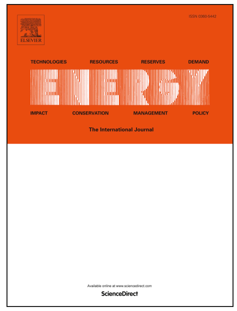
Accepted Manuscript



Radiation enhanced chemical production: Improving the value proposition of nuclear power

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PII: S0360-5442(18)31505-6

DOI: 10.1016/j.energy.2018.07.208

Reference: EGY 13473

To appear in: *Energy*

Received Date: 30 June 2017

Revised Date: 24 July 2018

Accepted Date: 31 July 2018

Radiation enhanced chemical production: Improving the value proposition of Nuclear Power.

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Abstract

Nuclear power is one of the means for large-scale CO_2-free heat and electricity generation. Commercial designs, developed decades ago, have not adopted technological innovations and struggle to be cost-competitive with state-of-the-art fossil-fuel power systems. Though fuel is relatively inexpensive, nuclear power plants are expensive to build and produce only low-value electricity. One strategy to improve the process economics is to use unique characteristics of nuclear reactors to provide additional sources of revenue by co-producing higher value products. A conceptual process is analysed, which combines a molten salt nuclear power reactor and a chemical process using the reactor's gamma radiation to facilitate the production of propylene. This facility is able to co-produce electricity and high volume commodity chemicals using, otherwise wasted radiation. The conceptual process model suggests that integration of units producing an energy product with one that produces more valuable chemicals leads to significant economic benefits for the overall facility. Despite the improvements, the system studied is unable to deliver an acceptable return on investment for small power plants independent of the size of the chemical plant integrated. Conversely, large plants are capable of delivering acceptable return on investment, in some cases generating returns comparable to other modern investment options.

Keywords: Nuclear Economics, Radiation Chemistry, Process Integration, Techno economic analysis.

1. Introduction

Civilian commercial nuclear power plants (NPP[1]) have been proven by decades of operation to be the most reliable technology for large-scale, carbon-free, electric power generation [1]. Today, most reactors built and operated make use of basic designs created in the 1960's and earlier. Despite their reliability, safety, and low environmental impact, in most locations they are unable to compete with modern, state-of-the-art, fossil fuel-based power plants.

Although the fuel and operational costs for nuclear power plants are relatively small, their significantly higher capital cost and the costs associated with the political and public resistance provide no compelling investment incentive for nuclear power [2–4]. There are no shortage of examples in this regards, Olkiluto NPP in Finland (1600 MWe) and the Flamanville facility in France (1630 MWe) costed over US$5,300/$kW_e$ [2,5,6], while the capital cost for ultra-supercritical coal fired power stations in Europe is approximately US$2010/$kW_e$ [7].

[1] NPP: Nuclear Power Plant