# An ex-ante cost effectiveness analysis of lignocellulosic bioethanol promotion policy in Japan

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# Outline

1. Introduction: background information

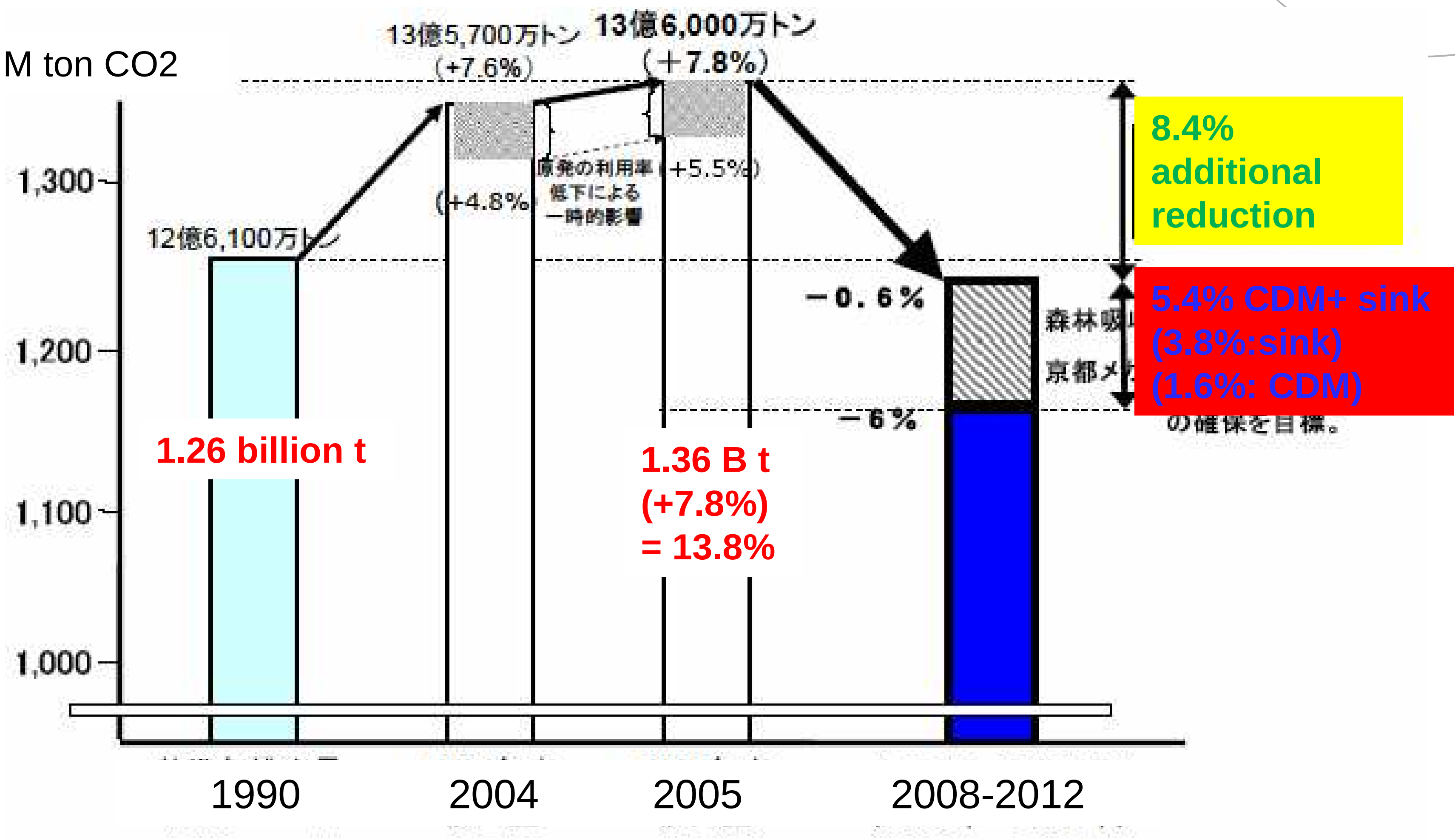
2. Potential estimate lignocellulosic bioethanol production in Japan

3. Trial calculation of bioethanol production costs

4. CO2 reduction costs by bioethanol

# 1. Kyoto Protocol and present status in Japan

- 13.8% additional reduction required by 2008-2012



# 1. Prospect of Bioenergy until 2010

- New energy : 1.8% in TPES(2003) to 3%(2010)
- Half of total New Energy (2010) from Bioenergy

| New Energy Introduction Target | | FY2003 | FY2010 target |
|---|---|---|---|
| Power generation field | Photovoltaic power generation | 210,000 kl (860,000 kW) | 1,180,000 kl (4,820,000 kW) |
| | Wind power generation | 276,000 kl (678,000 kW) | 1,340,000 kl (3,000,000 kW) |
| | Waste power generation + Biomass power generation | 2,137,000 kl (1,739,000 kW) | 5,860,000 kl (4,500,000 kW) |
| Thermal utilization field | Solar thermal utilization | 690,000 kl | 900,000 kl |
| | Thermal utilization of waste | 1,610,000 kl | 1,860,000 kl |
| | Biomass thermal utilization | 790,000 kl | (*1) 3,080,000 kl |
| | Unused energy | 42,000 kl | 50,000 kl |
| | Black liquid, waste material, etc. | 4,780,000 kl | 4,830,000 kl |
| Total (rate in total primary energy supply) | | 10,540,000 kl (1.8%) | 19,100,000 kl (about 3%) |

*1 Includes biomass-derived fuel (500,000 kl) for transportation.

# 1. “ambitious” biofuels targets

- Japan set “ambitious” biofuels targets by domestic biomass
  - By 2010: 500 million Liter of Oil Equivalent (LOE), equal to 760 million L bioethanol (0.8% of petrol consumption in Japan)
  - By 2030: 3600 million LOE, 6000 million L bioethanol (10%)
- However Japan is very limited for domestic biofuels productions
  - The present biofuels production: Bioethanol 30kL and BDF 5million L
  - Japanese food self-sufficiency ratic

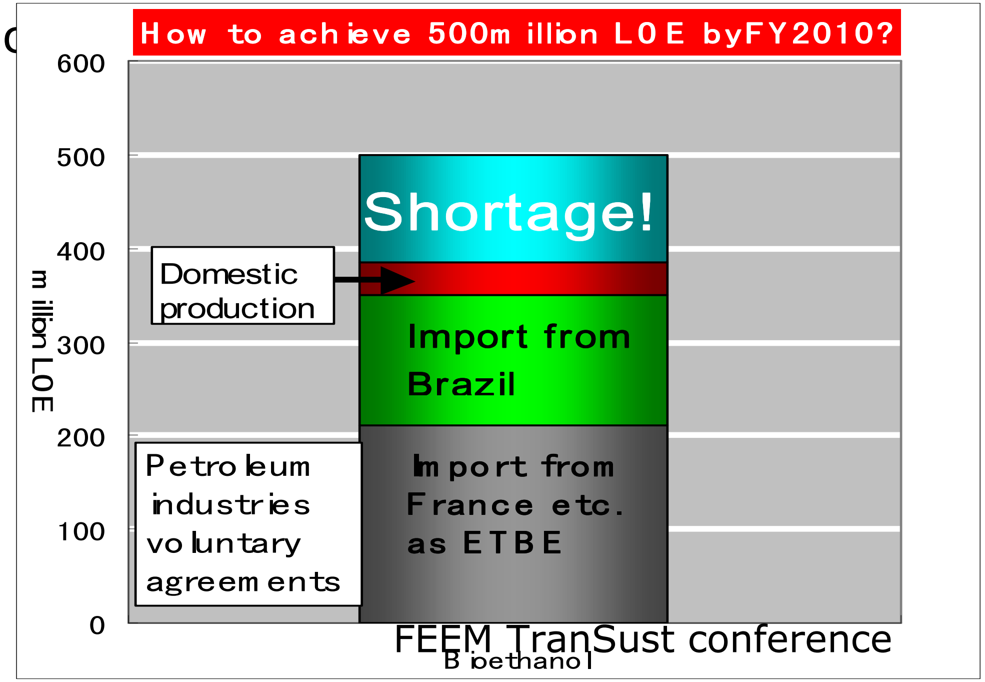
**•How to achieve 500million LOE by 2010?**

**–Petroleum industries: 210m LOE**

**–Import from Brazil: 140m LOE**

**–Domestic: MAFF+MOE= 40m LOE**

**–Shortage 100m LOE…import from Brazil??**



# 1. Research objectives

- Focus on the 2nd generation bioethanol
  - Like other industrialized countries: food competition, GHG reduction potentials…
  - Low food self sufficient ratio
  - Huge lignocellulosic biomass potentials in Japan
    - Rice husk, rice straw
    - Woody biomass

- Three research objectives
  1. Potential estimate lignocellulosic bioethanol in
  2. Trial calculation of bioethanol production costs
  3. CO2 reduction costs by bioethanol

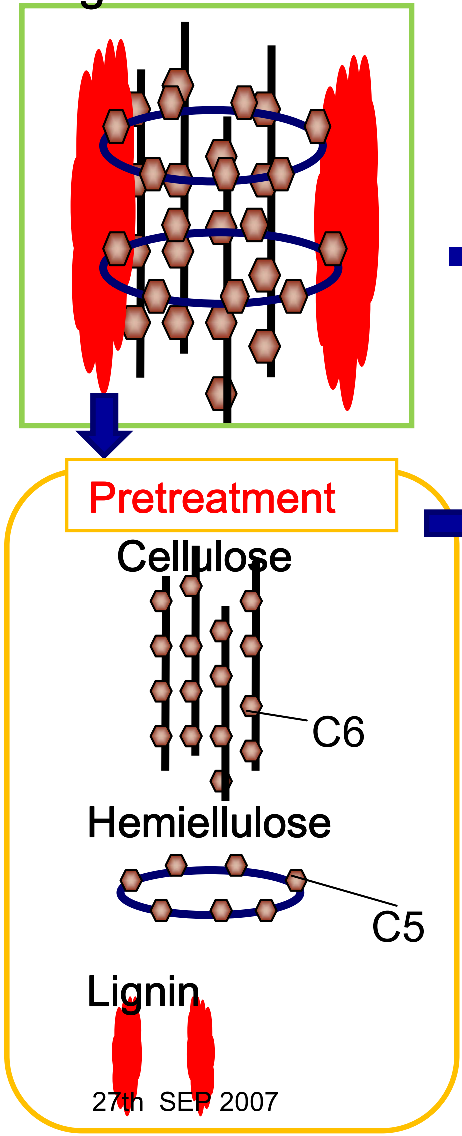
# 1. Methodology

1. Setting the optimal transport distance
   - Biomass feedstock costs estimate in the 50km radius, according to Fujimoto et.al (2004)
   - 8 lignocellulosic feedstock costs including transportation costs

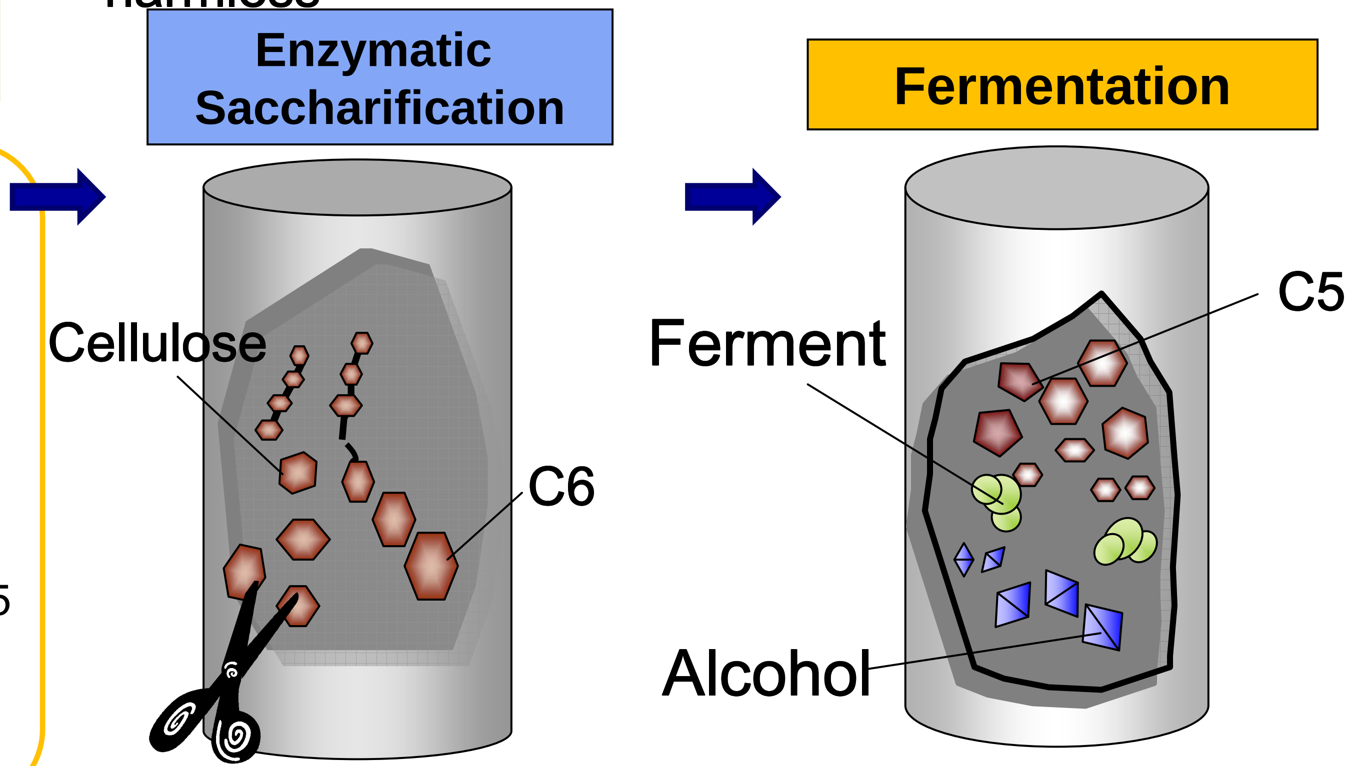
2. Production cost both the present case and the innovative case
   - The present case: Saccharification with strong sulfuric acid, so called NEDO(New Energy and Industrial technology Development Organization) process
   - The Innovative case:
     I. Innovation in saccharification and fermentation process
        – Saccharification without sulfuric acid, AIST(National Institute of Advanced Industrial Science and Technology)
     II. Up scaling factor in ethanol production plant

# 1. Introduction: Saccharificaition and fermentation process

Lignocelluloses




- AIST process:
  - Lignocelluloses are activated and degraded to lower molecules through hydrothermal treatment (treatment with high pressure hot water at more than 100 C) and mechanochemical treatment (causing a chemical reaction with mechanical crushing energy)
- more efficient saccharification and environmental harmless



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1. Introduction: background information
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# 2 Potential estimate bioethanol production in Japan

1. Feedstock and innovation in logistics
   - 8 feedstock: Waste timber from construction, By-product from lamwood manufacture, Branches, Thinned wood, Rice husk, Rice straw, Logging residue, Unutilized bamboo, bamboo glass
   - Innovation in logistics
     I. The present case: Potential minus Material use with the existing collecting process
     II. The innovative case: innovation in collecting process

2. Bioethanol potential and feedstock costs in the 50 km radius, the optimal transport distance in Japan

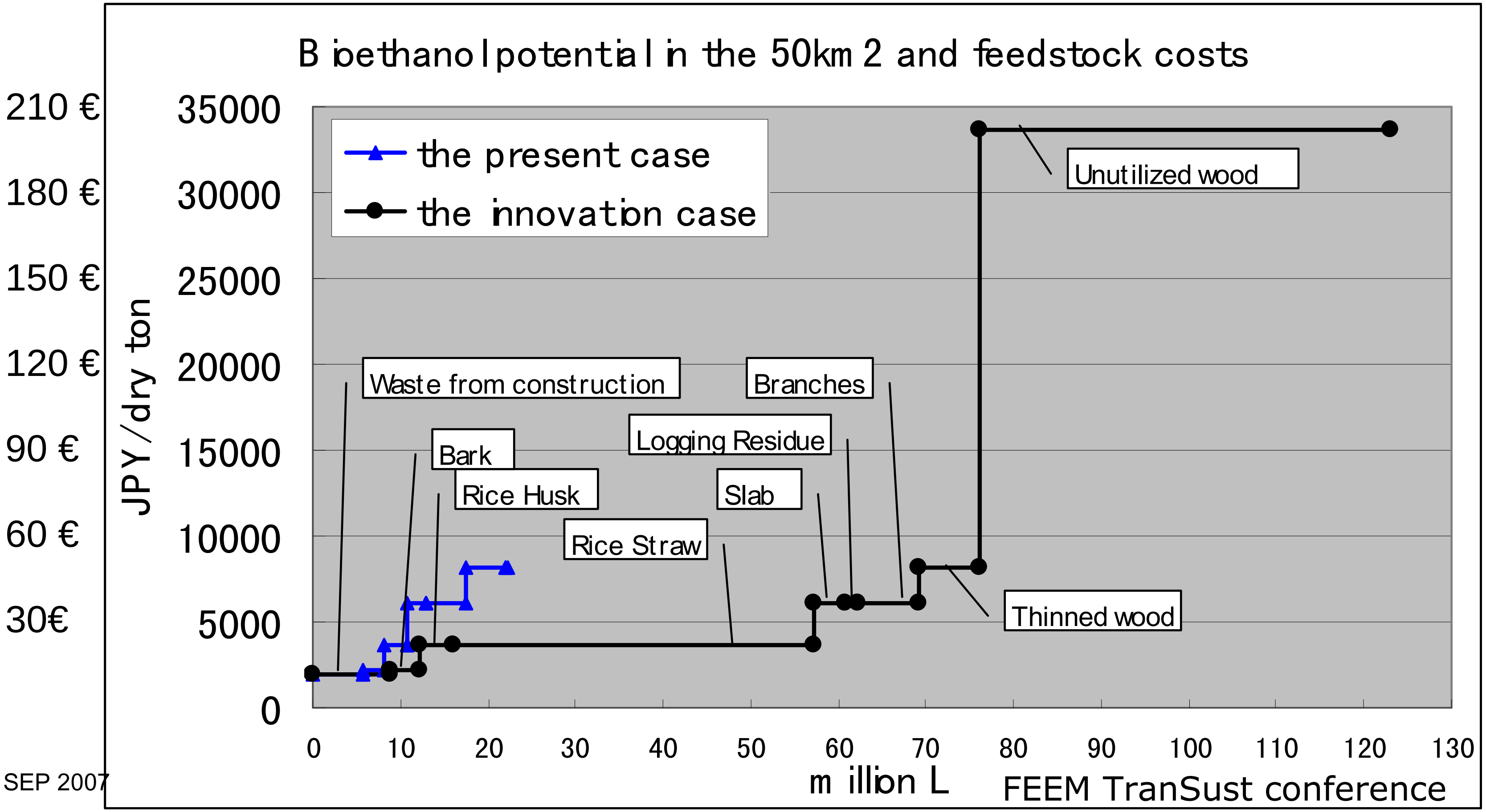
3. Innovation in saccharification and fermentation process

   I. The Present case: NEDO Process:244L/dry-t wood

   II. The Innovative case: AISTProcess:366L/dry-t wood

# 2 Potential estimate bioethanol production in Japan

- Bioethanol potentials are very limited within the 50km radius
  - The Present case: 20million L in the 50km radius, total 1 billion L
  - The Innovative case: 120 million L, total 5.8 billion L, equal to 10% of transport fuel consumption



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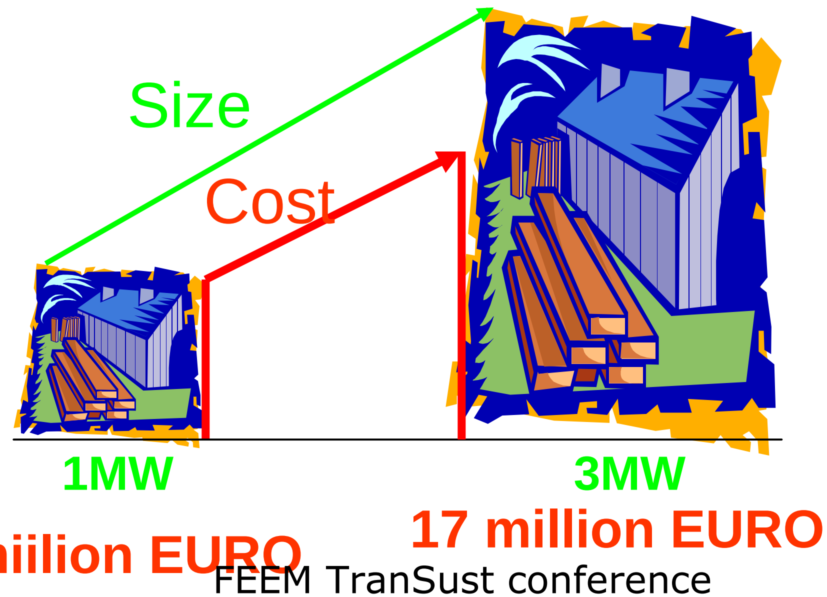
# 3 Calculation of bioethanol production costs

- Bioethanol production costs: 5 costs contents

| Feedstock costs | Plant costs | Personnel costs | Operational costs | Maintenance costs |
|---|---|---|---|---|

  - Up scaling factor: Biomass projects tend to strong “economies of scale”
  - Yamada et. al (2006): 0.67 for lignocellulosic bioethanol plants

$$\frac{Cost_2}{Cost_1} = \left(\frac{Size_2}{Size_1}\right)^{0.6}$$

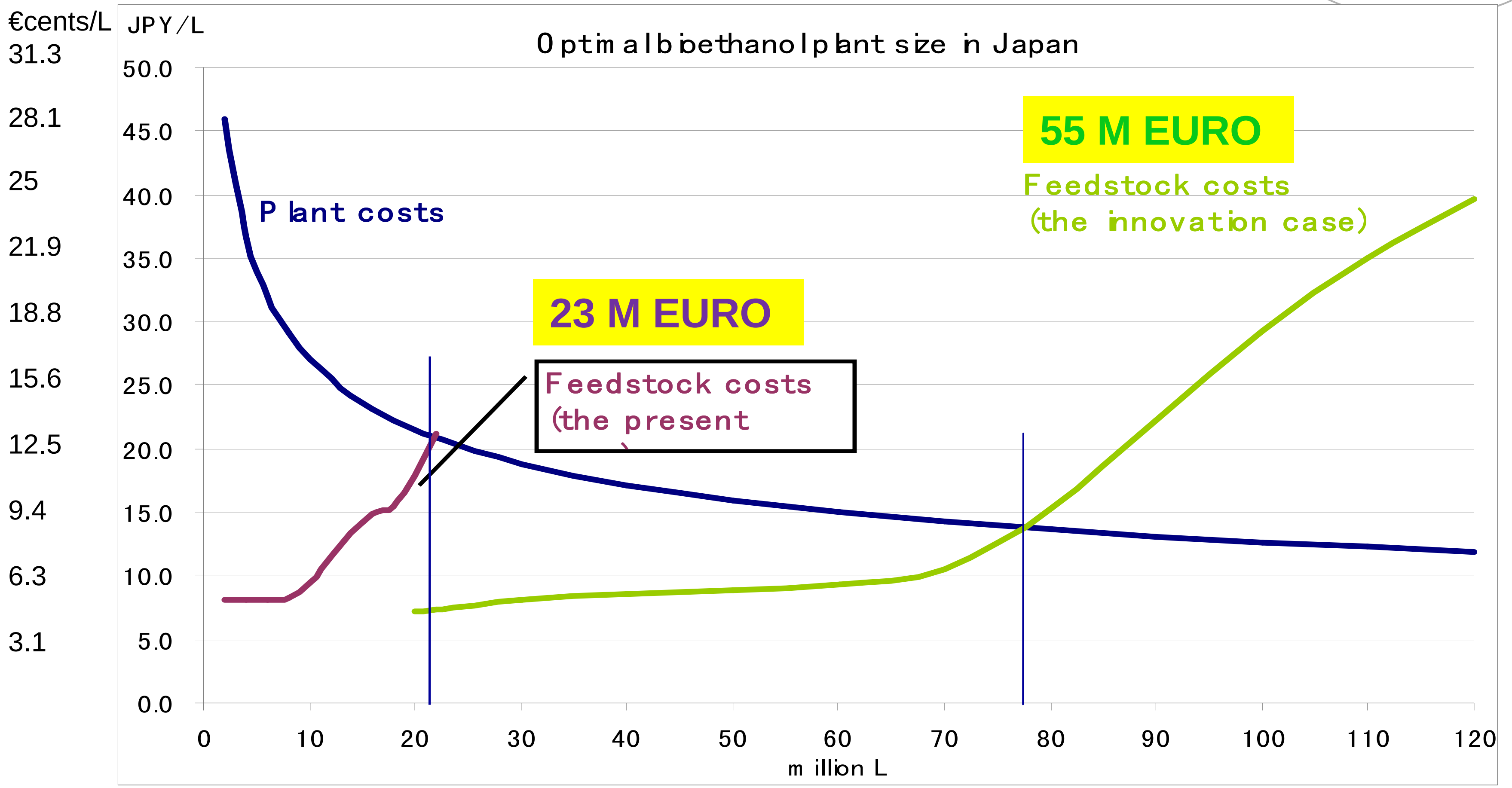


# 3 Calculation of bioethanol production costs

- **Assumption of calculation**
  1. Basic plant information
     - Plants size: 20 million litter per year in the present case and 70 million litter per year in the innovation case
  2. Plant costs (Construction costs)
     - 20million L=3.8 billion JPY
       - according to Yamada et. Al (2006)
       - Up scaling factor: 0.68
     - Depreciation period 15years, interest rates 4%
  3. Personnel costs
     - Personnel costs per person: average yearly personnel costs 4.67 million JPY
     - Number of person: up scaling factor 0.27
  4. Operational costs
     - 3% of construction costs
  5. Others
     - No initial subsidies

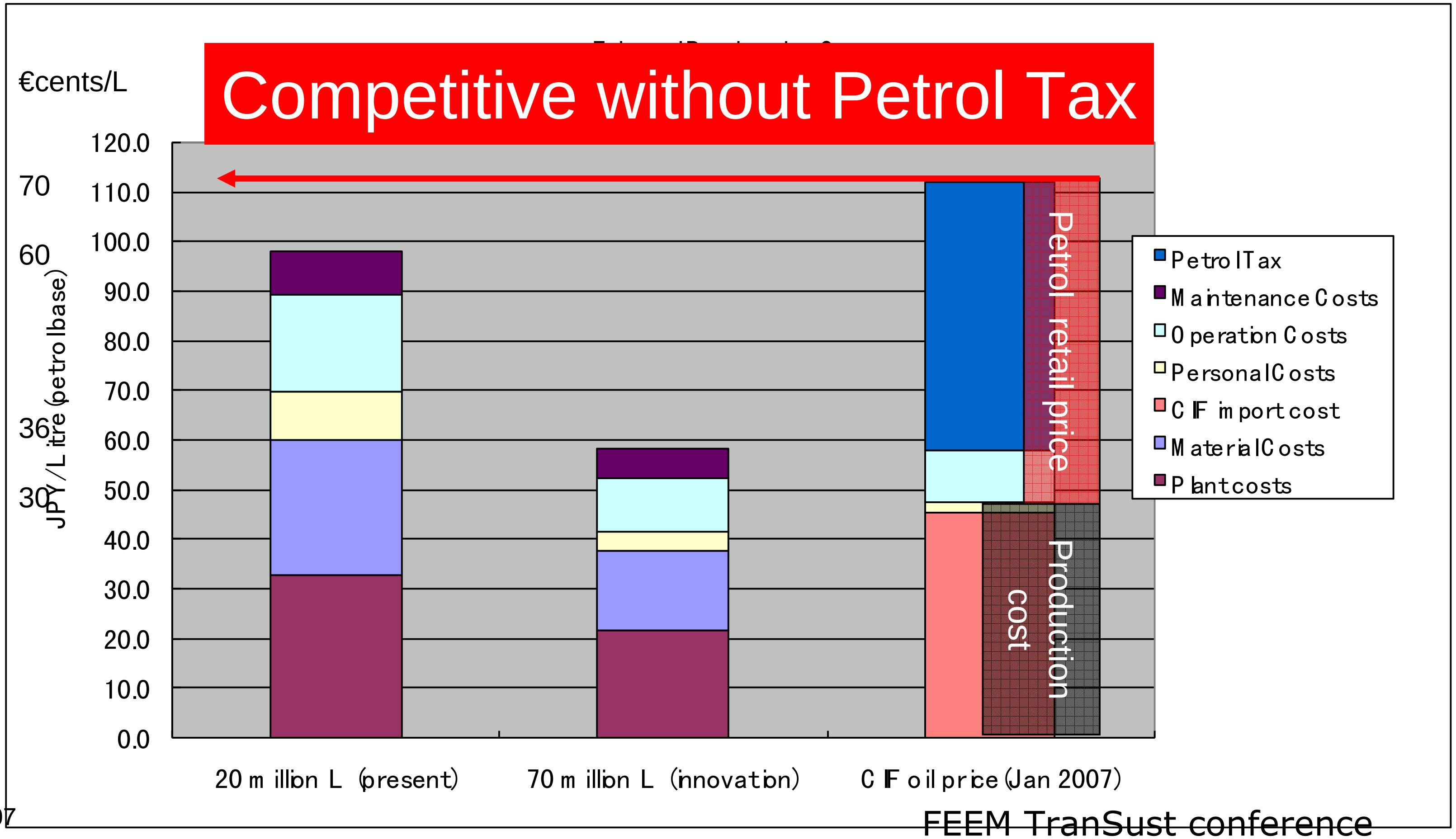
# 3 Calculation of bioethanol production costs
## The optimal scale questions

- The present case: 20 million litter per year, Feedstock amount 91,000dry-t/year,
- The innovative case: 70 million litter per year, 208,000t/year



# 3 Calculation of bioethanol production costs

- The present case: 98 JPY (62cents)/ L of petrol equivalent
- The Innovative case: 58.1 JPY(36cents)/ L of petrol equivalent



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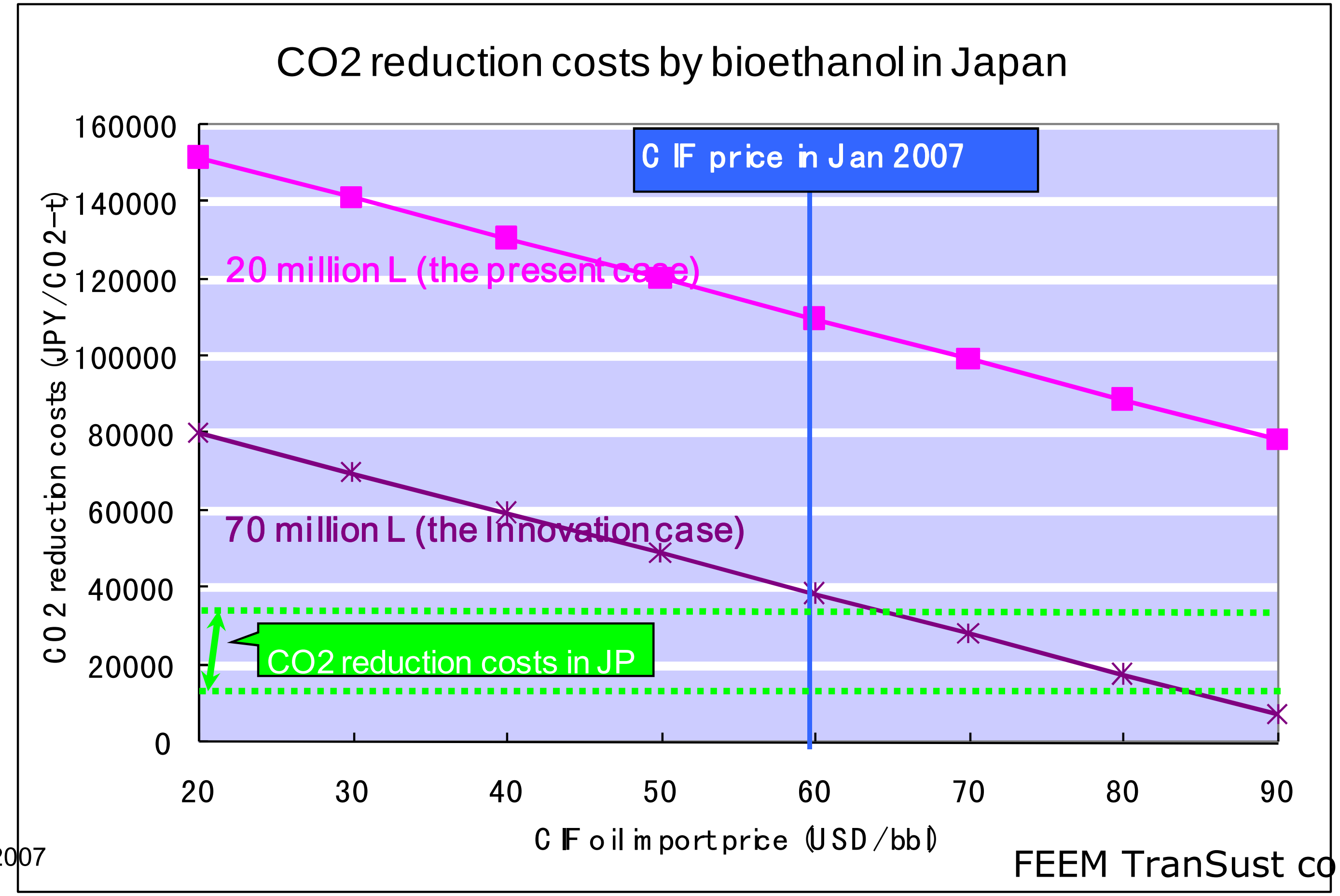
# 4 CO2 reduction costs caliculation

- **Bioethanol: cost effective only more than 70$/bbl case**
  - The existing study: 20,700JPY-34,700JPY (120-200Euro) /CO2-t in Japan
  - Bioethanol: 7,000JPY-32,000JPY(45-130Euro)/CO2-t
- **CO2reduction costs highly depend on oil price**
  - Huge fluctuation of CIF oil import price 24$/bbl(Jan.1997)→60$/bbl(Jan.2007)



# 5 Conclusions

I. lignocellulosic bioethanol potentials are very limited within the 50km radius
   - The optimal size of bioethanol plants are: 20 million litter per year in the present case and 70 million litter per year in the innovative case

II. Biothanol production costs: competitive without petrol taxes
   - The present case 98 JPY(62Euro cents)/L , and the innovative case 58.1JPY (36 Euro cents)/L

III. CO2 reduction costs: not cost effectiveness
   - The present case: 78,000–150,000JPY/ $CO_2$,
   - The innovative case: 7,000-32,000 JPY(45-130Euro)/ $CO_2$ only in high oil price 70 to 90USD/bbl

- Promoting bioethanol in Japan
  - important for energy security points of view
  - hard to recommend as GHG mitigation option

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