

Canadian Hydrogen Safety Centre

Executive Summary



Prepared by

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1. Canadian Hydrogen Safety Centre (CH₂SC)

The **mission** of the Canadian Hydrogen Safety Centre (CH₂SC or referred as “the Centre”) is to develop and deliver safety solutions to Canadian industries *that are either established or new to hydrogen*; enabling the safe adoption of hydrogen as: *a fuel, an energy carrier, a storage medium, and a feedstock*.

The **objectives** of the Centre include:

- **Forecast and understand industry needs** to prioritize activities and align resources
- **Coordinate nationally** Canada’s hydrogen safety expertise and capabilities
- **Support the development and implementation** of regulations, codes, bylaws, and standards (RCBS)
- **Enable access** to a network of infrastructure, facilities, and expertise from Canada and the World
- **Serve in an advisory capacity** to governments, regulators, policy makers, and industry
- **Achieve safe handling of hydrogen** at scale and on par with industry standards

The **purpose** of the Centre is to convene stakeholders for collective development of *tangible safety solutions* such as technologies, devices, etc. and *intangible safety solutions* such as experimental data for codes and standards; development of protocols, procedures, guidelines, etc. The safety solutions development is enabled through joint effort such that the benefits are shared and realized by more than a member or a stakeholder. The impact from each solution is aimed at an entire industrial sector to adopt hydrogen for sector growth, economic development, and minimize environmental degradation.

2. Not-for-Profit (NFP) Corporate Structure

The Centre will be setup as a not-for-profit (NFP) organization in Canada. This is to ensure that the Centre operates as an independent private sector company focused on the safety of hydrogen-based processes, systems, appliances, devices, etc. The NFP organizational structure requires staffing and governing documents.

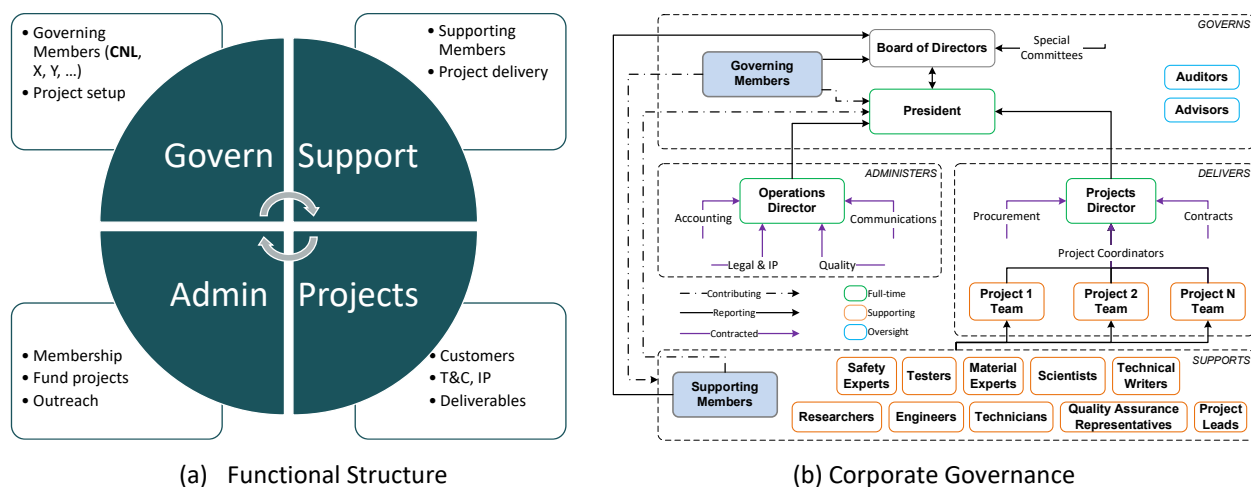


Figure 2-1 CH₂SC Functional and Corporate Governance Structures

2.1 Centre Functional Structure

In Figure 2-1 (a), the Centre structure with four functional layers is shown, with these roles:

- Govern layer:** Formed by the Governing Members, Board of Directors, and the President. This layer is responsible for the decision making on all matters relating to the Centre. In addition, the projects are prioritised, selected and approved by this layer.

- (ii) **Support layer:** Formed by qualified people from Supporting Members and certain Governing Members to support the projects – development, delivery, and upkeep.
- (iii) **Projects layer:** Formed by the project teams comprised of people from Govern and Support layers. The Projects Director leads and coordinates the projects and deliverables through various contracted positions. Most of the Centre outcomes will be enabled through projects.
- (iv) **Admin layer:** Formed by the Operations Director with contracted staff to fulfill activities on a periodic basis. This layer will manage the financial aspects of the Centre including project budgets and membership. In addition, the Outreach program would reside within this layer to support outreach activities.

2.2 Corporate Governance

In Figure 2-1 (b), the Centre corporate governance structure is shown. Expected attributes include:

- **Activities:** are restricted to hydrogen safety related solutions and projects only. Non-safety related hydrogen activities will not be undertaken.
- **Board of directors (BOD):** shall have a minimum of 5 and maximum of 9 directors, with 2-year terms with an extension for another consecutive term. The directors are not the sole members of the corporation. Any vacancy on the board shall be filled by a vote of the members. In the early stages, the GM are expected to be in the board, but future board could have non-members as well.
- **Members:** There are two classes of members – Governing and Supporting (detailed later).
- **Officers:** Includes the President, Operations Director, and Projects Director are the only sole members of the corporation, with a 2-year term.
- **Meetings:** All directors will attend BOD meetings; all members attend Members meetings.
- **Locations:** Three physical offices for the Centre will be located within Member organizations across Canada in these provinces – Alberta, Ontario and Quebec.

2.3 Intellectual Property Framework

In Figure 2-2, the shared-outcomes Intellectual Property (IP) model is shown. There are two categories of IP that the Centre is expected to develop:

- **Category 1. Standard/Safety Data Solutions (SSDS)** to support low/non-TRL projects directed at addressing gaps in hydrogen safety standards/codes/etc., where intangible research results are the primary goal. This set of solutions is applicable as administrative control to attain safety.
- **Category 2. Safety Technology Solutions (STS)** to support mid-TRL projects, where the creation of a tangible device and/or technology system is the primary goal. This in effect makes the Centre a transition entity placed between academics and industrial partners with respect safety technology development. This set of solutions is applicable as engineered control to attain safety.

It is expected that the Centre will retain licenses to any administrative and engineered controls related IP, developed through projects under the proposed model.

- Those licenses would be retained to ensure the Centre, and its membership, can learn and build upon the knowledge generated by each project.
- Ownership of the IP will remain with those members participating in each project with the allocation of those rights determined on a project-by-project basis by the participating members and with the assistance of the Centre as necessary.
- Through this model the commercial value of any IP developed during a project will be retained by the members participating in the project.
- Additional IP categories would evolve as the Centre starts operations. Since one-off safety solutions that are unique and non-standard would be developed for the paying rights owner or member.

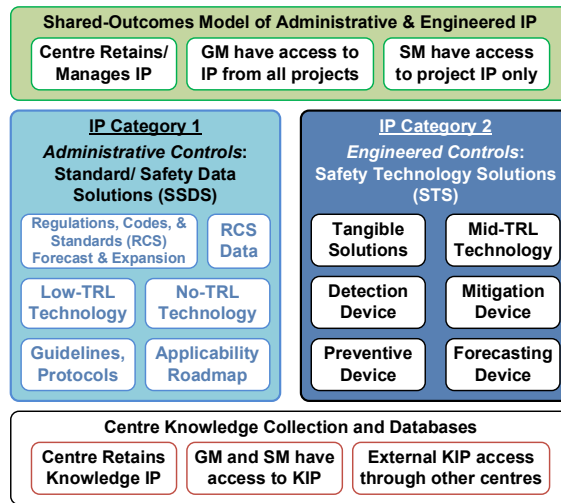


Figure 2-2 CH₂SC Intellectual Property Framework – Shared-Outcomes Model

3. Program of Work and Services

The Centre is setup to serve all industries that require safe handling of hydrogen. Hence, the program of work is formulated with four areas of work to address issues and problems currently relevant to various industries. Each area has three programs currently, as shown in Figure 3-1.

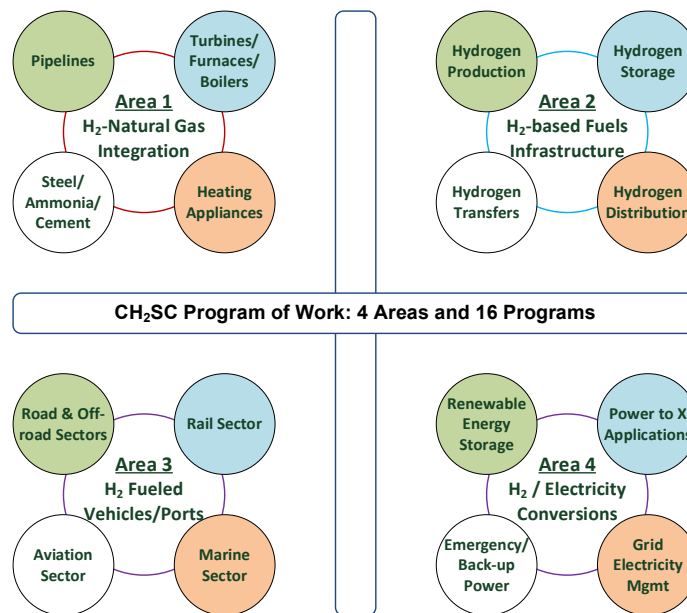


Figure 3-1 CH₂SC Program of Work Currently Planned

These programs and areas of work would evolve in the future to align with growth in applications of hydrogen in various industrial sectors. This is expected to align with the growth in the Centre membership from these sectors. Across all areas of work, the following stakeholders are required for coordination and advancement of hydrogen technologies and applications: technology developers, standards developers, regulators, certification and qualification companies. The Centre will become a repository for safety information and knowledge, through various databases to be developed specific to each program or work and captured after each project that the Centre undertakes. Detail on each program is available in the **Program of Work** document.

3.1 Centre Caters to Stakeholders on Safety in the Hydrogen Value Chain

As a member, it is expected that the Centre will offer opportunities to learn and understand hydrogen safety problems and solutions; as well as to apply the skills and to grow member capabilities for future projects. In this regard, the Centre is envisioning a safety landscape as illustrated in Figure 3-2.

- The levels identified could be seen as the types of safety solutions that the Centre will help develop using various Members and the broader safety community in Canada and elsewhere.
- The levels also indicate the safety requirement increasing in the intensity with each level from 1 to 5 with the diverse set of stakeholders involved at each level.
- The levels could be interpreted as various stages of operational preparedness required from a safety aspect, to handle hydrogen in any application.
- The final level (#5) would achieve the mission of the Centre which will likely be required when hydrogen is widely adopted in most industrial sectors.

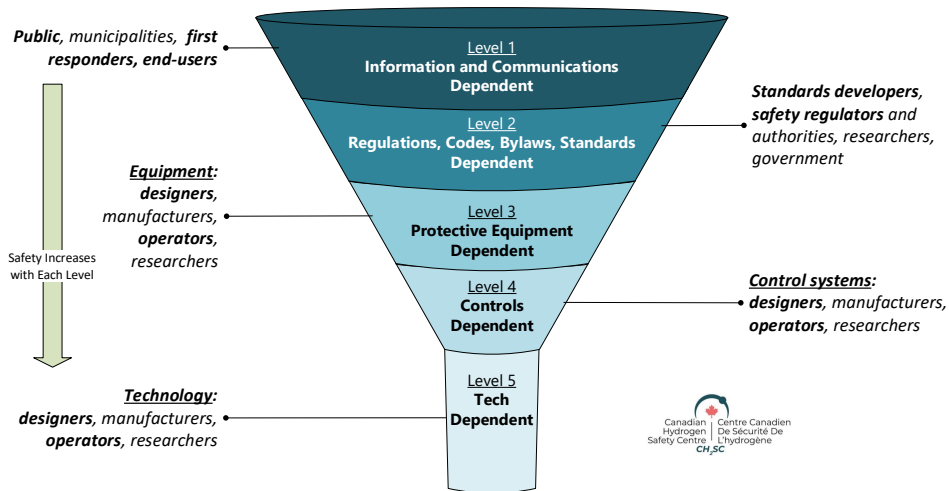


Figure 3-2 Mission of CH₂SC is to Help Stakeholders Achieve Relevant Safety Levels

Hydrogen value chain is being built in pieces, hence CH₂SC is focused to bring together the various stakeholders and enable coordinated approach to fulfill gaps that currently exist, as illustrated in Figure 3-3.

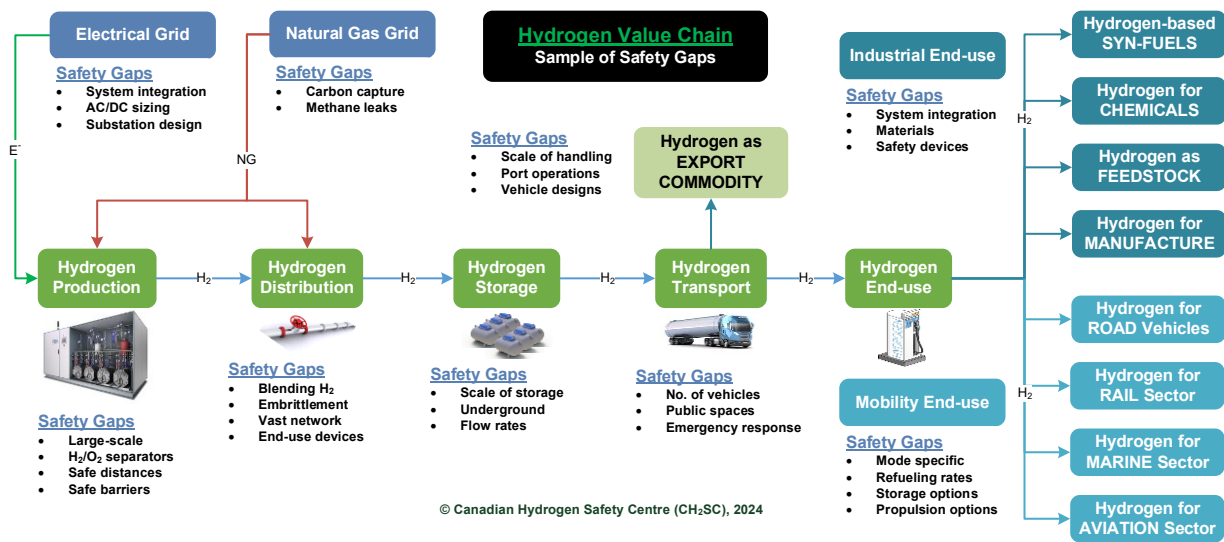


Figure 3-3 Sample of Gaps in Safety within Hydrogen Value Chain

3.2 Centre Services and Advantages

The Centre will achieve the tangible solutions through a series of planned projects in the appropriate sequence within each program of work. This approach helps the Centre to create a series of safety services with unique advantages, as illustrated and described in Figure 3-4.

- The pyramid structure emphasises the need for safety consultancy as the foundation with the broad network of safety experts and other stakeholders. The forecasting of issues and problems that would arise during various stages of operation and maintenance sits within the consultancy service scope. The mechanism of interaction with various stakeholders would depend on the problem and number of impacted members and partners.
- The problem definition step would narrow the focus to establish the first principle basis and the identify the related assumptions and boundary
- The solution development step begins with a safety team which becomes the project team when the solution pathway is established, and various capabilities are identified and allocated.
- The RCBS (regulations, codes, bylaws, and standards) compliance step brings together the standards developers, regulators, municipalities, and the solution proponents together.
- The safe operations step ensures that the solutions are properly implemented, and ongoing feedback is in place for continuous improvement.

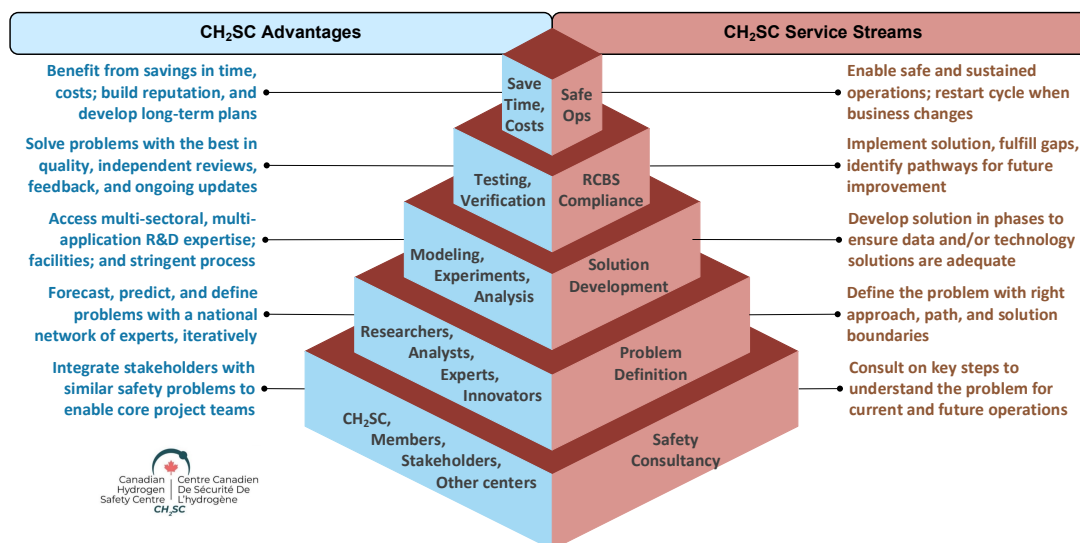


Figure 3-4 CH₂SC Services and Advantages

Safety as a service is a core philosophy of the Centre, since:

- Safety services would be evolving to fulfill gaps in safety as the industries adopt hydrogen for various applications. The capacity to deliver such services through partnerships with other entities and centres.
- One safety service leads to the other and this is cyclical in nature, as the continuous operations of various hydrogen handling processes would create issues that will need ongoing evaluations.

3.3 Centre Projects

The Centre is envisioned to deliver safety solutions through projects on an ongoing basis to solve industry-wide hydrogen safety related problems. The projects will be partly funded through membership fees, funding from Project Partners and public programs. The Centre will develop solutions by facilitating collaborative projects between industry, academia, and researchers who become members to the Centre.

The information on Centre projects is grouped in Table 3-1 as a summary of attributes and hence each column should be read in isolation and are not related to each other.

Table 3-1 Summary of Centre Project Attributes (Independent Columns)

Project Types	Project Selection	Project Team	Project Execution
Program of work	Problems definition	Governing members	Proposal development
Regulator directed	Projects selection committee	Supporting members	Define project team roles
Member directed	Projects identified for the type and target	Centre administration	Project schedule and budget
Strategic plans	Projects stakeholders	Subject matter experts	Terms and conditions
Advancing areas	Project team requirements	Authorities having jurisdiction	Start and end of project
Centre initiated	Projects team selection	Reviewers	Performance assessment

4. Our Journey with Stakeholders and Potential Members

The Centre concept began with a whitepaper that CNL had developed back in 2019. Since, then there has been a continuous journey of exploring hydrogen safety market and the need for a congregation of efforts to focus on a national entity. The activities since 2022 in getting towards the Centre concept and incorporation is shown in Figure 4-1.

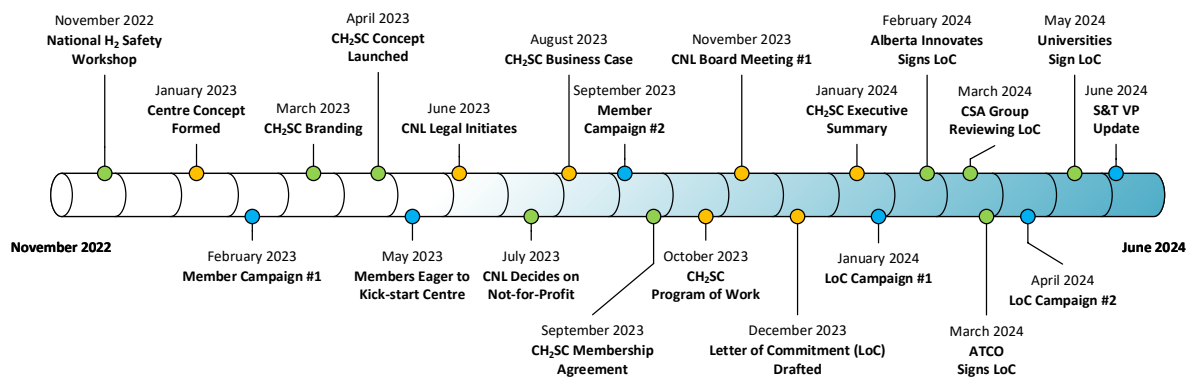


Figure 4-1 CH₂SC Journey with CNL and External Engagements

The types of stakeholders engaged, and the categories are given in Table 4-1. Starting with 20% of engaged stakeholders as members, the Centre is expected to have three stages of development: (i) early-stage in 1 to 2 years; (ii) growth-stage in 3 to 5 years; and (iii) established-stage in 6 to 8 years.

Table 4-1 Category and Types of Stakeholders Engaged on Centre Concept

Potential Members		Strategic Partners		Government Agencies	
Type	Count	Type	Count	Type	Count
Pipeline companies	5	Standards developers	2	Federal departments	5
Engg. & professional services	5	Hydrogen safety groups	3	Provincial regulators	4
National labs	2	Industry associations	3	Safety regulators	2
Energy companies	3	Safety groups	4	Safety standards group	1
Equipment manufacturers	5	Pipeline association	1	First responders	1
Universities	5	Provincial research institute	2	Municipalities	1
Total	25	Total	15	Total	14
Signed: 7 Interested: 8		Signed: 1 Interested: 4		Support: 3 Aligned: 3	

4.1 Safety Engagement Experience

CNL has experience in developing hydrogen safety solutions for the nuclear industry. Our non-nuclear industry experience has brought us into leading the formation of CH₂SC. Few case studies as examples of experience interacting with different industrial sectors is shown in Table 4-2.

Table 4-2 Sample of Case Studies from Different Industrial Sectors

Sectors	Rail	Marine	Gas Industry
Primary Stakeholders	<ul style="list-style-type: none"> • Metrolinx (GO Trains) • Transport Canada 	<ul style="list-style-type: none"> • Canadian Coast Guard • Lloyd’s Register • American Bureau of Shipping 	<ul style="list-style-type: none"> • CSA Z341 Std Task Force • Gas Industry Members • Provincial regulators
Hydrogen safety items	<ul style="list-style-type: none"> • RCS gap analysis • Risk matrix • Regulations framework 	<ul style="list-style-type: none"> • Risk evaluation of LH₂ vessel • Risk matrix • Mitigation plan 	<ul style="list-style-type: none"> • Review of existing standard • Develop H₂ supplement • Address comments
CNL role	<ul style="list-style-type: none"> • Safety team; Framework 	<ul style="list-style-type: none"> • SME in the review panel 	<ul style="list-style-type: none"> • SME in the task force
Key learnings	<ul style="list-style-type: none"> • Independent risk evaluation was effective • One-off effort was not helping the sector • No sectoral coordination or leadership 	<ul style="list-style-type: none"> • Bringing stakeholders together was effective • Group risk evaluation induced bias and influence • Leadership only with operator and no sector coordination 	<ul style="list-style-type: none"> • Bringing change in attitude towards H₂ was effective • Industry influence exists, introduced bias • Leadership but no sector coordination

4.2 Value of the Centre on National Coordination and Leadership

CH₂SC is setup to bring various industries in stages to achieve national coordination and international harmonization on hydrogen safety RCS. An example of the coordination is illustrated in Figure 4-2. This is part of a long journey, and the expectation is for the membership to provide guidance and support.

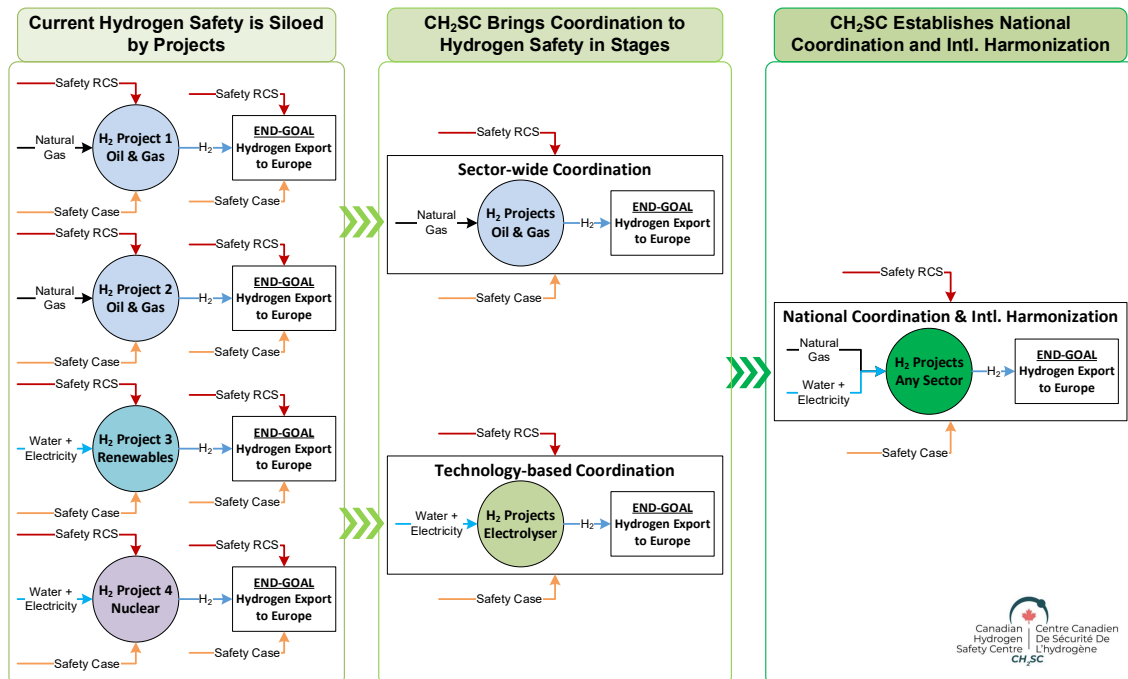


Figure 4-2 CH₂SC to Bring National Coordination and International Harmonization

5. Membership Details

The Centre is a membership-based organization, with two levels of primary memberships: Governing and Supporting. Member benefits and obligations are specific to the categories within the primary memberships. The details are discussed in the **Letter of Commitment** for each of the categories.

5.1 Governing Membership

Governing membership is for organizations having issues or problems concerning hydrogen safety and hence seeking solutions. It is also for organizations with deep hydrogen expertise willing to contribute and invest in the Centre for long-term growth and planning. There are four categories as given in Table 5-1. More categories are expected based on interest in the stakeholders and their need for the Centre.

Table 5-1 Governing Membership Categories and Fee Breakdown

Governing Member Categories				
Member Organization Categories	Industry/ Developer	Expert/ National Lab	End-users/ Finance	Investor/ Philanthropy
Category ID	GM-ID	GM-ENL	GM-EF	GM-IP
Value of Centre Services Package for Member	k\$/y	Experience Gained	Value Earned (ESG, Social)	Value Earned (Enabling)
Safety consultation (discussion, engagement, path identification, etc.)	15	Yes	No	Yes
Safety forecast and problems definition	20	Yes	Yes	Yes
Safety risks assessment and gaps analysis	15	Yes	No	No
Safety risk mitigation and planning	10	Yes	No	No
Safety case for licensing and approval	15	Yes	No	No
Safety roadmap for new applications	15	Yes	Yes	No
Safety data solution for regulations, codes, bylaws, standards (RCBS)	30	Yes	Yes	Yes
Safety technology solution for abnormal/ emergency situations	80	Yes	Yes	Yes
Value of Centre Benefits for Member	k\$/y	k\$/y	k\$/y	k\$/y
Access centre workshops, training, & conferences	10	25	20	25
Access centre committees	5	10	20	25
Access individual project IP	5	10	20	25
Access all centre IP	15	30	20	25
Access centre safety database	5	15	20	25
Access centre SME network	5	15	20	25
Access experience and knowledge IP	5	10	20	20
Board member seat	10	25	200	250
Support for Centre Operations	k\$/y	k\$/y	k\$/y	k\$/y
Administration	15	30	30	40
Outreach	25	30	30	40
TOTAL Value of Benefits for Member	300	200	400	500
Leveraged Value of Member Capabilities	Supports	k\$/y	k\$/y	k\$/y
Test equipment and facilities	Yes	10	N/A	N/A
Safety solution development experience	Yes	5	N/A	N/A
Bring Subject Matter Expert to the centre	Yes	15	N/A	N/A
Bring prior data or information	Yes	5	N/A	N/A
Hydrogen experience	Yes	5	N/A	N/A
Bring more members, projects, and funds	Yes	10	50	50
TOTAL Leveraged Value for Centre	0	50	50	50
GOVERNING MEMBERSHIP FEE	300	150	350	450

5.2 Supporting Membership

Supporting Membership is for organizations that have one-off or unique hydrogen capabilities required to support the safety services offered by the Centre. Within the Supporting membership, there are five categories as given in Table 5-2. More categories would evolve based on the growth in hydrogen adoption across various economic sectors and corresponding increase in safety scope for effective operations.

Table 5-2 Supporting Membership Categories and Fee Breakdown

Supporting Member Categories					
Member Organization Categories	Industrial Research	Academic Research	Engineering & Services	Project Management	Device Builders
Category ID	SM-IR	SM-AR	SM-ES	SM-PM	SM-OEM
Value of Centre Benefits for Member	k\$/y	k\$/y	k\$/y	k\$/y	k\$/y
Access centre workshops, training, conferences	10	10	10	10	10
Access centre committees	5	5	5	5	5
Access individual project IP	5	5	5	5	5
Access all centre IP	15	15	15	15	15
Access centre safety database	5	5	5	5	5
Access centre SME network	5	5	5	5	5
Access experience and knowledge IP	5	5	5	5	5
Access projects and planning discussion	10	10	10	10	10
Support for Centre Operations	k\$/y	k\$/y	k\$/y	k\$/y	k\$/y
Administration	15	15	15	15	15
Outreach	25	25	25	25	25
TOTAL Value of Benefits for Member	100	100	100	100	100
Leveraged Value of Member Capabilities	k\$/y	k\$/y	k\$/y	k\$/y	k\$/y
Test equipment and facilities	5	10	5		
Safety consultation	10	5	5	5	
Safety forecast and problems definition	5	5	5	5	
Safety risks assessment and gaps analysis	5	5	5	5	
Safety risk mitigation and planning	5	5	5	5	
Safety case for licensing and approval	10	5	5	5	5
Safety roadmap for new applications	10	10	5		5
Safety data solution for regulations, codes, bylaws, standards (RCBS)	10	10	10	20	5
Safety technology solution for abnormal/emergency situations	10	10	10	20	50
Bring Subject Matter Expert to the centre	10	30	5	10	5
TOTAL Leveraged Value for Centre	80	95	60	75	70
SUPPORTING MEMBERSHIP FEE	20	5	40	25	30

In a Nutshell: CH₂SC is Neutral, Credible, Independent, & Timely

The CH₂SC brings leadership, coordination, and unbiased approach to development of safety solutions. In this effort, the CH₂SC offers services across multiple sectors within the scope of hydrogen safety. Hence, bringing together expertise and capabilities from wide ranging industries, academics, and government research institutions.

6. Contacts

Let us know your interests and intention to join

You may contact the Centre staff from CNL:

- **Nirmal Gnanapragasam, Nirmal.Gnanapragasam@cnl.ca**
- **Ian Castillo, Ian.Castillo@cnl.ca**

More Centre details are available at the website: www.ch2sc.ca