Advancing commercialization of Hydrogen and Fuel Cell technologies through international cooperation of Regulations, Codes and Standards (RCS)

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Introduction: The world is steadily moving into the post-fossil fuel age. The new energy mix will comprise of a number of energy solutions, including hydrogen. When combined with renewable energy such as wind, solar etc., hydrogen has the potential to 'decarbonize' the energy system. It also offers a pathway for renewable energy to generate transportation fuel, reliable power and distributed energy.

This paper discusses the importance of international cooperation in the development of regulations, codes and standards on hydrogen and fuel cell technologies. To facilitate commercialization of these new technologies, it is essential to remove non tariff barriers by harmonizing regulations, codes and standards to enable global trade.

This subject matter should be of interest to decision makers from energy, automotive and infrastructure companies as well as high-level government representatives. They will learn about updates on the development of regulations, codes and standards, challenges and benefits of international cooperation. A special focus will be paid to the hydrogen refuelling stations, which represent one of the key elements for accelerating the energy paradigm shift.

1. Hydrogen - a part of the new energy mix

Due to considerations associated with climate change and security of energy supply, the world is steadily moving into the post-fossil fuel age. There is a general consensus that the emerging energy mix will comprise of a number of energy solutions such as wind, solar and other new energy technologies, including hydrogen.

Hydrogen, being a universal energy carrier, provides a pathway for renewable energy to generate transportation fuel, reliable power and distributed energy. It is one of the solutions that can be used to overcome the storage challenge faced by the use of intermittent renewable energy sources (ex. Electricity from wind or solar).

Although hydrogen, fuel cell and renewable energy technologies present environmental and societal benefits, business as usual will not ensure that the energy paradigm shift happen in the timeframe that is needed to overcome the climate change challenges. ***The leadership of government and industry will have to work together to enable the energy shift through RCS harmonization and other means!***

In the case of RCS, business as usual will not achieve the goal of having «One product, One standard» in the necessary timeframe. Strong international cooperation will be required to avoid market fragmentation that is often associated with the proliferation of national and regional standards.

2. Regulations, codes and standards (RCS) - a necessary step to commercialization

It is well recognized that a major barrier to commercialization of hydrogen and fuel cell technologies is the lack of globally harmonized RCS. Industry will be well served when a comprehensive set of international

standards is available to guide the development and facilitate the commercialization of these new technologies on a worldwide basis.

The existence of non-harmonized standards for a given product in different countries or regions contributes to the so-called Technical Barriers to Trade (TBT). Indeed, fair competition needs to be based on clearly defined common references that are recognized from one country to the next and from one region to another. International standards, developed by consensus among trading partners, serve as the language of trade and represent a key ingredient of the *World Trade Organization's* (WTO) *Agreement on Technical Barriers to Trade (TBT).*

The *International Organization for Standardization* (ISO) www.iso.org together with the *International Electrotechnical Commission* (IEC) www.iec.ch have built a strategic partnership with the WTO. This partnership aims to avoid the proliferation of TBTs, which generally result from the preparation, adoption and application of technical regulations and standards in a discriminatory manner.

The TBT agreement recognizes the important contribution that international standards make towards facilitating international trade. Where international standards exist or their completion is imminent, the TBT agreement requires that member countries use them as a basis for the standards that they develop.

The TBT agreement also aims at the harmonization of standards on as wide a basis as possible, encouraging all member countries to participate in the development of international standards.

Furthermore, the number of standardization bodies, which have accepted the *Code of Good Practice for the Preparation, Adoption and Application of Standards* presented in Annex 3 to the WTO's TBT Agreement underlines the global importance and reach of this accord. As of October 1, 2009, some 172 standardization bodies from 132 countries have accepted this Code of Good Practice.

3. International RCS bodies - responsible for the standardization of hydrogen and fuel cell technologies

ISO and IEC play an important role in the development of international standards for hydrogen and fuel cell technologies. ISO/TC 197, which is one of the 208 technical committees of ISO, is responsible for the development of international standards for hydrogen technologies. IEC/TC 105, which is one of 94 technical committees of IEC, is responsible for the development of international standards for fuel cell technologies.

Both of these technical committees are very active. Each has a work program to meet the current stakeholders' needs in terms of international standards. The ISO/TC 197 work covers infrastructure, automotive and transportable hydrogen applications. The IEC/TC 105 work covers stationary, transportation, portable and micro fuel cell applications.

The ISO and IEC work results in international agreements, which are published as International Standards. These international standards are market driven and globally relevant. They are based on the principle of consensus and are recognized as providing solutions that meet both the requirements of business and the broader needs of society.

These international standards could eventually form a significant portion of global regulations. For example, the ISO/TC 197 and IEC/TC 105 international standards have been used as the basis for the global regulations that apply to the transport of dangerous goods, which are being developed under the auspices of the UN Sub-Committee of Experts on the Transport of Dangerous Goods (SCETDG) and the International Civil Aviation Organization (ICAO). As an example, the UN/SCETDG made the decision to use ISO 16111 as the basis for the *UN Model Regulations* in December 2008. The provisions of the *UN Model regulations* applicable to hydrogen stored in metal hydride assemblies are now written in such a way that they will allow shipment of hydrogen storage assemblies certified as conforming to ISO 16111 to become routine. Industry will no longer need special permits allocated on a case-by-case basis and the hydrogen stored in metal hydride assemblies will be able to travel across international borders. The removal of this TBT, is a result of a close cooperation between ISO and the UN/SCETDG. Similarly, the ISO/TC 197 and IEC/TC 105 standards could be referred to in the Global Technical Regulations (GTR) for hydrogen and fuel cell vehicles that are being developed by the *World Forum for Harmonization of Vehicle Regulations* (WP.29).

4. International cooperation in RCS

Although all the instruments are already in place to facilitate global harmonization of RCS, further efforts are required. This is the acknowledgment that emanated from the *ISO Roundtable on Global Harmonization of RCS for Gaseous Fuels and Vehicles* that was held on 10 January 2007 in Geneva, Switzerland. The same conclusions were reached during the *Roundtable on Advancing Commercialization of Hydrogen and Fuel Cell Technologies, a part of the new energy mix, through international cooperation of Regulations, Codes and Standards (RCS)* that was held as part of the 2009 European Future Energy Forum on 10 June 2009 in Bilbao, Spain.

The participants of both roundtables agreed that it was of the utmost importance that ***the leadership of government and industry work together to enable the energy shift through RCS harmonization and other means!*** It was recognized that it is important to create a willingness on the part of decision-makers to work towards the ultimate goal of «*One product, One standard*» that is so critical for the large-scale deployment of the hydrogen and fuel cell technologies.

To avoid the proliferation of national standards that differ from one country to the next, it was recommended that countries be encouraged to contribute to the development of ISO and IEC International Standards and to use or adopt them as required by the WTO's TBT Agreement. Further, to avoid duplication of work, national Standards Development Organizations should be encouraged to bring their work to ISO/IEC and cooperate with ISO/IEC in the development of international standards. Lastly, the UN and the national regulatory bodies should be encouraged to recognize the value of the consensus-based ISO and IEC international standards by referring to them in global or national regulations.

The key to this effort resides in the commitment of high level government and industry representatives to provide the necessary resources and drive in support of international cooperation to achieve global harmonization of RCS for hydrogen and fuel cell technologies. It is only through this kind of cooperation that a full set of globally harmonized RCS will be available when the technologies are ready to enter the market.

5. International cooperation between RCS and pre-normative research (PNR)

International cooperation is also required between the global RCS bodies and the research organizations, specifically those involved in pre-normative research (PNR). On many hydrogen safety issues, there are gaps in the knowledge base that need to be addressed through research before they can be addressed in international standards. PNR work generally requires experimental activities that are resource based and time consuming. It is therefore essential to ensure that the PNR work is fully in line with the needs expressed by the RCS bodies to cover knowledge gaps. At the same time, it is also vital to have a process to ensure that the results of PNR are validated and then communicated to the RCS bodies.

In the current state-of-the-art, knowledge gaps still need to be addressed in many areas. For example, PNR work is required to better understand the degradation mechanisms that can affect composite cylinders used for the high pressure storage (70 MPa) of hydrogen. This knowledge is required to develop enhanced design requirements and testing procedures that can be incorporated into international standards with the view of ensuring the mechanical integrity of these cylinders throughout their service life. PNR work is also required to fully understand the impact of hydrogen fuel impurities on fuel cells and to develop appropriate methods for testing hydrogen fuel quality. The safe use of fuel cells indoors also presents some challenges. PNR work is required to close the knowledge gaps in hydrogen dispersion, fires, and explosions in confined spaces. The objective would be to develop prevention and mitigation measures that can be included as part of the indoor installation requirements for fuel cell systems. PNR work is also required to support the development of international standard on hydrogen refuelling stations (HRS) which will be discussed in more detail in the next section.

6. Hydrogen refuelling stations (HRS)

In terms of market entry, the roll out of hydrogen fuel cell vehicles is expected to gain momentum from 2015 onward in several regions of the world. To ensure the smooth operation of these initial vehicle populations counting in the 10s of thousands, an initial refuelling infrastructure is required consisting of several hundred stations per region through 2020.

To support the development of the hydrogen refuelling infrastructure, ISO/TC 197 has been working on the development of ISO 20100 *Gaseous Hydrogen — Fuelling Stations*. ISO/TC 197 WG 11, which is responsible for this work, has already developed a technical specification (TS) last year. It is continuing its work towards the development and eventual publication of an international standard which will support the planned build-up of refuelling infrastructure.

A lot of effort is going into the work of WG11. A task group is looking specifically at safety distances and hazardous locations. In terms of safety distances, the task group is looking at improving the ISO/TS 20100 safety distance table for each type/category of equipment using a risk-informed rationale. This approach, which is quite innovative and supported by pre-normative work, will allow more flexibility in the design of the fuelling stations without compromising the safety of the installations.

Another task group is looking at defining the requirements applicable to the compressor and dispensing system. One of the interesting aspects that this task group has been working on is the preparation of a dispenser protection table. The dispenser protection table will identify safeguards necessary for each possible equipment malfunction. In this way, the standard will address safety of the users and protection of the downstream equipment on the vehicles.

ISO/TC 197 WG 11 is working on a 48 month schedule towards the publication of the international standard. It is expected that the international standard will be published in May 2012. The scope of their work is to cover the safety requirements applicable to the design, operation and maintenance of standalone outdoor public and non-public, and indoor warehouse fuelling stations that dispense gaseous hydrogen used as fuel onboard land vehicles of all types.

To support the ISO/TC 197 work on the hydrogen refuelling infrastructure, a number of PNR projects have been initiated. Some modelling and experiments have already been completed to support the new safety distance risk based approach. Also, some work has been done on the methods of measurement of the response and recovery time of hydrogen sensors, which was initiated in support of the ISO/TC 197 WG 13 work on hydrogen detection apparatus.

In the environment of HRS, it is important that hydrogen sensors can reliably and accurately signal where hydrogen is present. The ISO 26142 standard is being developed to define the performance requirements and test methods of hydrogen detection apparatus which measure and monitor hydrogen concentrations in stationary applications. The PNR work is aimed at defining a reliable method for evaluating sensor response time and recovery time.

When the ISO 20100 standard is finally published as an international standard, it will be up to adopting countries to use it as a basis for the approval of the HRS that will be built on their territory. It is interesting to note that to successfully facilitate the implementation of HRS, Europeans have already recognized the need for harmonized minimum requirements for safe design, operation and maintenance of HRS as well as the application of a harmonized permitting process.

In addition to the ISO work, a consortium of European companies completed in 2007 the *HyApproval Handbook,* which is intended to serve as a guideline to this approach. The key recommendation from *HyApproval* was to develop an EC regulatory framework for HRS based on the proven combination of essential requirements and harmonized standards (e.g. ISO 20100). Through this approach, the upcoming EC framework regulation will allow HRS built to the requirements to be accepted across Europe. This will facilitate the implementation of the hydrogen infrastructure, especially in Germany, where major companies signed the *Hydrogen Mobility* initiative on September 10, 2009.

7. Conclusion

The large-scale deployment of hydrogen and fuel cell technologies is anticipated around 2015. In the meantime, a collective effort needs to be made to prepare a comprehensive set of globally harmonized RCS that will facilitate the commercialization of fuel cell and hydrogen technologies when these products are ready. Since these international standards have to reflect the state-of-the-art, they should be well supported by PNR work. A special effort should be made on the part of the research organizations to make sure that their PNR work is in line with the expressed needs of RCS bodies [reflecting industry's needs].

It is only through a truly international spirit of cooperation that large scale deployment of fuel cell and hydrogen products and systems can be achieved within the timeframe needed by industry. Decision makers have a key role to play as success involves moving away from current trends and business as usual. It is however not an impossible task; other industry sectors such as the telecommunication industry have successfully overcome this challenge. We should be inspired by their success.

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