HIAD – HYDROGEN INCIDENT AND ACCIDENT DATABASE

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ABSTRACT

The Hydrogen Incident and Accident Database (HIAD) is being developed as a repository of systematic data describing in detail hydrogen-related undesired events (incidents or accidents). It is an open web-based information system serving various purposes such as a data source for risk assessments, lessons learned and risk communication. The paper describes the features of the three HIAD modules - the Data Entry Module (DEM), the Data Retrieval Module (DRM) and the Data Analysis Module (DAM) - and the potential impact the database may have on hydrogen safety. The importance of the quality assurance process is also addressed.

1.0 INTRODUCTION

Hydrogen technologies are expected to play a key role in implementing the transition of the energy systems from fossil-fuel-based to a more sustainable lower-carbon ones [1], [2] and [3]. A clear political message on hydrogen potential role was communicated in 2003 both from the European Union and the United States which agreed on cooperating for the establishment of the hydrogen economy [4]. In this context, international and national joint efforts have fostered scientific research towards the development of safe and reliable technologies for hydrogen production, storage, transport and consumption. Examples are the numerous European co-funded projects within the 6th and 7th Framework Programme [5] e.g. the European Integrated Hydrogen Project, HyApproval, StorHy, NATURALHY, HySafe and others. Meanwhile, coordinated research efforts have been also continuously increased from the side of petroleum companies and automotive industries, who are investing in alternative energy systems, including hydrogen technologies [6]. In the 7th Framework Programme, the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) was established by the Council of the European Union [7]. FCH JU is a public-private partnership whose goal is to accelerate the development and deployment of fuel cell and hydrogen technologies to the point of launching them commercially by 2020, realising their potential as an instrument in achieving a carbon-lean energy society.

Technologies and applications based on hydrogen should at least provide the same level of safety, reliability and comfort as the current ones. Hydrogen introduces different safety and regulatory issues compared to current fossil energy carriers which need to be understood and tackled. So far, hydrogen has already been used in several application areas (e.g. in aerospace technology, chemical processing, food and electronic industries) and handled safely for many years. There is some information related to hydrogen incidents and accidents available on the internet and in literature. However, the statistics on relevant events are not directly accessible [8]. In the past, protective measures for dealing with the oldest energy source (wood, coal, natural gas) were developed through trial and error. With the introduction of nuclear power generation this approach was no more possible and risk assessment was developed as a tool for identifying, assessing and prioritizing risks, in order to prevent and mitigate the consequences of potential accidents. Risk assessment methodologies have been adopted in most

sectors of energy production and together with the previous and ongoing research experiences can help to manage the challenges posed by hydrogen introduction in a safe and consumer friendly way [9].

The Hydrogen Incident and Accident Database was designed to hold high quality information of historical accidents and incidents related to hydrogen production, transport (road/rail/pipeline), supply and commercial use. The database is maintained such that it can be updated with the latest information concerning each event in order to take advantage of results from accident investigations. Hence, HIAD will serve as an important tool for most tasks constituting a risk analysis process beyond being an international hydrogen accident and incident database and a reporting platform. The development of such a database was one of the main tasks within the HySafe EC co-funded Network of Excellence, which aimed at filling the lack of information clearly identified by the scientific community [10].

2.0 HYSAFE FRAMEWORK

HySafe (2004-2009) aimed at facilitating the safe introduction of hydrogen as an energy carrier, contributing to the safe transition to a more sustainable development in Europe [11]. The HySafe network brought together competencies and experience of 24 partners from 12 European countries and one partner from Canada, representing private industries (automotive, gas and oil, chemical and nuclear), universities and research institutions; more than 100 scientists performed integrated research activities related to hydrogen safety issues. The main objective of the HySafe network was to strengthen, integrate and focus fragmented research efforts to provide a basis that will allow removal of safety-related barriers to the implementation of hydrogen as an energy carrier. Synthesis, integration and harmonization of these efforts aimed at breaking new ground in the field of hydrogen safety and at contributing to the increase of public acceptability of hydrogen technology within Europe by providing a basis for communicating the risks associated with hydrogen. One of the means to achieve those objectives was the development and establishment of the Hydrogen Incident and Accident Database, HIAD [12].

After the end of HySafe NoE in 2009, a new legal entity was founded to continue the activities such as HIAD and the bi-annual International Conference on Hydrogen Safety. The new legal entity is a non-profit organization, the International Association for Hydrogen Safety (IA HySafe) [13] whose mission is to facilitate the international coordination, development and dissemination of hydrogen safety knowledge through the establishment of the Hydrogen Safety Information System (HySafe-IS).
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The following section will provide a detailed description of the HIAD features, giving an overview on current analysis capabilities and applicability of the information collected within the database.

3.0 HIAD DATABASE

HIAD was designed not to become a standard industrial accident database but a multi-task tool: an open communication platform suitable for safety lessons learnt and risk communication as well as a potential data source for risk assessment. HIAD website, whose initial page is shown in Figure 1, is hosted at JRC's ODIN portal (https://odin.jrc.nl), which is the Online Data & Information Network for Energy provided by the European Commission Joint Research Centre (JRC) to the European energy research community.

The development of HIAD has undergone three different phases [14]:

I. Pre-operation: database design and realization prior to HIAD release

II. Limited operation: population and regular updates of database contents by HySafe partners

III. Full operation: regular access and updates of HIAD to unlimited number of users.

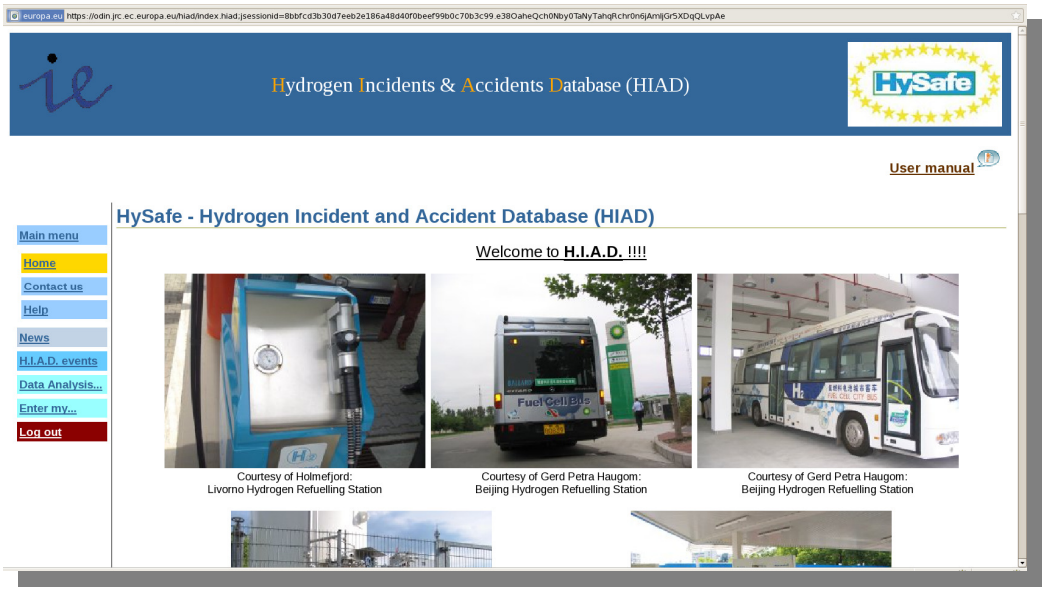

Figure 1. HIAD website.

Initially the collection of data on hydrogen-related events was based on publicly available information and open source references and was operated only by HySafe partners. In the long term (full) operation HIAD has been made available to a wider range of interest groups and users, and a common user-driven methodology of data collection has been developed. Contributors from the Industry are encouraged to report their own version of the same event in order to record different safety actions applied and highlight differences in the risk perception and treatment.

The US DOE developed in a concerted effort a similar database (http://www.h2incidents.org/). However, the data structure is less complex compared to HIAD, and the focus of this resource is mainly on lessons learned.

At present, HIAD is fully operational, with more than 300 events recorded, and is available online by requesting access rights via the Odin portal (https://odin.jrc.nl).

3.1 Main Features

HIAD was designed to be a collaborative and communicative web-based information platform, aimed at promoting the safety performance of existing hydrogen technologies and safety actions adopted following hydrogen events. HIAD constitutes in fact an important part of the future Hydrogen Safety Information System, HySafe-IS, to be established by the IA HySafe [13] for sharing experience and data related to hydrogen safety during production, transportation and use of hydrogen.

The main purpose of HIAD is to assist all stakeholders in better understanding hydrogen-related undesired events, to serve as an important data source for risk assessment of hydrogen applications and to be an international hydrogen accident and incident reporting platform. Specifically, HIAD is intended to [14]:

- Contribute to the integration and harmonization of fragmented experience and knowledge on hydrogen safety;
- Contribute to the progress in common understanding of hydrogen hazards and risks;
- Constitute a reliable tool that provides inputs for safety and risk assessment;
- Enable generation of common generic accident and incident statistics;
- Serve as a common reference database for ongoing data collection and storage;

- Keep the industry updated with recent hydrogen events, along with trend analyses;
- Represent a reference source for the understanding and experience transfer of hydrogen accident phenomena, scenarios and hazard potential;
- Encourage and facilitate industry partners to share experience.

In order to comply with established objectives, HIAD data collection is characterized by a significant degree of detail and specifications about recorded events (e.g. causes, releases, fires, explosions, consequences), not limited only to real incident and accidents but also including hazardous situations and near-misses; as an example, HIAD contains hydrogen release events both ignited and not ignited. In addition, in order to avoid focusing just on negative effects of an accident, HIAD contains also information about post-event treatment when available [14].

HIAD presents therefore a new dynamic approach, as it promotes direct interaction with users, it fosters international collaboration within the hydrogen community and it supports the so called "reflexive learning process" among stakeholders (see [15] and [16] for more details), thus encouraging trust between users. The introduction of this rather innovative approach is mainly due to the peculiarity of the current international framework concerning hydrogen legislation and technological development:

- European and international regulations, at present, do not establish as mandatory to report hydrogen events to any official access-restricted/partly open database system: an open user group as HIAD can fulfil its target by working only on voluntary basis;

- While dealing with a rather new and continuously developing technology, it is challenging to access existing knowledge and take advantage of state-of-the-art expertise, especially from industries.

3.2 HIAD Structure

The user/system interface was developed in order to ensure appropriate flexibility for the various purposes of HIAD; efforts were also dedicated to the attainment of user friendliness of the interface to facilitate data recording and extraction.

The first version was launched in 2006 and the latest version of HIAD is available since 2010, and it comprises three different modules, as described in the HIAD manual [17]:

1. The Data Entry Module (DEM), enabling allowed users to entry data directly online;
2. The Data Retrieval Module (DRM), allowing users to access hydrogen events recorded;
3. The Data Analysis Module (DAM), permitting the users to analyse online information contained in HIAD.

The access interfaces to the three modules are presented in Figure 2, while Table 1 gives an overview on the general HIAD structure [9].

To add new data, the user has to register as an "event provider": the event datasheet will also contain information related to his/her profile as supplier of information. As can be observed from Figure 2 (top), when adding a new event, several fields of information can be filled in, concerning not only the event itself (location, weather, scenario,…), but also its consequences (injuries, damages,…) and post-event actions (clean-up, restoration,…). Information about sources, references and available documentation related to the uploaded event are also requested. DEM interface also allows searching for an existing event in order to give the user the possibility to provide additional information or to modify the existing information, if the user has more complete or updated data compared to the first time that he/she inserted the event into HIAD via the DEM. Modifications by the user are possible only before the Quality Assurance process is finalized. After the end of the Quality Assurance process,

only the administrator can modified the data of the event. All provided information is subdivided into the six Building Blocks described in Table 1.

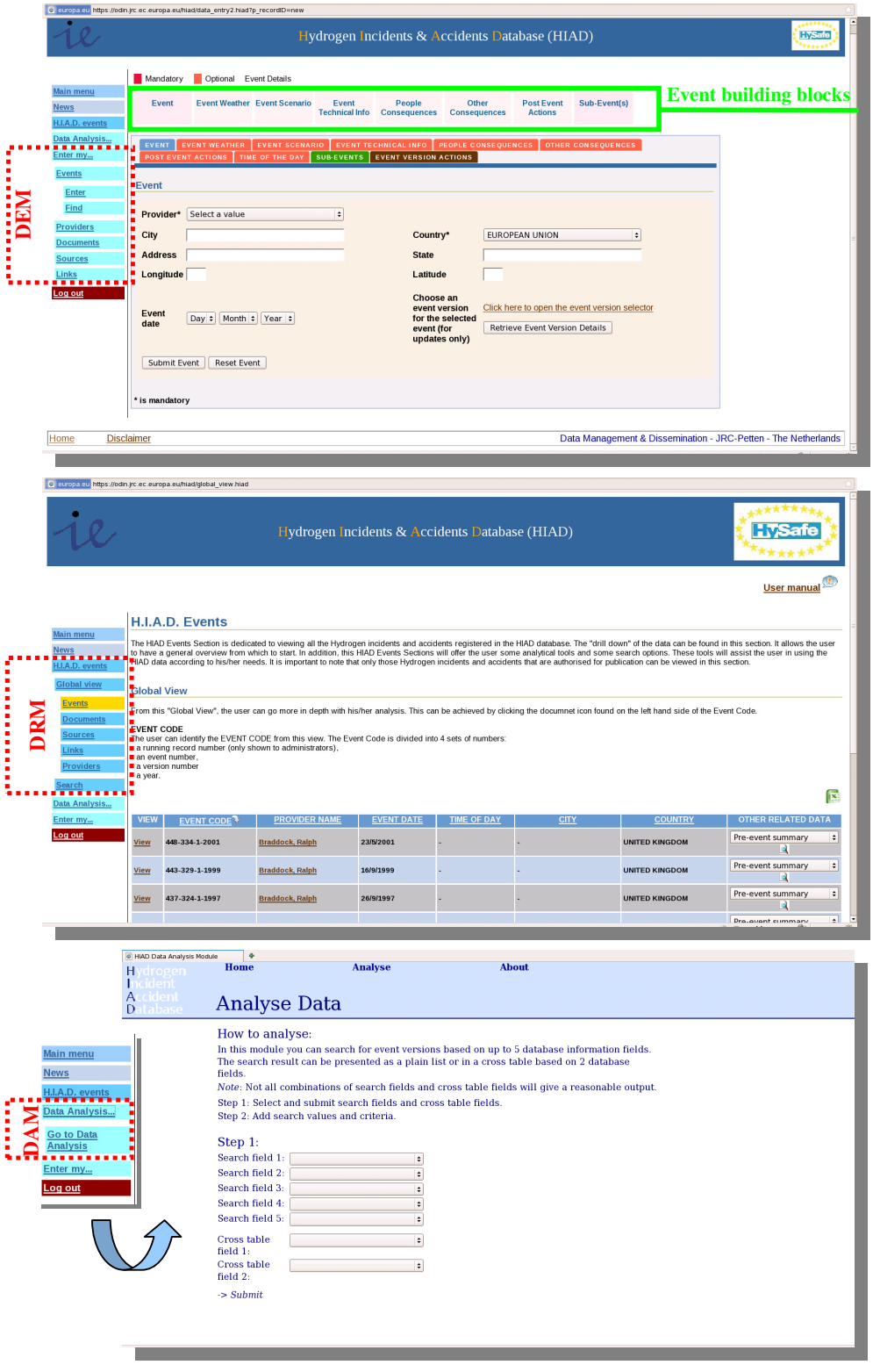

Figure 2. DEM (top), DRM (centre) and DAM (bottom) access interface.

Table 1. HIAD Database Structure [12].

BLOCK	PARAMETER EXAMPLES
1. H.I.A.D. Administration	Event coding Information sources Dates of entry and last revision H.I.A.D. operator and data provider details
2. Pre-event conditions	Date and time of event Weather conditions Geographical location Type of H2 application Operation phase or mode
3. Nature of event	Systems and components affected or involved Chain of events Causal relations Relevant safety systems and emergency response Release, fire and explosion specifications/details
4. Consequences of event	Fatalities and injuries Property, environment and economical loss and damage
5. Post-event actions	Clean-up and restoration Legal/legislation initiatives Lessons learned Investments made
6. References	Hyperlinks/references to files and documents, web-sites, etc. Specification of attachments, e.g. maps, drawings, photos, etc.

The DRM interface (central part of Figure 2) allows users to explore HIAD contents and search for information on selected events. The Global overview option gives access to collected data on hydrogen events, to available documents, information sources, relevant links and providers list. The events table available within this page lists the incidents/accidents provided by the users, classified depending on an associated code, provider name, date, time, city and country; for each event, users can decide whether to view all available information or select only the desired ones. Listed documents, sources and providers are directly linked to all related events. The search engine enables the user to explore collected data by defining desired specifications for event selection; available query criteria are: event provider, event, event nature, event details, event consequences, keywords search on comments field.

The third HIAD module, the DAM, is a tool for conducting simple analyses of the data recorded into the database: it enables the user to retrieve HIAD content through a search based on any data fields available in HIAD (choosing up to 5 different data fields), view/print record contents and create simple two-dimensional cross tables. DAM can be accessed directly from the HIAD main menu; by selecting the Analyse option, the Analysis Data page is shown (see Figure 2, bottom), where the user can enter the search criteria and fields of cross-table creation. The DAM search output as well as the cross-table data can be downloaded by the user.

3.3 Data Quality Assurance

A Quality Assurance Plan was developed to ensure the quality of all collected data into the HIAD database. Each Event submitted by a provider to the HIAD should therefore be subject to the Quality Assurance process.

The quality plan describes how to implement the quality assurance process, ranging from the initial judgment and evaluation of the sources of information, through the actual recording into the database, to the final checking prior to publication (i.e. before making the data official). A Quality Assurance Expert Group (QAEG) was formed to properly manage this process, as illustrated in Figure 3.

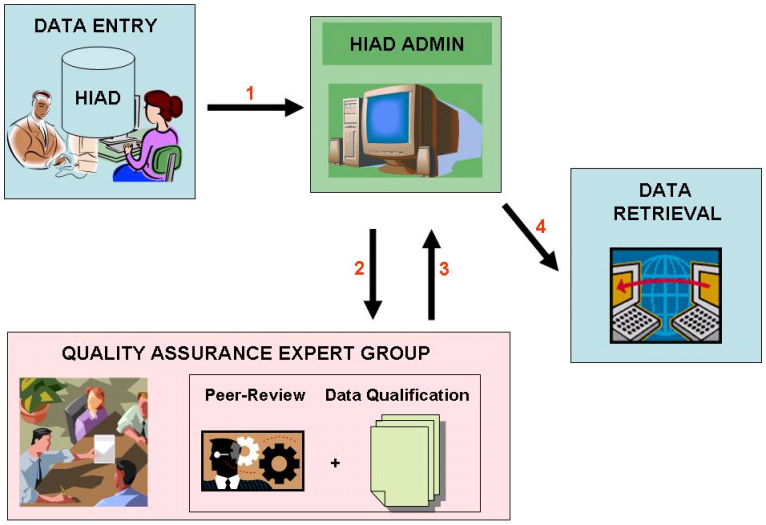

Figure 3. HIAD Data Quality Assurance process (HIAD Newsletter No 3 on http://www.hysafe.net/HIAD_News).

As previously described, data were initially collected by HySafe partners from available literature, databases, internet and other sources. After the closure of the HySafe project, every external user is entitled to insert the necessary information directly online through the DEM. The draft information inserted, not yet quality-assured, are initially available only to the event-provider, to HIAD Administrators and to the Quality Assurance Expert Group. The draft has then to be evaluated and verified by the QA Expert Group before becoming a final quality-assured event stored in HIAD and accessible to all users. At present, 252 events are already quality-assured and 74 are under qualification

3.4 Example of Data Analysis

This section presents an example of the Data Analysis Module (DAM) capabilities. As mentioned above, DAM allows simple analyses of the data recorded into the database, enabling the user to search archived events by choosing up to 5 different data fields. The user can perform very focused searches, for example selecting the “event location” field (data available for events in buildings, industrial plants, open road, highway, railway line, refinery, refuelling stations, ...), or the “principal event” field (data available for burst of tank accidents, tank rupture, continuous release in open/confined atmosphere, fires, explosions, …). More general queries are also possible, for example selecting criteria like “year”(equals, more or equals, less or equals than) and “Country” (single Country or multiple selection).

By downloading cross-tables data the user can further develop the statistical data analysis with diagrams, as shown in Figure 4, as well as consider the information within a risk assessment study. In the example all hydrogen events recorded within the European Union since 1985 are addressed; retrieved data are classified into the cross-table by year and type of (principal) event. Two examples of obtainable cross-tables (event counting on the left and total number of affected persons onsite on the right) and of corresponding data elaboration are shown in Figure 4.

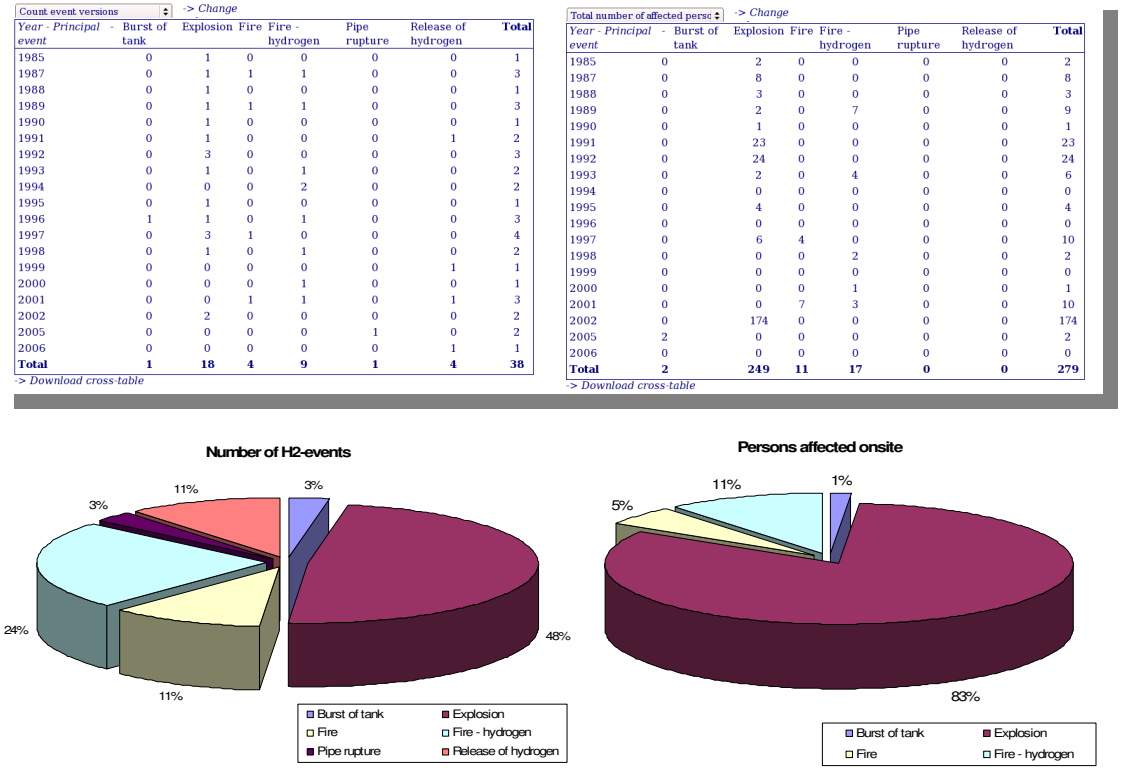

Figure 4. Events in EU since 1985: number of events (left) and of involved persons onsite (right).

4.0 CONCLUDING REMARKS

The Hydrogen Incident and Accident database (HIAD) was designed in order to represent a reliable multi-task open communication platform for safety lessons learned and risk communication, as well as a potential data source for risk assessment. The database was developed within the framework of the NoE HySafe and the last release is available online since 2010. HIAD is intended to become the up-to-date repository of any accidental event related to hydrogen technology.

5.0 ACKNOWLEDGMENTS

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