EVALUATING REGULATORY FRICTION IN CANADIAN HYDROGEN CODES AND STANDARDS FOR THE DEPLOYMENT OF HYDROGEN BLENDS IN ALBERTA

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Agenda

1. *Introduction*
2. *Research Motivations*
3. *Research Objectives*
4. *Methodology*
5. *Key Findings*
6. *References*

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Introduction: Hydrogen Blending

- Hydrogen blending: Controlled introduction of hydrogen into existing natural gas systems
- Offers a pragmatic pathway for hydrogen adoption
- Blends can be deployed incrementally
- Provide demand pull for low-carbon hydrogen production
- Alberta advancing legislative frameworks to deploy hydrogen blends – Bill 52

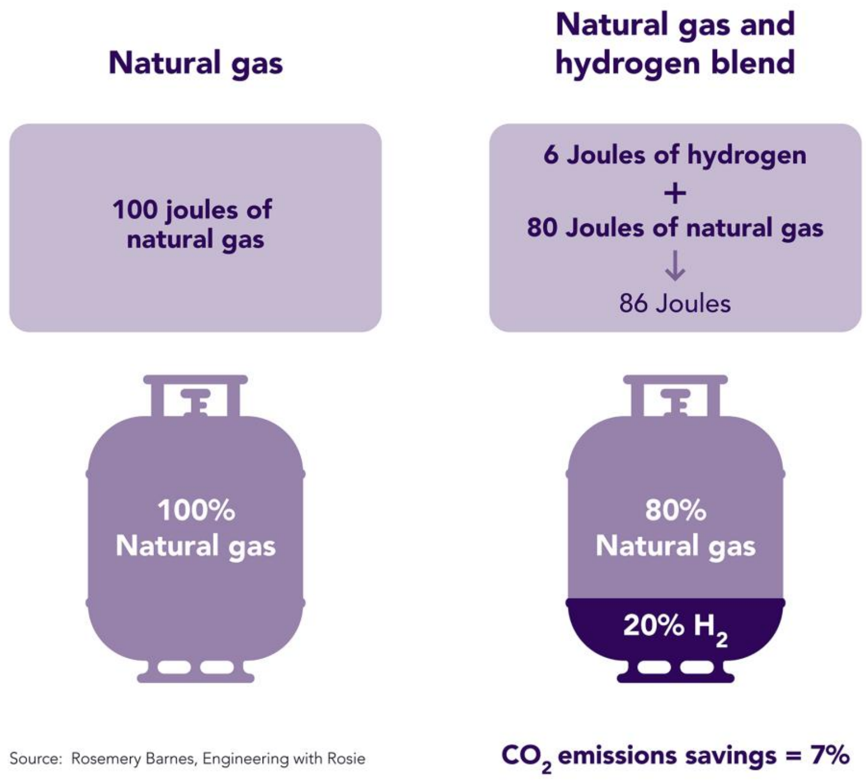

Figure 1. Climate benefits of hydrogen blending

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1. M.-D. Bloj, R. G. Ripeanu, A. Diniță, V. O. Oprea, and M. Tănase, "Comprehensive review of hydrogen-natural gas blending: Global project insights with a focus on implementation and impact in Romanian gas networks," Heliyon, vol. 11, no. 6, p. e43090, Mar. 2025, doi: 10.1016/j.heliyon.2025.e43090.
2. "Global Hydrogen Review 2024 – Analysis," IEA. Accessed: Feb. 25, 2026. [Online]. Available: https://www.iea.org/reports/global-hydrogen-review-2024

Introduction: Barriers to Deployment

- Technical requirements for hydrogen blending not established by a single global authority
- Multiple jurisdictions and standards organizations are involved
- Thus, textual and structural divergence between technical codes exists
- Creates uncertainty for engineers, regulators, and project developers

Bridging the gap

- Requires scalable methods to systematically compare hydrogen blending regulations

3. "Global Hydrogen Review 2025," 2025.
4. "2024 Annual Merit Review and Peer Evaluation Report | Hydrogen Program." Accessed: Feb. 25, 2026. [Online]. Available: https://www.hydrogen.energy.gov/library/annual-review/2024-annual-merit-review-and-peer-evaluation-report

Research Motivations

- Natural Language Processing (NLP) offers a robust pathway for systematic textual comparison
- Treating regulatory friction as a semantic, structural problem
- Systematically identifies semantic inconsistencies
- Transformer-based models
    - Fine-tuned BERT (Bidirectional Encoder Representations from Transformers) models

5. O. Weber and Q. Wang, "Sustainable Finance Research, Standards, and Reporting: Insights from Quantitative and Qualitative Data Using Fine-Tuned BERT Models Work in Progress," Mar. 25, 2025, Social Science Research Network, Rochester, NY: 5193239. doi: 10.2139/ssrn.5193239.
6. Q. Li, Z. Xiao, and Y. Zhao, "Research on the Classification of New Energy Industry Policy Texts Based on BERT Model," Sustainability, vol. 15, no. 14, Jul. 2023, doi: 10.3390/su151411186.
7. O. N. Okonicha and A. Sadovykh, "NLP-based automated compliance checking of data processing agreements against General Data Protection Regulation," vol. 16, pp. 1667–1685, 2025, doi: 10.20537/2076-7633-2025-16-7-1667-1685.

Research Objectives

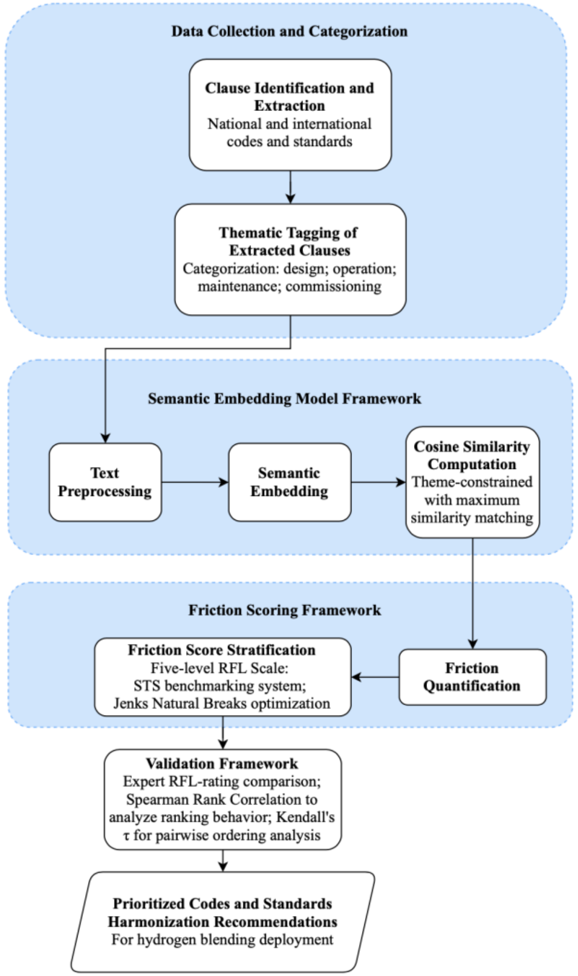
- The objective of this study was to **develop an NLP-based framework to identify and quantify regulatory friction in Canadian hydrogen codes**
- Identification of key regulatory gaps and development of code harmonization recommendations

Supporting safer and more scalable hydrogen blends deployment

Methodology

1. Data collection and categorization
2. Semantic embedding model framework
3. Friction scoring framework
4. Validation framework
5. Code harmonization recommendations

RFL Scale	
1.	Negligible
2.	Low
3.	Moderate
4.	High
5.	Critical



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Key Findings

Model Sensitivity Analysis

- Sentence-BERT provides balanced and reliable semantic comparison
- Baseline BERT overestimates similarity
- MiniLM highly conservative

Table 1. Model Sensitivity Statistical Results

Model	Mean Similarity	Std Dev	Gap Detection (<0.70 Similarity)	Behavior
SBERT	0.6496	0.0897	70.95%	Balanced
Baseline BERT	0.8155	0.0539	3.57%	Inflated similarity
MiniLM	0.5741	0.0921	91.67%	Conservative

SBERT chosen as the core model

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Key Findings

58.6% of clause pairs showed "Moderate" to "High" regulatory friction

343 clause pairs in total

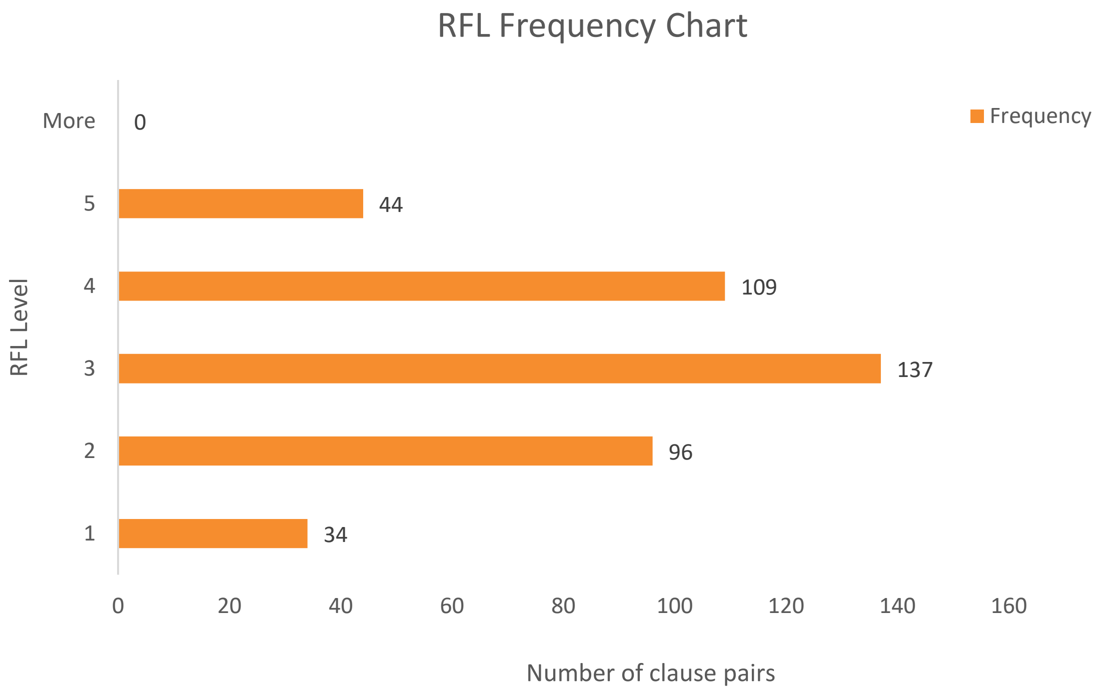

Figure 2. RFL frequency chart

5 – Critical

4 – High

3 – Moderate

2 – Low

1 - Negligible

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Key Findings

- Strong statistical and expert-based validation results
  - Model-expert rating comparison shows almost perfect agreement (**K = 0.800**)
  - Spearman's RC (**ϱ = 0.817**) shows very strong correlation between SBERT and expert ratings
  - Kendall's Tau (**τ = 0.748**) confirms strong model-expert ranking agreement

Model depicts reliable agreement with human technical judgment

Key Findings

Priority Harmonization Actions

- Integrate hydrogen-specific design provisions
- Adopt a hybrid of prescriptive and performance-based frameworks
- Strengthen inspection, commissioning, and validation requirements
- Implement lifecycle-based documentation practices
- Shift toward system-level safety design integration

References

1. M.-D. Bloj, R. G. Ripeanu, A. Diniţă, V. O. Oprea, and M. Tănase, "Comprehensive review of hydrogen-natural gas blending: Global project insights with a focus on implementation and impact in Romanian gas networks," Heliyon, vol. 11, no. 6, p. e43090, Mar. 2025, doi: 10.1016/j.heliyon.2025.e43090.
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9. M. Saleh, "Evaluation of Jenks Natural Breaks Clustering Algorithm for Changepoint Identification in Streaming Sensor Data," 2024, Accessed: Feb. 28, 2026. [Online]. Available: https://www.authorea.com/users/814216/articles/1215838-evaluation-of-jenks-natural-breaks-clustering-algorithm-for-changepoint-identification-in-streaming-sensor-data?commit=a9b26ea5862a7aa68deaa04f428e9328feb6f53f

Thank you!

Any questions?

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