A simulation-based model for the green fleet management: A case of Colombia

Cristiam Gil[a,b], Ana María Montes[a], Andres Rey[a,b], Emrah Demir [b], Wessam Abouarghoub[b], Vasco Sanchez-Rodrigues[b], Gordon Wilmsmeier [a,c]

[a] Universidad de los Andes, Bogota, Colombia

[b] Cardiff University, Wales, United Kingdom

[c] Kühne Logistics University (KLU), Hamburg, Germany

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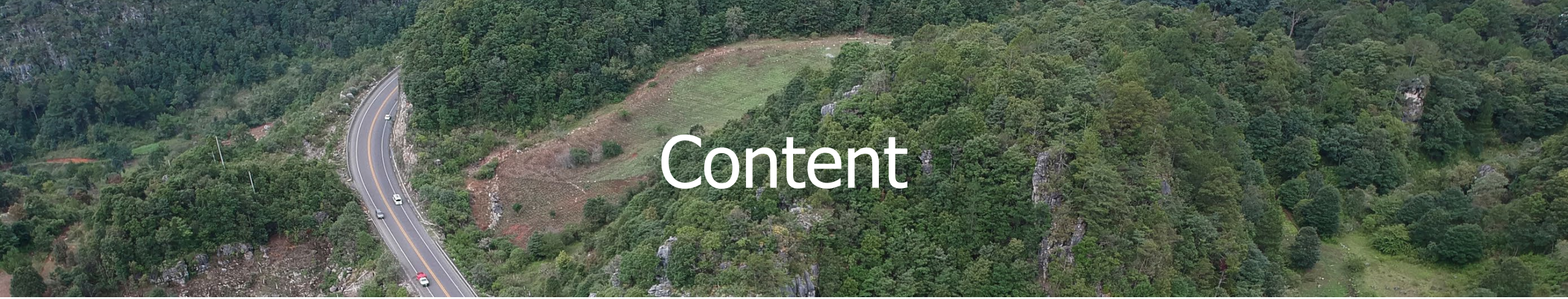

Content

Context and relevance

Background and related work

Methodology

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Conclusions

Status quo on CO_2 emissions

- Colombia's transport emissions represent 35% of total energy-related emissions and have increased steadily by 2% yearly. Half of road transport emissions are generated by freight transport, reflecting the freight sector's dependence on road transport, use of diesel, and the poor state of vehicles.
- In pursuit of road freight decarbonisation, a collaborative initiative has been launched to pave the way for zero-emission targets in the country's road freight transportation sector by 2030 and 2050.
- Colombia is committed to achieving a 51% reduction in GHG emissions and a 40% decrease in black carbon emissions by 2030.

Road Freight Transport Sector – zero emissions?

Lack of incentives to invest in zero-emission technologies or penalties for not doing so.

It is impossible to anticipate which technology will be available in a specific year and at what cost.

Potential conflicts between governments and the private sector due to new policies and regulations.



On the journey, there are risks and uncertainties.



The recovery from the pandemic can slow down the transition in favour of short-term stability.

Budget constraints in the public sector and low capacity for investment and execution.

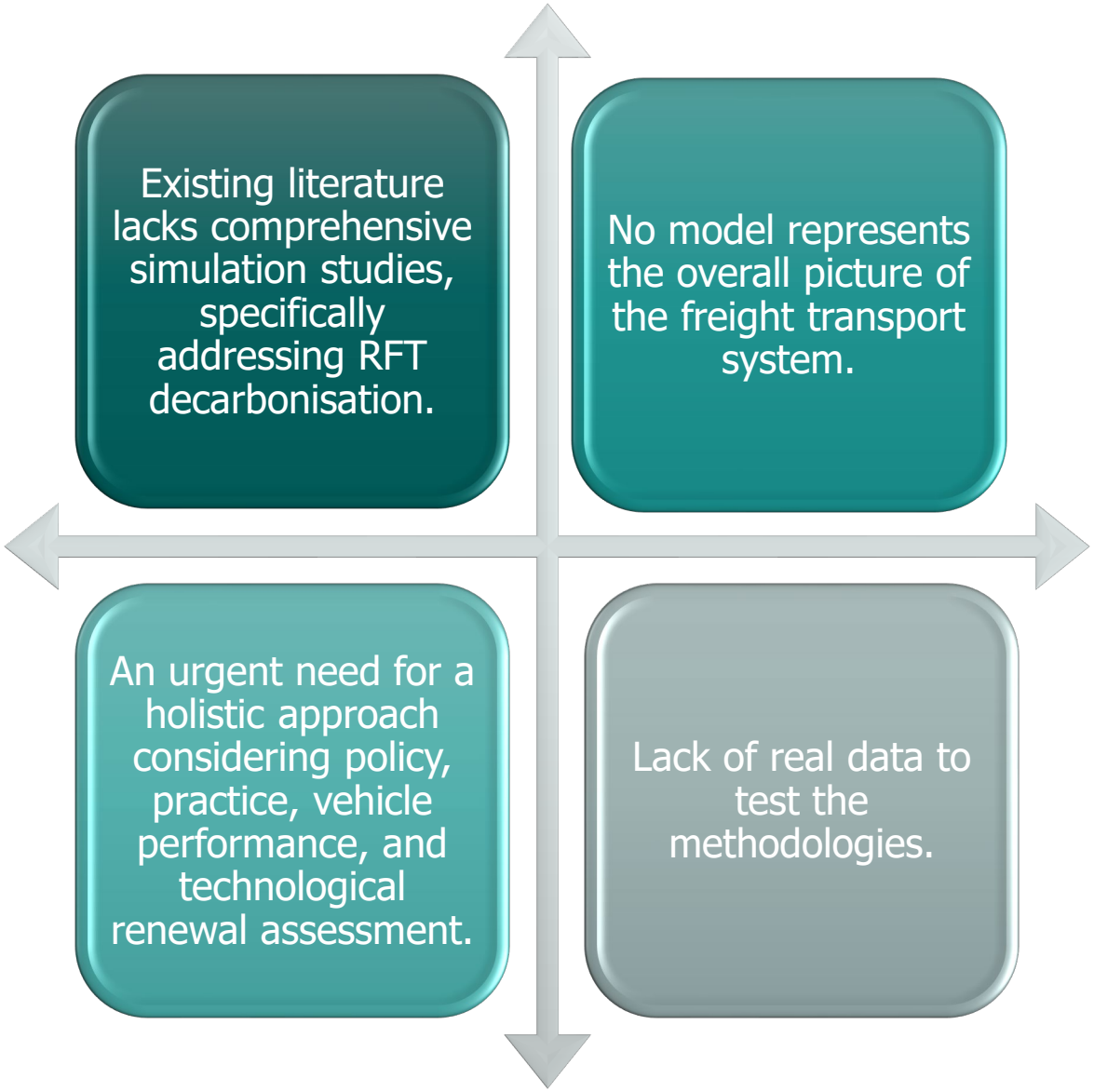
Misaligned interests between international commitments and the needs of populations dependent on industries that have not yet decarbonised.

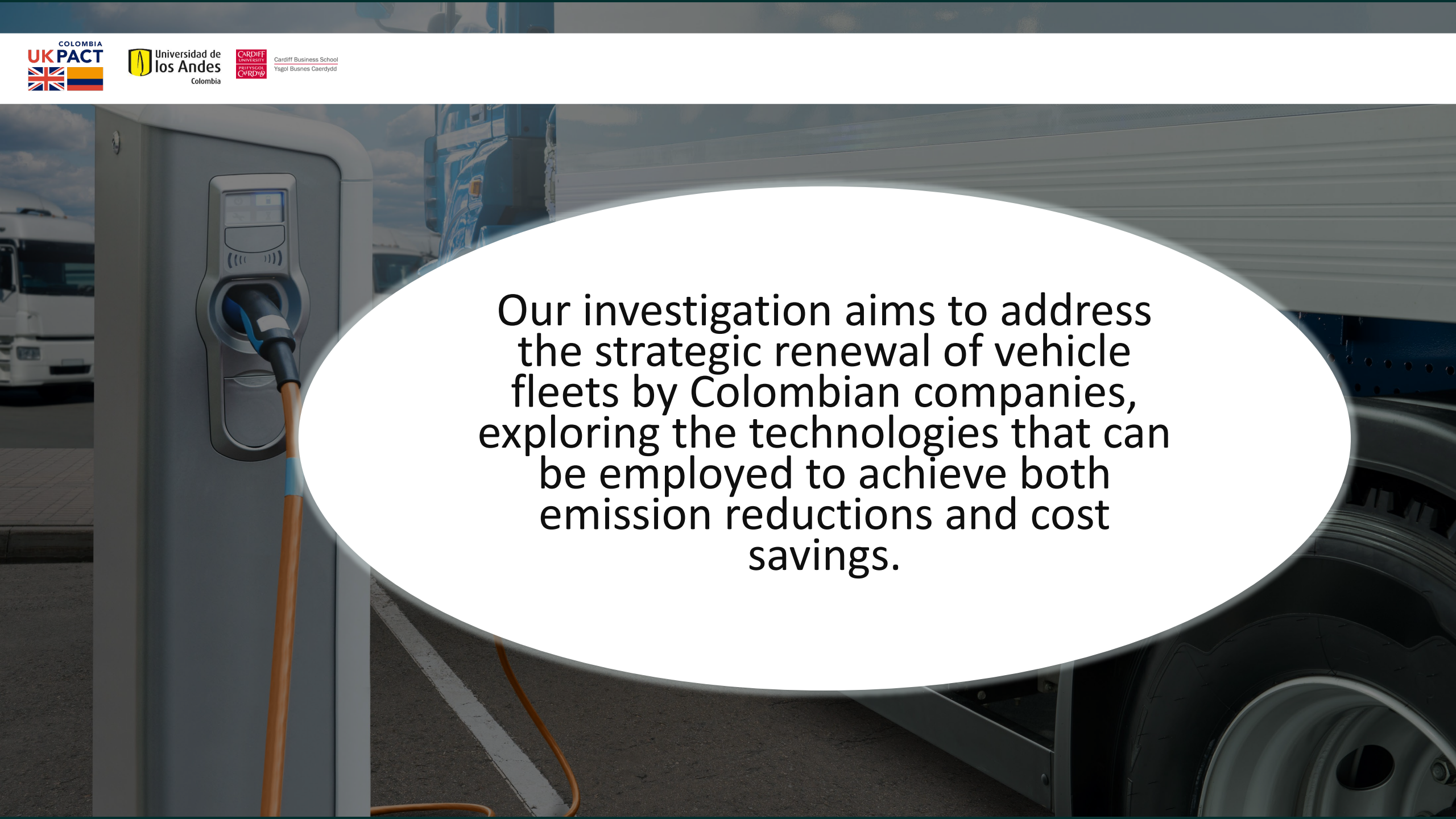
Comparison between the most relevant works and the proposed approach

Feature	Hickman et al. (2010)	Selvakkumaran and Limmeechokchai (2015)	Keith et al. (2017)	Yan et al. (2021)	This paper
Consider freight transport	x			x	x
Vehicle efficiencies		x	x	x	x
Technological Renewal		x	x		x
Policies and incentives	x		x	x	x
Horizon planning to adoption		x	x		x
Real Data	x	x		x	x
Including collaborative practices	x		x		x

The current research takes a holistic approach by considering the key components when assessing the impact of decarbonisation policies in the freight sector related to micro level decision-making, adding technological renewal and horizon planning components.

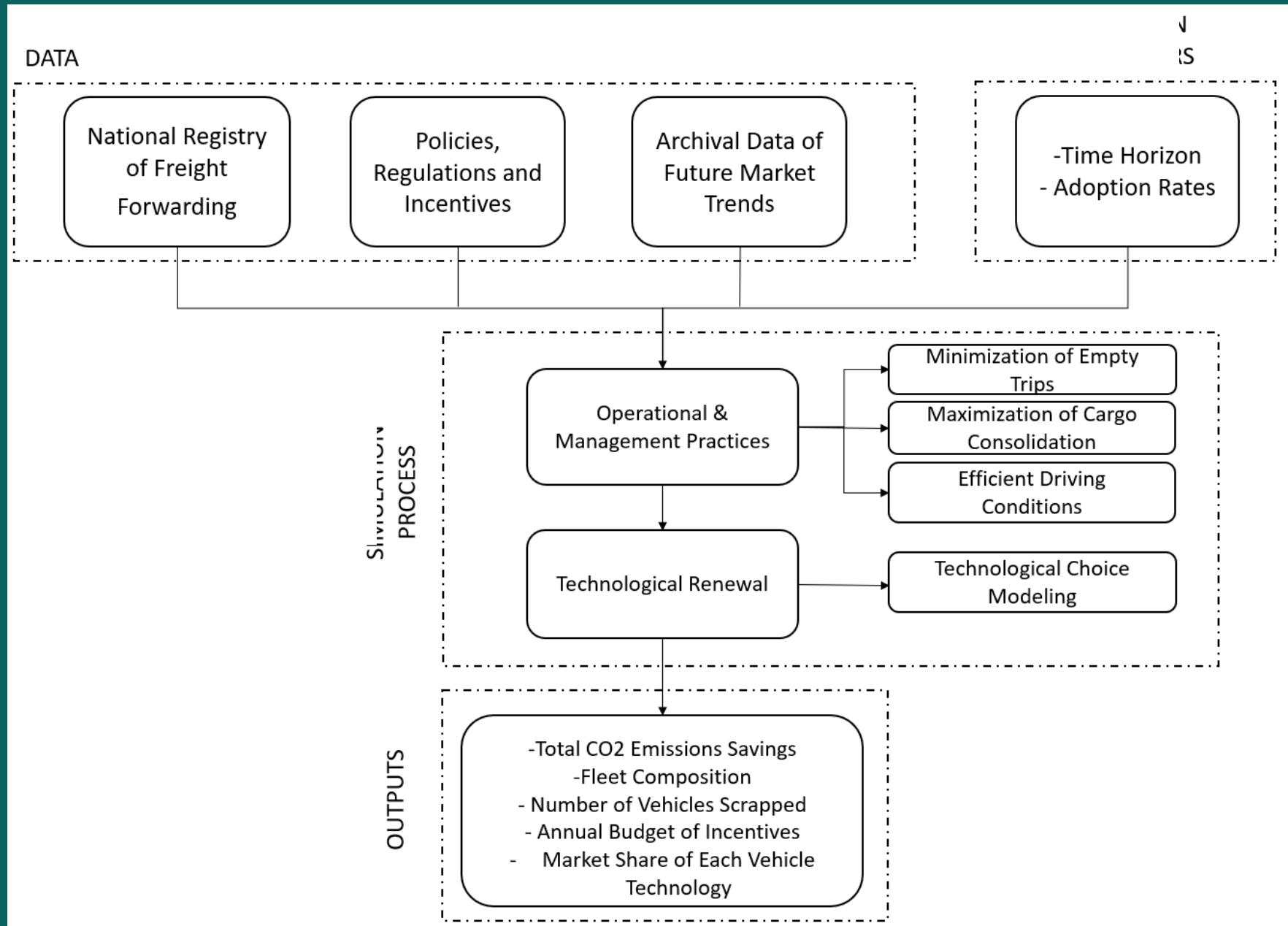
GAP


Existing literature lacks comprehensive simulation studies, specifically addressing RFT decarbonisation.
No model represents the overall picture of the freight transport system.
An urgent need for a holistic approach considering policy, practice, vehicle performance, and technological renewal assessment.
Lack of real data to test the methodologies.



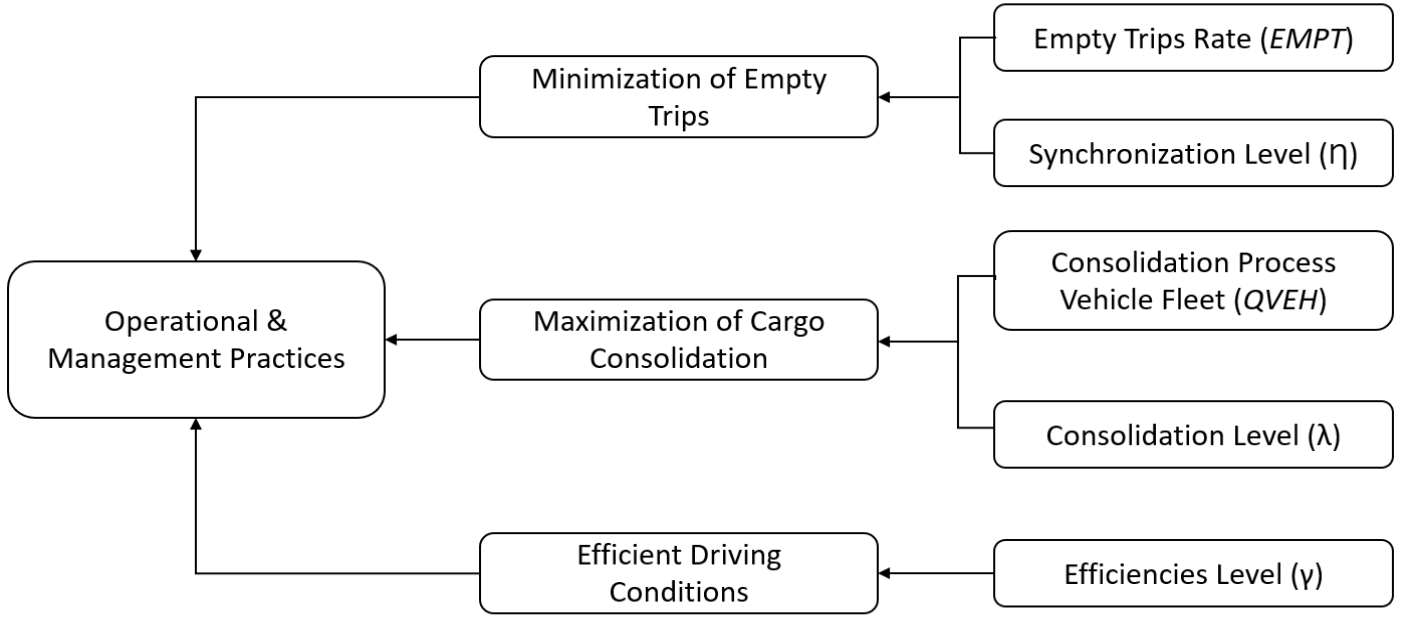
Our investigation aims to address the strategic renewal of vehicle fleets by Colombian companies, exploring the technologies that can be employed to achieve both emission reductions and cost savings.

Methodology

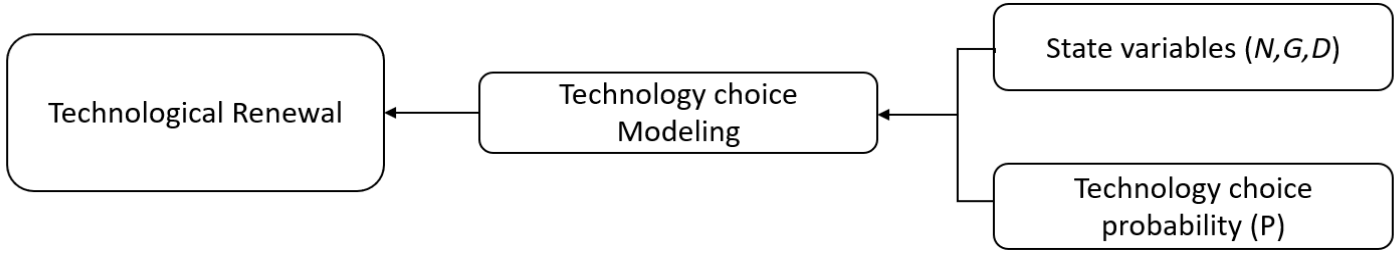


Main components:

Strategy 1



Strategy 2



Micro level components

Objective Function

- Minimise the Net Present Value (NPV) considering the costs of assets, maintenance, and operational costs directly related to fuel cost.

First Set of Logical Constraints:

- Relates to the investment considering the initial fleet.
- Number of vehicles in operation.
- Vehicles purchased.

Second Set of Constraints:

- Refers to the CO_2 target compliance.
- Strongly ties to the last year of the time horizon with emissions = 0 (Year 2050).

Third Set of Auxiliary Constraints:

- Related to the NPV costs of assets, maintenance, and fuel.

National registry of freight forwarding (RNDC)

Data characteristics

- Comprehensive cargo dispatch data
- Shipment details
- Transport company information
- Carrier details
- Cargo tracking information

Integration with stakeholders

- Transport companies
- Cargo owners
- Carriers
- Government authorities

Time period

- ✓ Systematized since 2015
- ✓ **Time horizon:** Per month
- ✓ **Period analysis:** 2019 - 2022

Database size

- ✓ Represent 43% of all transport movements in the country.
- ✓ Consisting of approximately 30.540.000 trips.
- ✓ **Amount of data**: 7.99 millions records

In 2022 transportation involved 118.9 million tons and covering a distance of 2.8 billion kilometres.

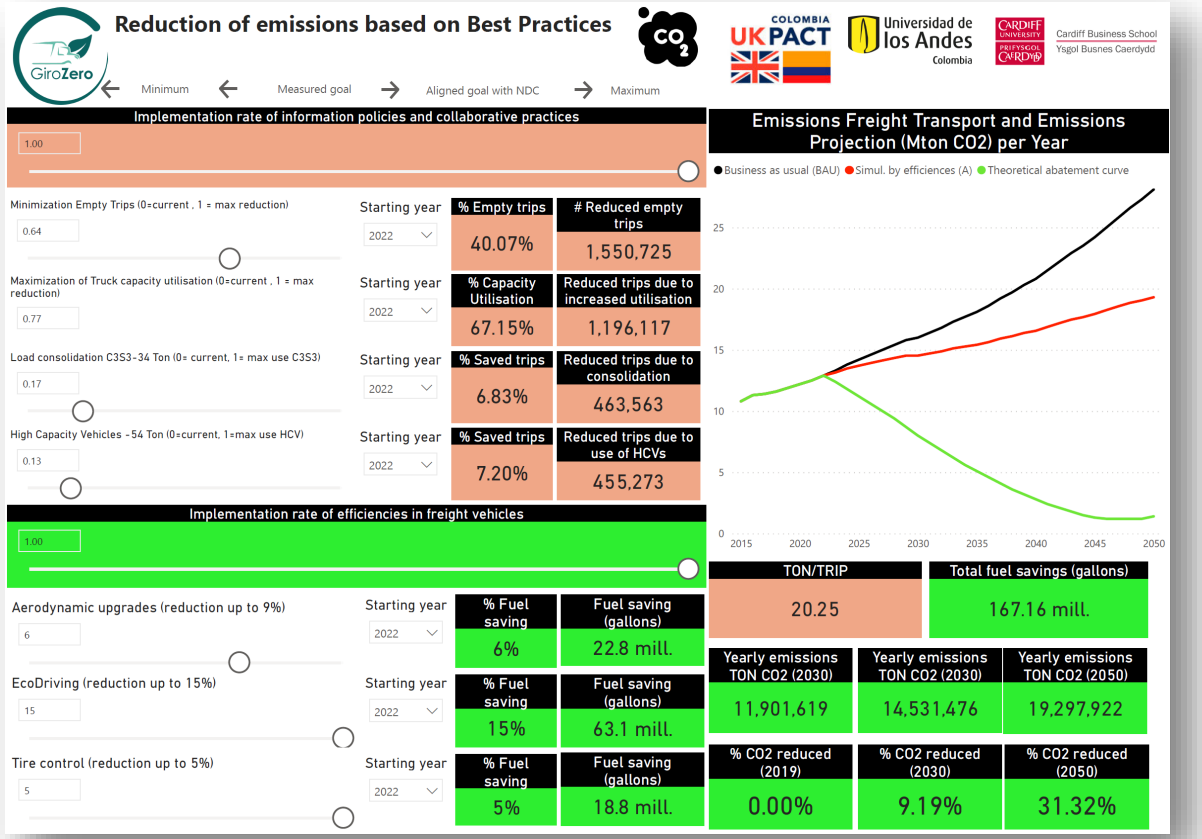
Nutresa Company

- **License Plate**
- **Vehicle Model**
- **Average Age**
- **Fuel Type**
- **Capacity**
- **Average Mileage**
- **Vehicle Type**
- **Performance**

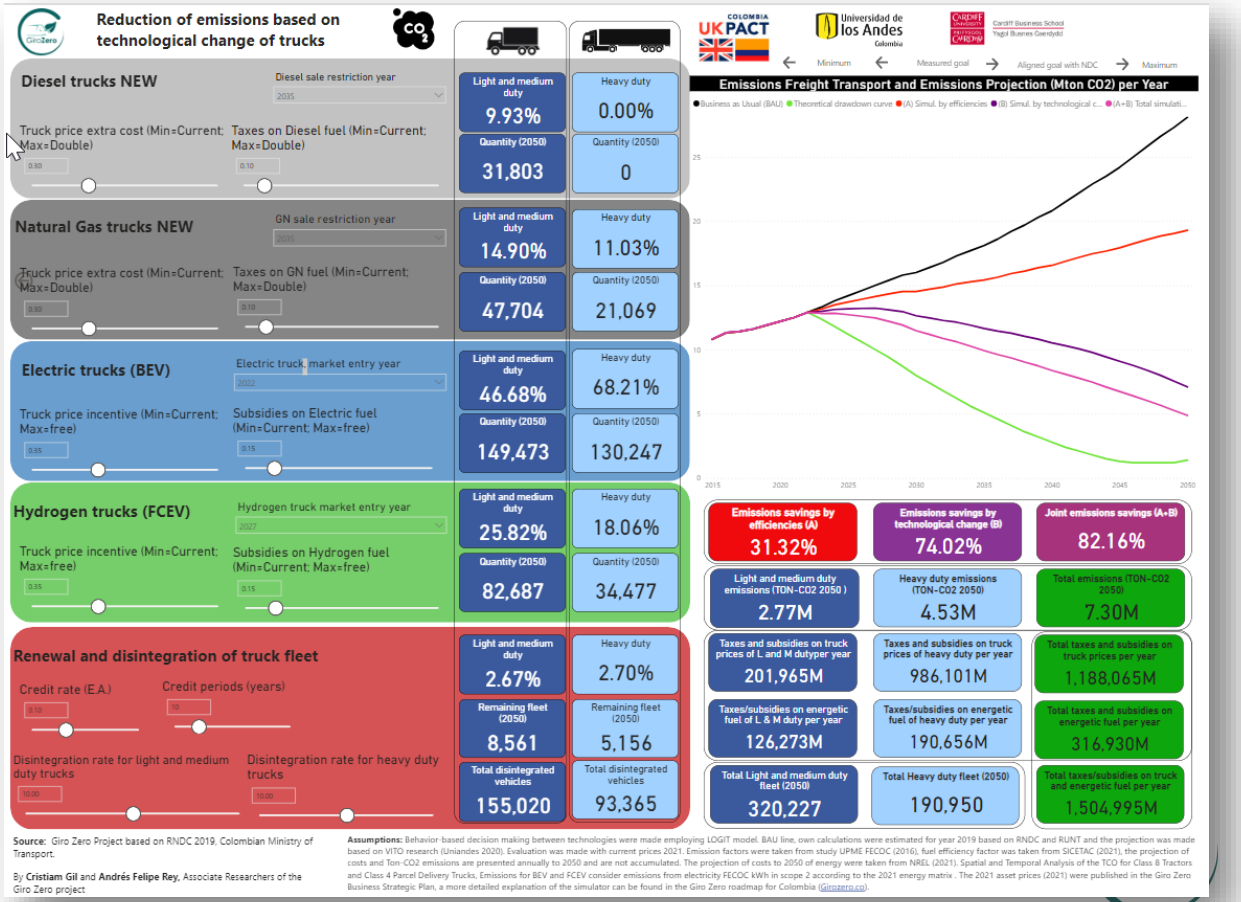
Light Trucks	14
Medium Trucks	7
Total Trucks	21

Results: Macro Level

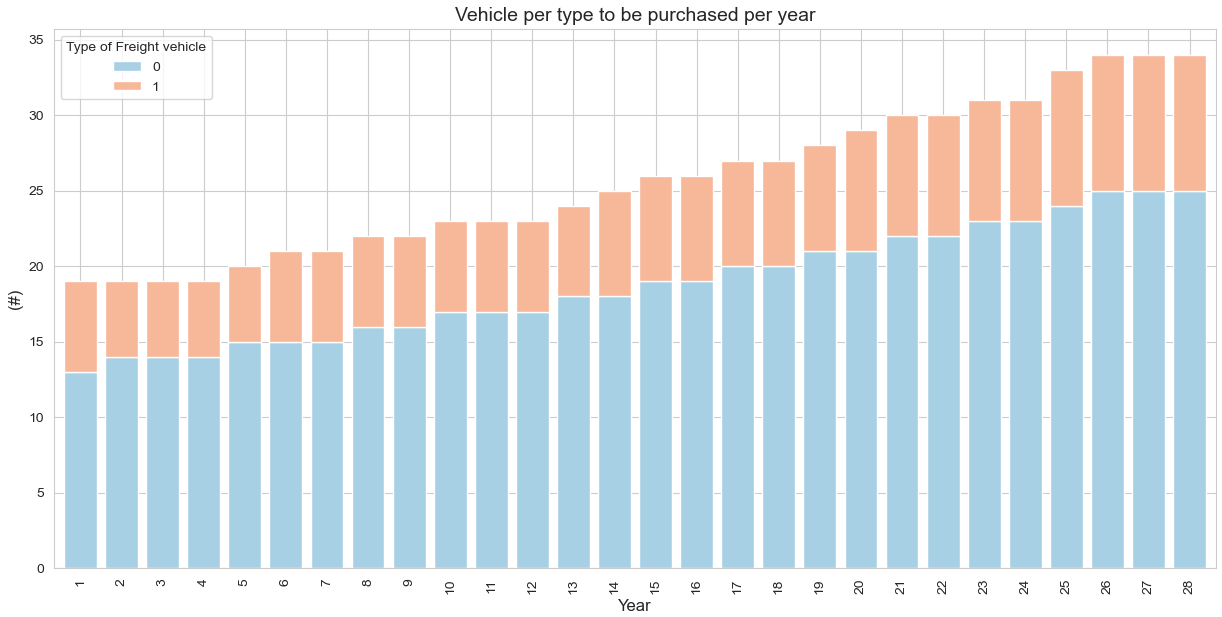
Operational measurements

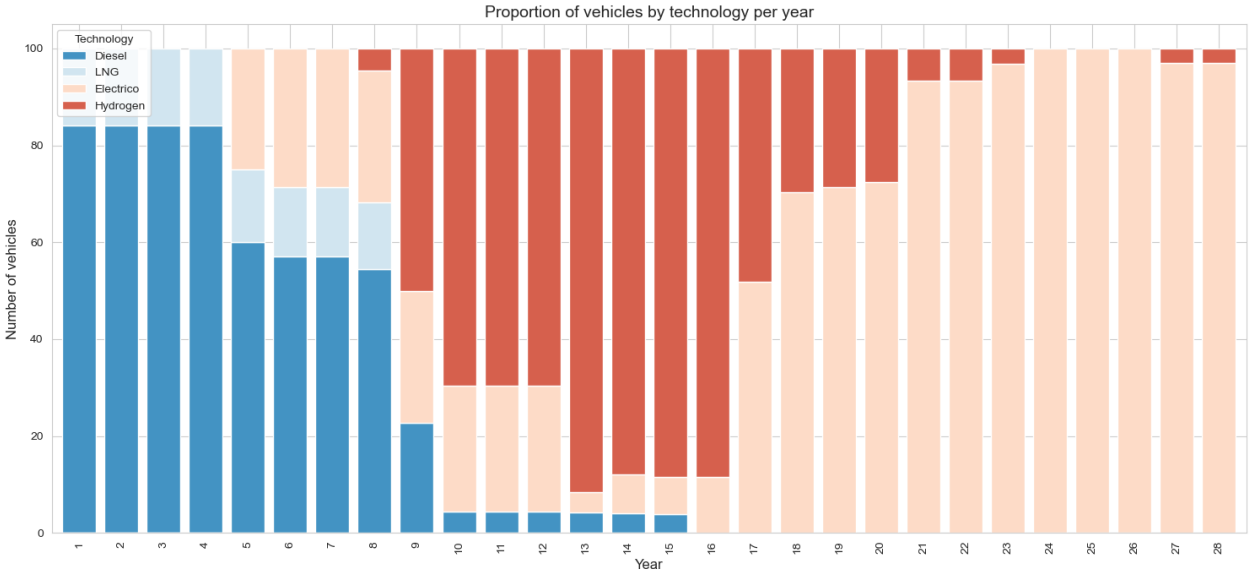


Technological measurements

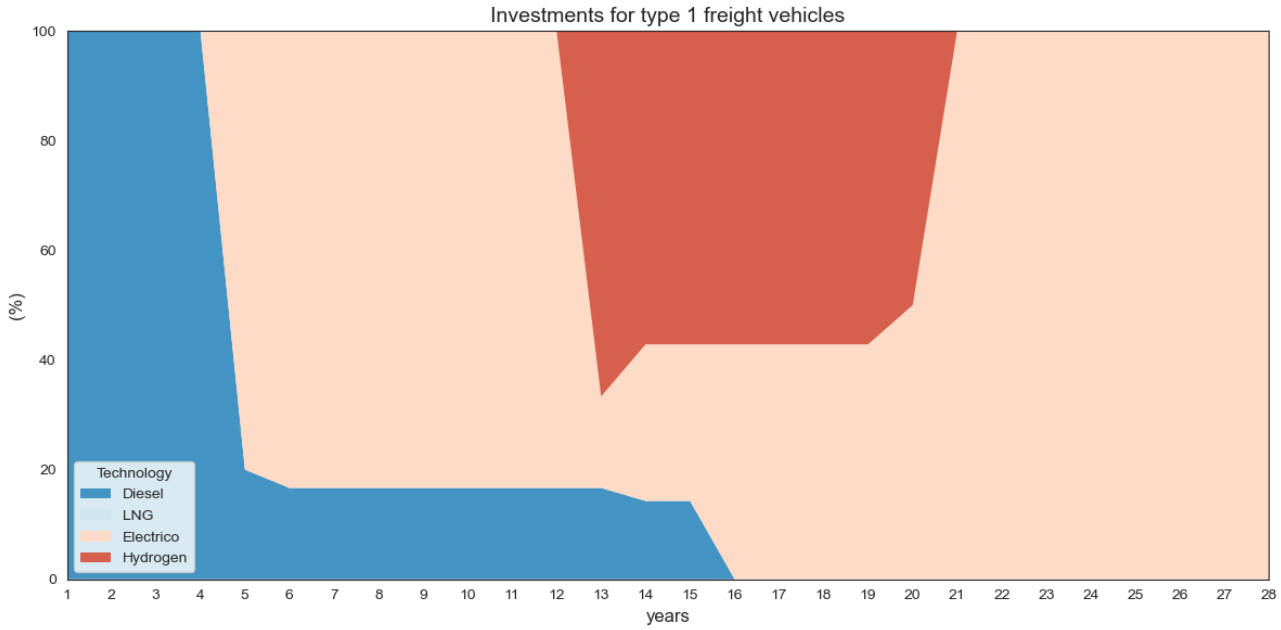


Results: Replacement plan for Noel





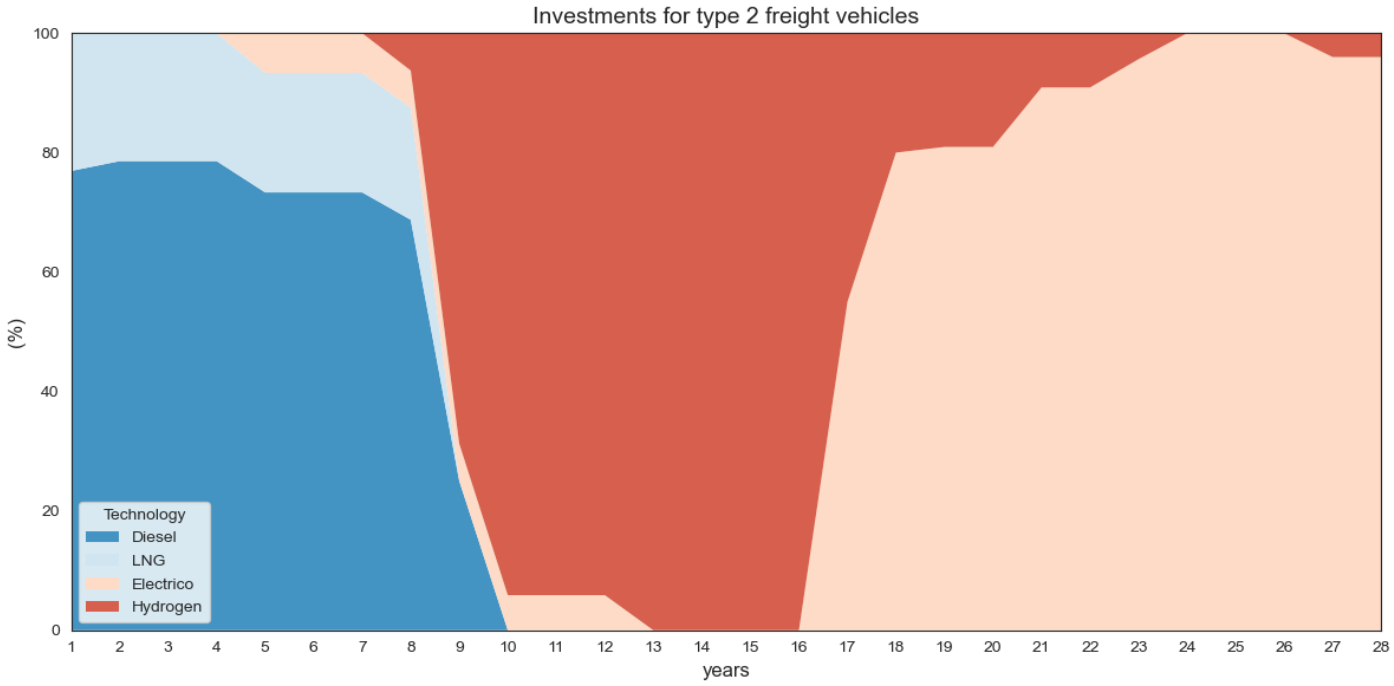
- The data illustrates an increase in the number of vehicles needed for acquisition by the Noel company to meet decarbonisation objectives. Notably, the study reveals that hydrogen technology serve as a transitional technology, with electric vehicles emerging as the predominant technology in the latter years of the study period.



If we separate the fleet between light- (type 1) and medium-type (type 2) vehicles, we observe that:

- In the case of type 1 vehicles, LNG technology lacks appeal, and from the early years of the time horizon, electric vehicle technology emerges as a promising investment option. In comparison to type 2 vehicles, hydrogen technology is less preferable in the medium term.

- In the short term, LNG technology remains crucial for type 2 vehicles, transitioning to hydrogen vehicles in the medium term, and ultimately giving way to electric vehicles as the predominant option in the long term.



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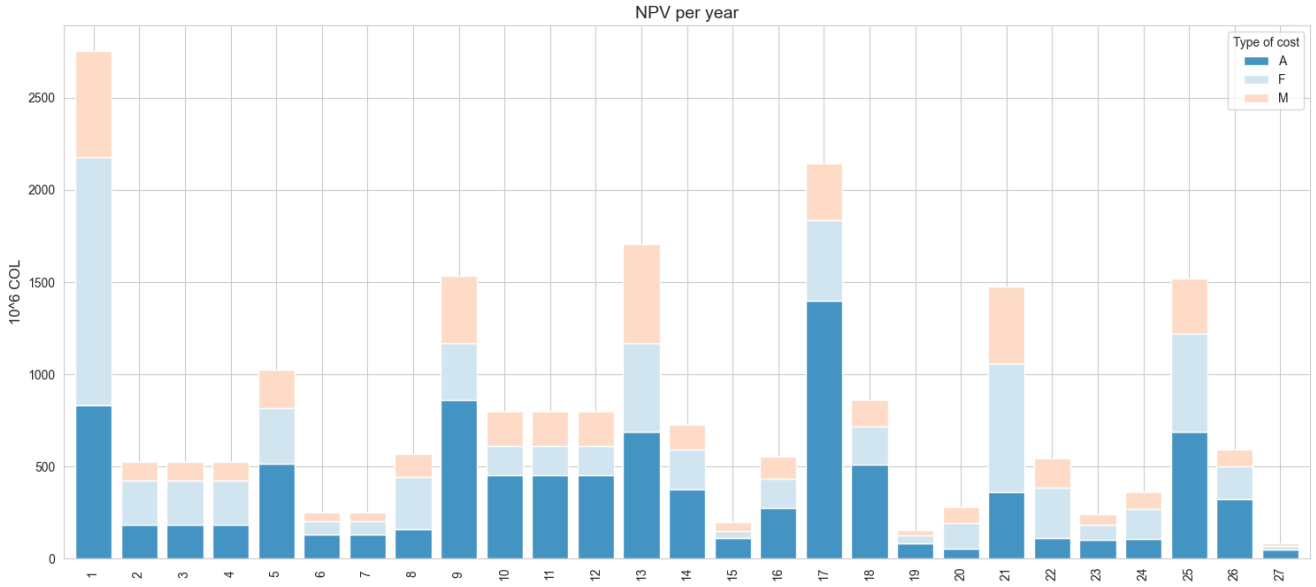

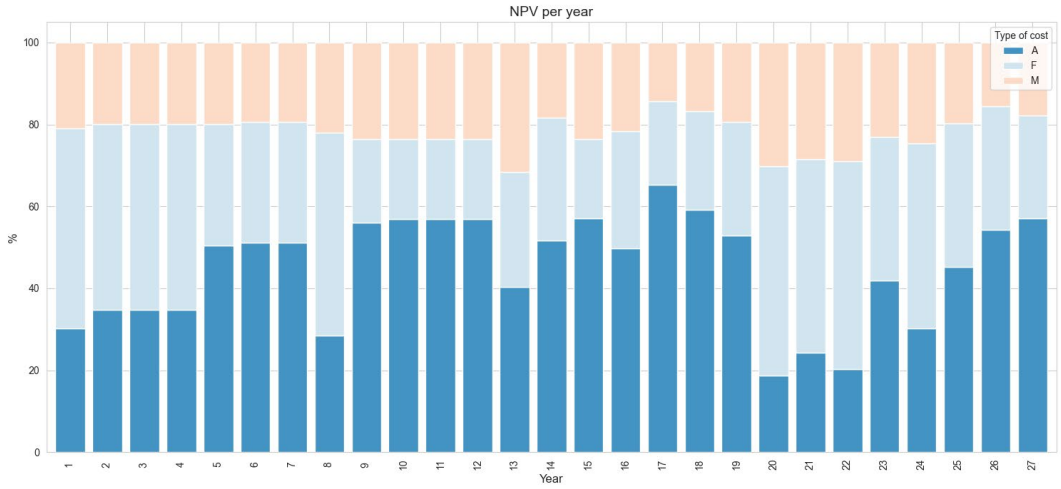

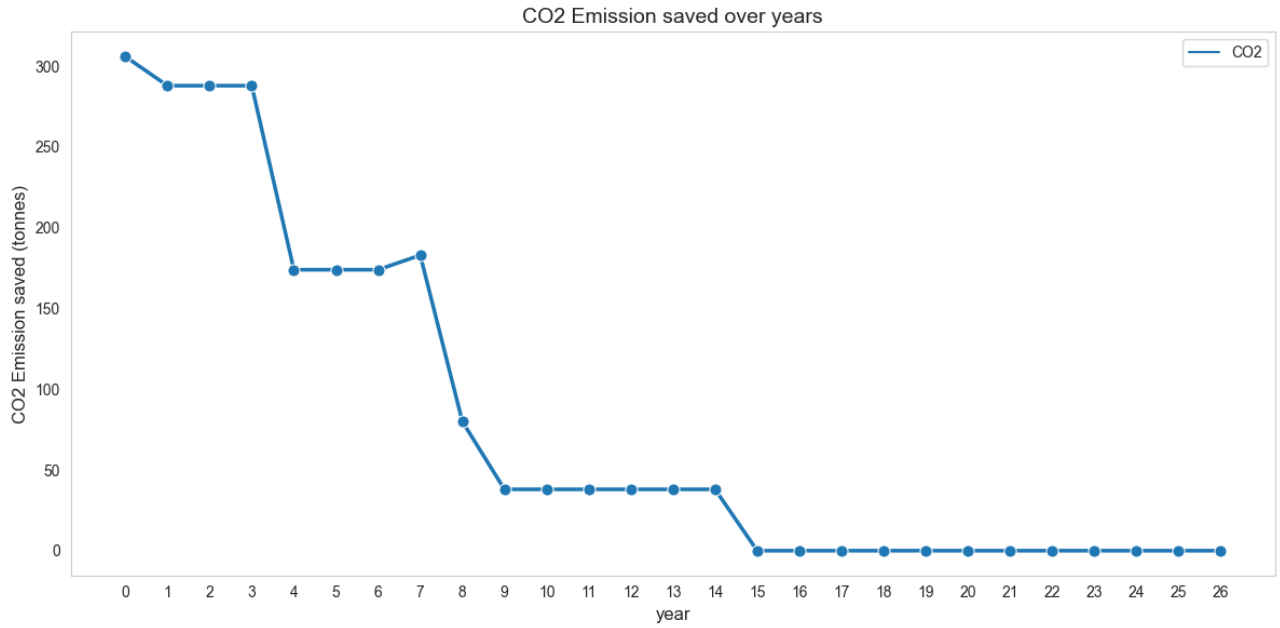

Conclusions

The proposed approach provides a robust solution for decarbonisation.

Incentives such as interest rates and subsidies play a crucial role in shaping the composition of the freight vehicle fleet.

In the short term, it is necessary to combine actions and focus on operational efficiencies and logistics optimisation.

Further research is needed to refine methodology, considering heavy trucks and different fleet size.

Achieving Colombia's Net Zero goal in the RFT sector by 2050 requires joint efforts from governments, industries, and the public sector.

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UK PACT (Partnering for Accelerated Climate Transitions) es un programa único de desarrollo de capacidades. Gobernado y financiado conjuntamente por la Oficina de Relaciones Exteriores, Bienestar Común y Desarrollo (FCDO) del Gobierno del Reino Unido y el Departamento de Negocios, Energía y Estrategia Industrial (BEIS) a través de International Climate Finance del Reino Unido, trabaja en asociación con países con alto potencial de reducción de emisiones para apoyarlos para implementar y aumentar sus ambiciones para abordar el cambio climático. El Reino Unido está comprometido con la lucha contra el cambio climático y está invirtiendo 11 600 millones de libras esterlinas a través de ICF durante los cinco años hasta marzo de 2026.
UK PACT se asocia con Colombia, un país con un fuerte compromiso con la acción nacional e internacional sobre el cambio climático y el crecimiento sostenible. El programa PACT Colombia-Reino Unido ha financiado 34 proyectos hasta la fecha, así como más de 15 acciones de habilidades complementarias, que ya están generando un cambio en el mundo real para apoyar el crecimiento sostenible y la reducción de emisiones. En Colombia, el programa se centra en el apoyo a la naturaleza (incluidos los medios de vida sostenibles y las soluciones basadas en la naturaleza), la política de bajas emisiones de carbono, la movilidad, la energía y las finanzas, como medios para apoyar la acción climática.