



**Asia-Pacific
Economic Cooperation**



**Bureau of Energy,
Ministry of Economic Affairs**

Bio-pellet technologies and demonstration of white-leadtree pellet fired in existing boilers for green energy application

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2017,10,24**



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APEC Project (1/2)

- This study is carried out under the APEC Project
 - Heating Applications of Bio-pellet, made from Eco-Hazard Plant, in Small and Medium Enterprises to Enhance Utilization of Renewable Energy in the APEC Region.
- White leadtree (*Leucaena leucocephala*)
 - White leadtree is a highly invasive species in northern Australia, Chinese Taipei, Hong Kong, the Hawaiian Islands , Indonesia, Malaysia, Philippines, Thailand, South America and Europe.
 - White leadtree is considered one of the 100 worst invasive species by the Invasive Species Specialist Group of the IUCN Species Survival Commission.



White leadtree

APEC Project (2/2)

- SMEs in the APEC region
 - Most enterprises especially in the APEC's developing economics are small and medium enterprises (SMEs).
 - These enterprises rely on firing fossil fuel with boilers to obtain heating required for the manufacturing process.
 - It is difficult for these SMEs to use modern green energy, especially the wind power and solar PV, due to the limited space available or located in the proximity of the city.
- White-leadtree Pellet Fuel
 - Getting rid of the white leadtree to make bio-pellet for replacing fossil fuel in SMEs boiler.
 - Cultivating native trees for the sustainability of feedstocks for the bio-pellet after eradicating the white leadtree.

Greenhouse Gas and ENSO Effect

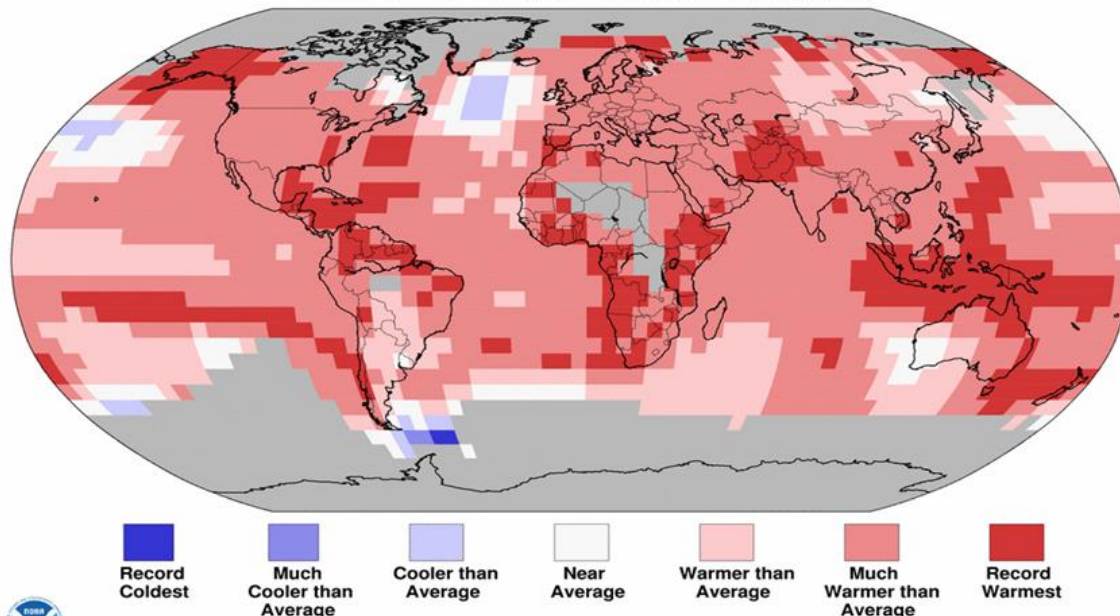
- Since the Industrial Revolution, the greenhouse gas and ENSO effects have impacted the environment.
- The majority areas of the earth are in a warming state that exceeds the average temperature.

Changes of average temperatures in various cities of the world in 2016.

Land & Ocean Temperature Percentiles Jan–Dec 2016

NOAA's National Centers for Environmental Information

Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0



source: NOAA

Wood Pellet Fuels

- In 1976, during the world oil crisis, the first wood pellet patent came out in the United States, and was applied to small-scale regional thermal applications.
- Comparing to logs or other fuels, wood pellets have following advantages:
 - Density is usually greater than 640 kg/m^3 .
 - Suitable for automatic feeding system.
 - Can be used for fireplaces or boilers.
 - Can be used for different scales of heating purposes.
 - Easy to handle, store and transport.
 - Combustion characteristics, such as calorific value, are higher than the original raw materials.

Raw Materials Suitable for Wood Pellets

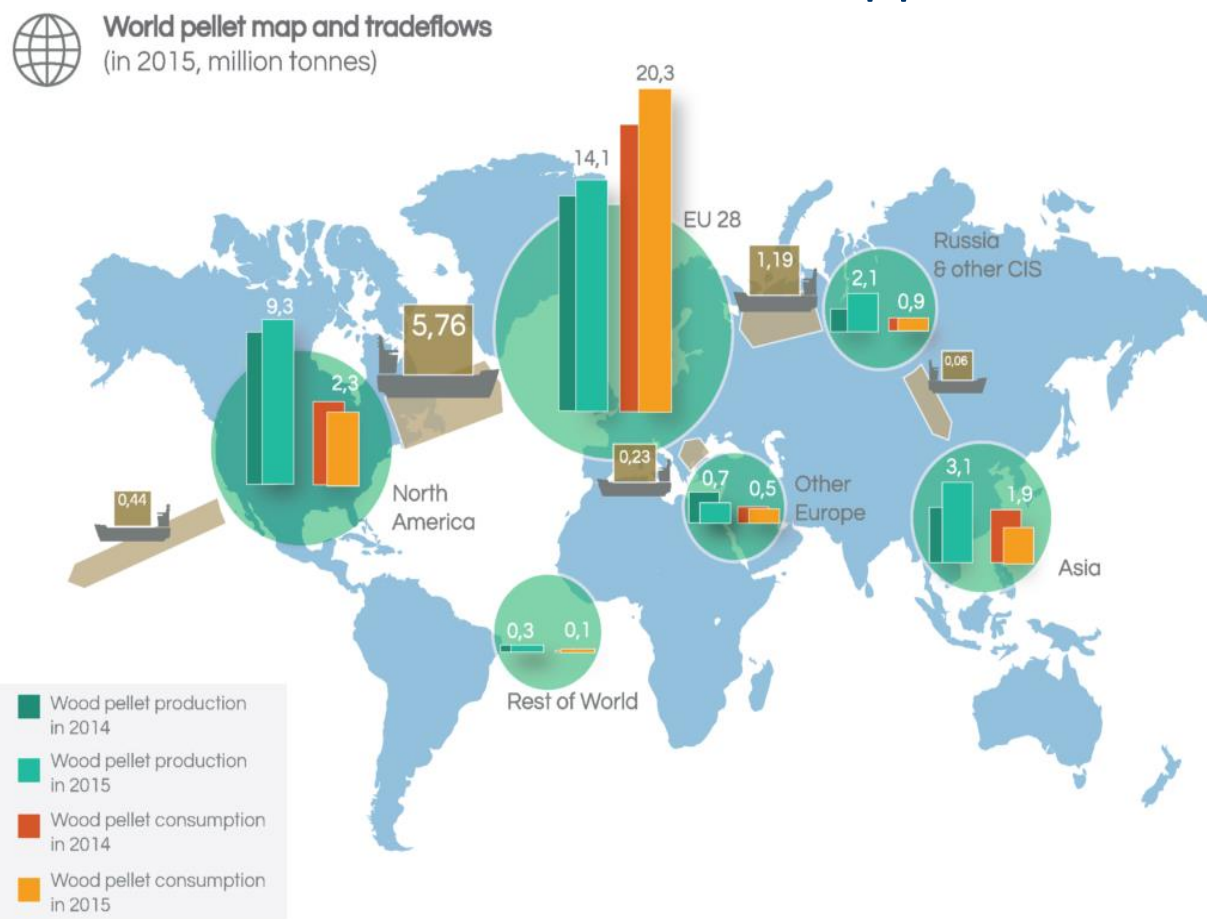
- Wastes of wood industry process are used as raw materials of wood-pellets with potential accounted for about 50%.
- Roots, flowers, wild fruits, fruit flocks and others, they are not suitable in producing bio-pellets. They have been listed as unusable raw materials in various economies.

Wood pellets for the small-consumer market	Wood pellets for the medium-sized and greater power range	Other pellets for use in the power station sector or in plants for agricultural fuels
	1.1.1 Whole trees with roots	
1.1.2 Whole trees without roots		
1.1.3 Trunk wood		
	1.1.4 Forest offcuts	
		1.1.5 Stumps/roots
	1.1.6 Bark	
		1.1.7 Assorted wood from landscape conservation and gardens
1.2.1 Chemically untreated residues (industrial wood cutoffs)		
		1.2.2 Chemically treated residues (fibers and wood components)
	1.3.1 Chemically untreated residues (industrial wood cutoffs)	
		1.3.2 Chemically treated residues
		2 Stalk-like biomass
		3 Biomass from fruits

source: Power from Pellets, 2013

Global Wood Pellet Map and Trade Flows

- In carbon reduction, bio-pellets have the characteristics of "carbon neutral" that it is an effective approach for replacing fossil fuels in industrial combustion applications.

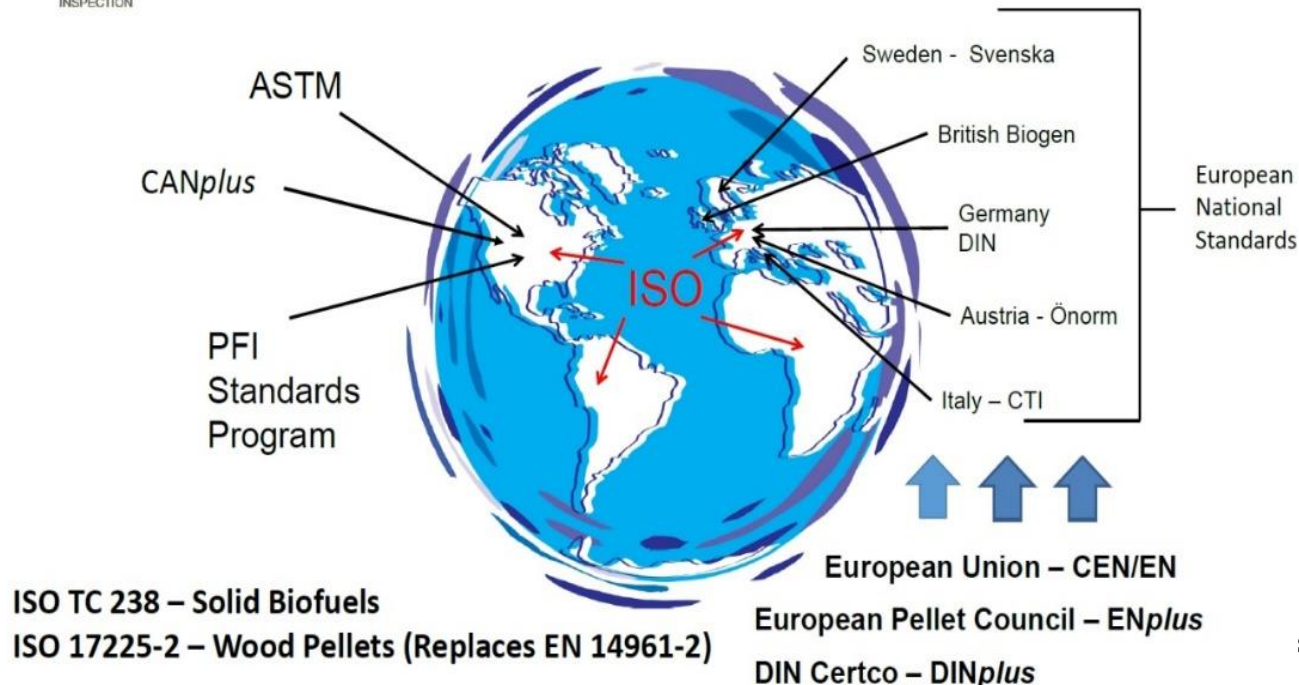


Bio-pellet Fuel Standards

- Wood pellets have many specifications, such as
 - ENplus and DINplus standards in the Europe
 - ASTM, CANplus and PFI standards in the North America
 - ISO standards all over the world.

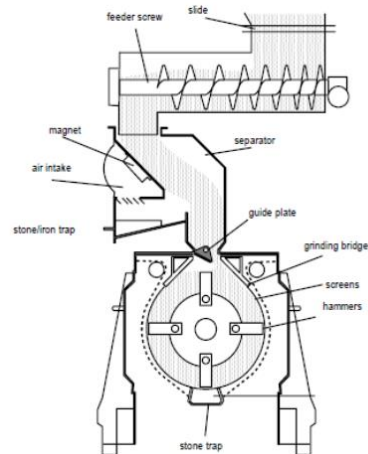
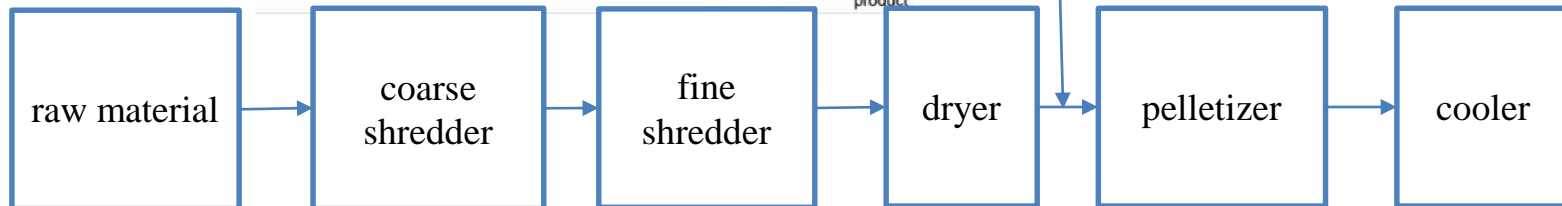
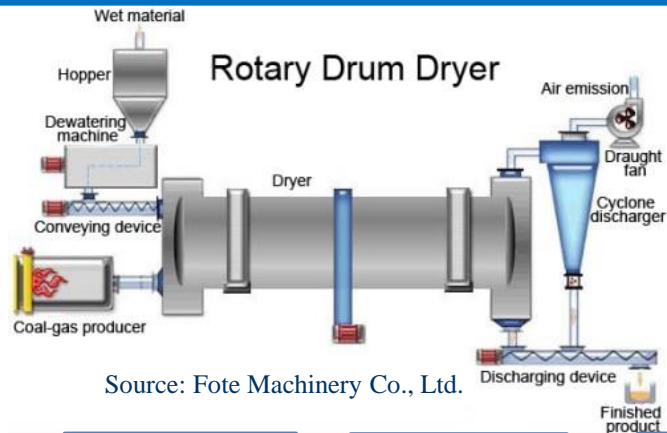


The World of Solid Biofuel Standards



source: TPI

Manufacturing process of bio-pellets



Hammer mill, Source: Koppejan J., Cremers M.F.G., 2016



Source: Kahl Co. flat-die pelletizer

Bio-Pellet Handling

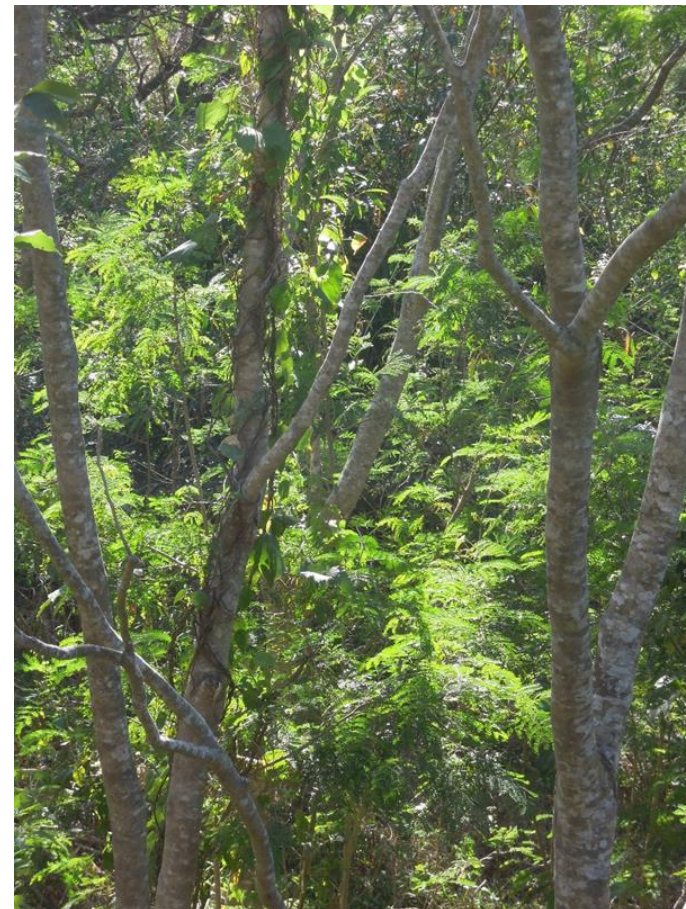
- Pneumatic pump and conveyor for Bio-pellet delivery
 - When a pneumatic pump is used to deliver bio-pellet, pellet damages should be avoided due to pellet speed being too high, sharp turns in the transport pipeline and potential impact portions.
 - If a conveyor is used for transports, it should minimize high-drop dropping operations, and also pay attention to avoid moisture absorption of the pellets.
- Bio-pellet transports
 - During the periods of pellet transports, the risks of dust generation, ignition, and explosion must be minimized.
 - Measures such as spark detection and fire extinguishing systems are used to avoid overheating or burning of pellet or fine powder.

White leadtree

- White leadtree (*Leucaena leucocephala*) is a fast-growing mimosoid tree native to southern Mexico and northern Central America, but is now adapted throughout the tropics.
- The white leadtree is one of the 100 worst invasive species and is a very common species in APEC economics



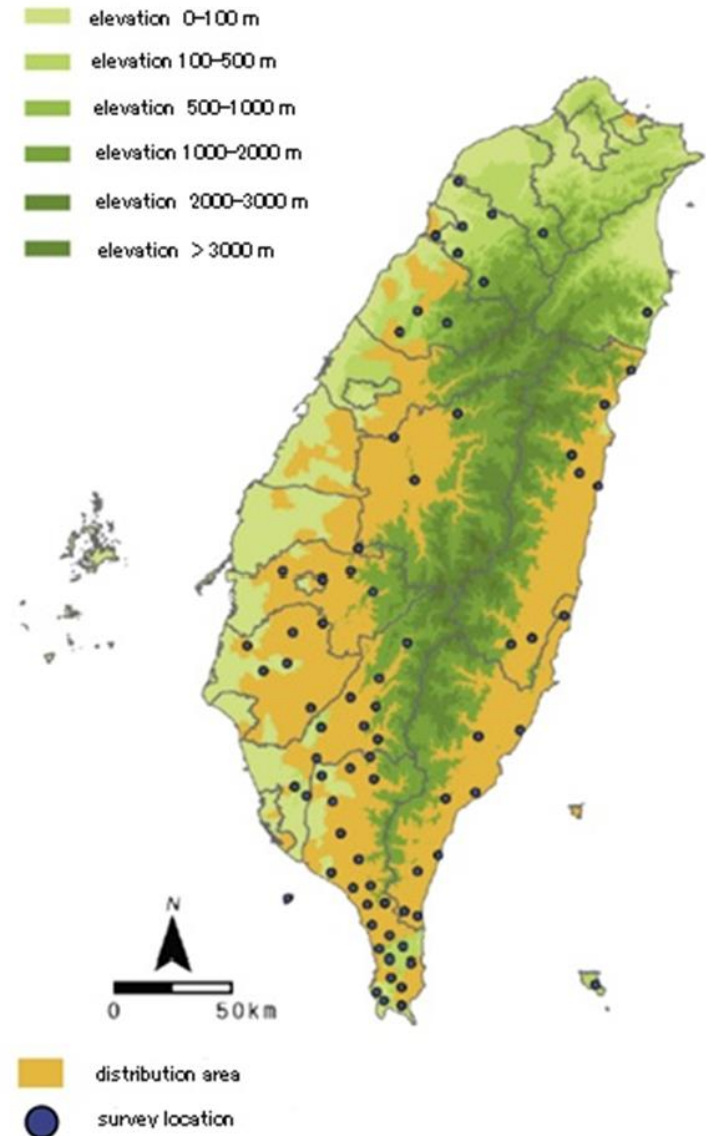
White leadtree



Invasion of white leadtree in
Chinese Taipei mountains

White leadtree in Chinese Taipei

- There are no clear statistics about the number of the white leadtree in Chinese Taipei yet.
- Highly populated areas of the white leadtree in Chinese Taipei are mostly in the east and south regions of Taiwan, i.e. south of Taimali, Taitung County and south of Fangliao, Pingtung County, respectively.



Eradication of white leadtree

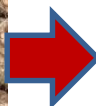
- Trees of Chinese Taipei native species, such as the Taiwan acacia and others, are planted in the forest land areas after the white leadtree plants are eradicated.



Manufacturing of white-leadtree pellet (1/2)



White-leadtree log



Conveyor delivery



Feeding



Drum slicer



Vibrating screen



Coarse particle



Manufacturing of white-leadtree pellet (2/2)



Fine shredder



Pneumatic conveyor dryer



Measure moisture content



White-leadtree pellet



Horizontal-type ring die



Pelletizer

White-leadtree Pellet Characteristics

- Currently, Chinese Taipei has not established the bio-pellet standards yet.
- Compared with the German DIN 51731 standards, the ash and chlorine contents are higher than the DIN standards.



Analysis	Item	White-leadtree pellet	Test method
Proximate analysis (wt.%)	Moisture	7.16±0.07	NIEA R213.21C
	Ash	1.83±0.06	NIEA R205.01C
	Volatile	75.01±1.06	CNS 10823
	Fixed carbon	16.00	
Ultimate Analysis (dry and ash free basis wt.%)	Carbon	43.69±1.21	NIEA M403.01B
	Hydrogen	5.88±0.22	
	Nitrogen	0.88±0.14	
	Sulfur	N.D.	
	Chlorine	0.17±0.02	NIEA M402.00C NIEA W415.53B
	Oxygen	40.39	NIER R125.02C
Heating value (MJ/kg)	HV (dry basis)	18.23±0.88	NIEA R214.01C
	HHV	16.93	
	LHV	15.41	

Repeat 5 samples analysis

Bio-pellet packaged boiler

- Due to the high cost of natural gas, the natural-gas-fired boiler is retrofitted into a bio-pellet-fired boiler in a SME.
- Natural-gas burner is replaced by a pellet feeder and a pellet burner without replacing the boiler main body.



Natural-gas-fired boiler



Bio-pellet-fired boiler

Packaged boiler fired with white-leadtrees pellet

- A steam rate of 7.2 ton/hr packaged boiler

Boiler type	Operation pressure	Evaporization rate	Burner capacity
Fire tube boiler	8.0 kg/cm ²	7,200 kg/h	4,320,000 kcal/h
Heating surface	Max. operating pressure	Bio-pellet feeding rate	Combustion control
147.97m ²	10 kg/cm ²	8~10 kg/min	Fuel/air area ratio

- Flue gases emission meets the air pollution standard

O ₂ (%)	CO (%)	CO ₂ (%)	NO _x (ppm @6% O ₂)	SO _x (ppm @6% O ₂)	Flue gases temperature (°C)
2.3	N.D.	18.3	76.6	6	212

- The boiler efficiency of the white-leadtrees pellet fired boiler is 89.6%.

Closing Remark

- This study is carried out under the APEC project “Heating Applications of Bio-pellet, made from Eco-Hazard Plant, in SMEs to Enhance Utilization of Renewable Energy in the APEC Region”.
 - To demonstrate a win-win strategy that eradication of white leadtree is not only good for land environment but also beneficial to climate environment by providing SMEs “carbon neutral” bio-pellet for boiler application.
- The white-leadtree pellet replacing natural gas is demonstrated in a SME boiler. The air pollution of bio-pellet boiler can meet the Chinese Taipei standards. The boiler efficiency is 89.6%.

Thank You for Your Attention



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