Quality Assurance Plan

Deliverable D1.2

STANDARDS REVIEW AND TECHNOLOGY TRANSFER

- DELIVERABLE D7.1 -

RICAS - 2020 -

DESIGN STUDY FOR THE EUROPEAN UNDERGROUND RESEARCH INFRASTRUCTURE RELATED TO ADVANCED ADIABATIC COMPRESSED AIR ENERGY STORAGE

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Abstract: The Standards Review and Technology Transfer report examines the possibility of using existing norms, regulations, and applicable experience from relevant projects for the implementation of RICAS2020.

VERSION	DATE	REASON OF CHANGE
1	02/02/2016	Submission of the document to all partners.
2	15/04/2016	Final document

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1 Executive Summary

Herein information on relevant CAES projects, as well as other underground gas storage installations, namely CO_2 and natural gas storage, is provided.

Furthermore the corresponding norms and regulations for CAES, CO_2, and natural gas storage are described. Although no concrete legislation exists for the construction of CAES plant, it is expected that the procedures used in similar installations will be applied as well.

Additionally, a number of case studies are shortly described to provide insight in two subjects, namely part of the approval procedure and safety. The environmental approval documentation of an under construction CAES plant is reported. It is expected that it will form the basis of the analogous environmental impact analysis of RICAS2020. The safety aspects of underground gas storage are also investigated within two case studies. They provide information on the long term aspects of an underground gas storage facility.

Finally the approval procedure of an underground installation in Germany is described.

The present report is supplemented in course of the project.

2 Introduction

2.1 Purpose of the Standards Review and Technology Transfer

The document reports on any legislation, standards, norms, and regulations that are relevant for the implementation of the RICAS2020 project. Furthermore technology standards from other areas which are applicable to the project are mentioned.

2.2 Scope of the Standards Review and Technology Transfer

The document provides information on relevant CAES projects, as well as other underground gas storage installations, namely CO_2 and natural gas storage. The corresponding norms and regulations for CAES, CO_2, and natural gas storage are given. A number of case studies are also reported to provide insight on the approval procedure as well as safety aspects of underground gas storage. Finally the approval procedure of an underground installation in Germany is described.

2.3 Related Documents

The document builds the basis for two aspects of the project, namely the approval procedure and the safety and security concept (D7.2).

3 Relevant Projects

In the following relevant CAES projects, as well as underground gas storage systems are shortly summarised. It is expected that the experiences from these projects will be utilised during the implementation of the AA-CAES project.

3.1 CAES Installations

3.1.1 Operating installations

During the compilation time of this report, only two operational conventional CAES plants are in existence:

- Huntorf, Lower Saxony, Germany: The plant is in operation since 1978 and has a rated power output of approximately 290 MW for up to 2 h of operation. The round-trip efficiency of the plant is around 42 %. The compressed air is stored in excavated salt cavern.
- McIntosh, Alabama, U.S.A.: The plant was commissioned in 1991 generating 110 MW of power for up to 26 h of operation. Contrary to the Huntorf plant, heat recuperation is employed to reuse part of the heat energy from the exhaust of the gas turbine, increasing the round-trip efficiency to 54 %. As in the case of Huntorf, the compressed air is stored in a salt cavern.

3.1.2 Current development

A number of CAES, both conventional and adiabatic are planned for construction in the following years. The projects having the highest relevance to the RICAS2020 project are listed in the following:

- ADELE: The ADELE project is the first large scale adiabatic CAES under development. Design goals are a power output of 200 MW, operation between 4-8 h and a cycle efficiency of 70 %. Involved in the project are RWE, General Electric, Zueblin, and the German Aerospace Center.
- ALACAES: A subsidiary of Airlight Energy. Amberg Engineering and Lombardi, which is currently building a technology demonstrator of an AA-CAES plant in the Swiss Alps. The plant is designed to provide 100 MW peak power for about 5 h. A cycle efficiency of 70 % is aimed for.
- PG&E: Pacific Gas and Electric Company (PG&E) is planning a 300 MW, 10 h operation CAES plant near Bakersfield, California, U.S.A.

3.2 Carbon Capture and Storage

Injections of CO_2 into geological formations have been used for several decades for various purposes, mostly oil recovery. The long term storage of CO_2 to mitigate fossil fuel emissions however is a relatively new concept.

Geological storage of CO_2 usually involves depleted oil and gas fields as well as saline aquifers. There are several dozen industrial projects for carbon sequestration and their listing is beyond the scope of the present document.

3.3 Underground Gas Storage

Underground reservoirs are the most important type of gas storage. Depleted gas fields are the most common reservoirs used. Aquifers and salt caverns are less frequently employed.

The number of underground gas storage sites worldwide is more than 550 and the amount of gas stored is about 11 % the current global gas consumption. Operating pressures for depleted gas fields and salt caverns are in the range of > 200 bar.

4 Norms and Regulations

4.1 CAES Installations

The regulatory framework concerning CAES is currently under development. There are no concrete references at the International, European, or National level for CAES storage facilities. This is due to the fact that CAES installations have been until now rarely employed.

It is therefore suggested that the current regulations governing underground CO_2 and natural gas storage should be used, as well as relevant literature regarding case studies and safety reports, to provide a rough framework for the implementation of the RICAS2020 project.

Furthermore, after discussion with the Authorities of Lower Saxony, where the Huntorf plant is located, it was revealed that in Germany for any type of underground construction an audit with the Authorities must take place before approval. In this audit the environmental and structural issues are being investigated. Further safety issues are covered by the corresponding regulations for plant engineering. It is expected, but it still must be verified, that a similar evaluation process applies in Austria. For details regarding the auditing process, see Chapter 6.

4.2 Carbon Capture and Storage

The regulatory framework concerning CO_2 is primarily defined at European level. National regulations exist also in most European countries.

4.2.1 EU

Directive 2009/31/EC establishes the legal framework for the environmentally safe geological storage of CO_2. It should be noted, that the directive however does not automatically apply to the member states. Instead it has to explicitly be incorporated at the national level.

The guideline addresses the following issues among others:

- Selection of storage sites
- Monitoring
- Measures in case of leakages
- Closure and post closure obligations
- Information to the public

4.2.2 Germany

In Germany the underground CO_2 storage is governed by the Law for long term storage of carbon dioxide (Gesetz zur Demonstration der dauerhaften Speicherung von Kohlenstoffdioxid – KSpG). The law is an implementation of the relevant European regulation.

4.2.3 Austria

In Austria the long term CO_2 storage is not allowed. Only storage of amounts up to 100kt CO_2 is permitted for research purposes.

4.3 Underground Gas Storage

The regulatory framework concerning underground gas storage is defined at European as well as national level.

4.3.1 EU

Directive 2009/73/EC establishes the rules for gas storage among others, including transmission, distribution, and supply of natural gas, at a European level. The criteria and procedures for the authorisation of natural gas storage are also defined.

4.3.2 Germany

The Federal Mining Act (BBergG) defines also the framework for the underground gas storage in Germany.

4.3.3 Austria

As in the case of Germany, underground gas storage is subject to regulation through the Austrian Mining Law. The conditions and terms applying are similar to those of Germany.

5 Case studies

Of interest for the technology transfer as well as for the regulatory matters are case studies, in which technical or regulatory issues are accordingly described. In the following, the regulatory framework regarding the environmental approval of the planned PG&E CAES project is shortly presented.

Furthermore, cases in which the safety of underground gas storage facilities was compromised are reported.

5.1 Environmental Assessment

The final environmental assessment of the under construction PG&E CAES plant was released for the public after its completion. In report the following are being investigated:

- Background information on renewable energy storage
- Project overview
- Alternative solutions
- Affected environment
  - Air quality
  - Biological resources
  - Soils
  - Geological hazards
  - Noise and vibration
  - Cultural resources
  - Socioeconomic analysis
- Public and occupational health and safety
- Water resources
- Unavoidable adverse impacts

5.2 Safety

Of interest are also cases where a mishap occurred in an underground gas storage facility. It should be noted that incidents in natural gas storage facilities are generally rare, and when they do happen, they rarely lead to loss of life. Although an accident in a CAES installation is not expected to be as potentially dangerous for the structures and population in the surrounding area compared to an incident at a natural gas storage facility, the gained experience may prove valuable.

Of great importance are the lessons regarding the lifespan of underground storage plants. The incidents reported below occurred in facilities that have been operating for several decades.

5.2.1 Mont Belvieu

The accident occurred in Mont Belvieu, Texas, U.S.A. where a salt dome was used for storage of petroleum gas. The gas escaped the dome and accumulated under the foundations of a nearby household. Due to a spark from an electrical appliance the gas was ignited destroying the house. In the following days several more houses in the area had to be evacuated.

The cause of the problem was traced back to the cement casing on the top of the cavity which after 22 years had become leaky.

5.2.2 Hutchinson

Gas at an underground storage facility in Hutschinson, Kansas, U.S.A. escaped through the salt cavern and migrated under the local town some 14 km away. The gas did not cause any structural problems at the nearby houses and it was diffused through old wells. In one instance however it was ignited killing two persons.

The subsequent investigation determined that the cause of the problem was a damaged well, which compromised the structural integrity of the salt cavern.

6 Approval procedures

The construction of underground installations in the EU is subject to approval. For an installation to be approved specific national regulations must be satisfied. There is no common European Mining Law or Regulation. As example, the approval procedures in Germany and Austria are reported in the following paragraphs.

6.1 Approval procedure in Germany

Since in a CAES plant the air is not stored in a container, the Federal Mining Law is the applicable regulatory framework which defines the approval procedure.

If during the construction no soils are to be mined (§ 3 BBergG), a limited version of the Federal Mining Law applies, which simplifies the approval procedure.

Officially approved Operating Plans are needed for the authorisation. The types of documents needed are listed in the following:

6.1.1 Main Operating Plan

Description of the installation and its operation for a period of two years.

6.1.2 General Operating Plan

General description, technical execution; and time schedule of the project execution. The environmental impact assessment is a special form of the General Operating Plan according to the Regulation for the environmental impact assessment during the planning approval process.

6.1.3 Special Operating Plan

Detailed operating plan regarding the specific components of the installation.

6.1.4 Closure Plan

The Closure Plan contains information on the closing of the facility and on any removal procedures for equipment or installations.

6.1.5 Business Plan

The Business Plan contains information on the Business Plan in case more than corporate entities are involved.

The Operating Plans are approved by the Authorities, when the obligatory precautions against loss of life, for the protection of public health and material assets, and for the protection of the employees and third persons in the facility are satisfied and when the applicable regulations for the construction and operation of the facility are held.

Furthermore the following aspects are most critical for the approval procedure:

- Top soil protection
- Proper operation, removal of any waste
- Provisions for the reuse of the surface area

- No destruction of natural resources

The compliance to the above mentioned criteria can be documented in the reports listed below. The extent of these reports must be defined in cooperation with the Authorities.

- Expert opinion on emissions
- Expert opinion on noise levels
- Safety report
- Fire protection concept
- Expert opinion on explosions
- Expert opinion on ground water protection
- Geological report
- Expert opinion on Industrial Safety Regulations
- Expert opinion on Hazardous Substances Ordnance

6.2 Approval procedure in Austria

The approval procedure in Austria will be described in detail in Deliverable D7.2.

7 Glossary

7.1 Abbreviations

AA-CAES	Advanced Adiabatic Compressed Air Energy Storage
BBergG	Bundesberggesetz – Federal Mining Law, Germany
CAES	Compressed Air Energy Storage
KSpG	Gesetz zur Demonstration der dauerhaften Speicherung von Kohlenstoffdioxid – Law for long term storage of carbon dioxide