How Topographical Data Can Be Leveraged to Reduce Carbon Emissions and Fuel Consumption in Transportation

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Two Reason to Think About Fuel Cut: Climate Change

- "Human activities (primarily the burning of fossil fuels)" causes "concentration of GHG in Earth's atmosphere and warming the planet." (NASA)
- IPCC reports major "IRREVERSIBLE" effects of climate change so far, and in future, including Changes in Precipitation Patterns, Droughts, Heat Waves, Stronger Hurricanes, Rise of the Sea Level.
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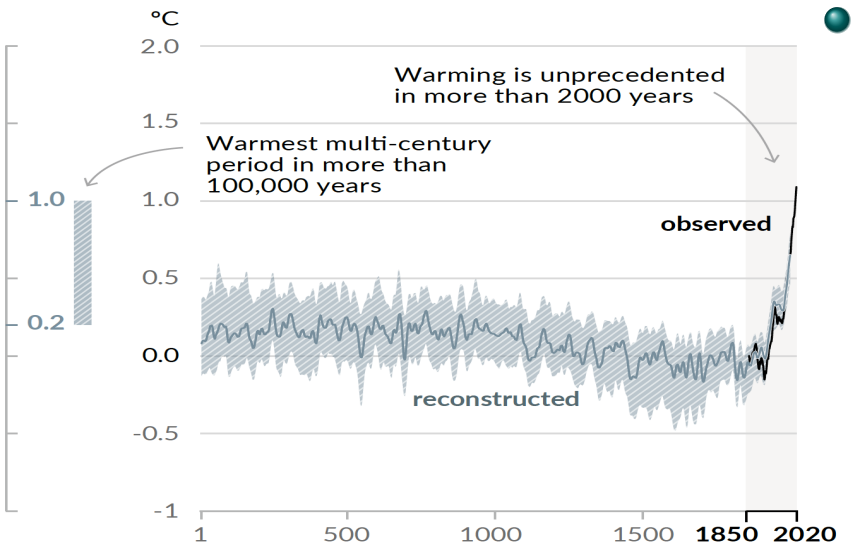

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Figure: Change in global temperature

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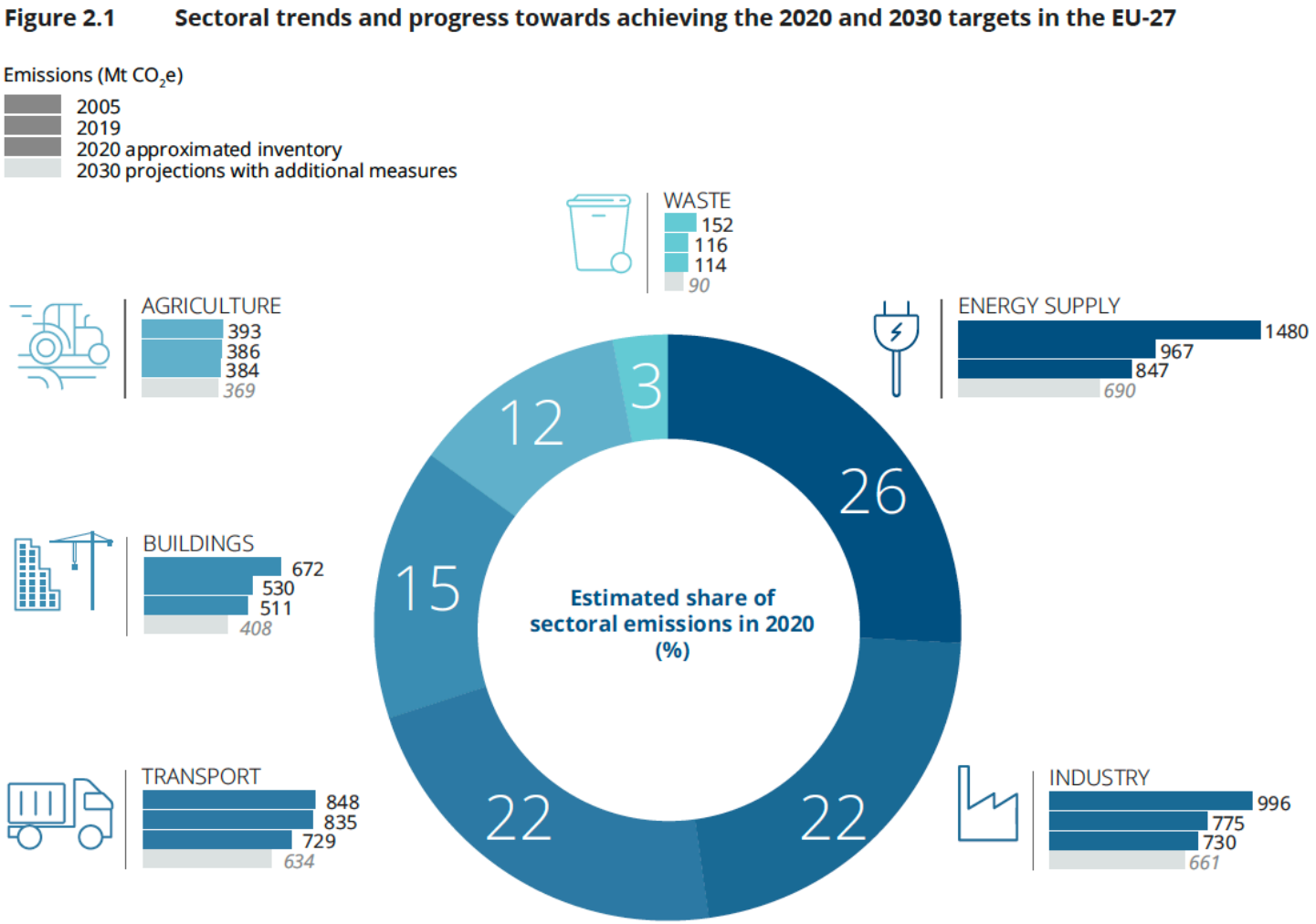

Figure: Source: European Environment Agency

Two Reason to Think About Fuel Cut: Fuel Price Surge

Figure: WTI Oil Price Over the Last Year.

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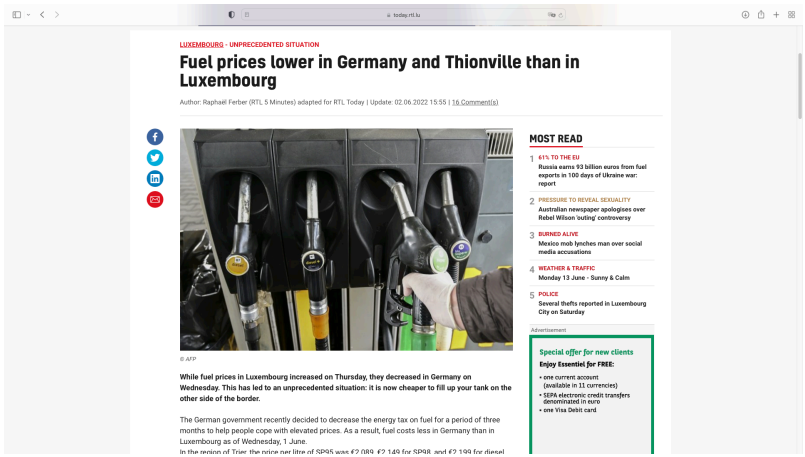

LUXEMBOURG - UNPRECEDENTED SITUATION

Fuel prices lower in Germany and Thionville than in Luxembourg

Author: Raphaël Ferber (RTL 5 Minutes) adapted for RTL Today | Update: 02.06.2022 15:55 | 16 Comment(s)

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While fuel prices in Luxembourg increased on Thursday, they decreased in Germany on Wednesday. This has led to an unprecedented situation: it is now cheaper to fill up your tank on the other side of the border.

The German government recently decided to decrease the energy tax on fuel for a period of three months to help people cope with elevated prices. As a result, fuel costs less in Germany than in Luxembourg as of Wednesday, 1 June.

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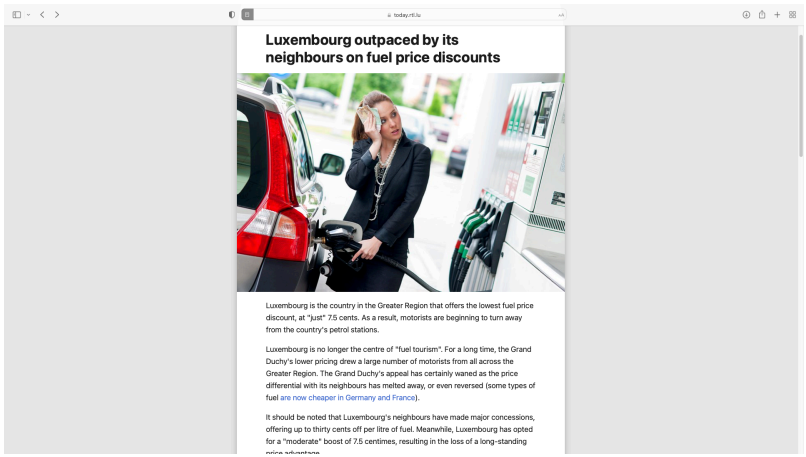
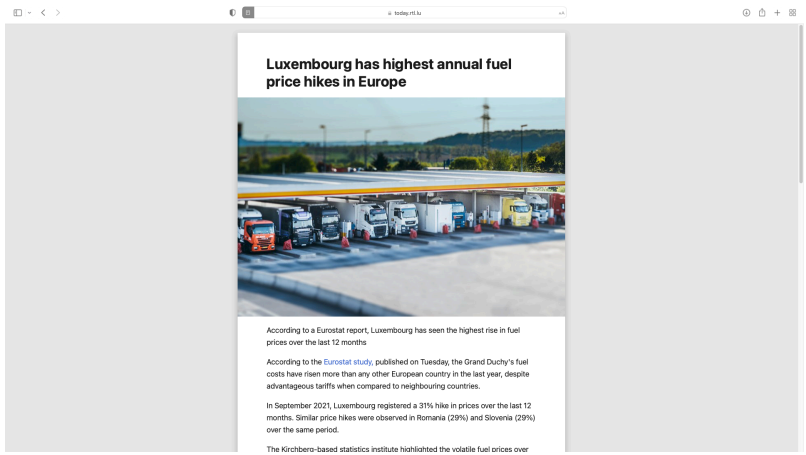


Luxembourg outpaced by its neighbours on fuel price discounts

Luxembourg is the country in the Greater Region that offers the lowest fuel price discount, at "just" 7.5 cents. As a result, motorists are beginning to turn away from the country's petrol stations.

Luxembourg is no longer the centre of "fuel tourism". For a long time, the Grand Duchy's lower pricing drew a large number of motorists from all across the Greater Region. The Grand Duchy's appeal has certainly waned as the price differential with its neighbours has melted away, or even reversed (some types of fuel are now cheaper in Germany and France).

It should be noted that Luxembourg's neighbours have made major concessions, offering up to thirty cents off per litre of fuel. Meanwhile, Luxembourg has opted for a "moderate" boost of 7.5 centimes, resulting in the loss of a long-standing



Luxembourg has highest annual fuel price hikes in Europe

According to a Eurostat report, Luxembourg has seen the highest rise in fuel prices over the last 12 months

According to the Eurostat study, published on Tuesday, the Grand Duchy's fuel costs have risen more than any other European country in the last year, despite advantageous tariffs when compared to neighbouring countries.

In September 2021, Luxembourg registered a 31% hike in prices over the last 12 months. Similar price hikes were observed in Romania (29%) and Slovenia (29%) over the same period.

The Kirchberg-based statistics institute highlighted the volatile fuel prices over

Figure: Unprecedented Fuel Price Increase in Luxembourg

Transportation Emissions Reduction

- Sustainability and profitability entail the fuel consumption reduction.
- Interest in green transportation has been growing over the past two decades.
- Many models have been proposed for emissions in macro and micro levels.
- The effect of several parameters including load/weight, speed, distance, and acceleration have been studied extensively.
- To the best of our knowledge no extensive study has been done to demonstrate the gain as to inclusion of the topographical data in emissions models.

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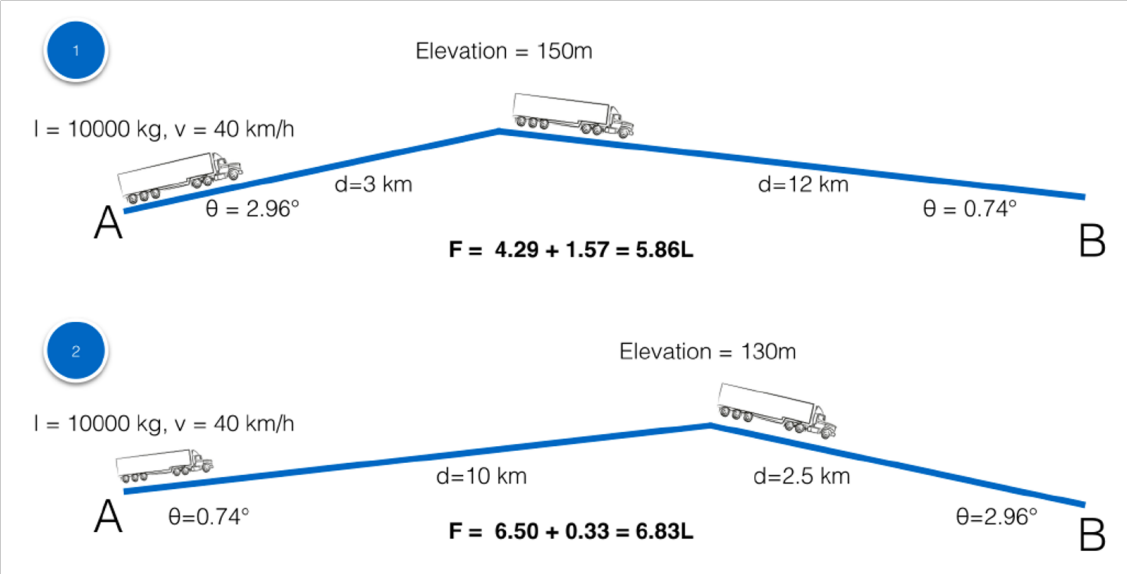

Figure: SP is not Always the LPP

- Consider a class 8 HDD truck.
- Arc 1 is 20% longer.
- Arc 1 reduces fuel consumption by 14%.

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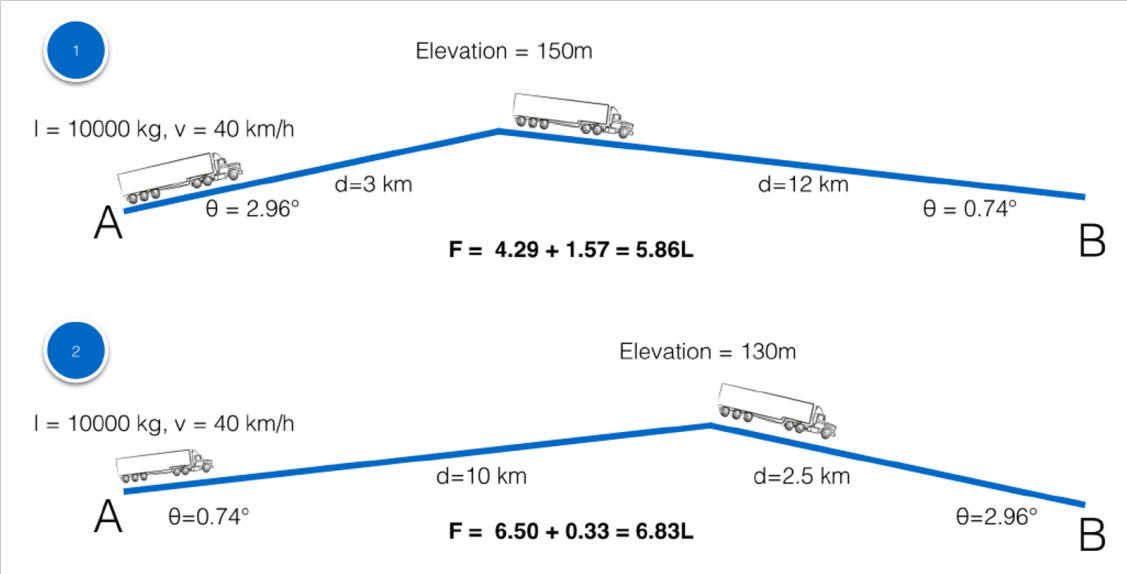

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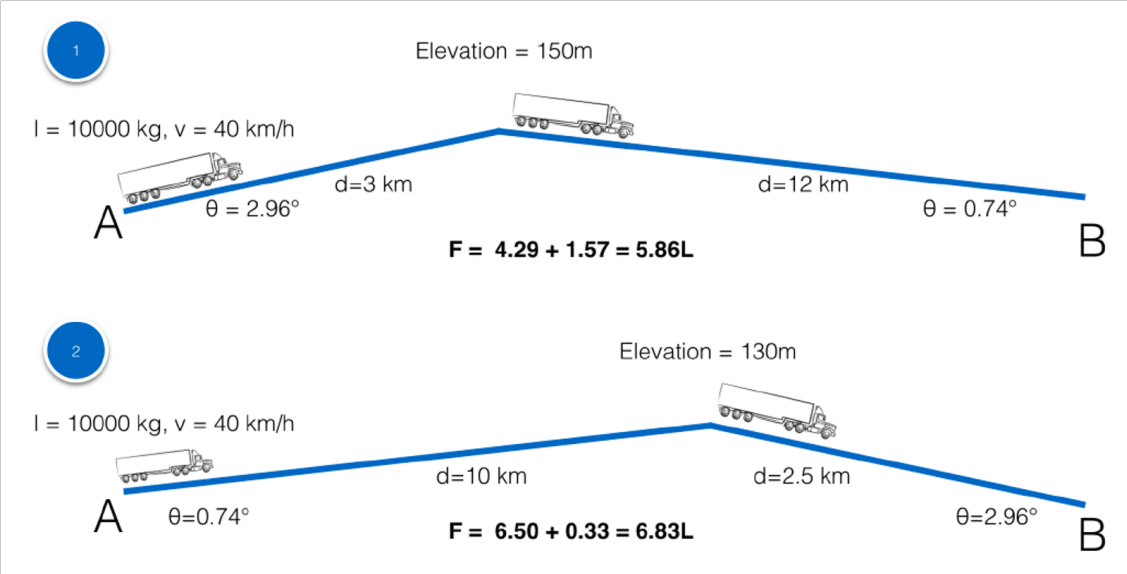

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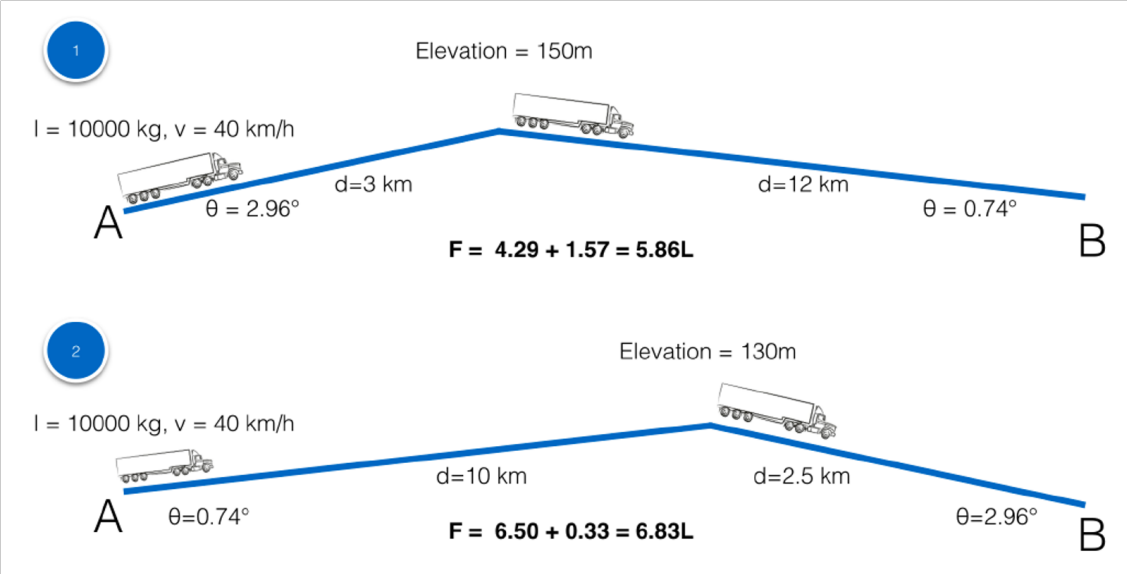

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Large Scale Numerical Experiment Setup

- We consider 24 mostly hilly cities in 5 continents.
- We utilize the Open Street Map data base to form the road network of the cities. Our networks cover $20km$ around the center of each city.
- We use the SRTM 1 Arc-Second Global data sets from the Earth Explorer data base (U.S. Geological Survey). The Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global "elevation data offer worldwide coverage of void filled data at a resolution of 1 arc-second (30 meters) and provide open distribution of this high-resolution global data set."
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- Due to the size of each dataset (several GB) and the required computation power we make use of the high performance server of the LCL's Chair in Digital Procurement.

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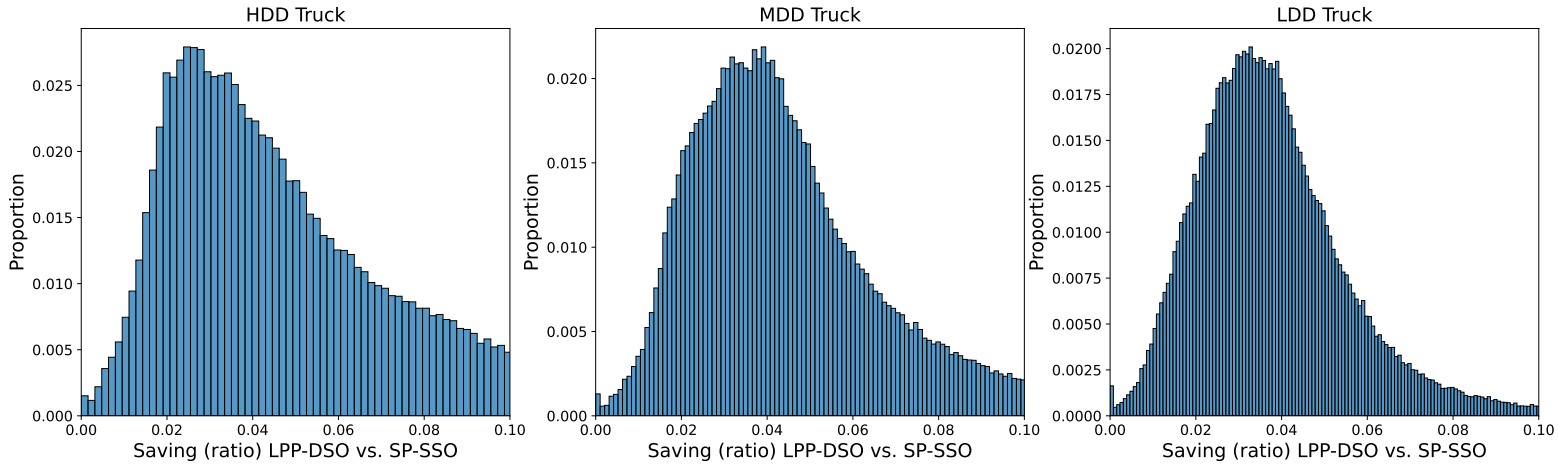

Figure: Saving (%) Through Considering Both Topography and Dynamic Speed Optimization

- Mean saving with 95% confidence: $5.61\% \pm 0.03\%$ for HDD, $4.77\% \pm 0.01\%$ for MDD, and $3.89\% \pm 0.007\%$ for LDD trucks.
- In 25% of cases the saving is greater than: 7.30% for HDD, 6.84% for MDD, and 4.75% for LDD trucks.
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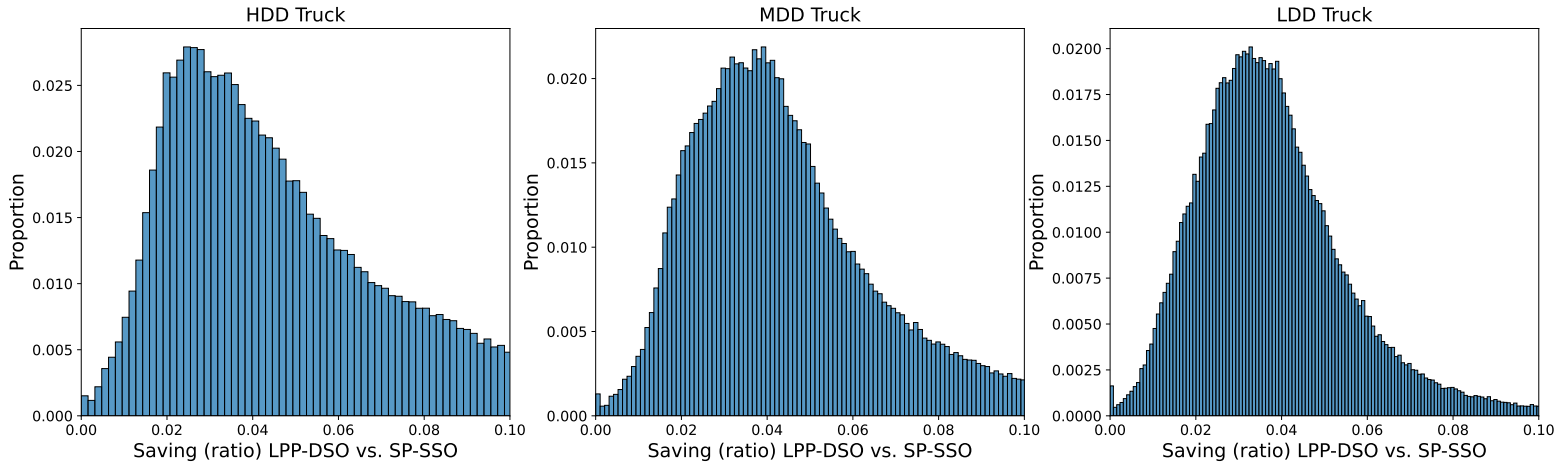

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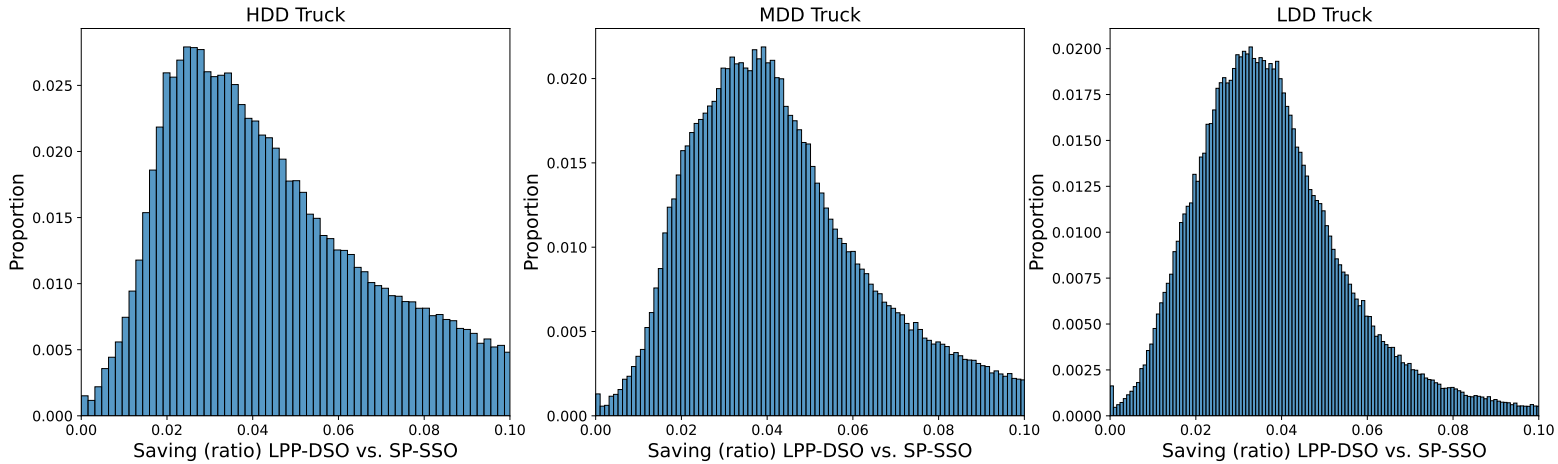

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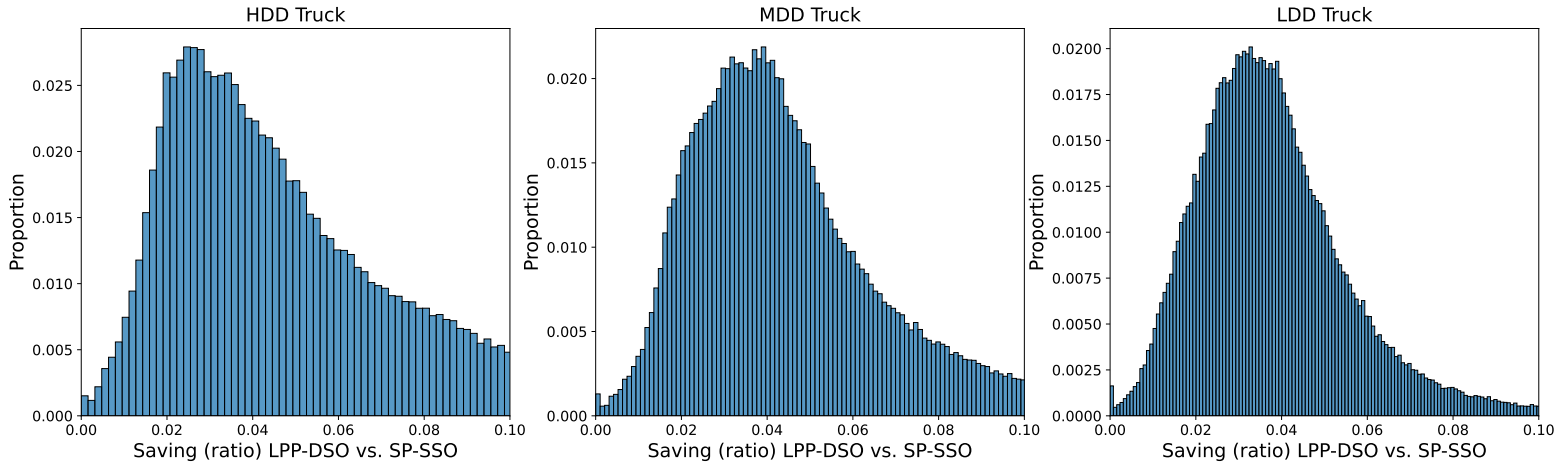

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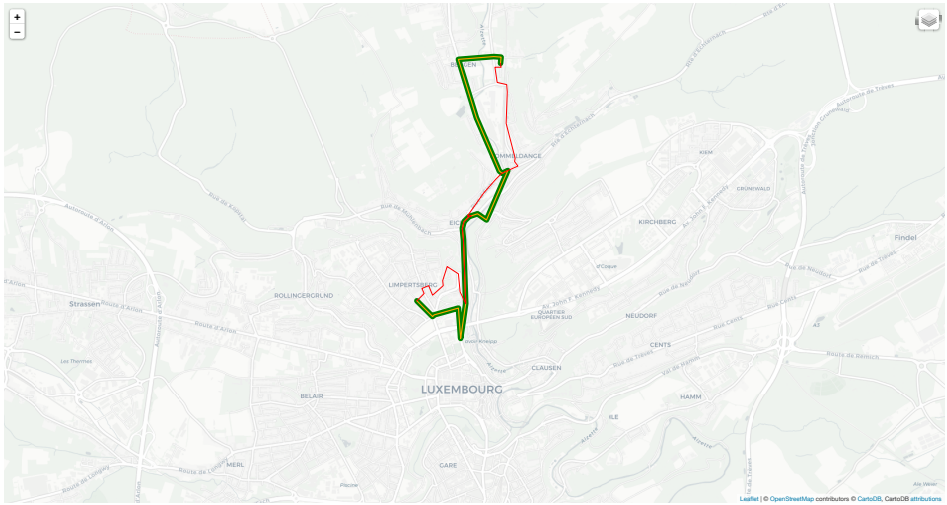
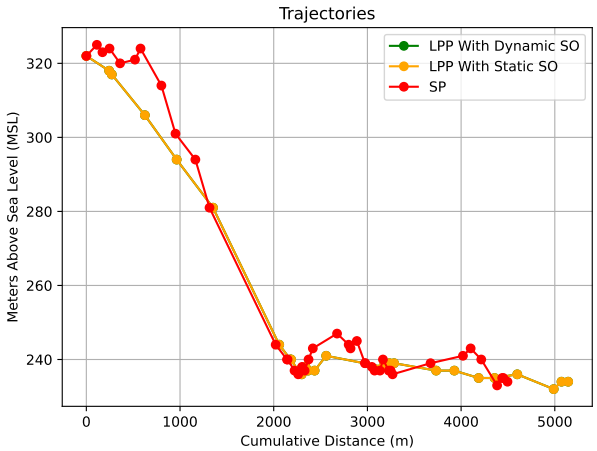
Case 1: Luxembourg, HDD Truck, LPP 14% Longer, 30%-37% Less Polluting





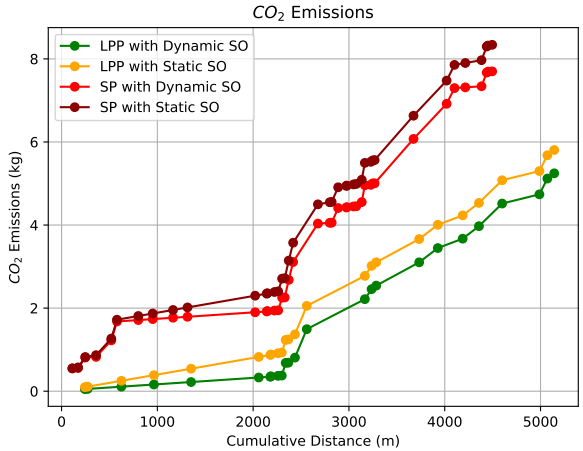
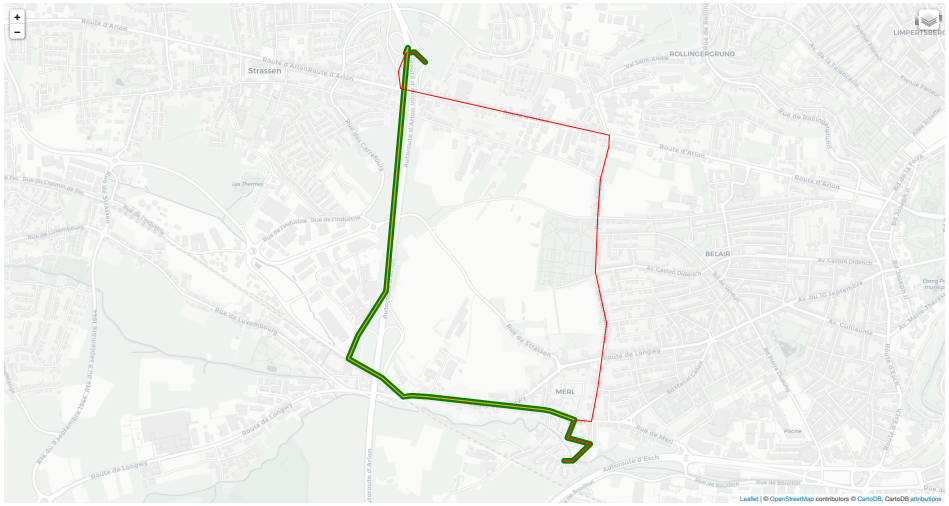
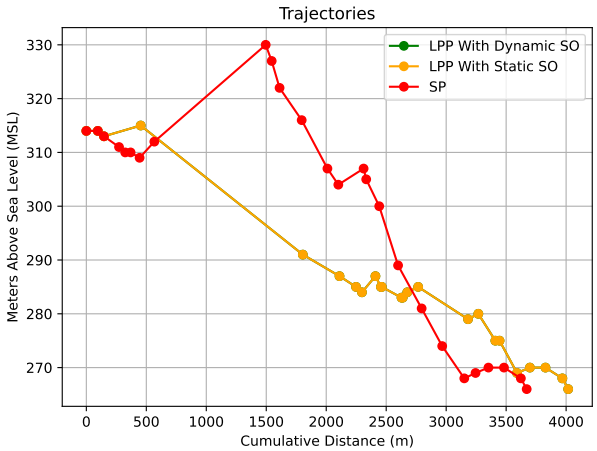
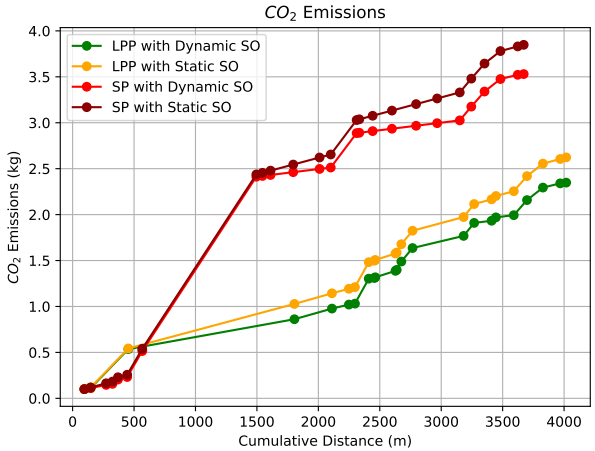


Figure: Red (Thin): Shortest Path, Green (Thick): LP Path with Dynamic SO, Orange (Medium): LP Path with Static SO

Case 2: Luxembourg, MDD Truck, LPP 6% Longer, 45%-46% Less Polluting







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Key Take-Away

- Consider LPP instead of SP or fastest path.
- Using topographical data can improve the CO_2 emissions typically more than speed optimization.
- Computing the LPP requires better digitization and data-driven decision making, yet NO investment in fleet or infrastructures.
- Higher level of digitization and integration of data across companies can help to build more precise emission models to compute the LPP.

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Thank You

Thank You for Your Attention!

E-mail: poulad.moradi@uni.lu