NUCLEAR RESULTS IN 2018 AND FUTURE PERSPECTIVES

Foro Nuclear
Foro de la Industria Nuclear Española
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The Spanish Nuclear Industry Forum is an association that has been representing the interests of the country’s nuclear industry since 1962. It brings 50 companies and organizations under the same roof, including electric utilities, nuclear power plants, engineering firms, service companies and system and large component suppliers, as well as industry associations, foundations and universities. It advances its international presence - since it is a world-renowned, able technological industry- and supports maintaining and continuing the operation of Spanish NPPs.

The dissemination of scientific knowledge, with the aim of informing the public of the characteristics of nuclear energy and, as far as possible, banishing the myths and prejudices that surround it, is one of the goals pursued by Foro Nuclear. It is an association that organizes and participates in conferences, courses and events aimed at different interest groups, answers the questions of the media, prepares studies and technical reports, as well as informative publications, and defends the sector’s interests before public administrations.

All the activities that Foro Nuclear - which represents 100 per cent of the electricity production of a nuclear origin and 85 per cent of the main companies in the nuclear sector in Spain - carries out can be looked up on its institutional website (www.foronuclear.org) and checked on the various social media through which it spreads nuclear news and the different applications of nuclear technology.
In a year where energy transition and the steps that are needed to implement it were on everybody’s lips, we would like to appreciate the contributions of nuclear power to the Spanish electricity system: It is the leading source of generation, thus guaranteeing the supply of electricity, plus the one that operated the longest; in addition, it is a zero-carbon technology.

In the face of this transition to a decarbonized economy, nuclear power plants will play an essential role in reaching climate targets while guaranteeing the supply of electricity. In 2018 the seven Spanish nuclear reactors generated 20.39% of all consumed electricity. They led production for another straight year, outputting 53,198 net GWh with only 6.84% of the net installed capacity and operated 85.33% of the time during the year. This leadership comes on top of their essential role in arresting climate change. In fact, Spanish reactors were the source of electricity that helped prevent CO$_2$ emissions the most as they produced 34.39% of all clean electricity last year.

In addition to being leaders in production, operating hours and emissions reduction, they had exemplary operation (among the best operational data in the world), their time availability and unit capability factors being close to 90%. All this is possible thanks to the commitment, professionalism and training of all sector workers and to the technical capabilities of and the services and products with a high technological value provided by our country’s nuclear industry -both within Spain and abroad.

The excellent results achieved by Spanish NPPs, together with the sector’s continued support of their operation with the maximum guarantees as to their safety, are complemented by the international outlook of our industry, which year after year wins new contracts and strengthens its alliances and synergies in different countries. China, Russia, Turkey, Argentina, the U.A.E., Sweden, Finland and France are some of the 40 countries that have requested the wide range of services and technology provided by the Spanish nuclear sector: engineering, equipment, construction and assembly, fuel, refueling outage support, radiation protection, training and so on and so forth. This is a clear sign that our industry has achieved international renown and that nuclear power continues to grow globally, 55 new units currently being built and 450 reactors in operation across the world.

I would like to wrap things up by restating the good work done by the Spanish nuclear industry and the need to keep using this type of power in our country and thanking our readers, the sector as a whole and, more specifically, our members for their support and contributions so that this annual publication may reflect the actual situation of nuclear power in Spain and beyond.
Net electricity production in Spain in 2018 was 260,906 GWh, a slight 0.5% decrease with regard to 2017. Production from conventional facilities -nuclear, coal, hydropower, combined cycle and fuel/gas- decreased by 1.2% to 163,309 GWh, while the rest of technologies -cogeneration, waste, wind, solar and other renewables- saw their output go up by 0.6% to 97,597 GWh altogether.

The production decrease experienced by conventional technologies was caused by a 17.2% drop in coal and an 18.9% slump in combined natural gas cycles, which could not be completely offset by the sharp 74.4% upsurge in hydro production. For the eighth consecutive year nuclear energy was the generation source with the greatest contribution to the national electricity system, with 20.39% of total production, despite having a share of all net installed power of just 6.8%.

CO$_2$-free production -nuclear, hydraulic, solar and other renewables- increased to 59% of the whole, four percentage points higher than in the previous year. Spanish nuclear power plants generated almost 35% of all clean electricity in Spain.

The Spanish system’s total net installed power -104,053 MW- remained practically unchanged with respect to 2017; conventional technologies represented 63.7% thereof and other technologies the remaining 36.3%. Installed nuclear power did not experience any changes, with 7,117 net MW and 7,398.7 gross MW.

With regard to the average number of operating hours by technology, as usual nuclear power plants stood out in 2018 with 7,475 h, followed by cogeneration with 5,041 h. Coal-fired power stations operated for 3,716 h and wind farms for 2,110 h.

As far as exchanges of electricity with France, Portugal, Andorra and Morocco are concerned, the Spanish electricity system had, as in the year before, an evident import balance of 11,102 GWh, that is, it experienced a considerable 21.1% surge as a result of a drop in the electricity it exported to Morocco. Thus, Spain was a net importer of electricity for the third straight year, compared to the net exports it had between 2004 and 2015.
<table>
<thead>
<tr>
<th>NET INSTALLED CAPACITY (MW)</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RENEWABLES AND WASTE</strong></td>
<td>51,515</td>
<td>51,895</td>
</tr>
<tr>
<td>▶ HYDRO</td>
<td>20,361</td>
<td>20,380</td>
</tr>
<tr>
<td>▶ WIND</td>
<td>23,130</td>
<td>23,478</td>
</tr>
<tr>
<td>▶ SOLAR (*)</td>
<td>6,992</td>
<td>7,011</td>
</tr>
<tr>
<td>▶ OTHER RENEWABLES (**)</td>
<td>870</td>
<td>864</td>
</tr>
<tr>
<td>▶ RENEWABLE WASTE</td>
<td>162</td>
<td>162</td>
</tr>
<tr>
<td><strong>COGENERATION AND NON-RENEWABLE WASTE</strong></td>
<td>6,318</td>
<td>6,237</td>
</tr>
<tr>
<td><strong>THERMAL CONVENTIONAL (</strong>*))**</td>
<td>39,164</td>
<td>38,804</td>
</tr>
<tr>
<td><strong>NUCLEAR</strong></td>
<td>7,117</td>
<td>7,117</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>104,114</td>
<td>104,053</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ESTIMATED NET PRODUCTION OF ELECTRICITY BY TYPE OF FACILITY (GWh)</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RENEWABLES AND WASTE</strong></td>
<td>86,860</td>
<td>102,260</td>
</tr>
<tr>
<td>▶ HYDRO</td>
<td>20,700</td>
<td>36,109</td>
</tr>
<tr>
<td>▶ WIND</td>
<td>47,907</td>
<td>49,526</td>
</tr>
<tr>
<td>▶ SOLAR (*)</td>
<td>13,746</td>
<td>12,171</td>
</tr>
<tr>
<td>▶ OTHER RENEWABLES (**)</td>
<td>3,630</td>
<td>3,580</td>
</tr>
<tr>
<td>▶ RENEWABLE WASTE</td>
<td>877</td>
<td>874</td>
</tr>
<tr>
<td><strong>COGENERATION AND NON-RENEWABLE WASTE</strong></td>
<td>30,820</td>
<td>31,447</td>
</tr>
<tr>
<td><strong>THERMAL CONVENTIONAL (</strong>*))**</td>
<td>89,087</td>
<td>74,001</td>
</tr>
<tr>
<td><strong>NUCLEAR</strong></td>
<td>55,539</td>
<td>53,198</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>262,306</td>
<td>260,906</td>
</tr>
</tbody>
</table>

(*) Including solar thermal and photovoltaic power / (**) Including biogas, biomass, wind-hydro, marine hydro and geothermal power / (***)) Including coal, combined cycles and fuel/gas / Source: Foro Nuclear with data from REE and AELEC
### Estimated Net Production of Electricity by Energy Source (GWh)

<table>
<thead>
<tr>
<th>Source</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Renewables and Waste (*)</strong></td>
<td>86,860</td>
<td>102,259</td>
</tr>
<tr>
<td>Nuclear</td>
<td>55,539</td>
<td>53,198</td>
</tr>
<tr>
<td>Coal</td>
<td>45,109</td>
<td>37,274</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>65,278</td>
<td>59,055</td>
</tr>
<tr>
<td>Oil Products (***)</td>
<td>9,610</td>
<td>9,120</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>262,306</td>
<td>260,906</td>
</tr>
</tbody>
</table>

(*) Including hydro, wind, solar, other renewables and renewable waste / (***) Including fuel/gas and non-renewable waste / Source: Foro Nuclear with data from REE and AELEC

### Evolution of Installed Capacity (MW)

- **Nuclear**
- **Thermal Conventional (*)**
- **Rest**

(*) Including coal, combined cycles and fuel/gas / From 2015 onward it refers to net power / Source: Foro Nuclear with data from REE, UNESA and AELEC
EVOLUCIÓN DE LA PRODUCCIÓN DE ELECTRICIDAD ESTIMADA (GWh)

(*) Incluyendo carbón, ciclos combinados y gas / Desde 2015, se refiere a la producción neta / Fuente: Foro Nuclear con datos de REE, UNESA y AELEC

EVOLUCIÓN DE CAMBIOS EN LA CONSUMICIÓN DE ELECTRICIDAD (%)

Fuente: Foro Nuclear con datos de REE y AELEC
Net electricity production from nuclear sources in 2018 amounted to 53,198 GWh, **20.39% of the total net electricity production in Spain**. Gross output stood at 55,670 GWh.

As of December 31, 2018, the Spanish electricity generation system’s total net installed power came to 104,053 MW, of which **7,117 net MW corresponded to Spanish nuclear power plants**, i.e. **6.8% of the country’s total net installed capacity**. On the other hand, gross power totaled 7,398.7 MW.

**Nuclear power was the leading source of energy in Spain in 2018, generating 20.39% of all electricity**

The overall performance indicators of Spanish NPPs in 2018 are as follows:

- **Load Factor**: 85.89%
- **Time Availability Factor**: 87.05%
- **Unit Capability Factor**: 86.29%
- **Unplanned Capability Loss Factor**: 4.17%
Nuclear power generation accounted for 34.39% of all zero-carbon electricity generated in Spain.

At year’s end, there were 450 reactors in a position to operate in 31 countries around the world. 2.575,28 TWh of electricity from nuclear sources were produced, which represents approximately 11.5% of the all electricity consumed worldwide. Another 55 new reactors were under construction in 16 countries.

Thus, as of December 31, there were 142 nuclear reactors in 13 countries that had been authorized by the various regulators to operate beyond 40 years. They represent over 30% of all nuclear reactors in operation at the moment.

More than 30% of nuclear reactors in operation around the world have been authorized to keep running beyond 40 years.
1

SPANISH NUCLEAR POWER PLANTS
There are seven nuclear reactors at five sites in Spain. They are owned by Spanish utilities -EDP, Endesa, Iberdrola and Naturgy-, whose aim is to strive unflaggingly toward excellence in the management thereof and are committed to their continued operation in a safe, reliable manner while promoting growth in the surrounding areas.

Each owner’s share and the date of commencement of operation of these seven reactors are as follows:

<table>
<thead>
<tr>
<th>NPP</th>
<th>Owner</th>
<th>%</th>
<th>Start of Commercial Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALMARAZ I</td>
<td>IBERDROLA ENDESA NATURGY</td>
<td>53 36 11</td>
<td>SEPTEMBER 1983</td>
</tr>
<tr>
<td>ALMARAZ II</td>
<td>IBERDROLA ENDESA NATURGY</td>
<td>53 36 11</td>
<td>JULY 1984</td>
</tr>
<tr>
<td>ASCÓ I</td>
<td>ENDESA</td>
<td>100</td>
<td>DECEMBER 1984</td>
</tr>
<tr>
<td>ASCÓ II</td>
<td>ENDESA IBERDROLA</td>
<td>85 15</td>
<td>MARCH 1986</td>
</tr>
<tr>
<td>COFRENTES</td>
<td>IBERDROLA</td>
<td>100</td>
<td>MARCH 1985</td>
</tr>
<tr>
<td>TRILLO</td>
<td>IBERDROLA NATURGY EDP NUCLENOR (*)</td>
<td>48 34.5 15.5 2</td>
<td>AUGUST 1988</td>
</tr>
<tr>
<td>VANDELLÓS II</td>
<td>ENDESA IBERDROLA</td>
<td>72 28</td>
<td>MARCH 1988</td>
</tr>
</tbody>
</table>

(*) Nuclenor is jointly owned by Endesa (50%) and Iberdrola (50%). / Source: Foro Nuclear
LOCATION OF NUCLEAR POWER PLANTS IN SPAIN

ALMARAZ I Y II
CÁCERES

TRILLO
GUADALAJARA

ASCÓ I Y II
TARRAGONA

VANDELLÓS II
TARRAGONA

COFRENTES
VALENCIA
During 2018, the net electrical power produced by Spanish nuclear power stations was 53,198 GWh, which amounted to 20.39% of the country’s total net electrical production of 260,906 GWh. Gross output stood at 55,674.44 GWh. Nuclear power was the source that generated the most electricity in the Spanish electricity system. The nuclear output accounted for 34.39% of all emissions-free electricity generated in Spain. The contribution from the different generation sources in terms of net installed power and net production in 2018 was as follows:

(*) It also includes pumping turbination / (**) Including biogas, biomass, wind-hydro, marine hydro and geothermal power / Source: Foro Nuclear with data from REE and AELEC
34.39% of the emissions-free electricity generated in 2018 was nuclear in origin
As of December 31, 2018, the Spanish electricity generation system’s total net installed capacity stood at 104,053 MW, of which 7,117 net MW corresponded to the combined power of the seven Spanish reactors, or 6.8% of the country’s total net installed capacity.

The installed capacity of each Spanish NPP is as follows:

<table>
<thead>
<tr>
<th>NPP</th>
<th>NET CAPACITY (MWe)</th>
<th>GROSS CAPACITY (MWe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALMARAZ I</td>
<td>1,011.3</td>
<td>1,049.4</td>
</tr>
<tr>
<td>ALMARAZ II</td>
<td>1,005.8</td>
<td>1,044.5</td>
</tr>
<tr>
<td>ASCÓ I</td>
<td>995.8</td>
<td>1,032.5</td>
</tr>
<tr>
<td>ASCÓ II</td>
<td>991.7</td>
<td>1,027.2</td>
</tr>
<tr>
<td>COFRENTES</td>
<td>1,063.9</td>
<td>1,092.0</td>
</tr>
<tr>
<td>TRILLO</td>
<td>1,003.0</td>
<td>1,066.0</td>
</tr>
<tr>
<td>VANDELLÓS II</td>
<td>1,045.3</td>
<td>1,087.1</td>
</tr>
</tbody>
</table>

Data valid as of December 31, 2018 / Source: Foro Nuclear
1.3 PERFORMANCE INDICATORS

Performance indicators are measurable parameters that are representative of the degree of excellence in the operation and operational safety of a nuclear power station. They have been standardized and approved by the United Nations’ International Atomic Energy Agency (IAEA) and the World Association of Nuclear Operators (WANO) for all nuclear power plants throughout the world.

The performance indicators of Spanish NPPs in 2018 are shown in the table below:

- **Load factor:** The ratio of the electrical power produced in a period of time to the power that could have been produced in the same period if the plant had operated continuously at its rated capacity.
- **Time availability factor:** The ratio of the number of hours a plant has been connected to the grid to the total number of hours in the period considered.
- **Unit capability factor:** The amount resulting from subtracting the sum of the planned energy loss factor and the unplanned capability loss factor from 100.
- **Unplanned capability loss factor:** The ratio of the power that could not be produced due to planned outages or power reductions ascribable to a plant to the power that would have been generated in the same period if the plant had operated continuously at its rated power.
- **Unplanned capability loss factor:** The ratio of the power that could not be produced due to unplanned outages or power reductions ascribable to a plant to the power that could have been generated in the same period if the plant had operated continuously at its rated power.

<table>
<thead>
<tr>
<th>NPP</th>
<th>Gross Production (GWh)</th>
<th>Load Factor (%)</th>
<th>Time Availability Factor (%)</th>
<th>Unit Capability Factor (%)</th>
<th>Unplanned Capability Loss Factor (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALMARAZ I</td>
<td>8,141.11</td>
<td>88.56</td>
<td>90.57</td>
<td>89.96</td>
<td>0.03</td>
</tr>
<tr>
<td>ALMARAZ II</td>
<td>8,176.54</td>
<td>89.37</td>
<td>90.96</td>
<td>90.39</td>
<td>0.00</td>
</tr>
<tr>
<td>ASCÓ I</td>
<td>7,907.08</td>
<td>87.42</td>
<td>88.11</td>
<td>87.26</td>
<td>2.44</td>
</tr>
<tr>
<td>ASCÓ II</td>
<td>8,811.55</td>
<td>97.92</td>
<td>97.96</td>
<td>97.35</td>
<td>2.53</td>
</tr>
<tr>
<td>COFRENTES</td>
<td>9,150.28</td>
<td>95.65</td>
<td>96.31</td>
<td>95.00</td>
<td>4.58</td>
</tr>
<tr>
<td>TRILLO</td>
<td>8,267.25</td>
<td>88.53</td>
<td>89.51</td>
<td>89.28</td>
<td>0.11</td>
</tr>
<tr>
<td>VANDELLÓS II</td>
<td>5,216.64</td>
<td>54.78</td>
<td>56.87</td>
<td>55.73</td>
<td>18.95</td>
</tr>
<tr>
<td>TOTAL/OVERALL</td>
<td>55,670.44</td>
<td>85.89</td>
<td>87.05</td>
<td>86.29</td>
<td>4.17</td>
</tr>
</tbody>
</table>

Source: Foro Nuclear
Spanish nuclear power plants operate with excellent safety levels.
In Spain, the lifespan of nuclear power plants is not established for a fixed amount of time. Operating licenses are periodically renewed after the Nuclear Safety Council studies each case and the relevant Ministry grants them.

<table>
<thead>
<tr>
<th>NPP</th>
<th>DATE OF CURRENT LICENSE</th>
<th>PERIOD OF VALIDITY</th>
<th>DATE OF NEXT RENEWAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALMARAZ I</td>
<td>06/08/2010</td>
<td>10 YEARS</td>
<td>JUNE 2020</td>
</tr>
<tr>
<td>ALMARAZ II</td>
<td>06/08/2010</td>
<td>10 YEARS</td>
<td>JUNE 2020</td>
</tr>
<tr>
<td>ASCÓ I</td>
<td>09/22/2011</td>
<td>10 YEARS</td>
<td>SEPTEMBER 2021</td>
</tr>
<tr>
<td>ASCÓ II</td>
<td>09/22/2011</td>
<td>10 YEARS</td>
<td>SEPTEMBER 2021</td>
</tr>
<tr>
<td>COFRENTES</td>
<td>03/20/2011</td>
<td>10 YEARS</td>
<td>MARCH 2021</td>
</tr>
<tr>
<td>TRILLO</td>
<td>11/17/2014</td>
<td>10 YEARS</td>
<td>NOVEMBER 2024</td>
</tr>
<tr>
<td>VANDELLÓS II</td>
<td>07/26/2010</td>
<td>10 YEARS</td>
<td>JULY 2020</td>
</tr>
</tbody>
</table>

Source: Foro Nuclear
### 1.5 Refueling Outages

A refueling outage is the time period in which a plant performs all necessary activities to replace spent nuclear fuel. In addition, during these outages improvements are made to update and upgrade the plant, and preventive and corrective maintenance activities are carried out in all systems, components, structures and installations of the facility.

Depending on the characteristics of the plant, the operating cycle, i.e. the time between two refueling outages, lasts 12, 18 or 24 months.

The refueling outages Spanish nuclear power stations underwent in 2018, and those which are scheduled next, are shown below:

<table>
<thead>
<tr>
<th>NPP</th>
<th>2018</th>
<th>Next Outage</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALMARAZ I</td>
<td>OCTOBER 9 TILL DECEMBER 2</td>
<td>MAY 2020</td>
</tr>
<tr>
<td>ALMARAZ II</td>
<td>APRIL 8 TILL MAY 11</td>
<td>OCTOBER 2019</td>
</tr>
<tr>
<td>ASCÓ I</td>
<td>NOVEMBER 10 TILL DECEMBER 23</td>
<td>APRIL 2020</td>
</tr>
<tr>
<td>ASCÓ II</td>
<td>–</td>
<td>APRIL 2019</td>
</tr>
<tr>
<td>COFRENTES</td>
<td>–</td>
<td>OCTOBER 2019</td>
</tr>
<tr>
<td>TRILLO</td>
<td>MAY 18 TILL JUNE 26</td>
<td>MAY 2019</td>
</tr>
<tr>
<td>VANDELLÓS II</td>
<td>MAY 12 TILL JULY 20</td>
<td>NOVEMBER 2019</td>
</tr>
</tbody>
</table>

Spanish NPPs stop to refuel every 12, 18 or 24 months

Source: Nuclear power plants and Foro Nuclear
The most significant activities that were carried out at each Spanish nuclear power plant in 2018 and the objectives that have been planned for 2019 are detailed below.

**ALMARAZ NPP**

The gross electrical power jointly generated by Almaraz NPP’s two units in 2018 was 16,318 GWh, their best joint historical output—in a year where both units underwent a refueling outage.

As far as each unit is concerned, Unit I’s gross electricity production was 8,141.11 GWh; from the start of its commercial operation in September 1983 until December 31, 2018, it has generated an accumulated 266,262 GWh.

Unit II’s gross electricity production was 8,176.54 GWh; it has accumulated 262,408 GWh since the beginning of its commercial operation in July 1984 until the end of 2018.

The plant’s Individualized Interim Storage for irradiated fuel was officially inaugurated in December with the loading of the first ENUN 32P type cask manufactured by ENSA.
HIGHLIGHTS OF 2018

Refueling outages

Unit I commenced the activities of its 26th refueling outage on October 28 and completed them by December 2, for which it had the help of 1,200+ workers in addition to its normal permanent staff, most of whom live in Extremadura.

During the refueling outage, 30 design modifications were implemented and more than 9,200 activities were performed, among them different tasks relating to the inspection of vessel nozzles and steam generator tubes, works on the TG set, and maintenance tasks on the auxiliary feedwater turbine and the main feedwater pump.

Unit II started the activities corresponding to its 24th refueling outage on April 9 and completed them by May 11, for which it had the help of 1,200+ workers in addition to its normal permanent staff, most of whom live in Extremadura.

During this refueling outage, 20 design modifications were implemented and more than 9,700 equipment and component inspection and maintenance activities were carried out, among them the ultrasound inspection of the welds of the vessel nozzles, the inspection of one of the bodies of the low pressure turbine, the visual inspection of the penetrations of the vessel head and bottom, and the test of the power supply from the Valdecañas hydraulic power plant.

Annual Onsite Emergency Drill

The Annual Onsite Emergency Drill was held on December 21. It involved an initial declaration of Category III (Emergency on the Site) owing to a complete loss of all functions needed to take Unit II to a hot shutdown, together with a simulated fire in the Safeguards Building, where two workers were injured; one of them would require outside medical attention and would ultimately be discharged. Next, Category IV (General Emergency) was declared during the drill, a category that calls for the evacuation of all non-essential personnel from the facility as the feedwater and condensate systems of the steam generators and two of the three passive physical barriers were lost, resulting in severe core damage. The drill was called off once the situation in Unit II went to normal.
Safety Culture

An OSART (Operational Safety Review Team) mission from the IAEA took place in February. Centrales Nucleares Almaraz-Trillo’s (CNAT) commitment to long-term safety - the organization’s main priority- and its desire for continuous improvement particularly stand out from the conclusions of the team of experts. The plant’s introduction of an Integrated Management System and its equipment upgrade plans were also acknowledged. The team assessed different aspects by comparing the plant’s processes, operation and reliability to the IAEA’s safety standards.

In October, the status of the action plan resulting from the Corporate Peer Review that WANO had subjected CNAT to in November 2015 was followed up on.

External Relations and Communication Activities

The Local Information Committee met on June 19. It was chaired by the Deputy Director-General for Nuclear Energy and attended by the Mayor of Almaraz and representatives from the towns in the plant’s vicinity as well as from the Nuclear Safety Council, the Directorate General for Civil Protection and Emergencies, the Spanish Government’s Regional Office in Cáceres, the Association of Municipalities in Areas nearby Nuclear Power Plants, the Portuguese Environment Agency and Almaraz NPP.

In 2018, 3,748 people visited the Information Center. Since it opened in 1977, more than 666,000 visitors have walked through its doors, thus highlighting the public’s interest in getting information on nuclear energy and the operation of this particular plant.

PERSPECTIVES FOR 2019

Unit II’s 25th refueling outage will take place in October, which is expected to last 35 days, and the IAEA team in charge of following up on the OSART mission conducted in February 2018 will arrive at the plant in November.
In 2018, the gross electrical power jointly generated by the two units of the Ascó nuclear power plant was 16,718.63 GWh.

Individually, Unit I generated 7,907.08 gross GWh; it has generated an accumulated 256,974 GWh from the beginning of its commercial operation in December 1983 till the end of 2018.

Unit II’s gross electricity production was 8,811.55 GWh for the year; it has produced a total of 250,943 GWh from the start of its commercial operation in March 1986 until December 31, 2018.

On July 1 the units reached the figure of 500,000 GWh of joint electrical production since they were put into service.

The plant buildings’ lighting systems were upgraded over the year -within the framework of Asociación Nuclear Ascó-Vandellós II’s (ANAV) Efficiency Plan-with 15,000 LED lamps so as to increase the plant’s energy savings and cut down on maintenance tasks.
One thousand workers from different specialized trades joined Ascó I’s regular staff to perform 13,000 work orders during the refueling outage.

HIGHLIGHTS OF 2018

Refueling Outage

Unit I’s 26th refueling outage took place between November 10 and December 23 after 503 days of uninterrupted operation. During the outage, 41 design modifications were made and 13,000+ work orders were taken care of. The replacement of 60 fuel assemblies; the replacement of four intranuclear thermocouples; the inspection of the bottom of the reactor vessel and the nozzles of the hot leg; the remote visual inspection of the vessel head; the eddy current inspection of the tubing of the three steam generators; the overhaul of the high pressure turbine; and the making of improvements to the alternator’s hydrogen treatment station stand out among them.

In order for it to be possible to carry out all the planned work within the scheduled time, the companies that rendered their services during the outage provided 1,000+ workers of different professional profiles and specialties.

Emergency Drills

The Annual Emergency Drill was performed on March 22. It consisted in a loss of outside power in both units and a fire in Unit II’s control room, which necessitated using the remote shutdown panel. The operating situation of the plant evolved into an accident with loss of coolant (LOCA) without external radiological impact. There were 5 injured workers: 2 inside the plant -for different reasons; one of them was contaminated- and 3 in the dummy fire.

The plant’s fire brigade, the firefighters from the Regional Government of Catalonia, the external support organizations, the rescue team and the medical services team all took part in the drill, and the Emergency Environmental Radiological Surveillance Plan (ERSP) was triggered.

In addition, five integrated-scope exercises were carried out between September and October, with the participation of the firefighters from the Regional Government of Catalonia. The entire emergency organization was mobilized and emergency communications were sent to the authorities. The exercises reached Category III of the Site Emergency Plan (SEP).
An earthquake was simulated at the site that caused a loss of outside power in Unit I and complete loss of outside and inside power in Unit II, as well as an exterior radioactive leak in the Electrical Penetrations Building. One person was injured and another ended up being contaminated.

**External Relations and Communication Activities**

Asociación Nuclear Ascó-Vandellós II’s (ANAV) continued to maintain its commitment to transparency, information and dissemination in the region surrounding its facilities throughout 2018. The Information Committee meetings convened by the Ministry for Ecological Transition were held, as well as various periodic meetings with the heads of nearby towns, institutional representatives and the media. Furthermore, ANAV stayed in touch with the public through social media and its corporate website. Additionally, Ascó supported different socio-cultural and educational activities that were carried out by different entities in its vicinity.

Since it opened for business in November 2011, ANAV’s information centre at Ascó has received over 18,000 visitors.

**PERSPECTIVES FOR 2019**

An IAEA Pre-Safety Aspects of Long Term Operation (Pre-SALTO) mission will arrive in January. **Unit II’s 25th refueling outage will be held in April**, and a WANO Peer Review mission in September. On the other hand, Civil Guard Response Units will be set up inside the facility on a permanent basis.
Cofrentes NPP’s gross electrical output in 2018 totalled 9,150.98 GWh. Its accumulated output from the moment it went into commercial operation in March 1985 till December 31, 2018 now stands at 264,321 GWh.

Cofrentes has been running for nine and a half straight years without experiencing a scram. The indicators and findings of the Integrated Plant Supervision System (SISC) -with which the Spanish Nuclear Safety Council systematically evaluates the operation of the Spanish nuclear power stations- ended the year in the green, which underscores the good safety standards to which the facility operates.

The formalities to inform the public about the environmental impact study that was conducted prior to the construction of the Individualized Interim Storage for spent fuel were completed in June. The study was later sent to the Ministry for Ecological Transition in order for it to be appraised by the Subdirectorate-General for Environmental Assessment.

For the second consecutive year, there were no work accidents with sick leave thanks to the plant’s efforts to train and raise the awareness of its personnel in occupational risk prevention matters.

HIGHLIGHTS OF 2018

Safety Culture

In February, joint working sessions were held with the Emergency Procedures Committee of the Boiling Water Reactors Owners’ Group (EPC-BWROG) with the aim of fostering mutual learning and the exchange of experiences according to the latest emergency management and nuclear safety improvements made in the industry.
A WANO Peer Review took place from April 16 to May 4, during which 29 international experts from other plants around the world made observations and interviewed plant personnel in order to compare the stations’ practices to WANO’s standards in the areas of organization, operation, maintenance, engineering, radiation protection and chemistry. The results were highly positive, especially in light of the fact that the facility has excellent operational safety standards for daily work practices.

In November, the Military Emergency Unit (UME) subjected its force to fire training exercises at the Cofrentes’ Fire Protection (FP) Training Camp; the plant’s fire brigade took part in these exercises.

**Annual Onsite Emergency Drill**

The annual drill of the Site Emergency Plan was carried out on September 20. A break-in and a rash of arsons were simulated, which required taking security measures and employing fire extinguishing means to protect the facility from these acts of sabotage. A General Emergency was consequently declared and all postulated mitigation actions were carried out to satisfaction.

Various organizations were mobilized, and communication channels were opened with the Nuclear Safety Council via Salem II (the alternative emergency room in Torrejón de Ardoz, Madrid) and between the Spanish Government’s Regional Office in Valencia and the Operational Coordination Center (CECOP) and the Emergency Support Centre (CAE) in Madrid.

**External Relations and Communication Activities**

On February 20 the plant director appeared before the Environment Commission of the Valencian Parliament -at the latter’s request- to report on the plant’s operation.

In May, the Cofrentes Town Council held the 18th meeting of the Local Information Committee -which was chaired by the Deputy Director-General for Nuclear Energy- with the aim of keeping the townspeople and the representatives from official bodies apprised of the activities regulated in the different licenses and authorizations and jointly dealing with matters of interest pertaining to the plant’s operation.
A group of senators visited Cofrentes in March as part of the Parliament-Companies Program, and the new Government Delegate in the Valencian Community, who is responsible for the proper execution of the Valencia Nuclear Emergency Plan, did so in July.

PERSPECTIVES FOR 2019

The plant’s 22nd refueling outage will take place in October, and is scheduled to last 35 days. 7,500 work orders and 45 project change orders are expected to be carried out during this outage.

Important actions will be undertaken to improve human performance at the plant by means of the delivery of courses and programs directed toward improving the execution of activities to ensure maximum quality.

Once the appropriate licenses are obtained, work will begin on the construction of the Individualized Interim Storage, which is expected to come into service in 2020.
Trillo nuclear power plant’s gross electrical output in 2018 amounted to 8,267.25 GWh. Since it started commercial operation in March 1988 until December 31, 2018, the plant has generated 247,292 GWh.

August 6 marked 30 years of Trillo’s commercial operation. 2018 was the eleventh year in a row that the plant has not suffered any scrams.

In 2018 the plant launched the necessary design modifications resulting from having stopped using the DPT-type cask (which has a capacity for 21 spent fuel assemblies) and switching to using ENSA’s ENUN 32P cask (which can hold 32 fuel assemblies) in its Individualized Interim Storage.

HIGHLIGHTS OF 2018

Refueling Outage

Trillo’s 18th refueling and general maintenance outage was held from the May 18 till June 26. Over the 40 days the outage lasted, inspections were made on the centering pins of the reactor’s upper internals, fuel assemblies and control rods and on the lower bearing of reactor cooling pump YD30D001. Additionally, the reactor pressure vessel and its base metal were inspected by mechanical means. All the tubes of steam generator 20 were subjected to an eddy current inspection, the primary circuit to pressure tests, batteries of the 2/6 redundancy to capacity tests, and the reactor protection system to general checks. In addition, the 1/5 redundancy was electrically and mechanically inspected, and the alternator and the exciter, as well as the valves of main steam loop 30, checked.
Annual Onsite Emergency Drill

The annual drill of the Site Emergency Plan (SEP) was carried out on October 4. The proposed scenario led to the initial declaration of Category II (Emergency Alert) on account of a fire in a transformer and, subsequently, of Category IV (General Emergency), resulting in the evacuation of all non-essential personnel. The Emergency Environmental Radiological Surveillance Plan (ERSP) was activated and all necessary external support organizations mobilized to deal with this situation. The organization’s preparedness, the operability of the assigned means, and the coordination with all involved parties were thus verified.

Safety Culture

In October, the mission to follow up on the status of the action plan resulting from the Corporate Peer Review which WANO had subjected CNAT to took place in November 2015.

Also in October, the Swiss Göesgen NPP and Trillo NPP benchmarked each other for the purpose of exchanging good practices, and the program of meetings to divulge the progress made in the A-CERO Prevention Program -which aims to raise awareness among CNAT’s team and its collaborating companies in order to bring down the number of potential occupational accidents as much as possible- was carried out.

Trillo plans to carry out 4,000 activities during its next refueling outage in 2019. All staff will be subjected to 48,000 hours of prior training on how to perform these jobs.
**External Relations and Communication Activities**

The 18\textsuperscript{th} meeting of Trillo NPP’s Information Committee, which was called by the Ministry of Energy, Tourism and the Digital Agenda, was held on April 10. It was presided over by the Deputy Director-General for Nuclear Energy and attended by the Mayor of Trillo, the Government Deputy Delegate in Guadalajara, representatives from the Nuclear Safety Council and the Directorate General for Civil Protection and Emergencies, and the plant director, who took stock of the year at the plant and emphasized the good results that had been obtained.

On October 18, members of WANO’s Board of Governors visited the plant and met with CNAT’s Management.

Throughout 2018 4,036 people visited the plant’s Information Centre, a total of 363,500 visitors having been reached since its inauguration in November 1981.

**PERSPECTIVES FOR 2019**

The 31\textsuperscript{st} refueling outage will take place in mid-May. 4,000+ activities will be carried out over the 29 days it is expected to last, including the replacement of 40 fuel assemblies; the inspection of components of a main pump; the replacement of components in the internal nuclear instrumentation; the capacity test on batteries of the 3/7 redundancy; the electrical and mechanical inspection of the 2/6 redundancy; and the test on the restoration of internal power from the external grid stand out.

Plant workers will be given 48,000+ hours of training in line with their professional activities.
In 2018 Vandellós II generated 5,216.64 gross GWh. Since it started commercial operation in March 1988 until the end of 2018, the plant has produced a total of 233,876 GWh.

**HIGHLIGHTS OF 2018:**

The plant remained in stable operation until March, when an unscheduled shutdown was carried out to identify the source of some dripping; it was found to be occurring in one of the vent valves. Later on, once the work had been satisfactorily completed, and when the plant was being preparing to reconnect to the grid, the need to upgrade some components of the thermocouple columns was detected on March 24. In view of this circumstance, the decision was made to keep the plant shut down and to reschedule the refueling outage to include the jobs to replace the affected components.

**Refueling Outage**

Vandellós’ 22nd refueling outage took place between May 12 and July 20, during which 10,000+ work orders were executed, 44 design modifications made and 18 components replaced in anticipation of the obsolescence of their materials. The most noteworthy activities were the transport from Ascó NPP and the replacement of the stator of the main generator and of the exciter.

**Safety Culture**

A WANO Peer Review mission took place between October 10 and 26, which brought with it new developments with regard to the tasks carried out in the past during these peer reviews, among which the changes made to the documentary information package that the plants have to prepare in advance and two additional activities prior to the mission stand out: the process for reviewing design-based information and the so-called observation of shift performance, which consists in witnessing the training of shift operators in the full-scope simulator.
Emergency Drills

The Annual Emergency Drill was held on April 12 to demonstrate the effectiveness of the Site Emergency Plan (SEP) and the emergency organization’s preparedness, in accordance with this Plan. Emergency notifications were sent to the Operational Coordination Centre (CECOP) of the Spanish’s Government Regional Office in Tarragona, the Nuclear Safety Council’s Emergency Room (SALEM) and other emergency organizations. The efforts to extinguish the fire declared during the drill were coordinated with the fire brigades and the firefighters from the Regional Government of Catalonia, and external technical support organizations were contacted by phone to request their mobilization.

Integrated-scope exercises were carried out in October and November in order for plant personnel to systematically perform the tasks that have been assigned to them in case of emergency.

On October 24 the plant carried out a joint exercise with the Military Emergency Unit’s Technological and Environmental Emergency Intervention Group in order for both organizations to achieve working together in a coordinated manner. The support capabilities in the movement of people and the fighting of fires and the effectiveness of the communications were checked. The coming into service of the Alternative Emergency Management Center (CAGE) was also simulated.
External Relations and Communication Activities

Asociación Nuclear Ascó-Vandellós II’s (ANAV) continued to maintain its commitment to transparency, information and dissemination in the region where its facilities are sited, throughout 2018. The Information Committee meetings convened by the Ministry for Ecological Transition were held, as well as various periodic meetings with the heads of nearby towns, institutional representatives and the media. Furthermore, ANAV kept in touch with the public via social media and its corporate website. Additionally, Vandellós supported different socio-cultural and educational activities that were carried out by different entities in its vicinity.

PERSPECTIVES FOR 2019

An IAEA Pre-Safety Aspects of Long Term Operation (Pre-SALTO) mission will arrive at the plant in January.

The plant’s 23rd refueling and general maintenance outage will be held in November, one of its main activities being the partial overhaul of the main alternator.
1.7 EVOLUTION OF OPERATING PARAMETERS

ALMARAZ | NPP
Source: Foro Nuclear and Monthly Operating Reports (IMEX)

VOLUMEN OF SOLID RADIOACTIVE WASTE

COLLECTIVE RADIATION EXPOSURE

Source: Foro Nuclear and Monthly Operating Reports (IMEX)
AVERAGE DAILY OPERATING POWER (%) YEAR 2018

CAPABILITY FACTORS

UNIT CAPABILITY FACTOR (%) 83.74 90.38 82.67 96.62 88.76 89.96
UNPLANNED CAPABILITY LOSS FACTOR (%) 0.00 0.00 0.38 0.31 0.03

REACTOR SCRAMS

SCRAMS (PER 7,000 h CRITICAL) 2.6 0.8 0.9 0.9 1.0 0.9 0.9 0.9 0.0 0.0
ALMARAZ II NPP

Source: Foro Nuclear and Monthly Operating Reports (IMEX)

VOLUMEN OF SOLID RADIOACTIVE WASTE

COLLECTIVE RADIATION EXPOSURE

m³

man·Sv
### Average Daily Operating Power (%)

YEAR 2018

#### Capability Factors

<table>
<thead>
<tr>
<th>Year</th>
<th>Unit Capability Factor (%)</th>
<th>Unplanned Capability Loss Factor (%)</th>
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</thead>
<tbody>
<tr>
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<td>3.50</td>
<td>85.94</td>
</tr>
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<td>2015</td>
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<td>87.08</td>
</tr>
<tr>
<td>2016</td>
<td>0.00</td>
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<td>98.54</td>
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<tr>
<td>2018</td>
<td>0.00</td>
<td>90.39</td>
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</table>

#### Reactor Scrams

<table>
<thead>
<tr>
<th>Year</th>
<th>Scrams (Per 7,000 h Critical)</th>
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</thead>
<tbody>
<tr>
<td>2009</td>
<td>1.0</td>
</tr>
<tr>
<td>2010</td>
<td>0.9</td>
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<tr>
<td>2011</td>
<td>0.9</td>
</tr>
<tr>
<td>2012</td>
<td>0.9</td>
</tr>
<tr>
<td>2013</td>
<td>0.9</td>
</tr>
<tr>
<td>2014</td>
<td>0.0</td>
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<td>2015</td>
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<td>2016</td>
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</tr>
<tr>
<td>2017</td>
<td>0.0</td>
</tr>
<tr>
<td>2018</td>
<td>0.0</td>
</tr>
</tbody>
</table>
ASCÓ I NPP
Source: Foro Nuclear and Monthly Operating Reports (IMEX)

VOLUME OF SOLID RADIOACTIVE WASTE

COLLECTIVE RADIATION EXPOSURE

m³
man·Sv
AVERAGE DAILY OPERATING POWER (\%) YEAR 2018

CAPABILITY FACTORS

UNIT CAPABILITY FACTOR (%)

UNPLANNED CAPABILITY LOSS FACTOR (%)

REACTOR SCRAMS

SCRAMS (PER 7,000 h CRITICAL)
ASCÓ II NPP
Source: Foro Nuclear and Monthly Operating Reports (IMEX)

**VOLUMEN OF SOLID RADIOACTIVE WASTE**

<table>
<thead>
<tr>
<th>Year</th>
<th>Volume (m³)</th>
</tr>
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<tbody>
<tr>
<td>2009</td>
<td>38.50</td>
</tr>
<tr>
<td>2010</td>
<td>75.46</td>
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<td>2011</td>
<td>109.33</td>
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<tr>
<td>2012</td>
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<tr>
<td>2013</td>
<td>75.68</td>
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<td>2015</td>
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<td>2016</td>
<td>80.30</td>
</tr>
<tr>
<td>2017</td>
<td>45.10</td>
</tr>
<tr>
<td>2018</td>
<td>39.82</td>
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</table>

**COLLECTIVE RADIATION EXPOSURE**

<table>
<thead>
<tr>
<th>Year</th>
<th>Exposure (man·Sv)</th>
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</thead>
<tbody>
<tr>
<td>2009</td>
<td>0.420</td>
</tr>
<tr>
<td>2010</td>
<td>0.410</td>
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<tr>
<td>2011</td>
<td>0.650</td>
</tr>
<tr>
<td>2012</td>
<td>0.350</td>
</tr>
<tr>
<td>2013</td>
<td>0.320</td>
</tr>
<tr>
<td>2014</td>
<td>0.730</td>
</tr>
<tr>
<td>2015</td>
<td>0.270</td>
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<tr>
<td>2016</td>
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<tr>
<td>2017</td>
<td>0.270</td>
</tr>
<tr>
<td>2018</td>
<td>0.430</td>
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</tbody>
</table>
AVERAGE DAILY OPERATING POWER (%) YEAR 2018

CAPABILITY FACTORS

REACTOR SCRAMS

UNIT CAPABILITY FACTOR (%) UNPLANNED CAPABILITY LOSS FACTOR (%)

SCRAMS (PER 7,000 h CRITICAL)
COFRENTE NPP
Source: Foro Nuclear and Monthly Operating Reports (IMEX)

VOLUMEN OF
SOLID RADIOACTIVE
WASTE

COLLECTIVE
RADIATION
EXPOSURE

Source: Foro Nuclear and Monthly Operating Reports (IMEX)
AVERAGE DAILY OPERATING POWER (%) YEAR 2018

CAPABILITY FACTORS

UNPLANNED CAPABILITY LOSS FACTOR (%)

UNIT CAPABILITY FACTOR (%)
TRILLO NPP
Source: Foro Nuclear and Monthly Operating Reports (IMEX)

VOLUMEN OF SOLID RADIOACTIVE WASTE

COLLECTIVE RADIATION EXPOSURE
VANDELLÓS II NPP
Source: Foro Nuclear and Monthly Operating Reports (IMEX)

VOLUMEN OF SOLID RADIOACTIVE WASTE

COLLECTIVE RADIATION EXPOSURE

Source: Foro Nuclear and Monthly Operating Reports (IMEX)
AVERAGE DAILY OPERATING POWER (%) YEAR 2018

CAPABILITY FACTORS

UNIT CAPABILITY FACTOR (%) UNPLANNED CAPABILITY LOSS FACTOR (%)

REACTOR SCRAMS

SCRAMS (PER 7,000 h CRITICAL)
In 2018 ENUSA Industrias Avanzadas S.A. supplied the Spanish nuclear power plants of Almaraz I, Ascó I and II and Trillo with a total of 102 tonnes of uranium (tU) of different degrees of enrichment, which is equivalent to 1,074 tonnes of uranium concentrates (U₃O₈), 906 tonnes of natural uranium in the form of UF₆ and 766 thousand SWUs (separative work units, a measure of the energy that is used up when separating uranium into two parts, one enriched and the other one depleted in the fissile isotope 235U. The number of SWUs that is needed is proportional to the degree of enrichment that is required).

The Juzbado fuel assembly factory, which is located in the province of Salamanca, Spain, manufactured 276.35 tU, out of which 69% was exported to plants in Germany, Belgium and France.

All in all, 615 fuel assemblies were assembled in 2018-557 for PWRs and 58 for BWRs.

Almost 70% of all fuel assemblies manufactured at Juzbado were intended for German, Belgian and French nuclear power plants.
The factory’s cumulative production since it started operating is shown in the table below:

### Cumulative Production from 1985 till 2018

<table>
<thead>
<tr>
<th>Year</th>
<th>PWR Total (tU)</th>
<th>BWR Total</th>
<th>Spain</th>
<th>Exported</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>6,004.03</td>
<td>1,909.18</td>
<td>4,150.15</td>
<td>3,763.06</td>
<td>7,913.21</td>
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<tr>
<td>1986</td>
<td>13,125</td>
<td>10,701</td>
<td>11,169</td>
<td>12,127</td>
<td>23,826</td>
</tr>
</tbody>
</table>

Source: ENUSA Industrias Avanzadas, S.A.
3

Radioactive Waste Management and Facilities Dismantling
3.1 VERY LOW, LOW AND INTERMEDIATE LEVEL WASTE

Spanish nuclear power plants condition all very low, low and intermediate level waste (VLLV, LLW and ILW) they generate during their operation. Thereafter, these wastes must fulfill the acceptance criteria that have been set for their definitive disposal at the El Cabril Centralized VLLW, LLW and ILW Storage Facility, which is owned and managed by Enresa (the Spanish Radioactive Waste Enterprise) and located in Hornachuelos (Córdoba). These wastes are temporarily stored at the installations that Spanish NPPs have on their respective sites until they are transferred to El Cabril.

826.61 m$^3$ of waste were generated by Spanish NPPs and 458.78 m$^3$ removed by Enresa in 2018. The table below lists the volumes of waste that was generated by every Spanish NPP and removed by Enresa, as well as the occupancy of their temporary storage installations.

* Data valid as of December 31, 2018 / ** Almaraz NPP’s two units share the same storage facility / Source: NPPs and Foro Nuclear
3.2 EL CABRIL WASTE CENTRALIZED STORAGE FACILITY

From the outset of its activities in 1986 till December 31, 2018, the El Cabril disposal facility has received 48,513 m$^3$ of waste, of which 35,733 m$^3$ were LILW and 12,780 m$^3$ VLLW.

El Cabril received in 2018 2,489 m$^3$ of radioactive waste, 721 m$^3$ of which being LILW and 1,768 m$^3$ VLLW. These wastes arrived at El Cabril in 265 shipments in all: 238 from nuclear facilities, amounting to 2,469 m$^3$ (712 m$^3$ of LILW and 1,757 m$^3$ of VLLW), and 27 from radioactive installations, adding up to 20 m$^3$ (9 m$^3$ of LILW and 11 m$^3$ of VLLW).
STORAGE OF VLLW

In 2018 El Cabril received 1,768 m$^3$ of VLLW, which were stored in structures specifically designed to hold this type of material. The first one came on line in October 2008 and the second in July 2016.

As of December 31, 2018, the volume stored equaled 15,491 m$^3$, representing 36% of their current operational capacity (11% of the total capacity of the 4 specific structures that have been envisaged for this type of waste).

STORAGE OF LLW AND ILW

In 2018 El Cabril received 721 m$^3$ of low and intermediate level wastes altogether.

As far as occupancy is concerned, out of the 28 LILW storage cells the facility has 21 cells were already full and closed at year’s end: the 16 structures of the north platform and 5 structures in the south platform, for a total of 33,602 m$^3$. This is a 77% occupancy of the total storage capacity for LILW.

<table>
<thead>
<tr>
<th>VOLUMES OF VLLW, LLW AND ILW RECEIVED AT EL CABRIL IN 2018 (m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FROM NUCLEAR FACILITIES</td>
</tr>
<tr>
<td>FROM RADIOACTIVE INSTALLATIONS (HOSPITALS, LABS AND RESEARCH CENTERS)</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

Source: Enresa
3.3 SPENT FUEL MANAGEMENT

Spanish NPPs were designed to store, for a limited period of time, their spent fuel inside the pools that were built for such purpose within their own facilities. When a spent fuel pool’s storage capacity becomes saturated, the oldest irradiated fuel is taken out and stored in an onsite Individualized Temporary Storage Facility (ATI) under dry conditions.

As of December 31, 2018, the number of irradiated fuel elements that were stored temporarily at Spanish NPPs stood at 15,838, 14,085 of which were kept in the pools and 1,753 in the ATIs.
The distribution and occupancy of the pool at each of the plants is as follows:

Trillo NPP has had ATI since 2002, which as of December 31, 2018 housed 34 casks (32 of the DPT type, with 21 fuel elements each, and 2 of the ENUN32P type, with 32 fuel elements each), for a total of 736 irradiated fuel elements. This means its occupancy then stood at 33.3%.

Ascó NPP has had an ATI for both its units since April 2013. In 2018, 4 HI-STORM casks holding 128 irradiated fuel elements from the pool in Unit I and 2 casks holding 64 elements from the pool in Unit II were loaded in the storage facility. Therefore, as of December 31, 2018, there were 10 casks with 320 irradiated fuel elements from Unit I and 9 casks with 288 irradiated fuel elements from Unit II stored on the respective slabs for each unit.

<table>
<thead>
<tr>
<th>NPP</th>
<th>Irradiated Fuel Elements (Units)</th>
<th>Occupancy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALMARAZ I</td>
<td>1,544</td>
<td>93.75</td>
</tr>
<tr>
<td>ALMARAZ II</td>
<td>1,504</td>
<td>91.32</td>
</tr>
<tr>
<td>ASCÓ I</td>
<td>1,160</td>
<td>81.60</td>
</tr>
<tr>
<td>ASCÓ II</td>
<td>1,104</td>
<td>77.69</td>
</tr>
<tr>
<td>COFRENTES</td>
<td>4,484</td>
<td>93.81</td>
</tr>
<tr>
<td>SANTA MARÍA DE GAROÑA</td>
<td>2,505</td>
<td>96.01</td>
</tr>
<tr>
<td>TRILLO</td>
<td>516</td>
<td>82.17</td>
</tr>
<tr>
<td>VANDELLÓS II</td>
<td>1,268</td>
<td>88.52</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14,085</strong></td>
<td><strong>-</strong></td>
</tr>
</tbody>
</table>

Data valid as of December 31, 2018 / Source: NPPs and Foro Nuclear
Almaraz NPP’s own ATI came into service in December 2018. The loading and transfer of the first -ENUN32P- cask took place on December 12, which contained a total of 32 irradiated fuel elements from the pool in Unit I.

José Cabrera NPP, which is currently being dismantled, has had an ATI since 2009 for housing, inside 12 dry storage casks, the 377 irradiated fuel elements it used up throughout its operating life.

3.4 THE PRELIMINARY DISMANTLING OF SANTA MARÍA DE GAROÑA NPP

During 2018, following the Ministry of Energy, Tourism and Digital Agenda’s decision in August 2017 to refuse to renew the plant’s operating license, Santa María de Garoña’s nuclear power plant underwent a process to orderly stop all the activities that were directed toward its own continuity and an important process of staff restructuring -from 226 down to 119 employees dedicated to achieving the new objective of safely and efficiently transferring ownership of the facility to Enresa for dismantling.

The priorities of Nuclenor -the plant’s owner- continue to be the safe operation of the plant and the safe handling of all spent fuel and radioactive waste without any operating incidents or work accidents and its rigorous compliance with the standards of and the requirements set by the Spanish Nuclear Safety Council (CSN) especially in connection with maintaining the organizational capabilities that the new situation of the plant, which has devised a large number of staff replacement and knowledge transfer plans, calls for.
In addition, Nuclenor has been working on the following projects, which are specific to the new transition phase:

- **Completing the conditioning of low- and intermediate-level operational waste** that it initiated years ago and undertaking, together with Enresa, the treatment of the last pending streams of both classified and non-classified waste materials. A significant development in this activity was the sending, with Enresa’s authorization, of about 1,000 tonnes of metallic waste to Studsvick (Sweden) for smelting, in order for most of it to be reused and the secondary waste returned, thereby achieving a reduction in the volume to be stored of around 95%.

- **Reconfiguring the spent fuel pool cooling systems** for the overall optimization of the plant’s systems after more than 5 years cooling the irradiated fuel, while maintaining the required safety functions, with the following objectives: stepping up the monitoring of safety-related systems, reducing risks, facilitating pre-dismantling activities and meeting international standards.

- **Managing all irradiated fuel** as per Enresa’s instructions, preparing its Individualized Temporary Storage Facility (ATI) to house the first 5 irradiated fuel casks manufactured by ENSA as well as all the other casks that it will subsequently be supplied with to take out all the fuel that is currently stored in its spent fuel pool. In addition, Nuclenor worked with Enresa to draw up a Spent Fuel Management Plan defining the main aspects of the plant’s spent fuel management activities.

- **Preparing the plant for dismantling**, collaborating with Enresa in all preparatory activities and coming up with technical solutions allowing the overall dismantling process to be tackled efficiently.
On November 15th the plant carried out the annual site emergency drill, the main goal of which was to verify the suitability of the Onsite Emergency Plan, the established action procedures, the training of all personnel belonging to the emergency organization and the operation of emergency response equipment and installations. The Nuclear Safety Council’s Emergency Room (SALEM) was activated, as well as the Operational Coordination Center (CECOP) of the Spanish Government’s Regional Office in Burgos -something which is provided for in the province of Burgos’ Nuclear Emergency Plan (PENBU).

In 2019 the plant will keep the fuel safely stored inside the pool in the reactor building until it starts receiving the casks for the dry storage thereof and begins to gradually move it to the ATI.

**Nuclenor plans to carry out activities relating to the conditioning of the refueling plant and the spent fuel pool before undertaking the cask loading and transfer operations in due course,** to carry on with the risk reduction and facility simplification tasks, to collaborate with Enresa in drawing up the dismantling license application it will submit to the Nuclear Safety Council (CSN) and to proceed with the plans for replacing the staff and transferring all the knowledge that the plant’s organization needs to maintain its operational capabilities.
3.5 THE DISMANTLING OF JOSÉ CABRERA AND VANDELLÓS I NPPs

JOSÉ CABRERA NPP

The dismantling process of José Cabrera NPP, which is sited in the province of Guadalajara, entered the final stage in 2018 following the dismantling of the radiological components and the decontamination of most buildings. By the end of the year the project’s execution was 86 percent-complete.

Thousands of measurements and samples have been taken in order to decontaminate those buildings that are classified as radiological. Thus, and only in the containment building -the place where the reactor was housed, a surface area of 14,000 sqm was measured and will be declassified.

The taking down and removal of the plant’s ventilation stack, which was the point source of emission of -once filtered- the gaseous effluents from the facilities’ radiological buildings with ventilation systems stands out among the main work that was undertaken throughout the year.

This stack was made of reinforced concrete, measured 60 m in height, rested on a 4.5 m-deep foundation and had outer diameters ranging from 5 m at the base to 1.8 m at the top.

Approximately 19,500 tonnes of waste material were generated from the beginning of the dismantling work in February 2010 until December 31, 2018, of which 6,200 tonnes corresponded to conventional material, 6,700 tonnes to VLLW, LLW and ILW and 6,600 tonnes to declassifiable material (from radiological areas but which, once declassified, may be managed as conventional material). In addition, during this entire period 429 shipments of waste were sent to the El Cabril VLLW, LLW and ILW disposal facility.
Enresa dismantled a Spanish nuclear power plant -Vandellós I- for the first time between 1998 and 2003. Vandellós I was dismantled at Level 2, which meant removing all buildings, systems and equipment outside the reactor pressure vessel. The reactor, empty of fuel, was sealed in order to wait for the radioactivity of its internal structures to decay sufficiently -a time period known as the latency phase- to make them more feasible to dismantle them at Level 3 -the complete dismantling of the facility, which is expected to be completed by 2028.

The plant’s medium-term multidisciplinary action plan (2013-2018) for increasing the knowledge of the remaining facility, preparing all necessary documentation and drawing up the plans for its future dismantling was completed in 2018. This action plan has helped to analyze the different strategies that need to be applied at Dismantling Level 3.

Enresa carried out the following main activities in 2018:

- **Reconditioning all the VLLW** that was rejected during the declassification process of Level 2. A total of 387 CMD (Control of Declassifiable Materials) casks containing scrap and rubble were reconditioned, thus resulting in the reduction of up to 289 CMD containers and an optimization of 25% by volume.

- **Carrying out the general emergency drill corresponding to the interquinquennial period.** Two drills are conducted at the site every five years. One of them simulates a problem with the facility’s leak test and the other contingencies that may arise during the latency phase.

- **The homologation by the Autonomous Government of Catalonia (Generalitat de Catalunya) of the self-protection plan supplementing the existing Onsite Emergency Plan** with the aim of complying with current state and autonomous legislation.

- **Analyzing different strategies for dismantling the reactor pressure vessel** based on international projects that were conducted in the past and current Spanish and international projects.

- **Putting the results from positive experiences at other Enresa sites to good use** in order to consolidate the material and intangible assets in the dismantling field.
THE SPANISH NUCLEAR INDUSTRY
A large number of Spanish companies have focused their activity on the nuclear sector, thus gaining experience in the development of the Spain’s nuclear program from its inception and creating a competitive, experienced industry that supports the operation of Spanish nuclear power plants and currently serves a growing international market.

The companies that work for the Spanish nuclear industry are present throughout the value chain, from initial studies, conceptual design, construction, fuel manufacturing, operation and maintenance engineering, supply of equipment and components and involvement in new developments and R&D&I programs to the management of nuclear waste and the dismantling of facilities.

This entire industrial structure has evolved according to the circumstances at each moment in time, incorporating new technologies that are adapted to current needs and requirements and making it possible for the companies in the Spanish nuclear sector to be involved in nuclear projects in more than 40 countries. Some of these companies export more than 80% of their annual production.

The internationalization of nuclear activities has become consolidated in recent years and been favored by the growth of the market and the increased regulatory security and stability in those countries to which Spanish companies have expanded their activities.
Amphos 21 is a company that provides scientific, technological and strategic consulting services across the entire nuclear cycle and solutions to problems arising from the presence of radioactive material, among which those associated with nuclear fuel, high-, intermediate- and low-level waste, engineering barriers in waste stores, and safety analyses of nuclear facilities are worth mentioning. It has high experimental and advanced numerical simulation capabilities, which allow it to come up with reliable quantitative solutions.

In 2018 the company carried out projects pertaining to the nuclear sector in Sweden, France, Belgium, Finland, Spain, Japan and the U.K. It entered into framework collaboration agreements with the radioactive waste management agencies of Sweden (SKB) and France (ANDRA), the company’s two main clients. It actively took part in two of the most emblematic European R&D projects within the EURATOM program: CEBAMA, concerning cement and concrete barriers in radioactive waste stores, and DISCO, which seeks to increase scientific knowledge about spent fuel dissolution processes. In addition, it launched a multi-year training program for its consultants in both the scientific-technical sphere and management and communication.

The company will celebrate its 25th anniversary since its founding in 2019. It expects its sales in the nuclear market to grow by 10% in 2019 and by 25% cumulatively by 2021.
**CEN SOLUTIONS**
www.censolutions.es

**CEN Solutions** operates in the energy, oil & gas, industry and transport sectors providing solutions in the areas of equipment manufacturing and expert maintenance.

The manufacture of safety equipment is one of the key activities of the company, which is capable of supplying control panels and desks, auxiliary panels for reactor protection systems, sampling equipment, power and distribution panels, motor control centers, medium voltage cabinets, and isolated phase bus conduits.

CEN Solutions has quality, environmental and safety management systems in place in accordance with ISO, PECAL, NQA 10CFR50, UNE and ANSI standards and ASME codes, which are periodically audited in order for the company to remain officially approved and accredited as a supplier of nuclear safety-related electric equipment (Class 1E) in Spain and abroad.

*It has its own capabilities for commercializing electrical components* and carries out related processes for the components of the products it manufactures and the spare parts that the different nuclear power plants require.

In 2018 it inspected 10-kV and low-voltage busbars and replaced switches during refueling outages, Trillo NPP’s control panel and the control panel for the HVAC system of the Slovenian plant Krsko’s simulator, supplied spares to Spanish plants and designed and provided the nuclear safety control system for the ITER fusion project.

The company’s goal in 2019 is to increase its participation in existing plants and in international projects for the construction of new plants in order to continue being the reference manufacturer in the market of electric equipment for nuclear power plants.
Coapsa is an electrical and mechanical engineering company specializing in the supply, repair, maintenance and retrofitting of cranes with special requirements, mainly in the nuclear and port sectors, and designs and carries out turnkey projects for this type of equipment. Its activity rests on three basic pillars: work quality and good service, a well-trained human team and the integration and adaptation of the latest technologies.

In 2018 the company consolidated its presence in the port sector, gaining a lot of experience in terms of services and materials due to the high performance that is required of this type of cranes. It then applied this experience in cranes in the nuclear industry, where safety systems are paramount. Coapsa upgraded the crane for handling irradiated fuel casks in Almaraz II’s fuel building by replacing the old trolley with one that complies with Single Failure Proof Crane regulations. Two of its standout projects consisted in the manufacture of a new transport cart for Trillo NPP’s equipment hatch that was capable of handling the DPT irradiated fuel cask and the new ENUN32P cask and the refurbishment of the crane inside Almaraz NPP’s turbine hall. The company increased its presence in Spanish power plants by servicing their cranes during both operation and refueling outages.

In 2019 the company will refurbish many cranes at all Spanish nuclear power plants in order to increase their performance. The company expects to increase its activity in the industrial and port sectors to a great extent.
Empresarios Agrupados is an engineering organization that provides a full range of engineering services for nuclear, conventional, renewable energy and biomass power generation projects. It was founded in 1971 and now has a permanent staff of 900+ people, 80% of whom hold college degrees. *The American magazine Engineering News Record* ranked it among the 225 main international engineering companies in the world.

During 2018 Empresarios Agrupados provided the Spanish nuclear sector with engineering services in support of the operation of Almaraz, Trillo and Cofrentes NPPs and for the radiological calculations at Cofrentes’ individualized temporary storage facility.

Outside Spain, it performed the analysis on the bursting of high energy pipes on the nuclear island of the Slovak plant Mochove 3 and 4, currently under construction, and helped to answer the Slovak regulators’ questions about the project; managed the dismantling project of Units 1 to 4 of the Bulgarian plant Kozloduy; managed construction of Bulgaria’s National LLW and ILW Storage Facility; carried out the engineering calculations, analyses and site management of the construction of various buildings and infrastructures of the ITER project; planned and devised the methodology for the surveillance of buildings and structures at the Ukrainian VVER plants; drew up the project for the management of radioactive waste at the Chernobyl plant; designed and engineered various systems and equipment on the turbine island of the new British plants Wylfa Newydd and Hinkley Point C and designed the general layout of the turbine island, pipes and supports for Units 5 and 6 of the Hungarian plant Paks, Units 1 and 2 of the Egyptian plant El-Dabaa and the four units of the Turkish plant Akkuyu.

In 2019, the company will keep on working on engineering projects and providing services to support the operation of all seven Spanish nuclear power stations currently in operation; conducting probabilistic safety analyses for most Spanish plants; preparing the preliminary safety study for the Finnish plant Hanhikivi-1; providing engineering services for the dismantling of José Cabrera NPP in Spain; providing engineering services for the dismantling of the JRC in Ispra (Italy); providing engineering services for the nuclear safety control system of the ITER project; and providing engineering services to develop the conceptual design of the Myrrha research reactor in Mol (Belgium).
Ensa which was founded in 1975, is a Spanish state-owned enterprise specializing in the manufacture of large components for nuclear power plants all over the world, such as reactor vessels-including their internals, supports and head, steam generators, primary circuit piping, pressurizers, heat exchangers, fuel element heads, irradiated fuel storage and transport casks and fuel racks.

It has a department that is highly qualified for designing and licensing components, mainly for developing irradiated fuel storage systems, which it subsequently manufactures, in addition to providing training and helping plant teams to handle and use the said components. Through its Services, Waste and Dismantling Area, it works at nuclear power plants carrying out assembly, fuel management, installation repair and maintenance, decontamination and dismantling tasks, among others.

In 2018, Ensa was involved in the manufacture of components for French plants’ steam generators; the manufacture of pressurizers, reactor support rings and primary effluent tanks for Hinkley Point C; the engineering and manufacture of components for the Argentinean CAREM reactor project; the first loadings of newly designed ENUN32P irradiated fuel casks at Trillo and Almaraz and the loading of irradiated fuel casks at Ascó NPP.
In addition, it welded the sectors of the ITER project’s toroidal ring; designed, manufactured and supplied embedded tanks for and to Framatome; manufactured components for the Jules Horowitz reactor and designed and manufactured tanks and vitrified fuel casks for Vandellós I, and irradiated fuel casks and vessel heads for replacement.

In 2019, the company will enhance its employees’ occupational safety, reinforce its total quality management based on good practices, and promote a safe, effective and team-based work culture. Furthermore, it will increase its involvement in new, innovative generation projects, such as those pertaining to small modular reactors (SMRs), promote its Advanced Technology Center (ATC) for validating, qualifying, automating and robotizing materials and processes, and develop and promote facility dismantling technology by collaborating with different bodies in technological innovation projects.

ENUSA Industrias Avanzadas S.A., S.M.E.  
www.enusa.es

ENUSA is a Spanish enterprise that is owned by the State Industrial Ownership Corporation (SEPI) and the Center for Energy, Environmental and Technological Research (CIEMAT). Its activity is structured around two large business areas: the nuclear market and the environmental market.

It acts in the nuclear market as an enriched uranium purchasing agent for Spanish companies and designs, licenses, manufactures and supplies nuclear fuel assemblies for light water reactors (PWRs, BWRs and VVERs) in Spain and other European countries. In addition, it provides fuel services for both fuel in operation and irradiated fuel. It also supplies specialized fuel production and inspection equipment as well as irradiated fuel inspection systems.
ENUSA’s single most important milestone in 2018 was the renewal of its agreement with Endesa, Iberdrola and Naturgy, the owners of the Ascó, Vandellós II and Almaraz plants, for the integrated supply of both fresh and irradiated fuel during the 24 refueling outages that will take place between 2019 and 2017. Also worth mentioning are its services for Spanish PWRs for the characterization and classification of irradiated fuel assemblies, especially damaged ones, before storage inside their individualized temporary storage facilities. The company has intensified its collaboration with ENSA for designing and licensing storage and transport casks.

On the international front, it has supply contracts in France, Belgium, Sweden, Finland and Germany. With regard to the BWR market, 2018 was a very important year for GENUSA -a company started by ENUSA and GNF-A in 1996- because the Swedish company Vatenfall awarded it the contract to supply fuel during four refueling outages of Units 1 and 2 of Forsmark NPP. On the other hand, Finland’s TVO awarded it the contract to meet at least 50% of the fuel needs of the two Olkiluoto reactors until 2038. As far as PWR technology is concerned, ENUSA continues to supply the Belgian reactors Doel 3 and 4 and Tihange 2 and 3 and the EDF’s French reactors with EFG, an alliance with Westinghouse.

The company’s main challenge in 2019 is to meet all of its fuel design, licensing, engineering and manufacturing commitments. Of note is its project with ENGIE for repairing irradiated fuel assemblies at different plants of EFG (European Fuel Group) and non-EFG design before loading them in spent fuel casks for temporary storage. ENUSA will keep on supporting ENSA in the licensing of casks and, together with other state-owned enterprises and private companies, develop new capabilities for managing operational waste and dismantling nuclear facilities. Moreover, it will step up its internationalization and digital transformation processes and promote R&D&I projects while at the same time keeping the public informed of the benefits of nuclear power.
In 2018 it carried out work in all the refueling outages of Spanish NPPs and at some French plants. The company worked on both routine maintenance and design modifications for Ascó, Vandellós, Almaraz and Trillo, and had to do some unscheduled interventions for repairing large components in Spain and Belgium.

Its manufacturing activity focused on the prefabrication of components for steam generators and fuel and, to a lesser extent, for the naval industry. With regard to robotics, it experienced growth in the automotive industry, allocating some of its resources to its own house technology projects for developing equipment and processes.

ENWESA’s activity at French EDF plants—especially to perform valve inspections—has been consolidated for several years now.

The company works on staff qualification on an ongoing basis through its training plans, which in 2018 amounted to more than 18,000 hours. It also kept its specific quality, environmental, occupational risk prevention and welding process certifications.

In 2019 ENWESA will increase its nuclear service business for managing irradiated fuel, including the loading of dry storage casks, and manufacturing and assembling nuclear components at new facilities and carrying out design modifications. In addition, it has maintenance projects at French and Belgian stations and in new markets in the field of industrial robotics.
Equimodal is a manufacturer of special containers solutions which it specifically designs to meet the end-use needs of each of its clients. It works for the transport, energy, industry and defense sectors. Some examples of its products and services are transformation centers, electrical rooms, waste transport, etc. Its products fall in the ETO (Engineer-to-Order) category, and its design department works hand in hand with every client to meet the needs of each of their projects. The company has brought container and content together under a single concept, thus turning the former into the installation itself such that transport and assembly in the field are solved.

In 2018 it invested most of its resources in R&D&I&H (homologation), engineering being the cornerstone of all the solutions it provided. Some of the new models it developed are those for a pressurized container, steel electrical rooms of special dimensions, a container for waste transport, an expandable control center, and power substations (e-houses). The company increased its international presence, with an outstanding entry into the French nuclear market -with tailor-made transport and storage projects-. Equimodal expects to increase its activity in 2019 thanks to specific international projects. At the same time, it will strive to gain a significant share of the Spanish nuclear market. It currently has several storage solution, turnkey industrial plant and transport optimization projects in the works.
The Centro Tecnológico de Componentes (CTC) is a Spanish private foundation whose mission is to provide value through the application of science and technology, designing advanced practical solutions for the industry and developing innovative technology transfer processes. For the nuclear sector it performs structural integrity analyses of state-of-the-art reactors under the ASME design codes and designs components and auxiliary tools for plants in accordance with the ASME, RCC-M, Eurocode and FEM codes.

In 2018 it worked on the analysis of rack handling tools and platforms with the aim of arriving at a new fuel assembly distribution inside an irradiated fuel pool to optimize its capacity. Alternatively, it conducted analyses on freshwater and seawater heat exchangers and participated in the numerical modeling of curved part forming processes.

During 2019 it will continue designing tools for handling and testing components for the nuclear industry; making calculations and analyses of the structural integrity of components; carrying out welding simulation processes; treating contaminated water to trap radioactive isotopes and developing composite materials with radiation barrier properties.
GD Energy Services (GDES) is a Spanish business group which has been providing industrial services for more than 85 years in different fields, such as industrial maintenance, radiation protection, surface treatment, nuclear facility dismantling, logistics, network maintenance, renewable energies and emergencies.

In 2018 GD Energy Services carried out a project on passive fire protections inside electrical conduits at Vandellós II NPP, and provided cleaning and decontamination services inside the controlled zone, carried out special cleaning tasks, cleaned the reactor vessel flange and decontaminated the cavity during the refueling outage of Trillo NPP. Apart from this, it won structural repair, pipe metallization, paint maintenance and structure protection contracts at Cofrentes. In addition, the company delivered two robotic arms for retrieving objects from the irradiated fuel pools of the Cofrentes and Almaraz stations. On the other hand, it was awarded paint maintenance contracts by French NPPs; it applied, for the first time in the history of the French nuclear industry, the metallization technique as the solution to the erosion and pitting problems in a heat exchanger. Furthermore, it won its first contract for the removal of deposits in the exchangers of the primary circuit cooling system at Blayais NPP and entered into a framework agreement for providing design and engineering services at the Scottish nuclear facility in Dounreay.

In 2019 GDES will continue to work for the Spanish nuclear industry. Furthermore, it plans to consolidate its coating and paint application and nuclear maintenance business in France, strongly develop its dismantling business in France and the U.K. and promote a new business line to support the movement of fuel, passive protections, penetration sealing and thermal insulation. In addition, it will continue with the dismantling work currently taking place at José Cabrera NPP through the Monlain Temporary Joint Venture. In France it will continue with its paint maintenance and metallization work and increase its presence in the ITER project. As far as the U.K. is concerned, it will honor all of its dismantling service framework agreements.
GE Hitachi Nuclear Energy (GEH) is a worldwide leader in the design of advanced reactors and the provision of nuclear services, and is headquartered in Wilmington, North Carolina, U.S.A. GEH was established in 2007 by means of a global alliance between GE and Hitachi to serve the global nuclear industry, executing a joint strategy to create a broader portfolio of solutions so as to increase its capacity to find new opportunities for building reactors and providing its services.

In 2018 it participated in the project for the segmentation and conditioning of control rods and fuel channels at Cofrentes NPP with a view to reducing the volume of waste; this project was carried out by a joint GEH and ENSA team.

Abroad, it won a contract for the supply of fuel to two of three BWR units of the Swedish plant Forsmark starting in 2020 through its Spanish subsidiary GENUSA -a company it jointly owns with ENUSA, at whose Juzbado plant the fuel will be manufactured. On the other hand, it was awarded a fuel supply contract for the next 18 refueling outages of one unit of Olkiluoto NPP in Finland.

In 2019 GEH will continue to be a leading technology company in the supply of fuel to and the provision of services at BWR plants around the world, and will try to achieve greater penetration of BWR fuel at European plants and use GE’s digital platforms to continue developing nuclear plant optimization solutions.
Geocisa (Geotecnia y Cimientos S.A.) was founded in 1968 and specializes in geotechnical investigations, special foundations, road management, infrastructure monitoring, restoration, environmental activities and the radiological characterization of nuclear power stations and facilities.

In 2018, its Nuclear Department executed, as the main laboratory, the Environmental Radiological Surveillance Plans (ERSP) at Vandellós I and José Cabrera NPPs -which are currently being dismantled- as well as at the El Cabril LLW and ILW disposal facility and, as a quality control laboratory, for Ascó and Vandellós II NPPs.

It also completed the pre-operational phase of the Centralized Temporary Storage Facility’s (ATC) ERPS as the main laboratory. As a support laboratory, it helped José Cabrera’s and Vandellós I’s radiological protection services in the area of radiological measurements for the characterization, declassification and release of land and surfaces and operated El Cabril’s Waste Quality Verification Laboratory.

Additionally, it carried out the radiochemical determinations relative to operational radiation protection and wrote the Offsite Dose Calculation Manual (ODCM), and acted as the offsite laboratory service to make quality control measurements for the site restoration process corresponding to José Cabrera NPP’s dismantling and decommissioning plan. It also took groundwater measurements in the area of the outfall pipe discharging liquid radioactive effluent into the sea (SROA) of the Vandellós I site, and was in charge of the radiological surveillance program of the CRI-9 Inert Recovery Center in Huelva. At Almaraz it performed the radiological characterization of samples with a low radioactive content for declassification purposes.

In the field of bioassay dosimetry, it continued monitoring the excreta of José Cabrera’s exposed workers as well as that of external workers at the Juzbado nuclear fuel manufacturing facility.

During 2019 it will carry on with all its long-term projects and consolidate its position as one of the main companies in the field of radiological measurement and characterization.
The Eulen Group was established in 1962 and soon thereafter became one of the first companies in the nuclear sector to offer a professional cleaning service. Its broad experience and the training it subjected its workers to have allowed it to specialize in different industries: nuclear, automotive, steel, industrial, petrochemical, pharmaceutical, supermarket, healthcare, agribusiness, transport, office building management, etc.

In 2018 Eulen continued to render diverse services to Spanish NPPs both in standard operation and during their refueling outages, among which the cleaning of radiological zones and offsite areas, the decontamination of areas and tools, the operation of hot laundries, the management and conditioning of radioactive waste, the erection of scaffolding, and the running of the fire protection brigade and the radiation protection service at Santa María de Garoña, Ascó, Vandellós I, Vandellós II and Almaraz NPPs, as part of a temporary joint venture with Proinsa, stand out.

During 2019 it will continue rendering the services it has been providing at Spanish NPPs to date and expand them to other nuclear facilities and carry out and participate in waste management projects at plants both in operation and in the pre-dismantling and dismantling stages.
Idom is an independent international company that provides professional engineering, architecture and consultancy services, carried out by a team of nearly 3,500 people in more than 120 countries. It is on a path of continuous growth in the sphere of professional services, which it provides with excellence, innovation and commitment as well as by training and facilitating the professional development of its employees.

In 2018 its Nuclear Services Department worked for Spanish NPPs carrying out technical assessment, engineering, project management and work supervision tasks during design modifications and specialized calculations. Among its main activities, it was still part of the lifetime management and long-term operation projects for Ascó, Vandellós II, Almaraz and Trillo, as well as in the Periodic Safety Review (PSR) of Ascó and Vandellós II. At Santa María de Garoña NPP it completed the design and supervision of the construction work on the Individualized Temporary Storage Facility as well as the I&C engineering associated with the first pre-dismantling works. At Vandellós II, it came up with the re-racking engineering design for the irradiated fuel pool, while at Ascó it performed digital modeling services. On the other hand, it got involved in the IFMIF-DONES Project working for CIEMAT and began providing specialized support in the field of CFD (computational fluid dynamics) simulations for high-volume radioactive waste casks.

Idom expanded its international presence by winning contracts in Argentina, Chile, Brazil, Bulgaria, Slovenia, France, Turkey, Israel and the U.K. In Slovenia it continued providing engineering services and supplying components for the emergency control room at the Krško plant, in partnership with Tecnatom. As part of the ITER project, it worked on thermal hydraulic studies of the vacuum vessel, designed the diagnostic ports, supported the supervision of civil works and supported the contractual management.
Other noteworthy projects at the international level were providing technical support in the analysis of stresses in piping and primary and secondary systems of ATMEA reactors and Generation III+ EPRs, modeling an experimental reactor with neutron analysis codes in France and contributing to the Jules Horowitz Reactor project by designing of test bench.

In 2019 Idom will keep working in projects for Spanish NPPs, such as those pertaining to life management, safety studies and design modifications, and participating in the ITER project by carrying out advanced studies and design and work management and supervision activities. It will also carry on with its process of internationalization by participating in large projects for the construction of new plants, as well as consolidating its position in the dismantling and waste management sector, among other fields.
Newtesol is a company specializing in weld overlay cladding and hardfacing of all kinds of parts, including parts with complex shapes, using stainless steels and nickel alloys. It also manufactures components capable of withstanding pressures of up to 100 t, steam generator internals, pressure vessels, tanks and heat exchangers, spools and diverse casks for radioactive waste. It has the ASME U, U2, RCC-M and NPT stamps, as well as that of the NQA-1 quality system.

In 2018 the company received the Operational Experience Award in the category of SMEs at the Paris World Nuclear Exhibition for its developments in automated hardfacing processes. In addition, its ASME NPT nuclear certification was renewed for the third time.

Its new workshop, dedicated to the manufacture of high value-added nuclear components and capable of manufacturing equipment weighing up to 50 tonnes, will be fully operational in 2019.
Nusim, a company that provides technology solutions, comprises four divisions (radioactive waste, radiation protection, health and safety instrumentation and automation), all supported by their corresponding maintenance areas. It provides high-quality products and services to a wide range of clients, including nuclear power plants, government bodies, hospitals, universities, laboratories and other specialized industries. It has a quality system in place that meets the requirements of the UNE 73401:95, ISO 9001:2015 and ISO 14001:2015 standards, and has been certified by GES and Enresa.

In 2018 Nusim carried out startup work, supported the commissioner and trained the operations personnel of the NORM Waste Solidification Plant in Abu Dhabi, in connection with both plant equipment and all the radiation protection equipment it supplied.

In addition, it started the design phase for seven package handling units for the Monolith Production Facility (Belgoprocess -Ondraf/Niras), via the company Montair Process Technologies, covering equipment for handling drums (of up to 3 t) and concrete containers (of up to 40 t).

It developed new technical solutions for handling and turning drums that allow them to be stored vertically and horizontally, new autonomous equipment for CMT casks and Big-Bags that allow remote, installation-less operation from cranes or forklifts, and an extensive catalog of accessories and improvements for equipment already in place, such as lid handling accessories, drum turning rigs, etc.

In 2019 Nusim will work to develop for Iberdrola a prototype for removing exchanger tubes for decontamination purposes. The company will finish the engineering work for the seven package handling units for the Monolith Production Facility before they are actually manufactured, and complete the appropriate tests and supplies, throughout the year. Nusim will develop a special piece of equipment for internally transporting packages at Enresa’s El Cabril facility. In addition, it will continue to supply its radiation protection, handling, compaction, microwave volume reduction and liquid treatment equipment in Spain and other countries.
Proinsa is a company that is part of the Eulen Group and, as a Radiation Protection Technical Unit (RPTU), provides radiation protection services at nuclear and radioactive facilities, in addition to environmental protection services to large companies in the nuclear, chemical, steel and healthcare industries. It also provides material management and fire protection services at nuclear power plants.

In 2018 Proinsa provided its radiation protection services at Ascó, Vandellós II and Santa María de Garoña NPPs both in operation and during their refueling outages. It also provided its services as a RPTU for Enresa, carried out material management activities at Santa María de Garoña and provided fire protection services at both this plant and Almaraz.

Furthermore, at Spanish NPPs it provided services pertaining to nuclear and radiological emergencies and to the collaboration protocol for the radiological surveillance of metallic materials, and continued to give the staff of radioactive facilities diverse radiological protection courses -some specific to nuclear power plants and some monographic for different official institutions.

During 2019 it will carry on with the activities and projects it carried out in past years in the fields of radiation and environmental protection both at Spanish nuclear power plants and for different official bodies.
Ringo Válvulas is a manufacturer of valves up to nuclear class CN1 for the nuclear island and the BoP, for both ON/OFF service (gate, globe, bellows-sealed globe, check, butterfly, ball, and diaphragm) and control service (with box-guided globe valves). It has the ASME III N & NPT stamp certification for the manufacture of nuclear valves and broad supply experience thanks to its being present at 40+ nuclear power plants in 18 countries across Europe, America, Asia and Africa.

In 2018 Ringo Válvulas supplied valves and spares to all Spanish NPPs in operation, maintaining the turnover level of previous years.

The company continued its expansion process in the international nuclear market by winning its first contract from the Khmelnitskaya and Rivne III plants in Ukraine and getting its first order from the British Sizewell plant. The Russian nuclear market has been essential for Ringo, where it has won new contracts, while maintaining its presence in the Belgian, Nordic, Slovak and Slovenian markets.

In 2019 Ringo Válvulas expects to increase its turnover in the nuclear sector by stepping up its activity in the Spanish, Russian, Belgian and Turkish markets. In order to strengthen its presence in Sweden, the company will teach valve training courses to engineers from Forsmark and Ringhals NPPs.
Taim Weser has extensive experience in the worldwide supply of special bridge cranes and gantry cranes for handling intermediate- and high-level nuclear waste and nuclear fuel in both new plant construction and plant decommissioning projects. It carries out its projects according to its clients’ specific requirements and the principles of safety, high performance, precision of movements, low maintenance and operating costs, and maximum availability.

In 2018 Taim Weser continued carrying out the project to supply a set of high integrity out-cell nuclear bridge cranes for the British nuclear waste treatment center of Sellafield. This is a project with a 10-year completion deadline and where the cranes have been designed to be able to lift and move large nuclear packages, a process in which stability and robustness are critical to plant operations.

The company has strengthened and consolidated its alliances with its partners to take part in future international tenders in Europe, South America and Asia. Its assembly and after-sales department inspected, serviced and replaced components in units it has installed in British and Japanese nuclear stations.

During 2019 Taim Weser will continue to develop the out-cell crane project for the Sellafield center and will take part in several international tenders in Europe and Asia. Apart from that, it will keep on doing technical inspection, maintenance and technical assistance work for its clients, providing them with the latest technological advances in this field, such as technical inspections with drones, which significantly reduce inspection time and costs.
Tecnatom is an engineering firm with 60+ years of experience whose mission is to guarantee that nuclear power plants are operated and serviced to the highest level of safety. Its main activities revolve around component and structural integrity inspection, personnel training in advanced training environments, and support engineering for plant operation. Moreover, it is an international group that has subsidiaries in the U.S., France, Brazil, Mexico, China and the United Arab Emirates and projects in the energy, petrochemical, process industry and aerospace sectors in 20+ countries.

In 2018 it carried on with its strategic product and service diversification initiative. The Spanish market is still the foundation of all its business lines, where it has consolidated its position thanks to its ongoing innovation efforts. Staff training and the tasks it performs during refueling outages, as well as the projects for the second part of the nuclear cycle, as regards both irradiated fuel management and plant dismantling, represent the bulk of its activity.

As far as its international activities are concerned, it created the FarField company in the U.S. to provide inspection services in high technology industrial sectors, whereas the operations of its subsidiary Tecnatom Abu Dhabi, which is focused on the U.A.E.’s nuclear program, stand out in the Middle East. Additionally, it was chosen by Horizon Nuclear Power to be its strategic partner for training the entire staff at Wylfa NPP in the U.K., and stroke alliances with AMEC Foster Wheeler, the Technology Institute of Monterrey (Mexico) and Inprocess in the oil sector.

During 2019 Tecnatom will continue to develop new projects at Spanish NPPs to permit a more efficient and effective training of operations personnel through digital transformation and the use of new interactive platforms as well as the online monitoring of critical components.

In the international market, it will keep talking part in the development of new reactors of very different technologies (HPR1000, AP1000, VVER 1200, ABWR and SMR) and in different projects for developing new reactors in countries in Spain’s sphere of influence such as Hungary, Finland, Turkey and the U.K., as well as in collaboration with Russian and Chinese companies to help them to develop their domestic markets.
Virlab conducts dynamic vibration tests on all kinds of electrical, mechanical and instrumentation equipment. It has carried out at its Asteasu (Guipúzcoa) facilities more than 2,800 vibration tests for the nuclear, non-nuclear seismic, railway and wind power sectors, among others. It has several test racks, the largest having a test surface area measuring 2,500 mm x 2,500 mm, and electrodynamic exciters which can generate vibrations of up to 2,000 Hz and accelerations of up to 60 G and have a useful surface area of 750 mm x 750 mm.

In 2018 the company performed the seismic qualification of diverse components for Ascó, Vandellós II, Alamarz and Trillo NPPs, Belgian and French nuclear power plants and the British nuclear power station Hinkley Point.

It also took part in the seismic qualification of electrical equipment for the ITER project and the Jules Horowitz research reactor.

In 2019 it will disclose its capabilities to companies in the Turkish capital goods sector, purchase a new 110 kN electrodynamic rack with a useful surface area of 2,000 mm x 2,000 mm, and design and build a new 300 kN biaxial table with 3,000 mm x 3,000 mm of useful surface area.
Westinghouse is a multinational company that has been present in Spain for more than 45 years. Not only does it support Spanish nuclear power plants and facilities, but it also leads and collaborates in a multitude of projects all over the world from its Spanish headquarters. In addition to its capabilities as the designer of the nuclear steam generation system (NSSS) of PWRs, it has also acted as architect-engineer both in design and modifications and in the engineering and management of dismantling projects. In addition, it has capabilities in BWRs and in VVERs of Soviet design.

In 2018 Westinghouse Electric Spain led the consortium that was awarded the contract for dismantling the two VVER-440 units of the Slovak Bohunice V1 nuclear power plant, where it will be in charge of both the project’s management and the main dismantling engineering tasks. It also won the contract for drawing up the decommissioning plan for the South Korean nuclear power plant of Kori. Westinghouse Electric Spain’s support during the construction of the new Vogtle nuclear units in the U.S. stands out at the international level.
Within Spanish borders, it took part in the engineering projects for supporting the operation of Ascó and Vandellós II NPPs and El Cabril LLW and ILW disposal center, in the refueling activities carried out at Almaraz, Ascó and Vandellós II, and in various long-term projects with Enresa.

In 2019, Westinghouse Electric Spain will head the temporary joint venture for providing engineering services during the dismantling of Santa María de Garoña NPP, thus expanding the knowledge it has acquired in past international dismantling projects, and carry on with its engineering, inspection and modification activities associated with the continued operation of Spanish nuclear power plants.
5 MAIN EVENTS AROUND THE WORLD
As of December 31, 2018, there were 450 reactors in a position to operate in 31 countries around the world. 2,575,28 TWh of electricity of a nuclear origin were produced, which amounts approximately to 11,5% of the all the electricity consumed worldwide. Another 55 new reactors were under construction in 16 countries.

**DURING 2018**

5 reactors began to be built in 2018:
- **Bangladesh**: Unit 2 of Rooppur NPP, a 1,200 MWe VVER-523 PWR.
- **South Korea**: Unit 6 of Shin-Kori NPP, a 1,400 MWe APR-1400 PWR.
- **U.K**: Unit 1 of Hinkley Point C NPP, a 1,720 MWe EPR-1750 PWR.
- **Russia**: Unit 1 of Kursk 2 NPP, a 1,255 MWe VVER-V-510 PWR.
- **Turkey**: Unit 1 of Akkuyu NPP, a 1,200 MWe VVER-V-509 PWR.

9 reactors were connected to the grid in 2018:
- **China**: Units 1 and 2 of Haiyang HPP (two 1,250 MWe AP1000 PWRs), Units 1 and 2 of Sanmen NPP (two 1,200 MWe AP1000 PWRs), Unit 1 of Taishan NPP (a 1,750 MWe EPR-1750 PWR), Unit 4 of Tianwan NPP (a 1,125 MWe VVER-V-428M PWR) and Unit 5 of Yangjiang NPP (a 1,086 MWe ACPR-1000 PWR).
- **Russia**: Unit 1 of Leningrad 2 NPP (a 1,187 MWe VVER-V-491 PWR) and Unit 4 of Rostov NPP (a 1,030 MWe VVER-V-320 PWR).

7 reactors were permanently shut down in 2018:
- **U.S.A**: Oyster Creek NPP, a 650 MWe BWR.
- **Japan**: Unit 2 of Ikata NPP (a 566 MWe PWR) and Units 1 and 2 of Ohi NPP (two 1,175 MWe PWRs).
- **Russia**: Unit 1 of Leningrad NPP, a 1,000 MWe RBMK-1000 LWGR.
- **Taiwan**: Units 1 and 2 of Chinshan NPP, two 635 MWe BWR-4 BWRs.

Four reactors were reconnected to the grid in 2018:
- **Japan**: Units 3 and 4 of Genkai NPP (two 1,180 MWe PWRs) and Units 3 and 4 of Ohi NPP (two 1,180 MWe PWRs).
<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>REACTORS IN A POSITION TO OPERATE</th>
<th>REACTORS UNDER CONSTRUCTION</th>
<th>REACTORS SHUT DOWN</th>
<th>ELECTRICAL PRODUCTION OF NUCLEAR ORIGIN (TWh)</th>
<th>ELECTRICITY OF NUCLEAR ORIGIN (%)</th>
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<td><strong>TOTAL</strong></td>
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Data valid as of December 31, 2018 / Source: PRIS-IAEA and Foro Nuclear
Continuity of operation consists in the operation of a nuclear power plant, maintaining its safety level, beyond the period that was initially considered in its design. It is a common practice in different countries around the world and constitutes a sound and realistic strategy for simultaneously meeting the basic aspects of sustainable development, since it guarantees the independence and diversification of the energy supply and helps to combat climate change.

Various international studies show that it is technically feasible to operate nuclear power plants beyond their design life while maintaining the levels of safety and reliability required by national and international law.

Thus, as of December 31, 2018, there are 142 nuclear reactors in the world that have been authorized by the different regulatory bodies to operate for 40+ years. They account for more than 30% of the world’s existing nuclear reactors and are distributed as follows:

(*): These four reactors have been shut down since March 2011
Data valid as of December 31, 2018 / Source: Foro Nuclear with data from PRIS-IEAA, NEA, NRC, Rosatom, CNSC, ENSI, HAEA, FANC, NRA/Jaif, STUK, SJUB, SNRC, EPZ and ASN
REACTORS IN A POSITION TO OPERATE AND UNDER CONSTRUCTION THROUGHOUT THE WORLD

REACTORS IN EUROPE
There are 183 reactors in operation and 14 under construction in Europe.

Data valid as of December 31, 2018 / Source: PRIS-IAEA and Foro Nuclear
**REACTORS IN AMERICA**
There are 124 reactors in operation and 4 under construction in America.

**REACTORS IN ASIA**
There are 141 reactors in a position to operate and 36 under construction in Asia.

**IN AFRICA** there are two reactors in operation (Units 1 and 2 of Koeberg NPP, South Africa) and there are none being built.

Data valid as of December 31, 2018 / Source: PRIS-IAEA and Foro Nuclear
NOTEWORTHY REPORTS FROM INTERNATIONAL BODIES PUBLISHED DURING 2018

THE INTERNATIONAL ENERGY AGENCY’S 2018 WORLD ENERGY OUTLOOK REPORT

In November, the International Energy Agency (IEA) published a new edition of its World Energy Outlook 2018, report, in which it states that a lack of investment in both the continued operation of current nuclear reactors and the construction of new units could have serious consequences for the guaranteeing of the supply of electricity and the achievement of international environmental objectives.

The IEA says that “major transformations are taking place in the global energy sector, from the growth of electrification to the expansion of renewable energies, turbulences in oil production and the globalization of gas markets. The political decisions made by governments will determine the shape of the future energy system, in all regions and for all fuels.”
The report considers three scenarios for the world energy mix in 2040: the New Policies Scenario, which considers the impact of new government policies and commitments on demand, supply and investment; the Current Policies Scenario, which only takes approved policies into account, thereby providing a comparison standard and the Sustainable Development Scenario, which includes the energy goals set by the international community by means of the United Nations’ 2030 Agenda for Sustainable Development.

Nuclear power generation increases in all three scenarios. In the New Policies Scenario, it will jump from the 2,637 TWh generated in 2017 to 3,726 TWh in 2040, amounting to 9% of the total electricity demand. The predominance of fossil fuels will continue, but their share will fall from the current 66% to less than 50%. In the Current Policies Scenario, it will increase to 3,079 TWh by 2025 and 3,648 TWh by 2040, representing 8.5% of total electricity demand. In the Sustainable Development Scenario, it will rise to 3,303 TWh by 2025 and 4,960 TWh by 2040, or a 13.5% share of the total.

The IEA states that the extension of the useful life of reactors in operation “is not guaranteed due to significant challenges: The situation of the markets is creating stressful financial conditions for both existing reactors and investing in new ones.”

The report warns that “a substantial decrease of nuclear power-which generates electricity on a zero-emissions basis-will have serious consequences for the energy mix, the security of supply and the evolution of polluting emissions. A major geographical shift in the commitment to nuclear energy is going to take place. In all probability, by 2040 61 GW of installed power will be lost in the U.S., 102 in the E.U. and 33 in Japan, but 111 GW will be added in China (there are currently 37 GW), 32 in India (7 GW) and 11 in Russia (28 GW). To counter this, an average annual investment of USD 47,000M is needed until 2040 to both ensure the continued operation of current nuclear power plants and build new reactors. Globally, the world energy sector will require an investment of two trillion dollars per year, of which more than 70% will have to be made by governments.
THE URANIUM 2018: RESOURCES, PRODUCTION AND DEMAND REPORT FROM THE IEA AND THE IAEA

In December, the OECD’s Nuclear Energy Agency (NEA) and the UN’s International Atomic Energy Agency (IAEA) presented their biennial Uranium 2018: Resources, Production and Demand report. The 27th edition of the also known as Uranium Red Book shows the fundamental aspects of the global uranium market and presents a statistical compilation with data from 41 uranium producing and consuming countries.

The report indicates that global uranium production is more than sufficient to meet future demand, irrespective of the role nuclear power plays in the future in meeting growing electricity demand and climate targets. However, significant investments and technical expertise will be required to ensure that the reserves are put into production on time, including those mines which are currently undergoing maintenance and redesign.
The world’s identified uranium reserves amount to 6.14 million tonnes in the form of uranium metal (tU), with a cost of up to $130 per kilogram. This represents a 7.4% increase with respect to the previous report thanks to the discovery of new deposits and the revaluation of others that had been identified already.

Current world demand for uranium -for 450 reactors with an installed power of 391 GW that output about 11% of all electricity consumed in the world exceeds 62,800 tonnes per year, which means there are reserves for about 100 years. According to the NEA and the IAEA, and owing to the policies of the different countries, the installed power is expected to range from 331 GW -in a low growth scenario- to 568 GW -in a high growth scenario- by 2035, thus causing future demand to come to between 53,000 and 90,800 tU per year.

The largest reserves are in Australia (30%), Kazakhstan (14%), Canada and Russia (8% each), Namibia (5%) and Brazil, China, Niger and South Africa (5% each). The biggest producers in 2016 were Kazakhstan, with 40%, Canada, with 23%, and Australia, with 10%, the world total standing at 62,000+ tU, a 3% increase over the previous year.
As of December 31, 2018, **14 out of the 28 Member States of the E.U. had nuclear power plants in operation**. There were 126 reactors in operation altogether, which produced over the year about 26% of all the electricity consumed in the E.U. as a whole. Another 5 were under construction in 4 countries (Finland, France, Slovakia and the U.K.).

**5.1 EUROPEAN UNION**

The 126 reactors in operation in 14 of the 28 E.U. Member States generate 26% of all electricity.

**REACTORS IN THE E.U.**

- **Operation**
- **Construction**

Data valid as of December 31, 2018 / Source: PRIS-IAEA and Foro Nuclear
BELGIUM

During 2018, the 7 nuclear reactors in operation in Belgium produced 27,01 TWh, 39% of all the electricity consumed in the country. On the other hand, there is 1 reactor shut down.

In March, the Belgian government approved a new energy strategy that will lead the country to close its seven nuclear power stations between 2022 and 2025 and which also contemplates the allocation of investments to renewable energies, offshore wind farms in particular.

The Belgian Nuclear Forum (Forum Nucléaire) has nevertheless warned that the gradual phasing out of nuclear energy will harm the country’s chances of achieving its climate objectives, stressing that emissions would triple by 2050 in a scenario without any nuclear plants.

BULGARIA

During 2018, the 2 nuclear reactors in operation in Bulgaria produced 16.12 TWh, 34.66% of all the electricity consumed in the country. On the other hand, there are 4 reactors shut down.

In June, the Bulgarian government annulled a previous government decision from 2012 -following a previous request from Parliament, which put an end to the project for the construction of the Belene nuclear power plant. For all intents and purposes, this decision means that this project may be reactivated. Parliament gave a mandate to the Ministry of Energy to search for new funding formulas, in cooperation with a strategic investor, but without state guarantees.

The Belene project was originally proposed by the Communist government in the 1980s, but was brought to a halt in the early 1990s due to environmental and financial concerns. It was revived in 2008, but again abandoned in 2012 by decision of the government in power at the time.
During 2018, the 4 nuclear reactors in operation in Finland produced 21.88 TWh, 32.45% of all the electricity consumed in the country. On the other hand, there is 1 reactor under construction.

In September, the Finnish government approved renewing the operating licenses of Units 1 and 2 of Olkiluoto NPP till 2038. This decision follows another one made by the regulatory body in May which concluded that the plants are safe to operate, that their operation is in accordance with the law and that the company that owns and operates the plant -TVO- has the experience and resources to operate the units.

Olkiluoto’s two reactors meet about one-sixth of Finland’s electricity demand. Olkiluoto-1 is a 910 MWe BWR that began commercial operation in October 1979, whereas Olkiluoto-2, a 920 MWe BWR, went into service in July 1982.
FRANCE

During 2018, the 58 nuclear reactors in operation in France produced 393,20 TWh, 71,67% of all the electricity consumed in the country. Furthermore, there is 1 reactor under construction and 12 are shut down.

There have been several changes in the structure of the public companies that make up the French nuclear industry throughout the year. Thus, EDF bought Areva’s reactor construction division and renamed it Framatome. Moreover, the state-run New Areva group, which focuses on uranium mining and the different phases of nuclear fuel fabrication, was renamed Orano.

In June, the French nuclear regulator (Autorité de Sûreté Nucléaire, or ASN) decided to intensify its oversight of the production process for nuclear equipment and components as a result of the series of methodological discrepancies in manufacturing detected in 2015 at the Le Creusot large forged and cast parts factory.

ASN stated that the new measures will include strengthening the arrangements that must be made by manufacturers and licensees, which are still responsible for the quality of manufacturing and operations; employing external inspection bodies to support the supervision of all manufacturing activities; improving inspection methods; requiring that all irregularities detected be systematically reported; and introducing a system for collecting alerts from whistleblowers.

In July, EDF admitted that the costs of building Unit 3 of the Flamanville plant, an EPR under construction in northern France since 2007, went up from €10.5B to €10.9B, and that there was now an expected delay of one year in the first fuel loading, until 2019 4Q, owing to the safety checks that had to be made after defects were discovered in the secondary circuit welds.
U.K.

During 2018, the 15 nuclear reactors in operation in the U.K. produced 59,09 TWh, 17.72% of all the electricity consumed in the country. On the other hand, there is 1 reactor under construction and 30 are currently shut down.

There is still no official confirmation of the U.K.’s withdrawal from the European Nuclear Energy Community (Euratom) as a result of Brexit.

In November, Toshiba confirmed its plans to liquidate NuGeneration, the company that heads the project for the construction of three AP1000 units at the Moorside station in Cumbria, in the northwest of England.

Likewise, Hitachi and its subsidiary Horizon Nuclear Power have announced that they will likely cancel the project for the construction of two advanced boiling water reactors at the Wylfa Newydd site on the island of Anglesey in North Wales, as they were running into funding problems.

In December, the joint venture between EDF Energy and China General Nuclear officially began construction of Unit 1 of the Hinkley Point C station in Somerset, in the southwest of England, an EPR APWR with an installed electric power of 1,720 MWe that is expected to be put into service in 2025.
5.2 U.S.A.

During 2018, the 98 nuclear reactors in operation in the U.S. produced 807,08 TWh, 19.32% of all the electricity consumed in the country. On the other hand, there are 2 reactors under construction and 35 shut down.

In April, the U.S. Nuclear Regulatory Commission (NRC) authorized the issuance of combined construction and operating licenses to Florida Power & Light (FPL) for two new Westinghouse AP1000 APWRs at the Turkey Point site in the state of Florida, some 30 km south of the city of Miami. The NRC considers that the review of FPL’s application, which the company submitted in June 2009, is correct from the points of view of safety and environmental friendliness.

Environmental regulations and nuclear power

In April, the New Jersey State Senate and Legislature passed two bills to compensate the facilities that produce electricity without carbon emissions in the event the Hope Creek and Salem nuclear plants are shuttered. Just as the states of New York and Illinois had already done in 2016, a Zero Emissions Credits (ZEC) program was set up which recognizes the value of clean energy sources through a system of clean energy credits.
Renewal of operating licenses

In the United States operating licenses are granted for a 40-year period from the start of operation of plants. Subsequently, and after at least 20 years since the beginning of commercial operation, the owners of the plants may apply for the renewal of the operating license for a further 20 years. Once this license is granted for a total of 60 years in operation, they can submit the so-called subsequent application for renewal of the operating license for another 20 years, the plant’s operating life thus totaling 80 years.

In 2018, and continuing with the process initiated in 2000 with the two units of Calvert Cliffs NPP, the NRC renewed the operating licenses of the following 4 reactors for an additional period of 20 years:

- **Unit 2 of Indian Point NPP**, a PWR of 1,067 MWe of gross installed power, which went into commercial operation in August 1974 and has been authorized to operate until April 30, 2024.

- **Unit 3 of Indian Point NPP**, a PWR of 1,085 MWe of gross installed power, which went into commercial operation in August 1976 and has been authorized to operate until April 30, 2025.

- **River Bend NPP**, a PWR of 1,016 MWe of gross installed power, which went into commercial operation in June 1986 and has been authorized to operate until August 29, 2045.

- **Unit 3 of Waterford NPP**, a PWR of 1,250 MWe of gross installed power, which went into commercial operation in September 1985 and has been authorized to operate until December 18, 2044.
Thus, by the end of 2018 the NRC had renewed the operating licenses of 90 out of the 98 reactors in operation in the country. Another application is under review, and it is expected that a further 4 applications will be submitted in the next five years.

In 2018, the subsequent applications for the renewal of the operating license for a total of 80 years in operation were submitted by Units 3 and 4 of Turkey Point NPP, Units 2 and 3 of Peach Bottom NPP and Units 1 and 2 of Surry NPP.

In the power uprate plans, a 20% margin is calculated for BWRs and of 10% for PWRs. All in all, the NRC has approved 164 power uprates since the early 1970s, for a total increase of 23,769 MWt and an overall electrical power of 7,923 MWe, which equates to eight new units.

In 2018, Unit 1 of Hope Creek NPP was granted a power uprate authorization, which added 62 MWt to its gross installed power, which now stands at 1,240 MWe.
5.3 ASIA

CHINA

During 2018, the 46 nuclear reactors in operation in China produced 286.5 TWh, 4.22% of all the electricity consumed in the country. On the other hand, there are 11 reactor under construction.

Six new reactors began their commercial operation over the year. In addition to this figure, which is particularly high, it should be noted that these are projects based on different technological models: Russian, French, American and, for the first time, Chinese.

The world’s first Westinghouse AP1000 APWR -Sanmen-1- began commercial operation in September, whereas the world’s first Areva EPR - Taishan-1- did so in December.

SOUTH KOREA

During 2018, the 24 nuclear reactors in operation in South Korea produced 127.07 TWh, 23.67% of all the electricity consumed in the country. On the other hand, there are 5 reactors under construction and 1 is shut down.

In June, Korea Hydro and Nuclear Power (KHNP) announced that it will close Unit 1 of Wolsong NPP in 2022, before it reaches the milestone of 40 years of operational life. It is a PHWR with a gross installed power of 683 MWe that began producing electricity on a commercial basis in April 1983. This decision is in line with the plans announced in 2017 by the South Korean government to reduce nuclear power’s contribution to the country’s energy mix.

Similarly, KHNP will abandon its plans to build four new units at two sites on the southeast coast: Cheonji and Deajin.
Out of the 39 Japanese reactors, only 9 Units were operation in 2018, which produced 49,19 TWh, 6.20% of all the electricity consumed in the country. On the other hand, there are 2 reactors under construction and 21 shut down.

The Japanese government deems nuclear energy an important source of energy and wants it to produce 20% of the country’s electricity by 2030.
Of the 9 reactors in operation, Units 3 and 4 of Genkai NPP were respectively reconnected to the grid in March and June, while Units 3 and 4 of Ohi NPP were respectively reconnected in March and May, thereby joining Units 3 and 4 of Takahama NPP, which had done so in May and June 2017 respectively, Units 1 and 2 of Sendai NPP, in September and November 2015 respectively, and Unit 3 of Ikata NPP, in August 2016.

**In June, the Japanese government promised that nuclear power would account for at least 20% of the electricity supply by the tax year 2030,** calling it an “important and essential source of energy,” according to its basic energy planning project, which lays down the government’s energy policy in the medium and long terms and is reviewed every three years. According to the Government, this target is achievable if existing reactors are allowed to operate for 60 years—beyond the 40 years of life set by the strict rules that were approved in the wake of the Fukushima-Daiichi accident of March 2011.

The Japanese Atomic Industrial Forum (JAIF) has stated that some 30 reactors should be put back into operation in order to reach the minimum goal of 20%.

**TAIWAN**

During 2018, **the 4 nuclear reactors in operation in Taiwan produced 26,65 TWh, 11.43% of all the electricity consumed in the country.** On the other hand, there are 2 reactors under construction and 2 shut down.

In December, the Taiwanese government announced that it had agreed to scratch its earlier objective of becoming a nuclear-free country by 2025. The announcement followed on the heels of a referendum that was held in November, in which Taiwanese people overwhelmingly rejected ditching nuclear power (59% vs. 41%).
5.4 OTHER COUNTRIES WITH NUCLEAR PROGRAMS

SAUDI ARABIA

In March, the Saudi government approved developing a nuclear program, with all the necessary activities within the limits set by international treaties. Saudi Arabia, the world’s largest oil exporter, wants to diversify its energy supply by means of nuclear power. In order to do so, it is keen to reach civil nuclear cooperation agreements with companies from different countries. It has already received bids for engineering works, the procurement of equipment and systems and the construction of its first two reactors from five bidders from China, France, the U.S., South Korea and Russia.

UNITED ARAB EMIRATES

There are 4 reactors under construction in the U.A.E. The Emirates Nuclear Energy Corporation (ENEC) is building four APR-1400 APWRs of South Korean design with an installed power of 1,400 MW at the Barakah site.

In March, the Crown Prince of Abu Dhabi and the President of South Korea presided over the official ceremony of completion of the construction of Unit 1. As of then, Units 2, 3 and 4 were 92%, 81% and 66% complete respectively and 86% as a whole. Once the 4 reactors are in operation, they will produce 25% of the electricity consumed in the country.
RUSSIA

During 2018, the 36 nuclear reactors in operation in Russia produced 191,33 TWh, 17.87% of all the electricity consumed in the country. On the other hand, there are 6 reactors under construction and 7 shut down.

During the year, construction began on Unit 1 of Kursk 2 NPP, a VVER-V-510 PWR of 1,250 MWe of gross installed power, which is expected to come into service in 2023. In addition, two units-reactor 1 of Leningrad 2 NPP, and Unit 4 of Rostov NPP—were connected to the grid.

In July, Kola-1 was granted a license to operate until 2033, thus hitting 60-year mark since it began commercial operation in December 1973. This is the twelfth Russian reactor to receive such a license.
**SWITZERLAND**

During 2018, the 5 nuclear reactors in operation in Switzerland produced 24.49 TWh, 37.73% of all the electricity consumed in the country. On the other hand, there is 1 Swiss reactor shut down.

In March, **Unit 1 of Beznau NPP was reconnected to the grid** after the Swiss regulator -the Federal Nuclear Safety Inspectorate (ENSI)- approved the safety report submitted by its owner (Axpo). The plant was shut down following the discovery in 2015 of signs of defects in the reactor pressure vessel. ENSI pointed out that Axpo had performed numerous in-depth analyses to demonstrate the safety of the vessel.

Beznau-1 NPP, which is equipped with a PWR of 380 MWe of gross installed power, began commercial operation in December 1969 and is the oldest plant currently running in the country. It has a license to operate indefinitely.

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**Swiss Beznau 1 nuclear power plant has a license to operate indefinitely**
In April, the Turkish government confirmed to the IAEA the official commencement of the construction of the Akkuyu nuclear power plant - following the granting of the construction license by the Turkish Atomic Energy Authority.

The project consists of four Russian-designed APWRs - for a total power of 4,800 MWe, which are scheduled to enter commercial operation in 2026. The site is located on the Mediterranean coast, 500 km south of Ankara.

Turkey is the fourth country in the world that has launched a nuclear program in the last seven years, after the U.A.E. (2012), Belarus (2013) and Bangladesh (2017).
MEMBERS
OF FORO
NUCLEAR
ORDINARY MEMBERS

AMPHOS 21
CEN SOLUTIONS
CENTRAL NUCLEAR DE ALMARAZ
CENTRAL NUCLEAR DE ASCÓ
CENTRAL NUCLEAR DE COFRENTES
CENTRAL NUCLEAR DE TRILLO
CENTRAL NUCLEAR DE VANDELLÓS II
CENTRO TECNOLÓGICO DE COMPONENTES
COAPSA CONTROL
EDP
EMPRESARIOS AGRUPADOS
ENDESA
ENSA
ENUSA INDUSTRIAS AVANZADAS
ENWESA
EQUIMODAL
EULEN

GD ENERGY SERVICES
GE-HITACHI NUCLEAR ENERGY
GEOCISA
GHESA INGENIERÍA Y TECNOLOGÍA
IBERDROLA
IDOM CONSULTING, ENGINEERING & ARCHITECTURE
NATURGY
NEWTESOL
NUCLENOR
NUSIM
PROINSA
RINGO VÁLVULAS
TAIM WESER
TECNATOM
VIRLAB
WESTINGHOUSE ELECTRIC SPAIN
AEC (Asociación Española para la Calidad)
AMAC (Asociación de Municipios en Áreas de Centrales nucleares)
Aseguradores de Riesgos Nucleares
CEMA (Club Español del Medio Ambiente)
Colegio Oficial de Ingenieros de Minas del Centro de España
Consejo Superior de Colegios de Ingenieros de Minas de España
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Fundación Empresa y Clima
OFICEMEN (Agrupación de fabricantes de cemento de España)
SEOPAN (Asociación de Empresas Constructoras y Concesionarias de Infraestructuras)
SERCOBE (Asociación Nacional de Fabricantes de Bienes de Equipo)