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Evaluation of the Efficiency of Fuel Oil Energy Needs as an Influence of *Nyepi* Day in Bali

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ABSTRACT: *Nyepi* Day in Bali is a unique Hindu religious celebration, marked by a complete cessation of outdoor activities for 24 hours. This condition has a significant impact on energy consumption, especially fuel. This study aims to evaluate the efficiency of fuel needs during the *Nyepi* period based on consumption simulation data in Bali Province. The method used is a case study with a baseline of daily fuel consumption of 3.2 million litres, and an assumption of fuel consumption reductions of 30% on the day before *Nyepi* (D-1), 90% on *Nyepi*, and 25% on the day after *Nyepi* (D+1). The simulation results show a total savings of approximately 5.36 million litres of fuel over three days, equivalent to a reduction in CO_2 emissions of roughly 12,857 tons. This discussion connects these findings with previous studies on the impact of *Nyepi* on air quality and demand-side energy management strategies. This study recommends utilising *Nyepi* as a model for energy-saving policies in other regions through planned mobility restrictions.

KEYWORDS: *Nyepi*, Bali, fuel oil, energy efficiency, CO_2 emissions

I. INTRODUCTION

Bali Province has relatively high energy consumption compared to its regional capacity, driven by the tourism, transportation, and household sectors [1]. One unique phenomenon that occurs every year is *Nyepi* Day, which practically stops all economic activity and public mobility for a full 24 hours. During *Nyepi*, airports, ports, highways, and public activity centres are completely closed, so there is no land, sea, or air transportation activity [2].

Nyepi Day in Bali is a day of awakening, renewal, and purification of the self and the universe. It is also a time for introspection, reflection on life, and beginning the new year with a calm mind. Furthermore, *Nyepi* aims to maintain the balance of nature and the relationship between humans and nature. Previous studies have shown that *Nyepi* has a positive impact on air quality, with a decrease in pollutant gases (CO, NO2) and dust particles, concentrations of pollutants such as PM25 by around 47% in the 2020-2022 period, reduced air pollution, energy savings, and a reduced carbon footprint [3, 4]. Total irradiance during *Nyepi* on the island of Bali decreased by almost 100% as measured using NASA's Black Marble product series [5].

Based on fuel conditions, quantitative studies on fuel energy savings are still limited. However, this data is crucial for calculating environmental benefits more comprehensively, including estimating greenhouse gas emission reductions [6]. *Nyepi* not only has profound spiritual significance but also provides significant ecological benefits. During *Nyepi* celebrations, the cessation of flights and the absence of vehicles on the roads make Bali's air cleaner [7]. During *Nyepi*, fuel consumption also decreases significantly because transportation is stopped for 24 hours. Fuel consumption in Bali averages 3.2 million litres per day, with the largest proportion used for land transportation (±70%), according to 2023 BPS data [8]. This sector is highly vulnerable to changes in community mobility, so policies or events that restrict movement can directly impact fuel demand. This is also evident from the global experience of the COVID-19 pandemic. During the pandemic, energy consumption decreased significantly due to mobility restrictions [9]. According to a 2021 IEA study, the lockdown policy resulted in a 20% decrease in global fuel demand in April 2020 [10]. This is relevant to understanding the energy conservation mechanisms during *Nyepi*. According to Gellings, demand-side management (DSM) is an energy consumption management strategy to reduce peak loads and increase energy efficiency [11]. Indirectly, the *Nyepi* Day, a ritual, applies the principles of extreme DSM for a full 24 hours. *Nyepi* Day is a sacred day for Balinese Hindus and is observed annually based on the Saka calendar. The *Nyepi* celebration in Bali is a unique ritual in the world because all community activities come to a complete halt for 24 hours. Furthermore, air, land, and sea transportation come to a complete halt for 24 hours. This phenomenon provides a rare opportunity to observe significant changes in energy consumption and air quality.

This study aims to fill this gap by simulating the impact of *Nyepi* on daily fuel consumption in Bali. The focus is on the three days before *Nyepi* (D-1), during *Nyepi* (D), and after *Nyepi* (D+1), representing the preparation, implementation, and post-*Nyepi* phases. Furthermore, the discussion will link the simulation results to sustainable energy policies, thus providing a reference for other regions in Indonesia.

II. RESEARCH METHODS

This study uses simulated data based on historical fuel consumption trends in Bali from the Ministry of Energy and Mineral Resources and air quality data from the Meteorology, Climatology, and Geophysics Agency. This research method uses a quantitative approach with simulated data representing fuel consumption patterns in Bali from seven days before and seven days after *Nyepi*. The baseline data for daily fuel consumption is taken from the average fuel consumption in Bali, based on the 2023 BPS report, of approximately 3.2 million litres/day. Savings are as in Equation 1.

$$\text{Savings (l)} = \text{Baseline consumption} - \text{Actual consumption} \quad (1)$$

The assumption of reduced consumption is taken from a combination of previous *Nyepi* study data and projections of the impact of mobility restrictions [12, 10].

- D-1: 30% decrease (because mobility is starting to be reduced)
- *Nyepi* Day: 98% decrease (zero mobility)
- D+1: 25% decrease (gradual recovery)

The savings calculation is done by subtracting actual (simulated) consumption from the baseline, then calculating the estimated CO_2 emission reduction using the average emission factor for gasoline and diesel of 2.4 kg CO_2/liter [13].

III. RESULTS AND DISCUSSION

Nyepi is a holiday held in Bali and celebrated every Saka New Year. During *Nyepi*, all community activities stop, such as not lighting fires, not using electricity, and not using lighting (*amati gni*); not having fun or enjoying entertainment (*amati lelanguan*); not travelling or staying at home (*amati lelungan*); and not working or doing physical activities (*amati karya*) [14]. Table 1 presents baseline consumption, decreases, actual consumption, and savings based on the day, namely, seven days before *Nyepi*, during *Nyepi*, and seven days after *Nyepi*.

Table 1. Details of fuel consumption

Day	Baseline consumption (l)	Decrease (%)	Actual consumption (l)	Savings (l)
D-7	3,200,000	0%	3,200,000	0
D-6	3,200,000	0%	3,200,000	0
D-5	3,200,000	0%	3,200,000	0
D-4	3,200,000	0%	3,200,000	0
D-3	3,200,000	0%	3,200,000	0
D-2	3,200,000	0%	3,200,000	0
D-1	3,200,000	30%	2,240,000	960,000
Nyepi	3,200,000	90%	320,000	2,880,000
D+1	3,200,000	25%	2,400,000	800,000
D+2	3,200,000	0%	3,200,000	0
D+3	3,200,000	0%	3,200,000	0
D+4	3,200,000	0%	3,200,000	0
D+5	3,200,000	0%	3,200,000	0
D+6	3,200,000	0%	3,200,000	0
D+7	3,200,000	0%	3,200,000	0

Based on this, fuel consumption during *Nyepi* experienced a drastic decline. This was supported by the suspension of land, air, and sea transportation, except in urgent situations, such as transporting sick people to health services. Fuel consumption can be clarified as shown in Figure 1.

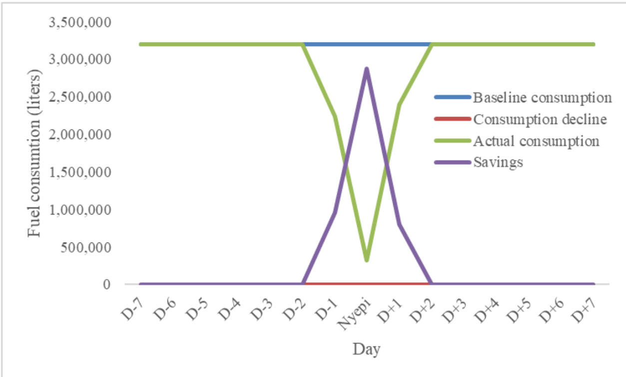

Figure 1. Trends in fuel consumption before, during, and after *Nyepi*

Simulation results show that the *Nyepi* period results in significant fuel savings. The largest reduction occurred on the day itself, amounting to 2,880,000 litres, equivalent to 90% of the normal daily consumption of 3,200,000 litres. Converted to CO_2 emissions, the savings of 5.36 million litres of fuel over three days translate to a reduction of approximately 12,857 tons of CO_2 [13]. This figure is equivalent to the annual emissions of approximately 2,780 gasoline-fueled passenger cars [15]. This finding strengthens the theory that large-scale mobility restrictions can be an effective strategy for energy savings [10, 11]. Although *Nyepi* is a religious celebration, this pattern can be adapted in the form of a "car-free day" or "energy lockdown" policy in large cities. In addition, these results also support the concept of co-benefit in environmental policy, where one intervention (mobility restrictions) produces double benefits: emission reductions and energy savings [16]. The 90% reduction in consumption on *Nyepi* Day demonstrates the significant potential for energy savings if activity restrictions are implemented periodically. Furthermore, the reduced consumption patterns the day before and after *Nyepi* reflect community preparation and adjustments to activities. This phenomenon can be used as a case study for designing periodic activity restriction policies for energy efficiency. An evaluation of *Nyepi*'s impact on fuel consumption provides important insights into the potential energy efficiency gains through massive activity restrictions. The *Nyepi* phenomenon provides a concrete example of how activity restriction policies can deliver environmental benefits quickly.

CONCLUSIONS

This study concluded that *Nyepi* in Bali significantly contributes to fuel savings and CO_2 emission reductions. With a baseline of 3.2 million litres/day, savings from D-1 to D+1 reached 5.36 million litres, or approximately 12,857 tons of CO_2.

Recommendations:

1. Local governments should consider energy conservation programs based on planned mobility restrictions.
2. Expand Research to measure impacts in the electricity and other energy sectors.

Integration of actual energy consumption data during the *Nyepi* period to validate simulations. The *Nyepi* phenomenon provides a concrete example of how activity restriction policies can provide environmental benefits in a short time.

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