The Prospect of TORREFACTION

~ Creation of Asia Biomass Community~

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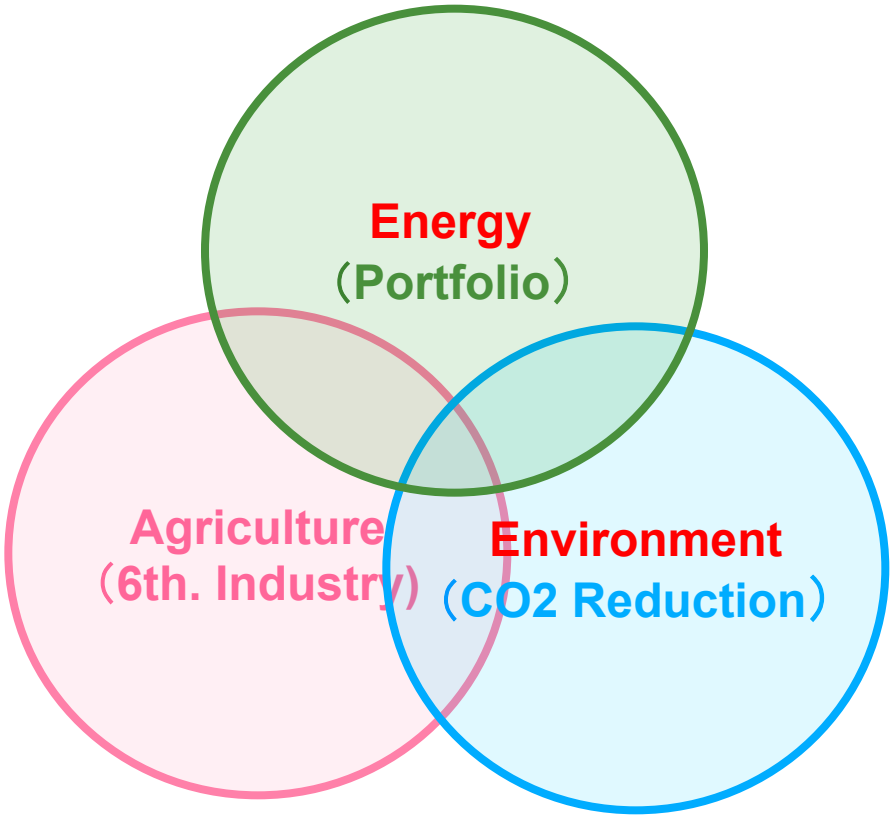
Issey Sawa

Driving force to create Biomass Energy Industry



Industrialization

Employment

- Political Action
- Strategic Promotion

Biomass Energy Policy EU & U.S. vs Japan

Policy	EU & U.S.	Japan
Energy	●As Energy Security ●As Energy Portforio ●Last Resort of Renewable Energies ●Ambitious Target ⇒ Industrial Scale ●Creation of Large Market	●Minority among Renewable Energies ●Limited Target ⇒ Small Market ●Small Scale
Agriculture	●New Application of Agri. and Forestry Product ⇒New Market , New Industry ●Creation of New Industry（6th. Industry ） ●Increase Farmer's Income and save subsidy spending (US$17.5bill. In 5years)	●Tech. development project by Engineering Co. ● Small scale Demo Projects supported by MOAFF are recognized as '' not economically viable''
Environment	●Most effective Method of CO2 Reduction	● Not recognized as CO2 Reduction Method ● Too much attention on F.V.F. and B.D. issues
Industry	●Promote as Strategic Industry ●New Employment Opportunity ●Sustainability Rule ⇒ Global Competition ●Subsidy・Tax Incentives ⇒ Obligation	●Projects based upon Governmental Subsidy （Tech. Development or Small Scale Demo Projects）

FIT (Feed in Tariff) for Biomass Power Generation

FIT was introduced on July 1,2012 by METI. During 2.5years, Renewable Energy was increased by 70% (15mill.kW as rated capacity) but more than 90% was PV. FIT rate for Biomass is as follows.

		Unutilized Wood (1)	General Wood (2)	Waste materials Sewage sludge	Recycled Wood
Cost	Power Plant Cost	\410,000/kW	\410,000/kW	\310,000/kW	\350,000/kW
	Annual O& M Cost	\27,000/kW	\27,000/kW	\22,000/kW	\27,000/kW
Expected IRR (before tax)		8%	4%	4%	4%
FIT (\ /kWh)		**32 (3)**	**24**	**17**	**13**
(US Cent / kWh)		40	30	21	16
Duration		20 years			

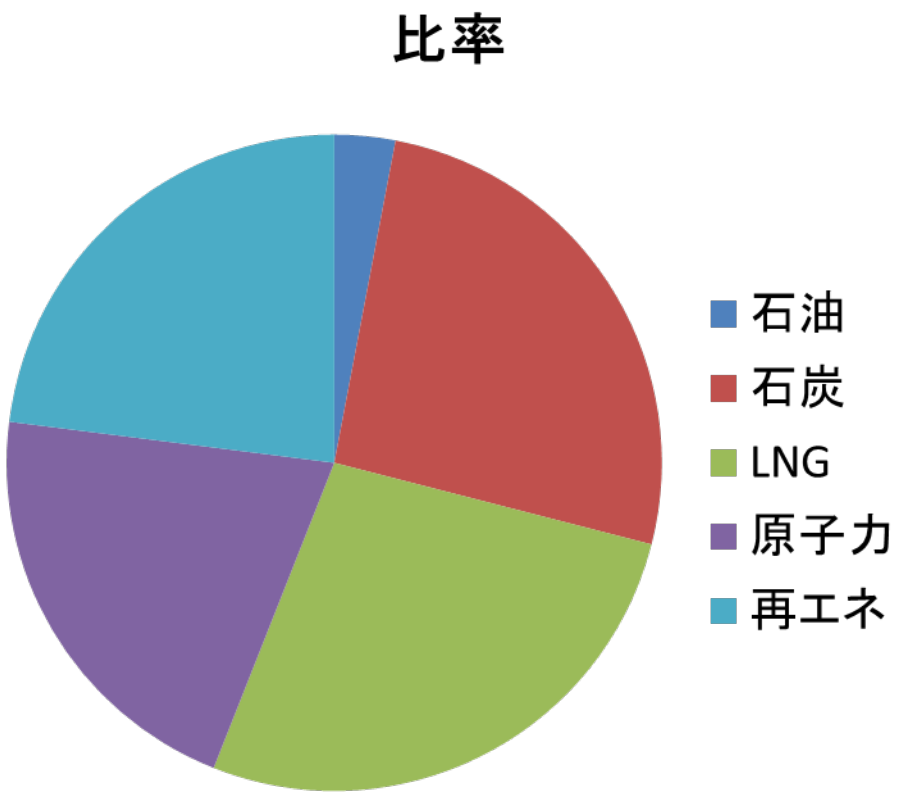
(1) Forest residues
(2) Wood Chips etc. **including imported one** (even PKS)
(3) Since April1,2015, the favorable rate **\ 40/kWh** is applied **for less than 2MW** projects.

Energy Mix. of Power Generation in 2030

- Oil : 31.5 Bill. kWh 3%
- Coal : 281 Bill. kWh 26%
- LNG : 284.5 Bill.kWh 27%
- Nuclear : 231.7～216.8 Bill.kWh 22～20%
- Renewable : 236.6～251.5 Bill.kWh 22～24%

Total : 1,065 Bill.kWh * 100%

(* Electric Consumption is 980.8 Bill. kWh after 17% energy saving from current assumption)



Breakdown of Renewable Energy (Ratio**)

- PV : 74.9Bill.kWh 7.0% (30%)
- Wind : 18.2Bill.kWh 1.7% (7%)
- Geothermal : 10.2～11.3Bill.kWh 1.0～1.1% (5%)
- Small Hydro : 93.9～98.1Bill.kWh 8.8～9.2% (39%)
- Biomass : 39.4～49 Bill. kWh 3.7～4.6% (19%)

(** Based upon upside case)

CO2 Reduction Target in 2030
⇒▲ 26% from 2013

Target of Biomass Power Generation in 2030

Categoly	2014 .11	2030 Target（Ratio）	Additional Facility
1. Utilized Wood	30MW	240MW （8 times）	+ 210MW
2. Recycled Wood	330MW	370MW （1.1 times）	+ 40MW
3.General Wood	100MkW	2740 ～4000MW (27.4 - 40 times）	+ 2640 - 3900MW
Wooden Biomass Total （Sum of 1～3 ）	460MW (3.2Bill.kWh)	3350 - 4610MW(7.3 - 10times) (22 - 31 Bill. kWh)	+ 2890 - 4150MW (+ 19 - 28Bill.kWh)
4. Biogas（Methane）	20MW	160MW （8 times）	+140MW
5. Waste	780MW	1240MW（1.6 times）	+ 460MW
6. RPS	1270MW	1270MW	
Biomass Total （Sum of 1～6）	2520MW (17.7Bill.kWh)	6020 - 7280MW (2.4-2.9times） (39.4 – 49 Bill. kWh)	+3490 – 4750 MW (+21.7-31.3BillkWh)

Forecast 2030: Wooden Biomass Power Generation in Japan

Type 2030	Size / Capacity	Collection of Biomass	Relevant Technology					Forecast (Nbr of Projects or Ratio)
			Co-gene	Gas	CFB/BFB	USC	Torrefaction	
Dedi-cated	～ 1MW	Forest Coop.	◎	○				50MW
(100)	1～2MW	Forest Coop.	○	◎				150MW (100)
	2～10MW	Wide Area		△	△		△	300MW (60)
	10MW ～ 20MW	W.A. + Import			○		○	300MW (20)
(20)	20MW ～	W.A. + Import			◎		○	1,000MW
	(Ave. 50MW)							
Co-Fire	Existing Non-Utility (10GW)	W.A. + Import				○	◎	1,000MW ◎ (10% mix)
	Newly built USC (20GW x 50% or 100%)	W.A. + Import			○	◎	◎	1,000 -2,000MW (10% mix)

FIT Total: 1,800MW (Dedicated) + 2,000 – 3,000 MW (Co-Fire) = 3,800 – 4,800MW

Target of 2030 Wooden Biomass Power Generation: 3,350 ～

7 Evaluation Criteria for Power Generation Sources

1. Efficiency ➡ Density, **EPR**
2. Convenience ➡ Storage, Transport
3. Stable Supply ➡ Availability, Stability
4. Safety ➡ Safety, Countermeasure
5. Economy ➡ **LCC** , Ripple Effect
6. Environment ➡ **LCA**(GHG), Waste Management
7. Social Impact ➡ New Industry, Employment

\+ Maturity of Technology and Reservation

Portfolio Optimization Analysis of Power Generation

Type	Energy Sources	Efficiency	Convenience	Stable Supply	Safety	Economy	Environment	Social Impact	Maturity of Technology	Availability
Thermal	Coal	◎	○	◎	○	◎	×	×	◎	○
	Oil	◎	◎	◎	○	△	×	×	◎	△
	LNG	◎	△	◎	△	△	○	○	◎	○
Nuclear	Nuclear	◎	△	○	×	○	△	△	△	△
Renewable	Hydro	○	○	○	○	○	○	○	○	△
	Geo Thermal	△	○	△	○	△	○	○	○	△
	Wind	△	×	×	△	○	○	○	○	△
	PV	△	×	×	○	×	○	○	○	△
	CSP	△	○	○	○	×	○	○	△	△
	Biomass (dedicated)	○	○	○	○	△	○	◎	○	○
	Biomass (Co-Fired)	○	○	○	○	○	○	◎	○	◎

Merit of Biomass Power and Co-Firing

1. Biomass power is stable power source and can control electric generation output volume like thermal power
   ⇒ Usable as back-up power for VRE (PV/ Wind power)

2. High Capacity Factor (Biomass 80%,PV13%,Wind 20%)

3. Power Source (Bio Fuel) can be transportable
   ⇒ Bio Fuel can be produced at different location.

4. Efficiency is 15% higher. (Co-Firing by Pulverized Coal boiler 40～45% vs Dedicated by CFB 25～30%)

5.Only Fuel Conversion without involvement of new investment for dedicated biomass power plants.

Significance of Co-Firing Bomass at PC PS

1. CO_2 emission reduction

The coal can be procured at the lowest price and its reserve is relatively large among fossil fuels but **CO_2 emission is the largest** (1.6 times of LNG).
IGCC and CCS can be recognized as future solution but co-firing of biomass is the most practical way to reduce CO2 at this moment.
It is one of the important sectors in order to achieve CO2 reduction at 26% in 2030.

2. Reduction of Fossil Fuel :

Replacement of coal by biomass is to reduce coal consumption.
In Japan, the ratio of coal fired power station is approx. 30% in 2013 and it should be reduced to 26% in 2030. Co-Firing of torrefaction pellet is the most effective way.

3. Effective way to introduce Renewable Energy (R.E.) :

The target of R.E. in Energy Mix 2030 is 22～24% and Biomass is around 4% of total energy supply consist of 60% share of wooden biomass.
We, therefor , would like to propose that Co-Firing of biomass at the existing PC PS is one of the most effective way, in view of economic viability.

The issues to promote Co-Firing Biomass at PC PS

1.Procurement of Biomass :

Foreign procurement is inevitable due to lack of domestic wooden biomass.

The domestic supply of wooden biomass shall be Max. 1.4 mill. ton/year

(Availability of wooden chips : 6 mill. m_3 = 2.4mill. Ton/year)

2.Economic viability :

Imported biomass based power generation can sell electricity **at \24/kWh**.

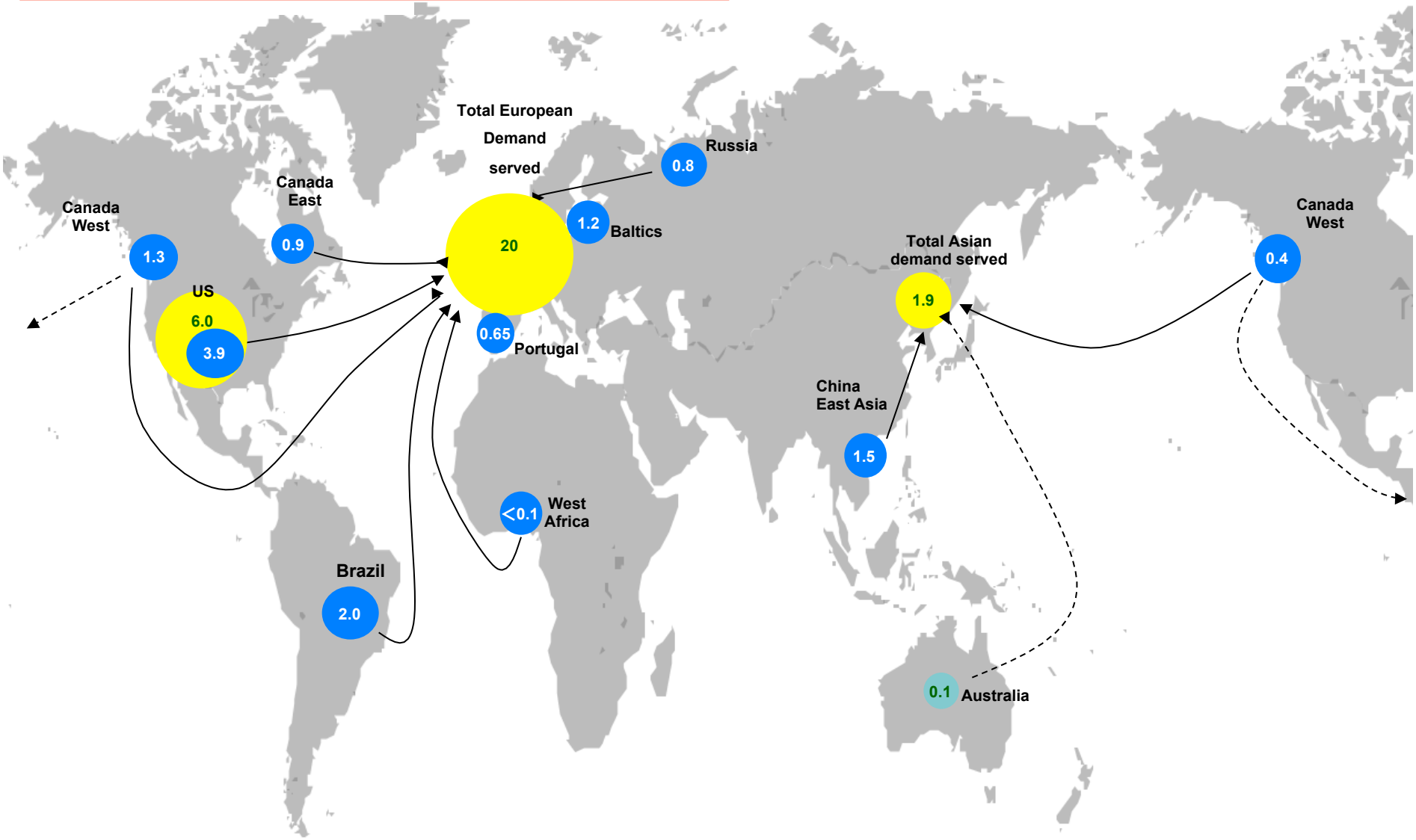
But LHV of normal wooden pellet is 2/3 of coal and its price is more than double. So it is **not so easy to make a profit** through operation.

3.Co-Firing Ratio :

The boiler manufacturers set up an upper limit of co-firing ratio of biomass **at 3% as calorific value**. As an countermeasure to increase the ratio, we can consider ① Torrefaction Pellet and ② Modification of mill and burner, that can achieve more than 25% ratio proven by NEDO project in the past.

We assume ① is more economically viable esp. for existing PC PS.

Wooden Pellet demand in the world (2014)



Biomass Co-Firing Potential in Japan (Current Facilities)

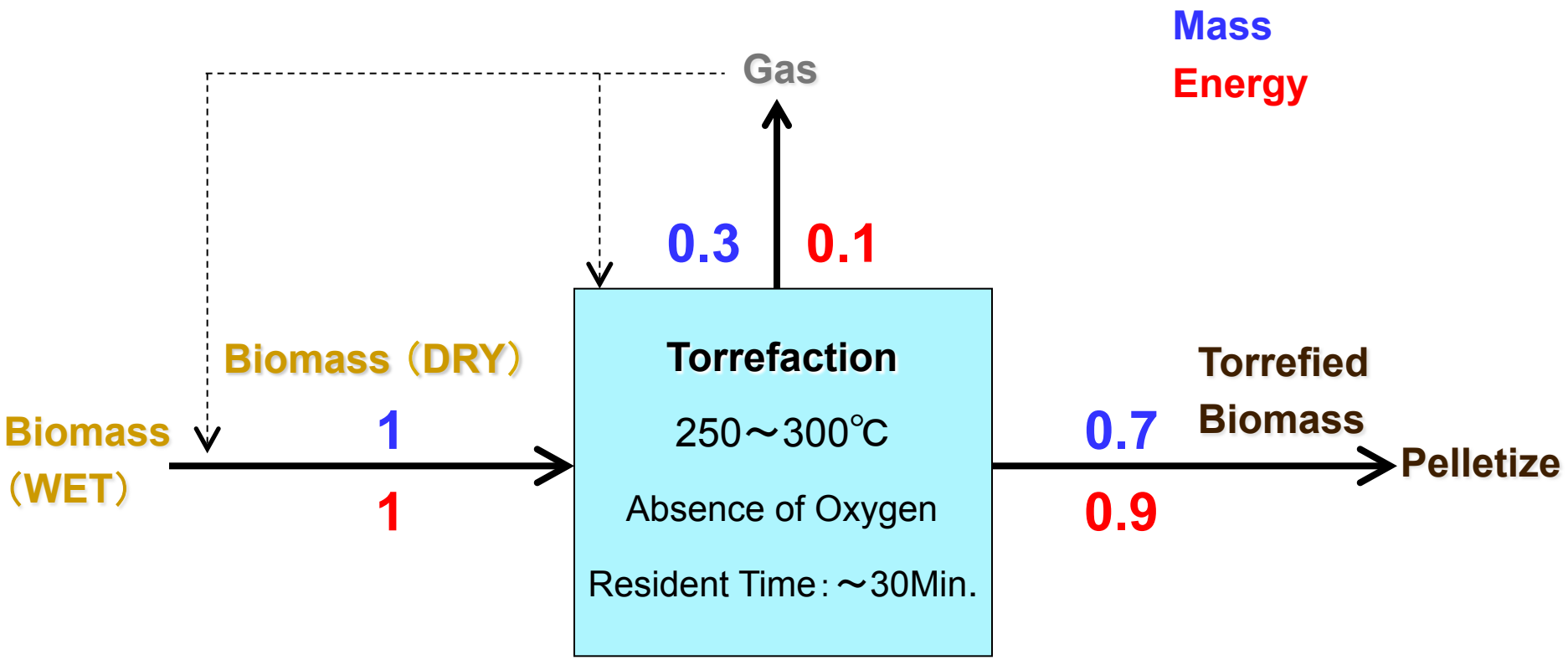
1. Thermal Coal Consumption:
   (1) Utilities : 80 Mill ton / Year
   (2) Industries : 20 Mill ton / Year

2. Present Consumption of Biomass Co-Firing:
   (1) Utilities : 400,000 ton / Year (0.5%)
   (2) Industries : 200,000 ton / Year (1 %)

3. Future Potential of Biomass Co-Firing :
   (1) Utilities : 1.6 ~ 2.4 Mill ton / Year (2~3 %)
   (2) Industries : 0.4 ~ 0.6 Mill ton / Year (2~3 %)
   (3) FIT : + ?
   (4) Torrefaction : + ?

⇒Utilities 5% + Industries10% makes 6 mill ton/Year
(= approx. 20bill kWh)

What is Torrefaction ？



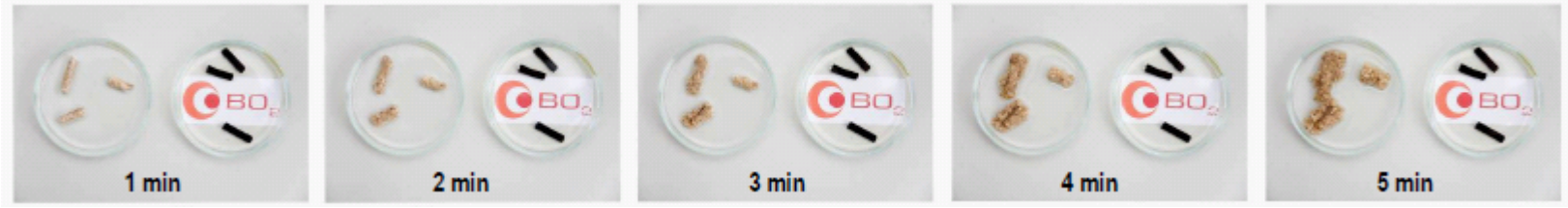
Energy Density（MJ／kg） $1 \times \frac{0.9}{0.7} = 1.3$

What is Torrefid Pellet？

1. Production Process of Torrefied Pellets

Biomass Feedstock **Torrefied Materials** **Torrefied Pellets**

2. Water Resistance of Torrefied Pellets



Source：ECN, Netherlands

Torrefied Pellets in perspective (vs Wood Chips & Pellets)

	Wood Chips	Wood Pellets	Torrefied Pellets
Water Content (%)	35%	10%	3%
Calorific Value LHV (MJ/kg)	10.5 (67%)	15.6 (100%)	19.9 (128%)
Bulk Density (kg/m^3)	475	650	750
Volume Energy Density (GJ/m^3)	5.0	10.1	14.9
Transport Efficiency	△ (50%)	○ (100%)	◎ **(150%)**
Storage/ Handling	○	△	◎
Friability/Grindability	△	○	◎

Source：ECN，Netherlands

Merit of Torrefied Pellet

1. **Sufficient Friability** ➡ **High Co-Firing ratio with Coal**

   (3% ⇔ More than 30%)

1. **High Energy Density** ➡ **Cost Saving in Transport / Storage**

   （20MJ/kg , 15GJ/m3） **(1/3 of Wood Chips , 2/3 of Wood Pellets)**

3. **Hydrophobic, Preserved** ➡ **Easy Handling and Storage**

   Similar to coal

4. **Diversification of Feedstock** ➡ **Wood Residues ,Crop Residues**

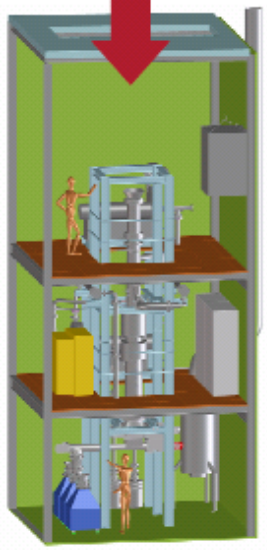
Comparison of Torrefaction plant

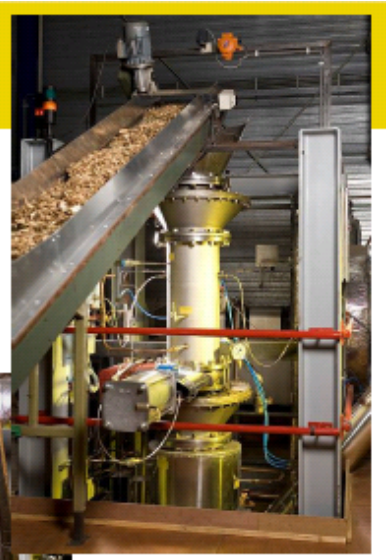
		A	B	C	ECN	D	E	F	G	H	I	J	K
	visit	○	○	○	○		○	○	○	○	○	○	○
	observation	○			○		○	○	○				
Category of Process													
	TORREFACTION	○			○		○						○
	CARBONIZATION		○	○		○		○	○	○	△	○	
REACTOR													
	MOVING BED	○			○								
	ROTARY DRUM			○		○				○	△	○	○
	MODIFIED DRYER		○				○		○				
Heating Method													
	Direct	○	○		○		○		○				○
	In-Direct			○				○		○	△	○	
Heat Treatement													
	COMBUSTER	○	○	○	○	○	○	○	○	○	○	○	○
	GAS.GAS H/EX	○	○						○				○
	HOT OIL SYSTEM				○		○						

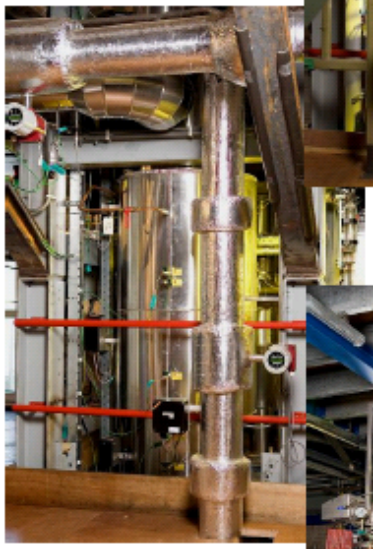
ECN PILOT PLANT PATRIG

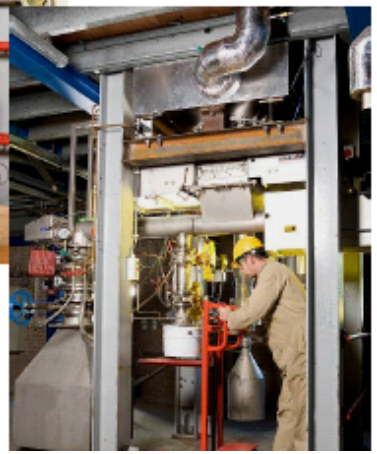
Pre-drying

Feeding









Torrefaction pilot-plant testing (50-100 kg/h)

Source: ECN, Netherlands

Japanese MAFF Subsidy for F/S by MC/ECN/FFPRI

1. Purpose :

   To verify Commercial Viability of ECN's Torrefaction Technology

2. Outline of the Project :

   - Production of 1 ton of sample Torrefied Pellet (TP) by PATRIG
     (Raw Material : European Poplar Chip, Japanese Cedar bark)
   - Collection of process data for Mass Balance and Energy Balance.
   - Analysis of TP's performance data:
     Heating Value, Water Content, Bulk Density, Ultimate Analysis,
     Proximate Analysis (Volatile Matter, Ash, Fixed Carbon, Fuel Rate) ,
     Grindability,Pyrophoric Property, Hydrohobic Property (Impregnation,
     Water Intake) ,Crush Strength

3. Members other than MC and ECN:

   - Forestry and Forest Products Research Institute under MAFF
   - Central Research Institute of Electric Power Industry (10 utilities)

4. Period: October 2010 ~ March 2011 (Reported to MAFF)

Andritz Demo Plant (1ton/h) in Denmark

Process：

Feedstock（**Wooden chips with bark**）

⇓ **feed**

Rotary Dryer

⇓ **M.C. 8-10%**

Vertical Torrefaction Reactor

⇓ **cooling**

Hammer Mill

⇓

Pelletizer (**without binder**)

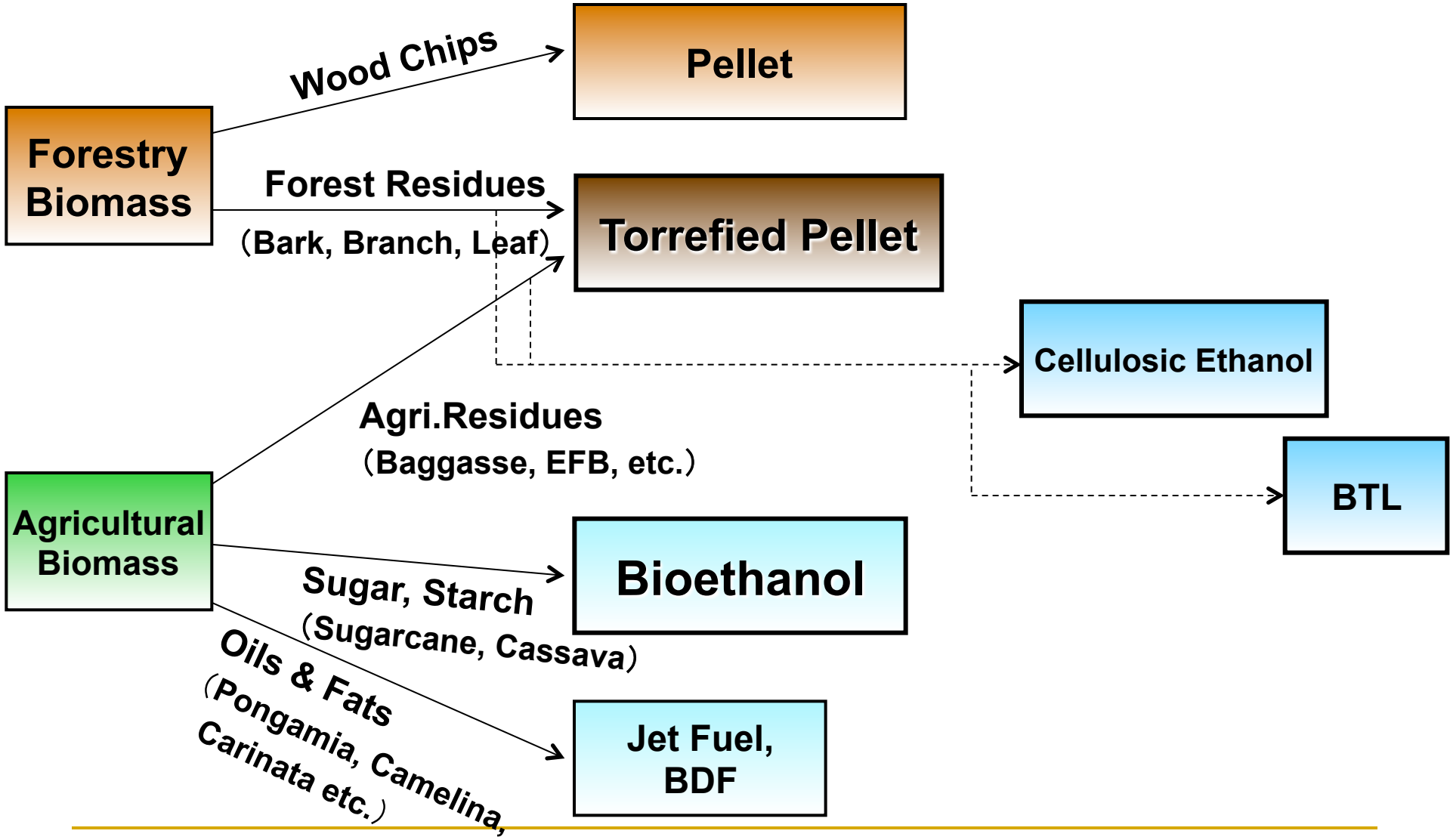
⇓

Torrefied Pellet (1ton/h)

Source：

Andritz

Project Concept based upon Torrefaction



Creation of "Asia Biomass Community"

- Background:
  - Need to Encourage Sustainable & Environmental Friendly Energy Industry in Asia.
  - Existence of Necessary Resources to create value chain of Biomass Energy Industry in Asia.

Creation of "Asia Biomass Community"

- Japan and South East Asia: Sharing their strengths

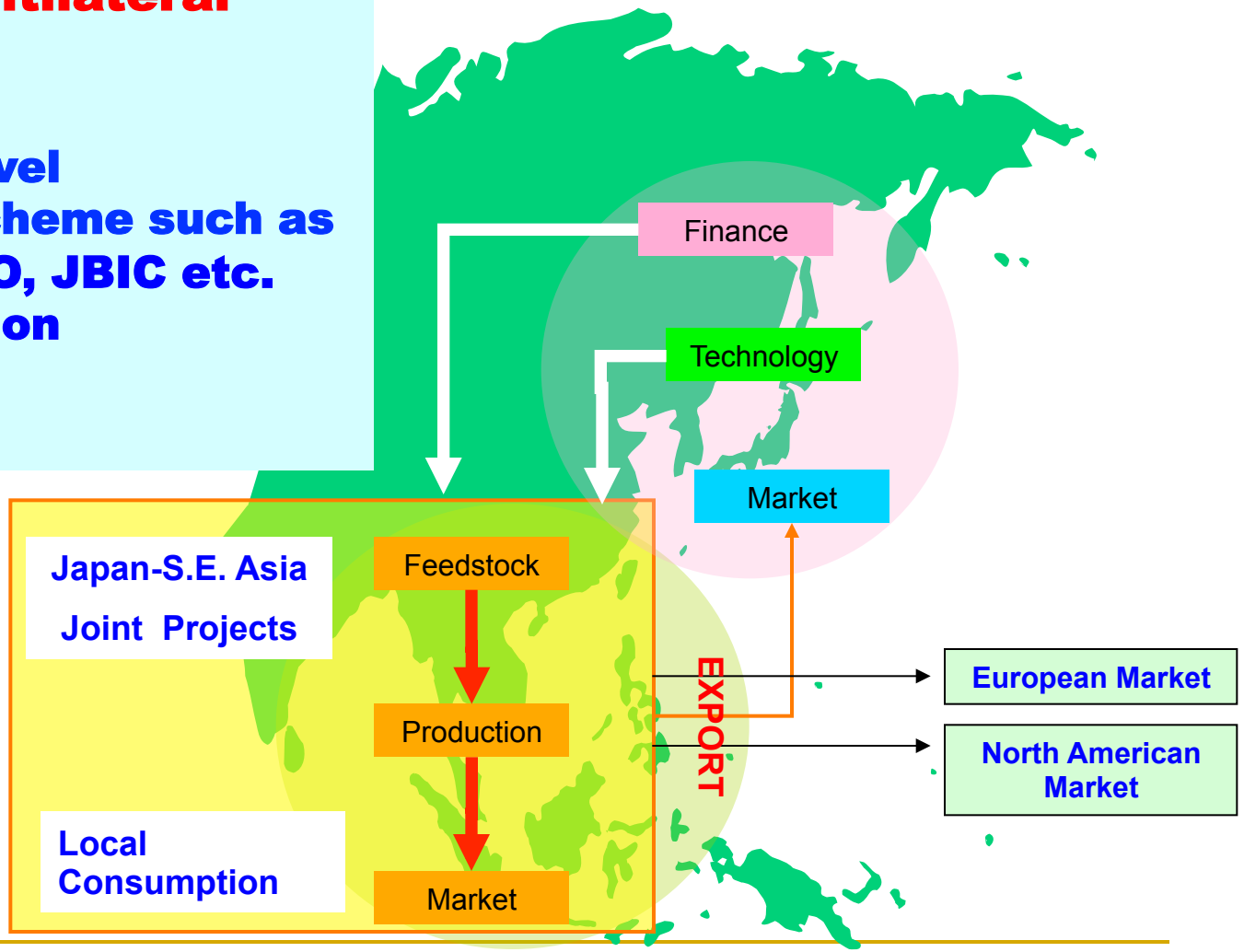
	Japan	South East Asia
Background	n Need to reduce CO_2 emission n Need to promote Biomass Energy Industry.	n Abundant **Resources** 1) Agriculture & Forest 2) Land 3) Labor force
Possible Contribution	n **Technology** development n **Financing** (Investment) n **Import** (as Consumer)	n **Production** n Local Consumption n Export

Creation of "Asia Biomass Community"

Enhance the Multilateral partnership

n**Governmental level**
- **Governmental scheme such as ODA , JCM, NEDO, JBIC etc.**
- **Biomass Plantation**

n**Private level**



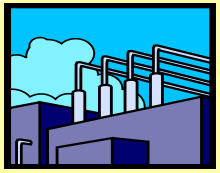
Establish Sustainable Biomass Industry

Biomass Plantation

- Next Generation Agriculture and Forestry "Contract Farming & Afforestation for Various usages"
- Biomass Plantation under ODA.

- Improvement of Yield
- Mechanization
- Infrastructure
- Logistics

Biomass Refinery



Biomass Industrial Complex

- Bio Ethanol (Cellulosic)
- Bio Pellet (⇒Torrefaction)
- Bio Jet Fuel (at existing Petrochemical Refinery)
- BDF (⇒High Quality)
- Biomass Power Generation
- Bio Chemical
- Feed, Fertilizer

Market

Stable & Matured Market

- Local Consumption
- Export to Japan
- Export to the other countries

- Long Term Offtake Agreement
- Reasonable Sales Price

Feedstock Management
(Stable Supply・Cascade Usage)

Industrialization
(Co-Production・Co-Location)

Establish Relationship with Buyers
(Utilities, Industries, Others)

Creation of Sustainable Supply Chain of Industrial Complex