Nov. 21, 2017 Statuskonferenz, Leipzig

Stand und Ausblick der Bi- oenergienutzung in Japan unter besonderer Berücksichtigung torrefizierter Biomasse

(Status and Outlook of Bioenergy Utilization in Japan with a Special Focus on Torrefied Biomass)



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National Research and Development Agency Forest Research and Management Organization

Forestry and Forest Products Research Institute

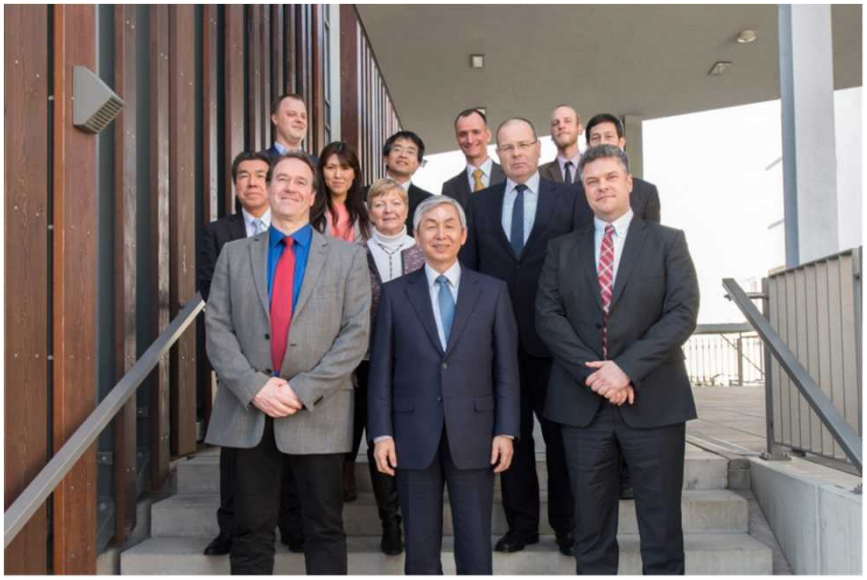
Established: 1905
Headquarter and 11 branches and field stations
Staff : 740
(Executives 6, Researchers 466, Officers & Expert 268)

Tsukuba Express (TX)

JR Joban Line

Memorandum of Understanding (MOU) between DBFZ and FFPRI

March 14, 2016



・We cooperate in science and technology through joint projects in the field of energetic use of biomass.
・Intensive research takes place in the field of production and consumption of torrefied wood pellets.

1. Wood resources and consumption in Japan

2/3 of land of Japan is covered with forest.

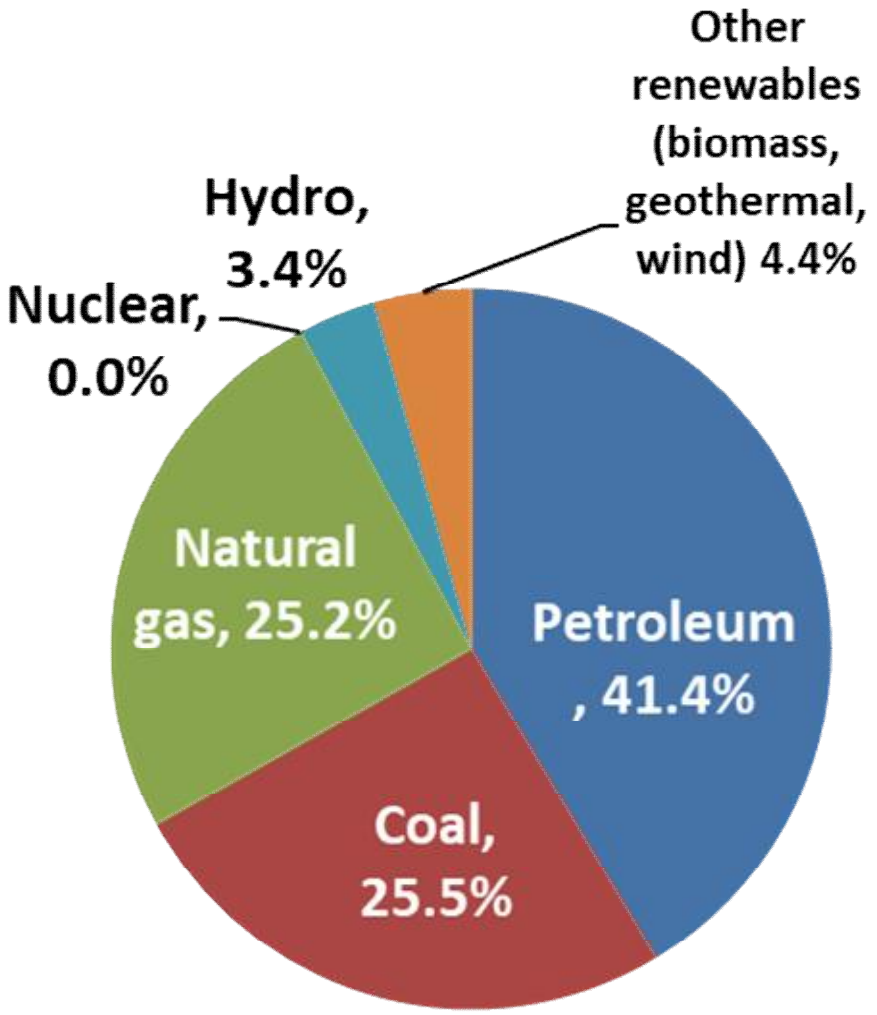
Forest area: 25 mil.ha
(Natural forest 15mil.ha
Manmade forest: 10mil.ha)
Volume: 5 bil.m^3

Consumption: 75 mil.m^3
(log-basis)
Wood from domestic 35%
from overseas 65%

More usage of wood resources from domestic is one of the most important matter in Japan.

FFPRI

2. Primary energy supply in Japan（2014）



Japan is strongly dependent on fossil fuels (>90%) , which are almost imported.

Woody biomass will be one of the most important renewable recourses for energy use in Japan.

Japan's Energy White Paper 2016

3. Feed-in-Tariff for biomass power generation

1 Euro (100 Cents) = 133 JPY

Resources	Unused thinning wood Forest residue		Sawmill residue Imported wood Oil Palm residue		Demolition wood
	< 2MW	≧ 2MW	< 20MW	≧ 20MW	
Price JPY/kWh (Cents/kWh)	40 (30)	32 (24)	24 (18)	21 (16)	13 (10)
Plants (from 2012-)	7	32	20		2
Power output(MW)	6.6	290	330		9.3

From 2012 this program started. Duration is 20 years.
In 2017 the number of large-scale plant using imported wood and oil palm has been rapidly increasing.
On the other hand the number of small scale CHP using domestic thinning wood and its derived pellet is gradually increasing.

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4. Small scale CHP plant

Burukhardt CHP (180kWe) Takayama City, Gifu
Operation from May 2017
Investment: EUR 1.55 mil.
(including additional facility and building)

http://hanjohanjo.jp/article/img/2017/05/15/7519/34388.html

Spanner CHP (45 kWe)
Kawaba Village, Gunma, from May 2017

http://fujitakk.com/archives/areas/1058.html

Entrade CHP (25 kWe)
Nishigo Village, Fukushima, from March 2017

7

5. Upgrading of wood fuel

Disadvantages

Lower calorific value than oil and coal	Weak hydrophobicity

Upgrading of chip / pellet by torrefaction

Torrefied wood pellet

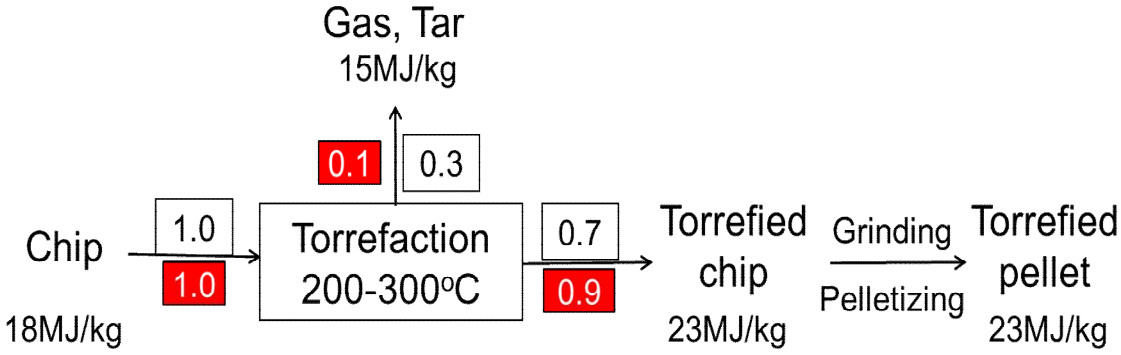
Higher calorific value	Better hydrophobicity

8

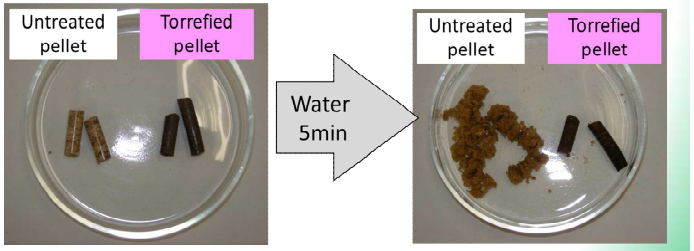
6. Feature of Torrefaction

- The mild heat treatment in the absence of oxygen around 250 – 300 ℃.
- It has been conventionally used for food like roasted coffee and tea.
- Torrefaction upgrades calorific value, hydrophobic properties and prevent biological degradation.
- 200 – 300℃ is initial stage of wood pyrolysis. Thermal degradation during torrefaction is not severe, compared to conventional charcoal production.

High energy yield



Good hydrophobicity



7. Characteristics of Torrefied fuel

	Wood	Wood pellet	Torrefied pellet	Charcoal	Coal
Moisture (w%-wb)	30-45	7-10	1-5	1-5	10-15
Lower heating value (MJ/kg)	9-12	15-18	20-24	30-32	23-28
Volatile matter (%-db)	70-75	70-75	55-65	10-12	15-30
Fixed Carbon (%-db)	20-25	20-25	28-35	85-87	50-55
Bulk Density (kg/m^3)	200-250	550-750	700-850	～200	800-850
Energy Density (GJ/m^3)	2.0-3.0	7.5-10.4	14.0-18.7	6-6.4	18.4-23.8
Dust	Average	Limited	Limited	High	Limited
Hydroscopic properties	hydrophyllic	hydrophyllic	hydrophobic	hydrophobic	hydrophobic
Biological degradation	Yes	Yes	No	No	No
Grindability	Poor	Poor	Good	Good	Good
Handling	Special	Special	Good	Good	Good
Quality variability	High	Limited	Limited	Limited	Limited

IEA Bioenergy Task32, Status Overview of torrefaction technologies, 9 (2012)
http://www.ieabcc.nl/publications/IEA_Bioenergy_T32_Torrefaction_review.pdf

8. Status of Torrefied fuel development

・Torrefaction process has been worldwide studied for various biomass feedstock on laboratory scale, pilot scale, and commercial scale plants. Achieving a higher energy density and hydrophobic properties during torrefaction has benefit for handling and transportation.

・Specific requirements for chemical and physical-mechanical characteristic of the pellets made from thermally treated are currently finalized in a technical specification (TS) on international level as ISO TS 17225-8

Torr-Coal
(Netherlands , Belgium)

ISO/TS 17225-8:2016

Solid biofuels — Fuel specifications and classes — Part 8: Graded thermally treated and densified biomass fuels

1 Scope

This International Technical Specification determines the fuel quality classes and specifications of graded densified solid biofuels produced from thermally treated biomass for non-industrial and industrial use. This International Technical Specification covers pellets and briquettes produced from the following raw materials (see ISO 17225–1, Table 1):

— 1.1 Forest, plantation and other virgin wood
— 1.2 By-products and residues from wood processing industry
— 1.3.1 Chemically untreated used wood
— 2. Herbaceous biomass
— 3. Fruit biomass
— 4. Aquatic biomass

Subcategories of the above stated raw materials are included.

ISO TS 17225-8

9. Utilization model of Torrefied Fuel

Torrefied pellet

Large scale

Power generation

Small scale

Heat

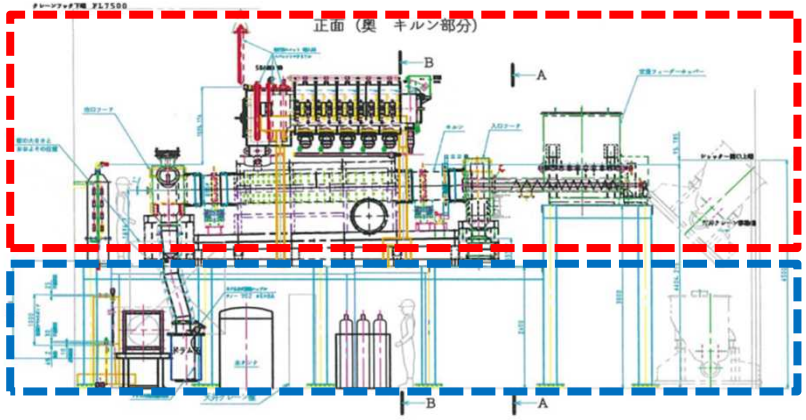
・Usage of torrefied fuel has been conventionally studied for large scale utilization such as coal-firing power because of increasing the mixing ratio of torrefied fuel greatly.
・Our group are mainly considering the usage for smaller usage such as pellet stove, boiler, burner and cooking stoves in rural areas.

FFPRI

10. Demonstration plant

・FFPRI, Actree and Sanyo-Trading built a demonstration plant of producing torrefied wood fuel.

・Continuous (24 hours) operation for torrefaction unit has been done for nearly 20 days (FY 2015), and image of the commercial plant (2,500t/y) has been designed.

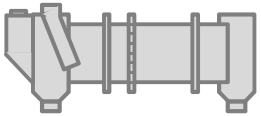


Torrefaction unit

Pelletization unit

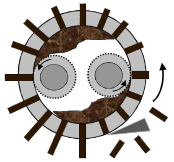
11. Process flow of demonstaration plant

Wet Wood chip
1



Torrefaction
2

Grinding
3



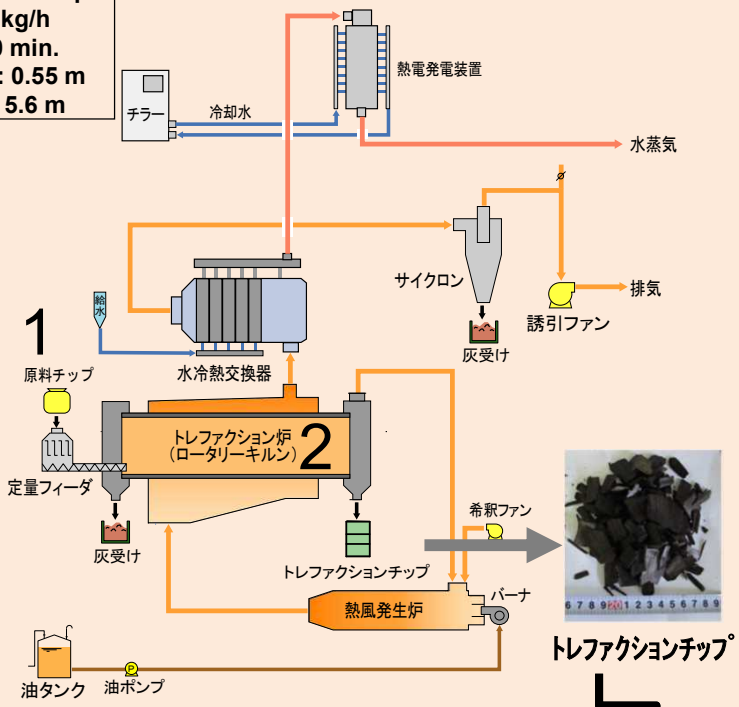
Pelletization
4

Torrefied pellet
5

Feedstock : Wood chip
Capacity : 20kg/h
Duration : 60 min.
Diameter of kiln: 0.55 m
Length of kiln : 5.6 m

Wood chip

Rotary kiln



トレファクションチップ

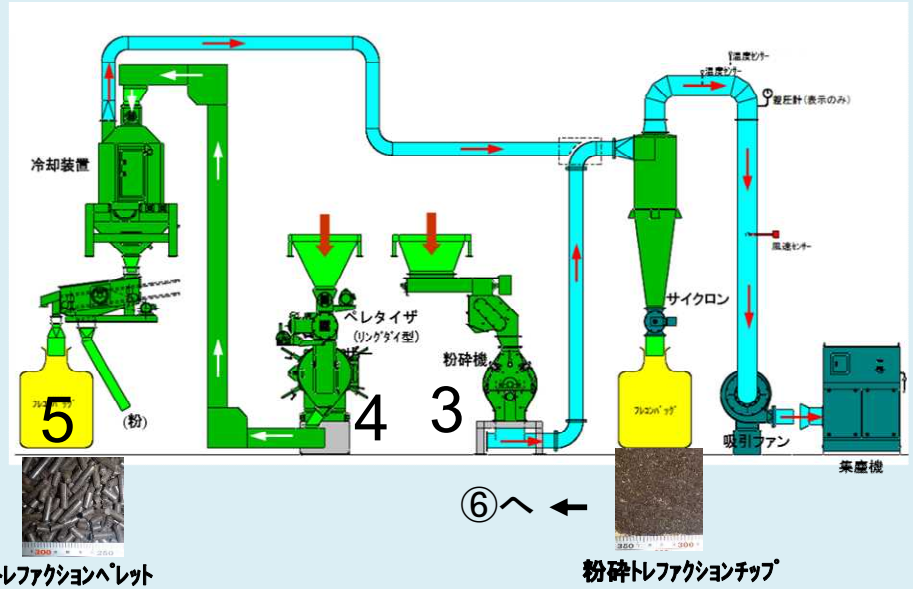
④へ

Torrefaction

Rotary kiln was applied.

ペレタイザー
粉砕されたトレファクションチップをペレット成型します。

粉砕機
トレファクションチップを粉砕します。



トレファクションペレット

粉砕トレファクションチップ

Pelletization

Ring die (CPM) was applied to produce torrefied pellet.

12. Grinding and Pelletizing Performance

・The power consumption for torrefied chip was less than 1/4. The bulk density was higher for torrefied chip, which might be due to smaller size of torrefied chip.

・The bulk density of torrefied pellet was more than 700kg/m^3 which met the standard value of property class TW1a of ISO TS 17225-8. The Lower Heating Value, mechanical DUrability, and Ash content met the class TW2a.

・Power consumption during the pelletization was 388 Wh/kg-pellet, that was much larger than the previous study. The reduction of pelletizing energy is the further study.

Table 3 Grinding performance of torrefied wood chip

Sample	Untreated	Torrefied
Feeding rate	397	498
Power consumption (kW)	7.57	1.56
Power consumption (kW/kg)	19.1	3.2
Bulk density (kg/m^3)	147	168

Table 4 Characteristic of torrefied pellet.

	ISO TS 17225-8		Torrefied pellet in this study
	Tw1a	Tw2a	
Bulk density (kg/m^3)	≥ 700	≥ 650	734
Moisture (wt%, wb)	≤ 8	≤ 8	1.3
LHV* (MJ/kg)	≥ 21.0	≥ 20.2	20.7
DU ** (%)	≥ 97.5	≥ 96.0	96.0
Ash (wt%, db)	≤ 1.2	≤ 3.0	1.9

13. Combustion performance with pellet stove

- The ignition time was shorter for torrefied pellet.
- The fuel ratio (=Fixed Carbon / Volatile Matter) is well-acknowledged as a parameter typically used to estimate the ignition properties. As the torrefied pellet showed higher fuel ratio, it might not be necessarily related to ignition.
- The volume (particle) density might affect the ignition time and further study for mechanism of shorter ignition is needed.
- The less smoke was observed for torrefied pellet as the result of smoke scale. This is due to decrease in volatile matter.

Table 5 Ignition properties for combustion in a commercial pellet stove.

	Normal pellet		Torrefied pellet
	1	2	
Volume density of pellet (g/m^3)	1.20	1.28	1.38
Ignition time (s)	325	332	264
Smoke scale (-)	6.2	2.8	2.0

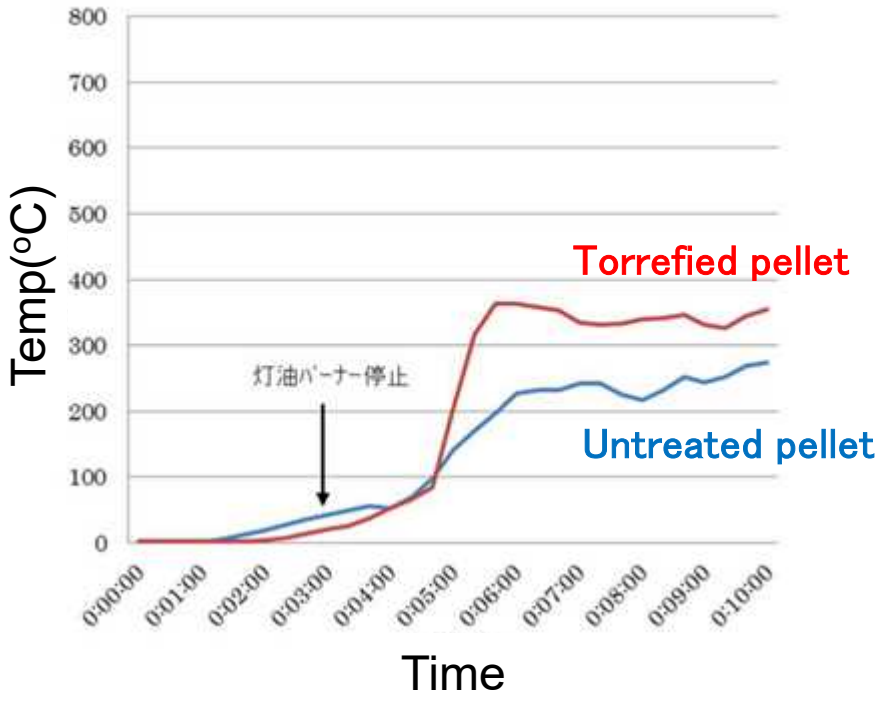
Fig. 3 Pellet stove (7.6kWth)

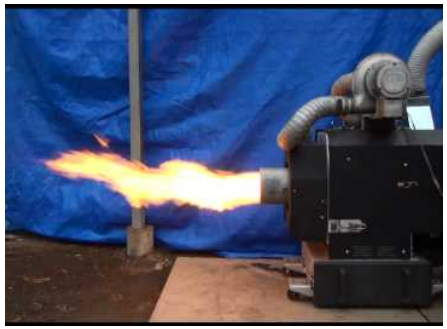
Table 3 Proximate analysis of sample.

	VM*	Ash	FC**	Fuel ratio***
Feedstock	79.8	1.6	18.6	0.23
Torrefied pellet	68.8	1.9	29.3	0.43

14. Utilization test in the agricultural greenhouse

Temperature profile in start-up period





Pellet heater (So-ai Co. Ltd., Japan)

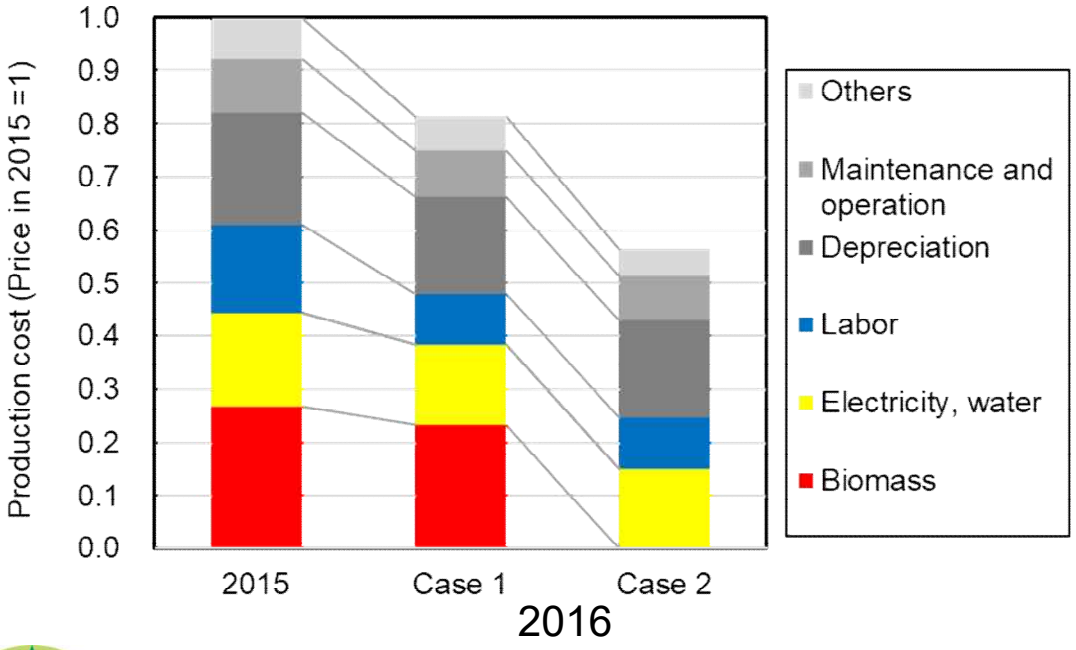
Application to agricultural greenhouse

In case of torrefied pellet, start up period is faster, thermal efficiency is 3 points larger, and less ash on the combustion grate, compared to the case of normal pellet.

15. Cost

・In case of production capacity 2,500 t/y, the price will be estimated to be almost same as briquette charcoal in the Japanese market.
・Benefit such as ignition, heating value and preservation can be incentive for implementing torrefied fuel into the market.

○Cost Simulation



Case 1: raw material JPY8/kg
Case 2: raw material JPY0/kg
(Production is done in sawmill)

○Advantage for torrefied fuel

Production

- Lower grinding energy
- Longer Storage

Utilization

- No deformation by water
- Lower transportation cost
- Higher thermal efficiency

Benefit to use torrefied fuel

16. Application to “Smart Bioenergy” in DBFZ

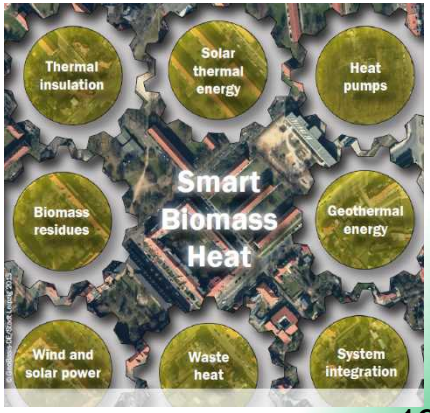
・European spruce chip

Torrefaction

Dr. Volker Lenz.

・Torrefied spruce chip

・In cooperation of the FFPRI (Japan) and the DBFZ (Germany) intensive research takes place in the field of production and consumption of torrefied wood pellets.
・So far about 350 kg of torrefied spruce chip was produced in the demonstration plant in Japan and will be analyzed and applied as fuel for micro CHP on “Smart bioenergy” project in DBFZ.



17. Utilization model

Bio-degrable

Distortion

Wood

Low calorific

Water absorption

Torrefaction

Upgrade !

- High CV
- Hydrophobicity
- Durability

Material

Fuel

Material

Indoor, civil usage

Torrefied chip

Covering for indoors

Pavement

Cascade utilization

Fuel

Heating, hot water supply, outdoors, emergency

outdoors, emergency

Cooking

Densified Soid fuel

Torrefied pellet

- Benefit such as ignition, heating value and preservation can be advantage to use for coking, outdoors, emergency and so on.

House Heating

Agricultural greenhouse

18. Conclusion

・Demonstration plant to produce torrefied wood fuel was constructed and continuous (24 hours) operation using a torrefaction demonstration plant unit has been done.
・Torrefied spruce chip was produced in the cooperation with DBFZ.
・The main speculation such as bulk density, moisture content and mechanical durability was met in ISO TS 17225-8.
・Torrefied pellet showed good performance in case of usage in a pellet stove and heater in a agriculture greenhouse.
・Benefit such as ignition, heating value and preservation can be advantage to use for coking, outdoors, emergency and so on.

We are grateful to Dr. Volker Lenz of DBFZ for valuable scientific and technical advice.

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