# POLICY OPTION FOR CONTROLLING CONGESTION IN KOLKATA

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## Abstract

The rising world population and consequent growth in the population of developing nation necessitate the development of a comprehensive urban transport network .India is no exception. Especially in the case of Kolkata the growth in the number of vehicles, diversified modes of transport coupled with the problem of narrow road space contribute towards traffic snarls during peak hours. Various policy options are examined to suggest a policy that may be effective in controlling traffic congestion on roads of Kolkata.

## Introduction

The rise in world population is accompanied by significantly high growth rate (1.8% per cent) of urban residents. In the developing countries, urban populations are growing at the rate of 2.2 percent. The percentage of urban population has gone up from 21 in 1975 to 40 in 2000 in these countries, and projected to reach 56 in 2030 (UGC, 2004). In India these figures are slightly less than the average for developing countries (UNDP, 2005). Along with growing urban populace India's population (presently at 1.2 billion) is growing at the rate of 1.46 per cent (U.N, 2011). To meet this growing demographic pressure Indian towns and cities will require high investments on infrastructural facilities.

Kolkata, located in the eastern India, is around 320 years old and the only mega city in the eastern region. Its expansion is limited by the river Ganges flowing along its western fringe and marshlands in the east. Thus the city has mainly expanded in the north and south directions. Absence of city planning has led to a haphazard city growth. Road coverage is highly restricted. Kolkata covers 185 square kilometer area under the Kolkata Municipal Corporation (KMC). Population, in the city, is 4.5 million and density is 24,760 persons per square kilometer. However, another 4.7 laky (approximately) enter the area (CMDA, 2001) in the daytime, increasing the vehicular density during the day. On the other hand, the total number of registered vehicles, which was a mere 50,000 or so in 1951, rose to 500,000 in 1991, 8,21,291 in 2002-2003, and to 1.07 million in 2005 (ADB, 2005). Yet, as mentioned earlier the road space, as a percentage of total area, is a mere 6%. Moreover, there is a huge diversity in the modes used. For passenger transport, the city has buses, three wheelers, taxis, trams, two wheelers and private cars plying on the roads as well as the metro, trains and water-ferries. There are both public and private buses, and the latter may be further categorized as ordinary buses, chartered buses, school buses, and minibuses. There are also the non motorized forms of passenger transport (rickshaws and bicycles). All of these factors contribute towards traffic snarls, especially during peak hours.

The objective of the paper is to devise a suitable policy option for controlling the problem of congestion in Kolkata.

## Congestion Pricing

A new vehicle entering a congested road, by increasing the level of congestion and reducing the average traffic speed, imposes a cost on the other users of that road. This cost is a negative externality, as it is not taken into account in the private cost (which is the depreciation and operational cost of a vehicle) incurred by the vehicle owners. It can therefore be called a "congestion externality". As discussed the present policy regime in Kolkata does not take into consideration this external cost of congestion. If, then we want to correct this by the introduction of congestion pricing, the estimation of the external cost of congestion would be a prerequisite.

Congestion charges have been extensively discussed in the literature since the concept was pioneered by Arthur Cecil Pious in 1920. It has been applied in various parts of the world with varying degrees of success. The area licensing scheme (ALS), introduced in Singapore in 1975, and is probably the first example of congestion pricing. After 23 years in operation, the ALS was replaced by an electronic version called the Electronic Road Pricing System in 1998. In 2003, the city of London introduced a congestion charge scheme in which vehicles entering a 22 square kilometer zone comprising core shopping. Government, entertainment, and business districts were required to pay a congestion charge of £5 between 7 a.m. and 6.30 p.m. on weekdays. The charge has been increased to £8 since July of 2005. Congestion charges not only help to correct transportation externalities but can also generate a significant amount of revenue. For example, annual revenues generated through congestion charges are much higher than the annual operating costs in Singapore and Norway. Congestion charges are thus designed differently depending on the goals. In Singapore, the United States, and the United Kingdom, the primary objective behind road pricing is congestion relief; whereas in Norway it was initially designed to generate revenue and is currently aimed at raising environmental quality and safety. In Singapore and the United Kingdom, motorists pay charges on a daily basis, unlike the United States and Norway where motorists pay a toll per passage. In Singapore, charges vary, depending on peak and off-peak periods. The primary objective of a congestion charge is to reduce traffic congestion. The congestion tax system introduced in London, for example, led to a reduction in city-center traffic of 12 percent, of which 50–60 percent shifted to public transport (Timeline & Dulal; 2008). It is estimated that daily inbound traffic would be reduced by 5 percent in New York if a toll (set at the level of current tolls on the two parallel Metropolitan Transportation Authority (MTA) tunnels) or a variable charge (with MTA tolls modified to match it) were introduced on the East River Bridge. A London-type congestion charge would reduce daily traffic volume in the city by 9 percent; if full variable pricing were introduced, the reduction could reach 13 percent (Zupan and Perrotta 2003).

## Traffic control in Kolkata

In Kolkata traffic is controlled by adhering to certain traffic control rules and measures. There are also parking restrictions in certain parts of the city. Road users are often fined for violation of traffic rules. The amount of fine is not determined by any study that can provide any scientific basis. Currently, the methods of reducing congestion that are used in Kolkata are (a) to control and restrict traffic (e.g. by the use of traffic lights, allowing only one-way streets), and (b) to build new roads or flyovers. The first, which falls under the "Command and Control" system, is inflexible and fail to provide incentives for changes in travel behavior or modal choices of the commuters. Although these rules roughly take into consideration traffic movements and congestion problems, there has been no scientific study of congestion in Kolkata, so as to be able to impose a tax directly on vehicles that are creating the congestion. The second is expensive and tends to be a temporary solution, as the ease of travel induces an increase in the number of vehicles on the road. It is therefore necessary to look at measures that would reduce the demand for travel, or the use of personal vehicles for travel. The imposition of a congestion tax that is calculated on the basis of congestion externality is fast gaining acceptance as an alternative policy option in cities (of developing countries) like Seoul, Shanghai, Beijing, Guangzhou and Singapore. However, none of the Indian cities has adopted this policy.

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## Implications of congestion tax

In cities like London and Singapore, they could control traffic by imposing certain congestion charges. Congestion charge increases the cost of travel. This may convince the motorist to alter their travel behaviour and take some diversion to other less congested routes. In case of Singapore in 1975, Area Licensing Scheme (ALS) was introduced to alter the travel behaviour. Under this system, only those cars with three or fewer people were charged. The charge ranged between $1.50 to $2.50 per day (Daniel and Bekka, 2000). In September 1998, after 23 years in operation, the ALS was replaced by an electronic version called the Electronic Road Pricing System (ERP), (Keong, 2002). In 2003, the city of London introduced a congestion charging scheme in which vehicles entering inside a 22-square km zone comprising core shopping, government, entertainment and business districts were required to pay a congestion charge of £5 between 7 AM and 18.30 PM on weekdays. The charge has been increased to £8 since July of 2005 (Schmöcker et. al., 2006). The London congestion charging has yielded the following results with respect to control of road congestion.

- Traffic level within the charging zone, has been reduced by 15%
- Traffic congestion in the zone has been reduced by 30%
- Carbon dioxide emissions in the zone has been reduced by 20%
- Reduction in emission of NOx and PM10 from road traffic by 12%
- Number of road accidents in the zone were reduced by 40 and 70 per year
- Bus ridership has increased by 46% over two years
- Time savings occurred as travelling times has been shortened.
- The speed in the congestion zone has increased from 14.3 km / h to 16.7 km/h, which is about a 20 per cent increase.
- The average travel distance by the road users within the charging zone takes about 5 km. (G. Santos and J. Bhakar, 2005)

- The above observations amply demonstrate the fact that by introducing congestion pricing, in London, traffic congestion can be largely reduced.

## Proposed Congestion Pricing Method

The standard economic prescription to internalize the costs of a negative externality is a Pigouvian tax. Pigou (1920) himself argued for a tax on congestion. Also, most economists have supported congestion pricing as congestion pricing represents the single most viable and sustainable approach to reduce traffic congestion (Lindsey, 2006). The objective of this policy is the use of the price mechanism to make road users more aware of the costs that they impose upon one another when traveling during the peak hour, and that they should pay for the additional congestion they create, thus encouraging the redistribution of the demand in space or in time (Button, 1993; Small et al 2007).

Several researchers have presented the methodological steps involved in estimation of congestion externality. Grant-Muller and Laird (2007), Litman (2009) have stated that estimation of congestion externality involves the following steps:

1. Collection of peak and off-peak traffic speed on different categories of road.
2. Calculation of the speed difference between peak period and baseline traffic speed on each type of road and use these results to calculate different components of road congestion externality
3. Using vehicle operating cost models to estimate the additional fuel consumption and pollution emission caused by congested travel.
4. Multiplying delay travel time, additional fuel consumption and emission with unit costs, that is, delay cost / km, additional fuel cost / km, health cost / kg of additional emission of pollutants on a congested road, respectively and summing up to calculate monetary value of congestion externality.
5. Using these estimates to predict the time and total economic savings of specific policy options to reduce congestion.

The baseline traffic speed (Step 2) is based on level of service for different categories of road (Annual Urban Mobility Report published by Texas Transport Institute, in the year 2011). At level of service C (LOS C) the ease of maneuverability declines and average flow speed is 70% of the free flow speed service (LOS) A (free flow traffic). Most economists recommend a more realistic baseline, such as roadway LOS C (i.e., a moderate level of congestion), which maximizes traffic volumes and therefore economic efficiency (Litman (2009), Transport Canada (2006), Taylor (2002)). Also, Bertini (2005) and Cortright (2010) emphasized that baseline transportation speed used for estimation of congestion externality shall be based on LOS C. They have pointed out that shift from moderate congestion to free flow state (LOSC/D to A/B) can increase cost since vehicle efficiency declines at higher speed . On the other hand shift from high to moderate congestion LOS E/F to C/D can save energy and reduce emission. They have pointed out that by shifting from LOS C to LOS a there may be a possible increase in fuel use. Moderate congestion (LOS C) reduces traffic speeds to levels that maximize vehicle throughput and vehicle fuel efficiency, although this can be the starting point of congestion (Zhao and Sisiopiku, 1997).

Various methods that are used to calculate congestion costs (Muller and Laird, 2007), are based on the difference between peak and some baseline travel speed. In several developed countries willingness-to-pay (WTP) has become an institutionally accepted means for deriving monetary values from revealed preference studies. This approach is not however represented among the methods currently applied in the transport sector of the less developed world. Du Due to widespread market failure which detracts from the application of revealed preference methods and the practicalities of eliciting responses to relatively complex surveys in developing countries, the WTP approach has usually been considered inappropriate (Ortuzar et al, 2007). A more economically optimal baseline is LOS C/D (45-55 mph on highways), since this tends to maximize traffic throughput and fuel efficiency, and generally reflects user willingness-to-pay, assuming that most motorists would prefer slightly lower peak-period traffic speeds in exchange for much lower road user fees (Litman,2012).

## Estimation of congestion tax for Kolkata

The encouraging results have prompted the researcher to design a tax scheme for Kolkata. However, the major constraint faced by the researcher is non availability of data on the benefits accrued by the road users while traveling on various modes of transport on the road. To obtain the congestion tax, I would require the marginal cost and benefit curves. I first derive the marginal private cost and marginal social cost curves. There is data on operational and maintenance costs (per kilometer) for each vehicle type in the manual by IRC (2009). The operational and maintenance cost is Rs. 4.3 per km. for a bus, Rs. 1.49 per km. for a car, and Rs. 0.56 per km. for a two-wheeler. As there is no separate data for the three wheeler, I have taken the same cost as for a two wheeler.

Table 5.1 gives the total congestion cost for different traffic flows expressed in PCU. PCU values of different traffic flows are derived using Annexure A. Adding the total private cost for each number of PCUs; we get the total social cost corresponding to each of these PCUs. This is plotted in Figure 5.1.

## Table 1: Calculation of Total Social Cost for Various PCU Values

| Vehicles | P.C.U | Congestion Cost (Rs./Km) | Total Private Cost (Rs./Km) | Total Social Cost (Rs./Km) |
|---|---|---|---|---|
| 3000 | 2314.68 | 5306.47 | 3030.55 | 8337.02 |
| 3500 | 2700.46 | 7352.12 | 3535.64 | 10887.8 |
| 4000 | 3086.24 | 9959.44 | 4040.74 | 14000.2 |
| 4500 | 3472.02 | 13286.2 | 4545.83 | 17832 |
| 4665* | 3599.33 | 14577.3 | 4712.51 | 19289.8 |
| 5000 | 3857.8 | 17554 | 5050.92 | 22604.9 |
| 5500 | 4243.58 | 23084.5 | 5556.01 | 28640.5 |
| 6000 | 4629.36 | 30362.3 | 6061.1 | 36423.4 |
| 6500 | 5015.14 | 40153.5 | 6566.2 | 46719.7 |
| 6664** | 5141.68 | 44107.5 | 6731.87 | 50839.4 |

*** Flow at LOS C ** Flow at LOS E**

**Source: Own Calculation**

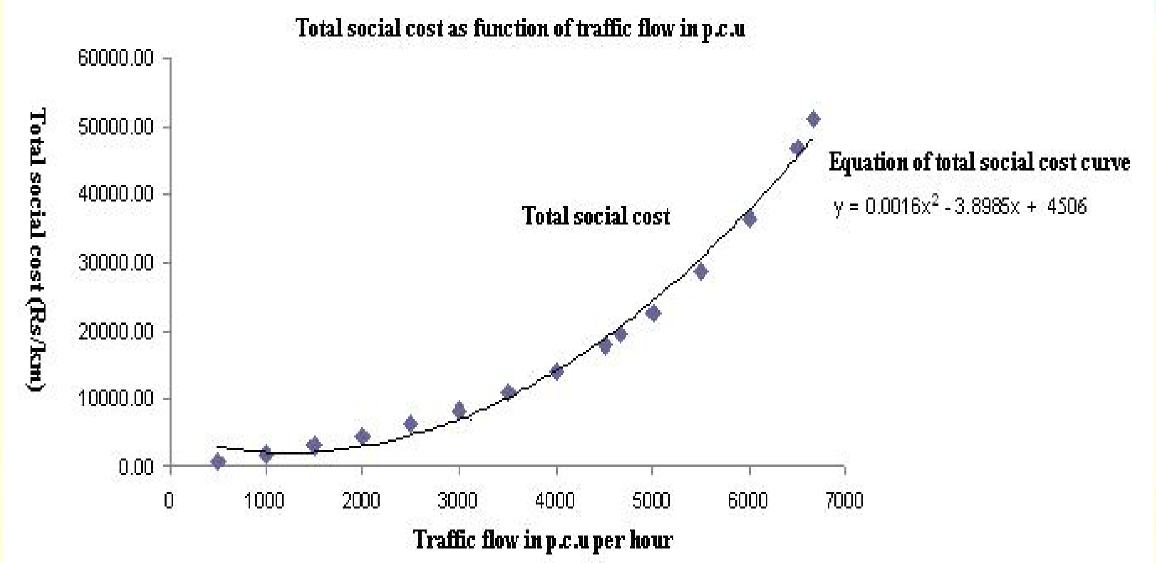


**Fig 1: Total Social Cost Curve**

The relationship between traffic flow in PCU per hour (x) and total social cost (y) can then be derived using Microsoft Excel, where the best fit is obtained from the scatter plot.

Total social cost = 0.0016 x (Flow) 2 – 3.8985 x (Flow) + 4506 -----------------------5.1

Differentiating the total social cost function with respect to traffic flow I get a marginal social cost (MSC) curve having the equation

Marginal social cost = 0.0032 x (Flow) - 3.8985 ----------------------------------------5.2

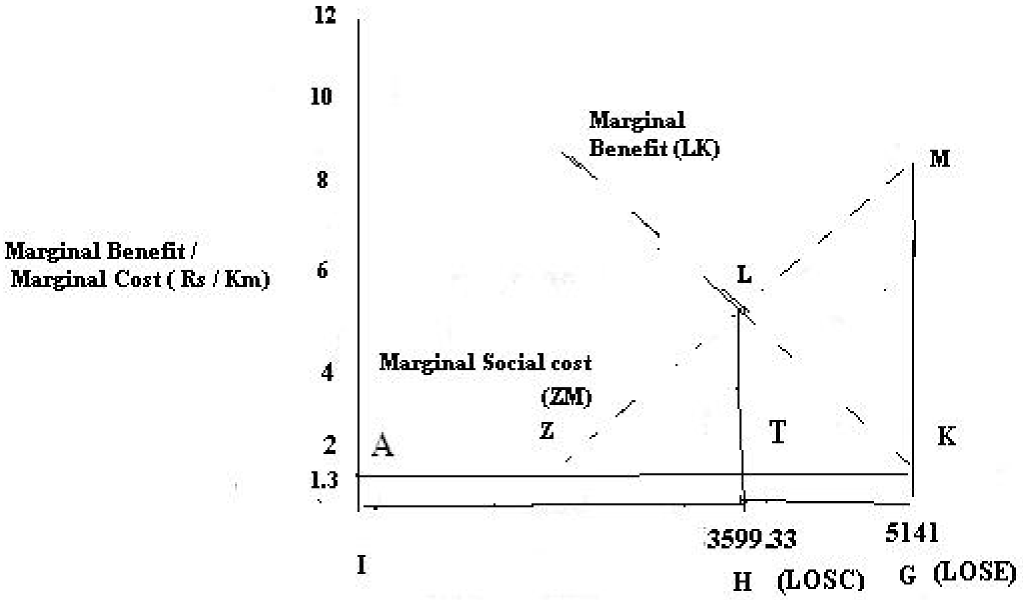
Table 5.2 gives values of PCU (corresponding to various traffic volumes) and their MSCs.

**Table 2: Marginal Social Cost (Rs/km) by PCU**

| Traffic Flow (P.C.U / Hour) | Marginal Social Cost (Rs/Km ) |
|---|---|
| 2314.68 | 2.10 |
| 2700.46 | 3.10 |
| 3086.24 | 4.10 |
| 3472.02 | 5.10 |
| 3599.33 | 5.43 |
| 3857.80 | 6.10 |
| 4243.58 | 7.10 |
| 4629.36 | 8.10 |
| 5015.14 | 9.10 |
| 5141.68 | 9.43 |

Source: Own Calculation

A rising marginal social cost curve is obtained as shown in Figure 5.2. In this figure, the traffic flow in passenger car units (PCU) per hour is shown on the horizontal axis. The vertical axis measures marginal benefit and marginal cost in Rs per km. AK is the marginal private cost, a fixed quantity per PCU.



Left to themselves, vehicle users opt for the level of service E where the traffic flow almost reaches the maximum capacity of the road. If the point G (in the diagram) represents the level of service E, then I can say that the marginal benefit curve intersects the marginal private cost curve at K, corresponding to the point G. We have not obtained marginal benefit, but I can say, on the basis of our previous statement, that it passes through the point K. Let us then draw a tentative Marginal Benefit curve passing through K. At LOS E (point G), the marginal social cost is much higher than marginal benefit and there is a net welfare loss to society as individual vehicle users are not paying for the congestion cost they impose on the other users. The state should then charge a tax equal to the difference of social cost and private cost (MK in diagram) for each PCU at level of service E. After the imposition of this tax, individual vehicle user's costs will be much higher compared to the benefit they derive at LOS E. Thus the number of vehicles on the road will reduce. As LOS C (at point H, say) is the economically optimal baseline and hence the ideal flow (Littman, 2012), the marginal benefit curve should intersect the Marginal Social Cost Curve at L, above H. In other words, the intersection point of the vertical line from H and marginal social cost needs to be the point through which the marginal benefit curve passes. Hence the vehicle users move from the point G to H, where the congestion cost and hence tax per PCU is LT.

The tax (MK) at LOS E is given by

TE = MSCE - MPCE = 9.43 – 1.309 = 8.12,

As PCU at LOS E is 5141.68, and at that PCU, MSC is 9.43 (see Table 5.2), and MPC is a constant at 1.309, the tax (LT) at LOS C is given by

TC= MSCC– MPCC = 5.43 – 1.309 = 4.12,

As PCU at LOS C is 3599.33, and at that PCU, MSC is 5.43 (see Table 5.2) and MPC remains the same at 1.309

Hence, the state should start off by charging a congestion tax of Rs. 8.12 per km. for each PCU, until the PCU drops to the ideal flow of LOS C (3599.33). This optimal would be maintained if the state continues to charge Rs. 4.12 per km. per PCU. This would then be the long term congestion tax. (Table 5.3)

**Table 3: Congestion Tax by Mode (Rs / Km)**

| **Mode** | **P.C.U** | **Tax Per Mode (Rs Per Km)*** |
|---|---|---|
| Bus | 2.2 | 11.4 |
| Car | 1 | 5.2 |
| Two Wheeler | 0.5 | 2.6 |
| Three Wheeler | 1.2 | 6.24 |

*The values are based on derived tax per PCU of Rs 5.2

Source: Calculated by Using Tax per P.C.U Equal to Rs 5.2

In practice, it would be nearly impossible to impose a congestion tax in Kolkata. Congestion tax needs to be differentiated by several factors such as time of the day and trip purpose. Also, speed flow curve is necessary for evolving a uniform tax scheme that can be used in general for all roads in Kolkata. There is difficulty in developing a speed flow curve because it varies from link to link, with variations in lane width, horizontal and vertical alignments, curvature, traffic control measures and other factors. Speed flow characteristic of different roads also depend upon the time of the day, day of the week as well as whether the roads are near CBD area, market places. I have calculated the tax for a specific type of road considering a particular speed flow. Further research is essential to evolve a dynamic taxation scheme using appropriate technology to overcome the difficulty arising out of variations in speed flow characteristics on different type of roads. However, it may be costly to introduce such technology; therefore comprehensive research should be carried out on these aspects. Costly technology is also essential to differentiate taxes considering variations in size, acceleration and braking capabilities and maneuverability.

Congestion varies with unpredictable incident like accident, bad weather, strikes etc. To evolve an effective tax system externalities arising out of road damage and accident should be internalized .Due to lack of relevant data it is difficult to internalize these costs. Such dynamic tax schemes may be both costly and technologically complex to implement in a developing country with scarce resources. It is also necessary to study how far it is worthwhile to introduce such costly technology in an old city with unplanned transport network and extremely limited road coverage of 6%. To end up this discussion it is stated that there are technological, economical or problems of public acceptability for implementation of congestion tax.

In the past few decades, there has occurred a significant demographic growth in urban centers in developing countries. This has exerted tremendous pressure on the existing urban passenger transportation network. An adequate transport infrastructure to accommodate the growing passenger transport fleet is lacking in most Indian cities, and Kolkata is no exception. In Kolkata, during peak hours, the traffic volume in different parts of the city is much above the designed road capacity; as a result, traffic snarls and road congestion are frequent, also, the average traffic speed is very low. In most Indian cities traffic control systems largely consist of certain preset traffic rules, and fiscal instruments are not used to reduce road congestion. But such instruments are being increasingly used in developed countries to change commuters‟ preferences from personal vehicles to high occupancy public transport systems like buses. One such instrument is the congestion tax. This thesis explores the possibility of imposing such a tax in order to solve the problem of traffic congestion in Kolkata.

The actual congestion tax that would be required to reduce congestion to a reasonable level of service (that is not the level at which the traffic flows freely, but a level that ensures a reasonable speed) as well as the tax that would keep the traffic at that level, were then deduced by deriving the marginal cost and benefit curves. Policy options for controlling congestion in Kolkata were discussed, and some of them evaluated and compared to the imposition of the congestion tax with the help of sensitivity analyses. Only those options that can be effective in an old city like Kolkata with limited possibilities for expansions in urban surface infrastructure were considered. Whilst the congestion tax is the most effective, imposing differential congestion taxes based on area and time of day, would be difficult to implement. Hence, ideally, a congestion tax in CBD areas during peak hours can be supported by several additional measures. These include policies to shift road users‟ preferences from private cars to mass transport. This thesis uses secondary data to value the costs on commuters caused by congestion – it would be even better if these costs are evaluated with the help of primary data. Moreover, whilst the congestion externalities are calculated for hypothetical (as well as ideal) flows of traffic, one can apply the results on actual flows in the city to determine congestion externalities. Also, more detailed studies on emission factors with respect to different road types as well as speed flow conditions would have improved the results.

## Conclusion

The problem of traffic congestion in Kolkata is going to take an alarming dimension with increase in urban population. To reduce congestion in Kolkata policy intervention is necessary. In the present command and control policy regime there is little incentive for change in travel behavior of the commuters. In this paper an attempt is made to use international experience in congestion pricing to devise economic instruments to control congestion by imposing of congestion tax

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