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Assessment of Greenhouse Gas Control Technology Options within the Energy, Water and Food Nexus

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The utilisation of Energy, Water and Food (EWF) resources can be described as a nexus of complex linkages embodied in industrial and natural processes. Food production is one such example of a system that mobilises EWF resources to deliver a product which is highly influenced by the efficiency of the industrial processes contributing to it and the conditions of the surrounding natural environment. Aggregating the utilisation of EWF resources into interconnected sub-systems is necessary for the accurate representation of the system's dynamics in terms of its material flow and resource consumption.
The methodology used in this study is an extension of previous work developed regarding nexus analysis (Al-Ansari et al. 2014a, Al-Ansari et al. 2014b). Life cycle assessment (LCA) is used to prepare detailed models of the sub-system components, determine the linkages between the different nexus constituents and evaluate impacts on the natural environment. The nexus system is comprised of water sub-systems represented by a reverse osmosis (RO) desalination process. Energy sub-systems for power generation include models for a combined cycle gas turbine (CCGT) and solar Photovoltaics (PV) energy generation, as well as an amine based CO_2 capture process enabling the utilisation of CO_2 for the artificial fertilization of crops. The agricultural sub-systems include the production and application of fertilizers and the raising of livestock. A biomass integrated gasification combined cycle (BIGCC) for power generation using waste manure from the livestock sub-system is also included.
The objective of this study is to consider a conventional food system in Qatar and enhance its environmental performance by using a nexus approach to examine different scenarios and operating modes. For the Qatar case study, three scenarios and four modes of operation were developed as part of the analysis. The baseline scenario uses fossil fuel to power the entire EWF nexus system using CCGT, the second scenario integrates PV to power the RO units and the third scenario uses solar PV to power the RO and fertilizer production facilities. The second operating mode integrates the BIGCC for power generation and the third mode utilises the gasification by-product biochar for the enhancement of agricultural productivity in addition to the power generated from the BIGCC. The final mode of operation examines the use of CO_2 capture technology in the baseline scenario to support fertilization resulting in productivity increases for crops.

References:
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