IEAGHG Information Paper: 2016-IP18; Degassing Volcanic Lakes

The CCS community is familiar with issues pertaining to limnic eruptions that occurred at Lakes Monoun and Nyos in Cameroon in 1984 and 1986 respectively, killing more than 1,700 people by asphyxiation. A limnic eruption, also referred to as a lake overturn, is a rare type of natural disaster in which dissolved carbon dioxide (CO_2) suddenly erupts from deep lake water[1].

Lake Kivu, is much larger lake than Nyos or Monoun, it is a 1,040-square-mile body of water that stretches over the border between Rwanda and the Democratic Republic of Congo (DRC). Because it sits between two volcanic regions in the western branch of the Great Rift Valley, the deep, perpetually stratified lake's bottommost waters absorb high concentrations of carbon dioxide (CO_2) from magma-heated springs deep underground, and microbes convert much of the CO_2 to methane. These dissolved gases are held in solution by pressures in the depths of the lake. The region is regularly subject to large-magnitude seismic events and volcanic discharges—and considering that methane has a high partial pressure—Lake Kivu is known to experience violent overturns. Geologists believe they occur at Lake Kivu about every 1,000 years—and that the lake is ripe for another.

To help reduce the risk of methane releases from Lake Kivu the Rwandan government has been looking at options to extract the methane from Kivu's depths. The benefits are two-fold: to mitigate the risk of a calamity caused by a limnic eruption at Lake Kivu and also to generate power.

The Rwandan government entered into a partnership with US based CountourGlobal to build a 25-MW power plant, called KivuWatt. The project had financial backing from the African Development Bank, the Emerging Africa Infrastructure Fund, the Netherlands Development Finance Co., and the Belgian Investment Co. for Developing Countries. In 2011, ContourGlobal contracted Finnish energy technology firm Wärtsilä to supply an engine-based plant with full engineering, procurement, and construction delivery.

The plant, which has been operational since December 2015 but was inaugurated in May, relies on two processes: methane extraction and power production. The gas extraction process, performed on a barge anchored 13km offshore in Lake Kivu. , The platform brings gas-rich waters from a depth of 300m and 35-bar pressure, reducing pressure to 2 bar in a gas separator, where gas bubbles are extracted from the water. Raw gas is then washed in four wash towers. The clean gas is then transported to the power plant via pipeline, where three Wärtsilä 34SG engines use it as fuel. According to Wärtsilä, the engines are optimized to run on Lake Kivu's gases, which have a lower heating value than standard natural gas[2].

The project has been very successful and Rwanda is now planning a second phase that will involve two or three barges to generate an additional 75 MW of electricity generation.

In contrast degassing of Lakes Nyos and Monoun in Cameroun has been underway since 2000. In both cases degassing has involved CO_2 not methane[3]. Again degassing columns from rafts in the lake have been used. The principle is simple: a pump lifts water from the bottom of the lake, heavily saturated with CO_2, until the loss of pressure begins releasing the gas from the diphasic fluid and thus makes the process self-powered. In 2001, the U.S. Office of Foreign Disaster Assistance funded a permanent installation at Nyos. In 2011, two additional pipes were installed to assure the complete degassing of Lake Nyos[4]. The emitted CO_2 is vented t the atmosphere.

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[1] https://en.wikipedia.org/wiki/Limnic_eruption
[2] http://www.powermag.com/rwandas-power-production-triumph-killer-lake/#.V3aWsTDkkdo.twitter
[3] https://en.wikipedia.org/wiki/Lake_Nyos
[4] https://en.wikipedia.org/wiki/Lake_Nyos

In 2015 Japanese researchers reported the degassing systems installed in the early 2000s at lakes Nyos and Monoun, Cameroon, have been working well, and resulting in significant removal of dissolved gas. However, the systems of both lakes started losing their capability due to a reduced CO_2 partial pressure in the bottom waters, especially after installation of additional pipes in 2011. This was due to changes in CO_2 profiles in the bottom layer of Lake Nyos over time showed that gas-poor shallow water has descended to the bottom, leaving little CO_2 in the bottom water. The degassing system at Lake Monoun has completely lost its gas self-lift capability as the reduced CO_2 partial pressure in the bottom water is too low to sustain the gas-lift system, and all the degassing pipes stopped working in 2010. This situation then led to the accumulation of CO_2 due to continued natural recharge of magmatic CO_2. To compensate this recharge of gas, they installed a new deep water removal system that is driven by solar power at Lake Monoun in December 2013. This system does not need power lines, fuel or complicated maintenance, thus it is convenient for remote lakes such as lakes Monoun and Nyos[5].

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[5] http://sp.lyellcollection.org/content/early/2015/12/17/SP437.3.abstract