



Nuclear energy in Spain - historical development and perspectives

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Outline:

- Development of the nuclear path in Spain (regarding shares in power production and number of nuclear power plants (NPPs))
- Initial phase I (1945-1955/56) & II (1955/56-1968)
- Nuclear (planning) boom & 1st / 2nd generation NPPs (1968 – 1983)
- civil opposition against nuclear power in Spain since 1973
- Nuclear moratorium & related subsidies (1984; 1994/95 onwards)
- Present and future of nuclear power in Spain
- Nuclear energy in Spain after Fukushima
- The related risks of nuclear energy 1:
Most important incidents/accidents in Spain's nuclear history
- The related related risks of nuclear energy 2: Spain's secret nuclear weapon programme (1963-1981)

Development of the nuclear path in Spain -1-:

Share of nuclear power in gross electricity production in Spain 1968-2010 (UNESA 2011)

Year	Share in %	Year	Share in %
1968	0.1	1990	35.8
1969	1.6	1991	34.9
1970	1.6	1992	34.6
1971	4.0	1993	34.8
1972	6.9	1994	33.5
1973	8.6	1995	32.8
1974	8.9	1996	31.9
1975	9.1	1997	29.2
1976	8.3	1998	30.0
1977	6.9	1999	28.0
1978	7.7	2000	27.6
1979	6.3	2001	26.8
1980	4.7	2002	25.5
1981	8.6	2003	23.3
1982	7.6	2004	22.6
1983	9.1	2005	19.5
1984	19.2	2006	19.9
1985	22.0	2007	17.6
1986	29.0	2008	18.6
1987	30.9	2009	17.6
1988	36.2	2010	20.2 (16 th worldwide)
1989	38.0		

Development of the nuclear path in Spain -2-:

Nuclear power reactors in Spain (constructed and put into operation) 2010 (IAEA 201; Foro Nuclear 2011)

Name	Type	Status	Location	Gross capacity (MWe)	Date of grid connection	Date of expiration of operating license
José Cabrera-1 (Zorita)	PWR	Permanent shutdown	Guadalajara	150	1968/07/14	2006/04/30
Santa María de Garoña	BWR	Operational	Burgos	466	1971/03/02	2013/05/07 (Permanent shutdown)
Vandellòs-1	GCR	Permanent shutdown	Tarragona	480	1972/05/06	1990/07/31
Almaraz-1	PWR	Operational	Cáceres	977	1981/05/01	2020/06
Ascó-1	PWR	Operational	Tarragona	995	1983/08/13	2011/01/01
Almaraz-2	PWR	Operational	Cáceres	980	1983/10/08	2020/06
Cofrentes	BWR	Operational	Valencia	1,064	1984/10/14	2021/03
Ascó-2	PWR	Operational	Tarragona	997	1985/10/23	2011/01/01
Vandellòs-2	PWR	Operational	Tarragona	1,045	1987/12/12	2020/07
Trillo-1	PWR	Operational	Guadalajara	1,003	1988/05/23	2014/11

PWR = Pressurised Water Reactor; BWR = Boiling Water Reactor; GCR = Gas-Cooled Reactor

The initial phase -1- (1945-1955/56):

1st phase of nuclear power (1): Start of exploration, R&D, institution building, formation & bilateral collaboration

➤ **1945: National Institute of Geology and Mining established a commission to explore possible uranium deposits in Spain**

➤ 10/1945: (Order of 4th of October) => reserved the right of all possible uranium deposits in 14 Spanish provinces to the Spanish State

➤ 4/1948: Agreement of collaboration between Spain & Italy regarding nuclear R&D

➤ **1949: Establishment of the Atomic Research Council (JIA) & of the company „Studies and Patents of Special Alloys“ (EPALE) => training & formation of staff, exploration of domestic uranium deposits, research on techniques for uranium extraction, uranium physics, geology, mining and chemistry.**

➤ End of 1940s/beginning of 1950s: sending of young Spanish researchers to foreign nuclear research institutes (mainly in the US, Germany and Italy) to create an own research infrastructure

➤ 1951: Start of construction of a pilot plant for uranium refining in the Madrid Central University

➤ **10/1951: Creation of the Nuclear Energy Board (Junta de Energía Nuclear - JEN):** First official public nuclear R&D centre => main aim: development of an autonomous nuclear programme, including uranium mining, production of fuel elements, design of nuclear reactors, etc. => First steps: Construction of a nuclear R&D research centre within the Spanish seat of government (Moncloa) (start: 1954), first open cast uranium mining in Saelices el Chico (Salamanca), first commercial uranium mill in Andújar (Andalusia) (start of construction: 1956)

The initial phase -2- (1955/56 – 1966/67):

First phase of nuclear power (2): continuation of bilateral cooperation, first experimental reactors, first nuclear law & first commercial reactor

- **7/1955: cooperation agreement between Spain & the US: supply of enriched uranium by the US to Spain for a first experimental reactor.** In return, the US obtains the right to control at any time all Spanish nuclear facilities => This agreement was updated & extended several times until 1974
- 1956: sales contract between the Spanish government and International General Electric (US) about the parts of equipment for the experimental reactor which can't be built by Spanish firms (reactor core, control equipment, parts of the cooling system)
- 1956-1958: Construction of the first experimental nuclear reactor in Spain (JEN-1)
- **27th of November, 1958: Put into operation of JEN-1** (a 3 MW swimming pool reactor with 20% enriched uranium and light water) within the atomic research institute of the Moncloa
- **1959: Start of operation of the uranium mill in Andújar** (until 1981)

The initial phase -2- (1955/56 – 1966/67):

- 6/1962: Put into operation of 2 nuclear research reactors in Barcelona (Argos) and Bilbao (Arbi), both moderated with graphite
- 1962/63: works on a domestic nuclear reactor type, named DON (Deuterium, Organic, Natural) based on a cooling system with liquid sodium, but abandoned in 1963
- 3/1963: purchase contract (between Spanish government and Westinghouse) for the first commercial nuclear reactor in Spain for the NPP Zorita
- **4/1964: Law 25/1964 on nuclear energy** => main basic regulation for civil use of nuclear energy (amongst others basic obligations regarding nuclear waste or sanctions) => still in force (even updated several times)
- 6/1964: Start of construction of NPP Zorita
- 10/1964: meeting between Spanish industry minister López Bravo & French atomic minister Palewski => talks about construction of a NPP of French type & under participation of EdF in Catalonia
- 8/1966: start of tenders for the construction of the Spanish/French NPP in Catalonia (Vandellòs-1)
- **1966: Start of uranium mining in La Haba** (Badajóz, Extremadura) (until 1990)

Nuclear (planning) boom & 1st / 2nd generation NPPs (1968-1983):

- **7/1968 + 3/1971 + 8/1972: Start of operation of Spain's 1st generation NPP Zorita (150 MW, PWR), Santa María de Garoña (466 MW, BWR) & Vandellòs-1 (480 MW, GCR)**
- **11/1973-4/1975: Nuclear planning boom: nearly 30 claims for construction permits and approved NPP projects within only 18 months**
- **1/1975: National energy plan 1975 (due to political changes never realised):**
 - Prospects for a NPP capacity of 24,000 MW in 1985
 - expected share of nuclear power in gross electricity production in 1985: 57,1% (22% were in fact reached)
 - every further growth in electricity consumption from 1985 onwards should be covered by nuclear power !
- **5/1981 & 8+10/1983: Put into operation of 2nd generation NPPs Almaraz I (977 MW), Ascó I (985 MW) & Almaraz II (980 MW) (all PWR)**

Planning & licensing history of Spanish NPPs (1963-1980):

Planned and / or approved NPP projects in Spain between 1963-1980 (Costa Morata 2001: 18 et sq.)

Name of NPP	Date of apply for construction permit (a) or issuing of construction licence (i)	Name of NPP	Date of apply for construction permit (a) or issuing of construction licence (i)
José Cabrera (Zorita)	3/1963 (i)	Escatrón I & II	3/1974 (a)
Sta. María de Garoña	5/1955 (i)	L'Ametlla I & II	3/1974 (a)
Vandellòs -1	~ 1966 (i) (start of construction: 6/1968)	Lemóniz I & II	3/1974 (i)
Trillo I & II	7/1972 (a)	Ascó I	5/1974 (i)
S. Vicente Barquera	6/1973 (a)	Ascó II	3/1975 (i)
Almaraz I & II	7/1973 (i)	Valencia Don Juan	4/1975 (a)
Deva I & II	11/1973 (a)	Chalamera	4/1975 (a)
Tudela	11/1973 (a)	Cofrentes	9/1975 (i)
Oguella (Ea-Ispáster) I & II	11/1973 (a)	Valdecaballeros I & II	9/1975 (i)
Moral de Sayago	11/1973 (a)	Vandellòs III	2/1976 (a)
Regodola	11/1973 (a)	Trillo I	8/1979 (i)
Águilas	12/1973 (a)	Vandellòs II	12/1980 (i)
Tarifa I & II	12/1973 (a)		
Sástago I & II	1/1974 (a)		
Almonte I & II	1/1974 (a)		

Civil opposition against nuclear power in Spain since 1973:

- 11/1973: numerous (6) applications for new NPP projects in the Basque region and Navarre in only 1 month => stimulus for the creation of a antinuclear movement, mainly of the local population
- Protests mainly because of the short distances between the projects and the fact that they would be build in a highly populated area
- NPP Lemóniz (Vizcaya): construction started already in summer 1972, but strong opposition against the NPP started not before 1975/76, when the Spanish anti nuclear movement was already well established => 1976: 150,000 signatures & first big demonstration with 50,000 participants against the project; 7/77: next big demonstration in Bilbao with 150,000 people
- 8/77-3/84: provincial government of Bizcaya votes in favour of the NPP Lemóniz => ETA starts to use the growing anti-Lemóniz movement for its own purposes => kills three people in two bomb attacks inside the NPP (3/78 & 6/79) and shoots the responsible engineer of the NPP (1/81) & the chief of the PPP commission for the construction & operation of the NPP (4/82) => led to first strong protests against ETA but also to the complete stop of the construction => 9/1982 conservative central Spanish government orders (via degree) to restart the project => 10/1982: Socialist (PSOE) win the central elections and stop again the project => 3/84 nuclear moratorium for 5 NPPs, including Lemóniz
- 1970s onwards: strong anti nuclear movement in the Basque region and Navarre create a national nuclear opposition, preventing most of the NPPs planned in other Spanish regions (mainly Andalusia and partly Catalonia) and establishing several anti-nuclear NGOs, still active today (in the form of its successors Greenpeace & Ecologists in Action)
- Today: Spain as one of the country within the EU with highest amounts of the population against nuclear energy (Eurobarometer 2005, 2007, 2010)

Nuclear moratorium & and the related subsidies (1984; 1994/95 onwards)

- 3/1984: Spanish government approved the National Energy Plan (PEN) 1983-1992 => cancellation of various planned NPPs and stop of construction of 5 NPP (Lemóniz I & II, Valdecaballeros I & II and Trillo II) => main arguments: high investment costs & overcapacities (no environmental or security reasons mentioned) => but PEN 1983-1992 also approved the completion of 4 other NPPs (Ascó II, Cofrentes, Vandellòs II & Trillo I) => put into operation between 10/84-5/1988
- 12/94+ 12/05: New Electricity Law: in its 8. supplementary provision, the new law also decided the definitive stop of the 5 NPPs in moratorium since 1984 & and compensation for the respective sunk costs amounting to 729.309 billion Ptas (~ 4,383 billion €) to be financed via a maximum share of the average electricity tariff of 3.54% during a period not exceeding 25 years (at the latest until 2020). => The details were regulated by the Royal Decree (RD) 2202/1995 (amongst others it provided that the yearly compensations might be adapted to the real costs for the complete dismantling, which in fact led to a higher overall compensation)
- 4/2006: RD 470/2006 => reduction of the compensation for sunk costs to 0.33% of the average electricity tariff until 2015

Nuclear moratorium & nuclear waste related subsidies (1984/85 / 1994/95 onwards)

Compensation payments for NPPs in definitive moratorium 1995-2010(BOEs 1996-2011)

Year	Amount of compensation in €
1995	446,998,223 €
1996	499,024,508 €
1997	464,427,217 €
1998	454,730,050 €
1999	457,860,489 €
2000	475,397,020 €
2001	482,124,596 €
2002	529,075,065 €
2003	538,998,546 €
2004	557,599,212 €
2005	592,829,857 €
2006	296,066,722 €
2007	31,112,877 €
2008	7,214,506 €
2009	9,386,692 €
2010	86,396,139 €
Total	5,890,914,336 €

⇒ **Further subsidies for nuclear waste** (as financed also as a share (0.8-1.2%) of the average electricity tariff: **1,835 M€** between 1985-3/2005 => since 4/2005 the NPP owners must set aside respective reserves

⇒ **further windfall profits for the average price paid at the Spanish power exchange (OMEL) in comparison to the marginal cost of nuclear electricity:** following calculations of APPA/Deloitte those extra profits amounted to **6,725 M€** only during 2007-2009

Present and future of nuclear power in Spain -1-

- Change of government in 3/2004 from conservative PP (pro nuclear) to socialists (PSOE) with proponents (Montilla, Clos) and opponents (Zapatero as prime minister)
- PSOE emphasised in its election programme of 2004 to gradually phase out nuclear (without putting at risk the security of supply), to replace nuclear by cleaner and less expensive types of energy & to elaborate a phase out plan
- first & oldest Spanish NPP Zorita definitely shut down at end of 4/2006 (although decision to close the NPP was taken already in 9/2002 under the PP government) after 38 years of operation
- Zapatero in various occasions (state of the nation speeches in 2005 and 2006) repeated its willingness to phase out nuclear & to come up with a detailed phase out plan still during this legislative period (until spring 2008) which he didn't fulfill
- various announcements of the Spanish government to close 2nd oldest NPP Garoña in 7/2009 (but the NPP owners Endesa & Iberdrola already in 7/2006 applied for a prolongation of the production permit for a further 10 year period from 2009-2019)
- 11/2005-5/2006: various meetings of the "nuclear round table" (mesa nuclear) of most important actors in the nuclear area in Spain => in its final meeting in 5/2006 the most important conclusions, structured in 4 different areas were presented:

Present and future of nuclear power in Spain -2-

- 1) Central Interim Storage Facility (ATC) for high radioactive waste (until ~ 2070): most of the participants of the round table in favour of an ATC, but precondition would be a brought political, institutional and social consensus at national & local level => but high resistance at local & national level against an ATC
- 2) To improve the information and participation of society in all crucial decision processes regarding the use of nuclear energy
- 3) Reform of the Nuclear Safety Commission (CSN): Aim: To increase its transparency & independency
- 4) Security of supply & future role of nuclear in Spain (most conflicting issue): low CO2 emissions on one side – generation of high radioactive waste on the other side (without long term solution up to now) => for a gradual substitution of nuclear power elaboration of an alternative scenario necessary (Greenpeace report “Renovables 2050” was already presented !)
=> if nuclear should also be used in the future, important technological progress (lower investment costs, higher safety standards, faster construction periods, less generation of nuclear waste & solution for the treatment of high radioactive waste) would be preconditions - including a brought political and social consensus => debate on the future use of primary energy sources in Spain (including nuclear) – based on the conclusions of the nuclear round table – should be continued during a period of at least 2 years in the Spanish parliament & results should be presented in the next legislative period => Haven't been presented yet

Present and future of nuclear power in Spain -3-

- No concrete nuclear phase out plan presented by ruling PSOE government, nor during the last election campaign beginning of 2008 nor during the present legislature period until late summer 2011
- Instead, in a new longer term energy scenario until 2035 prepared by a specific commission of the Spanish Parliament during 2010 the share of nuclear until 2020 was kept stable and for the period 2020-2035 the final document of the commission only stated that the decision about the future use of nuclear in Spain should be taken from around 2015 onwards taking into account all the inherent circumstances of this technology but in any case it would be “necessary to preserve the knowledge and technological and operating capabilities of these technologies, as they have a high strategic and economic value for our country”
- 7/2009: View days before the expiration of operating license of Spain’s oldest operating NPP Santa María de Garoña, Spanish government opted for a compromise between proponents and opponents of a further prolongation of the production license for another 10 years: prolongation was approved for further 4 years until 7/2013 => owner of Garoña (Nuclenor => Iberdrola & Endesa) went to court against this decision not only asking for a 10 year prolongation of the operating license but also claiming compensation
- 1/2011: Spanish government nominated Fabricio Hernández as new State Secretary for Energy: Hernández formerly worked for the consultancy which elaborated a study used as basis for the lawsuit of Nuclenor against the permanent shutdown of NPP Garoña in 2013 including a claim for compensation amounting to 950 M€

Present and future of nuclear power in Spain -4-:

- Unsolved problem of high radioactive waste: no Central Interim Storage Facility (ATC) before 2015? =>Due to strong opposition of Spanish citizens against nuclear power high probability of significant opposition with lengthy and expensive licensing procedures for an ATC
- process of a favourable location for ATC culminated for now in the selection of 7 possible sites with the villages of Ascó (Tarragona) and Zarra (Valencia) with the highest possibilities to be chosen. But presidents of Catalonia and Valencia opposed to these sites, besides strong local opposition. After bringing forward the next general elections to 20th November 2011 (instead of March 2012), the final decision will be taken during next legislature.
- After a court ruling caused by Greenpeace to make public concrete plans of the foreseen ATC the Spanish government had to admit that no concrete plans exist but only a preliminary and generic study on the security of the design of an ATC made by a French consultancy => Spanish government was willing to choose the definitive ATC site without disposing of the basic technical and security studies about it
- cost forecasts (made in the 6th General Radioactive Waste Plan, PGRR) of total nuclear waste management until 2070 amount to 13,023 million € (thereof 47.9% resp. 6,238 million € for spent fuel & high level waste) => cost estimates for and waste management & precise cost calculation methodology is not publicly available

Present and future of nuclear power in Spain -5-:

But...

- fast increase of electricity consumption in Spain => ~ 65% between 1997-2008 (one of the highest rises within EU) => although consumption dropped in 2009 by 4.5% due to the economic crisis in 2010 it increased again 3%
- strong pressure on Spain to fulfil its commitments in GHG reductions (+48% CO₂ increase between 1990 and 2007 vs. +15% allowed increase => with a strong decrease since 2008, reaching + 20% in 2010) & clever strategy of the nuclear lobby to demonstrate nuclear as the climate solution
- Strong nuclear lobby (Foro Nuclear) claiming for both prolongation of the operating periods of the Spanish NPPs from 40 to 60 years & to built 11 new NPPs until 2030 to increase share of nuclear power from the present level of 20% to 35% (creating up to 172,00 new jobs, investments of 33 billion € and save up to 21 billion € for avoided CO2 emission) => main arguments: Spain's climate commitments won't be fulfilled without nuclear, the contribution of nuclear to the security of supply & Spain's high energy import dependency, reaching 74% in 2010 (not mentioning that since 2001 Spain import 100% of the uranium needed for the NPPs still in operation)

Nuclear energy in Spain after Fukushima

- 7/2011: National High Court declared lawful the decision to definitely close oldest Spanish NPP Garoña in mid 2013 arguing with the incompatibility of (high shares) of nuclear energy and RES mainly because nuclear energy lacks required flexibility in rapidly adapting its load factor in times of abrupt changes of power production of variable energy sources like wind and solar energy => Nuclenor again will put forward a new lawsuit against the decision
- 8/2011: Proposal of CSN (not binding for the Spanish government) to prolong operating license for both reactors of NPP Ascó for further 10 years (until autumn 2021) without waiting for results of the stress tests for all Spanish NPPs
- Since 6/2011: Stress tests for all Spanish NPP started
 - Results to be finalised until end of 2011
 - tests include controls of the seismic security, but also analyses the risks of floods, loss of electric supply or the management of severe accidents like the meltdown of the reactor core, etc.
 - Critic: important risks won't be tested like terroristic attacks with planes, etc. Besides, tests are not undertaken by a neutral body but by the plant owners

The related risks of nuclear energy -1-

Most important incidents/accidents in Spain's nuclear history (1)

- During 1960s & 1970s: high contamination of workers in the first Spanish nuclear mining sector in Andújar (Andalusia) => 20% of the staff died of cancer (as shown by epidemiological studies in 1999/2000 after closing of the Andújar mining complex) => Spanish government was well informed about the high radioactive contamination since the 1960s but kept it secret
- During 1960s/1970s: more than 30 workers died in the Spanish uranium mining sites La Haba (Badajóz), Albalá (Cáceres) & Cerdaña (Córdoba) in a period of 5 years, after being declared incapacitated for work because of radiosilicosis => workers with same disease who survived have never been compensated
- 1/1966: collision between a U.S. B-52 bomber (with 4 unarmed nuclear bombs) and a tanker plane near the Spanish village of Palomares => The conventional explosives in two of the bombs detonated causing radioactive plutonium to be spread over the village, and one bomb was missing in the Mediterranean Sea for nearly 80 days => not before 1985 the local population got access to their medical files: ~ 30% of the population of Palomares showed elevated levels of plutonium => parts of the bombs were found by the Spanish military & gained information used for Spain's secret atomic weapon programme

The related risks of nuclear energy -1-

Most important incidents/accidents in Spain's nuclear history (2)

- 11/1970: leakage of 40-80 l of high radioactive liquid in the main office of the nuclear energy board (JEN in Madrid, reaching the sewerage system and contaminating an area up to Toledo (~ 80 km far from Madrid) => incident was kept top secret
- 10/1989: fire in the generator building of NPP Vandellòs I causing high material damages of the plant & its definite closure in 7/1990 => dismantling started in 1991 and will last until ~ 2030
- 8/2004 leakage in the cooling system of NPP Vandellòs II of 80 cm diameter because of long lasting corrosion caused to the marine ambient of the NPP site (directly at the Mediterranean coast) => plant owners Endesa (72%) and Iberdrola (28%) as well as the Nuclear Security Commission (CSN) both knew since years of the corrosion inside the cooling system as well as played down the seriousness of the incident, later qualified as a level 2 incident of the International Nuclear Event Scale (INES) (high level of contamination inside the NPP) and/or high radiation exposure of staff) => second most serious incident in a Spanish NPP after the fire in 1989 in Vandellòs I
- 11/2007 Asco I: Leakage of radioactive steam. Plant owner only informs CSN in April 2008, after being made public by Greenpeace. Released radioactivity up to 1,000 times higher as originally stated. In the period between the accident and its becoming known more than 2,500 visited the contaminated area of the plant and had all to be medically examined. Plant owner was finally be sentenced with a fine of 15.4 M€
- 8/2008 Vandellòs II: fire in the turbine building => it took month to repair the damages
- 4/2011 Ascó I: leakage of radioactive water within the reactor building contaminated 19 workers

The related risks of nuclear energy -2-

Military use: Spain's secret nuclear weapon programme (1963-1981) (1)

- 1963: First secret report of the Nuclear Energy Board (JEN) on the real possibilities for Spain to construct nuclear weapons => lack of technical knowledge and necessary amount of plutonium
- 1/1966 Palomares accident with the detonation of the conventional explosives of 2 uranium bombs => found by the Spanish military => provided insides in the technique of detonators & solved a lot of the hurdles the Spanish military was confronted with to construct a nuclear bomb
- 1967: first dossier within the Spanish foreign ministry which pointed to the ability to build a nuclear weapon => but the necessary plutonium was still missing
- 1968: installation of the first fast breeder in the office of JEN in Madrid which in 1969 started – under utmost secrecy – to produce weapons-grade plutonium

The related risks of nuclear energy -2-

Military use: Spain's secret nuclear weapon programme (1963-1981) (2)

- 1971: secret report showing Spain's immediate ability to start a nuclear weapon programme => plutonium to be produced mainly by the used uranium in the NPP Vandellòs I
- 1976: start of the Nuclear Research centre CINSO in Soria including a fast breeder able to produce up to 140 of plutonium per year => possible use for nuclear weapons
- 1977-1981: under the presidency of Jimmy Carter the US – worried about the possibilities for Spain to become the next nuclear power – and the fact that Spain hasn't signed the Non-Proliferation-Treaty (NPT) => the US administration exerted high pressure on the Spanish government to allow controls inside CINSO => in case of refusal: stop of supply of enriched uranium for Spanish NPPs
- 4/1981: Spain allowed controls of CINSO thereby definitely stopping its nuclear weapon ambitions
- 10/1987: Spain finally ratifies the NPT

THANKS FOR YOUR ATTENTION



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