Stakeholder Views on the Decarbonization of Medium- and Heavy-Duty Trucks in Canada

, ÈÙ. 2025

At McMaster

we recognize that the strength of our brand is integral to the achievement of our institutional objectives on a national and international scale.

Acknowledgment

- McMaster University sits on the traditional Territories of the Mississauga and Haudenosaunee Nations, and within the lands protected by the "***Dish With One Spoon***" wampum agreement.

- This project is support by Natural Resources Canada (NRCan), PCA-082.

- Kudos to Mark Ferguson, Louis-Paul Tardiff for leading the interviews.

- Kudos to Ahmed Foda for leading the analytical work.

About MITL

- The McMaster Institute for Transportation and Logistics (MITL) was formed in 2007, by **Pavlos Kanaroglou**, with the vision to establish a world-class institute at McMaster University for multidisciplinary applied research in transportation and logistics.

Agenda

- Context
- Participants & Prompts
- Knowledge Extraction
- The Way Forward
- Conclusion

Context

Context

- The market share of Zero-emission medium and heavy-duty vehicles (ZEMHDV) is marginal compared to personal vehicles.
- Little is known on the true costs and benefits of ZEMHDV from stakeholder's perspective.
- The wide range of operational structure, profile, and service types calls for more in-depth investigation of stakeholder's perspective.
- ZE-MHDV can bring substantial reductions in GHG emissions, improved air quality, and less reliance on fossil-based energy source.
- Capitalizes on the Canadian clean electricity generation profile.

Context

As such, we need to answer three fundamental questions:

1) What factors influence ZEMHDVs adoption decisions, including BEVs and HVs?

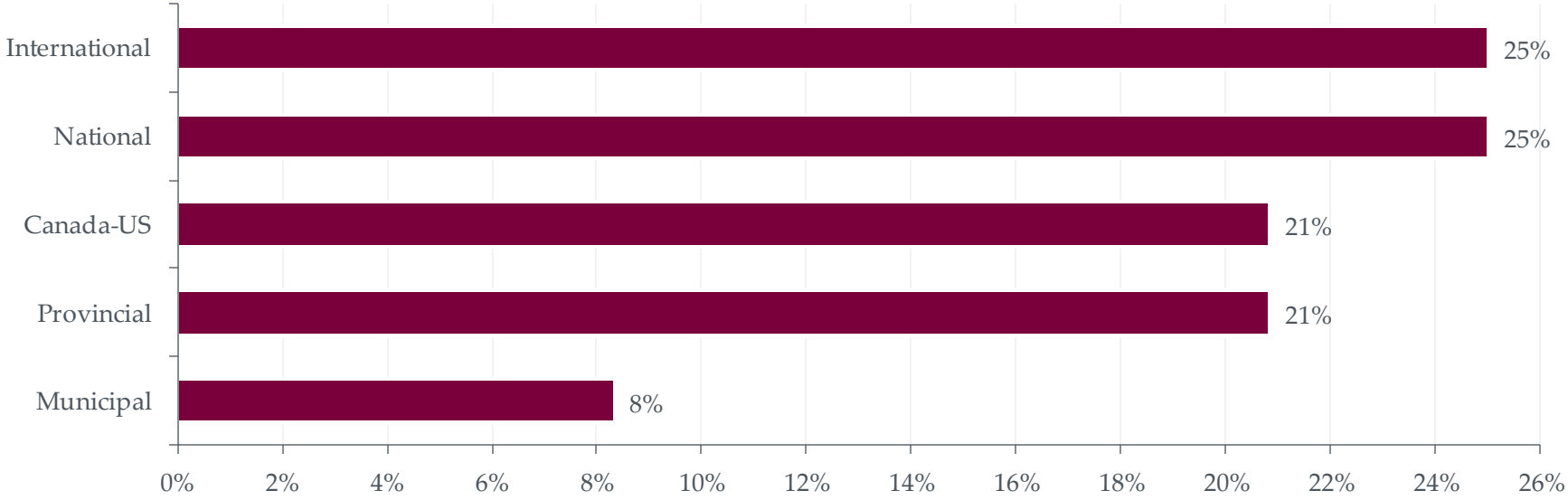
2) Among these factors, what are the barriers and enablers to ZEMHDV adoption from stakeholders' perspective?

3) What interventions are proposed by stakeholders to accelerate ZEMHDV uptake?

Participants

Who is involved

- A set of 24 organizations were interviewed, involving 32 individuals representing their respective organizations.



Participants

Who is involved

- A set of 24 organizations were interviewed, involving 32 individuals representing their respective organizations.

Type/class	Number of organizations
Third-Party Logistics	1
Association	6
Distributor	1
For-hire trucking	2
Freight Hub	1
Industrial	1

Type/class	Number of organizations
Original Equipment Manufacturer (OEM)	2
Media	1
Non-Governmental Organization	3
Municipal Fleet	1
Provincial Fleet	1
Retailer	4

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Prompts

- **Education and awareness:** Insights into the extent to which the lack of education, awareness, or misconceptions in certain circles/contexts is slowing the adoption of ZEMHDVs.

- **Policy:** Type of policies and incentives that could increase ZEMHDVs uptake in freight transport fleets.

- **Additional aspects:** From the organization's perspective, discussion of additional essential points regarding ZEMHDVs uptake in freight transport fleets.

Knowledge Extraction

Text data Preparation

- Transcript data 253,061 words.

- Raw data (interviewees text) 175,496 words
  - *Tokenized (e.g., breaking down each document into a set of words or tokens).*
  - *Lemmatization, a process that reduces words to their base or root form, known as the lemma (e.g., convert running to run).*
  - *Bigrams and trigrams detections (e.g., battery electric trucks and operational flexibility).*

- Cleaned and processed data 38,475 words

Extracting Topics

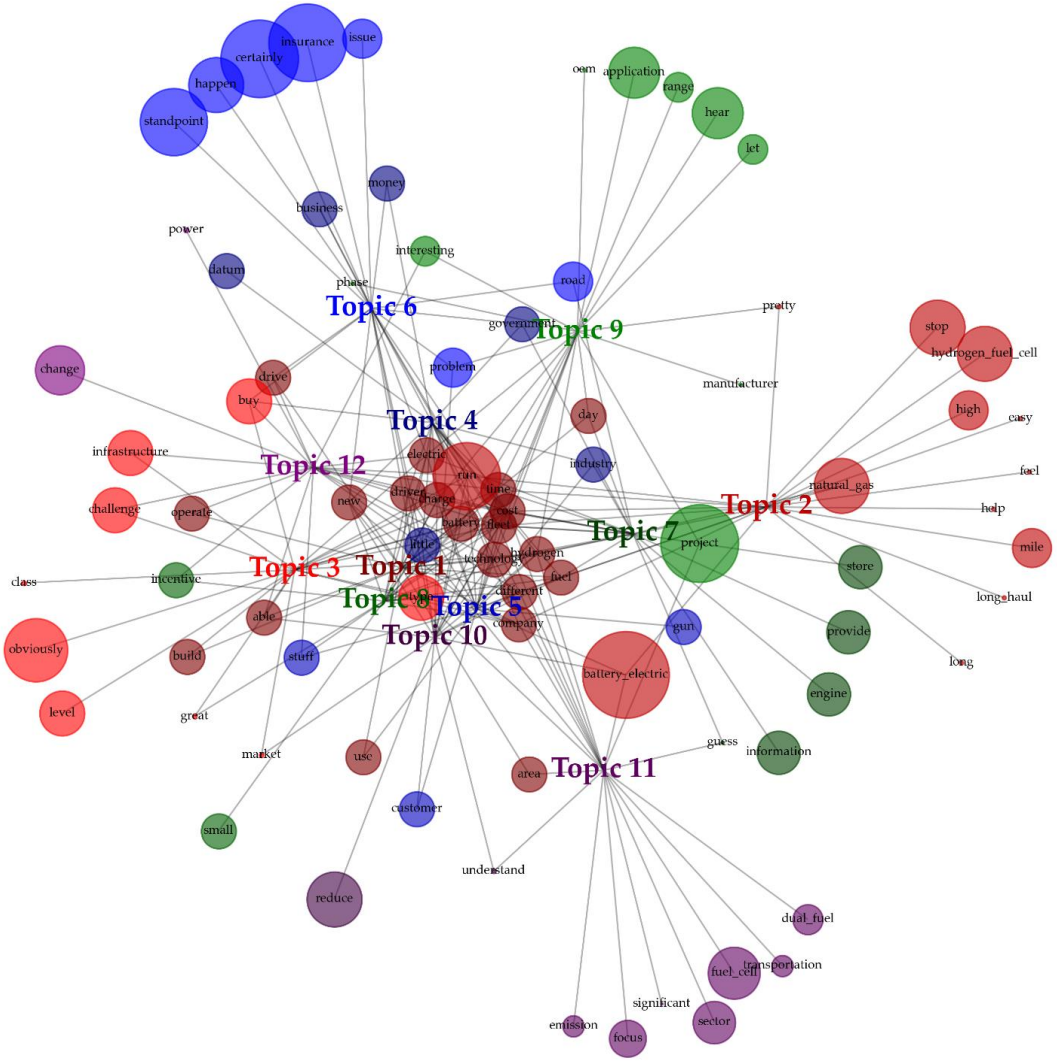
- We applied Machine Learning text data mining model (LDA) to automatically extract main topics from the data.

- This eliminates any personal interaction with the data.

- LDA is a powerful tool to uncover the hidden thematic structure in a collection of documents presented as a text corpus

Extracting Topics

Topic 1	Fleet size and costs
Topic 2	Technology choice
Topic 3	Infrastructure cost and availability
Topic 4	New system planning and configuration
Topic 5	Business, customer, and driver implications
Topic 6	Operational uncertainty
Topic 7	Information sharing and education resources
Topic 8	Incentives and policies
Topic 9	Operational constraints
Topic 10	Operational costs
Topic 11	Organization context
Topic 12	Operational challenges



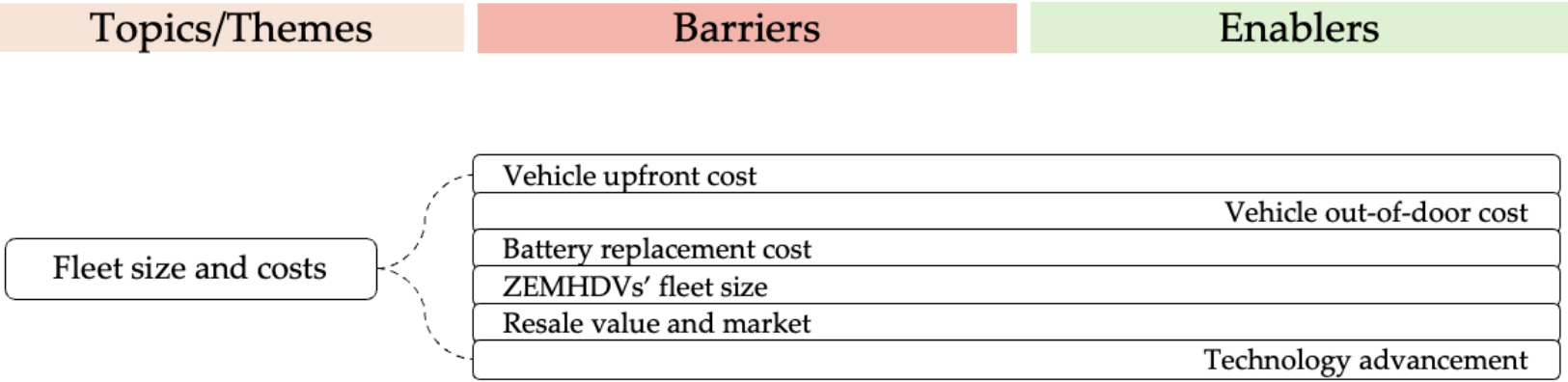
Enables and Barriers

- Each topic encamps both enablers and barriers.

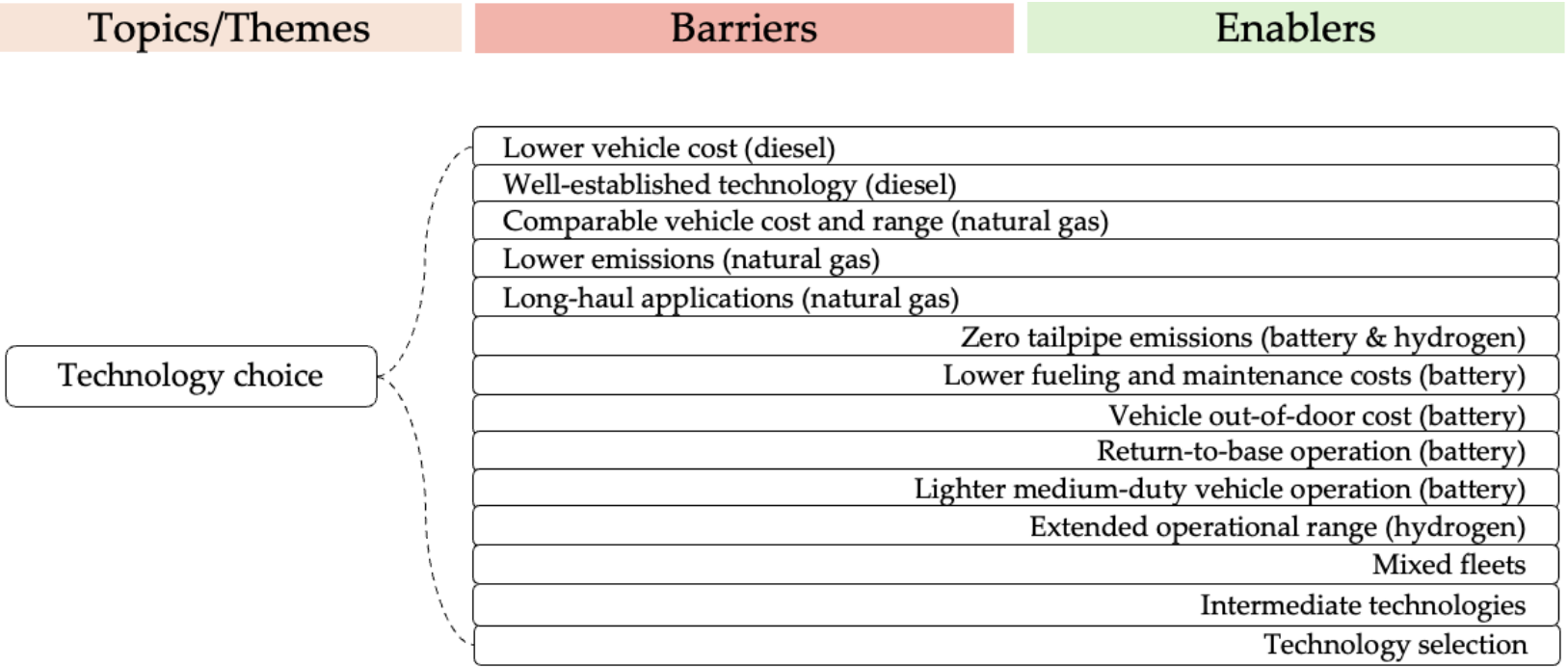
- We utilized a **Scoping Review** process to qualitatively review the text associated with each topic.

- The idea is to sort out **enablers** and **barriers** associated with each topic.

Enables and Barriers



Enables and Barriers



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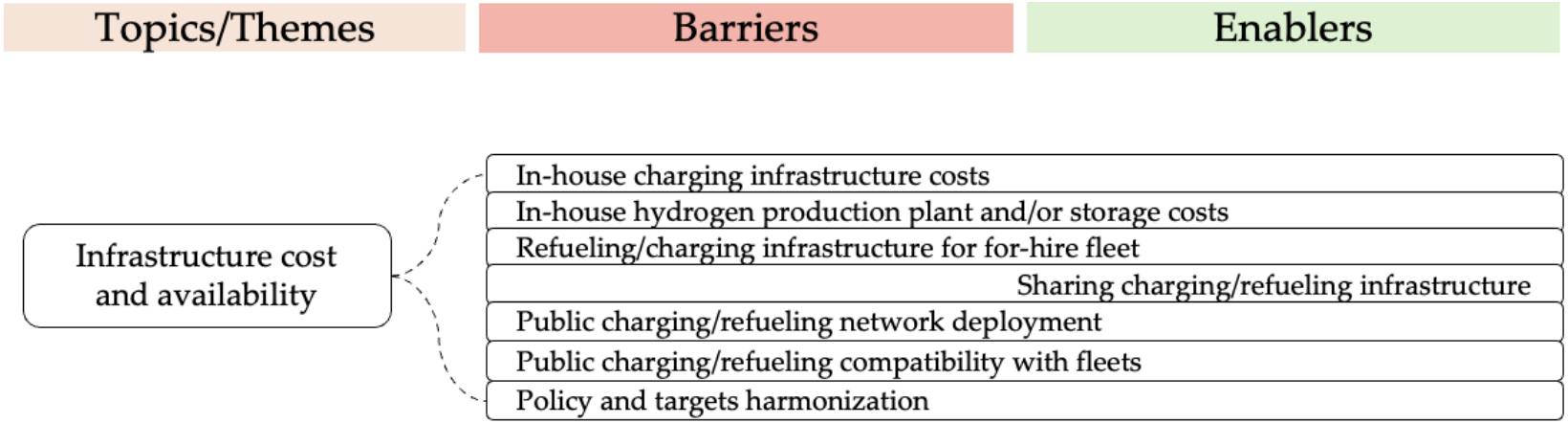

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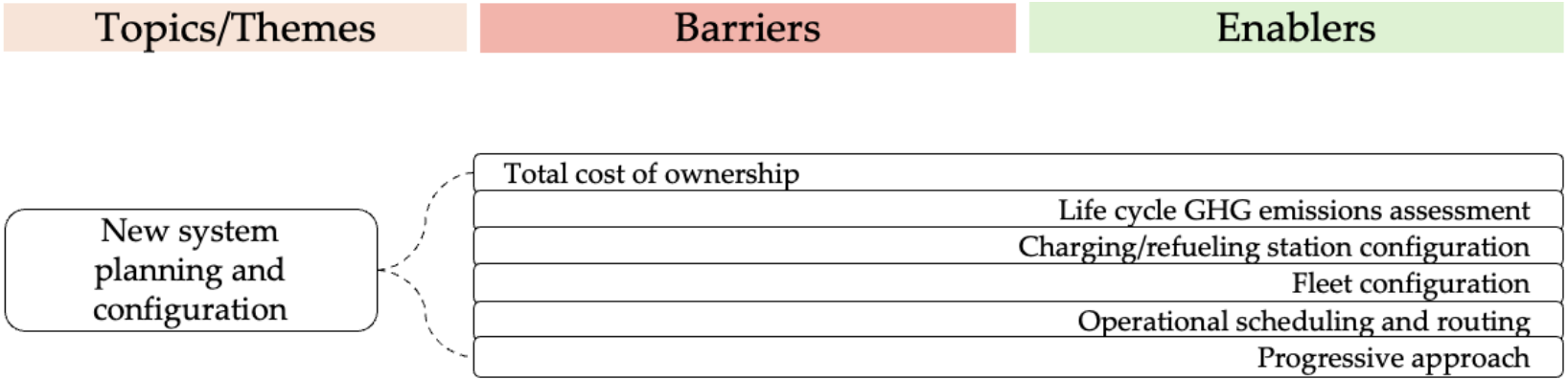

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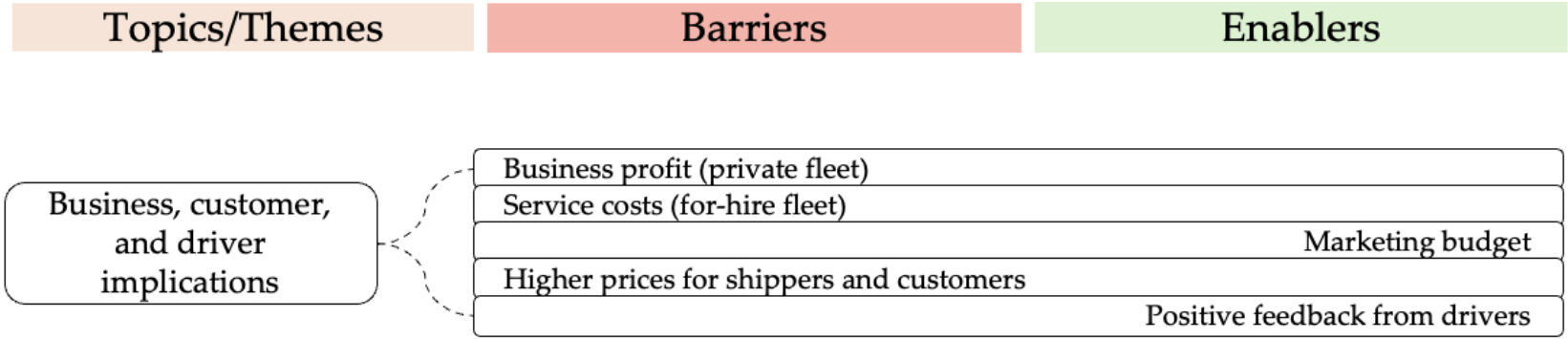

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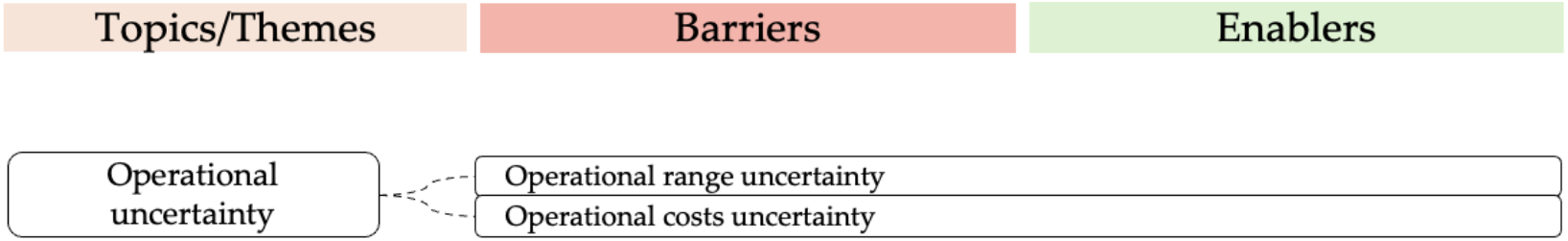

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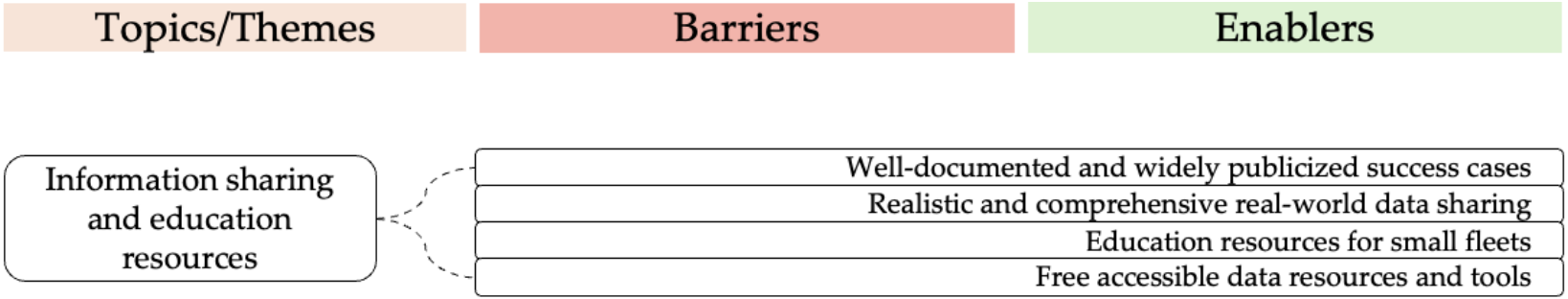

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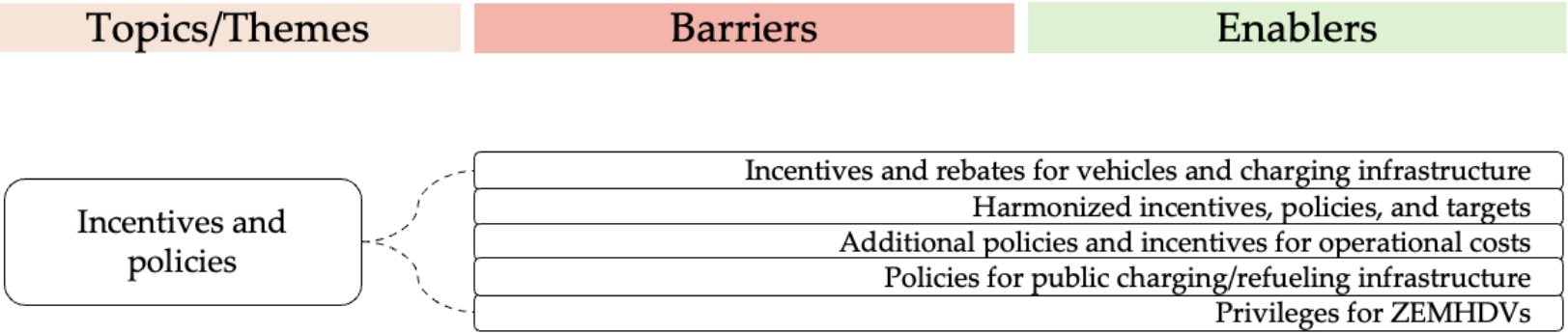

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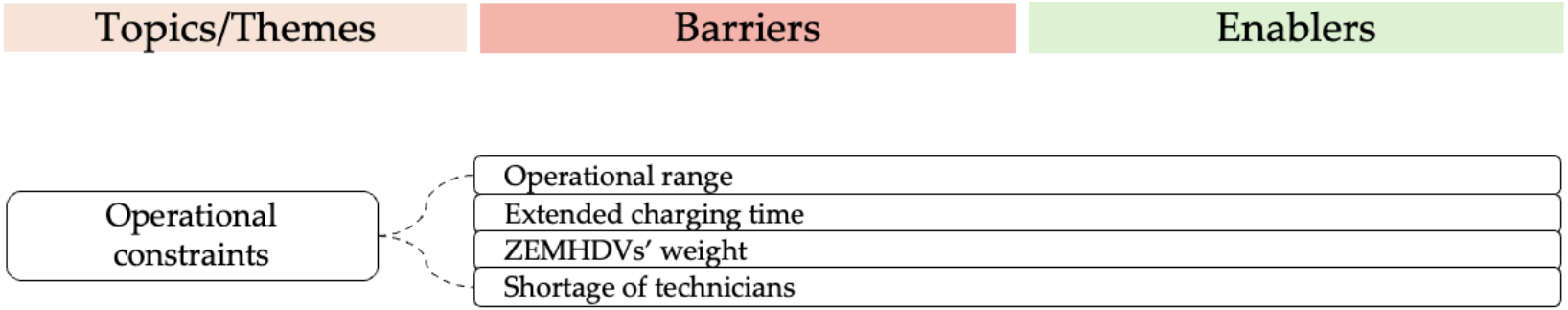

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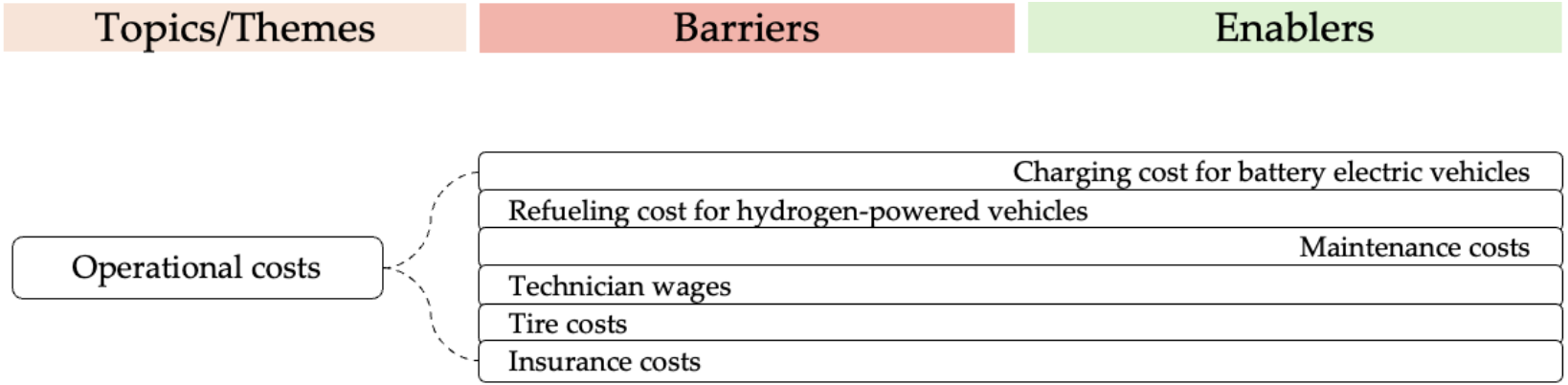

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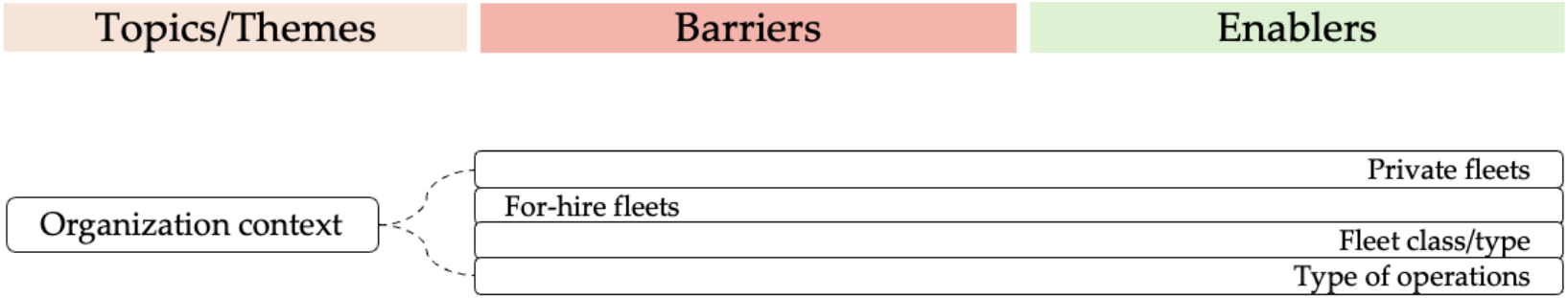

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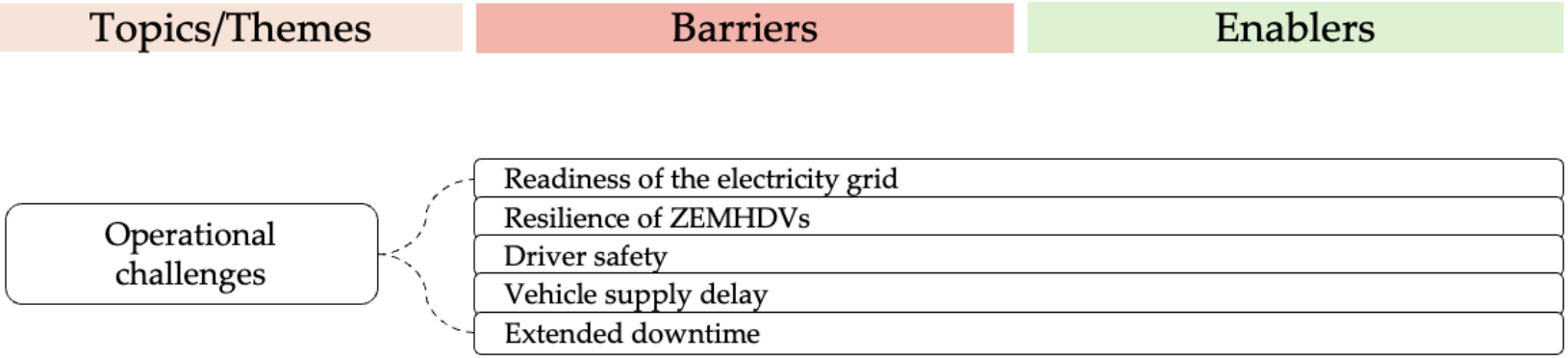


The Way Forward

The Way Forward

- The analysis underscored various critical aspects for the adoption of ZEMHDV in fleet operation.

- Based on this knowledge, we propose **five high-level interventions** to overcome barriers, and boost enablers for ZEMHDV adoption.

Proposed Interventions

Financial resources and incentives:

- Incentives are required from the government and should consider both CAPEX and OPEX, tailored to different technologies and vehicle classes, ensuring cost neutrality compared to diesel TCO.
- Incentives should be sensitive to operation type and ownership structure and include supporting facilities (e.g., charging/refueling infrastructure).
- Incentives should be harmonized across provinces.
- Incentives should include supportive activities such as data collection, data hubs, planning tools, and skills development programs.

Proposed Interventions

Technology advancement:

- Pilots and demonstrations are required to boost the feasibility of various technologies, in particular hydrogen fuel-cell vehicles.
- Research on battery technology to extend battery life, reduce weight, and lower replacement costs, thereby increasing payload capacity and range.
- Smart energy management for charging stations is essential to lower costs, reduce charging times, and ensure compatibility with various fleet classes and brands.
- Hydrogen production, transportation, and storage technologies should be advanced to reduce fuel costs and improve safety, making ZEMHDVs more economically and operationally viable.

Proposed Interventions

Tailored policies and regulations:

- A unified regulatory framework is required to streamline charging/refueling station construction, grid connection, and permit processes.
- Multi-stage or progressive sales targets should be implemented to enforce early adoption and enable gradual knowledge gain.
- Policies for public charging/refueling stations should ensure compatibility with all vehicle types while satisfying the energy/fuel demand.
- ZEMHDVs no monetary incentives should be promoted, such as access to certain zones, express highways, and dedicated lanes to reduce operational costs.
- Policies for upgrading the electricity grid to accommodate the projected energy demand for ZEMHDVs are essential.

Proposed Interventions

Planning and operational tools:

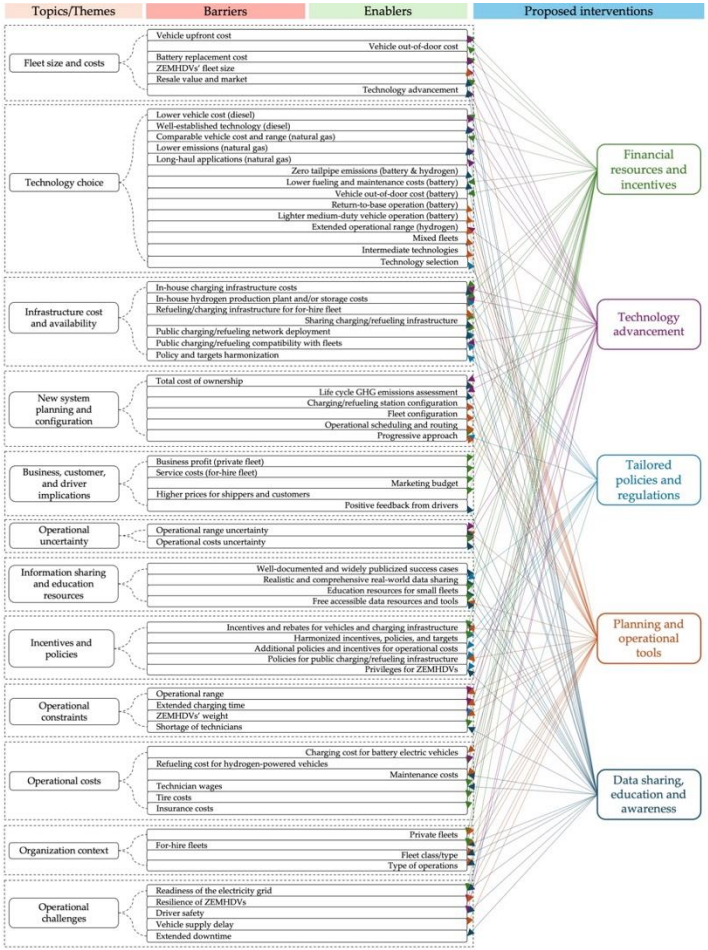
- Open-access planning tools are needed for operators. These tools should consider the operators' specific operations, fleet types, budget constraints, technologies, current fleet state, and available incentives.
- Planning tools are required to provide the operators with an optimal progressive multi-stage adoption approach, detailing the number of ZEMHDVs to adopt at each stage, the proportion of operations served, costs, and in-house charging/refueling station configurations.
- Real-time operational tools to predict feasibility (payload, range, and time) before trips and adapt to real-time conditions, providing alternatives and solutions.

Proposed Interventions

Data sharing, education resources, and awareness

- A comprehensive data hub should be developed to facilitate up-to-date data sharing, including details on upfront costs, ongoing expenses, incentives, and the charging station installation process.
- The hub must provide information on the current spatiotemporal adoption of ZEMHDVs, with data from pioneer adopters, including operational data, actual costs, downtime, maintenance schedules, detailed specifications, capabilities, and limitations.
- Education resources should be offered through the hub, including training materials for technicians, driver education on maximizing range, adoption planning, and safety hazard training.
- Awareness initiatives should be included in the hub, detailing the transportation sector's GHG emission share, emission reductions per vehicle or kilometer for each technology, and the importance of reducing GHG emissions to combat climate change.

Proposed Interventions



Conclusion

Key Remarks

- More effort is required to advance our knowledge on the barriers and enablers of ZEMHDV implementation in fleet operation.

- Tailored solutions are mandatory responding to a diverse market structure.

- Technology assessment, operational data, and decision support tools are required, to advance the knowledge base.

- **Knowledge Hubs** *(coming soon from MITL)* are powerful tool to de-risk the adoption of ZEMHDV.

Key Remarks

- We still don't know everything.

- The advent of **solid-state batteries** and **Hydrogen ICE Engines** (not HFCEV) will reshape the landscape of ZEMHDV.

- We need to overcome **Knowledge Obsolescence** and keep up with the rapid technological advances.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