# Making Alternative Fuel Vehicles Work for Everyone: Quantifying the Environmental and Equity Potential

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## Background and Key Questions

Burning fossil fuels for transportation accounts for more than one-quarter of carbon dioxide ($CO_2$) emissions in the United States. In addition to fueling climate change, internal combustion engine (ICE) vehicles contribute to urban air quality problems. Portland, Oregon has been a leader in local climate action planning, with aggressive reduction targets (80% less $CO_2$ by 2050). Hybrid electric and electric vehicles (HEVs and EVs) have the potential to reduce fossil fuel use. However, due to price premiums the benefits of alternative fuel vehicles have accrued disproportionately to higher-income households (Fig 1).

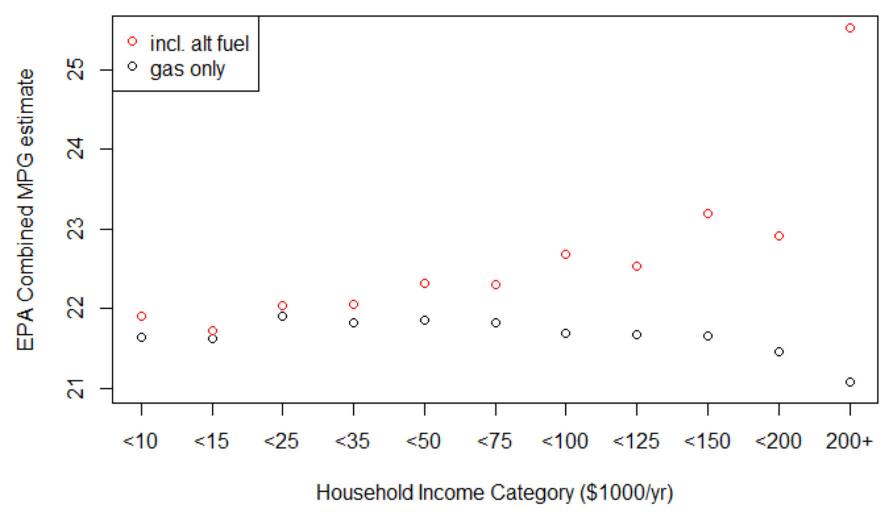



**Figure 1** Average **c**ombined MPG ratings by income with and without alt fuel vehicles (NHTS, 2017; EPA, 2018)

This research asks the following questions

- How much fuel could a region save by replacing some existing personal use vehicles with HEVs and EVs?
- What are the most effective methods for targeting vehicles to replace?
- Are there coordinated strategies that reduce fuel use *and* promote equitable access to efficient and clean mobility?

## Data and Method

We used a combination of national and local data sources to construct realistic policy scenarios (Fig. 2). Each scenario involved replacing a portion of the actual vehicle fleet in the Portland region.

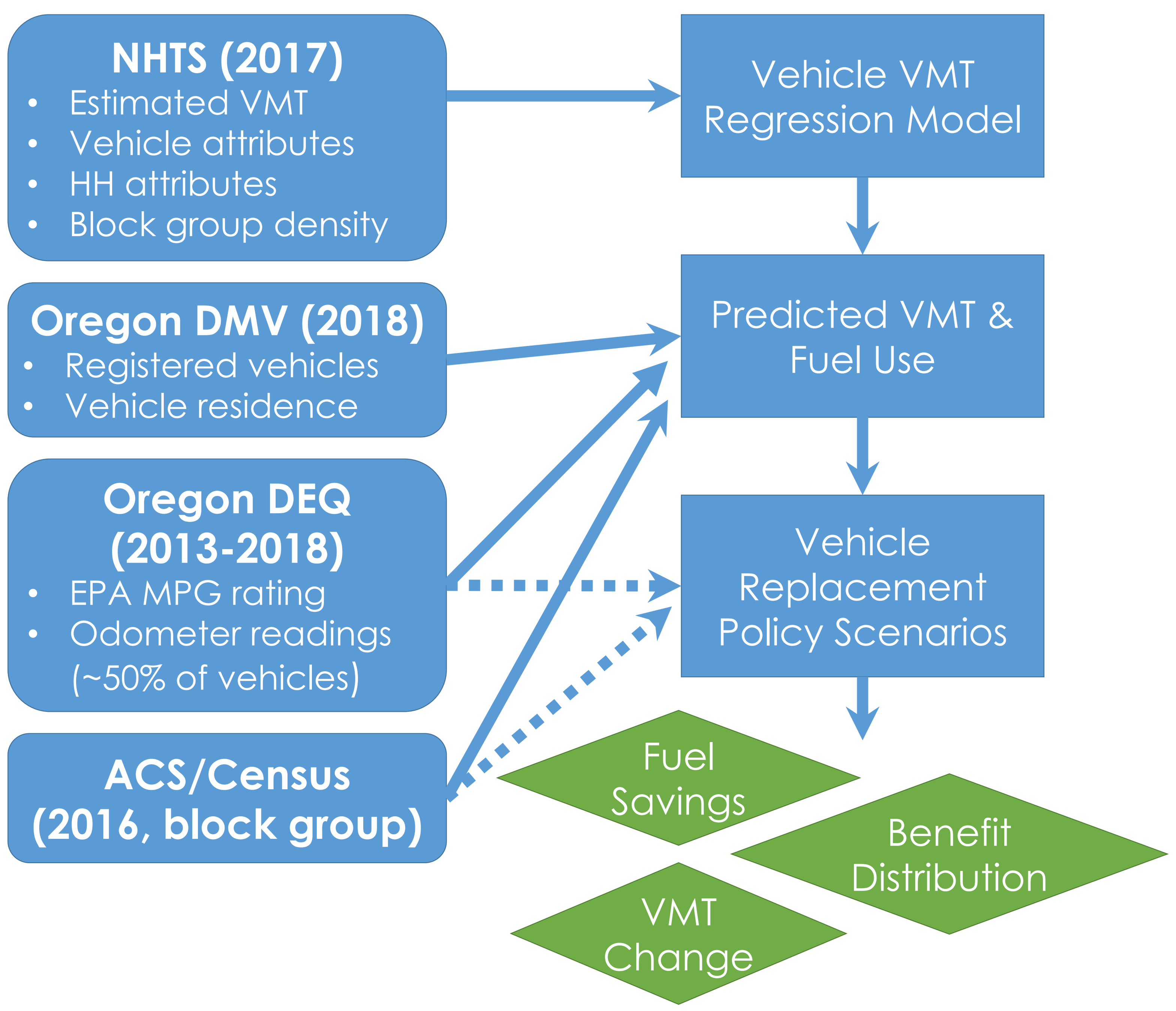



**Figure 2** Data and analysis schematic

## Vehicle Mileage Model

A national model of vehicle-level VMT was estimated in order to predict miles driven before and after policy interventions. We couldn't use local odometer data directly because it was not available for all vehicles and wasn't tied to household characteristics (Table 1).

**Table 1** Vehicle VMT Regression Model

*Dependent variable: Annual Miles Vehicle Driven*

| Variable | Coeff |
|---|---|
| *Vehicle attributes* | |
| Age (years) | -284 |
| Hybrid Gas/Electric | 1319 |
| Plug-in Hybrid | -993 |
| Electric (EV) | -854 |
| Diesel | 2148 |
| Truck | -1† |
| Diesel * Truck | -1717 |
| *Household attributes* | |
| Income < $35k/yr | (ref.) |
| …$35k to $75k/yr | 1936 |
| …$75k to $200k/yr) | 3199 |
| …$200k/yr + | 4470 |
| Each additional vehicle | -584 |
| Number of workers | 1553 |
| Number of kids | 488 |
| *Household location* | |
| Log(pop. density) (pop/mi$^2$) | -265 |
| Log(pop. density) * Inc. <$35k/yr | (ref.) |
| …* Inc. $35k to $75k/yr | -180 |
| …* Inc. $75k to $200k/yr | -319 |
| …* Inc. $200k/yr + | -547 |
| Census Region 1: Northeast | (ref.) |
| …Region 2: Midwest | 524 |
| …Region 3: South | 794 |
| …Region 4: West | -137† |
| …California*West | 469 |
| Intercept | 12213 |
| $R^2$ | 0.122 |
| n (vehicles) | 108253 |

"Rebound" effects consider that a newer, more efficient car might get driven more, potentially canceling out a portion of the environmental benefit. We found a rebound effect for HEVs but not EVs (yet). An HEV is driven an extra 1,300 miles per year, all else equal, while plug-in HEVs and EVs are driven 850-1000 fewer miles per year. This might change as the EV market matures.

Lower-income households tend to drive the same vehicle considerably fewer miles. As density increases, though, they reduce the driving they do by less than wealthier households.

## Policy Scenarios

Each scenario replaced 10% of the current ICE vehicle fleet in the Portland, Oregon region with new HEVs or EVs. To make things more realistic, we assumed 20% of vehicles would be targeted, and half of those would be replaced at random. Scenarios varied by how and where vehicles were targeted for replacement (Figs 3 & 4). We also considered versions of each policy with an explicit equity focus as well as an equity-only scenario that replaced vehicles in lower-income areas.

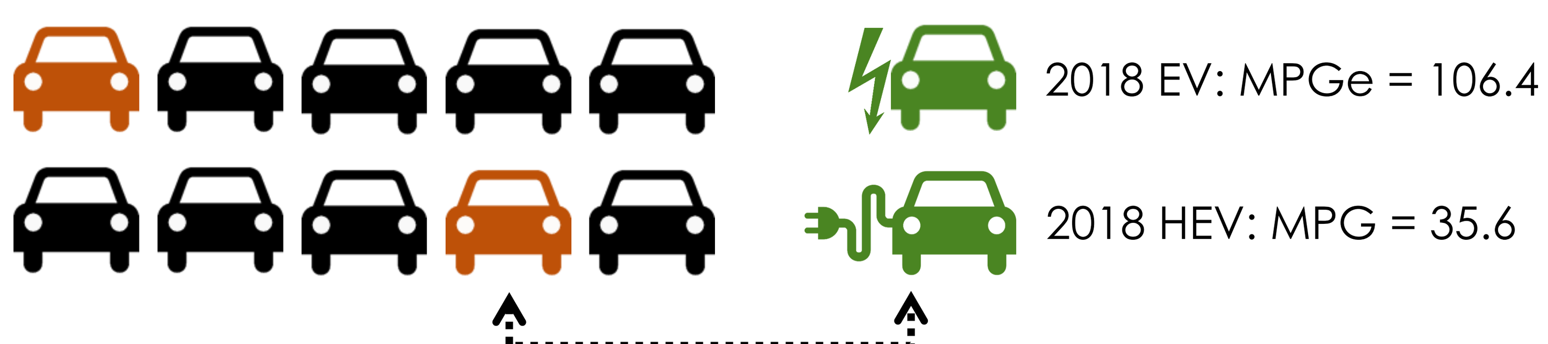
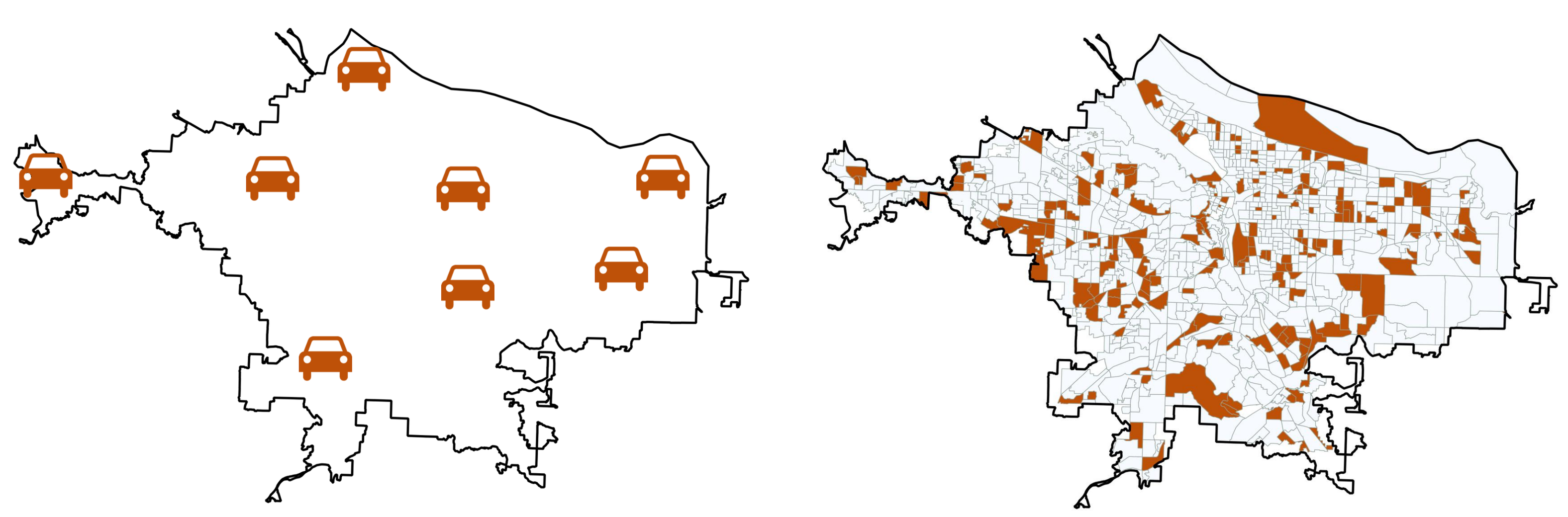



**Figure 3** Target "worst" 20% of vehicles by criterion; replace half (10%)



Target worst individual ICE vehicles region-wide (with and without a preference for lower-income areas)

Target ICE vehicles within block groups "worst" on average for given criteria.

**Figure 4** Geographic options for policy targets

## Results

Estimated fuel savings varied considerably by targeting strategy, ranging from a small increase in use (due to rebound effects) up to nearly 13% savings region-wide (Fig. 5). EVs performed better due to greater efficiency and lack of rebound effects.

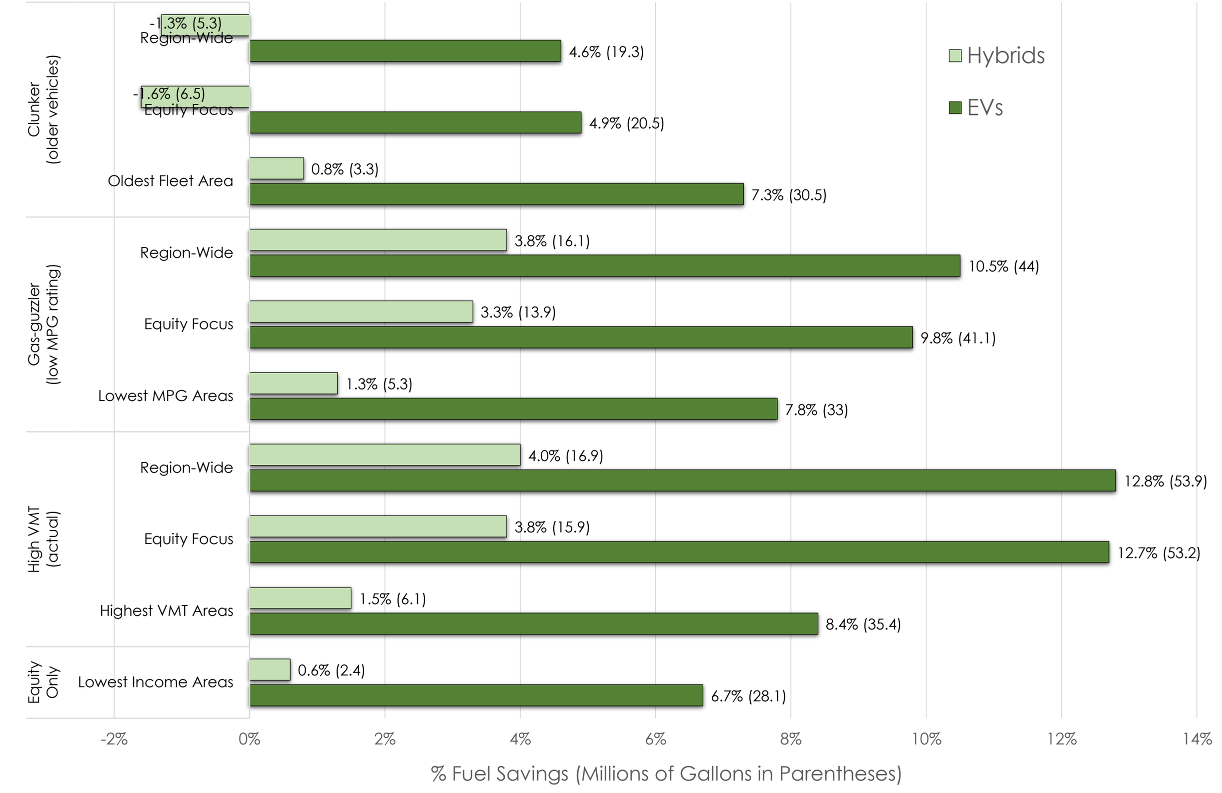



**Figure 5** Estimated regional fuel savings by policy scenario

The share of fuel savings accruing to low-income areas varied by both vehicle criteria and geographic target (Figs. 6-7). Equity-focused scenarios tended to increase benefit capture in lower-income areas by a sub-stantial amount.

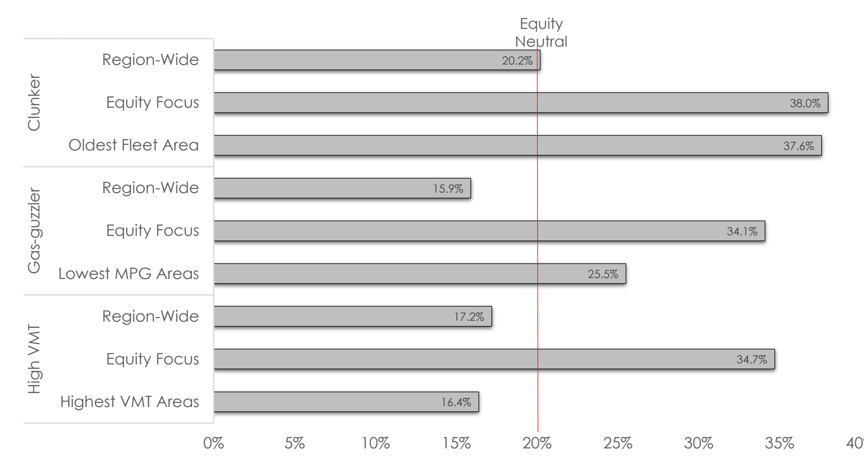
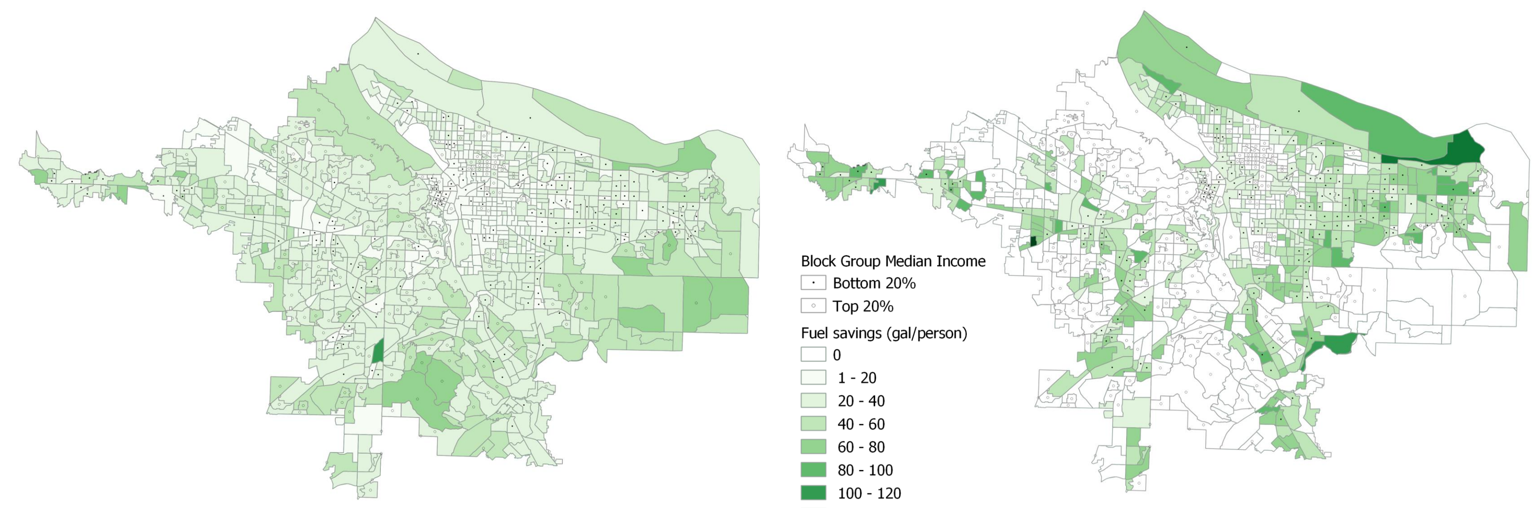



**Figure 6** Share of fuel savings to lowest-income quintile areas (EV scenarios)




No Equity Focus

Equity Focus

**Figure 7** Gas guzzler scenario with and without Equity Focus

## Conclusions

- Replacing 10% of existing vehicles with HEVs and EVs resulted in reducing regional fuel consumption up to 13%.
- Results varied considerably by how and where vehicles targeted for replacement; high annual mileage vehicles made best targets.
- If vehicle mileage data are not available, low-efficiency vehicles make better targets than older ones. Older vehicles are not always inefficient and are subject to potentially high rebound effects.
- Equity-focused policies led to large shifts in fuel savings to lower-income areas with similar overall efficiency gains. Could also increase mobility.
- This work focused on regional and small area impacts. Future work will seek to consider policy effects at household-level.

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