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Spanish Nuclear Industry - Future perspectives and reserves’ analysis

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Abstract

This article seeks to contextualize the international part of the Spanish nuclear energy industry, tries to expose the current situation by reviewing the numbers of supply and needs, in order to assess the current and future prospect in terms of resources and inventoried reserves. The aim is to provide a description of the field of nuclear power generation in terms of economic and environmental sustainability, assessing their potential growth as an economic sector, at a key moment, when is still recovering from the disaster of Fukushima.

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1. Introduction

The present study was done with the aim of analysing in terms of opportunity, the current situation and the future of the nuclear industry (NI), with special emphasis on Spanish.
The social perception of the nuclear industry has been associated with changes to the media impacts of nuclear accidents throughout history\(^1\). Chernobyl was a profound change in the approach to risk management, considering the engineering methods and towards a more proactive approach (e.g., Environmental Impact Assessment - EIA’s). Regarding the recent Fukushima accident and its temporal proximity, it is difficult to predict the effects in the future of NI. Definitely it is the new paradigm shift in relation to the NI\(^2\) and risk management. The expected change in perception about the NI will also play an important role on prices of traditional fuels, and the international economic situation, not being expected abandonment of IN\(^3\).

2. Methodology

The Spanish nuclear power generation sector was characterized in the framework of the European Union (EU), trying to establish advantages and disadvantages, compared to other types of energy. For this a literature review was performed and supplemented and filtered with open sources, specialized agencies: International Energy Agency (IEA), International Atomic Energy Agency (IAEA), Nuclear Energy Agency de la OCDE (NEA), Uranium Spanish National Enterprise (ENUSA).

The Spanish nuclear scenario has resulted in an analysis of the weaknesses and inherent strengths, which have been opposed to the threats, and external opportunities Strengths, Weaknesses, Opportunities, and Threats (SWOT)\(^4\).

3. Discussion and Results

3.1 Electric energy production with nuclear origin

Worldwide the number of operating nuclear plants by the end of 2012 was 437 with a total installed power of 372,325 MW, contributing approximately 14% of global electricity. To these working reactors it should add the 72 plants that were under construction in 2013. In the EU, the 143 reactors are distributed as: 58 in France, 17 in Germany, 19 in Britain, 10 in Sweden, 8 in Spain, and the rest spread unevenly. To these reactors must be added the 33 installed in Russia and 15 in Ukraine, which hardly have acceptable security systems by the EU standards. Also, it should not be forgotten the other 19 reactors under construction\(^5\).

3.2 Spanish energetic framework

The Spanish energy situation is outlined as follows; production of oil and natural gas is testimonial, coal availability together with the Kyoto commitments\(^6\) is a source in decline. On the other hand the increase in renewable energy production has created a financial issue, associated with the heavy subsidy from these sources, and only wind power has been successfully implemented, but it is considered as an edge energy source.

Conversely nuclear production in Spain, with eight operating reactors and a total capacity of 7514 MW installed against a total of 108,308 MW in 2012 generated an average of 61.36 TWh, equivalent to 20.58% of the total electricity produced.

3.3 Availability and consumption of radioactive fuels.

The known uranium reserves, exploited in a lower cost of $130 per kg are 5.4 million tonnes, of which 23% are located in Australia, 15% in Kazakhstan, 10% in Russia, 8% in Canada, the same as in South Africa, 6% in the U.S. and the remaining 40% is distributed between Africa, Asia mainly\(^7\). In Spain about 7.400 tons of Reasonably Assured Resources (RAR) by over $40/Kg and 6400 tons of IR are estimated. These reserves are divided into three areas, Salamanca and Extremadura in the Western region of the Iberian Peninsula and bordering with Portugal and Calaf in Cataluña in the Eastern region. Saelices el Chico deposits, in Ciudad Rodrigo, can provide 4650 t/yr with
operating costs below $130/kg. Worldwide annual fuel requirements for the conventional installed reactors, reached an approximated amount of 67000 TU and current RAR, known from a theoretical standpoint, would be sufficient to run the current nuclear fleet for 82 years⁸. The financial needs of the Spanish reactors are 1800 t/yr of U₃O₈ (uranium concentrates) and UF₆, for valid TU 150 enriched fuel reactors in Spanish. Today ENUSA ensures the availability of uranium by financial holdings in COMINAK (Akouta Mining Company) in the Republic of Niger and the enriching EURODIF. The problems of insecurity in the Sahel region, which have emerged in Mali and Niger exportable⁹ may endanger the security of supply, an alternative plan being necessary.

3.4 Uranium cost evolution

The cost of uranium accounts for approximately 43% of the total cost of nuclear fuel. This total manufacturing cost of fuel, which is about 11% the same³ is also included. Between 2003 and 2007 (Fig. 1 and 2), the price of uranium has been multiplied by 6 which would mean a considerable increase in areas geologically exploitable deposits of uranium. Between June 2010 and March 2011 another rally took place, however from the Fukushima accident (March 11, 2011) resulted in a dramatic decrease in the price¹⁰, a trend remains until today, with a price of U.S. $ 35.75 today (Fig.1). It is important to note the contrast in trends in uranium prices and a barrel of Brent from 2008 to the present, with a "gap" in favour of uranium as an energy source.

![Uranium & Crude Oil Brent Barrel- Price Rate of Change Comparison](1)

**Uranium edge**

The past and estimated evolution of uranium exploitation and its relation with world needs and reserves, reported in “Uranium resources and nuclear energy”¹², stands for:

Three uranium categories which can be observed in Fig 2. It is possible to define three different uranium edges for exploitation purposes. The two first ones correspond to a Reasonably Assured Resources (RAR), where the two groups are determined taking into account the exploitation cost: up to 40$/Kg and up to 130$/Kg. The third class of reserve is known as Inferred Resource (IR), and is mainly speculative.

It is possible to identify a production high edge in the begging of the eighties of last century, with a production of 70000 tons of natural uranium. In the last nineties, as a result of the “Megatons to megawatts” program, which is believed to have brought 472.5 tons of military uranium highly enriched, that turned to 13603 tons of fuel in American nuclear plants and, as a consequence introducing bias between the amounts exploited and the real needs? This USA & Russia agreement also has been expired on 2013.
In 2006 IEA introduces three possible tendency scenarios for uranium consumption (Fig.2):

- Constant capacity scenario;
- Reference scenario;
- Alternative policies scenario to fight against climate changes.

![Diagram showing uranium demand according to IEA scenarios and possible supply from known resources.](image)

*Fig. 2. Reasonably Assured Resources.*

The moderate growth hypothesis, at least up to 2010, is corroborated which estimates the global needs between 70000 and 75000 t/yr. For these conditions, it is expected a uranium edge between the years of 2020 and 2040 after which a descend tendency both on the proffer and the consumption. By 2012, the exploitation industry covered 86% of the world needs, according to World Nuclear Association (WNA). This tendency could suffer a total inversion if the technological outgrowth allows the use of thorium as nuclear fuel. In fact, thorium is about three times as common as uranium.

3.5 The nuclear moot

The nuclear moot can be synthesized by a SWOT analysis (Table 1) where we're considered the nuclear sector opportunities, the socioeconomic reality, underlying the straights and minimizing the weaknesses.

| Table 1. SWOT Analysis for NI |
|-----------------------------|
| **Internal factors** | **External Factors** | **Straights** | **Weaknesses** |
| Supply and prices stability; | - Rigid Production Systems; | - Technological control of the production cycle; | - Production of hazardous waste; |
| Production prices control; | - Uncontrolled accidents with catastrophic consequences | Low accidents rate; | |
| The basic energetic needs can be stocked as fuel rods; | | No CO₂ emissions into the atmosphere | |
| No CO₂ emissions into the atmosphere | | OS (Maxi-Maxi) | |
| Opportunities | | New research calls for prospection of new | |
| A solution to avoid the usage of fossil | | OW (Mini-Maxi) | |
| | | Research in waste reutilization | |
fuels;
  - Enough to cover the basic energetic needs;
  - Take advantage of the uranium’s price decendent tendency (contrasting with the fossil fuels growing tendency) which allows facilities redemption;
  - Potential use of thorium deposits.

deposits and strategic evaluation of impacts;
  - Research and development of new reactor technology for Thorium use;
  - Introduction of taxes for nuclear use and its application on mining remediation.

as well as in waste valuation as possible ancillary fuel sources.
  - Support for the NE to become energy source for the basic needs;
  - Nuclear accident research and suitable emergency answers.

| Threats | TS (Maxi-Mini) | TW (Mini-Mini) |
|---------|---------------|---------------|
| Social resistance | Clear divulgation actions for the nuclear sector advantages. | Simulation of extreme stress tests and implementation of new security measures; |
| Sensitive topic concerning media | | Divulgation throughout the media about the risks and hazards related to the NE. |

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