After the Fukushima nuclear power plant event in March 2011, the Council of the European Union declared: “the safety of all EU nuclear plants should be reviewed, on the basis of a comprehensive and transparent risk assessment (stress test), and in the light of the lessons learned from the accident in Japan.”

Stress test was defined as a targeted reassessment of the safety margins of nuclear power plants in the light of the events that occurred at Fukushima: extreme natural events challenging the plant safety functions and leading to a severe accident.

Soon after, the Spanish Regulatory Body (CSN) sent to the owners of Spanish nuclear power plants in operation an instruction requiring the realization of a stress tests program, following the principles developed by WENRA (Western European Nuclear Regulators Association) and endorsed by ENSREG (European Nuclear Safety Regulators Group).

CSN considered also necessary that this program was also applied to the Enusa fuel manufacturing plant in Juzbado, taking into account the appropriate specificities.

This reassessment would consist on the verification of the preventive measures and in the evaluation of the plant’s response when facing a set of extreme situations under technical scope, following a defense in depth criteria (initiating events, consequential loss of safety functions, severe accident management issues, etc.).

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In these extreme situations, a sequential loss of the lines of defense in depth is assumed, with a deterministic approach, irrespective of the probability of this loss.

The reassessment would report on the effectiveness of the preventive measures and on the response of the plant, noting any potential weak point and cliff-edge effect.

The CSN requirements for Enusa covered two main areas of interest. On one hand, the plant’s response in case of extreme natural events (such as Earthquake, Flooding and other severe natural conditions like hurricanes, snow, heavy rain, etc...), and the consequential loss of safety functions, e.g. loss of electrical power, including Station Black Out (SBO). On the other hand, the assessment of preventive and mitigating means according to a “defense in depth” philosophy: initiating event, loss of Safety Functions (BDB) and management of the consequences.

To improve the crisis management Enusa built a new Emergency Room Extension with some special characteristics concerning to seismic resistance and contamination and radiation protection.

To carry out the stress test assessment for every initial event, Enusa implemented a 4-step methodology:
- Step 1: Current Situation, in which the actual Design Basis are considered along with the Structures, Systems & Components (SSC’s) and procedures related with the initiating event, and the fulfillment of the License Basis.
- Step 2: Robustness Analysis, where safety margins are established and “cliff edge” situations, if any, are identified.
- Step 3: Beyond Design Basis (BDB), in which a risk analysis is done with a deterministic approach.
- Step 4: Crisis Management, where automatic actions, operator’s procedures, preventive, and recuperative or mitigating measures are addressed.

Following this methodology, Enusa analyzed the occurrence of earthquakes, flooding, hurricanes, snow and heavy rains, and in some cases combining the effect with concurrent events as fire and criticality accidents.

The conclusions of the analysis are that Enusa meets all the License Basis according to its Safety Case.

Also, there are some actions for improving the Plant’s behavior in case of going beyond the design situation. Enusa proposed them to CSN, and CSN has already approved these changes. The improvements are to increase the safety margins with a defense-in-depth philosophy.
These are some examples of the modifications carried out as result of these stress tests analysis.

Modification of \( \text{H}_2 \) supply pipes, minimizing pipelining inside the plant and giving them seismic resistance.

Design and implementation of handling clips to improve fasten BWR Fuel Bundle store and avoid the pendulum effect in the case of earthquake.

Construction of a new building devoted to component warehouse, aiming to minimize the fire load inside the main fabrication building.

Provide to the plant with a fire extinguishing system with seismic resistance (fixed or portable) to be used after an earthquake.

In conclusion, Enusa has carried out all the stress test required by the Spanish CSN. Some improvements and modifications have been agreed with CSN and are already implemented and therefore the Enusa Juzbado fuel manufacturing plant is now safer under normal conditions and in front of unexpected events, and it can be assured that the Plant will remain under control in every credible situation.

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Enusa Annual Customer meeting

From March 19th to March 21st Enusa Fuel Customers Meeting has been held in the city of Cadiz, in the Atlantic coast of the south of Spain.

Since 1987, this conference is held annually and brings the Spanish fuel customers together with Enusa to discuss about topics of mutual interest.

The agenda for this meeting covered different subjects. The current Nuclear Fuel market, the Juzbado Manufacturing Plant update, the status of the uranium enrichment market and a presentation about ETSA, Enusa nuclear fuel transportation company, were some of the topics presented by Enusa.

The LTA fuel supply to CN Trillo, an European Fuel Group project to supply eight fuel assemblies to this NPP, presented by CNAT (Almaraz-Trillo AIE) and the Zinc Injection program by ANAV (Asco-Vandellos AIE) were the two papers presented by the customers during the meeting.

It is important to mention the three plenary sessions. The first one dealt with the Spent Fuel Management in the Spanish NPPs, with participation of one representative of every customer in charge of the NPP operation. The new Centralized Storage facility (ATC), which will be commissioned in 2018, and the need to prepare the fuel to be shipped to this storage were the topics that were discussed in the session.

The Nuclear Generation in Spain was the subject of the second plenary session. In this, customer senior representatives from ANAV, CNAT and Nuclenor, company that manages Santa María de Garoña NPP, discussed about the future of Nuclear Energy in Spain, considering the new conditions imposed to this type of electricity generation. The speakers put special focus on the potential continuity of S.M de Garoña operation in the near future.

Finally, in the third plenary session Enusa wanted to commemorate the 40th anniversary of the License agreements signed with both Westinghouse Electric Company and General Electric.

For that reason, Kevin Walsh, GE-H Senior Vicepresident Nuclear Fuel Cycle, and Bob Buechel, Westinghouse Vicepresident for Strategy and Asia Fuel operations attended the conference in Cadiz.

They shared the session with Enusa Chairman and CEO, José Luis González.
Kevin Walsh expressed the importance of the long term relationship with Enusa since 1974, and how, thanks to this, Enusa and GE-H have served the European market. Both companies decided in 1996 to incorporate the joint venture GEnusa, company who is marketing BWR fuel in Europe and is delivering fuel, manufactured in the Enusa Juzbado manufacturing plant in Salamanca, to most of the BWR NPPs in Europe.

Bob Buechel gave Westinghouse perspective about these 40 years of license with Enusa. He mentioned how the partnership with Enusa, in the frame of PWR fuel, has allowed to both companies to be very active in Spain and in Europe. The European Fuel Group, strategic alliance between both companies incorporated in 1992, is the tool that has been used to grow in Europe, and has consolidated the position of both companies as a reference fuel supplier for European utilities.

Jose Luis González explained how Enusa has developed in these years. In the 70’s and early 80’s, Enusa employees were trained in USA in both Westinghouse and GE, and for both Engineering and Manufacturing technology. In 1985, Enusa manufactured the first batch at Juzbado for Asco I NPP. Since those days, Enusa maintains both License agreements, and has also been able to develop its own technology to become and strategic partner of Westinghouse and General Electric.

Close to 60 people have attended the XXVII annual fuel meeting. Representatives of all Spanish utilities Endesa, Gas Natural Fenosa and Iberdrola, with nuclear interests have attended. Also, the NPPs operators Nuclenor, ANAV and CNAT have sent senior representatives to the Conference.

This time we have been pleased to receive the senior managers of the most important Spanish partners of Enusa. Mr. Eduardo González Mesones and Rafael Triviño, Chairman/CEO and Managing Director of ENSA respectively, the Spanish public company in charge of heavy components, racks and casks manufacturing, Mr. Javier Guerrra, Managing Director of Tecnatom, the services company owned by the Spanish utilities, and Javier González, President of Westinghouse Spain.

For Enusa, the annual meeting is a very interesting opportunity to share and discuss with all his customers in Spain the latest experiences in an open environment, as well as to have the possibility to meet friends and establish an even closer relationship with them.
Enusa/EFG contract for Trillo NPP for manufacturing and delivery of 8 lead test assemblies

On April 2014 Enusa, as lead party within the European Fuel Group (EFG), and CN Trillo have entered into a contract to supply eight Lead Test Assemblies (LTAs). The LTAs will be delivered by January 2016 to be loaded on cycle 29 of CN Trillo.

Enusa will subcontract Westinghouse Sweden (WSE) the design and manufacturing of these LTAs. The WSE 16 x 16 fuel design intended for Trillo will be similar but shorter than the current fuel design manufactured by WSE for 16 x 16 PWR units in Germany. The fuel design will fulfill not only the requirements of the German TÜV but also the Spanish Nuclear Regulatory Authority (CSN).

This successful outcome is consequence of the work initiated two years ago when CNAT ordered feasibility studies for the future introduction in Trillo of 16x16 Westinghouse’s fuel design compatible with which has operated to date.

As for other European utilities the CNAT initiative must be framed within a long term vision on security of supply.
The above mentioned feasibility study was pursued by Enusa and WSE in 2012 focused on the differences between current WSE 16x16 fuel design and Areva resident reference fuel in Trillo. The impact of such differences for Trillo on the licensing basis as well as on the manufacturing and transport processes were analyzed. The conclusion was that WSE 16x16 fuel design used in German plants could be adapted to Trillo with reasonable efforts and that WSE had the licensing capability to meet the requirements of the TÜV and the CSN.

A technical meeting with CSN was held on the 9 of April with attendees of all the parties involved in the project (Enusa, WSE and CNAT) and where the following topics were presented:

- Reason and objectives of the LTAs program
- Operating experience of Westinghouse 16x16 fuel in Germany
- Irradiation and Inspection Program intended
- Design Characteristics of the LTAs

The feedback from CSN has been positive so far and new contacts are foreseen by the end of 2014 once the Design activities of the LTAs are completed and Design Reports are available to CNAT.

A seamless LTAs delivery and handling on site is also a must of the project. Therefore, a blank test using dummy assembly and real shipping containers is set up in Trillo next September to guarantee an optimum process during the nuclear fuel delivery and acceptance in January 2016.

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Fuel Supply to the Spanish nuclear power plants

Enusa has gradually changed the manufacturing model of nuclear fuel reload batches to CN Almaraz (units 1 and 2), CN Ascó I, CN Ascó II, and CN Vandellós II reactors, called in the Spanish nuclear market as 5PWR reactors, in order to respond to the needs of the Spanish utilities (ENDESA GENERACIÓN, IBERDROLA GENERACIÓN NUCLEAR and GAS NATURAL SDG) who jointly own the nuclear pressurized water reactors (PWR) in Spain.

In year 1985, in which Enusa delivered the first batch of nuclear fuel assemblies to CN Ascó I Nuclear Power Plant, the supply model was to manufacture, in a specific way for that reactor and cycle, the fresh fuel assemblies to be loaded into a new irradiation cycle. This manufacturing model was maintained during two decades until 2005, year in which a pilot project was initiated taking into account the product standardization, to provide more flexibility in the nuclear fuel supply. The pilot project was to manufacture jointly some assembly intermediate components for 5PWR reactors.

The good results allowed launching the "stock manufacturing" for the 5PWR national reactors, by which Enusa manufactures fuel rods and skeletons that could be used indistinctly by any of the five reactors mentioned above.

The whole process has been consolidated in year 2012 and since then all the assembly intermediate components are manufactured for the interim storage regardless the final destination.
Then, once the final nuclear design is performed for each reactor, the final fuel assembly design is defined. The manufacturing process ends by assigning against stock specific fuel rods and skeletons to each fuel assembly to complete the reload batch.

The Spanish utilities and Enusa agreed to establish at Enusa Juzbado Plant a Security of Supply Storage after a deep analysis of all manufacturing risks and in order to ensure the fuel supply and to be able to accommodate any unforeseen situation. This Storage is endowed with components and fuel rods that can only be used by any of the Spanish 5PWR reactors. This concept is already included in the current fuel supply Contracts.

With this Storage, the customers have also more flexibility to define the reload batch size, and have seen improved the manufacturing notifications.

The Enusa stock manufacturing process integrates this Security of Supply Storage in order to allow continuous rotation of the assembly components and fuel rods to avoid obsolescence. For doing so, it is managed using the FIFO (First In First Out) criteria.

On March 13, 2014, in the frame of this “stock manufacturing” model for the nuclear fuel for 5PWR national reactors, the Kick off meeting for this Project was held in Juzbado plant with the participation of Ascó-Vandellós II and Almaraz-Trillo representatives.

As a main result of this meeting, the manufacturing of the assembly intermediate components was released for the reload batches to be delivered in 2014 and beginning of 2015.

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Fuel assembly reconstitution campaign and fuel rod corrosion characterization at Tihange 3 NPP

Last January 2014, Enusa and its partners, Tecnatom, WTS and ENWESA, carried out a nuclear fuel service campaign in the Belgian nuclear power plant of Tihange-3. The campaign had two main purposes: firstly to repair a fuel assembly and secondly, to characterize some irradiated peripheral fuel rods to verify the oxide layer thickness.

The purpose of the repair campaign was to remove a leaked fuel rod, replacing it with a stainless steel dummy rod. After the extraction, the fuel rod was visually inspected to characterize the type of failure. At the end of the process, the fuel rod was transferred to a fuel rod storage basket (FRSB) specific for damaged rods.

For the repair, Enusa used the RRTN (Removable Top Nozzle Repair) equipment, installed in the new fuel elevator using the procedures applicable to this service (see figures 1 & 2).

It has been the first time that Enusa has repaired a fuel at Tihange. To prepare the campaign several activities had been implemented involving Enusa, its partners and the customer, including new tooling development, its qualification, and a blank test.
The results were satisfactory and demonstrated the Enusa ability to repair 17X17XL PWR fuel assemblies in this Plant.

The campaign also covered the second purpose, fuel rod oxide thickness characterization. Sixty peripheral fuel rods were inspected to determine the oxide layer thickness along their whole length. In addition, these sixty fuel rods were visually inspected with special magnified cameras. The fuel rods were selected from four different fuel assemblies that had particular irradiation histories, in order to have a wide range of fuel rods characteristics.

SICOM-COR equipment (see figure 3) is the tool that has been used to carry out the corrosion measurements. This equipment uses Eddy Current technique, based on the lift-off effect. The measurements are proportional to the separation distance between the base material and the probe caused by the non-conductive oxide layer. In order to carry out the calibrations, calibrated standards with known oxide layer thickness are used.

This equipment was developed, qualified and operated within the SICOM collaboration agreement between Enusa and Tecnatom. This is the second time that this equipment has been used at Tihange NPP.

The final purpose of this campaign is to confirm the behaviour and performance of the new cladding and then verify the analytical models that are used during the design phase.

Fig. 3 – SICOM-COR equipment

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Enusa works with ANAV to support Zinc Addition Programs

In year 2002 ANAV, the company operating Ascó I & II and Vandellòs II NPPs, started to consider a zinc addition program for its reactors. The expected benefit of this program, taking advantage of zinc’s ability to replace cobalt and nickel in oxides of the primary circuit surfaces, was not only to reduce radiation fields, but also to reduce PWSCC (Primary Water Stress Corrosion Cracking). However, there are some potential side effects on the fuel, due to crud composition changes and crud thickening, which need to be prevented: increased risks of Axial Offset Anomaly (AOA) and of a higher cladding corrosion rate.

Since 2003 Enusa, as a fuel vendor, supported ANAV in the definition and execution of the initial demonstration program in Vandellòs II. This program was aimed at demonstrating acceptable fuel performance in the zinc environment. The activities performed by Enusa included a technical feasibility evaluation, fuel safety analysis, initial ultrasonic fuel cleaning (UFC), operation surveillance and fuel inspections.

The injection program was initiated in 2005 in Vandellòs II and Ascó II, and during 2006 in Ascó I. Since then, Enusa has been working with ANAV in two areas to reduce the fuel related risks: definition and monitoring of the zinc injection strategy for each cycle,
based on state-of-the-art computer codes and thorough knowledge of the industry experience; and on-site fuel services, including crud characterization, fuel rod oxide thickness characterization and ultrasonic nuclear fuel cleaning.

The definition of the zinc injection strategy is based on the BOA model developed by EPRI-Westinghouse. Estimation of AOA risk with this model allows defining an acceptable zinc concentration target. Subsequent surveillance of the primary coolant chemistry parameters, along with axial shape monitoring using core instrumentation, is used to confirm the appropriate behaviour of the fuel during reactor operation. Enusa’s position as the Spanish industry representative in EPRI’s Fuel Reliability Program guarantees an updated knowledge and a prompt access to the latest industry experience.

In the Fuel Services area, Enusa works with ANAV on a regular basis to remove crud from the fuel, using an ultrasonic technique. The procurement and use of the original UFC equipment, and of the new high efficiency equipment (HE-UFC), has been coordinated by Enusa.

Enusa provides the visual and oxide thickness inspections required by ANAV program, and it also played a main role in the procurement of crud scrapping and analysis services during the program implementation.

At present Enusa is positioned to maintain and improve its Fuel Services and Engineering capabilities, and to continue satisfying its customers’ needs regarding primary coolant chemistry.

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During March and April two important meetings took place between Enusa and Westinghouse, both chaired by the EFG director, Torbjorn Noren.

The Heads of Manufacturing forum with the plant managers of Juzbado/Spain, Springfields/UK and Västerås/Sweden took place this time at the Swedish fuel plant. The purpose of this forum is to oversee and initiate key collaboration projects across the sites, utilizing the parties full experience and capabilities. It covers cross qualification programs, manufacturing technology investments, safety and environmental projects etc. One key outcome of the March meeting was the green light given to proceed with the joint Oxide Coating investment, building on the US experience to make this excellent debris fretting protection available also for European customers from early 2016. From that moment, both Västerås and Juzbado manufacturing plants will have this capability installed.

The Engineering forum was held in Paris, attended by the Enusa and Westinghouse Fuel Engineering heads together with key people from their organizations. This meeting has the purpose to both oversee the progress of the quite extensive list of joint development projects and to identify new opportunities to respond in the best possible way to the European PWR market need of additional Fuel engineering services, again building on the combined strength and experience of the two parties. Two key joint projects ongoing should be noted. To further support the spalled spent fuel issues, mainly during spent fuel transportation, continuing with hot cell investigations. And to support the need for more flexible operation modes/ extended power modulations as requested by several European utilities.

On April 8, José M. Alonso, head of Research and Development in Enusa, emphasized the commitment of the company with the excellence in technology and the investment in R&D, as the key factors for its commercial expansion over the European market, during the participation in the GACETA Forum on “Innovation and technology: growth drivers”.

This Forum brought together businessmen, politicians and academic representatives with the aim of analyzing, through practical experiences, the role of innovation on economic development and progress.

The University of Salamanca through its Science Park, the Junta de Castilla y León through its Department of Education and Indra, shared the Forum table with Enusa. All presentations underlined that innovation is becoming a must for any company to stay in the market. In addition, irrefutable data support the fact that countries investing more in innovation achieved the highest rates of Gross Domestic Product growth over the last decade.

Reload delivery at Oskarshamn (OKG, Sweden)

Oskarshamn Nuclear Power Plant is a GENUSA customer since 2010. The plant has three reactors producing about 10% of the electricity needs of Sweden. All reactors use BWR technology. A new reload (OH28) has been delivered at Oskarshamn unit 3 (one of the BWR most powerful reactors in the world). The reload consisting of 150 GE14 Nordic fuel bundles arrived at OKG on April 1 and the fuel channeling took place from the 7th to 15th of April.

This reload has the new bundle retention clip design that facilitates the channeling process while providing a better performance in operation. This feature has meant an important success as well as a satisfaction for the customer.

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