

# National H<sub>2</sub> Safety Centre

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Hydrogen Safety in Multiple Sectors

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**Market Brief**  
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# Canadian Hydrogen Safety Centre (CH<sub>2</sub>SC)

A not-for-profit company, with a global network and a national focus

## Mission

The CH<sub>2</sub>SC is committed to develop and deliver hydrogen safety solutions through coordination:

- In **multiple industrial sectors** in each region.
- For **apparent and non-apparent safety problems**.
- To **enable safe adoption** of hydrogen as *a fuel, an energy carrier, a storage medium, a chemical feedstock, etc.*

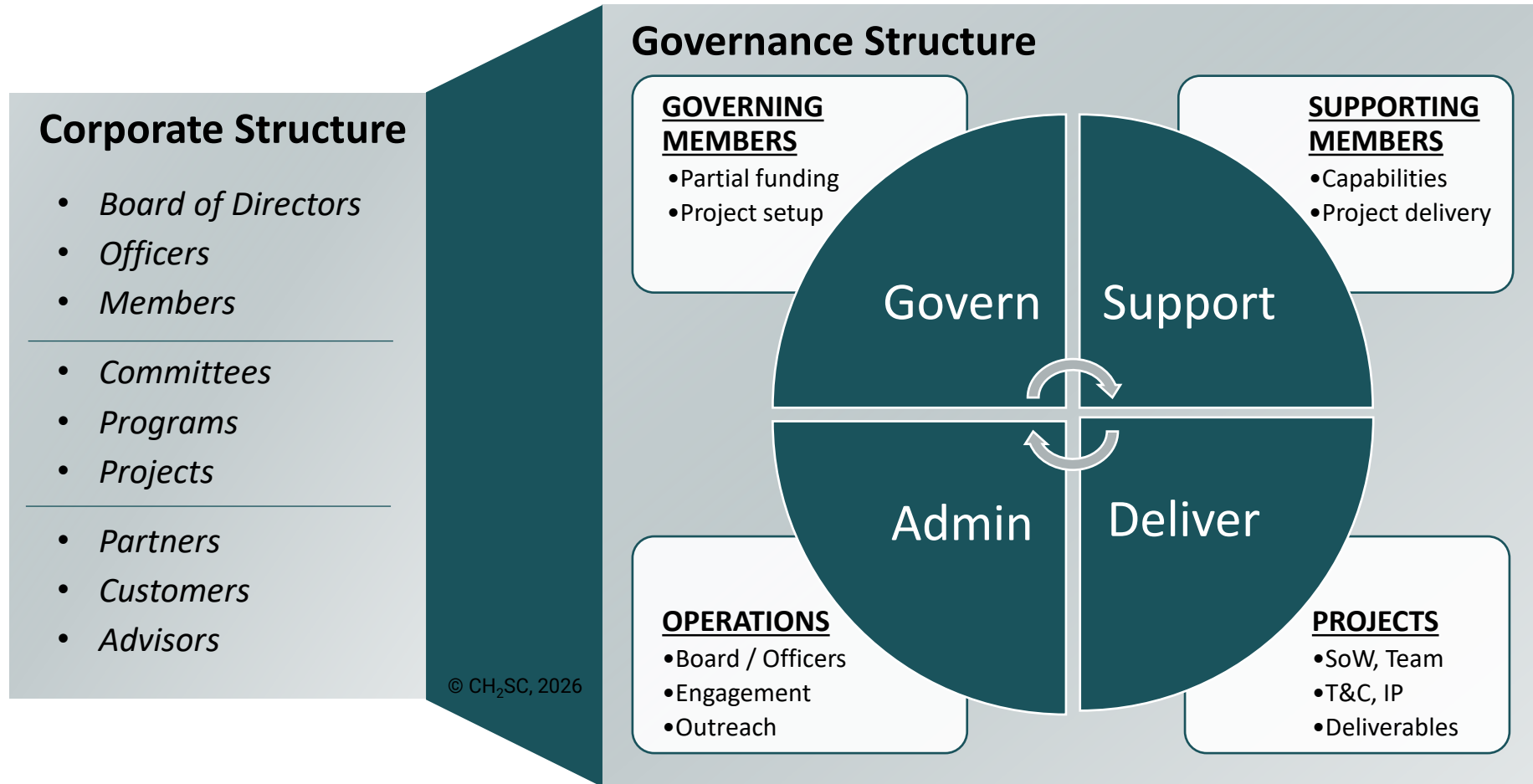
## Objectives

- **Consult and forecast safety problems** by identifying apparent and non-apparent safety problems; and prioritize activities to address problems in each industrial sector that uses hydrogen.
- **Initiate and execute projects to coordinate** hydrogen safety expertise and capabilities to enable solutions for safety problems, through consultancy and project support.
- **Enable and connect national and international network** of hydrogen labs, test facilities, and safety expertise to develop and adopt inherent safety principles in each hydrogen application.
- **Support and collaborate in the advancement and implementation** of codes, standards, bylaws, and regulations for each hydrogen application.
- **Learn from and advise governments, regulators, policymakers, and industry** on hydrogen safety.

*CH<sub>2</sub>SC helps integrate safety levels for each hydrogen application, for the full system & full project life*

# CH<sub>2</sub>SC Structure Aligned with the Mission

Independent, neutral, technology and industry agnostic, unbiased



# CH<sub>2</sub>SC Board and Officers

Team brings decades of industry experience from nuclear, hydrogen, oil and gas, and safety

## Board of Directors



**Peter Elder** (Chair)

Canadian Nuclear Laboratories (CNL)  
Chalk River, Ontario, Canada



**Bruno Pollet** (Vice Chair)

Université du Québec à Trois-Rivières (UQTR)  
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**Brent Lakeman**

Edmonton Region Hydrogen Hub  
Edmonton, Alberta, Canada



**Mikaa Blugeon-Mered**

La Mosaïque Hydrogène  
Paris, France



**Stuart Hawksworth**

Health & Safety Executive  
Buxton, United Kingdom

## Officers



**Nirmal Gnanapragasam**

President/CEO, CH<sub>2</sub>SC  
Petawawa, Ontario, Canada



**Steven McGee**

Projects Director/CPO, CH<sub>2</sub>SC  
Whitby, Ontario, Canada

## Advisors



**Briang Wagg**

C-FER Technologies  
Edmonton, Alberta, Canada

## Legal



**Marilyn Clarke**

Legal Council, LXM Law  
Ottawa, Ontario, Canada



**Janet Howard**

Strategic Advisor, Terrafirma Law  
Toronto, Ontario, Canada

# CH<sub>2</sub>SC Hydrogen PIVOT Workshop Series

Annual online series: Bringing together hydrogen industry participants for information sharing

## HYDROGEN ∞ PIVOT ONLINE WORKSHOP

### Spring Workshop

April

Hydrogen  
Production

FOCUS  
Technologies with  
low-energy &  
lower cost

### Summer Workshop

July

Hydrogen  
Storage

FOCUS  
Technologies with  
lower safety risks  
& modular

### Fall Workshop

October

Distribution &  
Infrastructure

FOCUS  
Technologies with  
permanent &  
long-term scope

### Winter Workshop

January

End-use | Niche  
Applications

FOCUS  
Technologies with  
dual use & long-  
term potentials

Safety is the underlying and integrating mechanism for hydrogen, hence CH<sub>2</sub>SC

# Canadian Hydrogen Training Committee (CHTC)

**A CH<sub>2</sub>SC Initiative:** To coordinate nationally on hydrogen training aspects with vision, quality & consistency

## Need for a Training Committee:

- **Strategic Alignment:** Ensures training initiatives directly support industry goals.
- **Needs Assessment:** Identifies specific skills shortages and training needs across different areas.
- **Effective Bridge:** Between technology developers and end-users; between operators and licensors; between trainers and trainees; etc.
- **Quality Assurance:** Reviews training materials and curriculum to ensure accuracy, relevance, and continuous improvement.
- **Compliance and Equity:** Ensures training adheres to industrial best-practices and legal requirements.
- **Resource Coordination:** Helps in planning, conducting, and evaluating training, maximizing the effectiveness of human performance development.

## Current Training Pillars:

- **Pillar 1: General Awareness**
  - *Focus:* Properties of hydrogen, environmental benefits, refueling, and general safety protocols.
  - *Best for:* General Public and Non-Technical Employees
- **Pillar 2: Safety and Integration**
  - *Focus:* Risk assessments (PHA/QRA), facility siting, and regulatory compliance.
  - *Best for:* Management, Safety Officers, Engineers, Designers
- **Pillar 3: Technical and Maintenance**
  - *Focus:* Hands-on competency in H<sub>2</sub> gas leak detection, LH<sub>2</sub> (liquid hydrogen) handling, ventilation, defueling, and high-pressure system repair.
  - *Best for:* Technicians, Operators, Gas Fitters
- **Pillar 4: Emergency Response**
  - *Focus:* Invisible flame detection, thermal imaging, safety distances, hydrogen fire response, and vehicle-specific extrication protocols.
  - *Best for:* Fire Services, Emergency Medical Services (EMS), Police

# Levels of Safety Planning

## CH<sub>2</sub>SC Brings Together Fundamental Approaches:

- **Level 1: Information layers** – safety regulations, codes, standards, guidelines, risk assessments, etc.
- **Level 2: Strategic focus** – ‘planning for order’ and ‘preparing for chaos’ in each hydrogen application.
- **Level 3: Analysis scope** – to forecast apparent and non-apparent problems; analyse & find solutions.
- **Level 4: Design basis** – with inherent safety principles, layers of protection, safety by design, scale considerations, etc.
- **Level 5: Integration** – of required levels and system boundaries for robust safety in all stages of operations for the full system.



# Information: Hydrogen Safety Networks

## Level 1: CH<sub>2</sub>SC is establishing partnership on hydrogen safety with a global network of experts

### International and General Focus

- **International Association for Hydrogen Safety (HySafe):**
  - A non-profit organization focused on facilitating the safe adoption of hydrogen as an energy carrier by advancing safety measures and coordinating research efforts.
  - Emerged from a European Commission initiative.
- **Center for Hydrogen Safety (CHS):**
  - Affiliated with **AIChE** (American Institute of Chemical Engineers).
  - Provides guidance, education (including the Fundamental Hydrogen Safety Credential), and collaborative forums.
  - Maintains the **Hydrogen Safety Panel (HSP)**, which develops training content.
- **Safe Hydrogen Project (an initiative of the Compressed Gas Association - CGA):**
  - Focuses on developing and distributing safety information and standards for the production, storage, transport, and use of hydrogen globally.
  - The **CGA** itself has been developing gas and equipment safety standards, including hydrogen standards, for many decades.

### Industry/Regional Associations

- **Safety Consultants:**
  - WHA International, Inc. a consulting firm, are leaders in hydrogen safety since 1988, with engineers from NASA and NREL.
  - Other notable consultants include: Jensen Hughes, Baker Risk, Gexcon, GTI Energy, etc.
- **Industrial Gases Associations (for regional safety frameworks):**
  - European Industrial Gases Association (EIGA)
  - Compressed Gas Association (CGA) (U.S. and Canada)
  - Asia Industrial Gases Association (AIGA)
  - Japan Industrial and Medical Gas Association (JIMGA)

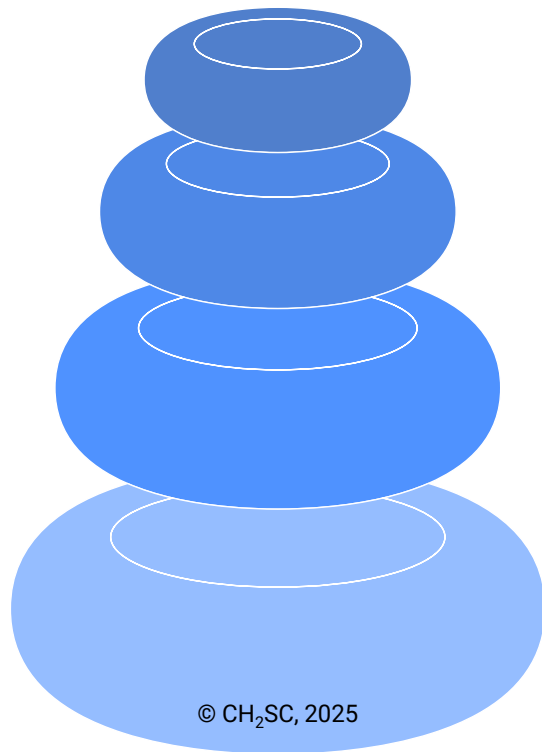
### Standards Development

- **NFPA 2: The National Fire Protection Association (NFPA) 2: Hydrogen Technologies Code** is a key standard, with leaders from other safety organizations (like CGA and WHA) serving on its technical committee.
- **ISO TC 197:** An international standards committee on hydrogen.
- **IEA Task 43:** Hydrogen TCP within IEA advancing RCS.
- **CSA Group:** Has more than 50 standards on hydrogen and helps harmonize standards with NFPA 2, CHIC, ISO, IEC, etc.

# Strategy: Planning vs Preparing

Level 2: Order and chaos coexist, hence CH<sub>2</sub>SC focus is on the strengths at the strategic planning stage

## STRENGTHS: Planning for Order (Ideal for NOAK)



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### Measurable Progress

Easy tracking and adjustments against milestones



### Control

Predictability and reassurance for teams



### Clarity

Shared understanding of objectives and responsibilities



### Efficiency

Optimized resource allocation and streamlined processes

Note: NOAK – N<sup>th</sup> Of A Kind

## STRENGTHS: Preparing for Chaos (Ideal for FOAK)



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### Resilience

The ability to withstand from beyond design basis



### Adaptability

The capacity to adjust to new situations and conditions



### Innovation

Approaching safety via inherent principles & innovate



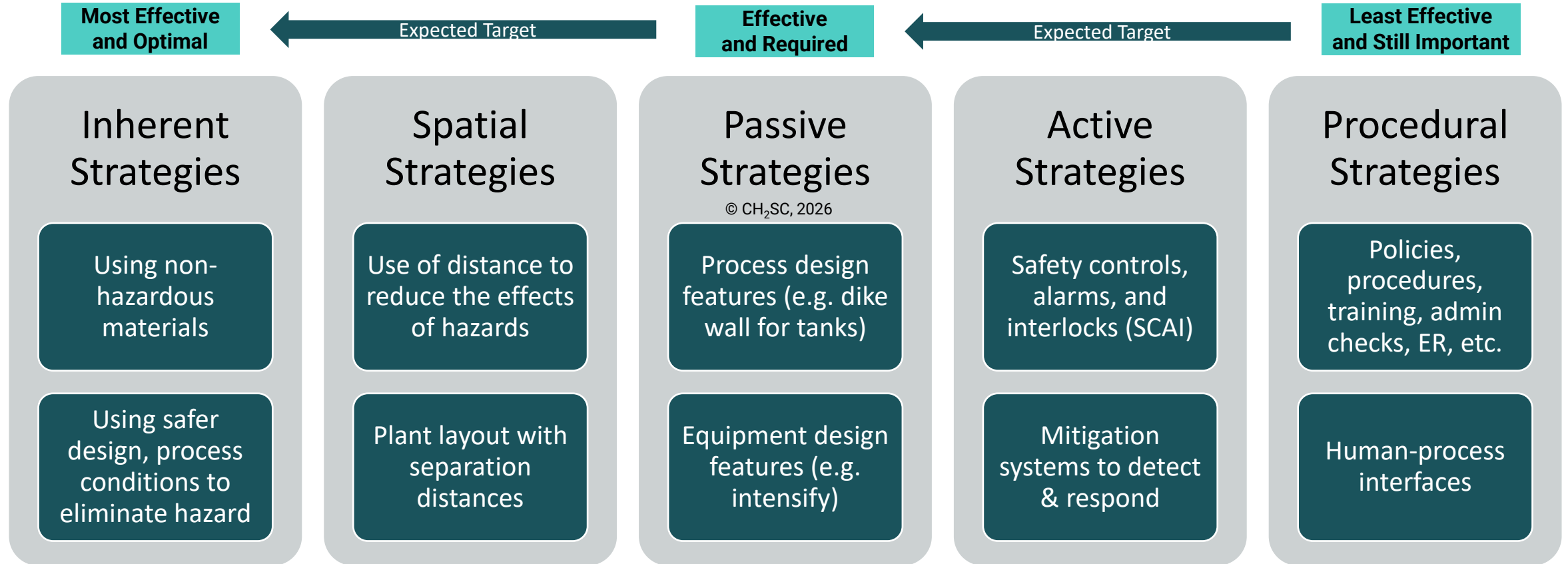
### Agility

The ability to respond quickly and effectively to change

Note: FOAK – First Of A Kind

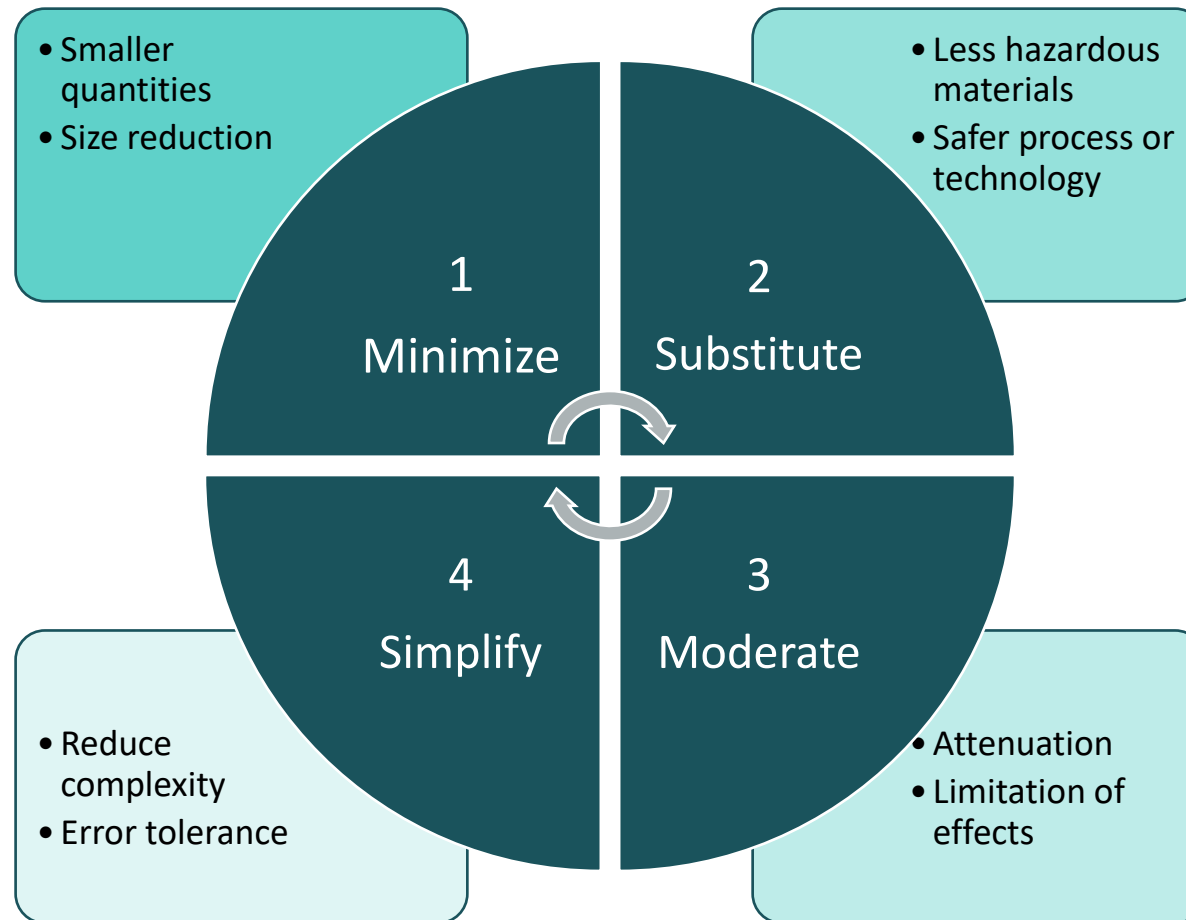
# Analysis: Reduce and Manage Safety Risks

Level 3: CH<sub>2</sub>SC aims to reduce the frequency of risks and the consequences of potential risks



# Design: Inherently Safer Design Principles

Level 4: CH<sub>2</sub>SC brings 'safety by design' and applies to each stage of the hydrogen plant lifecycle



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# Integration: Various Safety Elements

Level 5: CH<sub>2</sub>SC helps prepare for all safety problems, through the integration of safety levels & elements

An example of integration approach on two types of problems

Preparation	Design	Codes & Standards	Operations	System Boundaries
<b>Apparent Problems</b>	<ul style="list-style-type: none"> <li>Inadequate design</li> <li>Borrowed from non-hydrogen design</li> <li>Wrong fundamentals</li> </ul>	<ul style="list-style-type: none"> <li>Minimum requirements</li> <li>Gap exists when application changes</li> <li>Long development cycle</li> </ul>	<ul style="list-style-type: none"> <li>Design failure</li> <li>Dynamic operation</li> <li>Safety device failure</li> </ul>	<ul style="list-style-type: none"> <li>Cross-boundary interaction</li> <li>Safe distances</li> <li>Zoning principles</li> </ul>
<b>Non-apparent Problems</b>	<ul style="list-style-type: none"> <li>Wrong technology</li> <li>Improper design for hydrogen</li> <li>Inadequate testing of component quality</li> </ul>	<ul style="list-style-type: none"> <li>Safety data range</li> <li>Adapting new safety technologies</li> <li>Insufficient layers of protection</li> </ul>	<ul style="list-style-type: none"> <li>Emergency situations</li> <li>Insufficient operating mode</li> <li>Feedback controls</li> </ul>	<ul style="list-style-type: none"> <li>Interconnected boundary</li> <li>Quality control</li> <li>Safety device integrated networks</li> </ul>

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# CH<sub>2</sub>SC Offerings

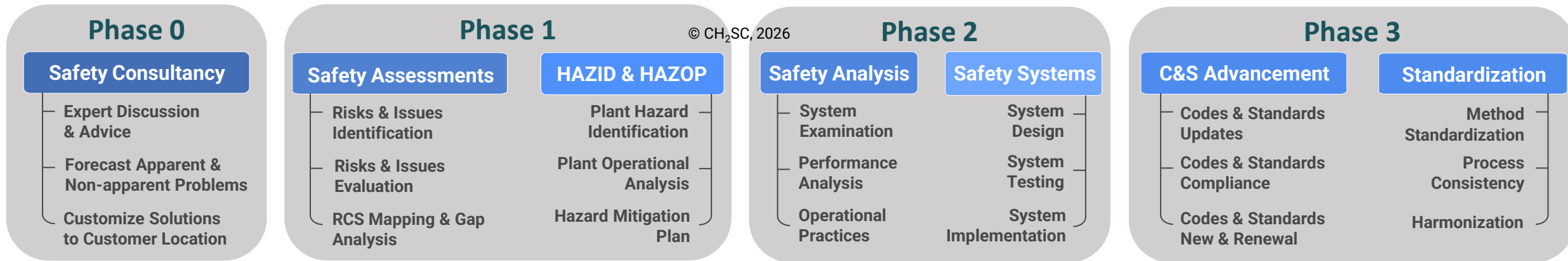
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- **Consultancy.** We will engage with relevant stakeholders to understand & define the problem.
- **Planning.** Initiate the right set of process steps and sequence activities to get to the required solution, with both short-term and long-term goals.
- **Integration.** At the implementation stage, integrate the required safety solutions with the hydrogen energy system being installed and operated.
- **Validation.** Hydrogen safety solutions and integrated systems are to be tested, evaluated, and optimized, with the learnings captured for future improvements, from each project.
- **Standardization.** Safety solution outcomes are to be standardized, to minimize duplication of effort and to align with evolving operational requirements.



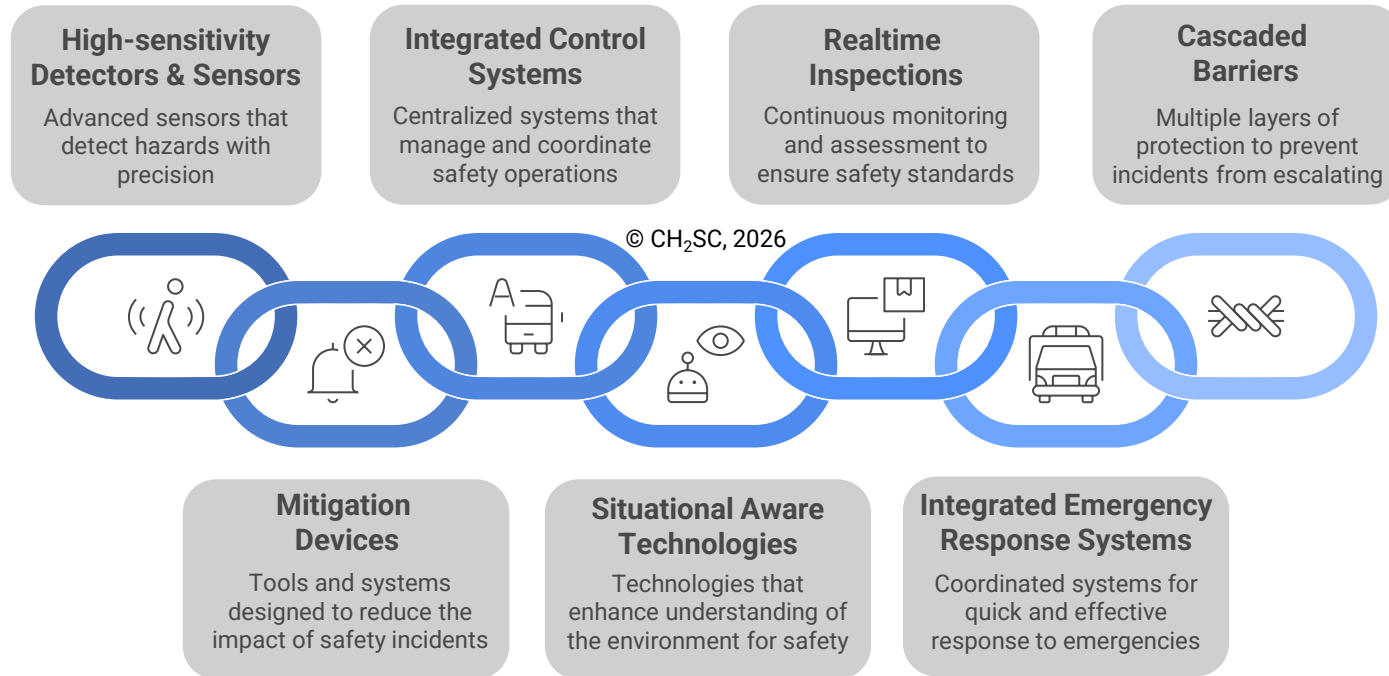
# CH<sub>2</sub>SC Safety Preparation Process Steps

Each hydrogen project would be subject to the “Safety Preparation Process” as indicated in this example



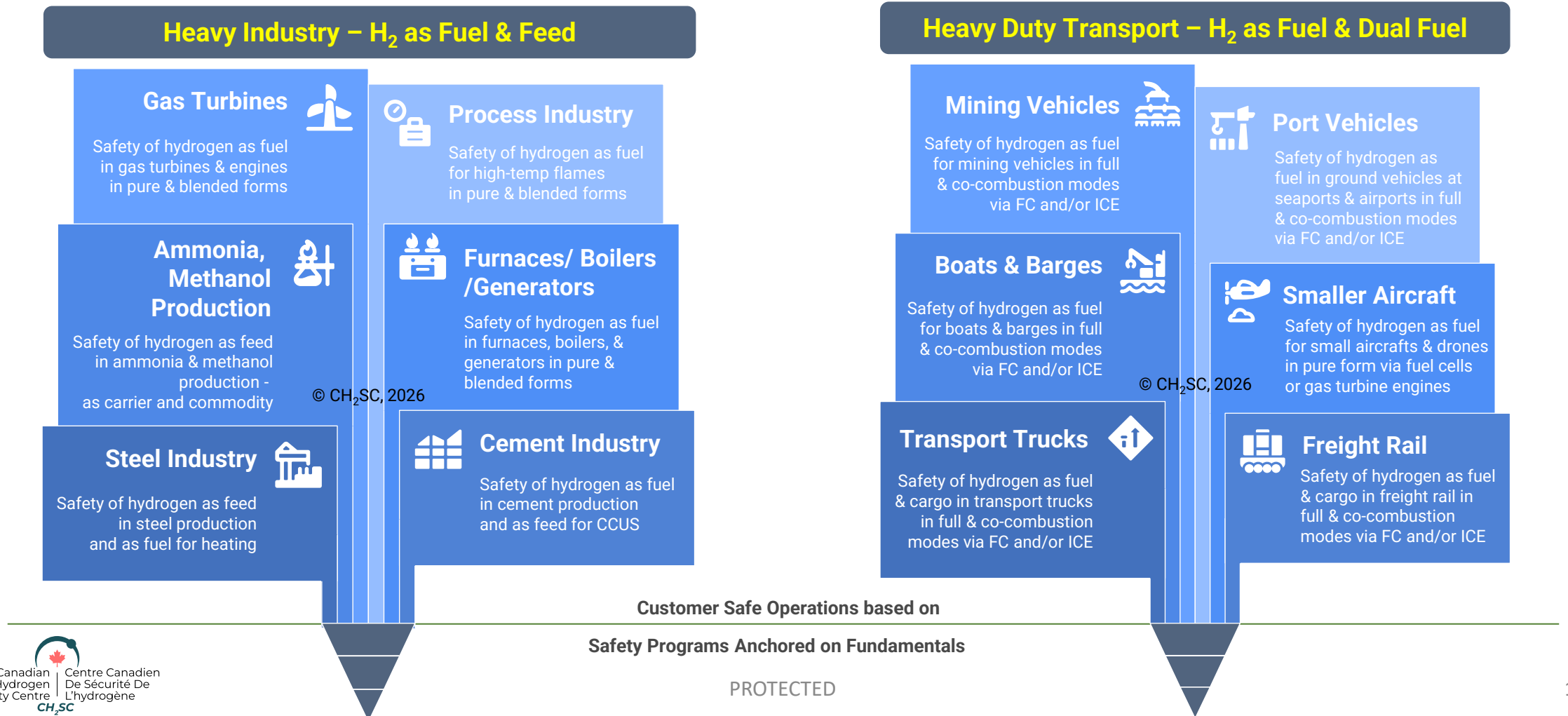
# CH<sub>2</sub>SC Safety Solutions Integration

Safety technologies and integrated layers for a given hydrogen application at a given location



# CH<sub>2</sub>SC Safety Project Areas 1 & 2

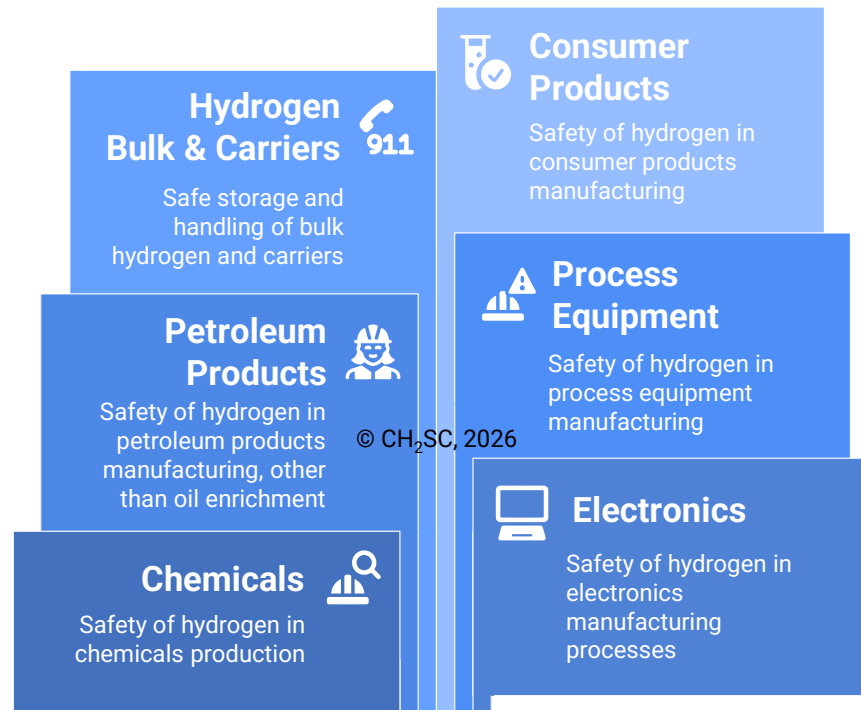
Prioritize project areas to deliver specific safety solutions and align with long-term impacts



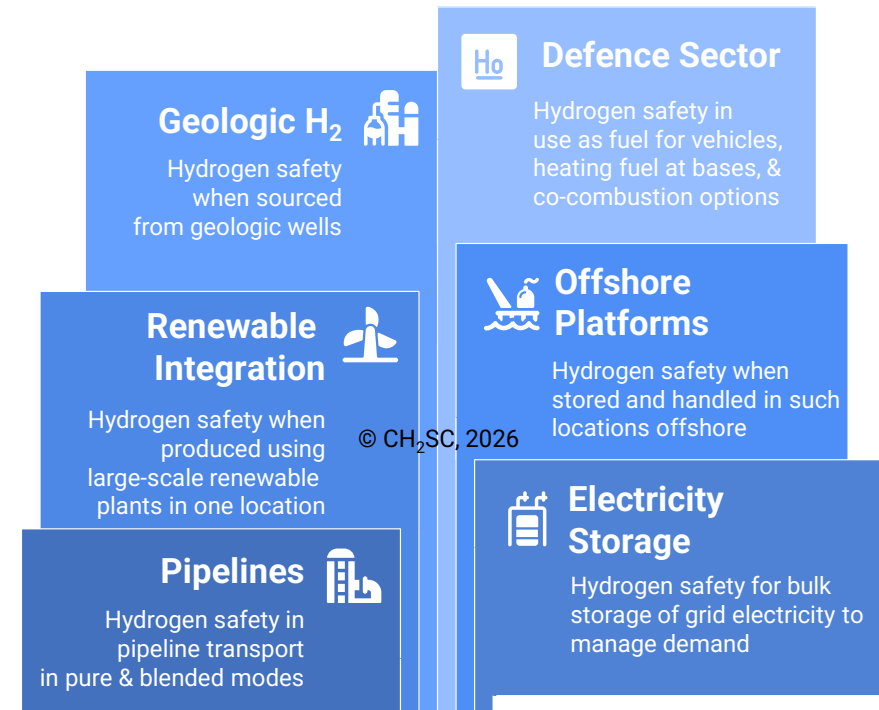
# CH<sub>2</sub>SC Safety Project Areas 3 & 4

Prioritize project areas to deliver specific safety solutions and align with long-term impacts

## Manufacturing – H<sub>2</sub> as Chemical Feedstock



## Energy Conversion – H<sub>2</sub> as Energy Carrier



Customer Safe Operations based on

Safety Programs Anchored on Fundamentals

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# CH<sub>2</sub>SC Safety Solution Outcomes

Outcomes are templated to be become standardized modules for application elsewhere



## Roadmap to Licensure

A plan outlining the steps to obtain necessary licenses for hydrogen plants



## Safety Cases

Documents presenting evidence that a system is acceptably safe



## Risk Mitigation Plans

Strategies to reduce the likelihood and impact of potential risks



## Safety Costing Models

Tools to estimate the expenses associated with safety measures



## Safety System Protocols

Standardized procedures for ensuring safety within a system



## Training Packages

Training courses: content creation, validation, delivery. For industry & first responders

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## Safety Test Data

Data from safety tests from internal and external projects to evaluate safety



## Safety Simulation Models

Computer programs that simulate safety scenarios to predict outcomes



## Safety System Implementation

The process of putting safety systems into practice & testing



## Safety Devices

Physical tools and equipment designed to enhance safety via integrated layers



## Safety Guidelines

Recommendations and best practices for maintaining safety



## National Coordination

On all hydrogen safety matters, Engaging networks in Canada and globally

# Thank You

## Contacts at the CH<sub>2</sub>SC:

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