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Reducing Global Warming and Stopping Unnecessary Pollution Through Regulating and Levying Private Transport Means in Bandung

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Abstract: Global warming is one of the greatest threats to humanity and the environment. This paper investigates the relationship between the increasing number of private cars in Bandung and its contribution to global warming. Bandung city population in 2010 was about 2.4 million, and the population density was 1,600. The global warming in Bandung has increased due to the intensive urban activities. Global warming is the warming that happens when certain gases in Earth's atmosphere trap heat. The main sources of global warming in Bandung are transportation, industry and household. The ever increasing number of cars is proportional to the increasing temperatures that reach 27°C at night and 30° during the day especially in downtown Bandung. My research focused on the private cars heading towards the Ciumbuleit-Cihampelas-Silwangi Junction during a busy Saturday afternoon for a period of 3months to see whether all the car seats are occupied by people, and to check whether all the cars are necessarily required on the road. Less than 20% of the cars were at least half filled with people. About 40% of the cars had only the driver and about 40% of the cars had more than 1 person but less than the half filled car capacity. All the Passengers could comfortably fit in only 60% of the cars. The mean of the data was 2.4 occupants per car where the car capacity ranged from 4 to 6 occupants per car. 50% of the cars were unnecessarily required on the road during the study period.

Keywords: *Global warming, private cars, gases, temperature*

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INTRODUCTION

Global warming is one of the greatest threats to humanity and the environment. A lot of research has been done to curb global warming. Alternative clean energy, Tree planting, carbon emission surcharges and anaerobic digestion are some of the measures that have been deployed world over to control climate change. Their impacts are yet to be felt. Bandung city in Indonesia is not immune from this tragedy. Bandung city in Indonesia is located 150 km southeast of the capital Jakarta. The population of this city as of the year 2010 was about 2.4 million, and the population density was 1,600 people per square kilometer. The global warming in Bandung has increased due to the intensive urban activities. Global warming refers to the warming that occurs when heat is trapped by certain gases in the atmosphere of the earth. The main sources of climate change in Bandung are transportation, industry and household. In this case we are focusing on the private car transportation as a source of greenhouse gases mainly methane (CH_4) and carbon dioxide (CO_2). Previous work by (Sharma et al., 2017; Tanuwidjaja, 2005) showed that the air pollution problems in Bandung are partly due to big numbers of privately owned cars and motorcycles. This is indicative of transportation practices that are unsustainable. It is on record that Lead, Carbon Oxides, Nitrogen oxides, Sulphur oxides, and suspended

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solids pollutant intensity in Bandung city has reached a hazardous level for human kind. The additional sources of air pollution are households, factories, and solid waste burnings.

The mayor decree of 2013 that provided for a “four in one” policy should be strengthened by introducing heavy fines in breach of the policy, and also spread to all the major roads with in Bandung city. This policy allows for each car for a single day of the week to have a minimum of four passengers only for a few selected roads.

The Bandung Master Plan 2013 (Tanuwidjaja, 2005) proposed strategies to improve the transport system, especially public transport. This plan consists of Primary and Secondary arteries, Primary and Secondary Collectors, and Local Roads. It is made up of;

- interior toll roads in Eastern and Northern area of Bandung
- planned internal rail line
- Upgrading of available rail line station into a regional station
- Construct an incorporated terminal in Gedebage so as to cater for public transportation, container operations and train stationing.
- Construct a fresh bus terminal in the City outskirts
- Make use of Husein Sastranegara Airport until a new airport is build.

However, this master plan can only be actualized if Bandung is analysed together with other neighbouring urban centres, these also play a part in the congestion of cars in the Bandung city centre. Bandung together with those semi urban areas form the Bandung Metropolitan Area (BMA).

The BMA

BMA is located in the centre of West Java Province. BMA is characterized by a rising city population insufficiently provide for by the current system of transport, dilapidated standards of communal transport standards, increasing reliance on personal transport means (mainly motorcyles and cars), plus insufficient and worsening transport networks. Additionally, in the recent past, the transformations and development and improved standards in the BMA have also sparked-off the increase in the purchase of private cars. Furthermore, the motorway link between Jakarta and BMA (the Cipularang Toll Road commissioned in the year 2004) gravely made complex the traffic circumstances, particularly in Bandung City.

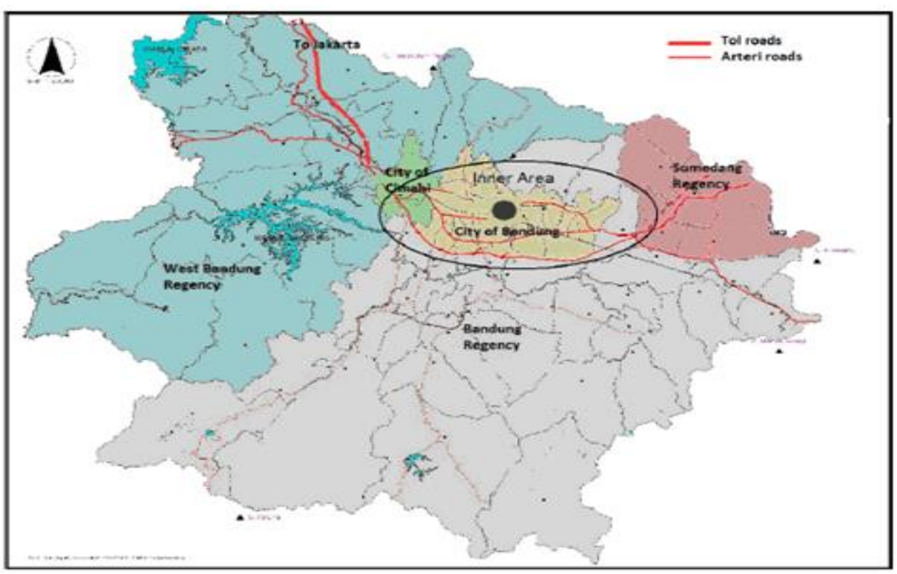

Figure 1 *The Map of BMA (Source: Bappeda Jawa Barat (2006))*

Objective of this Study

This study is aimed at investigating the relationship between the increasing number of private cars in Bandung and their contribution to global warming. It will also ascertain whether all the private saloon cars are unavoidably wanted on the road.

The study will analyse the increase in greenhouse gases in Bandung and cause of average temperature increase in the area.

LITERATURE REVIEW

Transport Situation in the BMA

Literally speaking, the communal transport services that subsist in and around Bandung are no longer adequate to serve the rising demand. Between 2000 and 2009, the middling travel time on working days in the area increased from 30 minutes to 65 minutes. As a result of the survey carried out by Dishub (2010), the condition worsened with the average travel time in the working days at about 50 minutes, and more than one hour particularly during weekend and rush evening hours(the average speed is 515 kph in most artery roads) when guests from Jakarta, and neighboring areas fill up the town centre.

Population Demographics in West Java and the BMA

By 2009 (BPS, 2010), west Java population was 43 million, which was about 18% of the Indonesia's population, for a surface area covering 5% of the Indonesia's total surface area. This makes West Java the most populous province in the country. Covering a surface area of 34,736 km^2, West Java is the most densely inhabited province in the country second to Jakarta province, with an average 1.19 people per square kilometer.

The BMA makes a megalopolis (Figure 1) with more than 8.3 million inhabitants (Table 1), with a surface area of 348,891.38 thousand hectares, whose middling population density is 2153 inhabitants per square kilometer. The inner area has more than 90% of the population, and is forecasted to rise to about 12 million by the year 2030 (77% of the projected highest population of 15 million). The fraction of the population in the inner area is anticipated to decline from 80 per cent as of 1995 to 79 per cent by the year 2030.

Employment and Economy of the BMA

Jobs are concerted mainly in the inner area and the eastern part of the city (Figure 1 and Table 1). More than 30 per cent of the jobs in these zones are in the state-military sector and 53.5 per cent are in the services segment. A small number of employment opportunities exist in the northern and in the southern parts of the city.

The Gross Domestic Product (GDP) of the BMA amplified drastically from 114,572 billion rupiah in 2008 to 123,543 billion rupiah in 2009. This symbolizes a tangible economic growth of 7.83% over a period of one year. This was the first year of considerable growth for the BMA whose GDP growth was earlier 7.53% as recorded in 2004 (Bappeda Jawa Barat, 2010).

Table 1 *Data about Population and Employment in the BMA*

Development Area	Population (000's)				Max. Density(ppm)	Employment (000's)		
	1995	2010	2030	Max		1995	2010	2030
Inner areas(total)	5147	6738	9276	12006	94	2127	3024	4991
	80%	80%	79%	79%		89%	90%	93%
City of Bandung	2235	2452	2890	3225	200	1152	1463	2342
	35%	29%	25%	21%		48%	44%	44%
Rest of inner areas	2912	4186	6386	8781	73	975	1461	2649
	20%	20%	21%	58%		41%	44%	49%
Outer areas	1309	1639	2424	3201		261	322	384
	20%	20%	21%	21%		11%	10%	7%
TOTAL	6456	8377	11700	15207	60	2388	3346	5375
	100%	100%	100%	100%		100%	100%	100%

Rest of inner areas: 1. Ciparay: 2.Rancakek: 3.Padalarang: 4 Soreang: 5. Tanjungsari
Outer areas: 1. Lembang: 2.Pacet : 3. Rendeh: 4. Sindang kerta: 5. Ciwidey
Source: Modified from Bappeda Jawa Barat (2010).

Traffic Condition and Growth in BMA

As of the previous 2 decades, the rise in the GDP of BMA has been trailed generally by an increase in urbanisation and the vehicle population also rose (see Table 2), while the surface area of the roads increased by just 0.5 per cent per year. The private cars population more than doubled from about 120,000 units in 2001 to 243,000 in 2009.

In the year 2009, the population of angkots/minibus declined. According to Dishub (2010), the number of angkot and bus passengers reduced up to 15 per cent and 25 per cent respectively as comapared to the previous five years.

Table 2 *Population of Vehicles in the BMA (000's)*

Year	Motorcycles	Private Cars	Bus	Angkot/minibus
1999	227.6	147	3	5.4
2001**	N/A	120.6	N/A	N/A
2002**	N/A	152.8	N/A	5.2
2003**	N/A	N/A	N/A	5.2
2004	400.7	219.1	3.5	5.2
2005	424.6	229.1	3.5	5.3
2006	448.5	243.7	3.9	5.3
2007	462.2	251.5	3.7	5.4
2008	479.5	260.3	3.7	5.4
2009	512.2	275.7	3.7	5.4
2013	1030.7	318.6	5.3	5.5

**number of private cars reduce by over 15% from 1999 to 2001 and buses reduce by 50% from 1999 to 2001, then rise by over 100% from the year 2002 to 2004. These statistics were a sign of the economic disaster in Indonesia that commenced in the year 1997 until 2003. (Source: modified from Dishub (2010))

Besides the boost in motorization, urbanization in BMA is happening swiftly and population rise in the BMA is anticipated to be high (Bappeda Jawa Barat, 2010). Residential land advancement is diffusing fast in the city out-skirts which lack reputable transport connections to Bandung city centre (the inner area) and other centers. There is a rapid growth in economy and this is anticipated to shoot even greater heights. And thus this will persuade more development of land and most likely will also raise personal vehicle ownership and use.

Previous Studies

A number of research studies analyzing the fate of Indonesia's elevated discharge of greenhouse gases have been put forward; not forgetting the numerous articles relating to the recommended resolutions and agendas that will assist this vulnerable country in combating the change in climate.

The United States Agency for International Development (United States Agency for International Development (USAID), 2008) projected a range of answers to the change in climate problems in Indonesia, such as a biodiversity and sustainable forest management and plummeting energy emissions. Some of these propositions are not new. For instance, the statement from the Indonesian Ministry of Environment (1999) talked about the labors of the United Nations Framework Convention on Climate Change (UNFCCC) to help Indonesia in solving its main change in climate distresses. The report consists of a detailed sketch of the broad programmatic and policy ladders that must be adopted by the Government of Indonesia to fight the problem of climate change. The report also argued out the objectives that must be accomplished in each of the subsequent areas: forestry, energy, transportation, international cooperation, waste, public health, coastal resources, and agriculture.

Indonesia made a commitment of reducing emissions from Greenhouse Gases (GHG) by 29% by the year 2030; therefore this warrants a check of the degree to which local governments and cities can cities can deal with the challenge of climate change mitigation (Gunawan, Bressers, Mohlakoana, & Hoppe, 2017).

The fast increase in population and expansion of human activities have had a detrimental effect on the climate because of anthropogenic emissions sources. Worldwide, the transport sector is responsible for 26% of global CO_2

emissions and is among the few areas where emissions are still on a rise (Gunawan et al., 2017).

Each year that passes, the number of vehicles in Bandung City (the third largest city in Indonesia) increases by 1015%. Besides that the increase in road construction has been at 0.45% per year thus inevitably rising the congestion in Bandung City (Bigazzi, 2011).

According to Bulkeley and Betsill (2013), the concept of "Sustainable Cities" tackles the issue city governance in relation to coping with change in climate and focusing on enabling actual spatial change, rather than a mere institutional change. Practically speaking, low-carbon cities have been used as a notion to alleviate the change in climate in developed world, predominantly in household energy management.

During the Conference of Parties (COP) 15 in the Copenhagen Accord and G-20 Pittsburgh assembly, the Government of Indonesia (GoI) made a commitment to reduce GHG emissions (Gunawan et al., 2017). This particular commitment was driven by top-down, rather than bottom-up strategies. Implementation challenges in the developing world that lack effective central regulatory regimes and plentiful budgets need the help of bottom-up analysts (Halsnaes, Shukla, & Garg, 2008; Thambiran & Diab, 2011). Three years later following the COP 15, the GoI developed a National Appropriate Mitigation Action (NAMA), which aimed at implementing actions below the national level. However, reducing GHG emissions from the transport sector was not only carried on by the central government, but also local level administration (Gunawan et al., 2017).

According to (Gunawan et al., 2017), the Mayor of Bandung previously prioritized the development of thematic gardens to solve severe existing environmental problems (congestion, street vendors, waste, floods and transportation) ever since he was first elected. One of the aims of this Mayor's policy was to fix climate change problems in a gradual manner. Beside the thematic garden, the Mayor also developed thematic days, which have become routine activities for Bandung citizens. Activities such as; a "car free day" on Sundays, cycling on Fridays and bus rides to schools every Monday, are all aimed at contributing to climate change motogation. The Institute for Global Environmental Strategies (IGES) initiated the workshop for stakeholders in Bandung in 2015 regarding the co-benefits of transport sectors. This workshop was intended on realising sustainable urban transport in Bandung City (Nugroho, 2016).

The mayor of Bandung in 2013 also came up with a "four in one" policy described under Mayor decree No.551/Kep. 582-Dishub/2013 regarding stipulation of zone traffic control and Liability transportation. This required at least 4 People or Passengers in each Vehicle on Specific roads in Bandung.

Many efforts have been tried to counter the issue of greenhouse gases and global warming. However a lot still needs to be done due to the fact that average temperature of Bandung is just going high. I believe levying heavily cars with less passengers will promote responsibility of those car owners and regulate on the ways such cars are used.

RESEARCH METHODOLOGY

Bandung is experiencing adverse climate change, to be specific rapid temperature increase. One of the possible visible reasons for this is the increasing number of cars which produce huge amounts of greenhouse gases, especially carbon dioxide. This study examines the rationale for having this huge amount of private cars on the road relative to the number of occupants per car. This research methodology was chosen because I wanted to be at the exact spot where the traffic congestion is, and try to quantify the magnitude of unwanted cars on the roads and relate it to the excessive greenhouse gases from such cars. And also the fact that the other sources of greenhouse gases such as deforestation and new factories are not evident in the study area.

My focus was on the Gandok triple road junction where two busy roads connect; that is to say Silwangi and Ciumbuleit roads. Ciumbuleit road connects traffic to and fro Lembang, Universitas katolik Parahyangan campus and students' hostels, big residential hotels and apartments, big western restaurants and wedding venues, the busy Cihampelas/Ciwalk mall, setiabudi area, and the main Jakarta road. Silwangi road connects traffic to and fro the zoo, the upper and lower Dago area, University students residences and the Dipatiukur University street. This junction therefore was suitable for the study, also owing to the small size of the roads and long queues of traffic that is always evident around the junction. I was as well able to find suitable areas for making observations and collecting data; for example walking paths where I could stand or walk from, Gandok market verandah where I could sit and Harris hotel parking where I could stand or sit as I observed the cars in traffic.

I looked through the transparent glasses and screens of the cars approaching the junction and noted down information about the number of people in each car. I did this while walking on the walking paths, standing and sitting at Harris hotel lobby and sitting at the market verandah. I used to spend about 50minutes around the junction each day I did the counting. This was done from the months of February to April 2018 during the busy days of Friday evenings and Saturday afternoons. The number of private tinted saloon cars was also noted. My observations campus excluded buses, minibuses, trucks and motorcycles. I was able to count the private saloon cars with; only the driver, less than half the seats occupied, and with at least half the seats occupied by people (Figure 2).

<table>
<tr><td colspan="4">TOTAL NUMBER OF PRIVATE SALOON CARS</td></tr>
<tr><td>TINTED</td><td colspan="3">NON-TINTED</td></tr>
<tr><td></td><td>ONLY DRIVER</td><td>< HALF</td><td>≥ HALF</td></tr>
<tr><td colspan="4">NECESSARY AND UNNECESSARY</td></tr>
</table>

Figure 2 *Research Model*

RESULTS

During the entire study Table 3, a total of 2947 private cars were observed for a period of 10weeks; 598 private saloon cars were tinted (this is 20.3% of the total number of cars studied); 2349 of the cars had non-tinted glasses/screens (this is 79.7% of the total number of cars studied).

Table 3 *Recorded Data of Private Saloon Cars During the Study Period*

Day/date	No of P.C/50mins	Tinted P.C/50mins	Non-Tinted P.C/50mins		
			O.D	H.S.O	H.S.O
Fri, 9th feb 2018	286	64	85	89	48
Sat, 17th feb 2018	294	77	79	84	54
sat, 24th feb 2018	263	52	90	83	38
Fri, 2nd mar 2018	304	62	99	93	50
Sat, 10th mar 2018	310	49	107	101	53
Fri, 16th mar 2018	288	63	94	96	35
Fri, 23rd mar 2018	311	63	102	92	54
Sat, 7th april 2018	287	71	84	88	44
Fri, 13th april 2018	305	40	114	111	40
Sat, 28th april 2018	299	57	92	99	51
TOTAL	2947	598	946	936	467

Note: As seen in the table, P.C means 'private cars', H.S.O means 'Half the Seats Occupied', O.D means 'Only Driver'

Mean of the Data

Mean is given by: $X = \frac{\sum fx}{\sum f}$ where $\sum fx$ is the sum of vehicles for all the sampling days and $\sum f$is the total number of sampling days.

Mean for the total number of private cars $X = \frac{2947}{10} = 294.7 \approx 295$

Mean for the Tinted private cars $X = \frac{598}{10} = 59.8 \approx 60$

Mean for the Non-Tinted private cars with only driver $X = \frac{946}{10} = 94.6 \approx 95$

Mean for the Non-Tinted private cars with less than half filled capacity $X = \frac{936}{10} = 93.694$

Mean for the Non-Tinted private cars with less atleast half filled capacity $X = \frac{467}{10} = 46.7 \approx 47$

The results of the study show that less than 20% of the cars were at least half filled with people, About 40% of the cars had only the driver and about 40% of the cars had more than 1 person but less than the half filled car capacity (Figure 3).

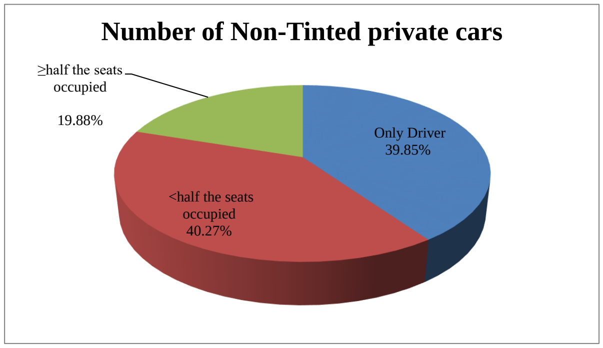

Figure 3 *Categorical Proportions of the Observed Non-tinted Private Saloon Cars*

DISCUSSION

The data was grouped into 3 classes and the statistics was computed in Table 4. The classes included 1 car occupant, 2-3 car occupants and 4-6 car occupants. X was got by computing the mid value (average) of the lower and upper class boundary of each of the car occupant classes. The mean $\bar{X}$ was calculated and it represents the average number of people per single car for the entire data; the variance (σ^2) was got by computing the average of the squared differences from the Mean; Standard deviation (σ) is the square root of variance

Table 4 *Grouped Data Statistics*

Class	Mid (X)	Freq (f)	fX	$X-\bar{X}$	$(X-\bar{X})^2$
1	1	946	946	-1.392933	1.940262
2-3	2.5	936	2340	0.107067	0.011463
4-6	5	467	2335	2.607067	6.796798
		$\sum f = 2349$	$\sum fX = 5621$		$\sum(X-\bar{X})^2 = 8.748523$

Mean $\bar{X} = \frac{\sum fX}{\sum f} = 2.392933$

Variance $\sigma^2 = \frac{\sum(X-\bar{X})^2}{\sum f} = 0.003724$

Standard deviation $\sigma = \sqrt{variance} = 0.061025$

Range = 6 -1 = 5

The Mean is less than 3 passengers per car and falls within the 2-3 class with 936 cars recorded during the study. This value represents the entire population data and it is less than half times the range of the occupants. The Mean value also implies further that 1.61 seats (40%) of the seats of the 4-occupants-capacity car are vacant and 3.61 seats (60%) of the 6- occupants-capacity car are vacant. The standard deviation of the Means instigate more the fact that the dominant class is the 2-3 class. Therefore, an average of 50% of the seats of each car are vacant and wasted. This is translated into 50% of the cars that were on the road during the study period as being unnecessarily required on the road.

Assuming the average capacity of the cars recorded was 5 seats per car (naverage = 5), the theoretical number of occupants (Notheo) for all the tinted private cars would be 11745people as opposed to 4219 people, the actual number of occupants (Noact) as seen in Table 4. The theoretical number of occupants (Notheo) is arrived at if all the car seats in each of the non-tinted cars observed were to be occupied by people. The theoretical number of cars that are supposed to be on the road, assuming each car was filled to capacity with a minimum average of 4 people, is 1054. This figure is 45% of the actual number (2349) of non-tinted private cars that were observed on the road (Table 5).

Therefore, 55% of these cars that were observed during the study period were not supposed to be on the road. They produced an avoidable amount of greenhouse gases. All the Passengers could comfortably and conveniently sit and fit in only 60% of these cars, after putting into account an extra allowance of 15% (otherwise they could theoretically use only 45% of the observed private cars). The factors that account for the extra 15% allowance are related to difference in destinations of the car occupants and other personal disparities.

Table 5 *Comparison of the Actual and Theoretical Data of the Study*

P.C Category	Actual No. of P.C (N_{ctheo})	Minimum No. of Occupants per Car(n_{min})	Actual No. of Occupants of P.C ($N_{oact} = N_c * n_{min}$)	Theoretical No. of Occupants of P.C ($N_{otheo} = N_{ctheo*}\ n_{average}$)	Theoretical No. of P.C $N_{ctheo} = N_{oact} / n_{average}$, Minimum $n_{average} = 4$
O.D	946	1	946	4730	236.5
< H.S.O	936	2	1872	4680	468
≥ H.S.O	467	3	1401	2335	350.25
TOTAL	2349		4219	11,745	1054.75

Note: As seen in the table, P.C means 'private cars', H.S.O means 'Half the Seats Occupied', O.D means 'Only Driver'

CONCLUSION AND IMPLICATIONS

50% of the cars were unjustifiably available on the road during the study in Bandung city. The Bandung atmosphere is filled up with Carbon dioxide part of which could be easily avoided if human beings became more responsible and sensitive to the environment. Car owners should at least half fill their cars with passengers before going on the road or else be heavily levied. A family should be restricted to having only one car. Alternatively, people or private car owners can resort to public means of transport. This research was limited by the fact that a lot of the private cars were tinted and slightly transparent. It took a little bit more time to make observations. Future direction should focus on how to use the collected revenue to make public transport more comfortable, accessible and convenient for everyone. The general public should be educated and sensitized on the dangers of pollution and global warming to the environment and future generation. They should also be counseled on the use of cars in a responsible way.

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