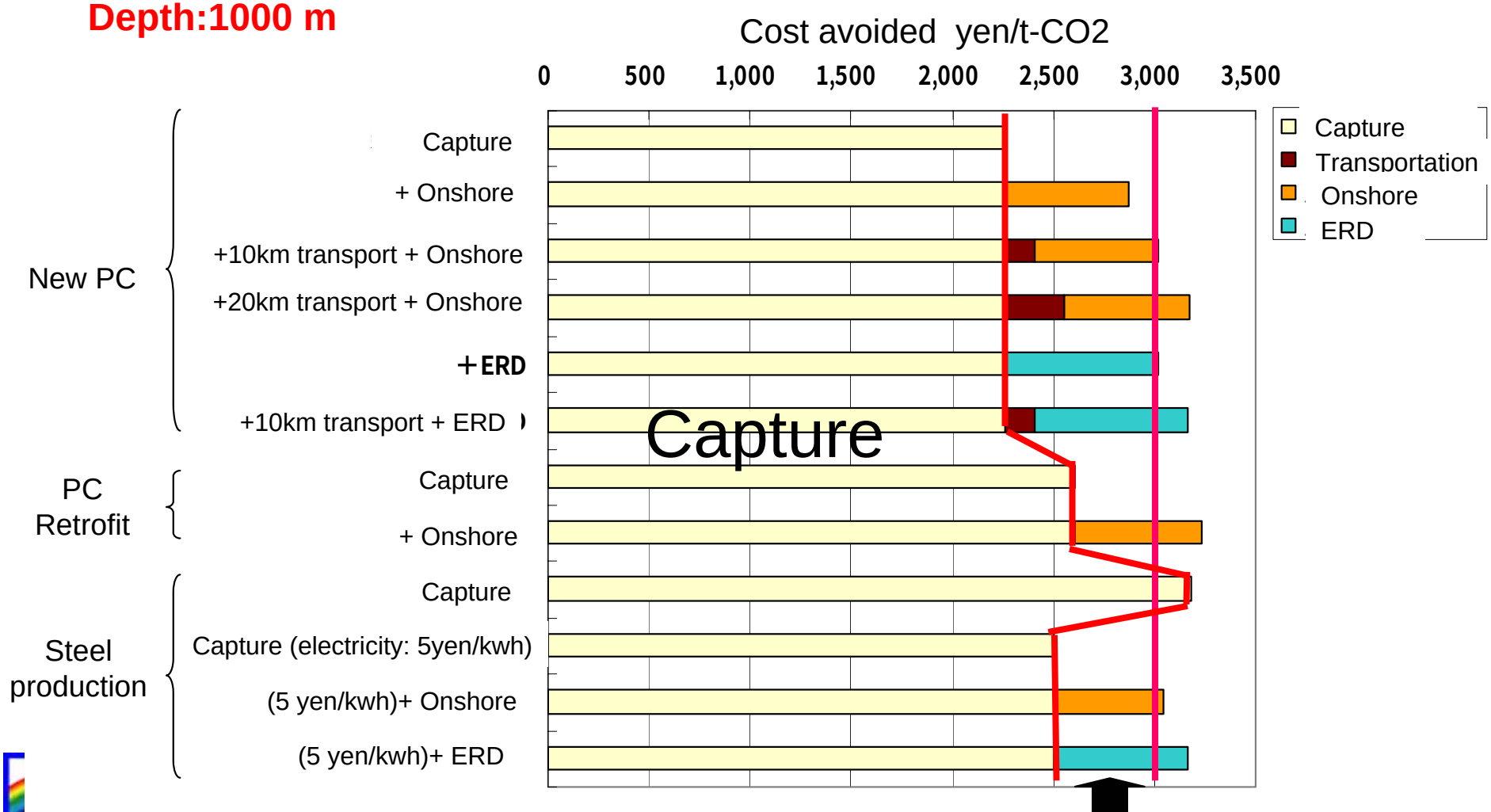
Capture Cost in future



- Capture cost will be dramatically reduced
- Compression cost won't be reduced too much.

Scenario of CCS cost reduction to 3000 yen/t-CO2 ?

Transportation：15MPa-1M t-CO2/year, **Injection：0.5 Mt-CO2/well/year**
Depth:1000 m



Issues for Cost Reduction in Transportation and Capture Processes

- Because transportation is expensive, a long distance transportation is unrealistic in Japan. Exploration reservoirs at short distances from large CO2 emission sources is necessary.
- We should also search reservoirs with a large penetration rate to reduce a storage cost.
- Development of the technology which increase a injection rate per well, such as multi-lateral well, is important.

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Q6. Does CCS become an effective mitigation option in Japan?

Recent Estimates of Potentials of CO_2 Geological Storage in Japan

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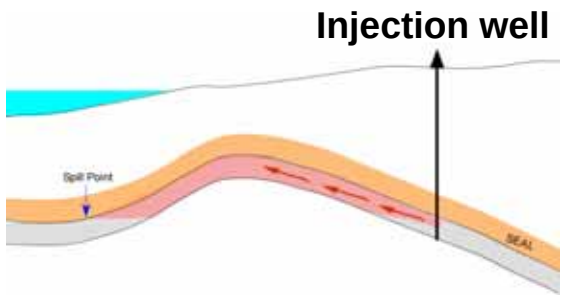
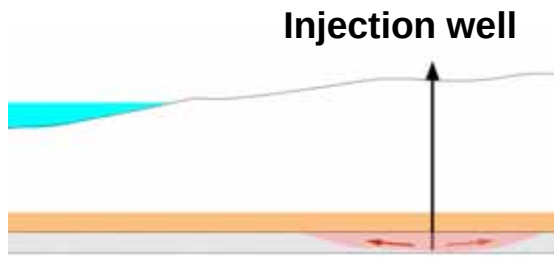
	Category A **With anticline structure**	***Category B*** **Unknown anticline structure**
Image of storage of CO_2		
Oil & gas field	***A1*** **3.5 $GtCO_2$**	***B1**** **27.5 $GtCO_2$**
Boring data existing	***A2*** **5.2 $GtCO_2$**	
Geophysical exploration data existing	***A3*** **21.4 $GtCO_2$**	***B2**** **88.5 $GtCO_2$**
Sub-total	**30.1 $GtCO_2$**	**116.0 $GtCO_2$**
Total	**146.1 $GtCO_2$**	

* B1 and B2 do not cover throughout Japan, and exclude the reservoirs existing offshore where the sea is deeper than 200 m.

Source: RITE/ENAA, 'Report on Development of Carbon Dioxide Geological Storage', 2006. (in Japanese)

CO2 Injection Costs and Potentials

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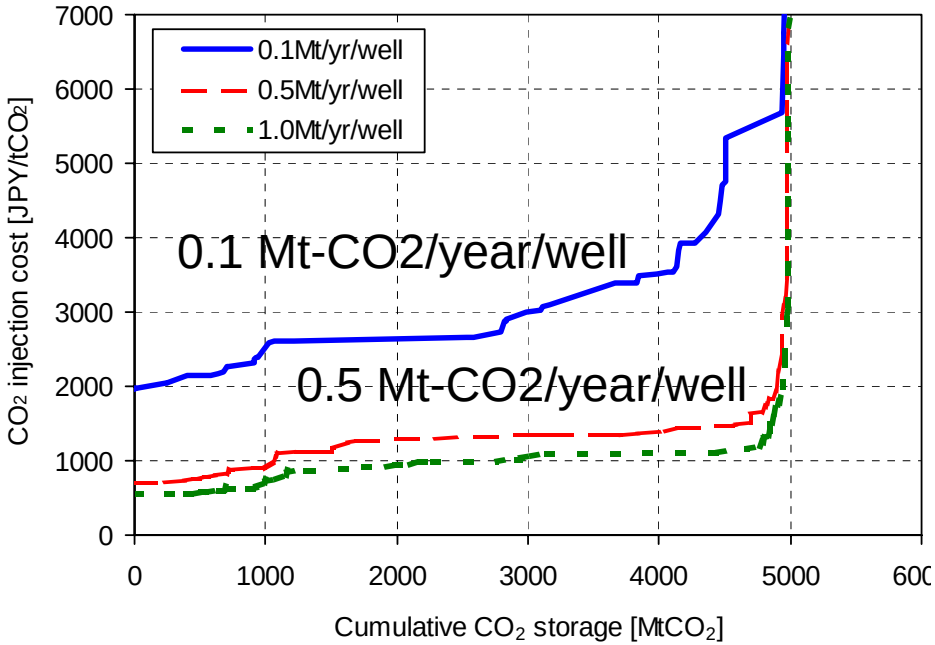
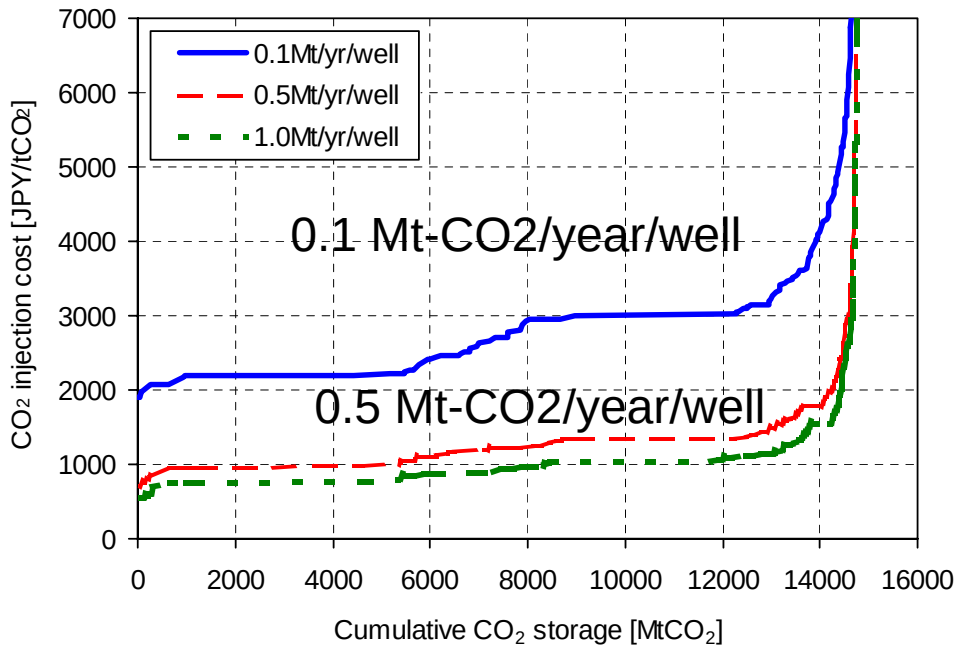
注）コスト評価の対象とした水深500m以浅のみを評価

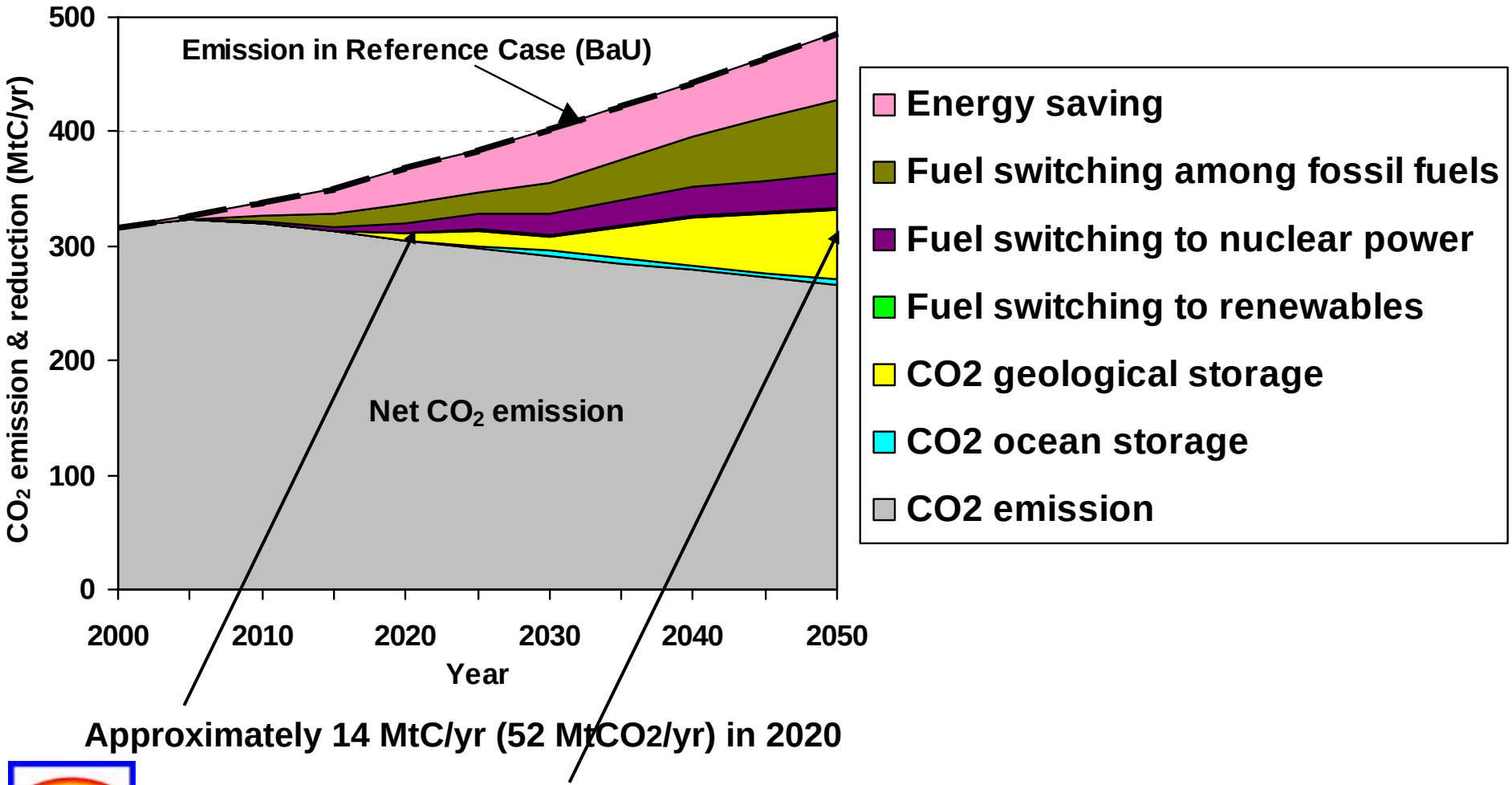


Category A2
By actual boring

Category A3
By geophysical exploration

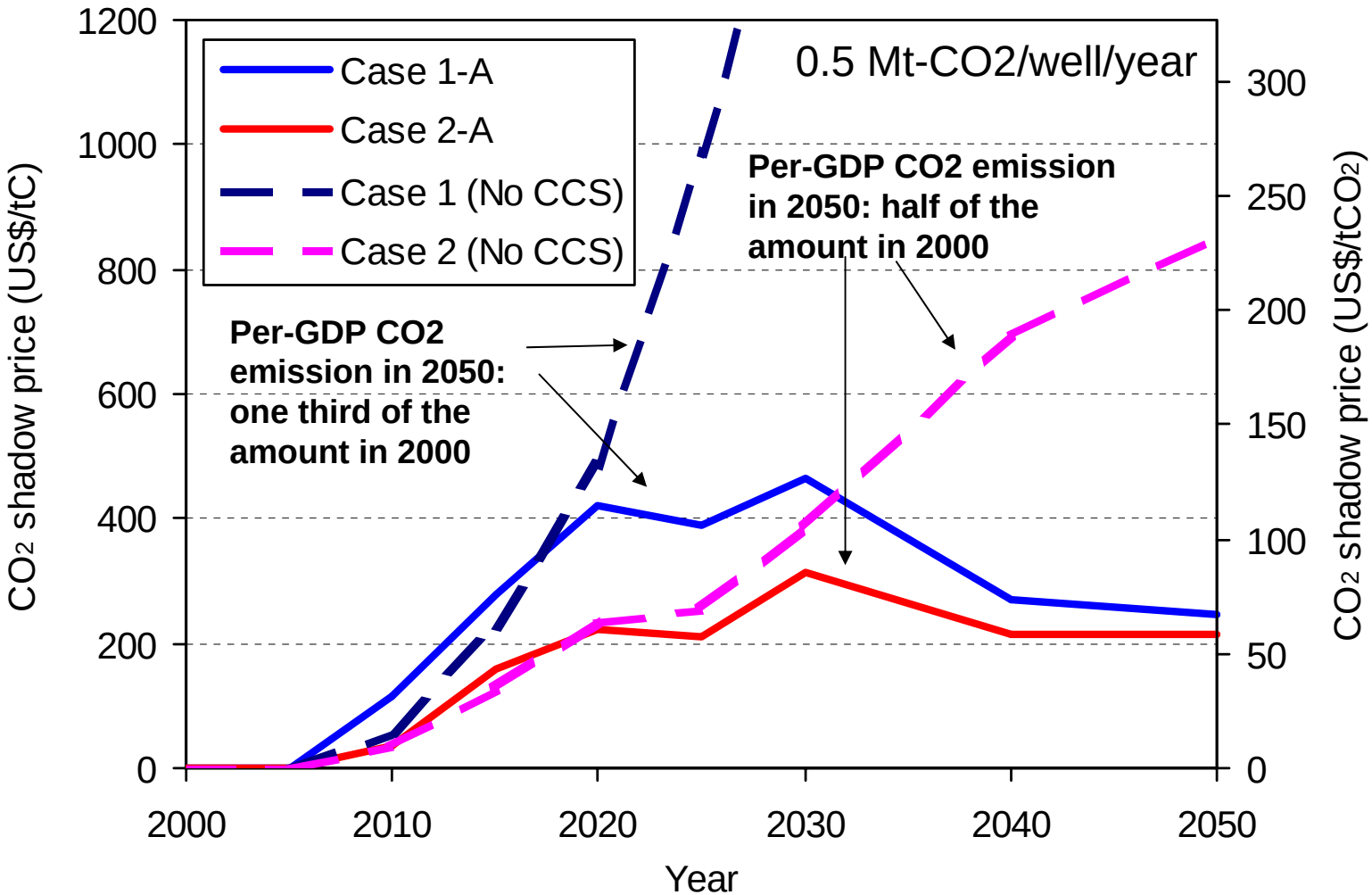


Cost-effective Options for CO2 Emission Reduction in Japan



Marginal CO2 Reduction Cost

CCS will play an important role for reduction of mitigation cost in Japan



Answer to Q6

- Although cost of CCS is estimated to be relatively high compared to other countries, CCS is still considered to be one of the cost-effective options for CO2 emission reduction in Japan.
- By implementation of CCS, mitigation cost in Japan is expected to substantially reduced.

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