Dynamic Optimization of Natural Gas Refueling Infrastructure for Freight Trucks

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Background

- **Natural gas (NG), both Liquefied Natural Gas (LNG) and Compressed Natural Gas (CNG)** as a vehicle fuel has the potential to be successful in select vehicle market segments based upon **favorable economics.**
- Success for LNG is an integrated network of **public access stations** and LNG infrastructure across the country that can support significant penetration of LNG natural gas vehicles (NGVs) for **long distance, cross-country travel**.
- Successful LNG infrastructure implementation seeks to minimize one or more of the three main cost components of the **LNG supply chain: 1) Feedstock Gas Cost 2) Liquefaction & Upgrade Cost and 3) Transportation Cost.**
- Renewable Natural Gas (RNG) as a feedstock source can improve to climate considerations of NG as a vehicle fuel.
- With strategic expansion of an LNG infrastructure network in specific regions, successful capture of the LNG Class 8 tractor market promises **attractive economics and large market potential.**
- Strategic and coordinated investments **along heavily used corridors,** such as the establishment of **co-located natural gas stations and diesel truck stops**, will be required to establish infrastructure networks that make LNG a major transportation fuel.

Model

Find the **Profit Maximizing** location to site LNG Refueling Stations and Micro-Liquefaction Plants while still satisfying local route demand. The ideal location will be based on the following factors:

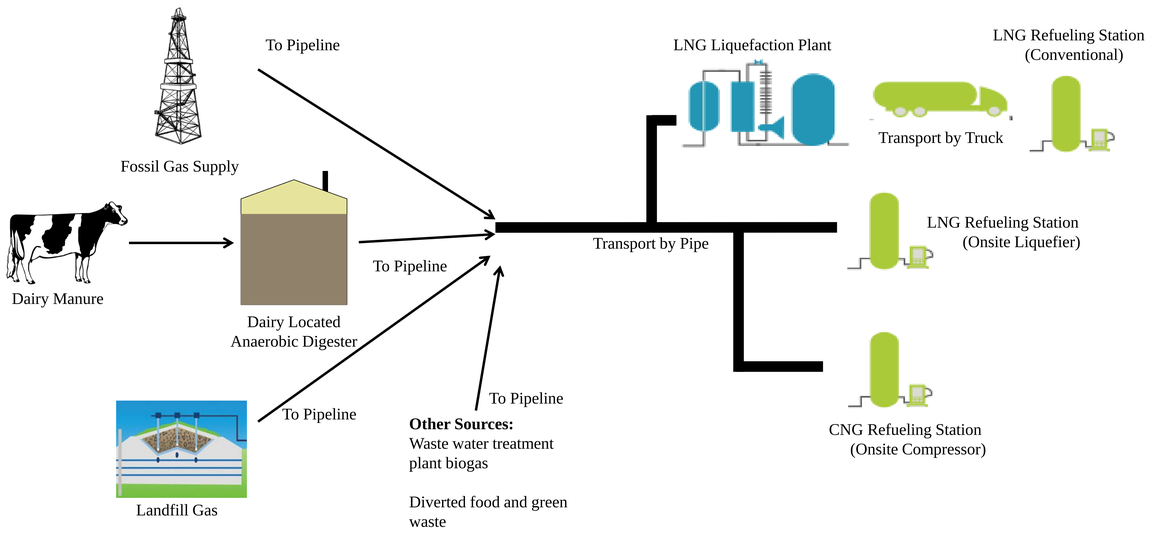
1) **Geography**= Distance to existing infrastructure (i.e. Natural Gas Pipelines, liquefaction plants, renewable gas sources)
2) **Supply** - producers and gas wells, city gate
   - 2a) Fossil Natural Gas
   - 2b) Renewable Natural Gas
3) **Demand**
   - 3a) Class 8 Heavy-Duty Freight Highway Demand
   - 3b) Light- and Medium-Duty Freight Urban Demand

Where are the most **Profitable Routes** which will be needed to be built out first in order to support the growing demand for future LNG Refueling Station Infrastructure

Constraints:

Station construction is evaluated on a **route-by-route basis**. Stations are only constructed if the station combination yields **positive profits for the route** taken as a whole and that the station combination is feasible in the sense that **LNG stations are within the range a LNG truck can travel on one tank** and **CNG stations are within the range a CNG truck can travel on one tank**.

Supply Pathways and Sources



Demand Sources

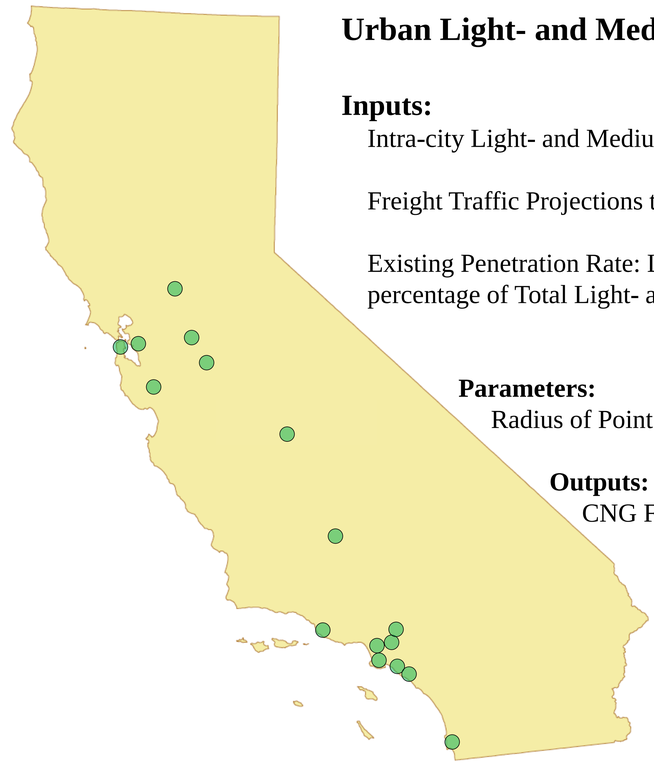
Point Demands for CNG:

1) Approximates localized CNG demand for urban light- and medium-duty trucks for intra-city freight and travel
2) Twenty largest CA cities selected (all > 200k population)
3) Provides additional demand to the model and makes the NG pathway more commercial in the face of low oil and diesel prices

Route Demands for LNG and CNG:

1) Annual Class-8 Heavy-Duty Truck Vehicle Miles Travelled
2) Base Penetration Rate
3) Iterative truck purchase model to update number of natural gas Class-8 Vehicles
4) Dynamically updated penetration rates.

Point CNG Demands for Light- and Medium Duty Trucks



Urban Light- and Medium Duty Point Demand: Sacramento

Inputs:

Intra-city Light- and Medium-Duty Freight Annual Vehicle Miles Travelled

Freight Traffic Projections through 2030

Existing Penetration Rate: Light- and Medium Duty Natural Gas Trucks as a percentage of Total Light- and Medium-Duty Trucks. -Vision Model

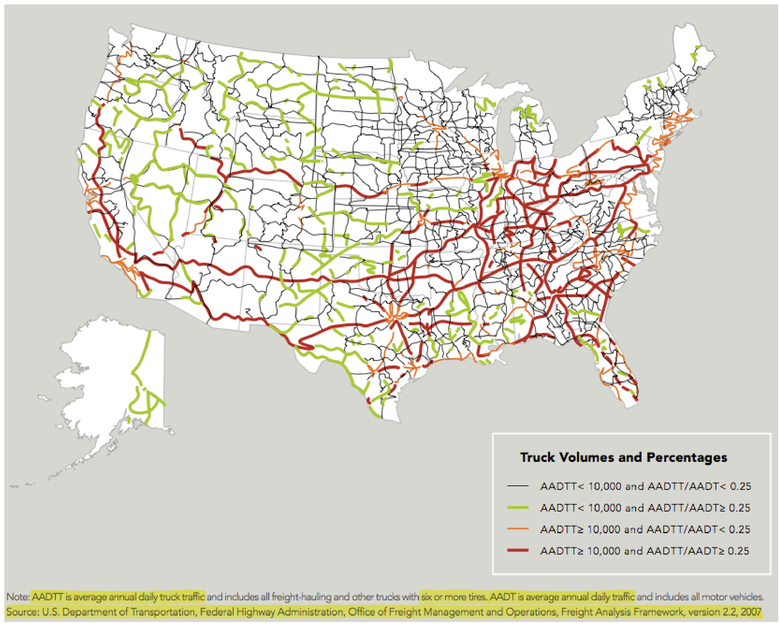
Parameters:

Radius of Point Demand

Outputs:

CNG Fuel Demand within Urban Radius

Route-based Demand for Heavy-Duty Class 8 Trucks



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