POWER, STEAM AND CARBON WITHOUT CO2 EMISSIONS.

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Overview

The emissions of carbon dioxide (CO2) during 2016 in Peru were 57 million tons, of which a quarter is due to the production of electricity. The energy demand will go from the current 5800 megawatts (MW) to a range between 9500 MW and 12300 MW by 2025 according to the GDP growth scenarios of 4.5% and 6.5% respectively informed by Mine and Energy Ministry; this implies a greater amount of CO2 emissions if fossil fuels are still used. Renewable energy in the country is still incipient to date due to the easy access to natural gas from Camisea, so the transition is expected to be slow although greenhouse gas (GHG) emissions such as this carbon compound, do not follow the same pattern in terms of its reduction.

One of the great challenges in the country is to massify energy distribution; there are areas in which the cost of carrying transmission lines would result in a high cost and for few users without counting how difficult it is to cross the Andes. This is where the need to generate electricity generation poles lies and with the challenge of minimizing the environmental impact; especially GHGs.

Within the infinity of technologies that are being developed to mitigate the impact of CO2, the use of partial methane combustion reactors in a controlled medium of oxygen and halogen salts with a lithium base is proposed, where the formation of oxides is avoided and the production of coal is forced. Lithium iodide and oxygen prevents the reaction of carbon with oxygen, which occurs more rapidly than the direct oxidation of hydrocarbons by oxygen. As suggested by Upan et. al (2018), the chain of reactions that occur in the reactor, promise an almost constant renewable production of energy, steam and coal, as well as a formation of less than 10% of the GHG. Its potential to use this technology in small cities is high, taking advantadge in provide remaining heat to increase quality of life.

Methods

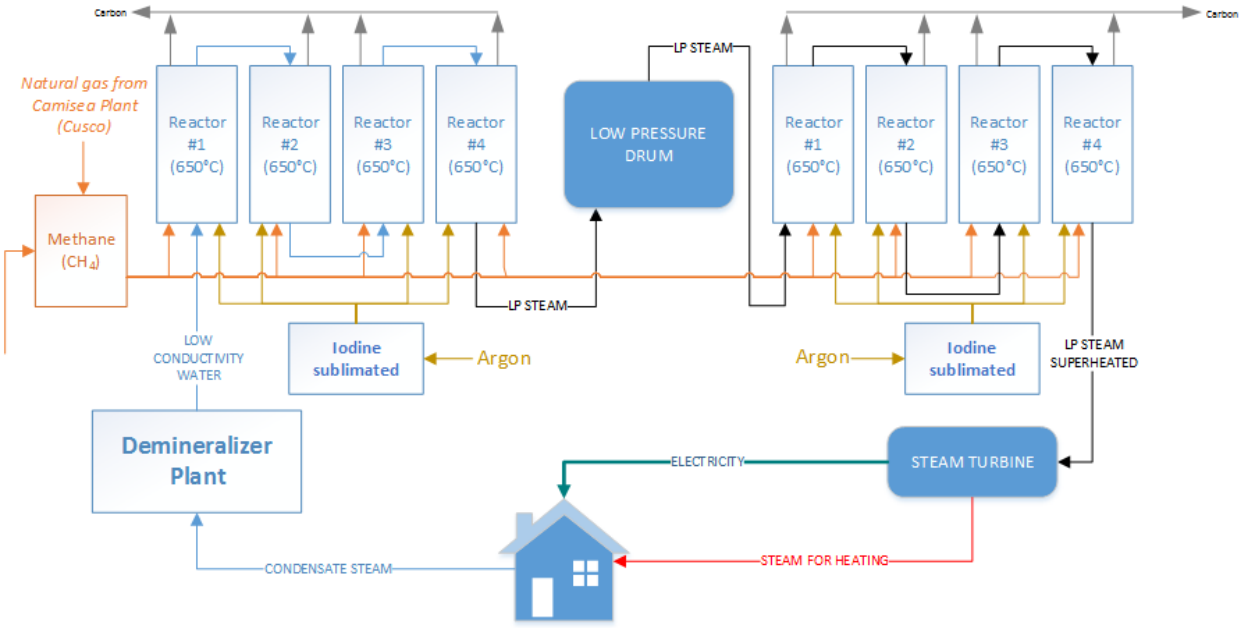
The combustion of carbon-containing materials to produce power has provided abundant, low-cost power for centuries. If methane oxidation could be limited to forming carbon and water, carbon dioxide would not be produced. The amount of heat per mole of methane is less when carbon is produced instead of carbon dioxide; however, the solid carbon produced from this reaction can be sold or stored in perpetuity. In addition, carbon dioxide is not released into the atmosphere. Production of solid carbon also avoids the costs and challenges associated with carbon dioxide sequestration. The challenge of avoiding carbon oxide formation has been recently addressed with separate methane and oxygen feeds in a multistep chemical looping process for partial combustion.

$$CH_4 + 2\,X_2 \rightarrow C + 4\,HX$$
$$\underline{4\,HX + O_2 \rightarrow 2\,X_2 + 2\,H_2O}$$
$$CH_4 + O_2 \rightarrow C + 2\,H_2O$$

According to the reaction, the use of Iodine as “X”, would fit better in the process than another halogen. The necessity of using a catalyzer which easily reacts with hydrocarbons its needed; lithium will fit this profile. The rapid consumption of molecular oxygen, by reaction with LiI,will limit carbon oxide formation. Iodine will be generated and react with methane in the gas phase. The resulting hydrogen iodide will then react with LiOH, completing the catalytic halogen cycle. This combination of reactions would enable the application of methane partial combustion for CO2-free power generation.

To take advantage of the amount of energy that is produced with the set of chemical reactions, a circuit of demineralized water can circulate, which will capture the heat generated forming steam. It will be necessary to concentrate it through a drum and separate water/steam phase, which will allow to gain pressure the steam will be in a subcritical state; from this, superheat and finally direct it towards the steam turbine. This will maximize the heat generated and turbine efficiency; likewise, by implementing a series of reactors, it will facilitate the expansion of electric power production capacity.

Proposal diagram:



The steam after having been used in the steam turbine, can be distributed in a heating line that can be used in nearby homes to then return to the demineralizing plant and close the cycle. The methane needed for the reactions can be obtained through the Camisea gas line, or through the production of this hydrocarbon by the decomposition of biomass.

Results

The expected results allow to define the operation variables as well as the amount of electrical energy can be produced. This will make it possible to decide the scope to be reached in addition to the number of reactors needed for the desired volume of both heat for heating and electricity. The use of other carrier gases that are less expensive and easy to obtain will also be observed.

Conclusions

The use of methane in conjunction with lithium salts, allows the generation of heat energy that is used for power generation and heating in high Andean areas, without the emission of greenhouse gases.

References

Upham, D. C., Snodgrass, Z. R., Palmer, C., Gordon, M. J., Metiu, H., & McFarland, E. W. (2018). Halogen-Mediated Partial Combustion of Methane in Molten Salts to Produce CO2-free Power and Solid Carbon. *ACS Sustainable Chemistry & Engineering*.