



LINK & LOOP

Technical Report



# A Life Cycle Assessment of Wood Pellets and Palm Kernel Shell in Taiwan

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**Linking innovations and closing Loops**



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# Executive Summary

Biomass from agriculture and forestry waste is an important focus for the development of the biomass industry. Wood pellets and palm kernel shells (also called PKS) have increased in popularity globally as a 'sustainable' biomass fuel. For example, Drax Power (U.K.) converted their coal-fired units to wood pellets, making the UK the world's largest importer of industrial wood pellets. Because of policy incentives in Japan and South Korea, the imports and demands for wood pellets and PKS have also increased significantly.

In this report, the life cycle assessment (LCA) approach is used to analyze the impact that wood pellets and PKS imported from Southeast Asian countries have on the environment. The results show that the impact of wood pellets and PKS are only 30.8% and 23.4% of the impact of coal, respectively. The main category of impact is human health. PKS's main impact takes the form of the solid residues produced during palm oil refining, while wood pellets impact results from processing including: size reduction, drying, sieving, grinding, and pelletizing. Thus, wood pellets have a slightly higher environmental impact than PKS.

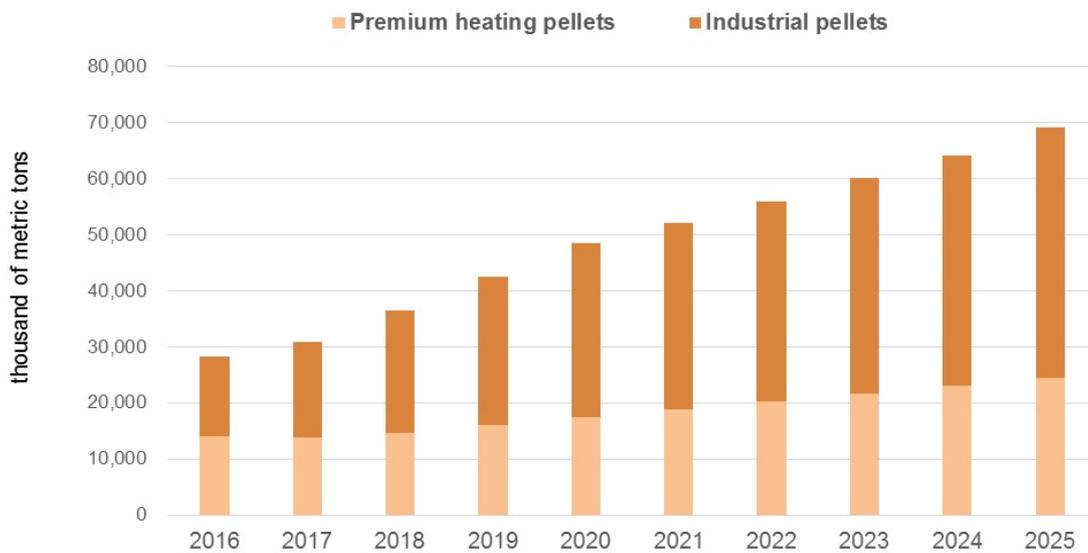


# Biomass and Sustainable Environment

Biomass energy is the oldest renewable energy source, and its scope covers solid, gaseous and liquid biomass energy. The development of biomass energy technology ranges from traditional biomass energy to fiber, agricultural and forestry surplus materials and waste. Now that doubts about using crops for energy instead of food been mitigated, so to has support been realized for biomass's role in reducing greenhouse gas emissions. Europe is the world's largest producer of biomass energy. The Asian market represented by Japan and South Korea has grown significantly in recent years and is the main force for future growth.

As the demand for wood pellets and palm shells grows, governments are increasingly faced with environmental groups and community doubts about whether these biofuels are truly environmentally beneficial. For example, wood pellets require granulation which some believe increases total impact. One question is whether this processing uses more energy than it creates, another concern is whether these sources are really from waste or sustainable materials. In response to these doubts, governments began to regulate the sustainability of biomass. The European Parliament and the European Council reached an agreement in 2018 to amend the Renewable Energy Directive (RED II), which includes proposals to enhance confidence in the sustainability of biomass energy.

Compared with other renewable energy sources (wind, solar, tidal, occasionally hydroelectric), the supply of biofuel is stable and can be directly used for thermal power to replace fossil fuels. As a fuel source for base-load electricity, global demand is growing year by year. Maintaining grid stability and energy system security will play an increasingly important role. For a country like Taiwan, where energy supplies depend on imports, the source of biofuels can perhaps shift to use local sources in the future.



Source: Argus Biomass Direct

**Figure 1 Global total demand for wood pellets**



# Recovery of Agriculture and Forestry Wastes

Wood pellets must be crushed, screened, dried and granulated to produce pellet fuels with specific shapes and compositions that meet precise specifications. Wood pellets are easy to transport and store due to their uniform size and calorific value and are directly applied to chain boilers. Fluidized bed boilers and power generation coal-fired boilers can use these as main fuels or mixed with coal. The source of wood pellet raw materials is mainly forestry waste, such as forest dredged timber and factory-produced sapwood.



The palm shell, also known as the palm kernel shell, is one of the by-products produced during the palm oil refining process. Palm fruit is divided into three layers, from the outside to the inside are the flesh, palm shell, and the palm kernel, of which the flesh and nucleolus have very high oil content. The palm shell is a solid residue produced during the palm oil refining process and can be used directly as fuel without processing.



# Life Cycle Assessment

According to the definition of ISO 14040, the Life Cycle Assessment (LCA) is the “consolidation and evaluation of inputs and outputs and potential environmental impacts in the life cycle of the production system from the acquisition of raw materials to the final disposal”, that is, it serves to assess the impact of the product's overall life process on the environment.

The entire life cycle of the product consists of five stages: “raw material”, “manufacturing”, “transportation”, “use” and “end of life”. The impact types include “human health”, “ecological impact” and “resource use”. The assessment targets a specific product, process or service, and the evaluation phase can be an overall life cycle or part of the phase, so it can be used as an environmental assessment tool for enterprise product development, or the public sector, to develop sustainability policies.

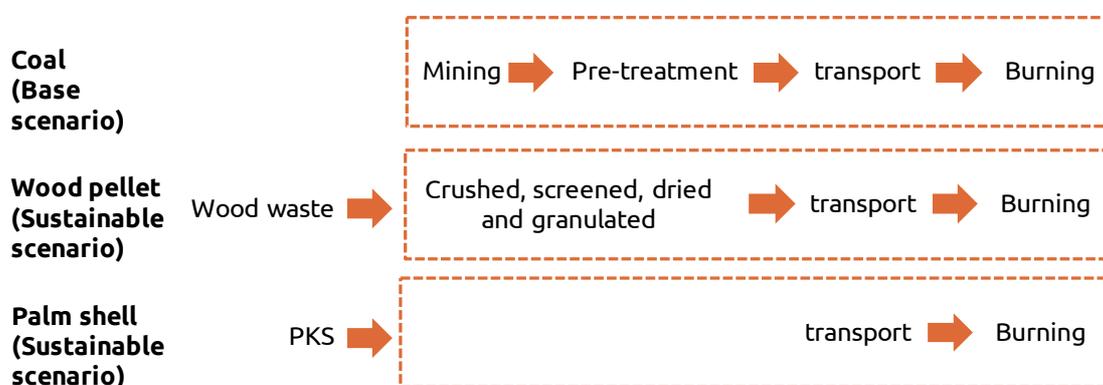
The life cycle assessment of this report is carried out in accordance with the ISO 14040 process. The life cycle impact assessment mode is selected and evaluated by IMPACT 2002+ for environmental impact.

- IPCC GWP 100a is widely used to evaluate the carbon reduction benefit analysis of products. In the impact evaluation method, the carbon dioxide equivalent (CO<sub>2</sub> eq) is used as the unit of measurement to calculate the carbon dioxide equivalent impact of greenhouse gas emissions during the 100 years after product formation.
- The IMPACT 2002+ impact assessment method classifies environmental impact into 17 impact categories and summarizes the impact results into the following four main groups: Human health, Ecosystem quality, Climate change, and Resources.

# Boundary Settings and Scenarios

The life cycle assessment of this report uses imported wood pellets and palm shells as the evaluation targets. The assessment scope includes transportation, processing and combustion heat generation stages. All energy, resources, equipment inputs and emissions in the process must be included in the calculation. The system boundary is set as shown in **Figure 2**; the basic situation is coal burning (import), and the regeneration situation is wood pellet (import) and palm shell (import).

Taiwan's wood pellet fuel relies on imports, mainly from Indonesia, Malaysia and Vietnam. Among them, transportation is divided into four stages: (1) transportation of raw materials to granulation plants; (2) transportation of granulation plants to export ports; (3) exporting countries from Southeast Asia to Taiwan; (4) port to use end. Taiwan palm shell fuel depends on imports, mainly from Indonesia and Malaysia. Among them, transportation is divided into three stages: (1) palm oil factory transport to export port; (2) Southeast Asian exporter to Taiwan; (3) import port to use end. The transport distance is estimated by the average distance.



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Note: Because the raw materials used in the study are scraps, according to the life cycle assessment cut-off criteria, the production process of raw materials is not included in the scope and can be ignored.

**Figure 2 Life cycle assessment system boundary and situational hypothesis**

# Results and Analysis

**Wood granules and palm hulls have far lower impact than coal combustion across all types of impact:** as assessed by IMPACT 2002+ method, wood granules (imports) and palm hulls (imports) impacts are far lower than coal in four major types of impact, of which the climate change and resource impact categories are the most evident.

**Human health is the most important category of impact:** in terms of coal-fired (import) analysis, human health is the most important category of impact, followed by climate change; in term of the analysis of wood pellets (imports) and palm shells (imports), human health remains the most important impact category, followed by ecological quality, which is much lower than that of wood pellets.

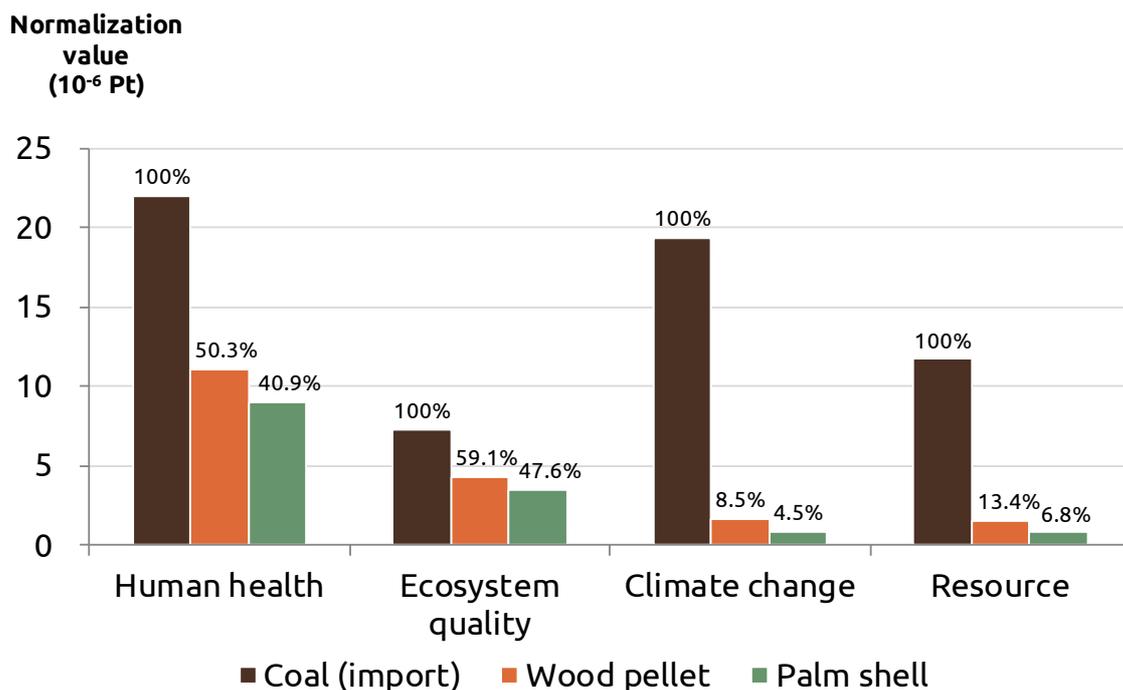
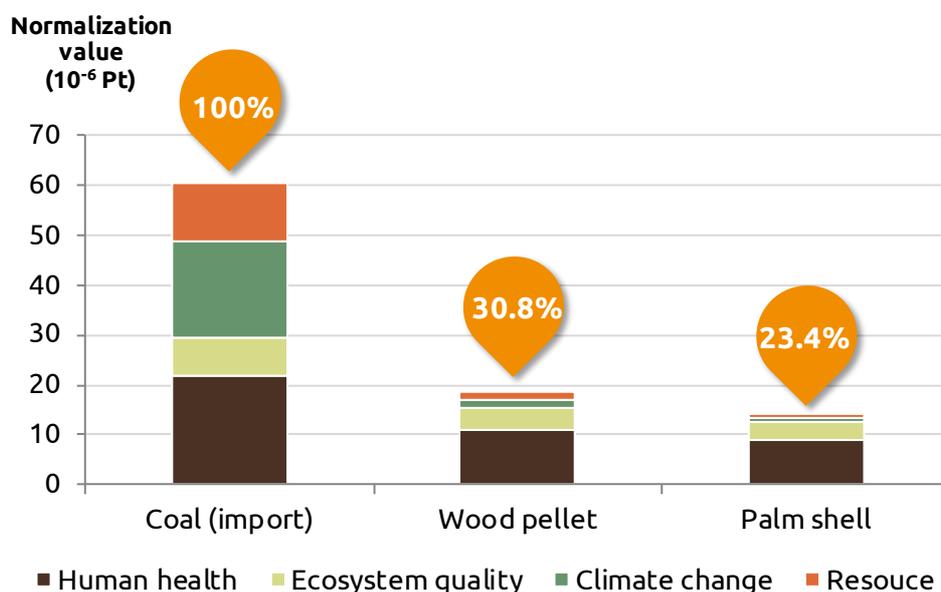


Figure 3 Life cycle assessment

# Results and Analysis

**The impact of wood particles and palm hulls on the overall environment is much lower than that of coal combustion:** comprehensive human health, ecological quality, climate change and resources, etc. The impact of wood particles (imports) and palm hulls (imports) on the overall environment is only 30.8% and 23.4% respectively.

**The environmental impacts of palm shells are small, the main influencing factors are the difference in calorific value and the processing procedure:** the palm shell has a high calorific value (4,800 kcal/kg) and does not require pre-treatment of the fuel, so the total input of raw materials and energy is minimal during the life cycle. The environmental impact of wood particles is slightly higher than that of palm shells. The calorific value of the two particles is similar (4,600 kcal/kg), but the wood pellets need to pass through the pre-granulation treatment stage. The plant construction and operation need to invest more energy and resources, so the environmental impact is larger.



**Figure 4 Life cycle assessment results - total impact**

# Conclusions and Suggestions

- Biomass energy is the oldest renewable energy source, and its scope covers solid, gaseous and liquid biomass energy. The development of biomass energy technology ranges from traditional biomass energy to fiber, agricultural and forestry surplus materials and waste. Europe is the world's largest producer of biomass energy. The Asian market represented by Japan and South Korea is a rising star in recent years and the main force for future growth.
- This report uses imported wood pellets and palm shells as the evaluation targets and uses imported coal as the baseline. The life cycle assessment method is used to analyze its impact on the environment, and the life cycle assessment (LCA) is used to evaluate the overall environmental impact.
- The overall research results show that the impact of imported wood particles and palm shells on the overall environment is only 30.8% and 23.4% of imported coal. In addition, across the four types of impact (human health, ecological quality, climate change and resources) wood pellets and palm shells are far lower impact than coal. Resource impact and climate change are the most obvious areas of benefit over coal.
- Compared with other renewable energy sources (wind, solar, hydro-electric, tidal), the supply of biofuel is stable and can be directly used for thermal power to replace fossil fuels. As a fuel source for base-load electricity, global demand is growing year by year. Maintaining grid stability and energy system security will play an increasingly important role.



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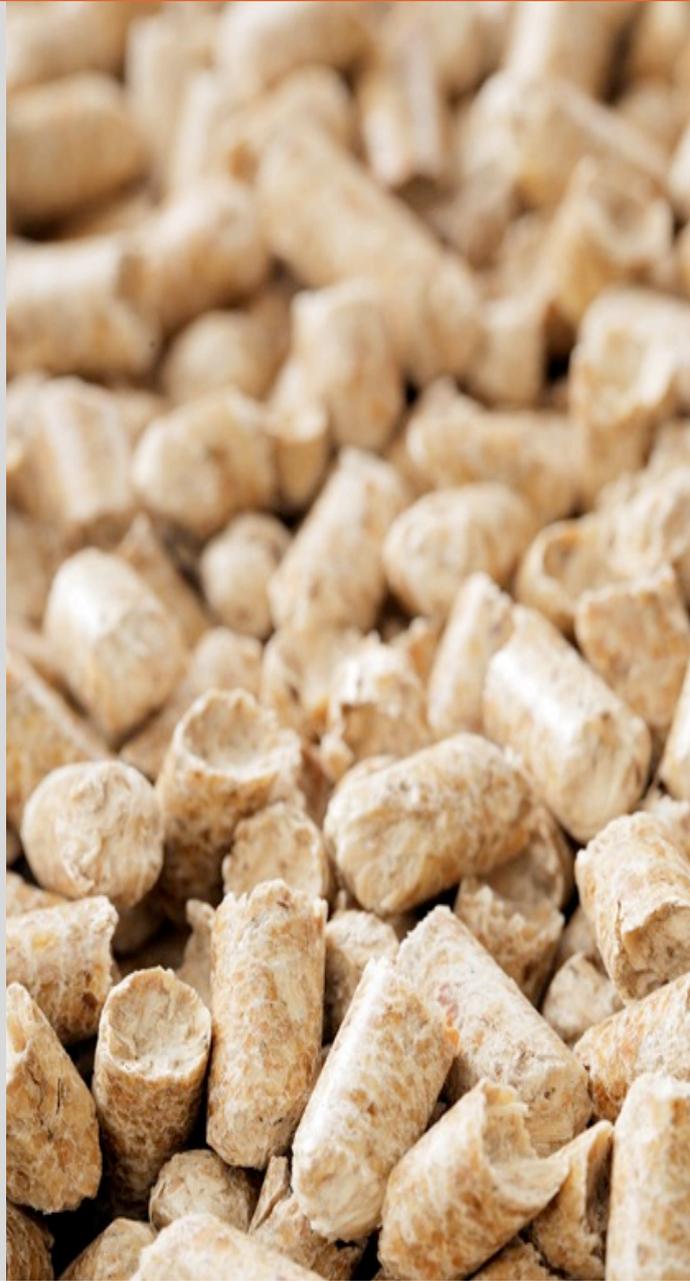
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