Reduction of Environmental Impacts by Development of Industrial Symbiosis in Japan

- Case Studies for Application of Co-production Technologies in Steel Industries and its Reduction Potential of Greenhouse Gas Emissions -

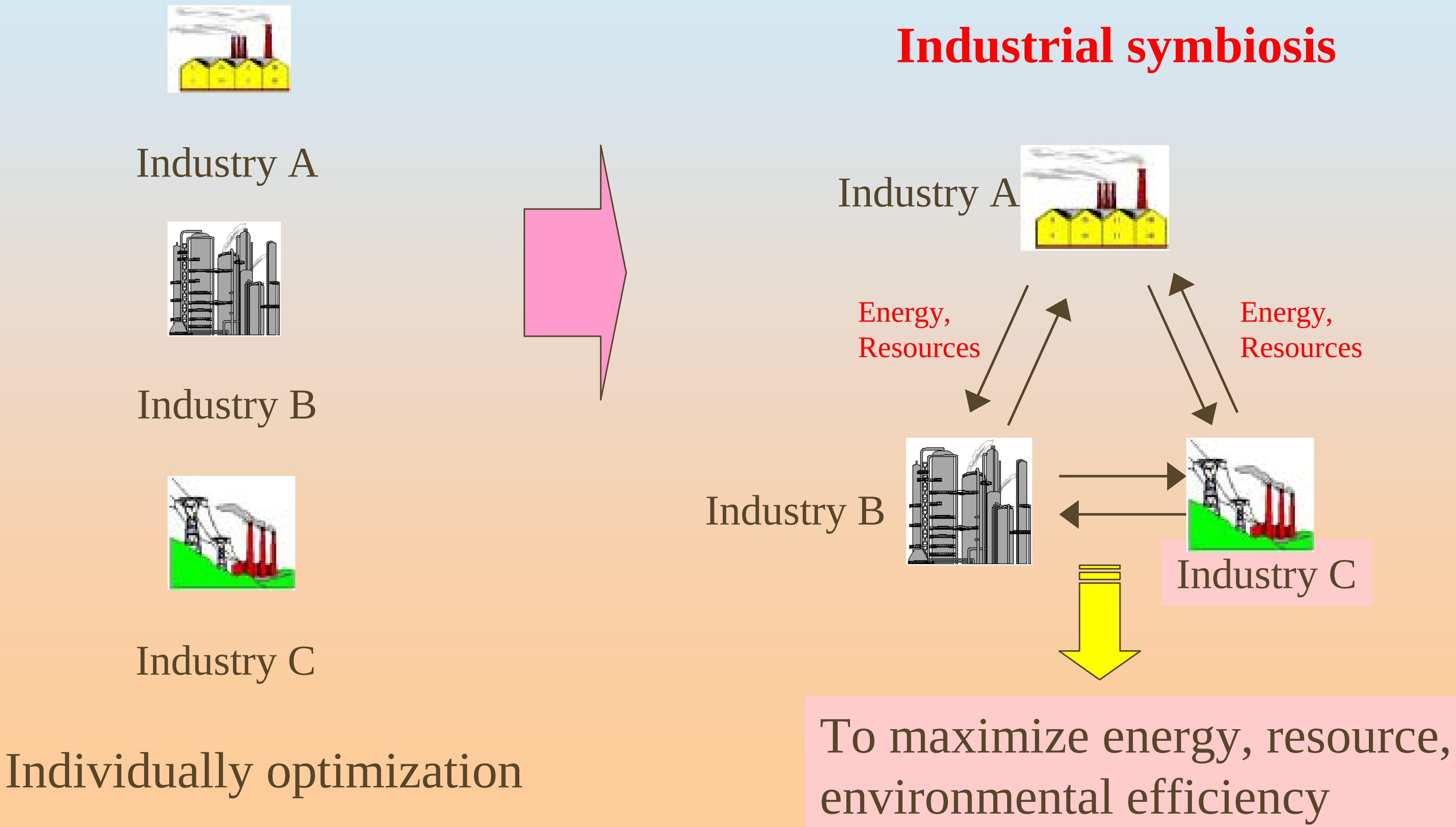
Yasunari Matsuno, Ichiro Daigo, Masaru Yamashita and Yoshihiro Adachi

Department of Material Engineering, Graduate School of Engineering, The University of Tokyo

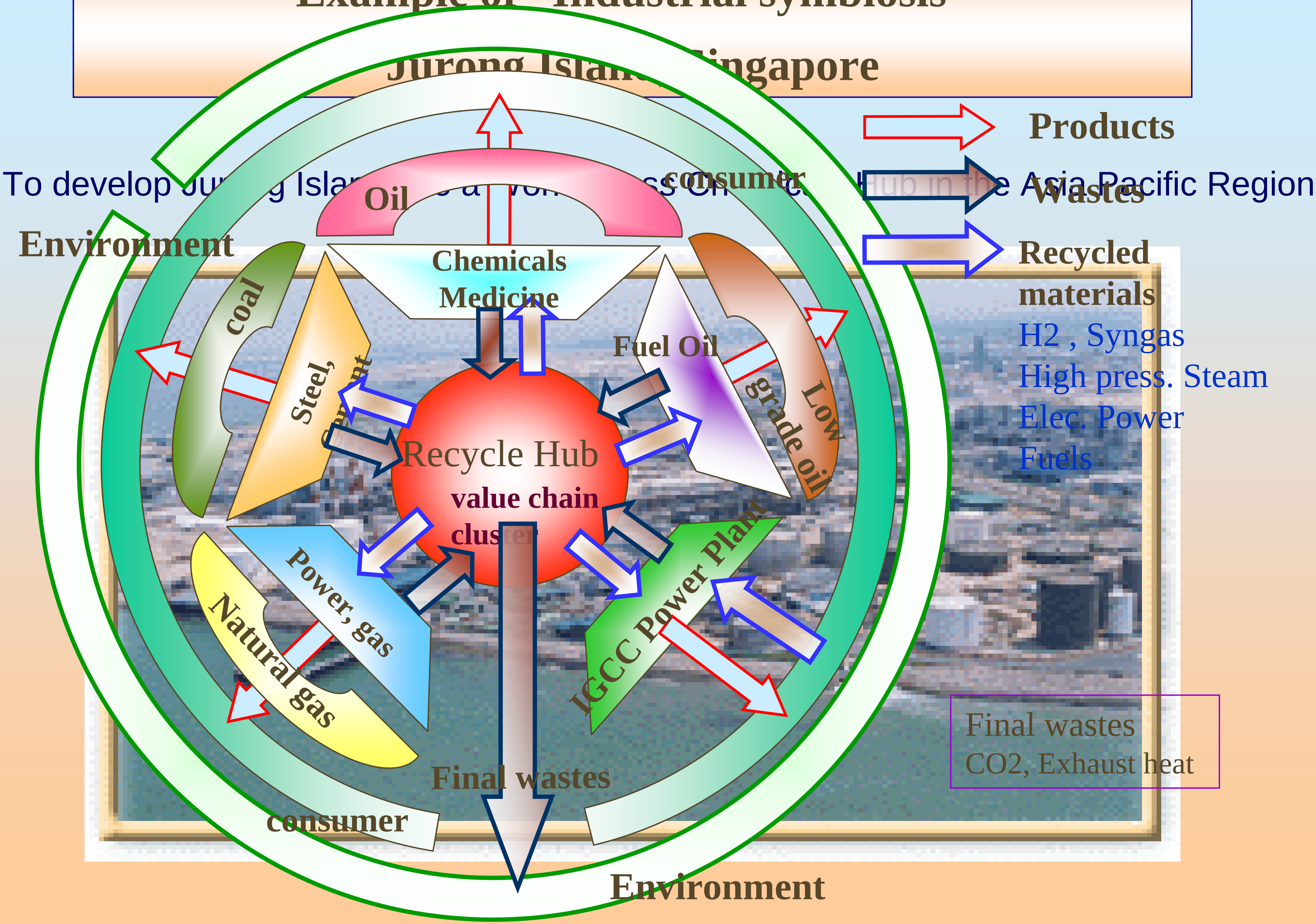
Topics

- Introduction – Backgrounds of this study
- What is “Co-production” technology
- Application of Co-production technologies in Steel industry
  - Low-temperature Gasification Plant
  - CO_2 Recovery and Utilization System
- Results of the case studies
- Conclusion

Recycle-oriented Society
Kyoto Protocol (Reduction of GHGs)

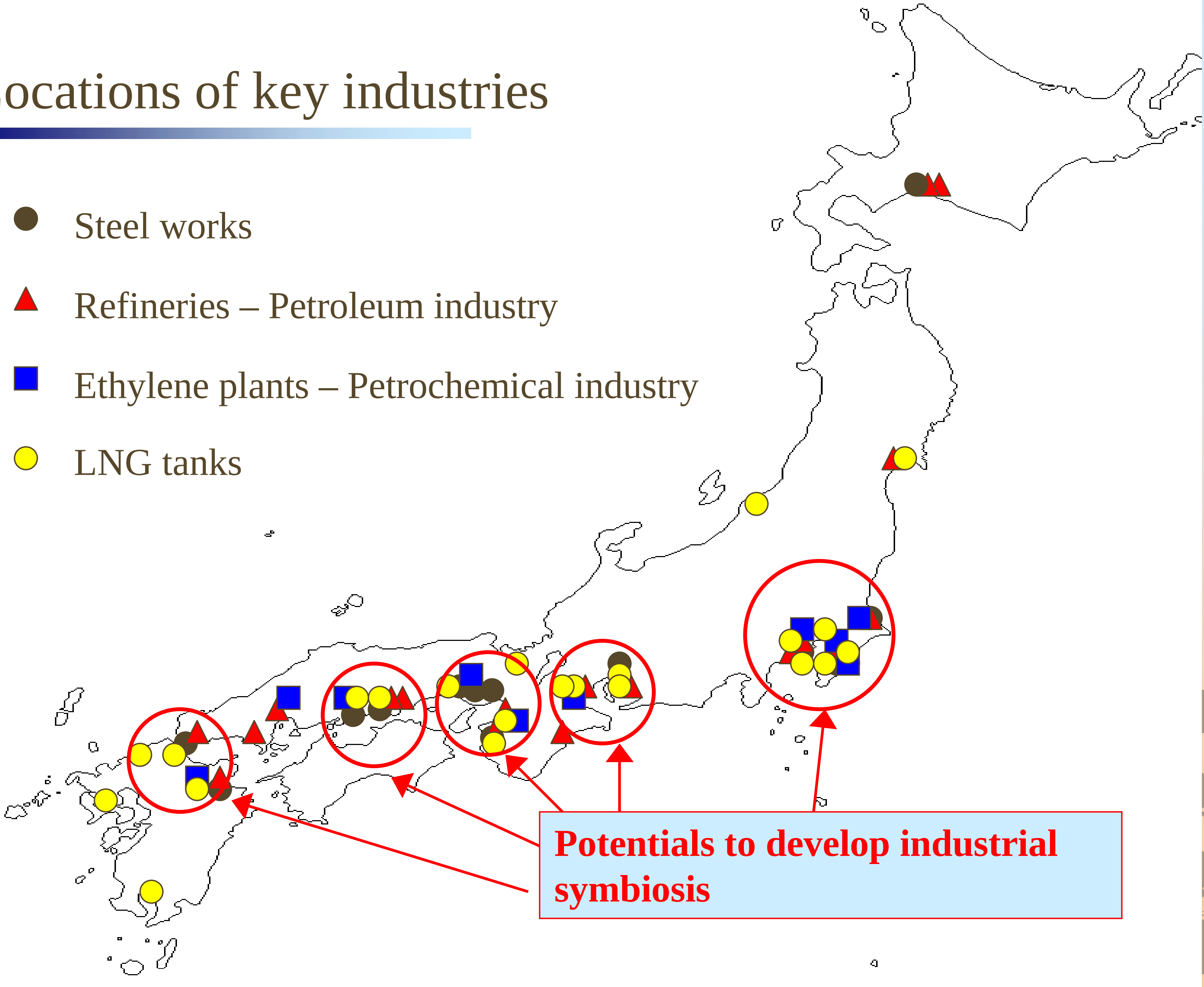


Example of “Industrial symbiosis”
Jurong Island, Singapore

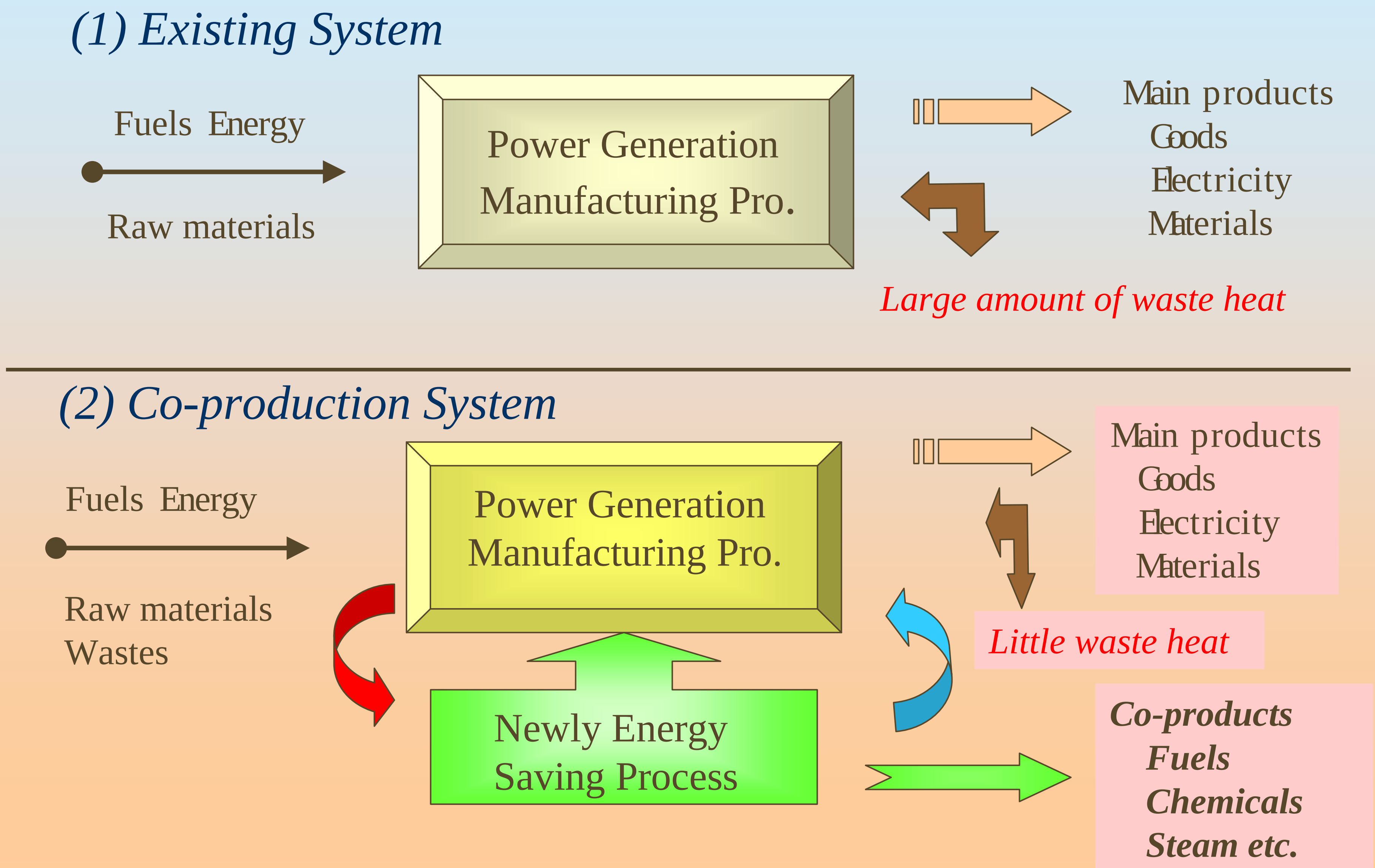


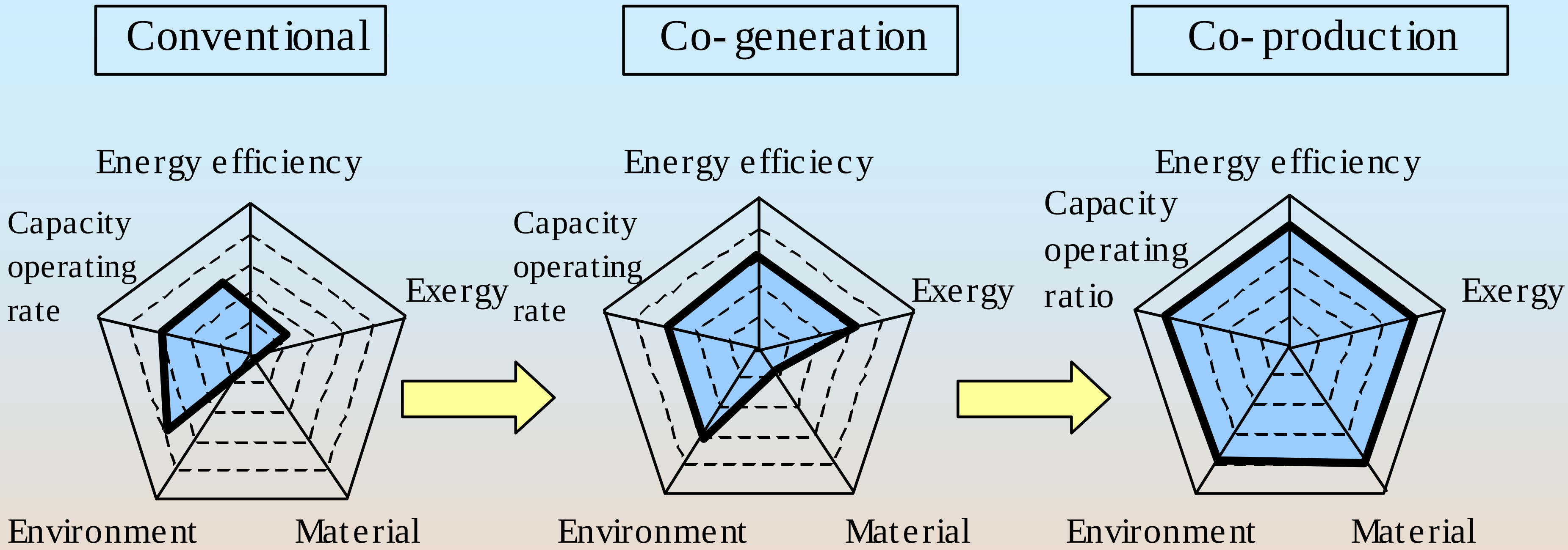
Locations of key industries

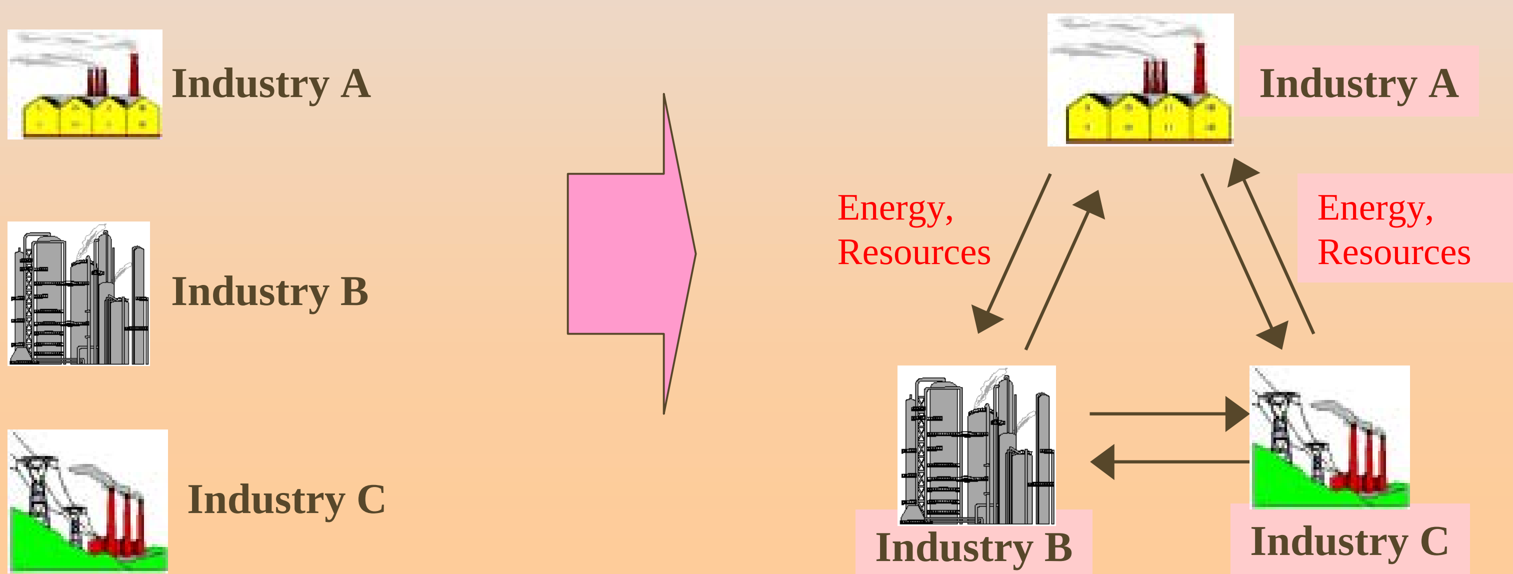
- ● Steel works
- ▲ Refineries – Petroleum industry
- ■ Ethylene plants – Petrochemical industry
- ○ LNG tanks



What is co-production technology?
- Technologies for Industrial symbiosis




Conventional
Co-generation
Co-production
Energy efficiency
Capacity operating rate
Exergy
Environment
Material
Energy efficiency
Capacity operating rate
Exergy
Environment
Material
Energy efficiency
Capacity operating ratio
Exergy
Environment
Material

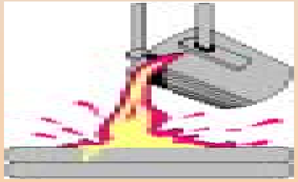

Industry A
Industry B
Industry C
Industry A
Energy, Resources
Energy, Resources
Industry B
Industry C

Goal and scope

To investigate environmental impacts of Co-production technologies (for Industrial symbiosis)

- Gasification plant
- Dry ice (cryogenic energy) production plant with CHP

Steel works



To expand system boundary to evaluate total environmental impacts

Methodology

1 To investigate where to apply co-production technologies

Industries (capacity, location)

Waste heat distribution

Demand and supply of products, energy

2 To conduct LCA for co-production technologies

- CO_2 emissions-

3 To optimize the transport of products by Linear Planning method

4 To investigate total environmental impacts

1st Step

To assess the reduction potential of environmental impacts by co-production technology.

To compare with current technology.

2nd Step

To assess the reduction potential of environmental impacts in a industrial cluster scale.

To investigate the demand and supply of energy and products.

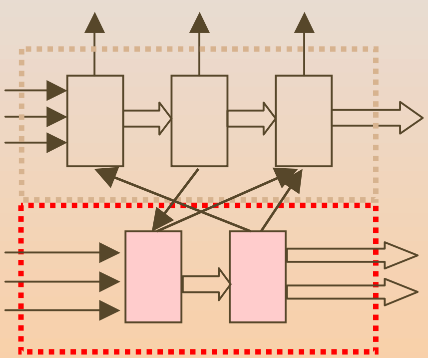
To develop a model

3rd Step

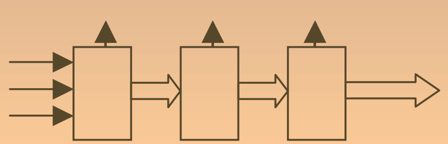
To assess the reduction potential of environmental impacts in a regional (country) scale.

To develop database.

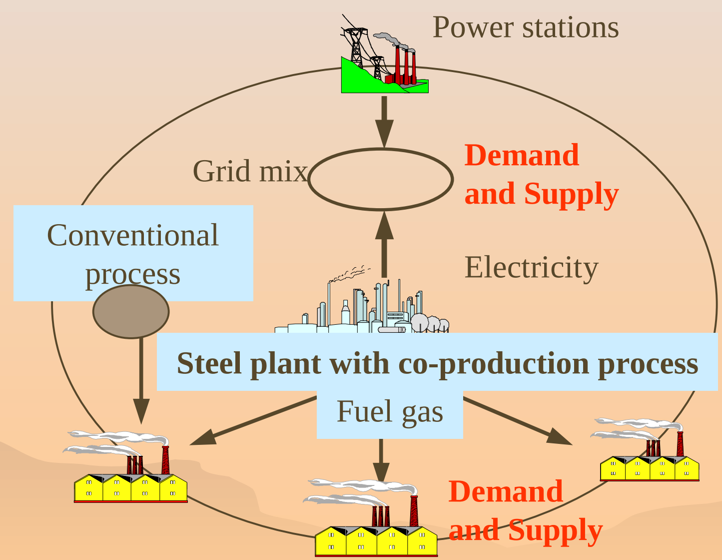
To integrate with other tools.

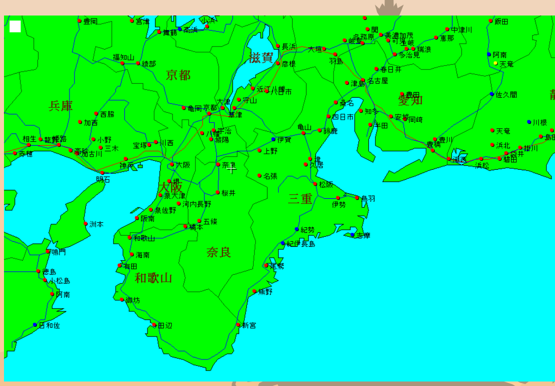


Co-production technology



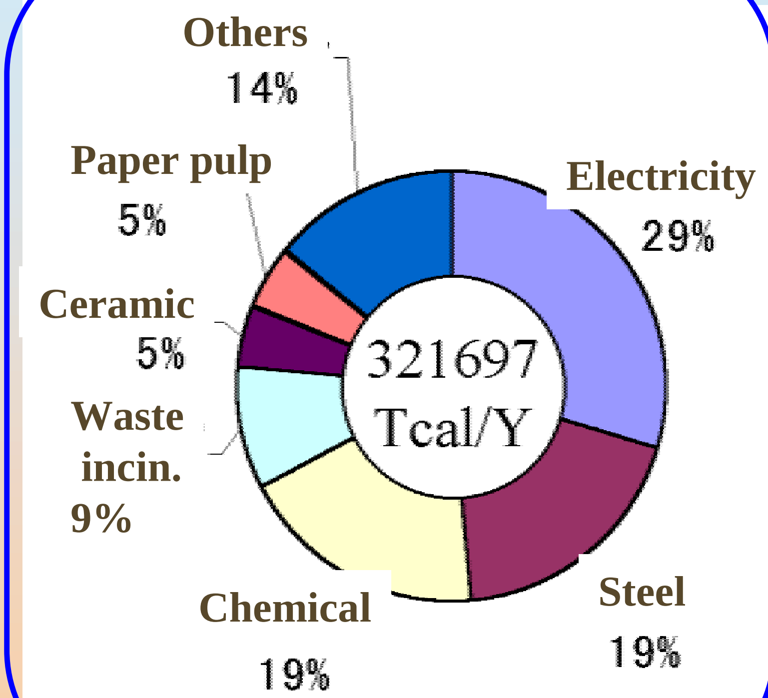
Current technology



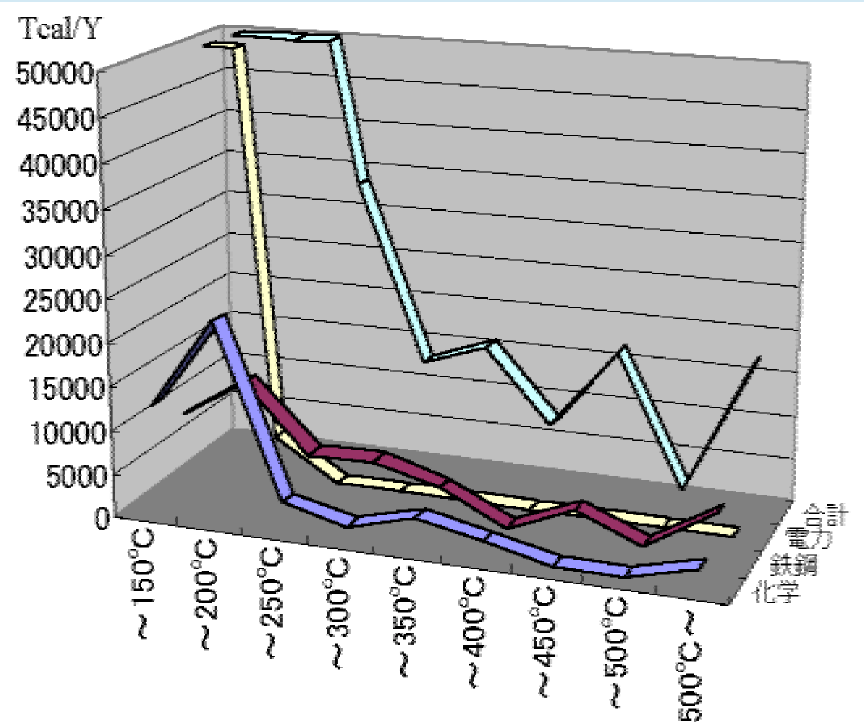


Where to apply co-production technologies?

- Waste heat distribution in industries in Japan



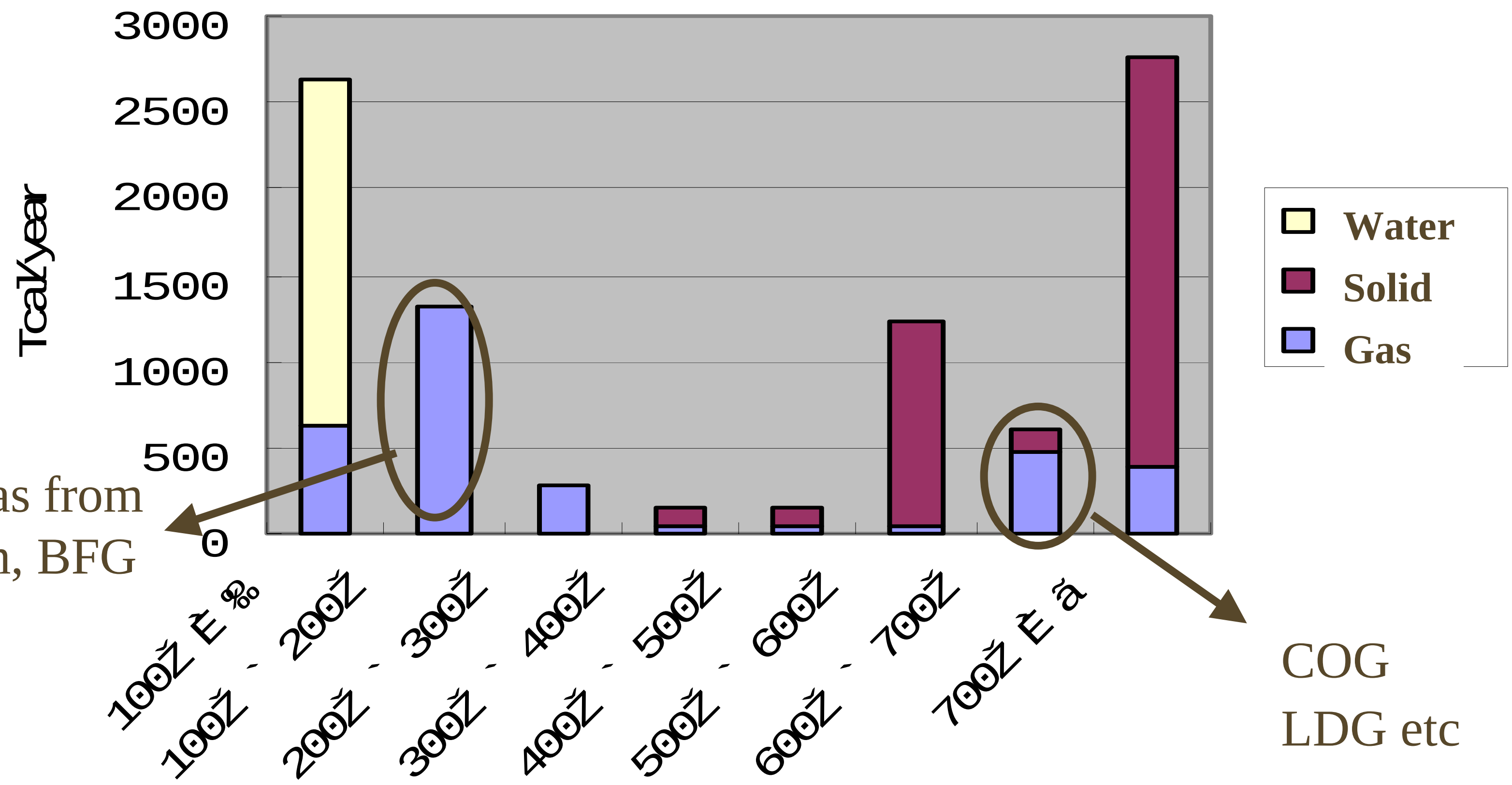
Waste heat amount



Waste heat distribution

Apply Co-production technology to Steel industry

Waste heat distribution in steel works



Exhaust gas from Coke oven, BFG etc

COG LDG etc

Co-production technology (1)

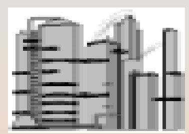
High efficiency gasification plant with high-temperature waste heat (600)

High-temperature

Waste heat

Tar
1t

Waste heat
at 873 K
1300 Mcal



Gasification
plant

Gas
CO/H_2 2
8300Mcal

Steam

Methanol
5810 Mcal

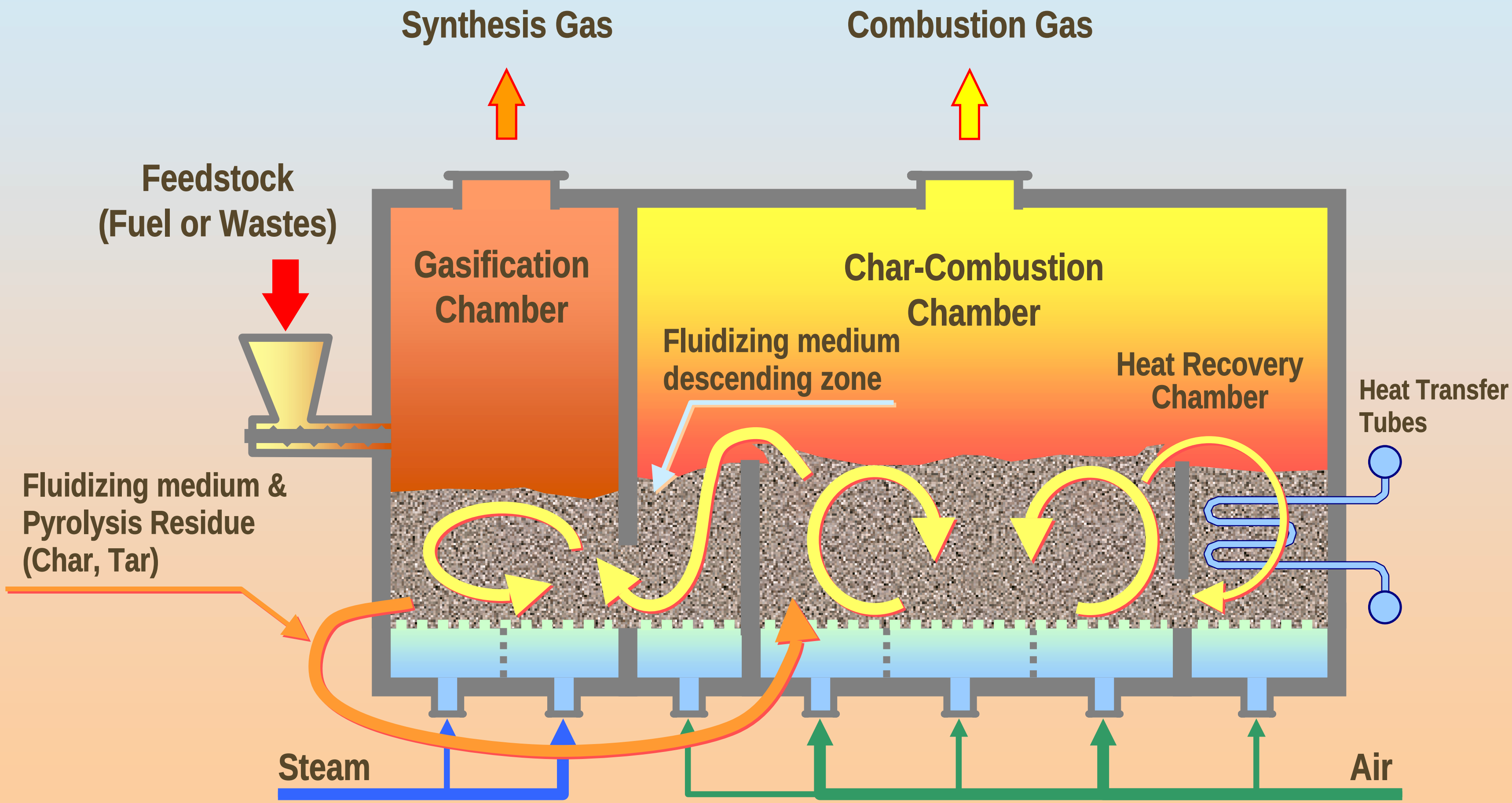
or

Electricity

Methanol: easy for storage,

Utilizing waste heat

ICFG : Internally Circulating Fluidized-bed Gasifier

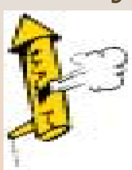


Co-production technology (2)

Low temperature waste heat

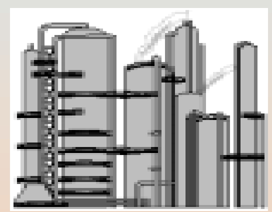
Dry Ice (cryogenic energy) production with CHP (Utilizing waste heat)

Exhaust gas recovery



Waste heat at at 423 K 305kcal

CHP



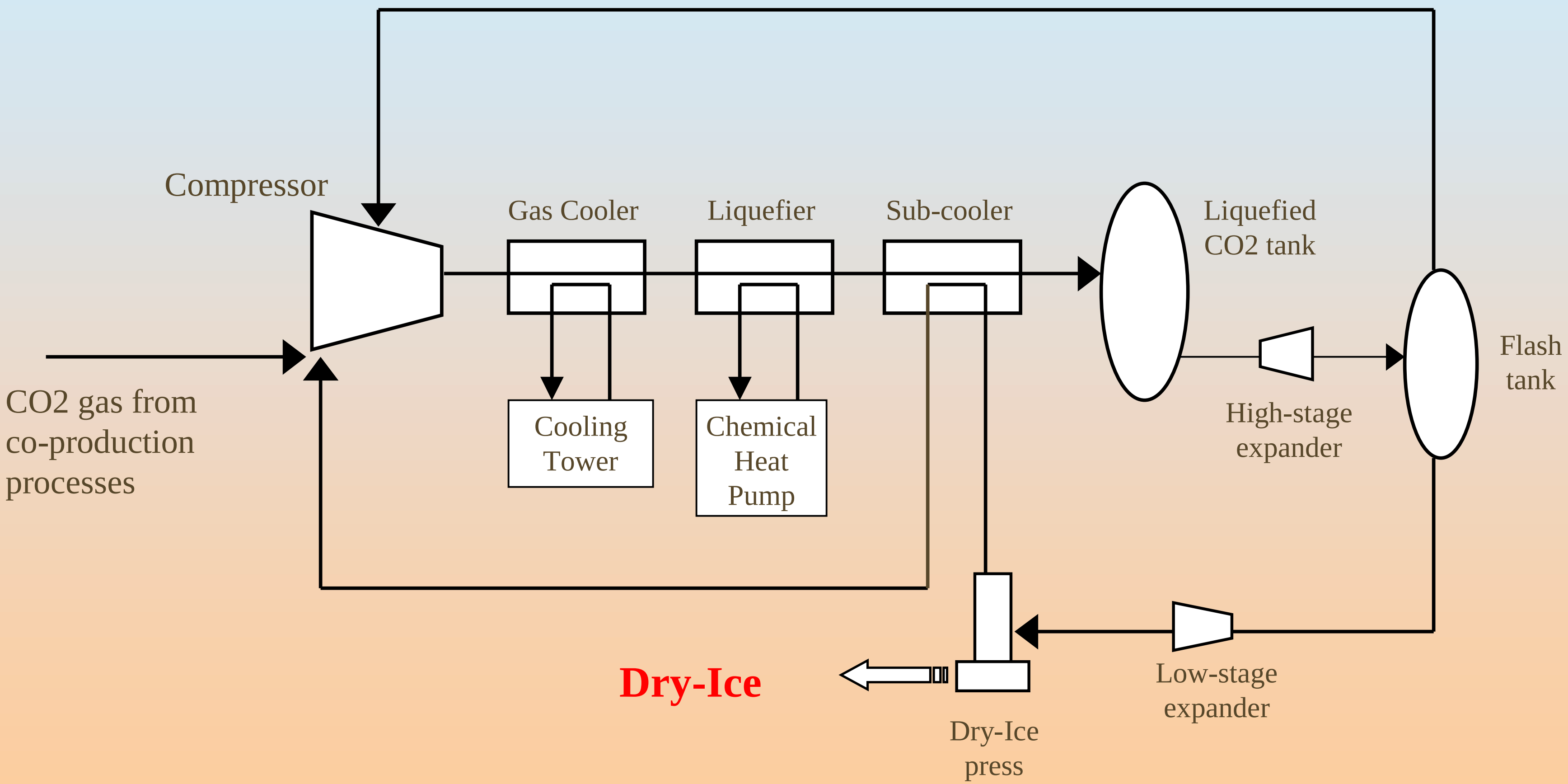
Dry ice production process

DI

1kg

Electricity: 0.176 kWh

Co-production technology (2)



LCA for Co-production technologies

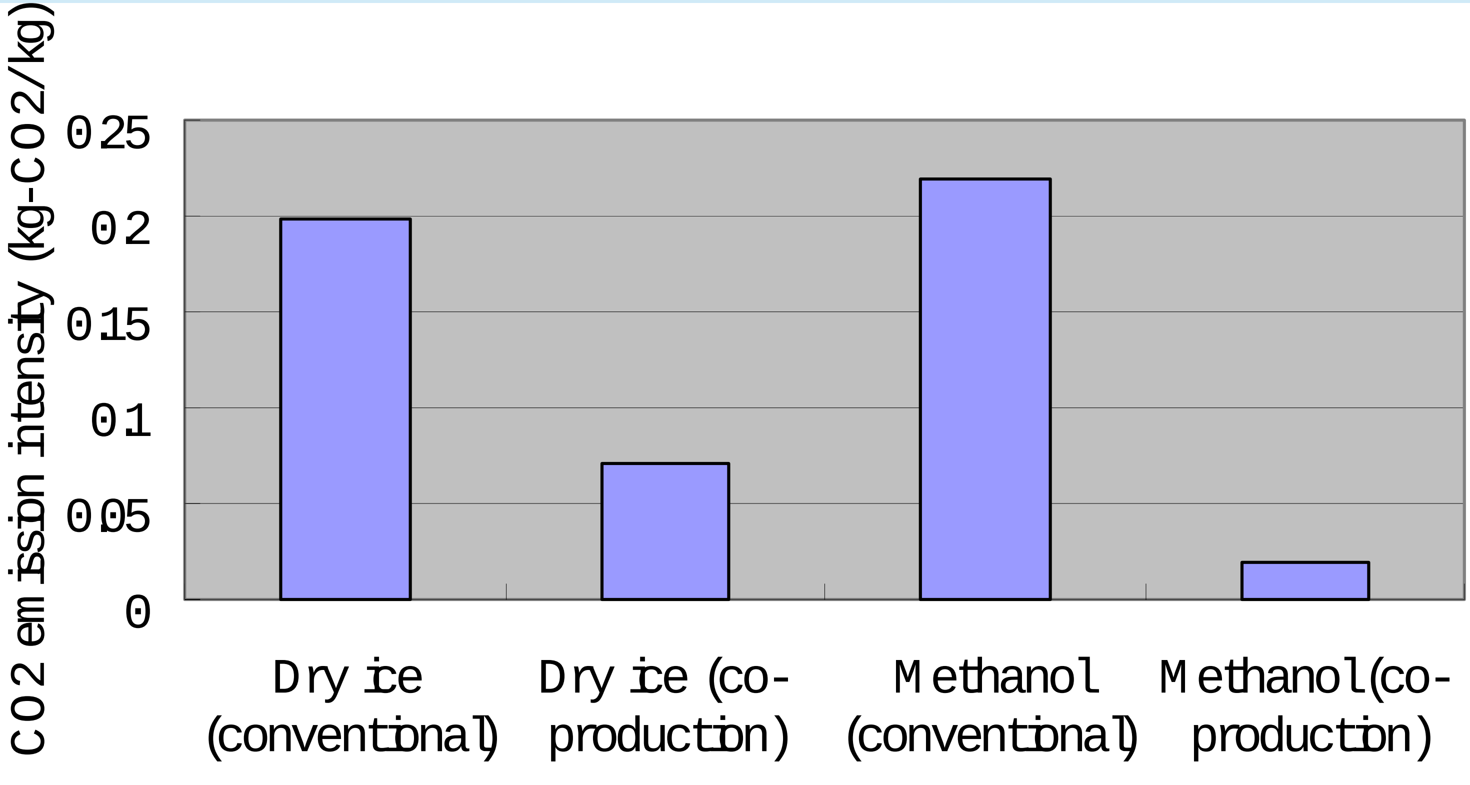
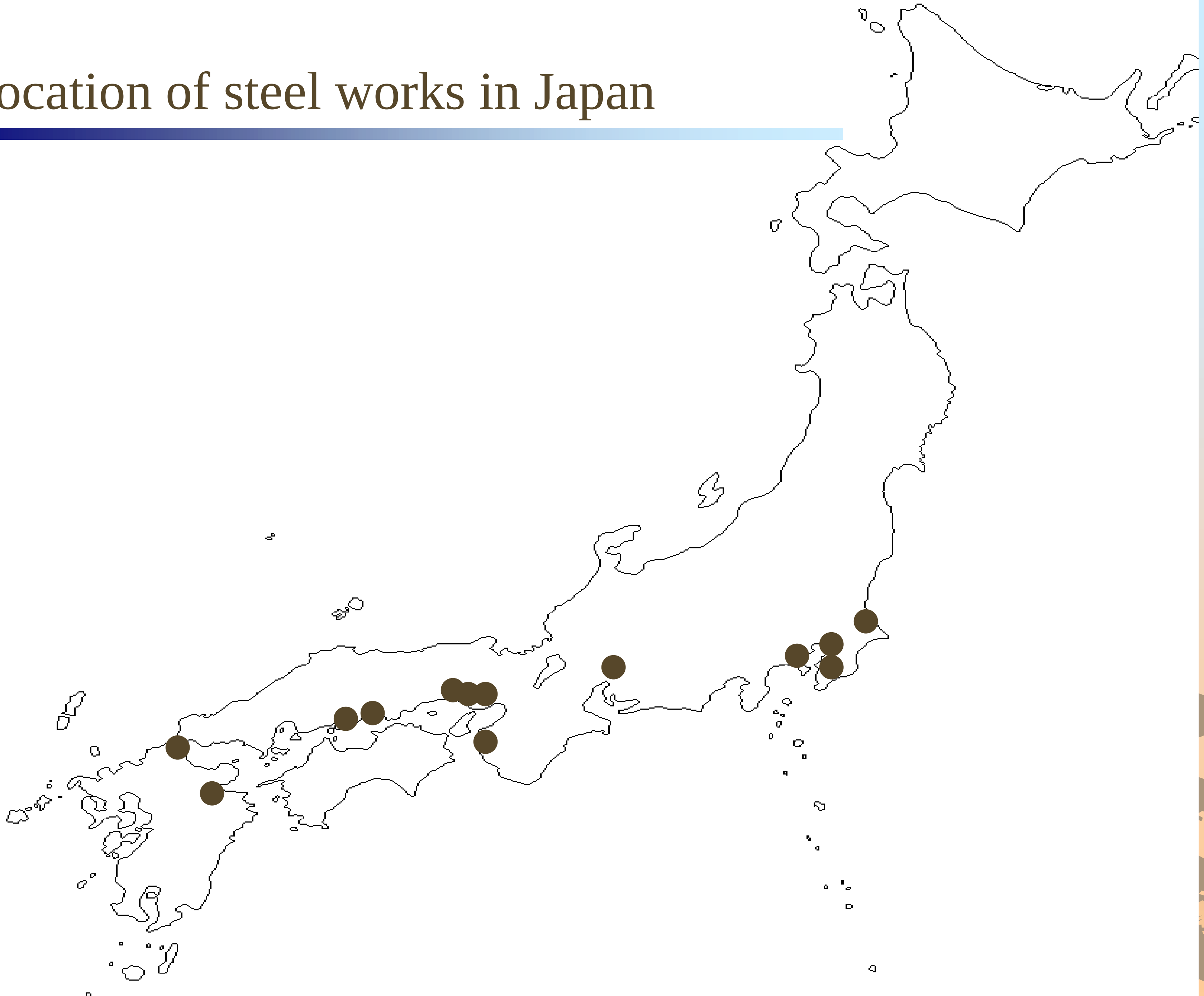
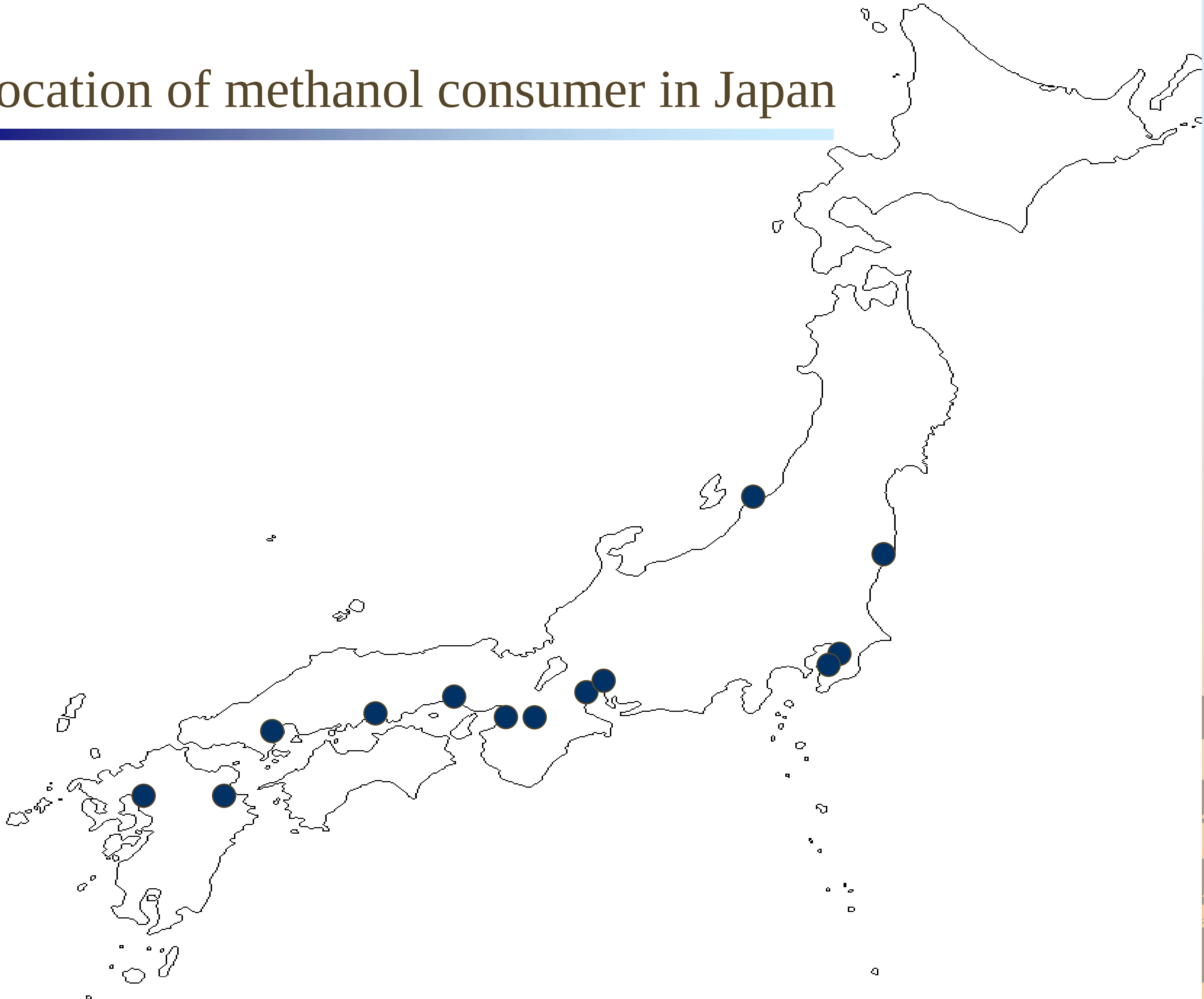


Fig. CO2 emission intensity for co-products (kg-CO2/kg)

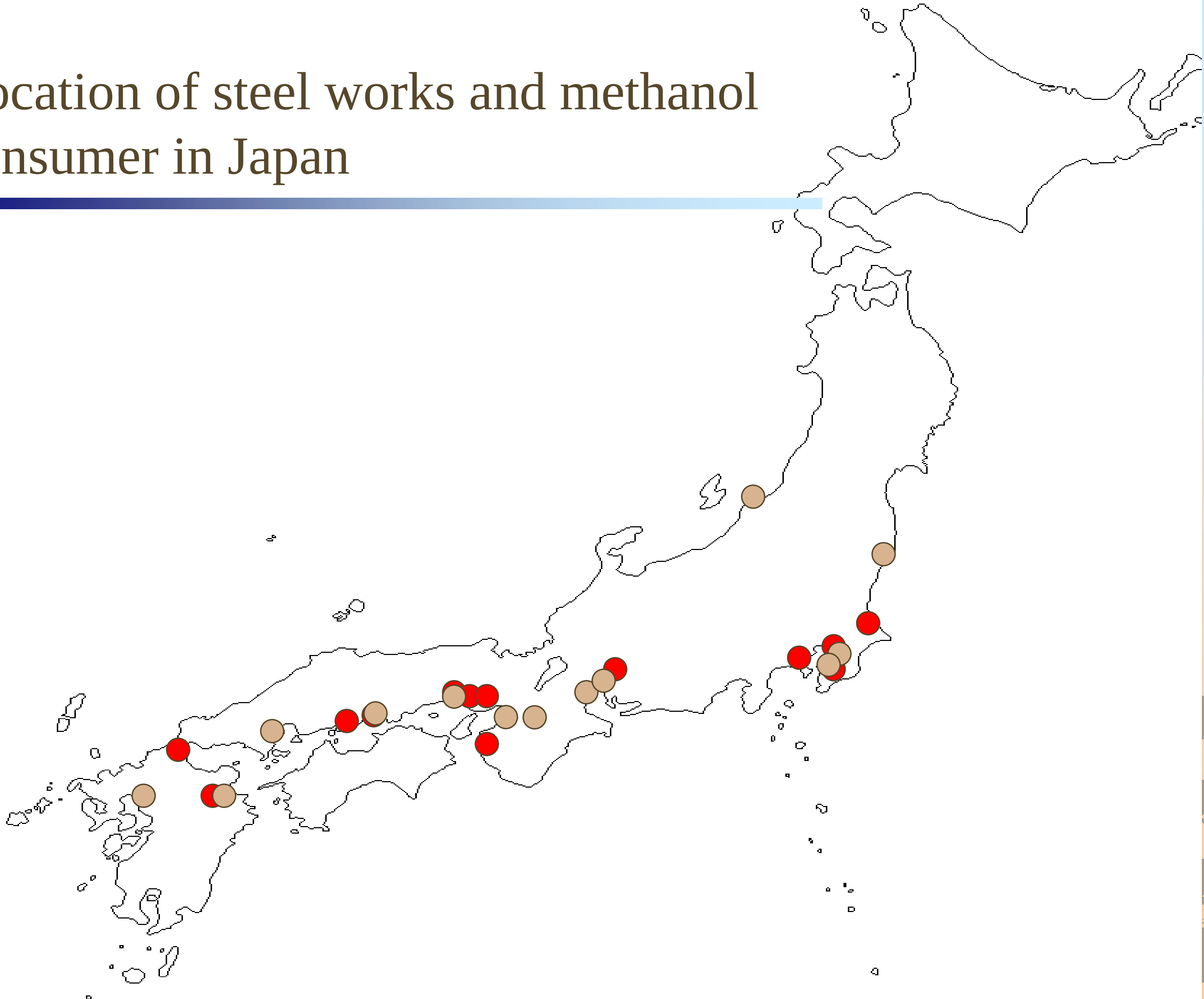
Location of steel works in Japan



Location of methanol consumer in Japan



Location of steel works and methanol consumer in Japan



Total CO2 emissions - Core technology

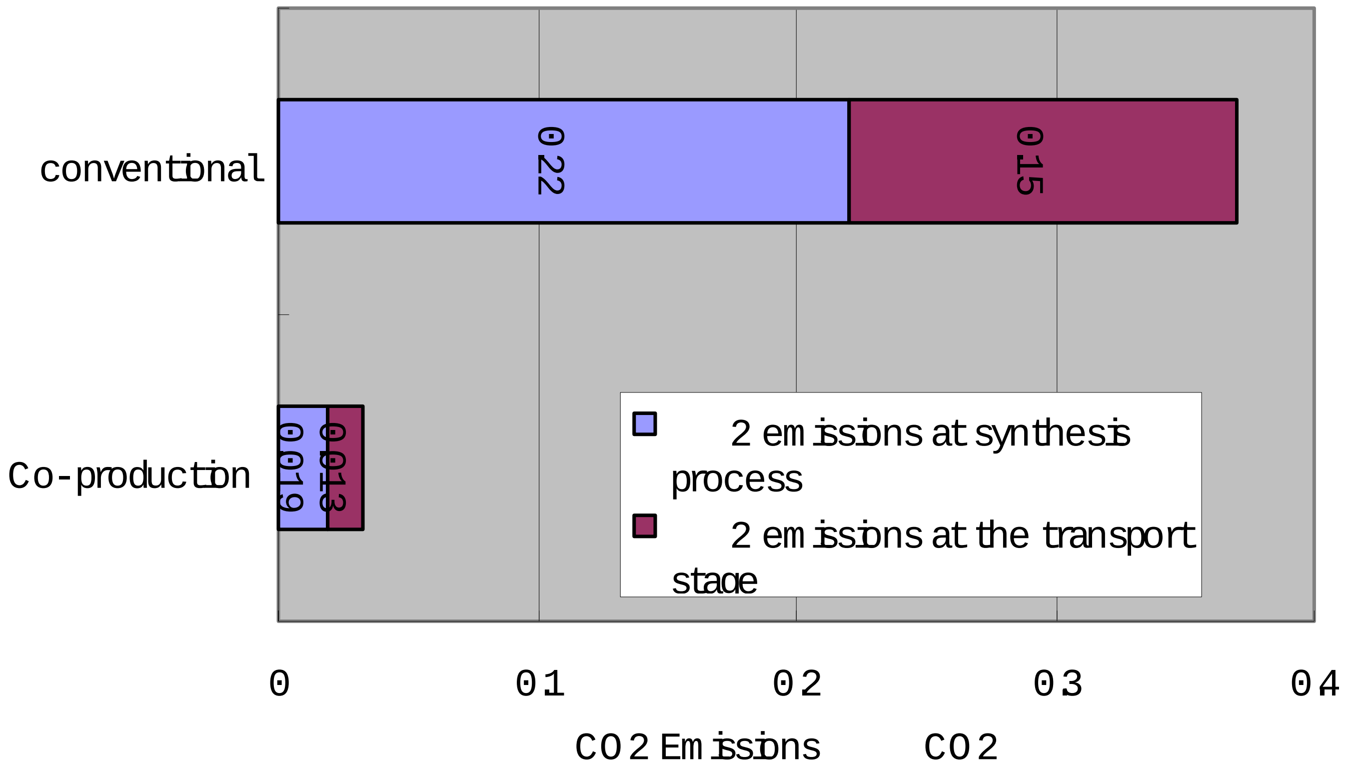


Fig. CO2 emission intensity of methanol

Total CO_2 emission reduction potential in Japan

CO_2 emission reduction potential by co-production technologies:

Methanol:	0.34 ton-CO_2/ton-methanol
Dry ice:	0.13 ton-CO_2/ton-dry ice

Current demand in Japan:

Methanol: 1.8 million ton/y,

Dry ice: 0.24 million ton/y

↓

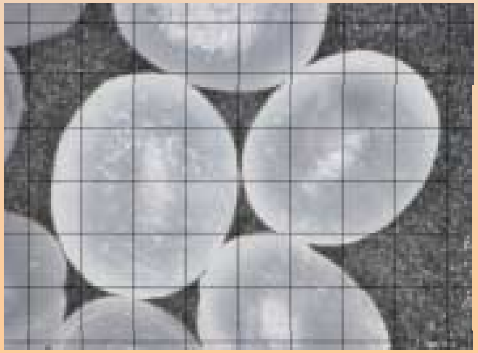
Total CO_2 emission reduction potential in Japan:

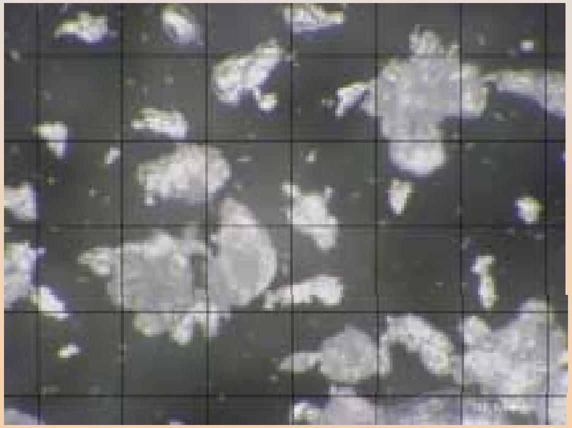
Methanol:	0.6 million ton/y
Dry ice:	0.03 million ton/y

Other possible application of dry ice

Low temperature crushing of PP pellet

PP pellet (3mm diameter)





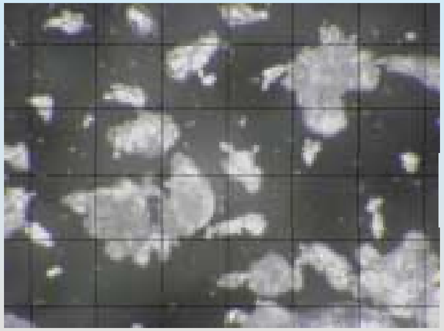
Microscope of crushed pp pellet (200μm/div)

Low temperature crushing of PP Conventional technology

PP pellet 1 kg

Liquefied N_2 9.68 kg

Crushed PP 1kg



CO2 emissions
2.33 kg-CO2

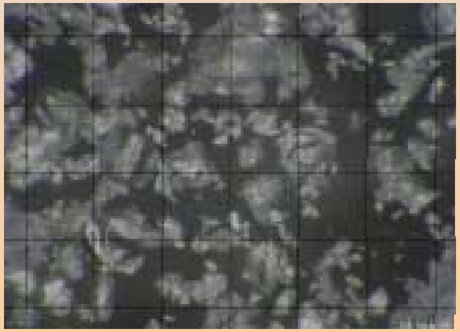
Δ2.10 kg-CO2

Low temperature crushing of PP by dry ice

PP pellet 1 kg

Dry ice 3 kg

Crushed PP 1kg



CO2 emissions
0.23 kg-CO2

Potential demand of crushed PP: 0.017 million ton/y (0.64% of total PP)

CO2 reduction potential: 0.036 million ton-CO2

Conclusion

- Methanol production by co-production technology (gasification plant) will reduce CO_2 emissions by 91% compared with conventional technology (92% reduction in production, 90% reduction in transport)

- Total CO_2 emission reduction potential in Japan by methanol production : 0.6 million ton-CO_2

- Dry Ice (cryogenic energy) production by co-production technology will also reduce CO_2 emissions by 64% compared with conventional technology. Total CO_2 emission reduction potential in Japan is 0.03 million ton-CO_2.

- Other CO_2 reduction potential by applying dry ice is being investigated, such as low temperature crushing of PP pellet

- Thank you very much for your attention.

- For further information;
matsuno@material.t.u-tokyo.ac.jp