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Opportunities and challenges of gas hydrate policies with consideration of environmental impacts

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ABSTRACT

Gas hydrates are crystalline compounds formed by gas molecules captured inside a water framework, which are substantially stored beneath the seafloor and permafrost regions at a stable condition of high pressure and low temperature. It is suggested as a potentially alternative form of energy, of which the reserves are even larger than the gross reserves of all the proved conventional fossil fuels incorporating coal, oil and natural gas. Intense research activities throughout the world are focusing on the exploration and exploitation of these enormous energy resources. However, changes of hydrate volumes and morphologies during exploitation and the resulting weakening of the sediment mechanical strength may likely trigger catastrophic seafloor instability. Besides, the permafrost ablation experienced in the Arctic could also induce potential methane gas released from the hydrates into the atmosphere and most likely exert certain impacts on the climate change. To date, most researches focus on the technical solutions to the total resource estimation, reservoir exploration, mining technologies, and physical properties of hydrate sediments. Yet, limited documents are found to illuminate the worldwide efforts on national policies proposed to promote the secure and efficient utilisation of this source of energy. Herein, the special attentions are placed on the opportunities and challenges of gas hydrate policies with consideration of environmental impacts to push forward the global developments of the renewable and sustainable energy resources.

1. Introduction

In 1778, Joseph Priestley observed gas hydrates by bubbling sulphur dioxide in the 0 °C water at an atmospheric pressure. However, he did not give name to the observed crystals as hydrates [1]. First documented by Davy in 1811, the development of hydrates studies stagnated for about a century till 1934, when Hammerschmidt found severe operational problems in the United States transportation pipelines of natural gas [2,3]. Then breakdowns during gas transport were occurring due to blockages of pipes caused by the hydrate formation under high pressures [4]. Dehydration of gas prior to shipping by heating the pipelines to temperatures above hydrate formation point could solve hydrate-problem [5]. In 1980s, hydrates started to arouse worldwide interest as large amount of hydrate reservoirs have been discovered; the interest remained growing substantially in 1990s, with numbers of publications released and ever-increasing funds invested. Consequently, the first gas hydrate conference was held in the U.S. in 1991 which was jointly hosted by the U.S. Department of Energy, the U.S. Geological Survey and the Naval Research Laboratory [6]. Currently, intense research activities are being conducted concerning resource exploration [7,8], mining technology [9], physical properties [10], as well as engineering application of gas hydrate techniques [11,12].

Gas hydrate is a vast energy source stored underneath the ocean seabed and permafrost. Nowadays, the global energy supply is dramatically relying on the conventional oil, natural gas and coal. Nearly 85.9% out of the total global energy supply is of fossil origin, yet with merely 9.6% of them originating from renewable resources [13]. Unfortunately, the non-renewable fossil fuels cannot meet the globally increasing energy demands as a result of growing populations, expanding industries and rising economics [14]. Therefore, a diversification of energy sources is crucially significant and highly required

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