Expansion of Nuclear Power in Mexico

L.C. Longoria, G.Alonso, J. Palacios

Instituto Nacional de Investigaciones Nucleares
Carretera Mexico-Toluca s/n, La Marquesa, Estado de Mexico, C.P. 52750, Mexico

Abstract. A power upgrade from nominal power to 105% was concluded in 1999 for the two BWR reactors of Laguna Verde. The current activities for the expansion of nuclear power in Mexico include an Extended Power Uprate from 105% to 120% nominal capacity. Long term plans include operational license extension of the two reactors for a total of 60 years. Although there are not government official plans to build new Nuclear Power Plants in Mexico; studies about technical and economical feasibility of new nuclear capacity are being carried out by the Mexican Utility CFE and the Mexican Nuclear Research Institute. These studies establish a medium term proposal which includes the construction of eight new reactors. In the official electricity program the Mexican government has stated to install 17,942 MWe by 2018 of new electricity capacity, of this amount 15,574 MWe will be generated using conventional sources and 2,368 MWe will be defined in the future, using other technologies that could include nuclear power.

1. INTRODUCTION

In Mexico, the electric power sector remains largely under state control. Electrical power generation is currently the only segment of the electricity sector that allows some private participation, the result of a 1992 amendment to Mexico´s Electricity Law[1]. Private companies (PIE´S) are allowed to generate electricity for areas not considered “public service.” They include generating electricity for export and generating electricity for public service during an emergency. Self- or co-generators and small producers may generate electricity for their own use, and independent power producers are permitted to sell excess power to the Federal Electricity Commission (CFE) under long term contracts.

From 1995 to 2008 the electricity installed capacity has been growing as it is shown in Table 1, where it can be seen the contribution of the private companies (PIE´S). In Table 1 it can also be seen that the electricity generating capacity has been steadily growing at a 3.9 % average annual rate due to better generating practices and higher availability power plants factors.

Figure 1 shows the contribution by source type to the total installed capacity at December 2008 and Figure 2 shows how the power plants are distributed through the whole country. The production of nuclear power is reserved to the state trough CFE, one of the two electricity state companies, Currently Mexico has a Nuclear Power Plant located at Laguna Verde Veracruz having two BWR type reactors of 650 MWe each one. The first reactor started operation in 1990 and the second one in 1995. In 1999 these reactors were upgraded to 682 MWe. Actually nuclear power contributes about 4.4 % of the total electricity produced in México and it represents 2.7% of the total installed capacity.

Table 1. Evolution of Electricity in Mexico

Year	Installed Capacity (MW)			Generation (GWh)		
	CFE	PIE´S	Total	CFE	PIE´S	Total
1995	32,166		32,166	140.82		140.82
1996	33,920		33,920	149.97		149.97
1997	33,944		33,944	159.83		159.83
1998	34,384		34,384	168.98		168.98
1999	34,839		34,839	179.07		179.07
2000	35,385	484	35,869	190	1.21	191.21
2001	36,236	1,455	37,691	190.88	4.04	194.92
2002	36,855	3,495	40,350	177.05	21.83	198.88
2003	36,971	6,756	43,727	169.32	31.62	200.94
2004	38,422	7,265	45,687	159.53	45.86	205.39
2005	37,325	8,251	45,576	170.07	45.56	215.63
2006	37,470	10,387	47,857	162.47	59.43	221.9
2007	38,397	11,457	49,854	157.51	70.98	228.49
2008	38,474	11,457	49,931	157.16	74.23	231.4

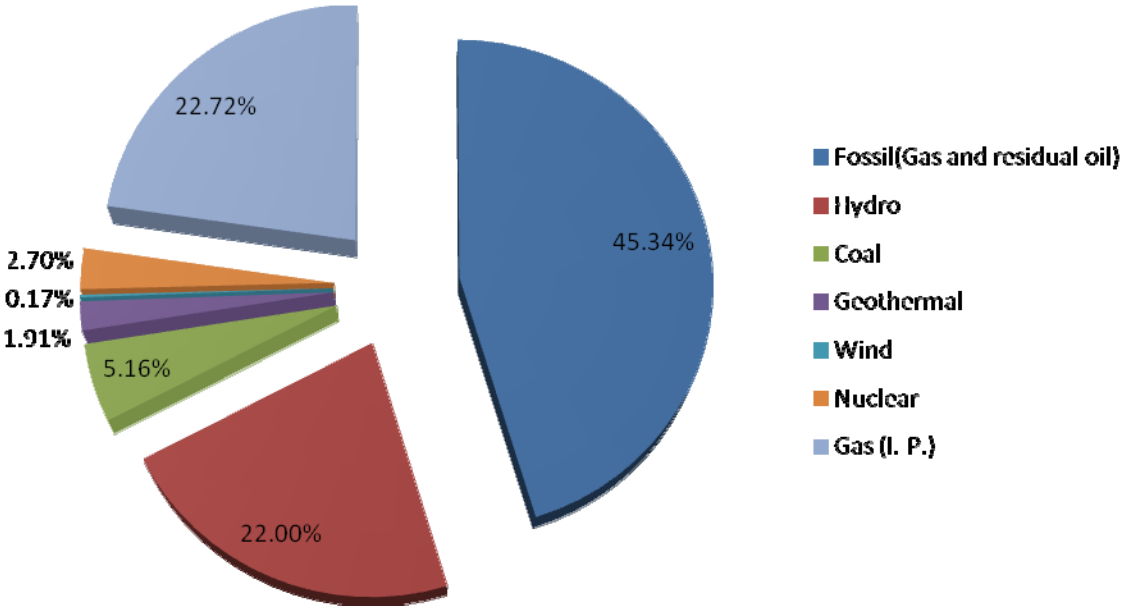

Fig. 1. Source Share

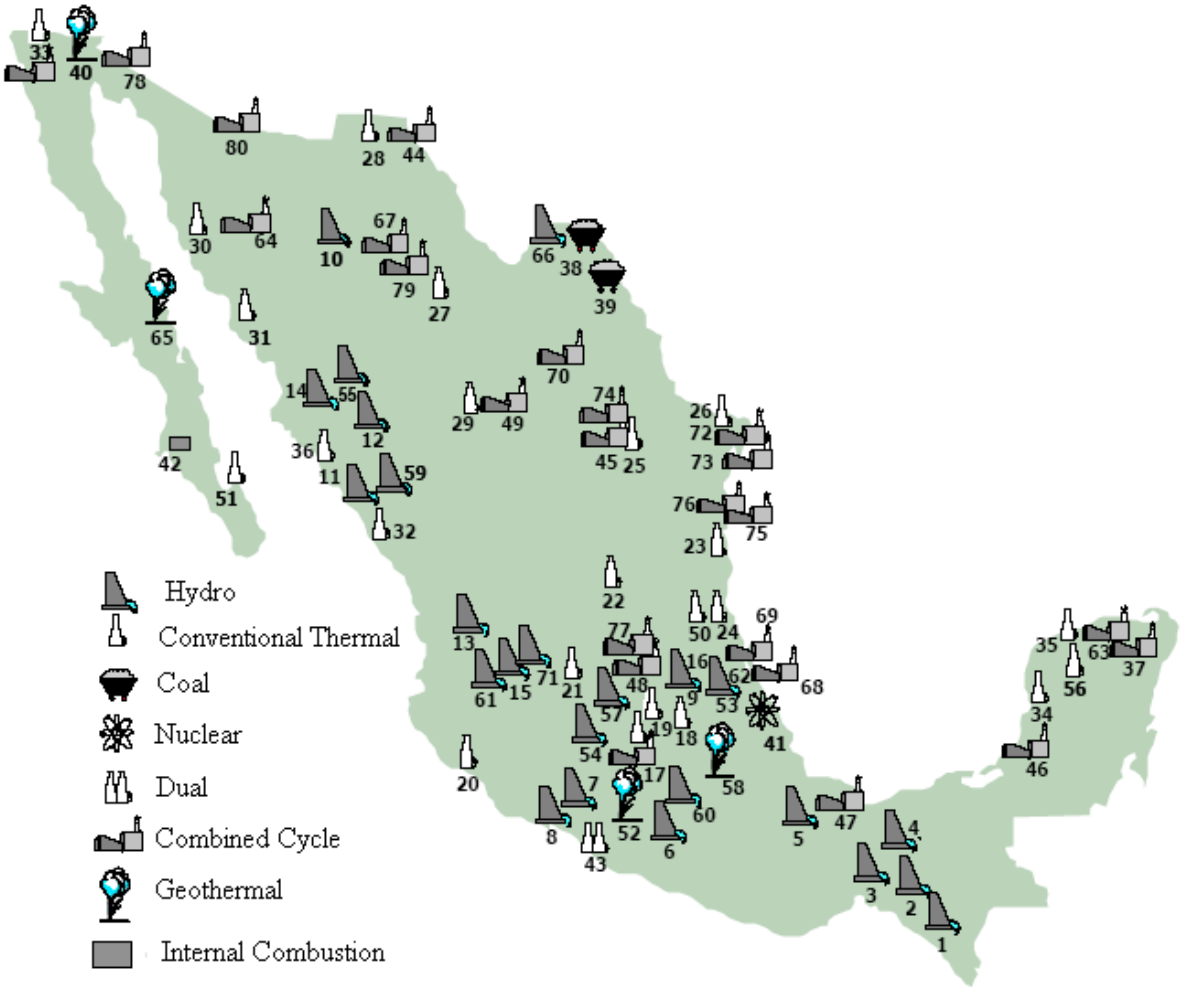

Fig. 2. Source Distribution

The Program of Works and Investment of the Electrical Sector (POISE) is an annual national electricity program that covers the electricity need for the following 10 years. In this program Mexican government (POISE 2009-2018) has stated plans to install 17,942 MWe by 2018 of new electricity capacity, of this amount 15,574 MWe will be produced using conventional sources and 2,368 MWe will be defined in the future, with technologies that could include nuclear power.

2. POWER UPRATE

One way to expand nuclear power is through power uprates. Some nuclear reactors are generally designed in such a way as to accommodate up to 20% more of its nominal rated power output. To increase the power output of a reactor, typically a utility will refuel a reactor with either slightly more enriched uranium fuel or a higher percentage of new fuel. This enables the reactor to produce more thermal energy and therefore more steam to drive a turbine generator to produce electricity. In order for this to be accomplished, components such as pipes, valves, pumps, heat exchangers, electrical transformers and generators must be evaluated to accommodate the conditions that would exist at the higher power level.

The traditional design of western commercial reactor has excess capacity needed to potentially allow for an uprate up to 20%, which can fall into one of three categories: 1) measurement of uncertainty recapture power uprates, less than 2%, 2) stretch power uprates, between 2% and 7%, and 3) extended power uprates, between 7% and 20%.

1) Measurement of uncertainty recapture power uprates are power increases less than 2 percent of the licensed power level, and are achieved by implementing enhanced techniques for calculating reactor power. This involves the use of state-of-the-art devices to more precisely measure feedwater flow which is used to calculate reactor power. More precise measurements reduce the degree of uncertainty in the power level which is used by analysts to predict the ability of the reactor to be safely shut down under possible accident conditions.

2) Stretch power uprates are typically between 2 percent and 7 percent, with the actual increase in power depending on a plant design's specific operating margin. Stretch power uprates usually involve changes to instrumentation settings but do not involve major plant modifications.

3) Extended power uprates are greater than stretch power uprates and have been approved for increases as high as 20 percent. Extended power uprates usually require significant modifications to major pieces of non-nuclear equipment such as high-pressure turbines, condensate pumps and motors, main generators, and/or transformers.

In August 1995 the CFE assessed the possibility to get a stretch power uprate of 5% in both of their BWR units at Laguna Verde Nuclear Power Plant. This power uprate could be done without physical changes of the structures, systems and components to avoid a new safety global analysis that could have a negative economical impact in the nuclear power plant.

In November 22, 1995, CFE officially communicated to the Mexican Regulatory Body (CNSNS) its intention to start the stretch power uprate (SPU) for the two units of Laguna Verde. In November 29, 1996, CFE presented before the CNSNS the program schedule for the SPU. In March 1999 CFE asked for the modification of the operation license for the 2 units of Laguna Verde before the CNSNS. The Ministry of Energy awarded the license modification starting on September 1999.

In this case the reactor dome pressure is maintained constant and the power increased is given through a higher steam flow. This change can be assessed through the power-flow map, the upper limit of extended load is modified up to it intercepts the 105% power line, the total flow is kept between 87% and 107% of its nominal power. Therefore its nominal power went from 1931 MWth to 2027 MWth.

The second uprate is in process, and it is an extended power uprate (EPU). The requested license power level is an increase to 2317 MWth from the current licensed reactor thermal power of 2027 MWth, this means that the uprate will go from 105% to 120% of its nominal power. In this approach it is maintained the current plant maximum normal operating reactor dome pressure, and it is referred as a Constant Pressure Power Uprate (CPPU).

An increase in the electrical output of a BWR plant is accomplished primarily by generating and supplying higher steam flow to the turbine-generator. Laguna Verde, as originally licensed, has an as-designed equipment and system capability to accommodate steam flow rates above the current rating. Also, the plant has sufficient design margins to allow the plant to be safely uprated significantly beyond its originally licensed power level.

In this case a higher steam flow will be achieved by the change, among other things of condenser and the turbine, as major equipment changes are required. Along with these changes the power uprate will be achieved by increasing the reactor power along specified control rod and core flow lines. Furthermore, a limited number of operating parameters are changed, some set points are adjusted and instruments are recalibrated. Plant procedures are revised, and tests similar to some of the original startup tests are performed.

Currently this uprate proposal is before the CNSNS and it is expected to be completed by 2010 to have the revision and likely acceptance to ask for the modification of the operation license for the two BWR Laguna Verde units.

Thus, with this power uprate for the Laguna Verde units there will be an additional 200 MWe of installed capacity to the Mexican Electricity Network.

Fig. 3. Laguna Verde Nuclear Power Plant

3. PLANS FOR ADDITIONAL UNITS

As in many countries around the world, besides to the technical and economical issues for nuclear power, in Mexico it is a very sensitive topic in the political arena. In Mexico a decision of this magnitude requires a presidential decision as well as the approval of the legislature because the needed investment as well as the social and environmental concerns.

Since 2003 several studies has been done to assess the viability of new additions of Nuclear Energy as part of the expansion of the Mexican Electrical System. Also, several national panels were installed to discuss this topic.

As part of the national policy in electricity each year a planning for the next 10 years is done, this plan forecast the needs of additional capacity in the country, which power plants must be deployed and what is the share of each technology.

This planning is issued in the POISE 2007-2016. In that document it was considered the use of nuclear power in a medium term program. The following was taken from that government document as a possible alternative.

The first point was to define a long term energy policy to avoid the concentration of any technology because a planning using least cost approach could result in an extensive use of a particular technology. Therefore this policy must establish the minimal and maximum shares for each technology and the year to start with its deployment.

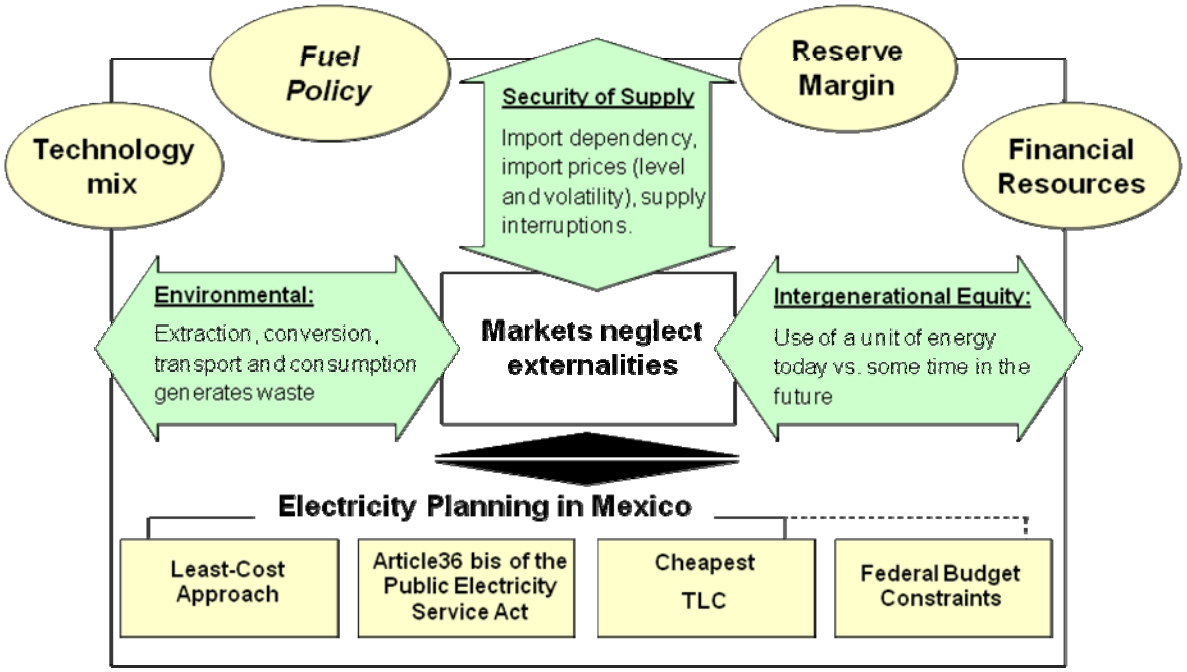

Fig. 4. Electricity planning considerations

In this sense the shifting of the current energy policy of evaluating the least cost approach of alternative technologies, to evaluate alternative generating portfolios and strategies (i.e. optimal risk/returns mix) provides the best means of hedging possible future outcomes.

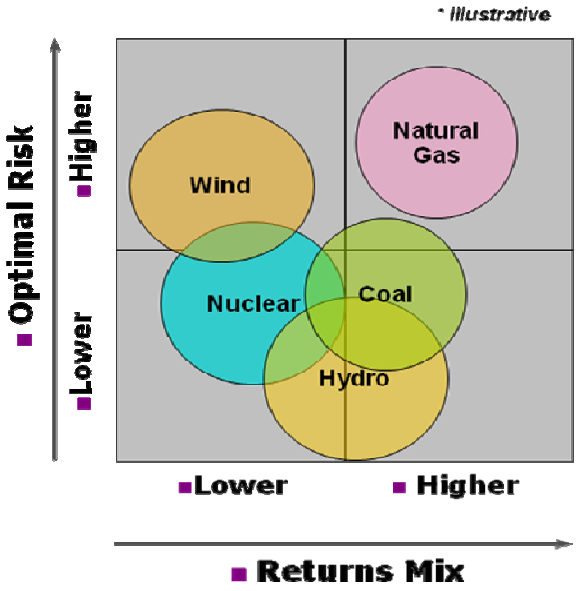

Fig. 5. Portfolio planning

In this regard, in the POISE 2007-2016, Appendix B, this policy is considered. The medium term planning 2007-2026 allows the use of nuclear power starting in 2015. In this scenario the share of nuclear power will be 12% by 2026 and 8 units could be deployed with a single capacity of 1,350 MW to add 10,800 MW in this period, where is expected a total electrical installed capacity grow of 55,000 MW. This nuclear deployment planning could be represented as shown in Figure 6.

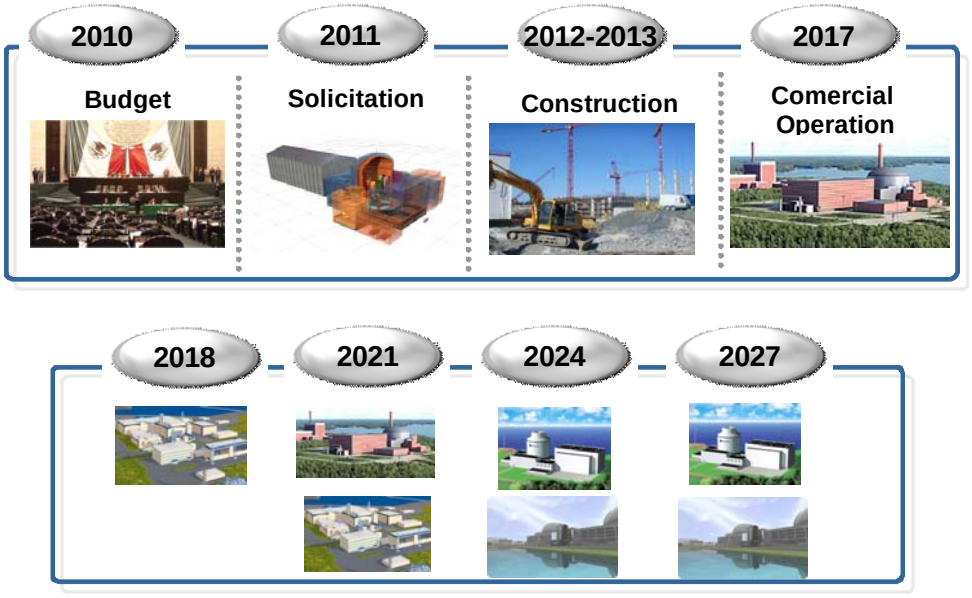

Fig. 6. Nuclear power deployment planning

According to this planning the total installed capacity for the Mexican Electrical Sector in 2026 will be 101,340 MW and the share for each technology is shown in Table 1.

Table 1. Technology Share in 2026

Technology	Share %
Coal	18
Hydro	15
Nuclear	12
Geothermal and Wind	5
Residual Oil and Diesel	5
Combined Cycle	40
Free	5

The current POISE 2009-2018 shows plans to install 17,942 MWe by 2018 of new electricity capacity, of this amount 15,574 MWe will be produced using conventional sources and 2,368 MWe will be defined in the future, with technologies that can include nuclear power. However, in this document that is produced by CFE (Mexican government utility) it is very clear that the use of nuclear power will happen only if the Ministry of Energy issue a policy energy document that address the use of nuclear power.

4. DISCUSSION

A diversification strategy can give greater protection against the volatility prices of primary fuels. It also diminished the dependence to one or two sources, especially if that dependence is external, among other benefits such an increase in market competition.
In Mexico several studies already consider nuclear energy an option to be considered as part of the electricity expansion, it makes a viable option from several different points of views. It can help to reduce or mitigate carbon emissions helping to alleviate climate change and also is already a competitive economical option in the long run.

Laguna Verde already has proven the adequate use of nuclear power providing with almost 5% per year in the last 10 years of the total annual electricity generation. In 2008 it only represented 2.7% of

the total installed capacity but due its better practices and with capacity factors around 90% it provided 4.7% of the total electricity generation. It shows that it is a mature technology that has been absorbed by the Mexican engineers.

However, in particular in Mexico the use of nuclear power is a Presidential and congress decision that involves a lot of political constraints. Therefore, it is very important to make consciences in all the political actors to proceed in a near future with new deployments of nuclear power in Mexico.

BIBLIOGRAPHY

[1] *Prospectiva del Sector Eléctrico 2005-2014*, Secretaria de Energía, México (2005).

[2] *Programa de obras e Infraestructura del Sector Eléctrico 2007-2016, CFE*, México (2007)

[3] *Programa de Obras e Infraestructura del Sector Eléctrico 2009-2018, CFE*, México (2009)

[4] *Evaluación de la Seguridad del Proyecto de Aumento de Potencia de la Central Laguna Verde Unidades 1 y 2*, Secretaria de Energía, México (1999)

[5] *S*afety Analysis Report for Laguna Verde Units 1 and 2 at Constant Pressure Power Uprate, CFE (2009)