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Renewable Energy Based On Compressed Air Energy Storage As a Technology Embedded In Gwalior MP

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Abstract: Compressed air energy storage (CAES) is one technology that is proposed to increase flexibility when integrating renewable energy sources such as wind, solar and tidal generation with the power grid. By creating a storage medium where the energy produced from these sources can be stored and dispatched to the grid as required, a higher penetration of renewable energy generation can be achieved. which is required to find out the air medium source by mode of storage in the form of compreesed air and the behaviour of wind speed with respect to power demand shows the exact location through which viable wind effect can be classify and By understanding the underlying geological and geographical constraints, a site selection study could proceed as the first phase, followed by an engineering and economic evaluation, and a subsequent optimisation of the facility.
Keywords: Compressed air; Energy storage, wind speed, Geological Survey, Power demand

I. CONTEXT AND OBJECTIVES

Compressed air energy storage (CAES) is a technology that can be used to fulfil two major niches in the electricity market. The first is an arbitrage mode where energy is stored in order to leverage low off-peak energy prices against higher peak prices. The second proposed mode of operation is in conjunction with renewable energy sources like wind farms. Clearly, conservation of energy resources and reduction of carbon emissions are both key in planning future generation assets and engaging other electricity infrastructure issues. A CAES facility co-located with a wind farm could alleviate this by allowing the excess power to be stored and released to the grid when it is required. In this way, CAES can serve to increase wind power penetration into the North American electricity market by making it 'dispatchable'. The authors recognise that some of the information in this paper may seem to be restricted to Ontario, but the research can be helpful in the assessment of the viability of CAES elsewhere in Gwalior.

II. CAES?

A traditional CAES facility as depicted in figure 1 consists of five major components: a compressor train, a motor/generator, a storage cavern/reservoir, a combustion chamber and an expander train. CAES facility consumes energy to store compressed air underground. The power used can be obtained from renewable sources such as wind, and solar, or from traditional sources such as nuclear. When the facility is operated in generation mode, the stored air is expanded through the combustor and mixed with a fuel such as natural gas (number 2 fuel oil has also been used). The mixture is burned to add heat energy to the stream. The hot gas stream then flows through the turbine, which drives the motor/generator as a generator and the facility sells electricity back to the grid at a higher price. In more advanced designs, the waste heat from the combustion process is used to pre-heat the expanding air.

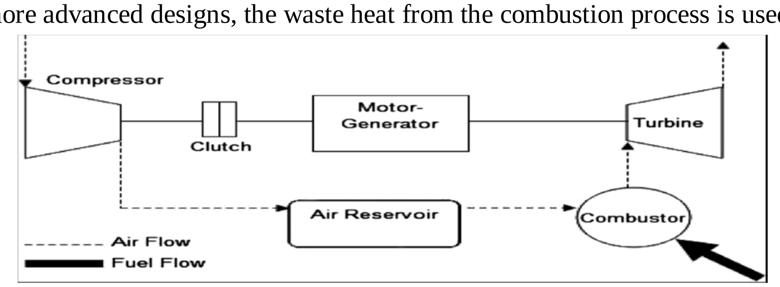

Figure 1: Layout of a traditional CAES

The main options for a CAES reservoir in places such as southwestern Ontario are depleted oil and gas reservoirs, reservoir configurations of strata without hydrocarbons, and artificial caverns, formed through the controlled solution mining of salt deposits.

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The design similarity between CAES and fossil fuel power plants would allow CAES to function also as spinning reserve, and, if coupled with a renewable energy source, would create a 'renewable spinning reserve'. When co-located with a renewable energy source such as a wind farm, a CAES facility can function as a buffer to reduce or eliminate curtailment and reduce the use of fossil fuels for generation. Power plants using coal and natural gas as their fuels are currently used to respond to short-term spikes in demand. Because of the ability to change quickly the output of these plants, and the fact that they are typically kept running at idle speeds to reduce response time, they are termed 'spinning reserve' plants

III. CAES AND RENEWABLE ENERGY

In international markets such as Gwalior that have high levels of renewable energy generation, CAES has been identified as a possible solution to the variability of renewable energy sources. By enabling these higher levels of wind penetration, CAES can enable electricity producers to lower their fuel consumption and emissions profiles. Because of the rapidly increasing amount of wind energy generation in India, and the comparable amount of nearby hydroelectric energy sources, it is used as a case study in this section

A. Variability of Wind in North East Gwalior

Power demand and wind speeds (and therefore available power from wind energy) vary not only hourly, but seasonally as well. Figure 2 shows a 72-hour moving average of both wind speed and Gwalior power demand for the period from 1 January 2015 to 30 march 2015. The use of a moving average, where each data point is averaged over the previous 72 hours of data, smooths the data to show more clearly the associated seasonal trends. Inspection of figure 2 shows increases in Gwalior power demand during the winter and summer months. It can be observed that situations may arise where the ability to store power generated by wind turbines over long periods of time would be desirable. The daily trend shown in figure 3 depicts a situation where CAES could be used to store otherwise wasted power and supply it to the grid during peak demand. Figure 3 presents the average hourly wind speeds and power demand in southwestern Gwalior Weather data were chosen from the Gwalior station and Gwalior power demand data were collected from the IESO . It can be inferred that although these figures represent only a small amount of the data available, situations which can make available storage advantageous do occur on a regular basis when renewable energy resources are included in the mix of generation.

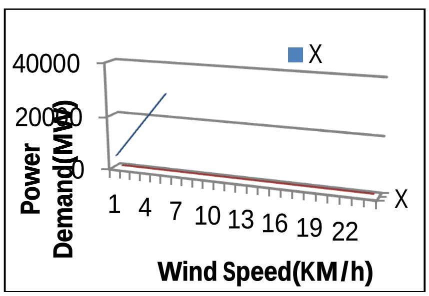

Figure2. Average Daily Wind Speed and Power Demand in March 2015

B. Caes as A Buffer For Renewable Energy

Figures 2 show the potential for an energy storage facility to act as a buffer between renewable energy sources and the power grid in Gwalior. By using a CAES facility in this way, renewable sources such as wind and solar could be left 'always-on' as opposed to curtailing them when transmission capacity is not available. The capacity to store this power when it is available affords the grid an on-demand source of electricity while reducing fossil fuel usage and taking advantage of renewable resources. It is also possible to foresee a configuration in which the CAES facility could be bypassed when conditions allowed for the renewable energy source to provide power to the grid directly. Further study of methods and configurations is required, and is continuing to quantify this relationship better. This has been undertaken also by others .By increasing renewable generation penetration, CAES can reduce reliance on fossil fuels and decrease the reliance of our electricity generation system on those energy sources

IV. CAES RESOURCES EXISTENCE

Two CAES facilities are currently in operation worldwide. Both use similar design and operating principles, as well as storage media. Several other proposed CAES projects are in various stages of proposal and completion. The operation of existing CAES facilities provides prior work from which a second generation CAES facility could be developed in Gwalior, India

A. Proposed Cases Facilities

There are currently several CAES facilities planned in India.Discussions are underway for additional facilities in Texas, NewYork, and California respectively although planning for these facilities is at the early stages.

V. THE INDIAN ELECTRICITY MARKET AND DEVELOPMENT OF RENEWABLE ENERGY RESOURCES

Between 2006 and 2009, more than 1050 MW of wind generation capacity were installed in india. With another 50 MW scheduled to come online in Quarter 4 of 2010 and 860 MW scheduled between Quarter 1 of 2011 and Quarter 2 of 2012 . Over 2009 and 2010 the average hourly power demand in India was 9.1 GW. While Ontario's installed wind power capacity is relatively high, solar photovoltaic installations are only slowly being introduced. The Indian Power Authority intends to increase India's renewable energy generation capacity (wind, solar and biomass) to 11% by 2018, from 3% today.requires a large increase in renewable energy generation, but they also plan to cut total demand by 21 TWh by 2030 [14]. With the large increase in renewable energy's contribution to electricity generation in India's electricity market, the variability of these energy sources needs to be confronted. While the contribution from solar photovoltaics is relatively predictable based on prevailing weather conditions, the output of wind farms is highly variable. Some element of energy storage will be required by the electricity system operators in order to act as a buffer allowing this power to be dispatched and reducing Gwalior's reliance on simple cycle and combined-cycle gas turbines for peak power generation.

A. Locations of Viable Wind Resources In North East Gwalior

Data on average wind speeds were acquired from the Ministry of Natural Resources (for example, figure 4). These data show average wind speeds at a height of 70 m above ground level (AGL). Data are available at 20 m intervals. Additionally, the location of existing wind and solar resources is also shown. When co-location of CAES and wind farms is discussed, the location of viable winds in relation to appropriate geology for CAES could be a critical factor for selecting a location for the CAES facility. Therefore it is necessary that such data are readily available for a first approximation of a CAES/wind site. In areas with already high levels of wind energy penetration, CAES could facilitate further development of wind resources

B. Economic Considerations

In petroleum exploration, sometimes geology that would normally be expected to contain trapped hydrocarbons for some reason does not. Often these formations consist of rock; which has a history of gas storage. In terms of CAES, this geology would be an economic success because it would be suitable for storage of compressed air. In addition to this geology, the cost of excavating caverns or solution-mining salt needs to be considered in any economic model. This cost is non-trivial especially for the very large reservoirs required to support plants for base load Provisions. As discussed in the previous sections on the geology and geography of southwestern Ontario, viable wind resources that are already being exploited coincide with appropriate geology for CAES across this area of the province. The Sarnia area appears to be particularly viable for development of a CAES facility due to the existing power generation and petroleum recovery infrastructure. The existence of porous rock-type geology which may have the required wellhead infrastructure already in place could significantly decrease the cost

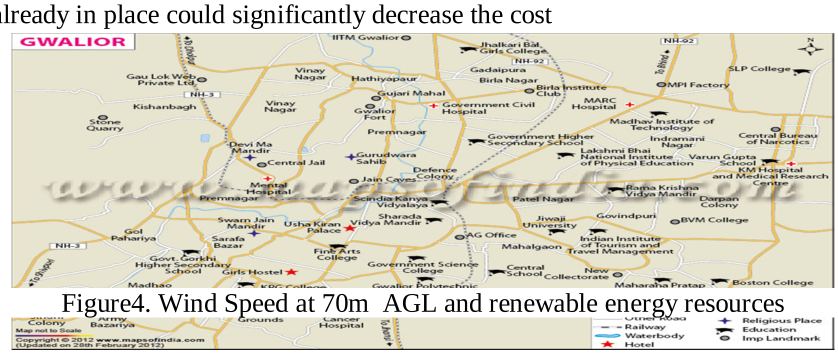

Figure4. Wind Speed at 70m AGL and renewable energy resources

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As discussed in the previous sections on the geology and geography of southwestern Gwalior, viable wind resources that are already being exploited coincide with appropriate geology for CAES across this area of the province. The area appears to be particularly viable for development of a CAES facility due to the existing power generation and petroleum recovery infrastructure. The existence of rock-type geology which may have the required wellhead infrastructure already in place could significantly decrease the cost of developing underground space for a CAES facility.

VI. CONCLUSIONS AND RECOMMENDATIONS

This brief survey of the state of CAES technology and development of CAES facilities shows the potential for further development in the Ontario electricity generation market. As an enabling technology for higher penetration of renewable resources, CAES can provide the necessary storage medium to supplant the variability and lack of 'dispatchability' in wind generation. As a standalone technology, it is evident how a CAES facility could operate for profit and assist with grid balancing by conducting energy arbitrage. Either way, CAES technology can reduce overall fuel usage and assist electricity generators in better using existing resources while reducing emissions at the same time. Higher levels of renewable energy generation enabled by CAES will strengthen this effort. Through careful analysis of existing CAES facilities, an optimised solution for the Ontario electricity market could be conceived. The results of this research create a basis for a feasibility study of CAES in Gwalior. By understanding the underlying geological and geographical constraints, a site selection study could proceed as the first phase, followed by an engineering and economic evaluation, and a subsequent optimisation of the facility. The completion of this prefeasibility examination provides the impetus to consider further the potential of CAES to serve as an enabling technology to assist the province of india and other interested parties in meeting their renewable energy generation goals in the near term.

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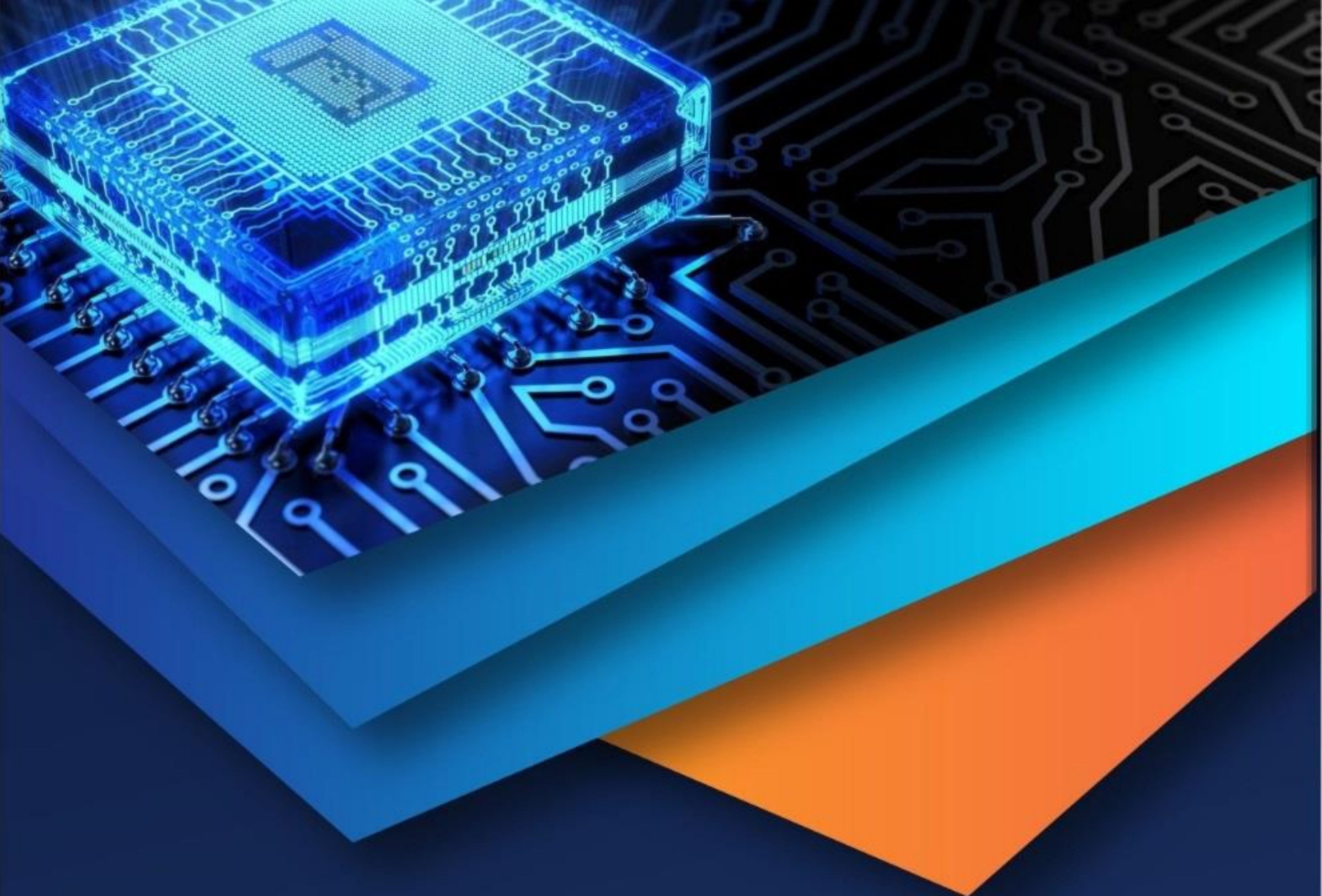

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