Zero-Emission-Vehicle Awareness Initiative (ZEVAI)

Knowledge Series 01

Transit Electrification Literature Review

4/7/23

NRCan – ZEVAI Project

Zero Emission Vehicle Awareness Initiative

This Zero Emission Bus Knowledge series is supported by the Natural Resources Canada (NRCan), Zero Emission Vehicle Awareness Initiative (ZEVAI), Project# PCA-032_CA.

The aim is spread Zero-Emission-Vehicle-Awareness within the transit community through a set of series of Knowledge series presentations, webinar, and reports.

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Knowledge Series 01

e-Bus Research

01 An overview of e-Bus research progress from 2000-2021

02 Highlight Saturated Knowledge domains and Knowledge gaps

03 Communicate key take-home messages

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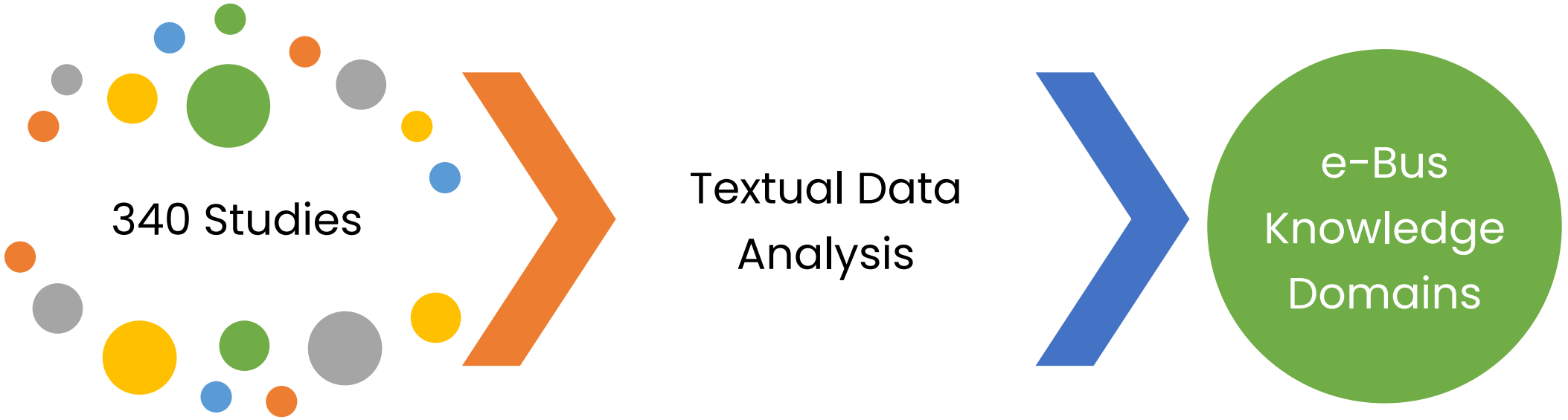
Knowledge Series 01

What is offered at this stage



Recommendations for transit providers and policymakers

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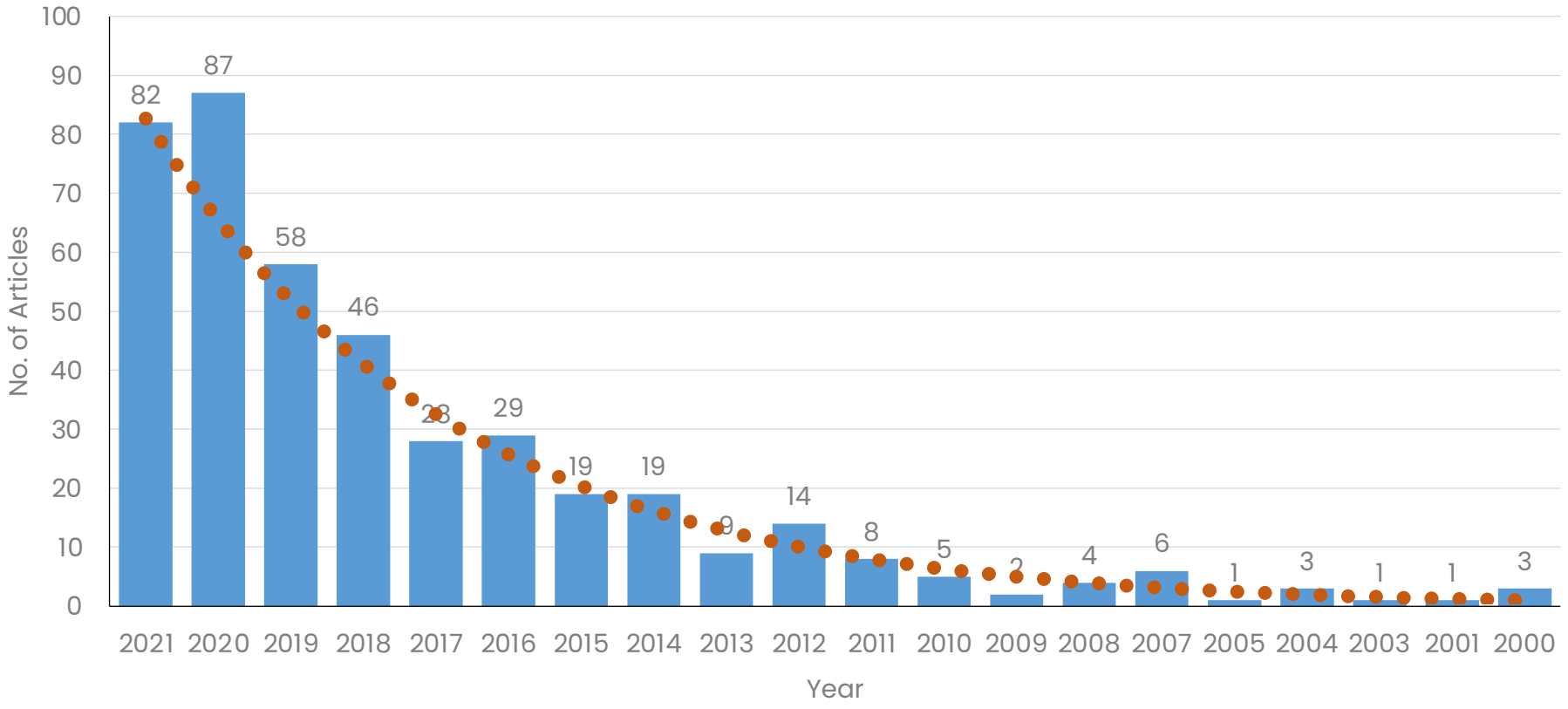
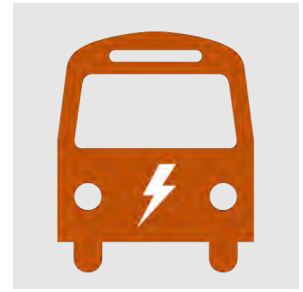
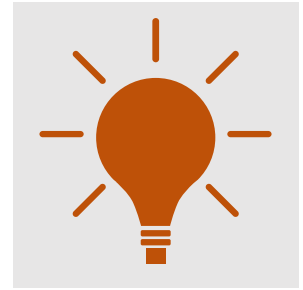
e-Bus Literature Mining (340 Studies)

"electric bus" OR "battery electric bus" OR "e-Bus" OR "ebus"







Number of e-Bus articles published in peer-reviewed journals from 2000-2021

e-Bus is receiving considerable academic attention

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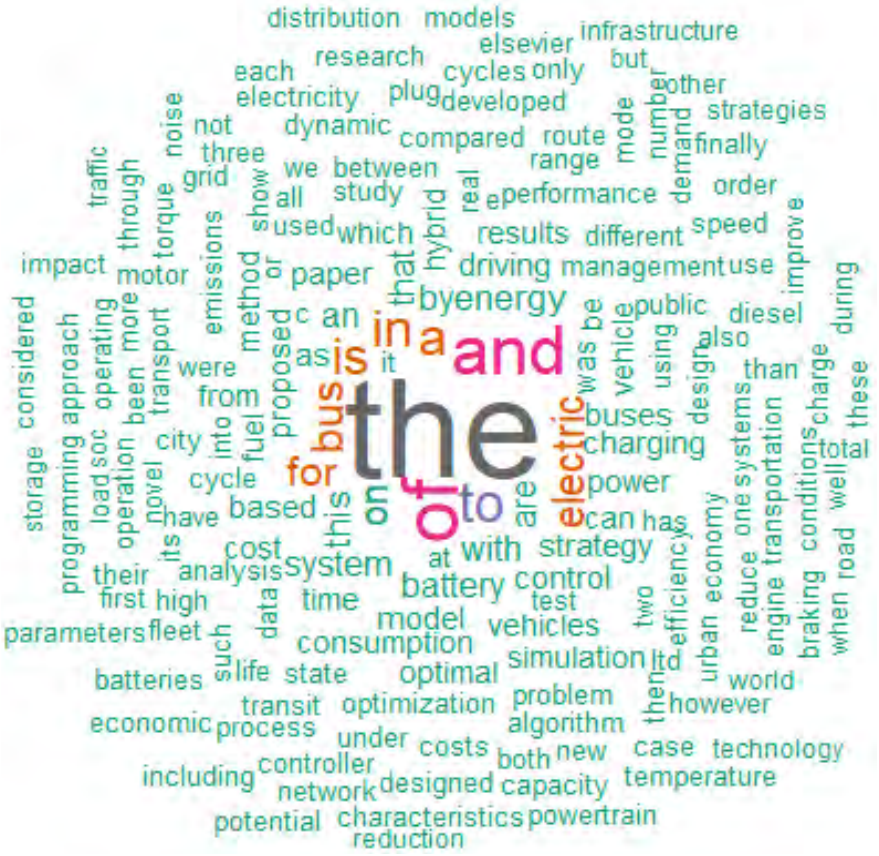
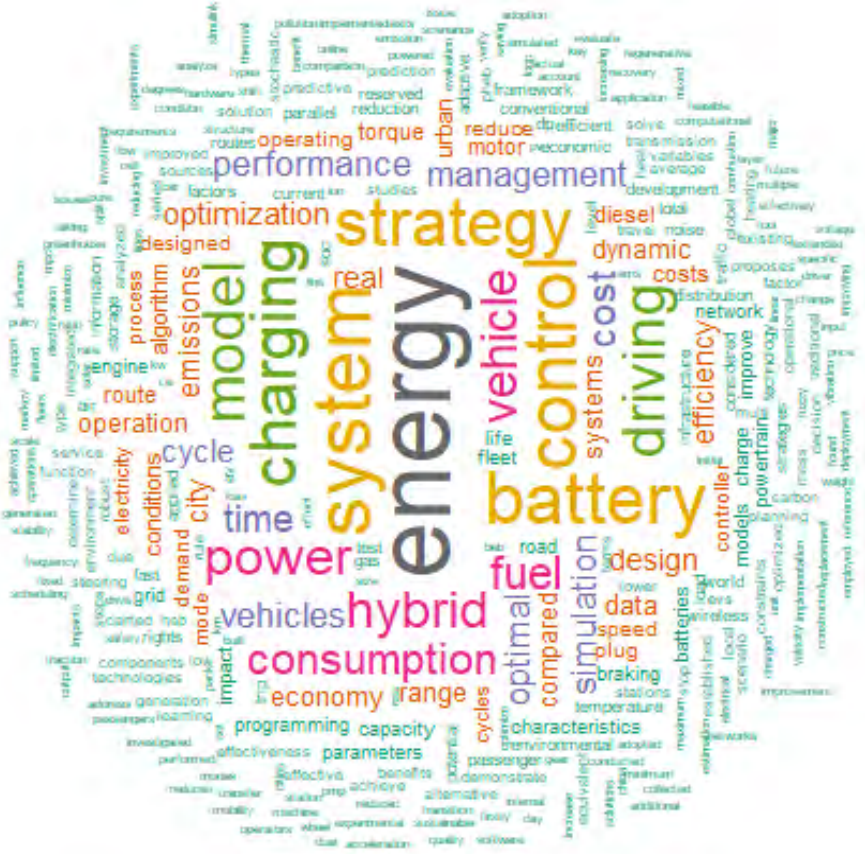
Machine Learning Analysis of Textual Data

Data Cleaning Process



Raw Word Cloud



Clean Word Cloud

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e-Bus Main 10 Topics

Topics 1 to 5

Topic 01 **Vehicle Dynamics**	Vehicle, system, motor, torque, controller, etc.
Topic 02 **Infrastructure Systems**	Charging, cost, fleet, infrastructure, fast, technology, wireless, models, EV, model, etc.
Topic 03 **Operational Factors**	Time, city, data, route, network, demand, real, traffic, trip, information, etc.
Topic 04 **Energy Consumption**	Energy, driving, consumption, cycle, efficiency, range, braking, simulation, characteristics, urban, etc.
Topic 05 **Power/Utility Impact**	Power, system, energy, systems, grid, operation, storage, load, distribution, vehicles, etc.

e-Bus Main 10 Topics

Topics 5 to 10

Topic 06 **Emission and Cost**	Emissions, vehicles, diesel, costs, cost, economic, impact, life, environmental, gas, etc.
Topic 07 **Battery Performance**	Battery, system, conditions, batteries, capacity, performance, temperature, heat, low, heating, etc.
Topic 08 **Optimization Models**	Model, optimization, algorithm, optimal, dynamic, prediction, predictive, parameters, functions, etc.
Topic 09 **External Factors**	Design, noise, reduce, factors, urban, development, constraints, motor, process, structure, etc.
Topic 10 **Comparative Analysis**	Charging, cost, fleet, infrastructure, fast, technology, wireless, models, EV, model, etc.

e-Bus Popular Topics

Topic Popularity Index

Topic 01
Vehicle Dynamics

Topic 02
Infrastructure Systems

Topic 04
Energy Consumption

Topic 05
Power/Utility Impact

Topic 07
Battery Performance

Topic 08
Optimization Models

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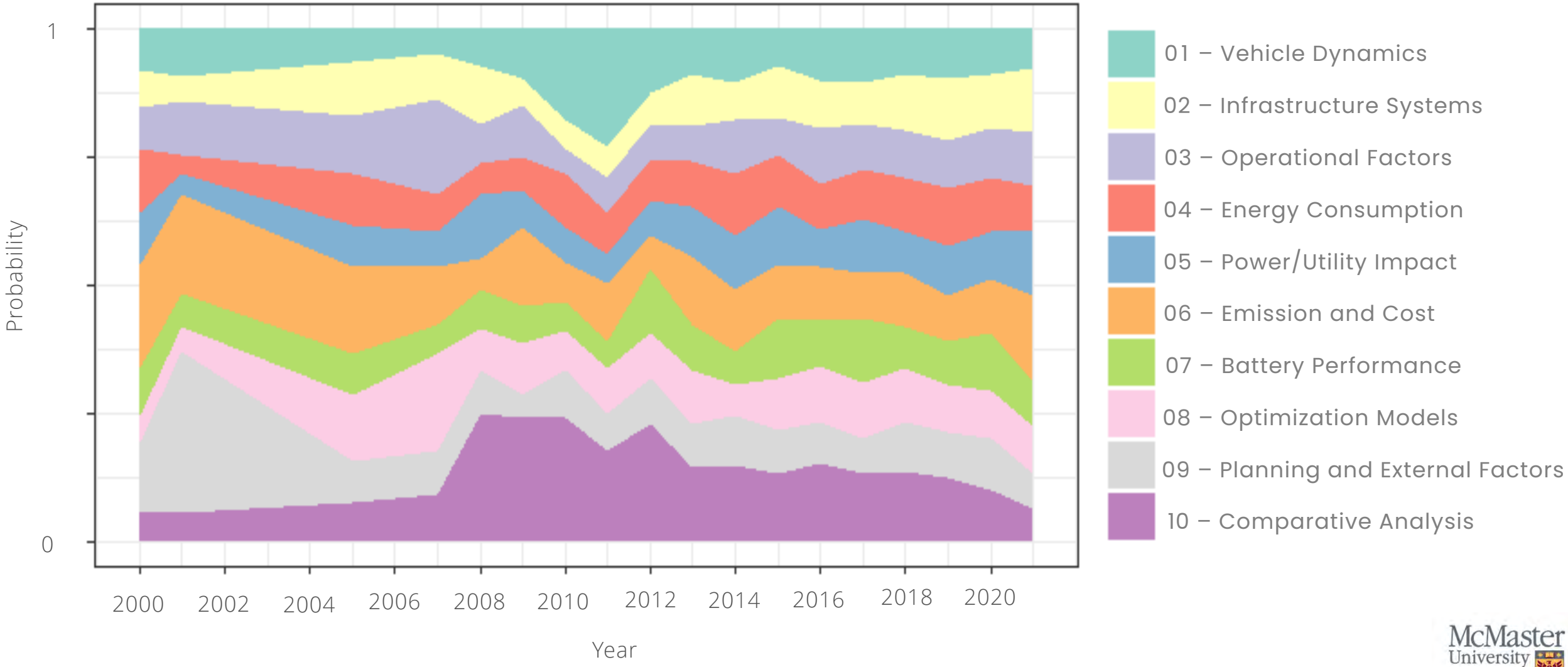
e-Bus Topics Overtime

Topic Distribution from 2000 - 2021



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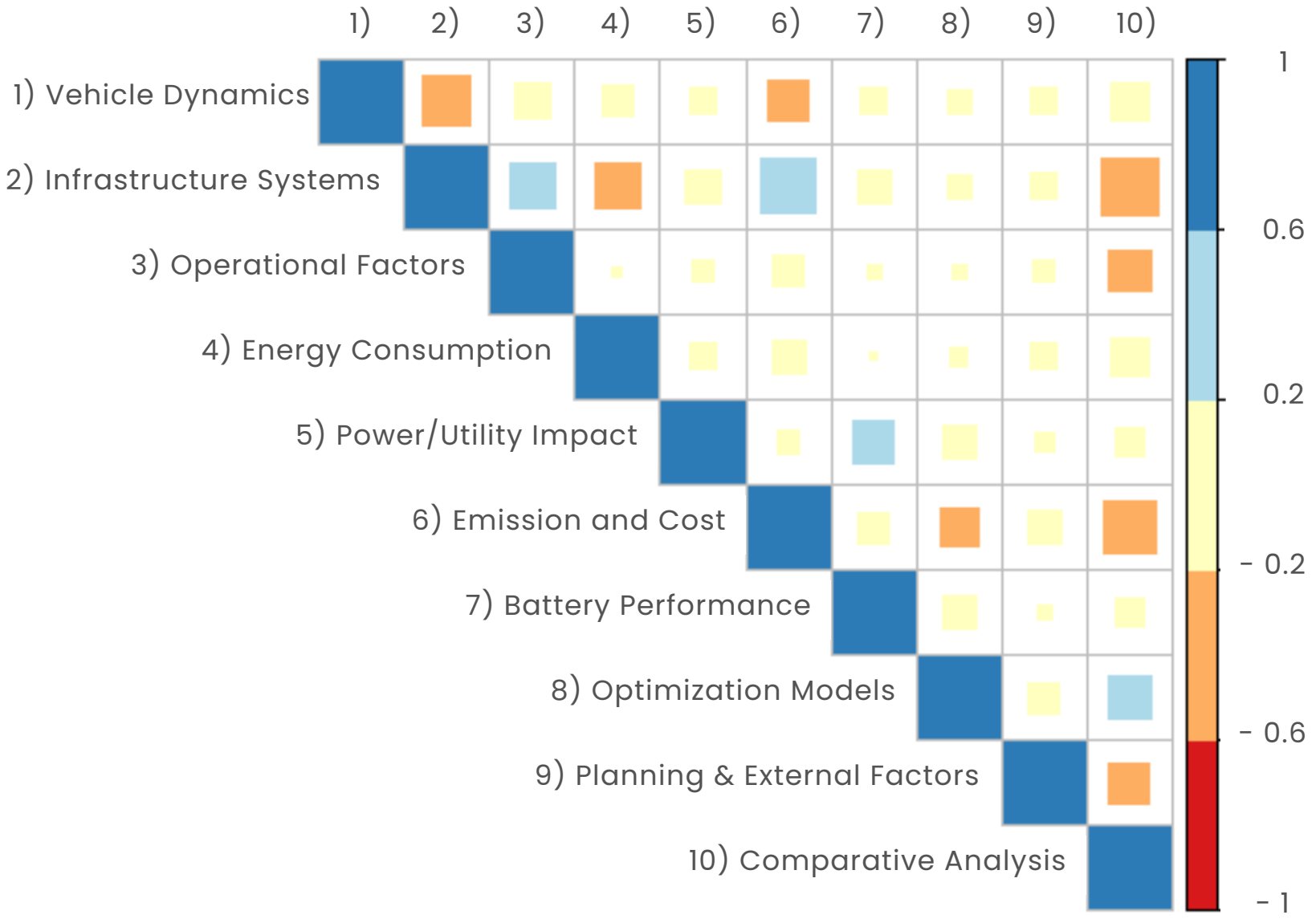
Topic Intersectionality

Knowledge Gaps & Saturated Knowledge



Blue cells = topics that are commonly studied together **(Saturated Knowledge)**

Red cells = topics that are rarely studied together **(Knowledge Gaps)**

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e-Bus Research Findings

Gaps in the current literature

Performance of a full e-transit network is yet to be reported in the literature

Current research is based on partial fleet replacement

Service providers' perspective toward transit electrification is understudied

e.g., barriers and enablers

There is an apparent lack of monetary support to incentivize transit electrification

The not-in-my-backyard (NIMBY) syndrome is a key barrier

There are no studies on the performance of an e-transit network under disruption

e.g., electricity outage, equipment malfunction

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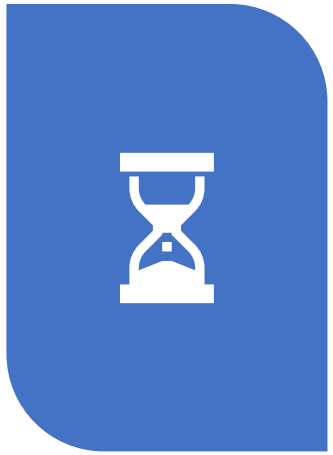
e-Bus Policy Implications

Tangible opportunities to advance system electrification

Policies associated with the procurement process must be updated to facilitate different ownership models.
(e.g., leasing, owning, financing)



At the operation level, policies and guidelines should include several safeguards to address the cascading impacts of service disruption.

Monetary incentives to enable transit providers to study, analyze and test electric buses in operation (Capacity development)

Technology awareness, knowledge mobilization and educational programs are required to further educate stakeholders on the true costs and benefits of transit electrification.

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e-Bus Recommendations for Transit Providers

Understanding the Knowledge Gaps

No available knowledge on the impact of **battery degradation** on the 12-year operation.

The **resiliency** and **robustness** of e-Bus system under disruption is not well studied.

Route-level based feasibility analyses **LEAD** to miss allocation of resources.

Technology awareness, knowledge mobilization and **educational programs** are required to further educate stakeholders on the costs and benefits of transit electrification.

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Coming soon

Knowledge Series 02
e-Bus Transit System Implementation Guidelines

Do & Don't!

hank you

TRiP

Transit Research-Informed Practice

Contact Us

Full report: https://www.researchgate.net/publication/362875150_e-Bus_Transit_Systems_Knowledge_Series_01_Transit_Electrification_Literature_Review