1.3 Technology Action Plans for the Kivu Methane CCGT with CCS

1.3.1 About the CCGT with CCS technology

The current Kivu methane power pilot project at Rubona / Gisenyi / Rubavu district is based on the simplified technology of internal spark combustion of methane gas; therefore any future investors can consider the improved option of CCGT technology based on both use of the (GT) gas turbine and the (ST) steam turbine. A unit of carbon capture and storage (CCS) for sequestration of undesirable GHG emission from the CCGT plant can be installed in order to optimize the mitigation scenarios. Therefore, the description presented below is in line with such an improved technology based on a complex system of the GT, the ST and the CCS. Once the CCS components associated to CCGT system are installed, the CO_2 emissions are separated and captured from the flue gases emitted by the CCGT power plants. Then the CO_2 gas is compressed before being transported through a pipelines' network towards a geological reservoir or an ocean or a lake. Note that the storage of CO_2 is cheaper in case of geological options.

The efficiency rate of reduction of CO_2 emissions i.e contribution to GHG mitigation is about 79% (IPCC, 2005). Therefore environmental benefits from use of CCGT with CCS are important. In fact, the GHG emissions produced by methane-based technologies are as follows: about 110 mg/Nm^3 of NO_x i.e lower than the emission standard rated at 125 mg/Nm^3 , about 400 mg/kWh of CO_2 by a CCGT option against 600 mg/kWh in case of a GT system taken alone (ESMAP, 2007).

1.3.2 Targets for transfer and diffusion of Kivu methane CCGT with CCS

Based on the results of surface exploration and the successful 3.6 MWe Kivu methane pilot project plant operational since November 2008, milestones are as follows:

- Negotiate and establish agreements with private sector and international investors for funding projects of 20 MWe to 50 MWe,

-Installation of about 300 MWe by the end of the year 2017 mainly by private promoters under support by the government agencies and donors,

-Negotiation between the governments of RD Congo and Rwanda for developing a joint 200 MWe power plant [1]based on methane gas,

-Liquefaction of methane gas for further replacement of biomass and diesel fuels used in households and industry sector[2].

1.3.3 Barriers to diffusion of Kivu methane CCGT with CCS

Table 5: Economic and financial barriers for Kivu methane CCGT with CCS

Barriers	Elements of barriers	Presentation and dimension
High cost of methane production	High cost of extracting methane gas	The preliminary steps of methane gas from lake Kivu are expensive, installation of appropriate equipment is expensive also; Biogas generation from householders and cooperatives is done in separate sites;
	Additional cost of storage of CO_2 and H_2S	Elimination of associated CO_2 is also an additional cost (especially it is up to 80% of gross mixed gases). It is also the case for H_2S
	High cost of liquefaction (temperature : 168°C below zero)	Transport of gas from production units requires liquefied gas;(it is also the case of use of gas for cooking and for industry purpose as planned by EWSA for the most important consumers like BRALIRWA in North-West and CIMERWA in South-West of the country.

[1] Modalities for such a regional joint venture is yet to be discussed and negotiated through among others the CPGEL (Communauté Economique des Pays des Grand Lacs i.e. Burundi,RD Congo and Rwanda)

[2] Liquefied methane gas (in addition to biogas, solar water heaters, biofuels, electricity) is greatly expected to contribute in reducing biomass use from 555 to 3000 kg-oil –equivalent, respectively from year 2008 to 2020.(MININFRA; 2012).

	High cost of sequestration of exhaust gases	The CCS is yet an expensive technology due to the main stages : separation ,compression ,transport through pipelines and design of geological storage reservoir

Table 6: Non Financial barriers for Kivu methane CCGT with CCS

Barriers	Elements of Barriers	Presentation and dimension
Unfamiliar new technology	Technical and skill limitation	The CCGT is complex and requires highly qualified managers , both gas turbine steam and recovery system are combined for increasing efficiency
	Limited gas production and distribution	CCGT requires enough preliminary production of methane gas from Kivu lake, and biogas from different regions and companies ; Problem of collection and transport of gas is critical and is hindering the development of CCGT technologies in Rwanda.
Conflict with the green policy	Kivu gas is an abundant energy resource and a relatively clean energy compared to the type of more pollutant fuels that it can replace	Even though the methane fuel is not highly pollutant like the petroleum fuels, its exploitation and use require additional and specific actions of sequestration of exhaust gases

1.3.4 Proposed action plan for Kivu methane CCGT with CCS

Table 7: **Technology Action Plan for Kivu methane CCGT with CCS technology**

Measure	**Justification**	**Responsible**	**Activities**	**Timeframe**	**Estimated cost (USD)**	**Source of funds**	**Success indicators**	**Success indicators**
B1.Set up a network of stakeholders	Coordination among interested investors and companies candidates to Kivu methane exploitation; share of information on new options like the CCS and the double use of gas and steam turbines	MININFRA and private sector	Organization of a seminar for all interested investors in Kivu methane; Visits to external existing CCGT and CCS installations and negotiations for joint ventures; Set up a preliminary network between EWSA and the companies already involved in extraction of gas from lake Kivu	5 years	200,000	GoR	Reports on joint meetings ; The number of joint ventures created; Number of visits done abroad and on local Kivu methane units and plants	Low level of lessons learnt from the visits of existing CCGT and CCS, due to non-similarity with the case of Lake Kivu
-B2-Establish a law on	-Necessity of combining CCS to	REMA and	Organization of campaigns for proving the	5 years	400,000	GoR	Published laws in Rwanda	Non operational joint the venture;

applying the CCS option - B3-Law of shared Kivu methane	CCGT for reducing GHG emissions -Need of promoting joint ventures between DRC and Rwanda	EWSA	role of using the CCS technology; Campaigns showing how the efficiency is improved when the gas and steam turbines are combined; Negotiations and discussion through the CPGL for a potential joint 200 MWe plant				official gazette	Law on sharing Kivu methane not easily operational for the countries; The CPEGL is ended while it was expected to be a good tool for negotiations and application of laws
B4-Control of evolution of methane resources and extraction	-Sustainability and variability of renewable resources - avoidance of risk of disturbance of stratification of Lake	EWSA; universities	Establishment of a research unit in charge of monitoring the methane resource and stability of the lake ; Regular records of data and update of the database	20 years	2.6 million	SIDA-SAREC; EU; GoR	Published reports on evolution of extracted methane gas and on renewability of resources of methane gas in lake Kivu	-Stratification and stability of the layers of the lake are affected; A sudden volcanic eruption at the bottom of the lake;
-B5-Subsidies for	-make more affordable these	World bank ;	- Negotiate access to the carbon-credit facilities and	10 years	24 millions		Financial impacts and	The World bank and other donors

combining CCS to CCGT -B6- incentives for the liquefaction of Kivu methane	options -Attract the investors to distribute methane to industries	EWSA	funds for promotion of replacing the petroleum fuels; -Installation of a mini CCGT/CCS pilot plant; - updating the installation of a gas-to-liquid pilot plant near the BRALIRWA (brasseries et limonaderie du Rwanda) in Rubavu district; - Awarding and distributing subsidies and incentives to all companies developing this technology				amount of subsidies delivered ; Number of companies which benefited from subsidies and incentives; Amount of electric power capacity added to the existing capacity	stop the funding once the liquefaction and use of gas in industries are considered as relatively pollutant fuel;
B7-Regular training and capacity building in CCGT and	CCGT and CCS are complex option requiring highly qualified managers and technicians	Universities; REMA; EWSA	-Organization of an annual training session in techniques of CCGT and CCS; -A two-years- visit to	10 years	400,000	GoR; GTZ	Annually number of certificates awarded to technicians	Technicians continue to consider that the CCS is very complex

CCS technology			external CCGT and CCS installations				,stakeholders and staff; Number of local experts who participated in abroad workshops	technology; Foreign units of CCGT and CCS not accepting to share their experience and keeping hidden their knowledge
B6-Award to innovative options of efficient exploitation of Kivu methane	There is a great need in applying CCS presenting lower costs	UNDP; World bank; REMA	-A two-year (day) - seminar for presenting the updated options and innovative CCS options; -Visit to pilot plants by potential developers; - Distribution of awards	10 years	2 millions	EU; JICA; GoR	Number of new types of CCS technology elaborated and successfully tested	

The proposed measures for the Kivu methane CCGT with CCS technology are especially influenced by the process of combining the steam turbine to the combustion gas turbine and capturing the CO_2 emissions before reaching the storage site (a natural or artificial reservoir/lake/geological). Due to the high level of the initial capital cost, appropriate subsidies are required in order to attract the local private sector and the external partners. We have to mention that this technology will succeed in Rwanda if the risk of unfunded component of the CCS is avoided. In fact without the CCS, the Kivu methane looses the eligibility to renewable category and the carbon credits.

Implementation of different phases for such a technology based on the methane gas extracted from deep layers of the Lake Kivu will require a huge budget. Therefore a special fund and grants with link to the low-carbon credit market for covering the particular costs of CCS components can be delivered for further developers and interested investors. Given that the Kivu methane CCGT with CCS technology is complex, its implementation in Rwanda will required both specific incentives (feed-in tariffs, exemption taxes of imported equipments…), organization of regular training and seminars aiming at increasing the number of qualified technicians and managers, a particular law for a future regulation and evaluation of such a shared resource.