STABALID

STAtionary Batteries LI-ion safe Deployment

Stuttgart, July 31, 2014

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1 Introduction

The development of the Smart Energy Networks is a key priority to facilitate the transition to a more sustainable energy supply in Europe. Li-ion battery is a very promising technology for improving the penetration of renewable energy sources (RES) in the energy mix and enabling a better management of energy in the European grid. The overall objective of the STABALID project is to facilitate the deployment of safe stationary batteries with energy content over1 MWh and cell size larger than 10 Ah. To this end, the consortium will develop a new testing procedure for stationary batteries that will become a new international standard document for this kind of energy system. The safety testing procedure will be developed based on a detailed risk analysis and the review of international existing standards (including those in preparation) applicable for stationary batteries, and taking into account the on-going research work on Li-ion batteries and on Electric Vehicle charging at EU (e.g.HELIOS, MERGE, SOL-ION projects) and at national levels. This work has already be done by SAFT in WP1 (D2.1: Selection of existing test protocols for the safety validation of stationary batteries). The new standard will be developed to guarantee safety during the whole life cycle of the batteries. The project and in particular the testing procedure will be developed in close cooperation with Japan thanks to collaboration with selected projects financed by METI and NEDO. STABALID project is technically led by a world leading manufacturing company, SAFT, and involves a utility company as representative of end-users, EDPD (Electricity de Portugal Distribuição), as well as reference organizations for safety inspection, testing, certification, and for integrated risk management. Thus, the consortium ambition is to have the new standard adopted during the course of the project using established connection with IEC committees.

In addition, the consortium will propose a strategy and roadmap to establish a harmonized regulatory framework in order to allow a safe implementation, operation and end of life of large Li-ion batteries for grid applications.

With the aim to achieve this objective, INERIS and EU-VRi have assessed the environmental regulatory frameworks existing in various countries and the corresponding barriers for the deployment of stationnary batteries.

This task consisted in carrying out a survey to identify the regulations in force on Li-ion stationary battery systems in different countries of Europe, both for accident prevention and mitigation, and for environmental impact in the framework of the Directive 2010/75/EC on industrial emissions (integrated pollution prevention and control).

The regulatory context related to Li-ion batteries for stationary applications has been compared in Europe and in Japan thanks to collaboration with Japanese experts from the Advisory Board and a meeting with representatives from NITE (National Institute of Technology and Evaluation) that took place on July 4, 2014 in Stuttgart.

The results of this activity are presented in the present report.

2 Method

The experts from INERIS and EU-VRi involved in the STABALID project drafted a survey aiming at assessing the regulatory framework. This survey has been submitted for review to the project partners and to the International Advisory Board members.

Then the survey has been largely spread out in order to maximize the chances to reach the persons with the right expertise to answer this survey.

The survey has been opened from 02.04.2014 to 24.06.2014 and has been sent to:

- The STABALID consortium,
- The STABALID International Advisory Board,
- The STALLION coordinator,
- The ETPIS secretariat (The European Technology on Industrial Safety – www.industrialsafety-tp.org) that has informed its 700+ stakeholders in a newsletter and has published the survey on its website,
- The EASE secretariat (the European Association for Storage of Energy - www.ease-storage.eu/)

The partners of the project as well as the IAB members have been invited to forward the survey to any relevant expert from their network.

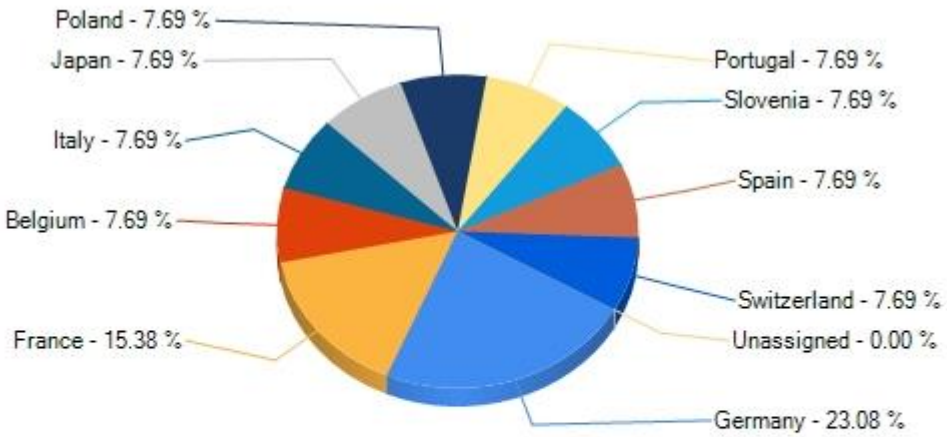
Then EU-VRi compiled and interpreted the results of the survey with other inputs collected through discussions and meetings to prepare the present report.

3 Results

3.1 Participants in the survey and countries addressed

3.1.1 Please specify the country for which you are going to answer this survey.

3.1.1.1 Results



Color	Name	Value	Percent
	Germany	3	23.08 %
	France	2	15.38 %
	Belgium	1	7.69 %
	Italy	1	7.69 %
	Japan	1	7.69 %
	Poland	1	7.69 %

Color	Name	Value	Percent
	Portugal	1	7.69 %
	Slovenia	1	7.69 %
	Spain	1	7.69 %
	Switzerland	1	7.69 %
	Unassigned	0	0.00 %

Figure 1: Origin of the participants

Countries represented

(1) Spain
(2) Poland
(3) Portugal
(4) Germany
(5) Italy
(6) Slovenia
(7) Germany
(8) Germany
(9) Belgium
(10) France
(11) France
(12) France (French Islands)
(13) Japan

3.1.1.2 Interpretation:

The 13 participants provide answers for 9 countries (8 EU member states and Japan).

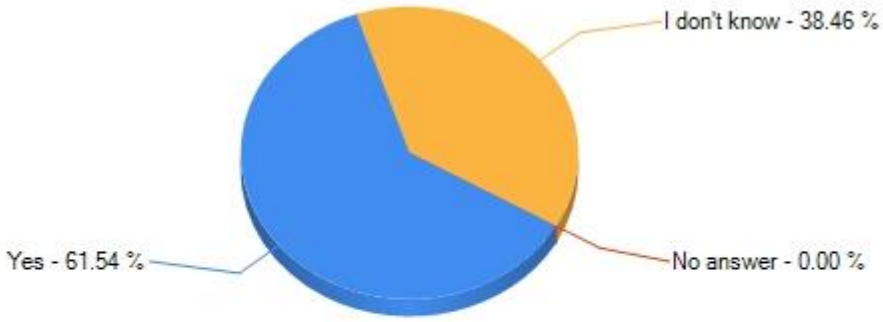
Thanks to the 8 EU member states represented among the participants, the mapping of the EU regulatory frameworks is well represented. The participant from Japan and the discussions with IAB members from Japan allow a good analysis of the Japan regulatory framework.

Despite the apparent low level of participation, EU-VRi and INERIS are confident in the results of the survey since the subject is very specific and the participants are experts in the field of large stationary batteries, which is a quite specific industrial sector.

3.2 Characterization of the type of storage facilities

3.2.1 Are there any stationary battery storage facilities in your country with around 1 MWh or more?

3.2.1.1 Results



Color	Name	Value	Percent
	Yes	8	61.54 %
	I don't know	5	38.46 %

Color	Name	Value	Percent
	No answer	0	0.00 %

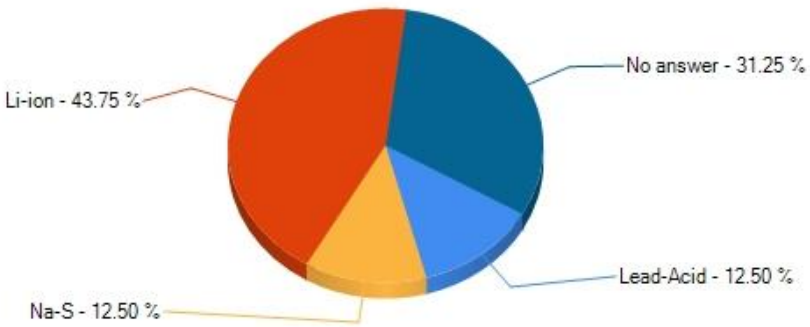
Figure 2: Stationary battery storage facilities in your country with around 1 MWh or more

3.2.1.2 Interpretation

40% of the respondents don't know if there are stationary battery storage facilities larger than 1MWh in their country. It means that it is difficult, even for the stationary batteries experts, to be aware of the existing installations in their country.

3.2.2 If yes, please indicate the technology:

3.2.2.1 Results



Color	Name	Value	Percent
	Lead-Acid	2	12.50 %
	Na-S	2	12.50 %

Color	Name	Value	Percent
	Li-ion	7	43.75 %
	No answer	5	31.25 %

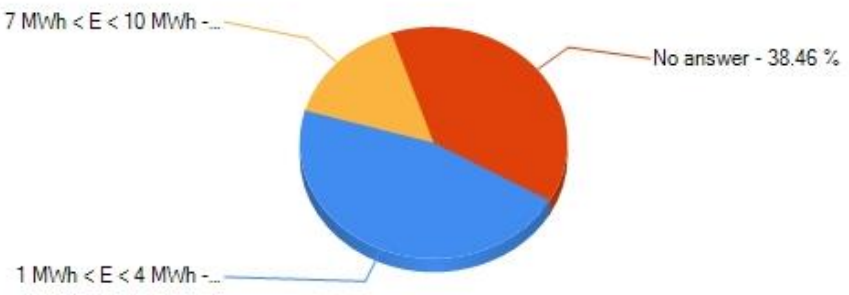
Figure 3: Technology of the battery

3.2.2.2 Interpretation

Around 44% of the answerers mentioned that Lithium-ion technology was used for stationary battery (7 answers), 12.5% mentioned Na-S technology (2 answers) and Lead-acid technology. The reference [1] reports that the worldwide installed electrochemical storage capacity for electrical energy in 2011 is divided into: 400 MW of Na-S, 45 MW of Li-ion, 45 MW of lead-acid and 40 MW of Ni-Cd. Hence, the results of the survey tend to show that Li-ion technology is under development for stationary applications.

3.2.3 If yes, please indicate the maximum energy storage capacity

3.2.3.1 Results



Color	Name	Value	Percent	Color	Name	Value	Percent
	1 MWh < E < 4 MWh	6	46.15 %		No answer	5	38.46 %
	7 MWh < E < 10 MWh	2	15.38 %				

Figure 4: Maximum energy storage capacity

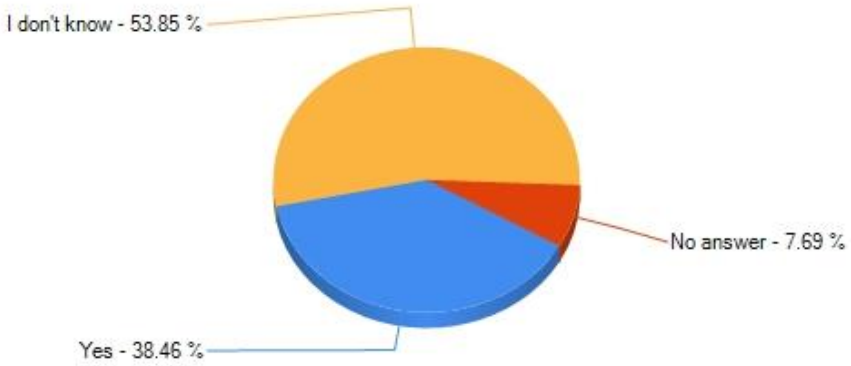
3.2.3.2 Interpretation

Almost half of the answerers indicated that the large stationary batteries have a storage capacity between 1 and 4 MWh.

3.3 Regulation in force

3.3.1 Do you know if any safety study has been performed for these facilities? If yes, does it include the environmental scope?

3.3.1.1 Results



Color	Name	Value	Percent	Color	Name	Value	Percent
	Yes	5	38.46 %		No answer	1	7.69 %
	I don't know	7	53.85 %				

Figure 5: Safety studies?

If yes, does it include the environmental scope?

- (6) I assume "these facilities" refer to 1MWh capacity. Since I'm not aware about the capacity of concrete installation the answer provided above is rather general. The same answer - Yes - stands also for the environmental scope.
- (10) Yes
- (11) Yes
- (12) Yes
- (13) Japanese standard JIS C 8715-2 has environmental tests such as impact test, drop test, and high temperature test. But I'm not sure about other environmental tests or considerations.

3.3.1.2 Interpretation

According to the answerers, safety studies (including the environmental scope) are performed.

3.3.2 Is there any available regulatory framework for energy storage in your country?

3.3.2.1 Results

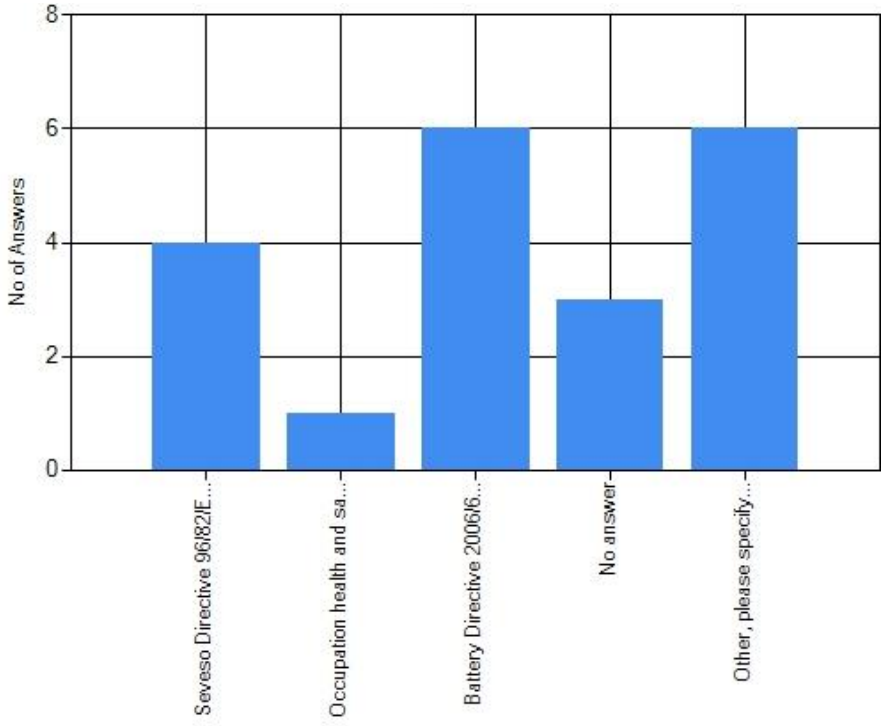


Figure 6: Available regulatory framework for energy storage in your country

Option	Number of answers	Percent
Battery Directive 2006/66/EC about recycling or end of life	6	46
Seveso Directive 96/82/EC on the control of major-accident hazards	4	31
Occupation health and safety Directive 89/391/EEC on OSH "Framework Directive"	1	8
No answer	3	23
Other, please specify • EIA Directive, SEA Directive • only transportation tests, no other tests are mandatory to my knowledge • French regulations on classified facilities • Law of 19th July 1976 on "installations classées pour la protection de l'environnement " (more specifically Article L511-1 to L-517-2 of Environmental Code) – French regulations • Fire protection law (Japanese law), JIS C 8715-2 Safety standard for Lithium-ion cells and batteries for Industrial applications	6	46

3.3.2.2 Interpretation

According to the respondents, the most relevant regulation is related to the implementation of the Seveso directive (major accident prevention). It is important to mention that this directive takes into account the quantities of dangerous substances present in the system. It

is important to notice that in the Seveso Directive, the article 4 entitled "Assessment of major-accident hazards for a particular dangerous substance" exists but different interpretation of this article could be done and a classification according to the substances that can be generated during abnormal situations is not clear and could be interpreted differently depending on the country. The regulations related to recycling (Directive 2006/66/EC) and to occupational health and safety (Directive 89/391/EEC) are not directly relevant for the scope of the project.

3.3.3 What is your criteria to evaluate hazard potential?

3.3.3.1 Results

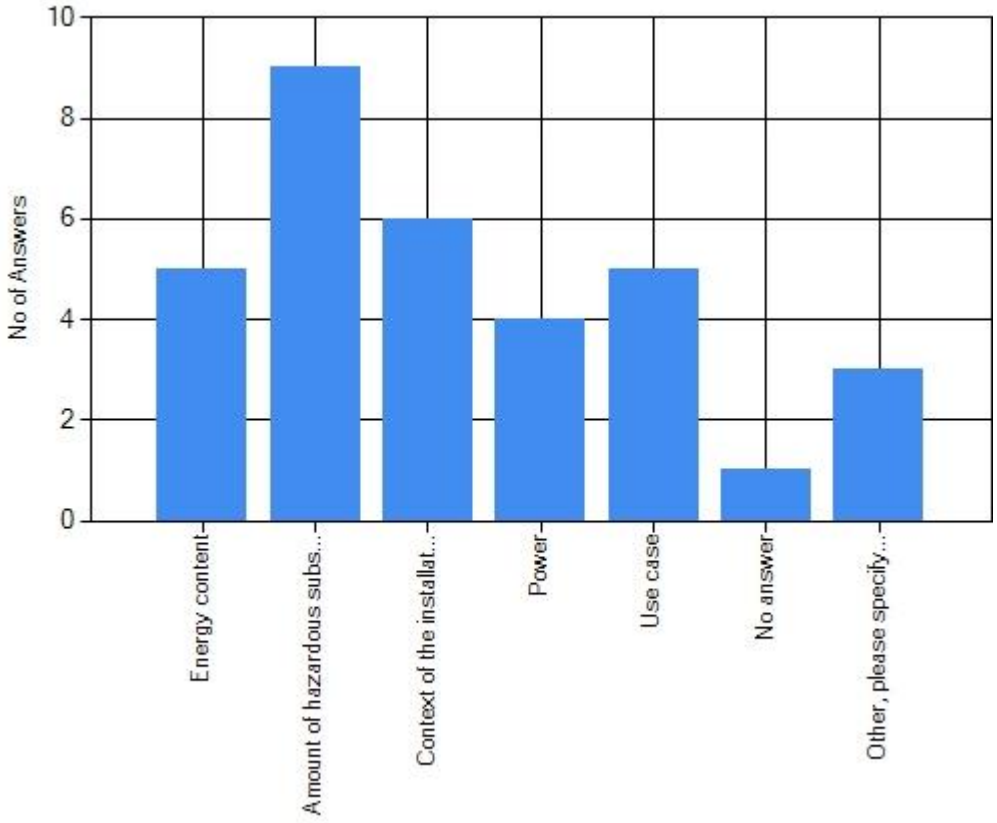


Figure 7: Criteria to evaluate hazard potential

Option	Number of answers	Percent
Energy content	5	38
Amount of hazardous substance (e.g. for the electrolyte)	9	69
Context of the installation (potential exposure to floods, heavy rain, vandalism, etc.)	6	46
Power	4	31
Use case	5	38
No answer	1	8
Other, please specify • There is a difference between existing and planned facilities. For planned ones it is important to consider site context (land-use, proximity of …), technological characteristics (production/storage activities, transport, infrastructure). • Reactivity and power characteristics	3	23

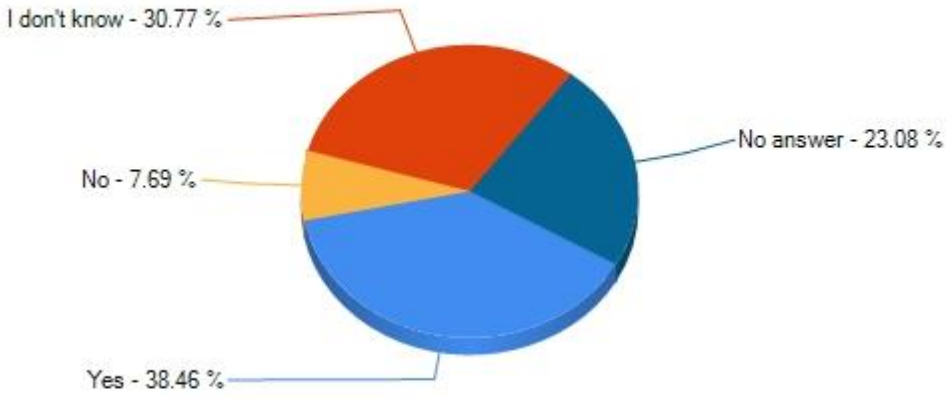
• Conditions of use of the equipment		

3.3.3.2 Interpretation

The result of this question indicates that the Seveso directive would be the most relevant available regulation since the majority of the votes indicate that the amount of hazardous substances is the most important criteria to evaluate the hazard potential. However, the results also shows that others criteria such as context of the installation, energy content, use case, and power could be taken into account to evaluate hazard potential.

3.3.4 Do you apply other reference document such as guideline, industry recommendations, authority recommendations, best practice document? If yes, just specify the reference.

3.3.4.1 Results



Color	Name	Value	Percent	Color	Name	Value	Percent
	Yes	5	38.46 %		I don't know	4	30.77 %
	No	1	7.69 %		No answer	3	23.08 %

Figure 8: Reference documents

If yes, just specify the reference:

- (3) I. Gyuk, L. Mears, H. Gotshall, H. Kamath, "EPRI-DOE Handbook of Energy Storage for Transmission and Distribution Applications", Final Report, Cap.2-5, pp.47-146,2003, USA; DIN VDE 0100; DIN VDE 0101; IEC 60439-1:1999 + A1:2004; IEC 146-1-1:1991; EN 50272-2:2001; EN 50160 2010; IEC 61000-2-2; IEC 721-3-3
- (12) environmental assessment notice (SAFT internal document provided to customers)
- (13) JIS8715-1 Performance standard for Lithium-ion cells and batteries for Industrial applications

3.3.4.2 Interpretation

The participants have provided the reference documents. Only few have been identified and there is no general, international or harmonized reference document.

3.3.5 Any recommendations regarding safety requirements in case of accident or incident? E.g. Development of guidance documents. (Please specify the reference to any document)

3.3.5.1 Results

(3) UVV / VBG / SBG Accident prevention regulation

(6) No (the requirements are both general - common sense, and facility/site specific).

(8) Training of the safety staff, fire Brigade etc.

Any kind of signs reflecting the interior state of the battery

Safety valves to protect against overpressure in the battery

Automatic shutdown mechanisms to avoid any Connection to the grid

(10) In case of fire, the possibility of toxic fumes exhausted has been evaluated. In case of Na-S storage battery, the main identified toxic gas is SO2. After the accident that occurred in Japan, the manufacturer has defined firefighting strategy using vermiculite projection and tested this extinguishing system. This guidance has been included in the safety report.

(12) SAFT has created a document named "Battery Information Sheet" (BIS) based on MSDS (material safety data sheet) model. This document is not mandatory and has been made in order to give all information useful to customers.

One of those information concerns safety requirements in case of accident or incident, and more specifically firefighting measures.

Excerpt from the BIS:

"12. FIRST AID MEASURES (not anticipated under normal use)

EYE CONTACT: Immediately flush with copious amount of water for more than 15 minutes. Seek immediate medical attention.

SKIN CONTACT: Remove contaminated clothing and flush affected areas with plenty of water for at least 15 minutes. Wash skin with soap and water. If skin irritation persists, call for a medical attention.

INHALATION: Remove to fresh air and seek immediate medical attention. Obtain medical advice.

INGESTION: Clear mouth with water and afterwards drink plenty of water. Do not induce vomiting. Seek immediate medical attention.

13. FIRE FIGHTING MEASURES (not anticipated under normal use)

ESTINGUISHING MEDIA:

• Small fires: use D type fire extinguisher, inert gas (for instance blend of argon and nitrogen), CO2, dry chemical powder or foam extinguishers

• Large fires: use large quantities of water for the surrounding fire and to prevent propagation. If water is used on live batteries, caution should be taken to avoid the electrical hazard that may be present.

SPECIAL FIRE FIGHTING PROCEDURES: Fire fighters should wear self-contained breathing apparatus.

Use approved / certified vapour respirator to avoid breathing toxic fumes. Wear protective clothing and equipment to prevent potential body contact with electrolyte solution. It is permissible to use any class of extinguishing medium, specified above, on these batteries or their packing material. Cool exterior of batteries if exposed to fire to prevent rupture.

PARTICULAR HAZARDS RESULTING FROM EXPOSURE TO THE SUBSTANCE/PREPARATION, TO COMBUSTION AND GAS

PRODUCTS: The cell can spout vaporized or decomposed electrolyte fumes with fire when being heated over +100°C (+212°F) or disposed in fire. Solvents within the electrolyte are flammable liquids and must be kept away from any kind of ignition source"

(13) I'm not sure.

3.3.5.2 Interpretation

The participants have provided reference of relevant documents. Not many documents were cited. Only SAFT provided a detailed excerpt of an internal document describing safety requirements.

3.3.6 Any recommendations regarding the lay-out or location of the battery facilities? e.g. Development of guidance documents. **(Please specify the reference to any document)**

3.3.6.1 Results

(3) - Batteries parallelization on the AC side (not on the DC side)
- Keep dangerous direct current voltages inaccessible
- High level personal and plant safety should be ensured, as the maximum voltage should be less than 60 V DC during handling of individual battery modules

(6) No

(8) dry, remote from living areas (inside living areas only with additional safety measures), avoid any additional dangers to the battery (dangerous traffic situations next to the storage System), enough space around the storage

(10) We don't have some much experience on location recommendations concerning large storage facilities. Safety report defines the installation conditions of the storage facility taking into account the risks on the environment.
IEC/TC120 Electrical Energy Storage System begins to work on planning an installation of such storage system and will consider the environmental and safety issues.

(12) Recommendations of the BIS:

"STORAGE : Store in a cool, dry and ventilated area. Elevated temperatures can result in shortened battery life. Since short
circuit can cause burn hazard, leakage or explosion hazard, keep batteries in original packaging until use and do not jumble
them."

(13) I'm not sure.

3.3.6.2 Interpretation

The participants have provided information already existing in available documentations. However, there is no generic rule available and it might be useful to provide guidance on this issue of lay-out and location of batteries facilities.

4 Additional inputs from discussions

4.1 Regulatory framework in Europe

During additional exchanges with SAFT, it has been highlighted that the Seveso Directive is not adapted to large storage systems.

The SAFT representative in charge of regulatory affairs provided the following written explanation:

- "The law of 19th July 1976 on "installations classées pour la protection de l'environnement" (more specifically Article L511-1 to L-517-2 of Environmental Code) could be applicable, even though there is no specific section about Energy Storage. To be prudent, SAFT has decided to apply section about substance storage even if substance inside batteries are not really stored. Section about substance handling and mixing is not applicable."

- "Within this directive, EPR (Extended Producer Responsibility) requires the establishment of a collection system for batteries at end of life and the duty of care costs by the producer costs (treatment, recycling). The Producer status is defined as such:
  - If SAFT sells a French OEM who sells a French installer, SAFT is the Producer. He is responsible for the end of life and must bear the associated costs (several tens of k€)
  - If a non-EU manufacturer sells to a French OEM who sells a French installer, French is the OEM Manufacturer. He will assume the costs associated with the end of life (it does not necessarily know at the time of sale).

  With this principle, we (European manufacturers) must incorporate the costs of end of life as opposed to non-European manufacturers.
  This is a major legislative barrier to facilitate the deployment of large storage systems by French manufacturers."

4.2 Regulatory framework in Japan

During a discussion with NITE (National Institute of Technology and Evaluation, working under the auspice of the METI) representatives on July 4, 2014 in Stuttgart, the Japanese experts have confirmed that there is no specific regulation for the safety of large batteries with stationary applications.

Toshiro MATSUYAMA, Senior Technical Staff from the Technology Planning Division" from NITE said: "There is no specific rule, only convention safety acts applies". He also confirmed that, according to his knowledge, no new activity related to the preparation of Seveso like rules has started.

He also concluded that "standard should not hinder the progress", and he explained that NITE is very interested by the work performed in STABALID and STALLION in relation with the IEC standardization because it will also apply to Japan.

Afterwards, STABALID team was surprised that they did not mentioned the standard: JIS C 8715-2 Safety standard for Lithium-ion cells and batteries for Industrial applications referred to in the survey.

5 Reference documents mentioned

5.1 In Europe

- Battery Directive 2006/66/EC about recycling or end of life
- Seveso Directive 96/82/EC on the control of major-accident hazards
- Occupation health and safety Directive 89/391/EEC on OSH "Framework Directive"
- EIA Directive 2014/52/EU on "Environmental Impact Assessment"
- SEA Directive 2001/42/EC on "Strategic Environmental Assessment"
- Gyuk, L. Mears, H. Gotshall, H. Kamath, "EPRI-DOE Handbook of Energy Storage for Transmission and Distribution Applications", Final Report, Cap.2-5, pp.47-146,2003, USA; DIN VDE 0100; DIN VDE 0101; IEC 60439-1:1999 + A1:2004; IEC 146-1-1:1991; EN 50272-2:2001; EN 50160 2010; IEC 61000-2-2; lEC 721-3-3
- Environmental assessment notice (SAFT internal document provided to customers)
- UVV / VBG / SBG Accident prevention regulation
- "Battery Information Sheet" (BIS) based on MSDS (material safety data sheet) model (SAFT internal document)
- ÉTUDE SUR LE POTENTIEL DU STOCKAGE D'ENERGIES. Rapport d'étude ADEME. 21/10/2013.

5.2 In Japan

- Japanese standard JIS C 8715-2 "Secondary lithium cells and batteries for use in industrial applications - Part 2: Tests and requirements of safety"
- Japanese standard JIS C 8715-1 "Secondary lithium cells and batteries for use in industrial applications - Part 1: Tests and requirements of performance"

6 Conclusion

The consultation has enabled to collect the view and data from the main stakeholders thanks to a survey that was addressed to a large number of stakeholders from industry, industry associations, public authorities and academics.

Only few stakeholders expressed their opinion through the questionnaire and only 13 answers were collected. However, EU-VRi is confident in the results of the survey since the subject is very specific and the participants are experts in the field of large stationary batteries.

The key finding of the survey can be summarized as follows:

- There is a lack of knowledge about the existing installation. The exchange of feedback and best practices could be improved.
- Among the available regulation documents implemented, the Seveso directive is the most appropriate.
- The implementation into laws at national level can generate differences in terms of regulation between the European Member States. Then there is still a need for EU harmonization.
- SAFT stressed the fact that the Seveso directive is applied to large stationary batteries but it is not the most relevant option. Indeed the Seveso directive does not take into account the specificity of the large stationary batteries and its environment into a dedicated section for example.

As conclusion of this survey, STABALID would recommend to develop a reference document such as a BREF and an EU reference technical document dedicated to the large stationary batteries and based on the Seveso directive.

In that sense, the standardization work done by STABALID by defining safety testing procedures to be included into an IEC standard will contribute to the harmonization of a safety regulation at international level dedicated to large stationary battery.

Annex 1 The questionnaire

Identification of existing regulations in force in EU on Li-ion battery systems

In relation with the initiative developed by the EU FP7 project STABALID, you are invited to take part in this survey to **provide information to identify existing regulations in force in EU on Li-ion battery systems.**

We kindly ask you to provide your inputs **by June 24, 2014**.

Don't hesitate to contact us at stabalid@eu-vri.eu if you have any question.

Page 1 of 5

Characterization of the type of storage facilities

1. Please specify the country for which you are going to answer this survey.
(if several countries, please use the link available at the end of this survey)

2. Are there any stationary battery storage facilities in your country with around 1 MWh or more?

- □ Yes
- □ No
- □ I don't know

3. If yes, please indicate the technology:

- □ Lead-Acid
- □ Ni-Cd
- □ Ni-MH
- □ Na-S
- □ Li-ion
- □ Zebra (Na-NiCl2)
- □ Other, please specify

4. If yes, please indicate the maximum energy storage capacity

- □ 1 MWh < E < 4 MWh
- □ 4 MWh < E < 7 MWh
- □ 7 MWh < E < 10 MWh
- □ 10 MWh < E

Regulation in force

5. Do you know if any safety study has been performed for these facilities?

□ Yes
□ No
□ I don't know

If yes, does it include the environmental scope?

6. Is there any available regulatory framework for energy storage in your country?
□ Seveso Directive 96/82/EC on the control of major-accident hazards
□ Occupation health and safety Directive 89/391/EEC on OSH "Framework Directive"
□ Battery Directive 2006/66/EC about recycling or end of life
□ Other, please specify

7. What is your criteria to evaluate hazard potential?
□ Energy content
□ Amount of hazardous substance (e.g. for the electrolyte)
□ Context of the installation (potential exposure to floods, heavy rain, vandalism, etc.)
□ Power
□ Use case
□ Other, please specify

8. Do you apply other reference document such as guideline, industry recommendations, authority recommendations, best practice document?

□ Yes
□ No
□ I don't know

If yes, just specify the reference

9. Any recommendations regarding safety requirements in case of accident or incident?
e.g. Development of guidance documents

(Please specify the reference to any document)

10. Any recommendations regarding the lay-out or location of the battery facilities?
e.g. Development of guidance documents

(Please specify the reference to any document)

Personal interview

11. I am available for personal interview for the topics covered in this survey

- ☐ Yes
- ☐ No