Available online at www.sciencedirect.com

ScienceDirect

Procedia Chemistry 21 (2016) 536 – 544

Procedia Chemistry

5th International ATALANTE Conference on Nuclear Chemistry for Sustainable Fuel Cycles

The Sustainability, a relevant Approach for defining the Roadmap for future Nuclear Fuel Cycles

Christophe Poinssot[a]*, Stéphane Bourg[a], Stéphane Grandjean[a], Bernard Boullis[b]

[a] *CEA, Nuclear Energy Division, Radiochemistry and Processes Department, CEA Marcoule, BP11, F-30207 BAGNOLS SUR CEZE, FRANCE*
[b] *CEA, Nuclear Energy Division, Innovation and Industrial Support Division, CEA Saclay, F-91191 GIF SUR YVETTE CEDEX, FRANCE*

Abstract

In the framework of the COP21 agreement of December 2015, nuclear energy could help mitigating the global climate change together with the renewable energies, due to its low green-house-gases emissions, its reliability and its high base-load capacity. However, the political uncertainty in many countries about the future of nuclear energy source clearly illustrates that there is a need for a global approach to compare nuclear energy with other energy sources and draw its potential future improvements. Indeed, beyond the well-known economic aspect, many other criteria are also implicitly considered when choosing a relevant energy mix to be implemented in a given country. This rather recent situation requires extending the classical approach based on the technological and economic optimization to a wider approach also including the overall environmental footprint and the more general social acceptance. Sustainability approach includes the different criteria describing the environmental, economic and societal fields. Therefore, it may be relevant to identify the current key figures of nuclear energy, and help to identify the most promising improvement directions. In this paper, we propose to assess the current nuclear fuel cycles regarding the different sustainability criteria. We will also address the most relevant improvements to be implemented in the future to ensure the sustainability of nuclear energy and support its development.

Peer-review under responsibility of the organizing committee of ATALANTE 2016

Keywords: Recycling, spent nuclear fuel, actinides, plutonium, minor actinides.

* Corresponding author.
e-mail address: Christophe.poinssot@cea.fr

Peer-review under responsibility of the organizing committee of ATALANTE 2016
doi:10.1016/j.proche.2016.10.075

1. Introduction

At the end of October 2011, humankind symbolically went over 7 billion people. Recent projections made under the auspice of the United Nations anticipate the population to be in the range of 9.6 billion by the year 2050 before reaching 10-12 billion around 2100 and stabilizing[1]. Although the population is almost stabilized in the developed countries such as Western Europe and Northern America, it is still increasing in the developing and emerging countries of Africa and Asia. As a result, the total world energy consumption will still increase in the near-future, estimated by roughly 50% by 2035 for primary energy, and by 75 to 90% for electricity production even in the case of a strong political shift towards the "green economy"[2]. Meeting this increasing need is the first part of the energetic challenge to be faced in the XXIst century.

On the other hand, the global climate change has now been clearly related to human activities[3]. This evolution is driven by the very large amount of green-house gases (GHG) that have been released in the atmosphere since the early time of the industrial revolution in the XIXth century for producing energy. Indeed, the current world energy portfolio is dominated at 80% by fossil fuels (coal, oil and gas). Decreasing GHG emissions is today one of the main worldwide issue to be tackled as evidenced by the large consensus at the COP21 meeting in Paris in December 2015. It will require a rapid transition towards low-carbon energy sources. This corresponds to the second part of the energetic challenge to be faced in the XXIst century.

When looking at the carbon intensity (gCO_2eq/KWh) as a function of the capacity factor (%equivalent full operation time) for the current world energy portfolio (Figure 1), it is noticeable that renewable energies have a low capacity factor due to their intermittency. This questions their capacity to meet the global energy need. But nuclear energy is of particular interest since its capacity factor is as high as 90%, allowing the baseload need to be fulfilled.

Despite this overall context showing that a low-carbon economy seems difficult to be achieved at a very short term without using a significant contribution of the high capacity nuclear energy, this energy source is regularly criticized and debated mainly because of the residual risk of accidents, the long-term waste management issue and a feeling of a lack of transparency. So, how to reconcile the increasing energy need, the decreasing of the GHG emissions, the low capacity factor of renewable energies and the low acceptance of nuclear energy?

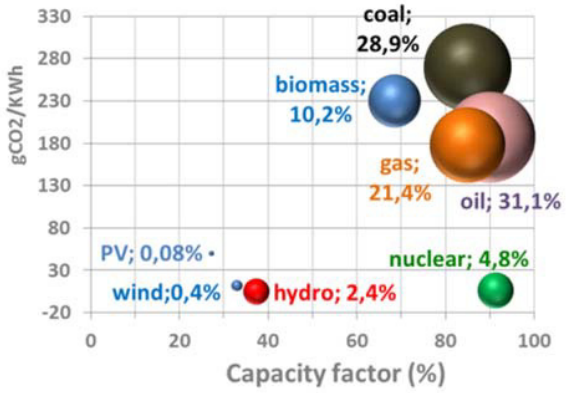

Fig. 1. World energy portfolio presented as a function of the carbon intensity (gCO2eq/KWh) and capacity factor (% equivalent full operation time). The size of the bubble represents the current share in the world energy portfolio.

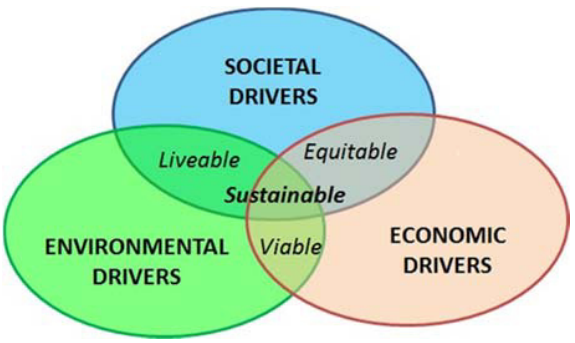

Fig. 2. The three interdependent and mutually reinforcing pillars of sustainable development[4].