Formation of fuel consumption norms for cargo transportation in Vietnam

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Abstract. The unified transport system of Vietnam includes road; rail; river; sea and air transport. Road freight transport has a particularly important role and provides for the delivery of goods, especially in large cities. Transport problems and the problem of improving the quality of freight transport in Vietnam are classified as difficult and still not resolved. The paper analyzes the role of road freight transport in the economy. Here we propose a refined approach to determining the rationing of fuel consumption of trucks and its features in Vietnam conditions. By assessing the influence of various factors on fuel consumption, it is possible to increase the accuracy of standardization and reduce fuel consumption.

Keywords: transport, road freight transportation, operation of trucks, rationing of fuel consumption, fuel consumption of vehicles.

1. The role of road transport for the development of the economy of the Socialist Republic of Vietnam (SRV)

During the years of existence of the SRV, a unified transport system (UTC) has been created in the country, which includes all types of transport: automobile; railway; river; sea; air. The main indicators of the efficiency of the transport system are the volume of cargo transportation, cargo turnover.

Visual representation of the using different types of transport in the transportation of goods for the period 2010–2017 is shown in Fig. 1.

The advantages of automobile transport are the possibility of direct delivery of goods from the warehouse of the sender to the warehouse of the recipient without transshipment operations at short distances, the possibility of centralized delivery and export of goods from stations, sea and river ports. When transporting large cargoes over long distances, preference is given to rail and sea transport.

Statistics show that in freight turnover, the first place is taken by sea transport, and the second place is occupied by road transport; in 2017, maritime transport provided a cargo turnover of 140,442.9 million tkm, while road transport – 63,803.5 million tkm [10].

According to fig. 1 it may be noted that in Vietnam there is an increasing trend in the volume of traffic by all modes of transport. Road freight transport plays a special role in meeting the demand for transport services. Carrying out a significant volume of freight transportation, road transport should essentially become the main carrier, which is facilitated by its objective market advantages.

Currently, SRV road freight transport plays an important role in the country's economy, and has a leading role in the transportation of goods in the country. Every year road transport carries about 75% of all cargo in the country.
The scope of application of road transport in Vietnam is very wide. It performs most of the short intra-district transportation, delivers goods to railway stations, seaports and river piers and delivers them to consumers. In the Northern regions and the Central plateau, where there are almost no other types of land transport, it carries out long-distance inter-district transport. Road transport has a flexible tariff policy, as there are many small motor transport enterprises in the country with different types of ownership.

In addition, it is known that one of the main tasks of road transport is the timely, high-quality and complete satisfaction of the needs of the national economy and the population in transportation, increasing the economic efficiency of their work. With regard to road transport, this can be achieved by improving the efficiency of the use of rolling stock, and energy (fuel).

It should be noted that this task can be achieved not only through the purchase of new vehicles, but also by improving the methods of maintenance and repair, as well as the development of methods for rationing the fuel consumption of vehicles.
Thus, in our opinion, the automobile transport of Vietnam is the most flexible and mass mode of transport. Mass motorization has a significant impact on the development of territories and settlements, on the processes of trade and consumption, on the formation of entrepreneurship. This accelerated development of road transport is due to the following main factors:

- About 80% of production, transport and distribution structures, as well as the majority of settlements do not have access roads other than automobile, which in these conditions determines the uncontested use of automobile transport.
- Automobile transport has the following advantages: high speed of delivery and the possibility of door-to-door and just-in-time delivery, high cargo safety, mobility, maneuverability, accessibility, the possibility of small-lot and container transportation, the possibility of transporting different types at the same time and in small batches.

These features allow us to consider it as the most market-oriented mode of transport. So, all these and other functions put the development of road transport in the category of the most important state tasks, make it an integral part of the economy of Vietnam as a whole.

2. Methodological approach to determining the fuel consumption rates of trucks in Vietnam

The number of vehicles used in Vietnam in 2017 amounted to 2,411,292 pieces. In particular, the number of trucks was 1,004,499 pieces. The annual growth rate of motor vehicles was 11.17% for the period from 2005 to 2017, and the growth of trucks was 12.35% (Fig. 3) [3, 4].

![Figure 3. Dynamics of growth in the number of freight vehicles in Vietnam](image)

The demand for transportation is constantly growing and, accordingly, the number of vehicles increases, which leads to an increase in fuel consumption. By the end of 2017, fuel consumption in road transport amounted to about 16 million tons, according to expert estimates, fuel consumption in 2020 in Vietnam will be 22.4 million tons, and in 2025 – 29.9 million tons. However, at present, domestic oil production meets approximately 40% of the fuel demand and 60% must be imported.

The above-mentioned facts point to the need for resource saving in the field of fuel consumption. Thus, in addition to decisions to modernize and improve the quality of the vehicle fleet by applying new technological advances and improving the quality of transport infrastructure, it is necessary to develop and implement a number of regulatory documents governing operating costs. To solve the ambitious task posed for trucks, it is necessary to develop a system of statistical monitoring in
automobile transport and improve the methods of standardization and estimation of operational fuel consumption.

According to the results of an expert survey conducted by World Bank, in Vietnam fuel costs account for about 65% of the total cost of transportation [8]. Due to the lack of state regulation in the field of rationing of fuel consumption of trucks, enterprises independently set fuel consumption rates for their trucks. The fuel rationing applied to all categories of motor vehicles is widely used by transport companies as follows.

The standard value of fuel consumption is calculated by the formula:

$$M_c = K_1 \cdot \frac{L}{100} + K_2 \cdot \frac{P}{100} + n \cdot K_3,$$

where $M_c$ is the standard fuel consumption, l; $L$ – vehicle mileage, km; $K_1$ – fuel consumption rate for running a vehicle in running condition without cargo (basic norm), l/100 km; $P$ – the volume of transport work, t·km or passenger·km; $K_2$ – fuel consumption rate for transport work, l/100 t·km or l/1000 passenger·km; $n$ is the number of stops, units; $K_3$ – fuel consumption rate for each stop, l.

The actual fuel consumption differs from the values obtained by this method (and most often do not correspond to reality). The calculations show that practically errors can be approximately 20–25%. This shows that the application of this method is not fully suitable for rationing freight traffic in the real conditions of Vietnam at the present time [7].

In Vietnam, most transport enterprises are small and medium-sized private trucking companies that do not have the financial capabilities and human resources to conduct studies on rationing fuel consumption that require large volumes of measurements with a large scale for a long time. The lack of state regulation in the field of rationing the fuel consumption of trucks leads to a lack of coordination in the field of rationing fuel consumption; some problems arise with the management and planning of transport. In addition, the quality of transport infrastructure is low: small width of roads; there is no lane reserved for each type of vehicle, which leads to difficult traffic conditions, etc. Therefore, it is necessary to develop a methodology for standardizing fuel consumption that is close to the actual operating conditions, the advantages of which are unnecessary for long and expensive experiments, a minimum of time spent to obtain a result, etc., which is convenient for practical use by motor transport enterprises workers.

**Figure 4.** Block diagram of the methodological approach to the definition of rationing fuel consumption for trucks
According to the rules of the Ministry of Transport of Vietnam “on the installation of equipment for monitoring trips on vehicles carrying goods (passengers)” of 01.01.2017, it is necessary to install equipment for monitoring trips on trucks. Based on this, a refined approach to standardizing fuel consumption for trucks is proposed, which consists in calculating an individual fuel consumption rate calculated according to the theory of a car based on polynomial dependencies using GPS technologies (Fig. 4) [1–3].

The proposed approach allows us to take into account the following factors that significantly affect fuel consumption:

- road conditions;
- transport conditions;
- natural and climatic conditions for the operation of vehicles.

Thus, it is possible to increase the accuracy of standardization and reduce fuel consumption.

3. The main factors affecting the fuel consumption of trucks in Vietnam

When developing a more advanced fuel management system, it is very important to correctly take into consideration all the variety vehicle operating conditions. Therefore, the features of rationing the fuel consumption of trucks in Vietnam take into account the following main factors.

3.1. Air temperature

Vietnam is completely located in the tropics, and the country's climate is characterized by high rainfall, high humidity, and many sunny days. The average annual air temperature varies from 22 to 25 degrees Celsius. Annual temperature fluctuations in the North range from 15–20° in winter to 22.5–27.5° in summer; in the South-from 26–27° in winter to 28–29° in summer. Almost the entire territory of Vietnam receives more than 1000 mm of rainfall per year, on the hills-from 2000 to 2500 mm. In addition, Vietnam is one of the countries most affected by natural disasters. According to the UN, Vietnam is among the five countries that will be affected most by climate change. Because of its climate, the country is at risk of flooding, drought, salt water intrusion, landslides and flooding due to rising sea levels. These circumstances have seriously affected the transport infrastructure, as well as transport activity in general [8, 10].

3.2. Road conditions

The SRV territory extends in the meridional direction (the distance between the extreme northern and southern points is about 1650 km), and in the latitudinal direction its length is from 616 km in the north (from Mongkai to the Vietnam-Laos border) to 46.5 km in the central part (in Quangbin Province). More than three quarters of the territory is occupied by mountains and plateaus, the country has two large alluvial-delta plains – the Hongha River Delta in the north and the Mekong Delta in the south. These characteristics do determine the spatial distribution of inhabitants and the corresponding transport infrastructures.

Vietnam's road network is divided into six categories: national highways, regional roads, district roads, urban roads, rural roads, specialized roads. Currently, the total length of Vietnam's roads includes more than 200,000 km of highways with the main road Langshon-Hanoi-Ho Chi Minh city passing along the railway, 5 major highways and 104 national highways. As of the road surface, in Vietnam there are 113,989 km of roads with asphalt-concrete, cement–concrete and asphalt coating, which is 52 % of the entire road network (table. 3.1). This means that the condition of the road network does not meet the needs for transportation. Most of the district, rural roads have gravel and soil coating. Approximately 60 % of these roads have less than two lanes. In addition, with the rapid growth in the number of vehicles, traffic jams are increasing along the main transport corridors, especially in the vicinity of large cities such as Hanoi, Ho Chi Minh city and others [6, 9, 10].
Table 1. Characteristics of the Vietnam Road Network

| Road category | Length of road, km | Length of roads by type of road surface, km |
|---------------|-------------------|--------------------------------------------|
|               | Asphalt-concrete  | Cement-concrete   | Asphalt | Grave | Dirt road |
| National      | 19.545            | 9.464             | 344     | 9.301 | 400       | 36       |
| Regional      | 25.335            | 5.474             | 2701    | 14.488| 1.926     | 746      |
| District      | 64.254            | 2.762             | 12.581  | 11.092| 19.957    | 17.862   |
| Rural         | 92.452            | 4.616             | 18.442  | 10.226| 24.907    | 34.261   |
| Urban         | 10.535            | 2.465             | 2.776   | 3.750 | 976       | 568      |
| Specialized   | 6.100             | 2.800             | 160     | 547   | 2.593     | 0        |
| Total         | 218.221           | 27.581            | 37.004  | 49.404| 50.759    | 53.473   |

3.3. Quality of operation of Motor Vehicles

Currently, there are about 1050 automobile transport companies in the transport performing freight transport in the country. Most of them are small and medium-sized enterprises. The privatization process has had a significant impact on road transport and as a result, the role of state-owned enterprises in providing transportation has decreased significantly. This has led to the formation of a market for transport services with a high level of competition. On the one hand, competition is a key element in increasing the ability to meet market requirements and reduce transportation prices. On the other hand, it can cause negative problems. So to reduce initial costs and operating costs, enterprises do not pay attention to the need to modernize the fleet of trucks, reduce the requirements for maintenance and repairing of rolling stock, overload vehicles, etc. This leads to increased fuel consumption, environmental pollution, an increase in the number of road traffic accidents [5].

3.4. Traffic conditions

Each type of transport has its own purpose in the national transport system. However, road transport due to its mobility and the ability to deliver goods “door to door” plays a dominant role in the implementation of freight transport in Vietnam. Road transport is able to meet the needs of the market for the transportation of various types of goods. The main ones are food and industrial products, construction materials.

According to statistics, up to 87% of the cargo volume in Vietnam is transported within 200 km, which is mainly due to domestic trade concentrated around Hanoi and Ho Chi Minh city. In the internal transport model of Vietnam, road transport occupies a large part with short distance freight transportation, but this share decreases sharply with increasing transportation distance (Fig. 5) [10].

The characteristics of road freight transport by city, region and route are presented in tables 2–4 [10].

The analysis of road freight transportation performed by road transport enterprises to various destinations using vehicles of different capacity allows assessing the efficiency of the transport infrastructure as a whole. Heavy trucks are often used for transportation in the industrial cities of Can Tho, Quignon, Danang, Hue, Haiphong, the central and southern parts of the country and at large distances from the cities of millionaires Hanoi, Ho Chi Minh.

The practice of freight transportation in Vietnam has its own characteristics:
- the average operating speed is 30–35 km/h and has some variation depending on the type of rolling stock;
- the utilization rate of the carrying capacity is of the greatest importance for vehicles performing transportation in the central region and on routes to cities with million-plus population. The percentage of rides of trucks returning without cargo is about 4%; compared with the national average of 28%;
- the average annual mileage also differs depending on the routes. The average annual mileage is of the greatest importance (63,000 km) for vehicles performing transportation on routes to cities with
million-plus population

Figure 5. Trucking volumes by distance

Table 2. Characteristics of road freight transport in Vietnam by cities

| Cities                              | Cities of over one million | Industrial cities | Other cities | Countrywide |
|-------------------------------------|----------------------------|-------------------|--------------|-------------|
| Age of trucks, year                | 16,5                       | 17,1              | 17,3         | 16,6        |
| Truck weight, t (a)                | 7,6                        | 12,9              | 8,7          | 8,0         |
| Cargo weight, t (b)                | 14,0                       | 21,1              | 13,3         | 14,6        |
| Overloading, t (c)                 | 8,3                        | 8,5               | 5,8          | 8,3         |
| Cargo weight / Truck weight. (b/a) | 1,8                        | 1,6               | 1,5          | 1,8         |
| Overloading / Truck weight. (c/a)  | 1,1                        | 0,7               | 0,7          | 1,0         |
| Number of times loading-unloading the truck | 45,0                       | 79,8              | 65,1         | 47,6        |
| Percentage of rides without cargo, % | 27,3                       | 40,2              | 28,5         | 28,2        |
| Transportation distance, km        | 499,4                      | 453,2             | 392,5        | 493,7       |
| The duration of the trip, h        | 14,1                       | 12,0              | 9,3          | 13,9        |
| Operational speed, km / h          | 33,7                       | 35,9              | 32,1         | 33,8        |
| Total mileage, km                  | 26750                      | 31338             | 24582        | 27019       |
### Table 3. Characteristics of road freight transport in Vietnam by region

| By region  | Northern | Central | South | Countrywide |
|------------|----------|---------|-------|-------------|
| Age of trucks, year | 17,1 | 17,1 | 15,9 | 16,6 |
| Truck weight, t (a) | 5,8 | 12,0 | 10,4 | 8,0 |
| Cargo weight, t (b) | 10,8 | 18,0 | 19,7 | 14,6 |
| Overloading, t (c) | 6,5 | 6,1 | 9,9 | 8,3 |
| Cargo weight / Truck weight. (b/a) | 1,9 | 1,5 | 1,9 | 1,8 |
| Overloading / Truck weight. (c/a) | 1,1 | 0,5 | 1,0 | 1,0 |
| Number of times loading-unloading the truck | 40,6 | 54,7 | 55,5 | 47,6 |
| Percentage of rides without cargo,% | 27,1 | 3,5 | 31,0 | 28,2 |
| Transportation distance, km | 393,8 | 780,9 | 643,5 | 493,7 |
| The duration of the trip, h | 11,0 | 20,9 | 17,9 | 13,9 |
| Operational speed, km / h | 35,8 | 39,8 | 30,8 | 33,8 |
| Total mileage, km | 22858 | 34424 | 32216 | 27019 |

### Table 4. Characteristics of road freight transport in Vietnam by route

| By route | To cities of over one million | road to international ports / border crossings | road to other cities / nearby rural areas | Countrywide |
|----------|-------------------------------|---------------------------------------------|------------------------------------------|-------------|
| Age of trucks, year | 17,4 | 16,9 | 16,0 | 16,6 |
| Truck weight, t (a) | 10,0 | 9,0 | 6,6 | 8,0 |
| Cargo weight, t (b) | 19,6 | 16,8 | 11,0 | 14,6 |
| Overloading, t (c) | 11,1 | 8,7 | 5,9 | 8,3 |
| Cargo weight / Truck weight. (b/a) | 2,0 | 1,9 | 1,7 | 1,8 |
| Overloading / Truck weight. (c/a) | 1,1 | 1,0 | 0,9 | 1,0 |
| Number of times loading-unloading the truck | 31,2 | 48,0 | 53,6 | 47,6 |
| Percentage of rides without cargo,% | 3,9 | 30,9 | 34,7 | 28,2 |
| Transportation distance, km | 1,516,2 | 343,4 | 226,0 | 493,7 |
| The duration of the trip, h | 42,8 | 13,2 | 6,3 | 13,9 |
| Operational speed, km / h | 31,7 | 34,0 | 34,6 | 33,8 |
| Total mileage, km | 63253 | 22368 | 16426 | 27019 |

### 4. Conclusion

The analysis of transport work performed by different modes of transport shows that the leading operator of freight transport in Vietnam remains road transport. To improve the efficiency of freight...
transport by road, it is necessary to determine the rational structure of the fleet, improve the production technical base of transport enterprises, develop and implement a number of regulatory documents governing operating costs – tire costs, fuel costs, maintenance costs, etc.

Based on the analysis, the following conclusions can be drawn:

1. Due to geographical, social and economic conditions, road transport plays a leading role in the transportation of goods in the country. Goods transported by trucks are mainly food, construction and industrial goods.

2. Transportation by trucks is mainly carried out over short distances (less than 400 km) around two major economic centers: Hanoi in the North and Ho Chi Minh city in the South.

3. Small and medium private motor transport enterprises do not have the financial capabilities to modernize the truck fleet. In addition, experiencing serious competition, enterprises do not pay due attention to the maintenance and repairing works of rolling stock, and trucks, often carry out transportation with significantly exceeded cargo masses from the permitted one, have a low operating speed. This leads to rapid physical aging, deterioration of the technical condition of vehicles, increased fuel consumption, environmental pollution, an increase in the number of road accidents.

4. The main drawback of the current methodology of rationing fuel consumption in Vietnam is the lack of an objective assessment of the operating conditions of vehicles, which makes it impossible to assign exact allowances to the linear norm. The current methodology does not explicitly take into account a number of basic parameters of the transport process.

The above allows us to conclude that the improvement of the current system of rationing fuel consumption is an urgent task that allows more objectively taking into account the operating conditions.

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