# Study on Conceptual Design of Ocean Compressed Air Energy Storage System

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**Abstract –** In **this paper we can study the ocean compressed air energy storage system. We can used any type of energy that is wind, ocean currents, tides in the system. The OCAES system with thermal energy storage is presented on the based on present compressed air energy storage system design. The overall efficiency is 65.9 %. . In addition, finite element simulations are presented which show the flow induced loads which will be experienced by OCAES air containers on the ocean floor. Compressed air energy storage is another promising energy storage technology worth studying because CAES is a scalable, economical, and proven technology.**

**Index Terms – Offshore, Ocean, Compressed Air Energy, Energy Storage, Ocean Energy, CAES, OCAES.**

## 1. INTRODUCTION

The electricity is the important of our day to day life. Because of increasing the demand of electricity reduced the decency on focil fuels, because the world wide efforts and increasing the demand for renewable energy sources. High quality of power provided to the grid, bulk energy storage system by the renewable energy system. During period of peak supply some energy is wasted in most renewable energy sources as it does not coincide with period of peak demand. There are different types of energy storage devices such as battery storage, flywheel energy storage and pump hydro energy storage. But the Battery storage system and FES are capable fast responding, but they are scat, but the construction is Almighty. Because of the worldwide efforts to reduce the dependency on fossil fuels, demand for renewable energy generation has been raised significantly in recent years. However these renewable energy sources have a critical disadvantage, namely unpredictability of supply. To provide high quality power from renewable energy sources to the grid, bulk energy storage system will be required as a buffer, due to the intermittent nature of renewable energy. Compressed air energy storage (CAES) is another promising energy storage technology worth studying because CAES is a scalable, economical, and proven technology. In North Carolina, efforts to utilize the potential of offshore energy have begun and ocean compressed air energy storage.

## 2. COMPRESSED AIR ENERGY STORAGE

Compressed air energy storage is a probable instead on a utility scale as shown in fig 1. CAES system's work by using electricity to compress ambient air, which is thereon stored in a hefty underground cave while compression heat is wasted within intercooler's. Electricity is generated by recovering compressed air form the storage chamber, collecting it with innate gas in a combustion chamber, and exhausting the combustion product through a turbine. The world's first compressed air storage power stead , the Huntorf plant has been operational in 1978. The 290 mw plant, located in Bremen Germany , is used to feeder wear shaving , handloom reserves and VAR support. A total volume of 11 million cubic feet is stored at pressure up to 1000 psi in two underground salt cave situated 2100 – 2600 feed beneath the superficies. It requires 12 hours of off – peak power to absolutely recharge, and then is able of distributes total output (290 mw) for up to 4 hours . This system operates a conventional cycle, and combusts innate gas prior to expansion. Alabama's Electric collaborator (AES) has been running the world's second CAES facility in 1991 called the McIntosh project , it's a 110 mw unit. The commercial venture is used to store off - peak power , generated peak power and provide spinning reserve. 19 million cubic feet is stored at pressure up to 1080 psi in a salt cave up to 2500 feet deep and can provide full power output for 26 hour's. This system recovers waste heat which reduces full usage by ~25% compared to the Huntorf plant. Iowa stored Energy park Announced in January of 2007 , the Iowa stored energy park is partnership between the Iowa party of Municipal Utilities and the Department of Energy. They plan to integrate a 75 to 150 mw wind farm with underground CAES, 3000 feet below the surface . The ISEP is currently in design phase with anticipated generation starting in 2011.

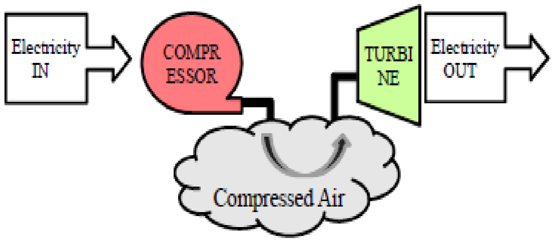


Fig 1. Concept of CAES

2.1 ADIABATIC CAES SYSTER

An adiabatic CAES system has a thermal energy storage (TES) system instead of a combustion chamber in order to increase overall efficiency by recycling compression heat. TES has been widely used in conjunction with solar energy generation since the 1980s. Suitable heat storage materials such as salt or concrete are the primary materials used for TES. In an adiabatic CAES system, heat generated during the air compression process is stored in a TES and supplied to the compressed air prior to expansion. This concept of an adiabatic CAES system with efficiencies over 70% was investigated by the EU-funded AA-CAES project for five years. Based on the analysis of the advanced adiabatic CAES model studied under the AA-CAES project, RWE, General Electric, Zublin AG, and the German Aerospace Center (DLR) launched the ADELE project to construct and test the world's first adiabatic CAES plant in Germany. The construction will begin in 2013 in Staßfurt, Sachsen-Anhalt, Germany. The simplified thermodynamics model of the adiabatic system being developed for our proposed OCAES system, makes use of the data form papers concerning the McIntosh plant and TES systems.

2.2. ISOTHERMAL CAES SYSTEM

Recently, isothermal compression and expansion systems on a CAES system are being developed by several companies, such as General Compression, Inc., Sustain X, Inc., and Light Sail Energy, Inc. In an isothermal process, a system changes while the temperature remains constant. Isothermal compression allows air to be compressed without a temperature increase, in other words, this process represents the minimum required work for the compression process. By increasing heat transfer between air and ambient 'infinite heat storage' during compression and expansion, there is no requirement for TES, a combustor, or a series of intercoolers. Various concepts for a isothermal system have been proposed: water injection, a hydraulic air compressor, a liquid flooded compressor, and liquid piston. Some demonstration plants are under construction to test the feasibility of a utility-size system. Although the overall efficiency of an isothermal CAES system is claimed to be as high as 90%, there are no or industrial machines as of yet which approach these efficiency levels. main challenges for a near-isothermal process are that it is a very slow process which requires very high heat transfer coefficients.

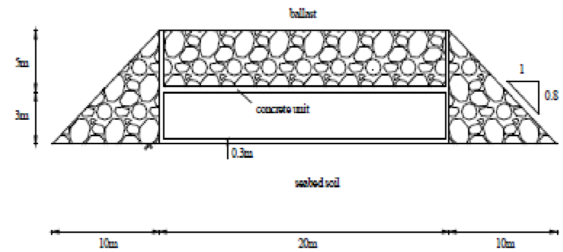


Fig 2. Diagram of CAES

3. OCEAN COMPRESSED AIR ENERGY STORAGE

The basic concepts of an OCAES system are introduced in the papers written by Seymour. In the papers, the concept of OCAES is described as a modified CAES system which is a promising alternative when an underground cavern is not available. The air chamber, which is installed on the seabed, can be an open-ended reservoir or a flexible bladder. Compressed air is delivered to the underwater air storage container and displaces seawater. Due to the hydrostatic pressure at a particular water depth, compressed air is maintained at a constant pressure. The papers present an overview of OCAES systems, and introduce two possible designs of an air chamber. In "Undersea Pumped Storage for Load Leveling", an OCAES system is presented which would have a 230MW capacity for 10 hours a day; this system would utilize compressed air kept at 60 bars contained in a pipe in which the diameter and length are 3.6m and 12.8km, respectively. Another approach, outline in "Ocean Energy On demand Using Under ocean Compressed Air Storage", is an air containment structure with a ballast bin. The paper describes that the tank, which is 30m wide, 8m high, and 300m in length at a depth of 650m, would contain enough compressed air to produce 1GWhr of electricity. The concept of OCAES systems integrated with offshore renewable energy brings significant benefits, especially on the North Carolina coast and along the southern east coast of the United States. Offshore energy production shows great promise, because the energy density of wind energy is much larger and more consistent in offshore areas. According to the National Renewable Energy Laboratory (NREL), the potential generating capacity from U.S. offshore winds is estimated to be more than four times the current electric capacity of the U.S. Offshore wind projects of more than 2,000 MW of capacity are being planned in the U.S., however no offshore wind project has been constructed in the U.S. so far. In addition, the Gulf Stream along the east coast of the U.S. is another energy source, which is from 25 to 80 km away from the North Carolina coastline. The Gulf Stream has a width ranging from 100 to 150 km, with a peak surface speed of over 1.5 m/s . Acquiring compressed air at a constant pressure from an underwater air chamber is another benefit of OCAES. In existing CAES systems, compressed air is throttled to around 45 bars from 70 bar due to the fact that a fixed inlet pressure is highly desirable in the design of turbines. Adjustment of air pressure through throttling is not necessary in an OCAES system, thus the system more efficiently extract the energy from high pressure of compressed air. In Fig. 4, the specific energy is shown and the gap between the blue and red line represents the energy loss due to throttling.

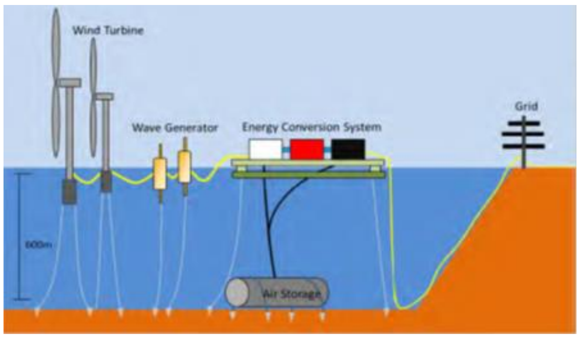


Fig 3. Concept of OCAC

The energy loss due to the pressure drop can be calculated assuming the air is expanded isothermally. The dissipated energy due to throttling is about 6.2 % of the total isothermal energy in the compressed air. Furthermore, the proposed OCAES system has the great advantage of a small storage volume compared to an underground cavern. The fixed volume of underground cavern must operate over a wide range of pressures (i.e. from 45 bar to70 bar), whereas the air chamber of OCAES always stays at the hydrostatic pressure associated with a particular water depth. For the underground caverns of the McIntosh plant, the pressure of compressed air is throttled to 45 bar. Since we do not know the volume of actual expanding air, the mass of compressed air can be used in the equation by the ideal gas law. It is also assumed that the air follows an ideal gas behavior based on the compressibility factor that is not less than 0.97 at 70 bar and 0°C. From Eqn. the energy density of the underground reservoir of McIntosh plant.

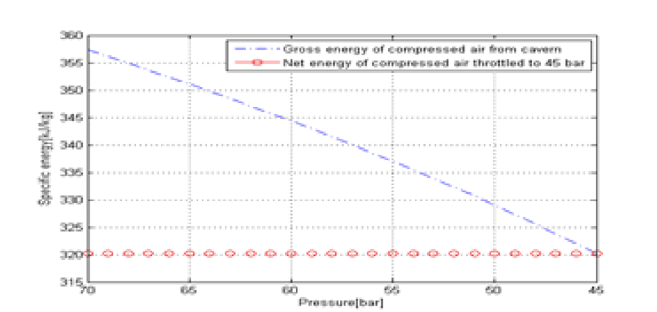


Fig 4. Comparison of specific energy in the compressed air

Strong wind is available in the area around 40km off the coast and a well-proven simple monopole foundation technology can be still offered in the water depth of less than 50m. Moreover since the Gulf Stream overlaps this area, it should be possible to harvest both wind and marine current energy in this area. The length of outfall pipes from a platform to an air chamber at the depth of 600m would be less than 30km in the horizontal direction if the platform is located between the wind farm and the air storage container.

## 4. CONCLUSION

This study shows that Compressed Air Energy Storage is a viable solution for energy storage needs in Colorado. With wind generation developing in the state at a very rapid rate, energy storage may become necessary, or at least profitable, in the near future. CAES is both technically feasible and financially competitive to provide energy storage in Colorado. . The end conclusion is that CAES reservoirs exist in many useful places in Colorado, but many of them will require significant study and financial risk because these types of reservoirs have never been built for CAES before. The strength of this project lies in the optimization methodology in the model.

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