



The state of Codes, Standards, and Regulations for Hydrogen in the Mining Industry

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Presentation Overview

- Introduction to Change Energy
- Overview of the Hydrogen Regulations, Codes, and Standards Landscape
 - Hydrogen Codes and Standards from CSA
- Hydrogen use in Mining
 - Some Sample Executed Projects
- What to Do in the Absence of a Clear Regulatory Pathway
 - Issues and Recommended Actions

The logo for CHANGE energy services, featuring the word "CHANGE" in a bold, green, sans-serif font, with "energy" and "services" in a smaller, grey, sans-serif font below it.

**Change
Energy**

CH₂NGE

Change
Energy


CES is an experienced engineering services firm specializing in Alternative Fuels System Solutions.

CES has been involved since the early days of gaseous fuels, as technologies, supply chains, best practices, and codes and standards were being developed. Today, many of these key areas have matured because of our involvement.

Our experience is international, including the development of approximately 150 gaseous vehicle refuelling stations.

For the past 30 years, we've been helping our client's transition to sustainable, low carbon solutions. Our scope includes:

- Vehicle refuelling facilities
- Bulk gaseous fuel delivery systems
- Full Life-Cycle Techno-Socioeconomic modelling of stations
- Safety and Risk Assessment
- Participation in the development of Regulations, Codes, and Standards.



Introduction to CHANGE ENERGY SERVICES


ABOUT CHANGE ENERGY

Applied sustainability is at the core of everything we do to maximize financial and environmental benefits for our customers.

– we implement it as a solution to consistently yield the economic, environmental, and social outcomes our Clients seek.

Past clients include:

- Governments (e.g., Federal, Provincial, Municipal)
- SDOs (e.g., CSA)
- NGOs (e.g., H2GO, HBC)
- Engineering Companies (e.g., GHD, Wood, WSP)
- Large Corporations (e.g., Greenfield Energy, Irving Oil, J. D. Irving)
- Gas utilities (e.g., Enbridge, Heritage Gas, Union Gas)
- Commercial fleets operators



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graph TD
    Start(( )) --> CONCEPT((CONCEPT))
    CONCEPT --> POSSIBILITY((POSSIBILITY))
    POSSIBILITY --> CHOICE((CHOICE))
    CHOICE --> IMPLEMENT((IMPLEMENT))
    IMPLEMENT --> OPERATE((OPERATE))
    OPERATE --> CHOICE
    
```

Introduction to CHANGE ENERGY SERVICES

CH₂NGE

SERVICE OFFERINGS

We support our clients through every stage of a project, from concept, to choosing a pathway forward, to implementation and operation.

- Infrastructure Planning
- Business Case Assessment & FVI
- Owners Engineer / Subject Matter Experts
- Facility Design, & Procurement
- Project Management and Training
- Performance Assessment, Troubleshooting
- **Risk Assessment**
- **Approvals with all AHJs**
- **Regulations, Codes, & Standards Development**



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Overview of the Hydrogen Regulations, Codes, and Standards Landscape

- **Why are codes and standards needed?**
 - In the absence of a Regulatory Landscape each project must be designed and assessed on its own merits.
 - Each jurisdiction will have its own approach and experience base.
 - New technologies will be judged based on prior experience with the closest analogous fuel, technology, and application.
 - Time frames and costs of Approvals cannot be guaranteed.
 - Deployment of new technologies and systems remain largely in “demonstration mode” until they fit within a Regulatory Framework.

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Overview of the Hydrogen Regulations, Codes, and Standards Landscape

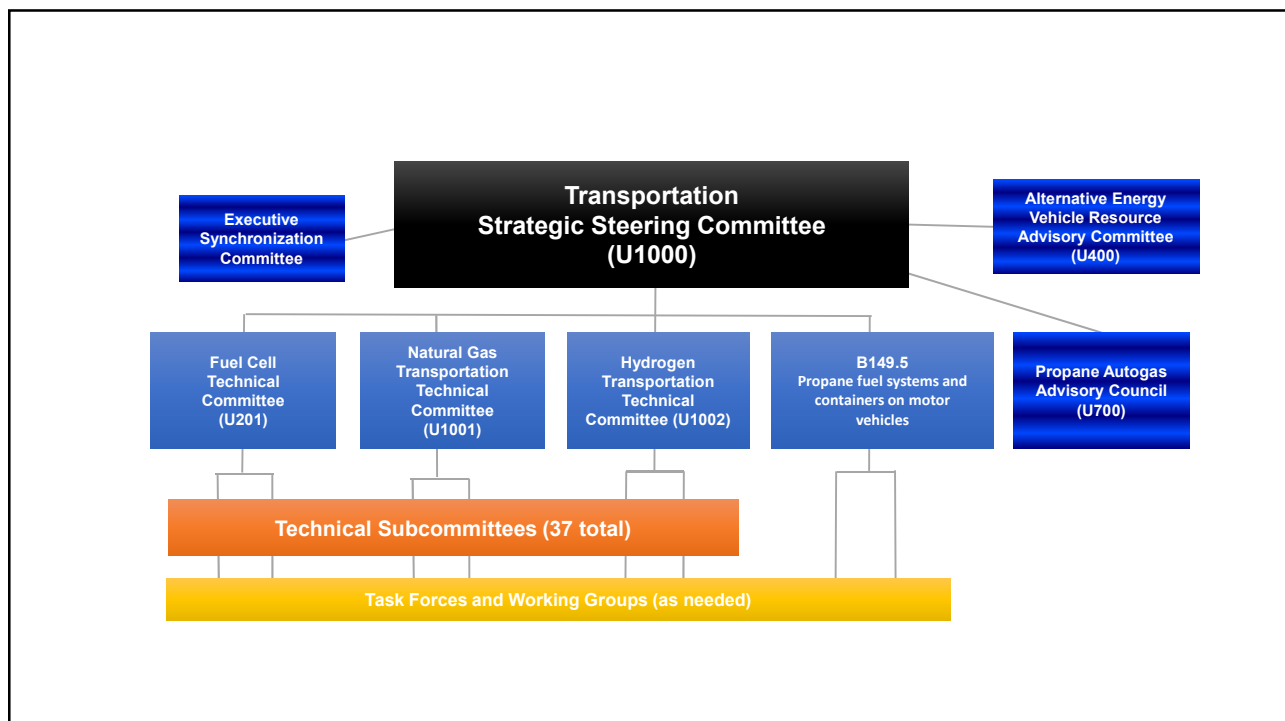
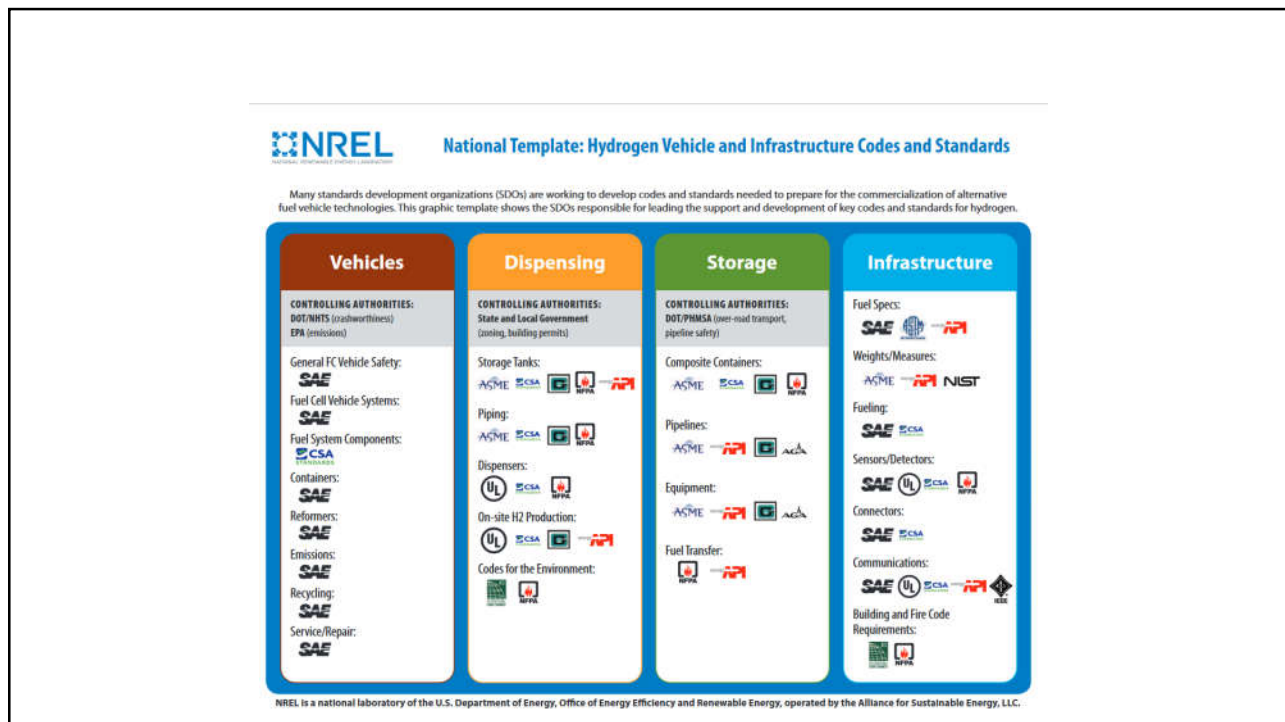
- **Regulations**
 - Laws that enforced by an AHJ
 - Typically reference codes (in whole or in part)
- **Codes**
 - Provide a set of rules for construction or use
 - Typically:
 - Establish Minimum level of safety
 - Embody best practices
 - Establish system proof test requirements
 - Usually reference equipment standards
- **Standards**
 - Provide:
 - Component specifications
 - Certification test requirements

CODE VERSUS STANDARD	
Model that is adaptable by law	Set of technical definitions, specifications, and guidelines
Clarifies what needs to be done	Clarifies how something should be done
Can be adopted into law	Is not legalized
Examples include International Building Code and ASME Boiler and Vessel Code	Examples include ASTM International standards and ISO standard

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Regulatory Authorities & Framework

- Regulating mining activity is primarily the responsibility of the Provinces.
 - For instance, in Ontario the TSSA would apply O. Reg. 214 to applications that dispense Hydrogen as a fuel.
 - O. Reg. 214 calls out the Canadian Hydrogen Installation Code – BNQ-1784-000. (The current version is about to be replaced by an updated code, likely before the end of 2021)
- Mining companies must, however, also adhere to several Federal acts and regulations. (e.g., TDG, Weights and Measures)
- CanmetMINING approves engines for use in underground mines, in accordance with appropriate CSA standards:
 - CSA M424.2-16 for non-gassy underground mines; or
 - CSA M424.1-16 for coal and other gassy mines.
 - NOTE: CSA is undertaking a restructuring of M424. This will include M424.4 “Non-rail-bound, self-propelled, electrically –driven, mobile machines for use in non-gassy underground mines”. This include new technologies – BEV, hydrogen, and diesel-hybrid.
 - M424.4 is currently at Public Review.
- The U.S. Mine Safety & Health Administration is referenced as well, to regulate hardware installed in mines.



Hydrogen and Fuel Cell Standards N.B. The following image is a draft under development

For more than two decades CSA Group has developed fuel cell and hydrogen standards

- 1 **CSA FC 1** Stationary Fuel Cell Power Systems
- 2 **CSA NPIT 2** Compressed Hydrogen Station and Components for Fueling Industrial Trucks
- 3 **CSA NPIT 1** Compressed Hydrogen Powered Industrial Trucks On Board Fuel Storage and Handling Components
- 4 **CSA HDV 4 SERIES:**
 - CSA HDV 4.1 Hydrogen Dispensing Systems
 - CSA HDV 4.2 Hoses for Compressed Hydrogen Fuel Stations, Dispensers, and Vehicle Fuel Systems
 - CSA HDV 4.4 Breakaway Devices for Compressed Hydrogen Dispensing Hoses and Systems
- 5 **CSA HDV 4.5** Priority and Securing Equipment for Hydrogen Vehicle Fueling
- 6 **CSA HDV 4.6** Manually Operated Valves for Use in Gaseous Hydrogen Vehicle Fueling Stations
- 7 **CSA HDV 4.7** Automatic Valves for Use in Gaseous Hydrogen Vehicle Fueling Stations
- 8 **CSA HDV 4.8** Hydrogen Gas Vehicle Fueling Station Compressor Guidelines
- 9 **CSA HDV 4.9** Hydrogen Fueling Station Guidelines
- 10 **CSA HDV 4.10** Fittings for Compressed Hydrogen Gas and Hydrogen Rich Gas Mixtures
- 11 **CSA HPRD 1** Thermal Actuated Pressure Relief Devices for Compressed Hydrogen Vehicle Fuel Containers
- 12 **CSA HDV 4.3** Test Methods for Hydrogen Fueling Parameter Evaluation
- 13 **CSA HDV 3.1** Fuel System Components for Compressed Hydrogen Gas Powered Vehicles
- 14 **CSA HDV 2** Compressed Hydrogen Gas Vehicle Fuel Containers
- 15 **CSA FC 3** Portable Fuel Cell Power Systems

New Standards:
 CHMC 2 – Material Compatibility (Non-Metals)
 HGV 5.1 – Vehicle Fueling Appliances



Hydrogen Use in Mining

- Energy production and storage
 - Hydrogen technologies can offer conversion efficiencies of ~65-75%, potentially leading to a cost-effective pathway to:
 - Reduced reliance on diesel for fuel - reducing tailpipe emissions
 - Improve overall reliability and operational efficiency of site activity vs other options
 - A means to store large amounts of renewable energy produced on-site
 - In addition to improving site efficiency and reliability, storage can help to:
 - Shift renewable energy from time of production to time of use
 - Balance monthly and seasonal variations in renewable energy production
 - Provide a secondary commodity that may be sold.
- Fuel cell electric mining vehicles and portable power generation
 - Heavy-duty vehicles such as mining haul trucks and trains can be replaced with fuel cell electric vehicles. Extended range, faster refuelling.
 - Portable electric power generation at significant energy levels anywhere on-site
- It is typical that as an alternative fuel is introduced co-benefits are revealed.
 - E.g., savings due to a reduced need to ventilate exhaust gases must also be considered.

Sample Initiatives & Projects

- Glencore's Raglan mine in northern Quebec, Canada
 - The mine has run on a micro-grid powered by an arctic rated turbine generator connected to a hydrogen energy storage unit since 2015.
- Anglo American mining haul truck in South Africa
 - Anglo American announced the development of the world's largest hydrogen-powered haul truck in 2019, which was to be trialled at the Mogalakwena platinum group metals mine in South Africa.
- Engie & Mining3's mining haul train in Chile
 - Launched in 2021, this project involves the development of a prototype for a mining haul train powered by 100-200 kW fuel cells.

Approvals Process

- In looking into the literature, most projects undertaken to date have been demonstrations and early deployments:
 - **Therefore, the approvals process looks to be one that is relatively ad hoc.**
- There do not appear to be any impediments to the use of hydrogen. However, based on past experience, in the absence of a clear regulatory framework it is essential that ALL potentially relevant AHJs be contacted and consulted.
 - A thorough approvals plan will require working with all interested local AHJs to develop approvals requirements
- It is informative to consult the approvals process used:
 1. In a similar application in a different jurisdiction
 2. For a similar application with another gaseous fuel (such as Natural Gas).
 - **A good starting point** is the Province-by-Province Approvals Guidelines published by the CNGVA.

Issues and Recommendations for Further Action – *NOT an Exhaustive List!*


- Standardization is difficult to achieve in the early days of alternative fuel development
 - Recommended action:
 - Work with Government and an appropriate Industry Association to develop a standardized approach for projects pertaining to the design, deployment, and use of new technologies and systems that utilize Hydrogen as a fuel in the mining sector
- Canada is a relatively small market
 - Recommended action:
 - Work with American and international bodies to ensure harmonization with other National and International Standards for mining equipment.

Thank you

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POSSIBILITY

Risk Assessment

A risk analyses must include the people, procedures, hardware, environment, and cost issues over the life cycle of our clients' energy system design. We determine if the system provides a safe environment for employees, the public, and capital assets.

Our reports provide a prioritized list of risks. If undertaken, our recommendations can lead to measurable benefits such as reduced lost-time injuries, improved system up-time, and reduced insurance premiums. These activities include:

- Safety Engineering (safety-by-design)
- Design disciplines tailored to the Alternative Energy Industry: HIRA, FMEA, FEA, CFD, SIS assessment
- Risk-Based Audits & Assessments
- Safety Training
 - Workplace specific training
 - Hazard Identification and Risk Assessment
 - Industrial or Construction Site Accident Investigation
 - Management System and Audit Training

HIRA: Risk Assessment Value

CONSEQUENCE PROBABILITY	CATASTROPHIC	CRITICAL	MARGINAL	NEGLECTIBLE
FREQUENT	UNACCEPTABLE	UNACCEPTABLE	UNACCEPTABLE	ACCEPTABLE*
PROBABLE	UNACCEPTABLE	UNACCEPTABLE	UNDESIRABLE	ACCEPTABLE*
OCCASIONAL	UNACCEPTABLE	UNDESIRABLE	UNDESIRABLE	ACCEPTABLE
REMOTE	UNDESIRABLE	UNDESIRABLE	ACCEPTABLE*	ACCEPTABLE
IMPROBABLE	ACCEPTABLE*	ACCEPTABLE*	ACCEPTABLE*	ACCEPTABLE

* requires more frequent monitoring and audit

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OPERATE

Approvals

Change Energy works with municipal, provincial/state, federal and international regulatory agencies to achieve full compliance with all applicable regulations, codes, and standards.

It is often the case with emerging technologies that an approvals pathway has not been developed or contemplated. Change Energy's extensive experience enables us to anticipate the approval process throughout the enter lifespan of a project and to seek out the appropriate regulatory authorities with whom to engage.

Regulations, Codes, & Standards Development

CES is an active member of several committees of the CSA (and other Standards Development Organizations), working with them on the development of codes and standards for the alternative fuels industry. This puts Change Energy in the optimal position to provide advice on compliance with the emerging regulatory landscape. Change Energy is also experienced in developing internal codes and standards for clients that want to align their project with a larger organizational mandate.

Adhering to regulations, codes and standards can be complex and time consuming. CES works with the regulatory authorities to make sure that an appropriate approvals pathway is in place.

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CLIENTS

Our Clients

A sampling of our Clients includes:

- ATCO Gas, Compressed Natural Gas:** Feasibility study for a network of stations for refuelling trucks
- DTE Energy Technologies, Hydrogen:** Demonstration facility - vehicle fuelling and distributed power generation
- Enbridge, Compressed Natural Gas:** Engineering support for a wide variety of new / existing stations for customer owned fleets
- Environment & Climate Change Canada, Hydrogen:** Phase 1 study to convert a 2000 HP diesel locomotive to hydrogen
- Ford Motor Company, Hydrogen:** H2 supply for fuel cell test facility
- Green For Life Environmental Inc. Natural Gas Vehicle Refueling:** Detailed engineering for refuelling a fleet of refuse haulers
- Irving Oil, Compressed Natural Gas:** Bulk transport solutions for region conversion from low-grade heating oil to CNG
- JD Irving, Compressed Natural Gas:** A 'Pipeline on Wheels' solution to provide a service their off-pipeline facility
- Nalcor, Hydrogen:** Peer review of process design for compliance with Canadian Hydrogen Installation Code
- NRCan c/o H₂ Go, Hydrogen:** Preliminary assessment of CO₂ Intensity of green/blue/gray H₂ from various technologies
- PEI Energy Corporation, Hydrogen:** Hydrogen Process Design for Prince Edward Island Wind/Hydrogen Village
- Toronto Transit Commission: Emissions Reduction:** Improved performance of defueling system, negotiation support

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Hydrogen Projects and Studies

Change Energy has been involved in the development of high-pressure gaseous fuel facilities for some 30 years. During this time, we have been involved in the design and development of well over 150 facilities (vehicle refuelling stations, bulk transport systems, building modifications), and have prepared numerous studies, assessments, training materials, draft codes, and the like.

Much of this work has dealt with the use of high-pressure hydrogen. We have engaged in hydrogen projects in Ontario, across Canada, and around the world.

CES is also actively engaged in the development of codes and standards (in particular with the CSA and BNQ), regulations (primarily with the Ontario TSSA), and approvals guidelines and certification programs (with several different governments and corporations).

Further Detail...

Change Energy has executed more than 20 Hydrogen Infrastructure projects and develop more than a dozen detailed hydrogen studies.

- A list of our infrastructure projects is available on request.
- Some of our most recent studies include:
 - Hydrail Railway Transition in Canada: Technological, Operational, Economical, and Societal (TOES) Barriers and Opportunities
 - (Available on the Transport Canada Website)
 - Assessment of the Design, Deployment Characteristics, and Requirements of a Hydrogen Fuel Cell Powered Switcher Locomotive
 - (Available on the Transport Canada Website)
 - EU Trade Commission: CETA themed report on Hydrogen
 - Available at: https://trade.ec.europa.eu/doclib/docs/2021/august/tradoc_159778.pdf
 - CSA Research Paper: Alternative Fuels and Energy Systems for the Marine Sector
 - Available at: <https://www.csagroup.org/wp-content/uploads/CSA-Group-Research-Alternative-Marine-Fuels-and-Energy.pdf>

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