Development of 2017 Default Onroad Activity Data

for the National Emissions Inventory

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Introduction

The default 2017 National Emissions Inventory (2014NEI) vehicle miles traveled (VMT) activity data are developed primarily from information provided directly by the Federal Highway Administration (FHWA), along with the FHWA's published Highway Statistics 2017 and data from the U.S. Census Bureau. Additionally, some data came from the 2017 Interstate Highway System (IHS) state vehicle registration database. Default VMT in units of annual millions of vehicle miles traveled were developed at the county, road type, vehicle type, and fuel type level of detail, to be used in the 2017NEI in areas for which no state or local agency provided VMT activity data. The vehicle types used were the thirteen MOVES2014 source (vehicle) types (see Table 1). The road types included were the four MOVES2014 roadway types (see Table 5). The fuel types were the five onroad MOVES2014 fuel types (see Table 6) according to the allowable vehicle modeling combinations (see Table 7).

Data used to generate EPA default data

The 2017 VMT data were developed using data supplied directly by FHWA as well as publicly available data from the 2017 version of FHWA's Highway Statistics data series, which can be found at the following Web site: http://www.fhwa.dot.gov/policyinformation/statistics/2017/.

The Highway Statistics data used in the VMT development include:

- Table VM-2, "Functional System Travel - Annual Vehicle-Miles," and
- Table VM-4, "Distribution of Annual Vehicle Distance Traveled."

The publicly available VM-2 table contains state-level summaries of 2017 miles of annual travel in each state by Highway Performance Monitoring System (HPMS) road type. VM-2 road types include interstate, other freeways/expressways, other principal arterial, minor arterial, major/minor collector, and local for both urban and rural areas. The US Department of Transportation (DOT) was able to provide HPMS VM-2 data at the county level directly to the EPA for most road types. However, not all road types were available at the county level from the US DOT. The road types not available at the county level were rural minor collector, rural local, and urban local.

Table VM-4 contains state-level distribution of annual vehicle distance traveled, expressed by the percentage of vehicle miles traveled by HPMS vehicle type for both rural and urban road type groupings. These grouping fractions were applied to all counties in their respective state to produce VMT by HPMS road type and vehicle type.

US Census population estimates were also used in developing default VMT. This included estimates of 2017 population by county. A ratio of county population to state population was developed for each county in the US to distribute state-level VM-2 VMT data to a county level where the US DOT county-level data were not available. US Census data is available from the following Web site: https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

To assign VMT to fuel types, 2017 IHS vehicle population data by fuel type was used to develop fuel splits by source type. These splits were used to apportion the VMT by MOVES source types, MOVES road types, and fuel type. Splits were developed at the county level for light-duty vehicles and at the state level for heavy-duty vehicles.

For the 2017NEI, vehicle population (VPOP) was derived from 2017 IHS data for light-duty vehicles. 2017 IHS data was not deemed usable for the heavy-duty VPOP due to some redistributions of heavy-duty vehicles that occurred between the 2014 and 2017 versions of IHS data. Instead VPOP splits from the 2016v1 NEI modeling platform (http://views.cira.colostate.edu/wiki/wiki/10202) were used to apportion heavy-duty VMT by HPMS road type and vehicle types to VMT by HPMS road type and MOVES source types. We then used an average miles/vehicle/year to back calculate VPOP for heavy-duty MOVES source types.

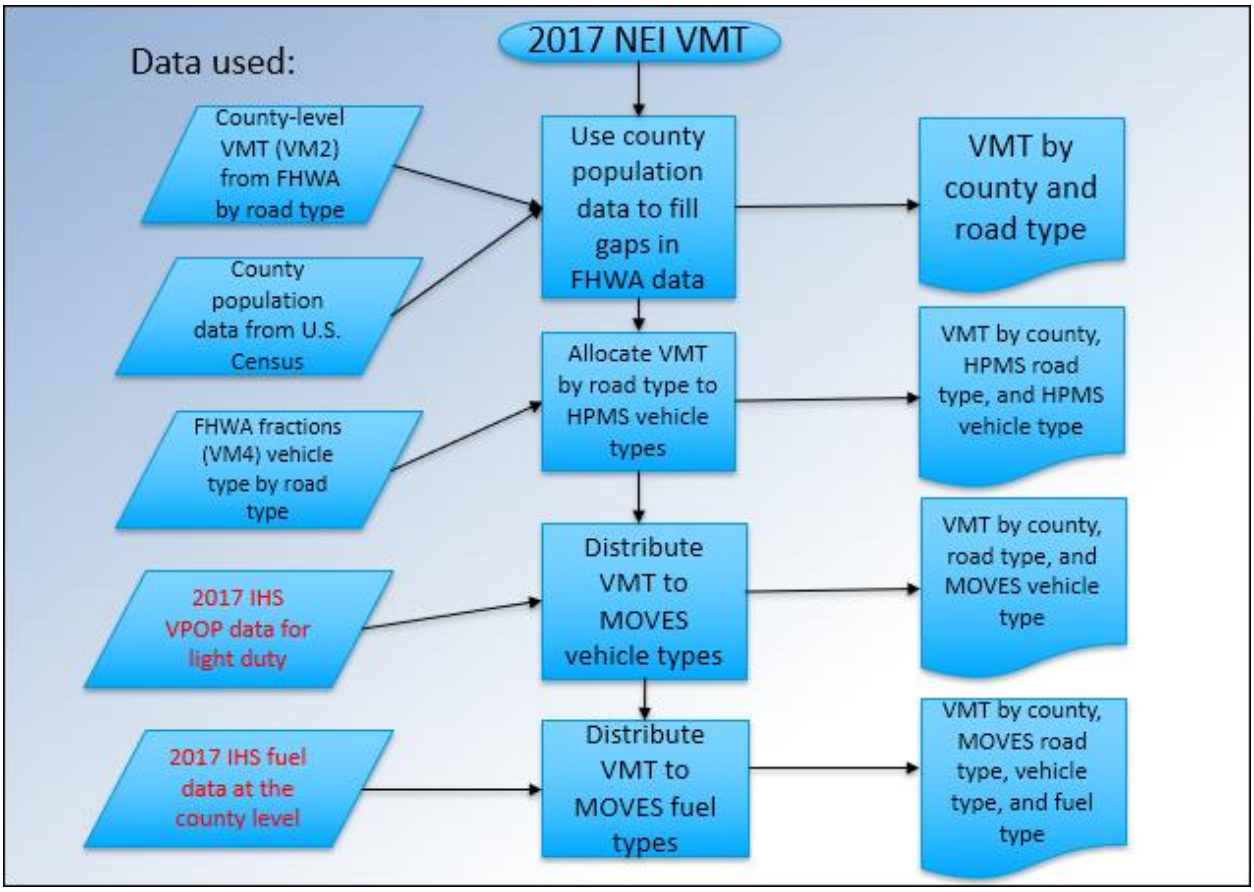
Development procedures for VMT and VPOP datasets

The procedures used in the development of the 2017 NEI default light-duty VMT are broken down into five parts (see Figure 1):

1. FHWA *Highway Statistics* VM-2 state-level VMT along with county-level human population data from US Census used to fill in gaps in FHWA VM-2 county-level data;
2. To allocate county-level VMT by HPMS road type to HPMS vehicle type the *Highway Statistics* Table VM-4 was used to develop VMT by county, HPMS road type, and HPMS vehicle type;
3. To distribute light-duty VMT to MOVES source types the IHS year 2017 vehicle population data were used to develop VMT by county, HPMS road type, and MOVES source (vehicle) type;
4. HPMS road types were combined to the four MOVES2014 road types to develop VMT by county, MOVES source type, and MOVES road type;
5. VMT was distributed to the MOVES fuel types using fractions derived from county-level 2017 IHS vehicle population data by fuel type to develop the final VMT by county, MOVES source type, MOVES road type, and MOVES fuel type.

Each of these steps in the development of the 2017 light-duty VMT is discussed separately below.

Figure 1. Overview of 2017 NEI default light-duty VMT development



Red text depicts differences between light-duty and heavy-duty procedure.

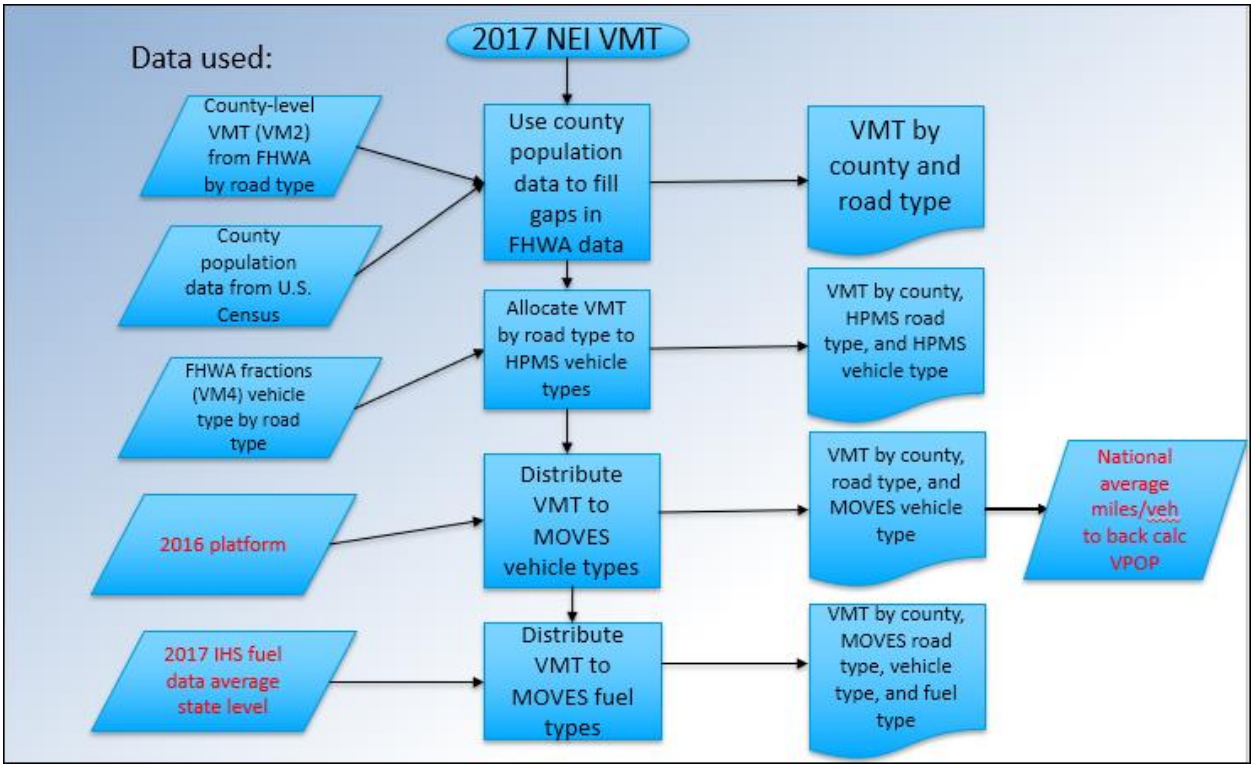
The procedures used in the development of the 2017 NEI default heavy-duty VMT are broken down into five parts (see Figure 2):

1. FHWA *Highway Statistics* VM-2 state-level VMT along with county-level human population data from US Census used to fill in gaps in FHWA VM-2 county-level data;
2. To allocate county-level VMT by HPMS road type to HPMS vehicle type the *Highway Statistics* Table VM-4 was used to develop VMT by county, HPMS road type, and HPMS vehicle type;
3. To distribute heavy-duty VMT to MOVES source types, fractions from the 2016v1 NEI modeling platform vehicle population data were used to develop VMT by county, HPMS road type, and MOVES source type;
4. HPMS road types were combined to the four MOVES2014 road types to develop VMT by county, MOVES source type, and MOVES road type;
5. An average miles/vehicle/year was then used to back calculate VPOP for each heavy-duty MOVES source type.

6. VMT was distributed to the MOVES fuel types using fractions derived from state average 2017 IHS vehicle population data by fuel type to develop the final VMT by county, MOVES source type, MOVES road type, and MOVES fuel type. Since some counties did not report certain vehicle/fuel types, but still had those vehicles on the road, state level fuel splits were developed and used at the county level to assure inclusion of those vehicle/fuel types on the roadways.

Each of these steps in the development of the 2017 heavy-duty VMT is discussed separately below.

Figure 2. Overview of 2017 NEI default heavy-duty VMT development



Red text depicts differences between light-duty and heavy-duty procedure.

2017 County-level VMT by HPMS Road Type

Highway Performance Maintenance System (HPMS) VM-2 county-level data from the US DOT contains the majority of the road types of interest. However, rural minor collectors and rural and urban locals (HPMS types RminCOLL, RLOC, and ULOC) were not available. For these missing road types, the HPMS VM-2 (state-level), Functional System Travel - Annual Vehicle-Miles (http://www.fhwa.dot.gov/policyinformation/statistics/2017/) and 2017 county-level US Census data (https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml) were used to fill in VMT for missing road types as follows:

$$2017\ state\ VMT * (county\ population)/(state\ population) = county\ VMT$$

2017 County-level VMT by HPMS Road Type and Vehicle Type

To allocate the county-level VMT by Highway Performance Maintenance System (HPMS) road type to HPMS vehicle type, the Table VM-4, Distribution of Annual Vehicle Distance Traveled (http://www.fhwa.dot.gov/policyinformation/statistics/2017/) was used to apportion 2017 county-level VMT by HPMS road type to HPMS vehicle type as follows:

HPMS vehicle type fraction ∗ county-level VMT=county VMT by HPMS road type and vehicle type

2017 County-level VMT by HPMS Road Type and MOVES2014 Source Type

For this step, HPMS vehicle types were mapped to MOVES2014 source types. The table below illustrates the mapping of the HPMS vehicle types to the MOVES2014 source types:

Table 1. MOVES2014 onroad source types

MOVES sourceType ID	MOVES Source Type Name	HPMSVTypeID	Description
11	Motorcycles	10	Motorcycles
21	Passenger Cars	25	Light-Duty Vehicles
31	Passenger Trucks	25	Light-Duty Vehicles
32	Light Commercial Trucks	25	Light-Duty Vehicles
41	Intercity Buses	40	Buses
42	Transit Buses	40	Buses
43	School Buses	40	Buses
51	Refuse Trucks	50	Single Unit Trucks
52	Single Unit Short-Haul Trucks	50	Single Unit Trucks
53	Single Unit Long-Haul Trucks	50	Single Unit Trucks
54	Motor Homes	50	Single Unit Trucks
61	Combination Short-Haul Trucks	60	Combination Trucks
62	Combination Long-Haul Trucks	60	Combination Trucks

Light-Duty Vehicles

In MOVES2014, the HPMS class for light-duty vehicles (25) denotes the sum of the FHWA Table VM-4 values for long wheelbase and short wheelbase light-duty vehicles. In order to further refine HPMSVType 25, the EPA used data compiled from 2017 state vehicle registration data from IHS to develop county-level fractions to break down HPMSVTypeID 25 into the three light-duty source types needed for MOVES2014 (passenger cars (21), passenger trucks (31), and light commercial trucks (32)) as follows:

2017 HPMSVTypeID 25 VMT ∗ county-level IHS fraction = county VMT by HPMS road type and MOVES source type

Thus, the light-duty source types are allocated in the same proportion as they were found in the county-level 2017 IHS data.

Buses (HPMSVTypeID 40)

2017 IHS data was not deemed usable for the heavy-duty VPOP due to some redistributions of heavy-duty vehicles that occurred between 2014 and 2017 versions of the IHS data. Instead VMT splits from

the 2016v1 NEI modeling platform were used to apportion heavy-duty VMT by HPMS road type and vehicle types to VMT by HPMS road type and MOVES source types. County-level fractions were used to break down HPMSVTypeID 40 into the three bus source types needed for MOVES2014 (intercity buses (41), transit buses (42), and school buses (43)) as follows:

2017 HPMSVTypeID 40 VMT ∗ county-level fraction=county VMT by HPMS road type and MOVES source type

Next, VPOP for the bus category was back calculated using an average miles per bus per year calculated from the 2016v1 modeling platform at the county level. We felt this apportionment was best, as it was representative of state submitted data. Table 2 shows the annual average miles per vehicle, along with the annual VMT from FHWA, which were used to back calculate the vehicle population.

Table 2. Estimated national average annual miles per bus, vehicle miles traveled, and vehicle population

Bus type	Estimated Annual miles/bus	Annual VMT	Vehicle Population
Intercity (41)	38,222	5,613,314,666	146,861
Transit (42)	21,970	3,295,183,321	149,986
School (43)	9,990	8,374,290,923	838,267
Total		17,282,788,910	1,135,114

Other sources were consulted for average miles per bus per year. The National Transit Database (https://www.transit.dot.gov/ntd/data-product/2017-annual-database-revenue-vehicle-inventory) was examined for the transit bus estimated average annual miles. Comparing to the 2017 National Transit Database (looking for all vehicles with a vehicle type of Articulated Bus, Bus, Double Decked Bus, and Cutaway), the average VMT per vehicle (weighted by the number of vehicles) is 33,234 miles per year. Additionally, the US Department of Energy (https://afdc.energy.gov/data/10309), estimates the average transit bus travels 34,053 miles per year. Both sources notably report significantly higher annual mileage for transit buses than the 2016 state submitted data. Although it is not clear from the data sources if and how they distinguish between transit and intercity buses. Additionally, neither of these sources report at the county level.

For comparison for school buses, School Bus Fleet (https://files.schoolbusfleet.com/stats/SBF-StateTransportationStats2017-18.pdf) reported an annual (2019) 7,253 miles/bus, a bit lower than the state submitted data for 2016, but comparable. Additionally, School Bus Fleet does not break down mileage to the county level as did the 2016v1 modeling platform. Furthermore, for comparison, the US Department of Energy estimated school buses travel 12,000 miles per bus per year for 2018 (https://afdc.energy.gov/data/10309).

Single-Unit Trucks (HPMSVtype 50)

In the development of VMT for the 2017NEI for HPMSVType 50 (single-unit trucks), the EPA used activity data from the 2016v1 NEI modeling platform to develop county-level VMT fractions to allocate the HPMSVTypeID 50 into the four single unit truck source types needed for MOVES2014 (refuse trucks (51), short-haul single unit trucks (52), long-haul single unit trucks (53), and motor homes (54)) as follows:

2017 HPMSVTypeID 50 VMT ∗ county-level fraction=county VMT by HPMS road type and MOVES source type

Next, VPOP for the single unit truck category was back calculated using an average miles per truck per year calculated from the 2016v1 modeling platform at the county level. The EPA felt this apportionment was best, as it was representative of state submitted data. Table 3 shows the annual average miles per vehicle, along with the annual VMT from FHWA, which were used to back calculate the vehicle population.

Table 3. Estimated national average annual miles per truck, annual vehicle miles traveled, and vehicle population

Single Unit Truck type	Estimated Annual miles/truck	Annual VMT	Vehicle Population
Refuse (51)	20,374	2,486,884,195	122,062
Single Unit Short-Haul (52)	13,782	70,465,115,979	5,112,837
Single Unit Long-Haul (53)	18,866	40,497,464,792	2,146,594
Motor Home (54)	2,223	3,112,029,773	1,399,923
Total		116,561,494,739	8,781,416

Other sources considered for comparison when determining annual average miles per truck included the US Department of Energy (https://afdc.energy.gov/data/10309), which estimates refuse trucks average 25,000 miles per year; USDOT (https://www.fhwa.dot.gov/reports/tswstudy/v2chap3.pdf), which estimates single unit short-haul trucks average 11,000 miles/year; and National Household Travel Survey (NHTS) (https://nhts.ornl.gov/), which estimates motor homes travel an average of 6,000 miles/year. It is noted that the state submitted data for motor home VMT was significantly less than that estimated by the NHTS.

Combination Trucks (HPMSVtype 60)

In the development of VMT for the 2017NEI for HPMSVType 60 (combination trucks), to determine long-haul (62) vs. short-haul (61) for combination trucks, the EPA used the 2016v1 NEI modeling platform to develop county-level VMT fractions to allocate the HPMSVTypeID 60 into the two combination truck source types needed for MOVES2014 (combination short-haul trucks (61) and combination long-haul trucks (62)) as follows:

2017 HPMSVTypeID 60 VMT ∗ county-level fraction=county VMT by HPMS road type and MOVES source type

Next, VPOP for the combination truck category was back calculated using an average miles per truck per year calculated from the 2016v1 modeling platform at the county level. We felt this apportionment was best, as it was representative of state submitted data. Table 4 shows the annual average miles per vehicle used along with the annual VMT from FHWA, which were used to back calculate the vehicle population.

Table 4. Estimated national average annual miles per truck, annual vehicle miles traveled, and vehicle population

Combination Truck type	Estimated Annual miles/truck	Annual VMT	Vehicle Population
Combination Short-Haul	31,561	62,856,366,744	1,991,583
Combination Long-Haul	85,522	118,749,765,014	1,388,529
Total		181,606,131,758	3,380,112

Other sources considered when determining annual average miles per truck included the US Department of Energy (https://afdc.energy.gov/data/10309), which estimates Class 8 trucks travel 68,155 miles per year on average. This figure does not however distinguish between short and long-haul vehicles. Additionally, the FHWA reports combination long-haul trucks average about 80,000 miles/year (https://www.fhwa.dot.gov/reports/tswstudy/v2chap3.pdf).

2017 County-level VMT by MOVES2014 Road Type, Source Type, and Fuel Type

To assign VMT from the FHWA functional types to the MOVES2014 road types, VMT was combined by the following table:

Table 5. MOVES2014 road types

roadTypeID	Description	FHWA Functional Types
2	Rural Interstate	Rural Interstate & Rural Freeway/Expressway
3	Rural Unrestricted Access	Rural Principal Arterial, Minor Arterial, Major Collector, Minor Collector & Local
4	Urban Restricted Access	Urban Interstate & Urban Freeway/Expressway
5	Urban Unrestricted Access	Urban Principal Arterial, Minor Arterial, Major Collector, Minor Collector & Local

The four MOVES road types (2-5) are thus aggregations of FHWA functional types.

2017 County-level VMT by HPMS Road Type, MOVES2017 Source Type and Fuel Type

To assign VMT to fuel type, the EPA used fuel fraction data from year 2017 IHS vehicle population databases for each MOVES source type. Fuel fractions were calculated at the county level for light-duty vehicles as follows:

$$\textit{county VMT by MOVES road type and MOVES source type} * \textit{county-level fuel fraction} = \textit{county VMT by MOVES road type, source type, and fuel type}$$

For heavy-duty vehicles, we found that some source types were not reported at the county level in some counties, even though it is likely that those source types travel those areas. Therefore, it was determined to apply fuel fractions averaged at the state level to the heavy-duty vehicle types as follows:

$$\textit{county VMT by MOVES road type and MOVES source type} * \textit{state-level fuel fraction} = \textit{county VMT by MOVES road type, source type, and fuel type}$$

MOVES 2014 fuel types and the matrix of allowable source type-fuel type combinations are shown in tables 6 and 7.

Table 6. MOVES2014 fuel types

fuelTypeID	Description
1	Gasoline
2	Diesel Fuel
3	Compressed Natural Gas (CNG)
5	Ethanol (E-85) Capable
9	Electricity

Table 7. Matrix of allowable source type-fuel type combinations in MOVES2014

	Motorcycles (11)	Passenger cars (21)	Passenger trucks (31)	Light comm. Trucks (32)	Intercity buses (41)	Transit buses (42)	School buses (43)	Refuse trucks (51)	Short-haul SUTs (52)	Long-haul SUTs (53)	Motor homes (54)	Comb. short-haul trucks (61)	Comb. long-haul trucks (62)
fuelTypeID													
Gasoline (1)	X	X	X	X		X	X	X	X	X	X	X	
Diesel (2)		X	X	X	X	X	X	X	X	X	X	X	X
CNG (3)						X							
E85-Capable (5)		X	X	X									
Electricity (9)		X	X	X									

References

2016 National Emissions Inventory modeling platform, http://views.cira.colostate.edu/wiki/wiki/10202

Highway Statistics Table VM-2 “Functional System Travel – 2017; Annual Vehicle-Miles”, http://www.fhwa.dot.gov/policyinformation/statistics/2017/

Highway Statistics Table VM-4 “Distribution of Annual Vehicle Distance Traveled”, http://www.fhwa.dot.gov/policyinformation/statistics/2017/

National Household Travel Survey, https://nhts.ornl.gov/

National Transit Database https://www.transit.dot.gov/ntd/data-product/2017-annual-database-revenue-vehicle-inventory

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