Effective Countermeasures for Preventing Accidents in Biomass Power Generation Facilities (1/2)

This document is produced based on the deliverables from the FY2024 Advanced Safety Regulation Project for New Energy Sources, etc., conducted by the Ministry of Economy, Trade and Industry, Japan.

JAPAN CARBON FRONTIER ORGANIZATION

1. Background of the Survey :

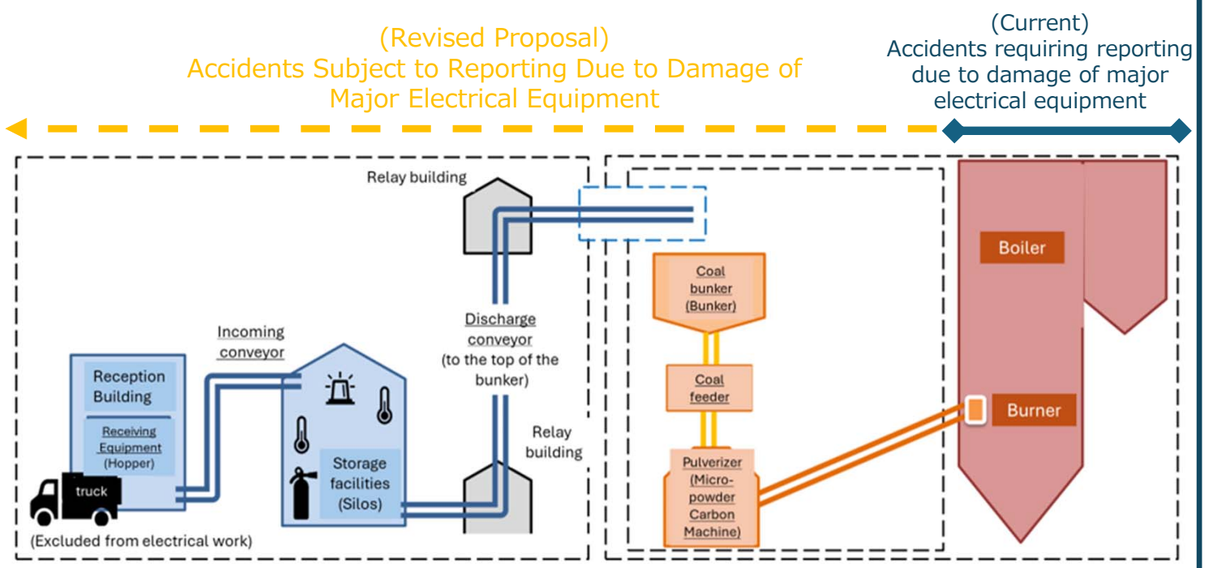
- Biomass power generation is expected to account for approximately 5% of the power source within the 2030 energy mix, also from the perspective of revitalizing the regional economy through local production for local consumption in Japan.
- While rising thermal power generation costs and fuel procurement challenges receive significant attention, in recent years, fires and accidents at domestic and overseas biomass power plants have become frequent, coursing human-made disasters and prolonged operational shutdowns.
- To ensure the sound development of biomass power generation, preventive technologies and recurrence prevention measures to prevent accidents are required.

2. Purpose of the Survey :

To prevent the occurrence of such accidents, we have investigated the causes of domestic and international incidents. We organized information on the current status of biomass power generation facilities in use at first, then analyzed the overview and causes of accidents that had occurred, and relevant laws and regulations. We considerd necessary effective countermeasures to prevent accidents. **We shall use this on the basis of future study on technical standards and accident reporting procedures, etc.**

3. Review of domestic legal regulations in Japan

The Ministry of Economy, Trade and Industry states that necessary rules should be revised to ensure equipment design and configuration based on biomass fuel characteristics, as well as operational management systems for monitoring, cleaning, and other tasks. (Proposed: Expanding the scope of equipment subject to accident reporting, **Consider countermeasures deemed effective for accident prevention** and clarified in the interpretation of technical standards under the Electricity Business Act, etc.)



Citation: 21st Meeting, Industrial Structure Council, Subcommittee on Safety and Consumer Product Safety, Electricity Safety Subcommittee, Working Group on Countermeasures for Natural Disasters and Other Emergencies in Electrical Equipment, Secretariat Materials

4. Survey Method

① We conducted detailed investigations (on-site inspections and interviews) targeting accidents that occurred in fiscal year 2020 and later, as listed in the table below.
② We conducted a questionnaire survey targeting domestic FIT-certified biomass power plants with a rated output of 2MW or more (35 coal co-firing plants and 44 biomass-only plants) to understand the status of safety assurance measures at domestic biomass power plants handling biomass fuel.
③ We also conducted the web and literature research about overseas accident cases and recurrence prevention measures.
④ **We have identified key points that must be took into consideration as recurrence prevention measures. In particular, the factors that caused the explosion are Prevent the generation (explosion) of dust** It has been clarified that countermeasures prioritizing effort (dust collection performance, safety return destination, enhanced cleaning, sudden ignition source suppression, etc.) are necessary.

	Power Plant Name	Kind of biomass	Power Generation Method	Location of the accident	Presumed cause
1	Yonago Biomass Power Plant	Wood pellets	Biomass-only combustion	Lower section of bucket elevator	Spontaneous combustion of wood pellets in silos Ignition of dust due to contact and heat generation between confounded metal objects and metal buckets
2	Taketoyo Thermal Power Plant	Wood pellets	Coal co-firing	From the bunker coal charging device into the bunker inside	Ignition of dust by sparks generated in sliding metal parts Ignition of dust by friction and heat generated in equipment
3	Ishikari New Port Biomass Power Plant	Wood pellets・PKS	Biomass-only combustion	Lower section of the bucket conveyor	Ignition of dust due to friction and heat generated by equipment
4	Sodegaura Biomass Power Plant	Wood pellets	Biomass-only combustion	Silo	Self-heating of wood pellets in silos
5	Hibiki-nada Coal and Biomass Power Plant	Wood pellets・wood chips	Coal co-firing	Discharge conveyor tail section	Ignition of fuel (wood pellets) due to friction heat from equipment
6	CEPO Handa Biomass Power Plant (I & II)	Wood pellets・PKS	Biomass-only combustion	Chip Yard Building / Fuel Supply Equipment Inspection manhole	Ignition of dust caused by among a short circuit in electrical equipment, residual heat in equipment, and metal fragments heated during wood chip processing
7	Hitachinaka Thermal Power Station	Wood pellets	Coal co-firing	Lower section of vertical bucket conveyor	Spontaneous combustion of biomass powder by flammable gas from fermentation and oxidation
8	Shimonoseki Biomass Power Plant	Wood pellets	Biomass-only combustion	Feeding screw Conveyor	Ignition of dust by spark of fire from boiler flames
9	Maizuru Thermal Power Plant	Wood pellets	Coal co-firing	Conjunction Tower	Wood pellets inside the silo spontaneously combusted, igniting combustible gases generated by fermentation and oxidation.

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5. Accident Prevention Measures: An expert review panel composed of members specializing in wood biomass fuel, combustion engineering, monitoring, and measurement was organized. Based on this survey, "countermeasures considered effective for preventing explosion and fire accidents" were compiled for each category (receiving facilities, storage facilities, conveying facilities, and others). We hope that power generation operators in charge to use this table as a reference and implement appropriate fire and explosion prevention measures tailored to the actual conditions of their fuel, equipment, and operations.

Category	Item	Proposed countermeasures considered effective	Supplementary Information (Reasons, Purpose, and Measures for Abnormal Conditions)	Diagnostic Check✓
Equipment Received, etc.	**Ignition Source Countermeasures for Receiving Equipment, etc.**	**Installing foreign object removal devices such as screens or magnetic separators at the bottom of the hopper**	Prevent sparks caused by confounded metal objects contamination.	
		Thoroughly ventilate the receiving building	Prevent the accumulation of flammable gas concentrations within the explosive limits. Additionally, install dust collection equipment and ensure thorough dust collection and ventilation.	
	Monitoring of receiving facilities, etc.	**Installing thermometers (for continuous monitoring) on the receiving conveyor pulley section and the receiving hopper discharge section**	When an abnormality is detected, work and equipment operations shall be stopped, and automatically activated fire suppression equipment (sprinklers, CO2 extinguishers, etc.) shall be installed.	
		Installing spark detectors and sprinklers	Install automatic fire suppression equipment (sprinklers, CO2 extinguishers, etc.) that activates upon detecting an abnormality.	
Storage equipment, etc.	**Prevention of heat accumulation in storage facilities, etc.**	**Strictly enforce first-in, first-out (FIFO) for fuel in warehouse operations**	No special mention	
	Dust control measures for storage facilities, etc.	**Installing dust collectors in appropriate locations (such as areas where biomass fuel falls, like receiving and discharge conveyors, or areas difficult for workers to clean, like restricted or closed-off areas)**	It is possible to reduce the concentration of airborne dust or the amount of settled dust.	
		Adjusting the speed of the circulating conveyor appropriately according to the fuel type.	The increase of the conveying speed, the more likely vibration and slippage occur, which can cause pellet pulverization.	
	Silo Design	**Installing an oxygen concentration reduction mechanism using inert gases (nitrogen, etc.) Establishing an early procurement system for inert gases or installing nitrogen generators, etc.**	Upon detecting abnormal temperature or flammable gas concentration, it automatically supplies inert gas to prevent high-temperature oxidation reactions.	
	Monitoring of storage facilities, etc.	**Using thermal imaging cameras and plug-in thermocouples in warehouses for investigation temperature monitoring within stockpiles**	If heat accumulation is detected, implement heat radiation measures such as reloading.	
		Installing combustible gas detectors (CO, methane, etc.) at the silo discharge section and on top of the silo	Develop a manual for countermeasures during abnormally high levels (alerting, purging, equipment shutdown, etc.) to prevent increases in flammable gas concentration through forced ventilation or inert gas blanketing.	
Material handling equipment, etc.	**Specifications for Vertical Conveying Equipment, etc.**	**Adopting resin buckets**	Prevents sparks from occurring due to contact with the metal casing section, other components, or metallic confounded objects.	
		Installing explosion safety devices, pressure relief mechanisms (bursting discs), and automatic sprinkler systems for fire suppression (fire hydrants)	Rapid mitigation mechanisms is necessary due to major accidents caused by pressure to propagate rapidly in the confined space inside the conveyor.	
	Specifications for Incline Conveying Equipment, etc.	**Adopting fire-resistant belts, such as resin coating for large conveyors Installing grounding for static electricity prevention**	It prevents the spread of fire via conveyor belts.	
		Installing abnormal noise and vibration monitoring system	Standardize countermeasures for abnormal noises (adjustment, stop inspection, emergency stop) in manuals to enable early detection of bearing abnormalities (vibration) in conveyors, etc., and prevent pulley overheating caused by belt misalignment.	
	Dust Control Measures for Conveying Equipment, etc.	**Installing dust collection equipment at each conveyor transfer point and thorough cleaning of connection points**	Fuel drop & damage due to height differences is unavoidable, and the risk increases when accumulated dust becomes dry and confounds into the fresh fuel.	
	Dust treatment for conveying equipment, etc.	**Discharging all dust collected by dust collectors and cleaning operations to outside**	It is desirable to reuse materials after implementing measures to prevent dust explosions caused by resuspension.	
		Installing regranulation and return process in case of reusing dust collected by dust collectors or cleaning operation	Since fixed-type dust removal systems cannot always eliminate accumulated dust completely, measures that allows easy manual removal are necessary.	
Others	**Disaster mitigation**	**Installing pressure relief devices (such as rupture discs and dampers) Adding automatic fire suppression systems like sprinklers and CO_2 extinguishers**	In the event of an explosion, the energy shall be forcibly dissipated into atmosphere safety to prevent secondary explosions.	
	Cleaning	**Thoroughly perform inspections and cleaning (vacuum cleaning)**	The frequency and method will be different on equipment conditions and fuel type, so they should be customized and sentenced in operation manuals at each power plant.	