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REGIONAL ECOSYSTEM OF USED COOKING OIL (UCO) MANAGEMENT IN CENTRAL JAVA PROVINCE

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Abstract

Indonesia is listed as the world's most used cooking oil (UCO) producing country. Biodiesel from UCO blends is claimed to have lower carbon emissions. A regional scale of sustainable UCO collection and processing ecosystem needs to be established to enhance the role of local authorities in the circular economy. Central Java has the potential for ecosystem planning for UCO management with a circular economy approach. Central Java Province has a total UCO potential of 36,217 kilo liters and can be used for biodiesel potential of 27,094 kilo liters per year. If it is assumed that the processing cost is IDR 9,000.00/liter. The biodiesel production cost for a year is IDR 243.86 trillion/year. Total revenue assumption of IDR 298.04 trillion/year (base price IDR 11,000.00/liter). The profit gain is IDR 54 trillion/year or IDR 4.5 billion/month. The B/C ratio of biodiesel processing is 0.22 and is considered profitable. This program is called Turn Oil On (TOOn).

***Keywords*:** *Used cooking oil, Biodiesel, Circular economy, Central Java*

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INTRODUCTION

Indonesia is one of biggest palm oil consumption in the world. According to Nation Master (2020), Indonesia's domestic consumption of palm oil is 15,050 thousand metric tons and rose 10.5% year on year. This consumption left residual called Used Cooking Oil (UCO), 40-60% of cooking oil was left over the cooking process (Perdana, 2021). UCO as waste from cooking process has environmental, economic, and social advantages when the disposal materials are well managed and coordinated. UCO already export as feedstocks to several countries in Asia, Europe, and USA. In 2021, the biggest exports were to the Netherlands with a value of US$ 23.6 million, followed by Singapore with US$ 22.3 million (Fitria Nurhayati, 2021). The utilization of UCO as feedstocks for biodiesel can cut the carbon emission from oil palm plantation.

A regional scale of sustainable UCO collection and processing ecosystem needs to be established to enhance the role of local authorities in the circular economy. Central Java has the potential for ecosystem planning for UCO management with a circular economy approach. Central Java has the potential to utilize used cooking oil as a source of raw materials for biodiesel. Central Java Province occupies the third position with the highest number of households in 2021 with a total of 12.49 million after the Provinces of West Java and East Java (Sundari et al., 2021). With a large number of households and the typical consumption of cooking oil, people who prefer the process of cooking by frying, the leftover cooking oil can be used as a feedstock for biofuel. The potential of UCO is an information model for managing UCO waste into biofuel in Central Java. With a total of 35 regencies/cities in Central Java Province, it has the potential to organize UCO management programs on a regional scale. Detection of UCO potencies based on ex-residency in Central Java to facilitate UCO data collection. There are 6 ex-residencies in Central Java Province, namely the ex-residencies of Banyumas, Kedu, Pati, Pekalongan, Semarang and Surakarta. This division based on ex-residency makes it easier to identify the use of cooking oil on a household and small and medium scale enterprise (SME), as well as the potential for UCO to be processed into biofuel. UCO management requires a clear supply chain and location determination for mini plants as a sorting route for biofuel raw materials in order to reduce biofuel production costs.

This article proposes the creation of a regional ecosystem for the management of waste cooking oil in Central Java Province. Secondary data were used to compute UCO feedstock and biodiesel potencies in Central Java Province. Then, using biodiesel price and processing cost assumptions, information on profit and B/C ratio from biodiesel production can be provided.

THEORETICAL BASIS

Biofuels definitions

Regulation of the President of the Republic of Indonesia No. 5/2006 translates biofuel as fuel from plant sources (Bahan Bakar Nabati (BBN)). Biofuels are any solid, liquid or gaseous fuels produced from organic materials. Biofuels can be produced directly from plants or indirectly from industrial, commercial, domestic or agricultural waste.

Biofuels are an attractive substitute to current petroleum-based fuels because they can be utilized as transportation fuels with diminutive changes to current technologies; they also have significant potential to improve sustainability and reduce greenhouse gas emissions. Liquid (i.e., ethanol, butanol, biodiesel) or gaseous (i.e., methane or hydrogen) biofuels are generally produced from organic materials such as starch, oilseeds, and animal fats, or cellulose, agricultural crops, or residues (Dahman et al., 2019).

There are various types of biofuel products available on the market. Biofuels are divided into oxygenated and non-oxygenated biofuels based on their features. The chemical makeup of oxygenated biofuel differs from that of ordinary petroleum fuel, which comprises simply carbon and hydrogen molecules. In contrast to ordinary petroleum fuel, which solely comprises carbon and hydrogen molecules, oxygenated biofuel contains oxygen molecules in its chemical composition. This category includes conventional biodiesel FAME (Fatty Acid Methyl Ester) and bioethanol. Non-oxygenated biofuel, also known as drop-in biofuel, has no oxygen molecules and is said to have similar properties to petroleum fuel (IESR, 2021).

Biodiesel is a partial replacement for petroleum diesel. It is combined with petroleum diesel at various blending ratios, with Indonesia currently having the highest blending ratio of 30%. With the exception of Thailand (20%) and Brazil (12%), it is frequently blended at less than a 10% ratio in other nations. Some countries, like Paraguay and Malaysia, intend to expand biodiesel blending rates above 10% (Lane, 2019 and IESR, 2021).

First, Second, and Third Generation of Biofuels

First-generation biofuels are produced from food crops such as corn and wheat (Singh et al., 2013). First-generation biofuels make up the majority of the biofuels used today. First-generation biodiesel and ethanol biofuels produced today also can use vegetable oils (e.g., corn oil) and animal fats as their source feedstock (Dillon et al., 2008) Therefore, there is a need to move away from relying on first-generation biofuels because their feedstock would otherwise be human food (Suganya et al., 2016). With a growing population, it is more reasonable to use human food feedstock byproducts, known as second-generation feedstock, to produce second-generation biofuels. Many first-generation biofuels are dependent on subsidies and are not cost-competitive with existing fossil fuels such as oil, and some produce only limited greenhouse gas emission savings. Considering emissions from production and transport, life cycle assessment from first-generation biofuels frequently exceeds those of traditional fossil fuels (Christenson and Sims, 2011).

Second-generation biofuels are made from non-food crops such as crop waste, agricultural residue, wood chips, and waste cooking oil (Singh et al., 2013). The non-edible byproduct of food crops is used to make second-generation biofuel feedstock. Second-generation feedstock includes wheat straw from wheat production and corn husks from corn agriculture (Begum et al., 2015). There are advantages to using the inevitable byproduct of the agricultural industry for biofuel production; no additional fertilizer, water, or land are required to grow this feedstock. Industry does use some of this nonedible byproduct to produce animal feed, however there is a substantial amount that could also be used for biofuel production (Syed, 2012). Expensive processes arguments against biofuel production from second-generation feedstock plague this biofuel pathway (Sims et al., 2010). Regardless, second-generation biofuel research and policy has the potential to develop this biofuel pathway into a productive source of biofuel (Balan, 2014 and Begum et al., 2015).

Since its inception in the 1950s, third-generation biofuels have been finding their way back into the business. Algae has been making a strong case since it has the ability to radically transform the energy sector. Algae have several advantages, including the fact that they simply require CO_2, nutrients, water, and sunlight to develop. Some algal cultures have been shown to grow in wastewater, which decreases costs even more by eliminating the need for a freshwater medium. Furthermore, when compared to traditional fuels, renewable biofuels have been shown to have a very favourable energy source, which means that the energy gained vs the energy required is substantially higher, while keeping a much lower carbon footprint. Third-generation biofuels are ones that are very new to the field and generally consist of algae and fast-growing trees (Singh et al., 2013). Third generation biofuels are for the most part in their development stage as there are very few commercial-scale plants. Biofuels have been regarded as a sustainable alternative as they have the capacity to reduce GHG emissions by up to 90%, depending on the biomass (Demirbas and Demirbas, 2011). Furthermore, biofuels have the advantage of being able to be combined with traditional fuels or utilized fully on their own. (Demirbas and Demirbas, 2011).

Regulation of Biofuel in Indonesia

Biofuel research in Indonesia began in 2006 in reaction to rising petroleum prices and increased fuel imports as domestic crude production fell. The National Energy Policy (KEN) of 2006 outlined an energy diversification policy that included the use of biofuels. There have been numerous significant policy milestones since the enactment, including the establishment of a blending mandate, price mechanism, and subsidy/incentive program. The biofuel mandate roadmap was developed in 2008, establishing blending targets for bioethanol, biodiesel, and pure vegetable oil. However, many of these targets have not been met for years, owing primarily to price incompatibility with petroleum (IESR, 2021). The biodiesel objective of 20% diesel consumption was very recently met in 2019. Meanwhile, bioethanol consumption as a fuel is almost non-existent since a modest blending fraction was introduced in 2009. With a pressing need to close the price difference between FAME (Fatty Acid Methyl Ester) and petroleum products, the government established the oil palm plantation fund (OPPF) in 2015 as the source of subsidy 2 for biodiesel, replacing the previous subsidy from the state budget, which had been suspended earlier that year. The fund is funded by an export fee on CPO and derivatives. In the beginning, the incentive solely applied to the incorporation of biodiesel into subsidized diesel fuel (Public Service Obligation/PSO). Later, in 2018, the subsidy was increased to cover non-PSO diesel fuel, which was critical in meeting the biodiesel blending obligation in 2019 (IESR, 2021)

Circular Economy Concept in Indonesia

The circular economy is an economic model whose goal is to generate goods and services in a sustainable manner by limiting resource consumption and waste (raw materials, water, energy) as well as waste production. (Solar Impulse Foundation, 2021). The white paper from the Ministry of National Planning and Development (Bappenas) on CE integrated policy in collaboration with the Embassy of Denmark and UNDP is used to determine the trajectory of Indonesian government's perspective on CE concepts (UNDP, 2021). Circular economy is a closed loop economy system method in which raw materials, components, and products are kept as usable and valuable as possible in order to limit the quantity of waste material that is not reused and is disposed of in landfills (UNDP, 2021). This definition emphasizes limited waste upcycling and downcycling. While it may provide a more realistic approach for policymakers, one of the long-term concerns that may arise in relation to this concept is a narrow understanding of regional or local authorities who develop CE initiatives.

Another key issue to address is data limitation, which causes mistakes in calculating the volume and kind of trash produced at the city or household level. In such a context, a definition proposed by Korhonen et al. (2018) is used for practical reasons and to minimize confusion and simplifying for the readers of this study. The circular economy is a type of economy made up of societal production-consumption systems that optimize the service produced by the linear nature-society-nature material and energy throughput flow. This is accomplished through the use of cyclical material changes, renewable energy sources, and cascading-type flows of energy.

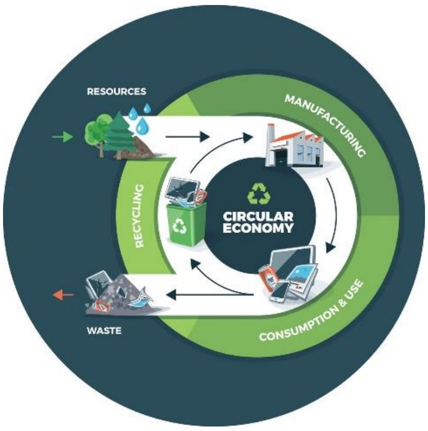


Figure 1. Cycle of Circular Economy
Source: Solar Impulse Foundation, 2021

RESEARCH METHODS

Type of Research

The research method used desks research with quantitative analysis of secondary data to determine the potential households and SME's palm oil consumption, used cooking oil (UCO), and biofuel potential in Central Java Province. Then combining accounts from news sites to obtain information about the present condition of UCO in Indonesia.

Data, Instrument, and Technique of Data Collection

The data used is secondary data on the number of households from BPS (Central Statistics Bureau) Central Java Province in 2019. The circular economy (CE) is a type of economy made up of societal production-consumption systems that optimize the service produced by the linear nature-society-nature material and energy throughput flow. The circular economy of UCO collecting target is households and SMEs in Central Java Province. With arrangement involved local government in micro element of district and sub district in every regency and city of Central Java Province. The assumption for the household palm oil consumption, UCO residual, and biofuel potencies based on Sundari et al. (2022) research. After calculating the potential households and SME's palm oil consumption, used cooking oil (UCO), and biofuel production from UCO process this information can provide the cost and revenue projection from biofuel production and selling.

Data Analysis Methods

Cost production of biodiesel formulated as the formula:

$$Cp = q \; x \; C$$

Whereas:

$Cp = total\ cost\ production$;

$q = total\ biodiesel\ quatity$;

$C = production\ cost\ per\ liter$

Revenue from biodiesel selling can be formulated as follows:

$$R = q\ x\ p$$

Whereas:

$R = revenue$;

$q = total\ biodiesel\ quatity$;

$p = price\ per\ liter$

Profit from biodiesel selling is calculated as follows:

$$\pi = R - Cp$$

Whereas:

$\pi = profit\ from\ biodiesel\ selling$;

$R = revenue$;

$Cp = total\ cost\ production$

Meanwhile, the Benefit Cost ratio calculated with formula:

$$\boldsymbol{B/C\ ratio = B/C}$$

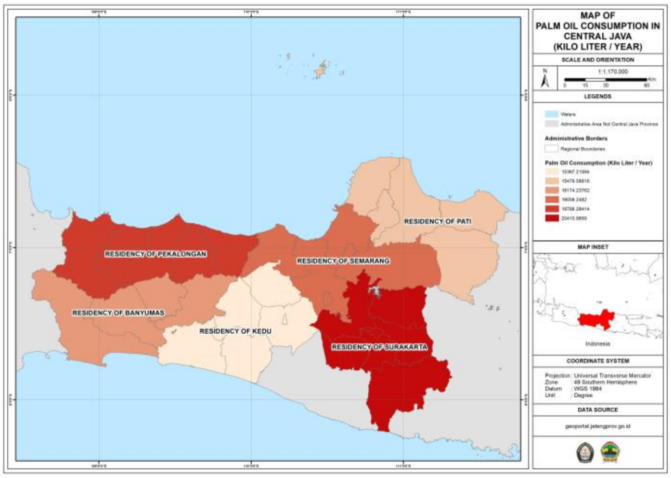
Whereas, B is benefit (profit) and C is cost production. The indicator for the feasibility study of biodiesel project can be summaries B/C ratio > 0 (feasible) and B/C ratio < 0 (non-feasible).

RESEARCH RESULTS AND DISCUSSION

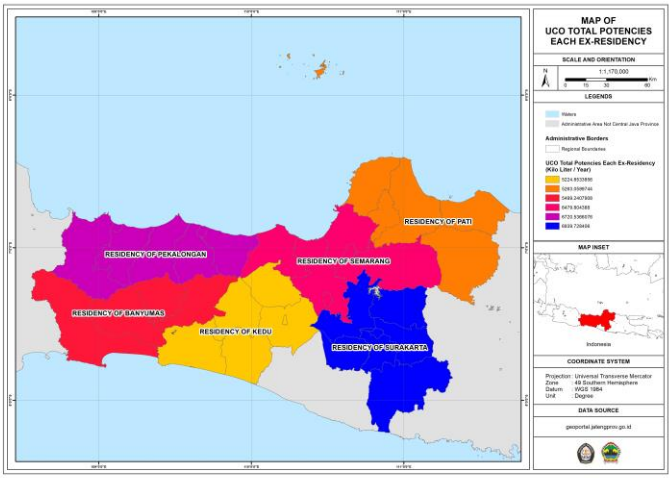
Potential Palm Oil Consumption, UCO, and Biodiesel

The assumption used in this study is that palm oil consumption in Central Java Province is based on Sundari et al. (2022) research on UCO potencies from households and SMEs in five major cities on Bali and Java Island. The average household palm oil consumption in Central Java Province was 11.58 liters per year, with a residual UCO of 20% from palm oil consumption. Furthermore, the biodiesel potencies from the UCO feedstock were 75%. This assumption served as a basis for calculating the Central Java Province's UCO and biodiesel production capacities. Because the total SMEs in each ex-residency were unable to obtain precise information, the UCO and Biodiesel potencies were calculated using 70% of the household potencies.

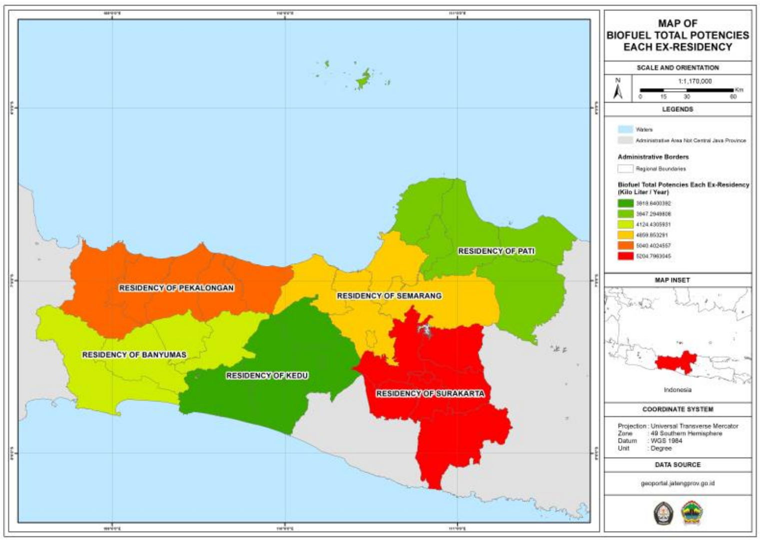
Central Java Province has a total UCO potential of 36,217 kilo liters and may be used to produce 27,094 kilo liters of biodiesel per year. Surakarta ex-residency has the highest UCO and Biodiesel potencies in Central Java, whereas Kedu ex-residency has the lowest. Figures 2-4 describe the UCO and biodiesel potencies for each ex-residency in Central Java Province.



Figs 2. Map of Palm Oil Consumption in Central Java Province



Figs 3. Map of UCO Potencies every Ex-Residency in Central Java Province



Figs 4. Map of Biofuel Total Potencies each Ex-Residency in Central Java Province

Biodiesel Production Financial Analysis

The assumption of UCO feedstock production cost turn into biodiesel was taken from the research of Nafiah and Fauziah (2020). Production cost of biodiesel IDR 9,000.00/liter. Price selling for the biodiesel product is IDR 11,000.00/liter. Central Java Province has an annual UCO potential of 36,217 kilo liters and a biodiesel potential of 27,094 kilo liters. If the processing cost is considered to be IDR 9,000.00 per liter. The annual cost of producing biodiesel is IDR 243.86 trillion. The overall revenue generated by biodiesel sales is IDR 298.04 trillion per year. Profit gain is IDR 54 trillion per year, or IDR 4.5 billion every month. Biodiesel processing has a B/C ratio of 0.22 and is considered profitable.

Regional ecosystem of UCO management in Central Java Province

Previously, Central Java Province was divided into six residencies. There were 6 ex-residencies in Central Java Province, namely the ex-residencies of Banyumas, Kedu, Pati, Pekalongan, Semarang and Surakarta. This ex-residency divide makes it easier to identify cooking oil use in households and small and medium-sized enterprises (SME), as well as the potential for UCO to be turned into biofuel (biodiesel). UCO management requires a clear supply chain and location determination for mini plants as a sorting route for biofuel raw materials in order to reduce biofuel production costs. UCO collection from households and SMEs is inefficient. This has evolved into a chance for the government to participate in the collection process. To cover the subdistrict area, the process must reach the lowest level from RT or RW. When UCO was is dumped into sewage, water, or even a landfill, it poses a risk. It contributed to severe water and land contamination. The government can provide incentives to sub-districts to purchase UCO waste from households and SMEs. In order to stimulate the program's effectiveness, an incentive is provided. Every month, UCO collection from families and SMEs may be scheduled to be taken from RT/RW in each sub district. This gathering process was carried out at the sub-district, district, and regency/city levels before being sorted in each ex-residency's region.

Biodiesel that produced by the local government can be offers as High-Speed Diesel or HSD (diesel fuel) subsidies replacement for the small-scale fishing or artisanal fishing in Central Java. According to Mulyatno (2012), the used of biodiesel (B20, B30, and B50) in fishing vessel operation. It is proven that biodiesel is more efficient than HSD with the same mileage and speed. Central Java Province has 16 regencies/cities that bordered by the Java Sea and the Indian Ocean. The use of diesel as fuel for fishing boats is often constrained by the scarcity of the diesel supply. For this purpose, producing biodiesel from UCO feedstock will be beneficial in resolving this issue.

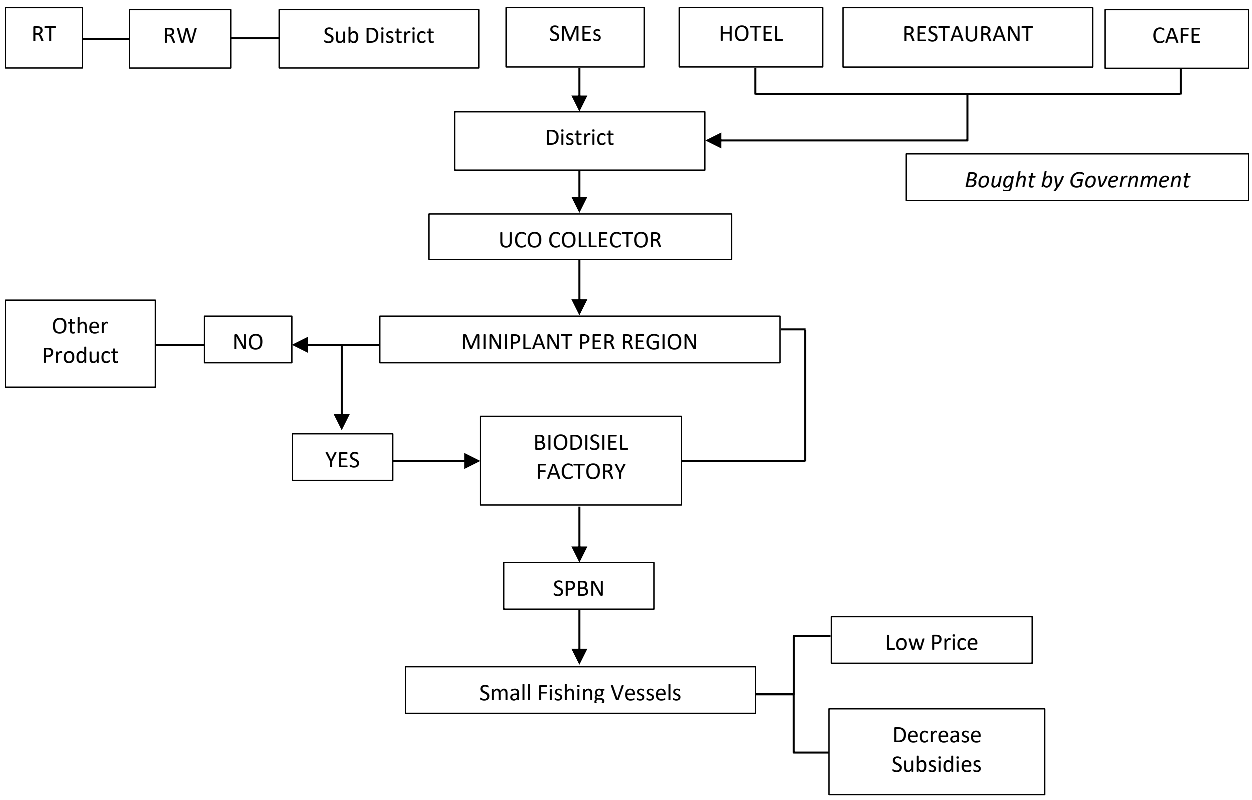


Figure 5. The UCO's collecting scheme in Central Java Province

CONCLUSIONS AND SUGGESTIONS

It is estimated that the biodiesel can be produced by the biodiesel plant is 27,094 kilo liters per year. Biodiesel sales provide an annual revenue of IDR 298.04 trillion. Profit gain per year is IDR 54 trillion, or IDR 4.5 billion each month. This research proposes a regional ecosystem management strategy for used cooking oil (UCO) in Central Java Province. Used cooking oil (UCO) as a biofuel feedstock that can supply the next bioenergy to replace dwindling conventional fuels. The scheme that we proposed is a circular economy strategy to enhancing the participation of local governments in UCO purchases and biodiesel manufacturing. The UCO collection and Biodiesel program in Central Java Province may provide a solution for managing UCO waste as a biodiesel feedstock. Another advantage of the idea is that it reduces diesel fuel subsidies for small fishing vessels while also providing fuel for artisanal fishing demand.

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