Issues to consider for the implementation of SMR technology in Mexico

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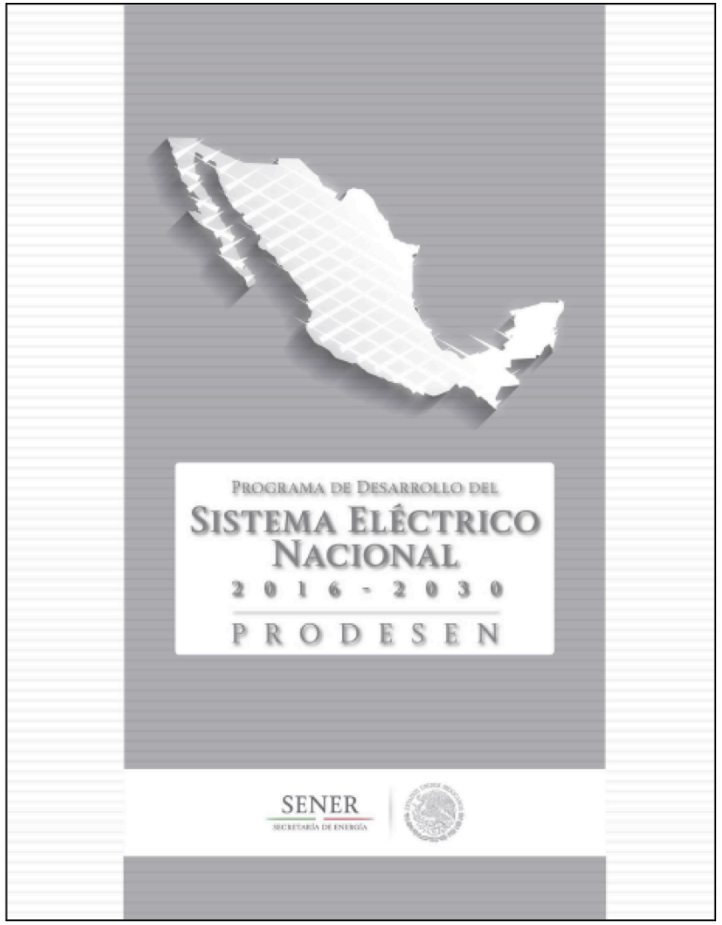
Present status in Mexico

Nuclear power in Mexico

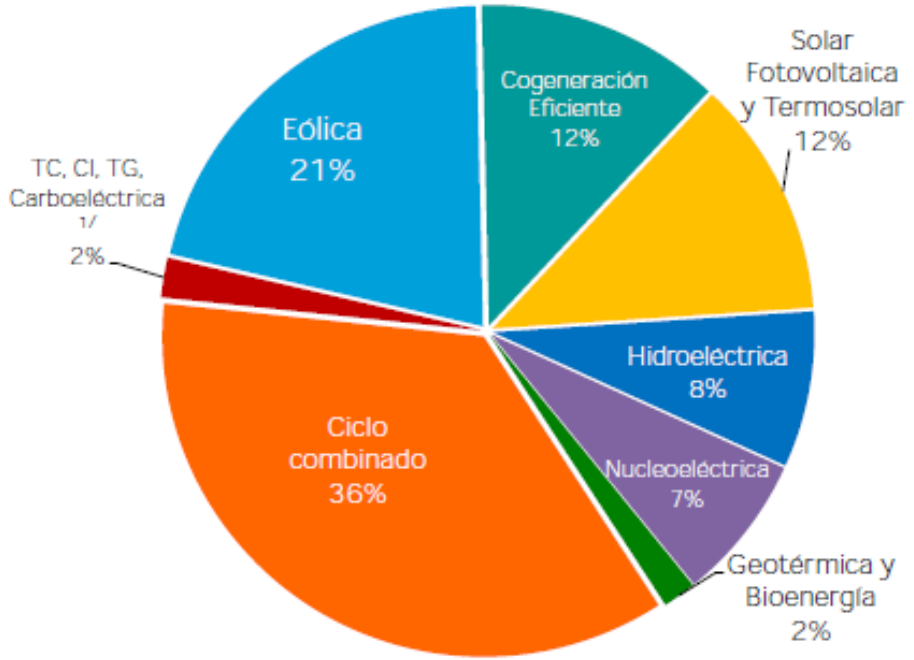
- Laguna Verde Units 1, 2
- On the coast of the Gulf of Mexico
- GE BWR5, 1,620 MW total
- In commercial operation since July 1990
- Represents 4.7% of total annual power generation

Plans for the expansion of nuclear installed capacity



Programme for the Development of the National Electricity System 2016-2030 (Ministy of Energy)

- 57,122 MW of additional capacity
- Technology participation in capacity additions, 2016-2030



Programme for the installation of new power plants 2016 - 2030

Project type	Location	Year required	Capacity (MW)	Projected investment (Million dollars)
Nuclear	Gulf Coast	2028	1,360	$6,200
Nuclear	Gulf Coast	2029	1,360	$6,200
Nuclear	Gulf Coast	2030	1,360	$6,200

Nuclear reactor technology assessment for implementation in Mexico

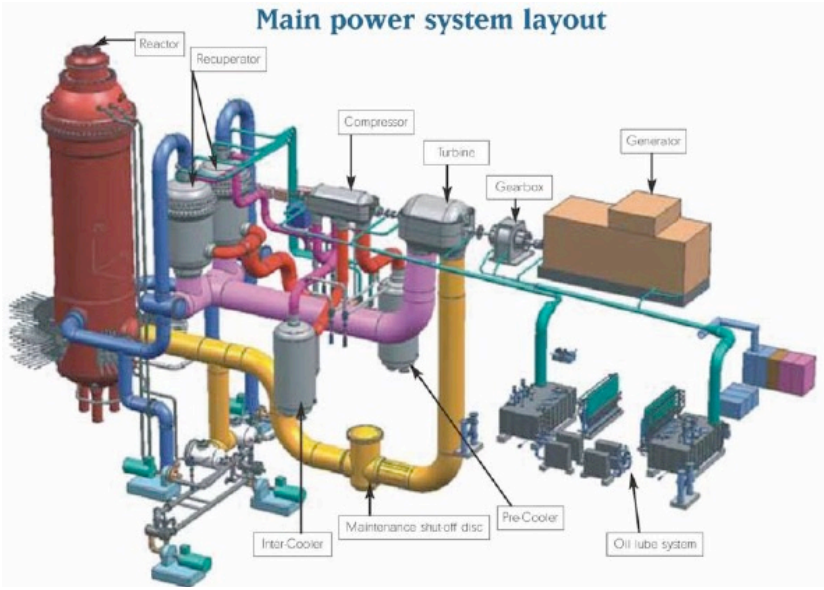
- In the last few years, different nuclear reactor technologies have been assessed for possible implementation in Mexico
- Tendency is toward large Generation III+ Advanced LWRs due to existing certification, operational experience, units under construction
- But studies have been made of possible uses and applications of SMR type reactors in the country

Cogeneration using a PBMR (pebble bed modular reactor)

- Production of process heat for an oil refinery
- 165 MWe: 100 MW for power, 65 MW for process heat

Electricity capacity	100 MWe
Cost of electricity	0.06 US$/kWh
Steam production	179.5 ton/hr
Cost of steam	7.33 US$/GJ*

*Cost of steam produced in industrial boiler = 9 US$/GJ

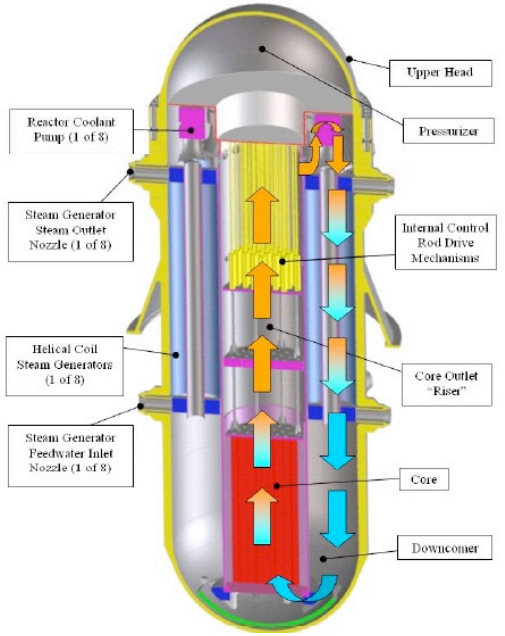


Ref. G.Alonso, R.Ramirez. “Cogeneration using a nuclear reactor to generate process heat”. ININ. 2009.

Water desalination using an IRIS reactor

- Cogeneration using an IRIS reactor to produce power and desalted water
- Different desalination processes were analysed
- Using 3 IRIS modular reactors with 335 MWe capacity each

	(Average)
Salable electric power	900 MWe
Cost of electricity	0.062 US$/kWh
Desalted water production	260,000 m^3/day
Cost of water	0.985 US$/$m^3$
Power for desalination plant	34 MWe



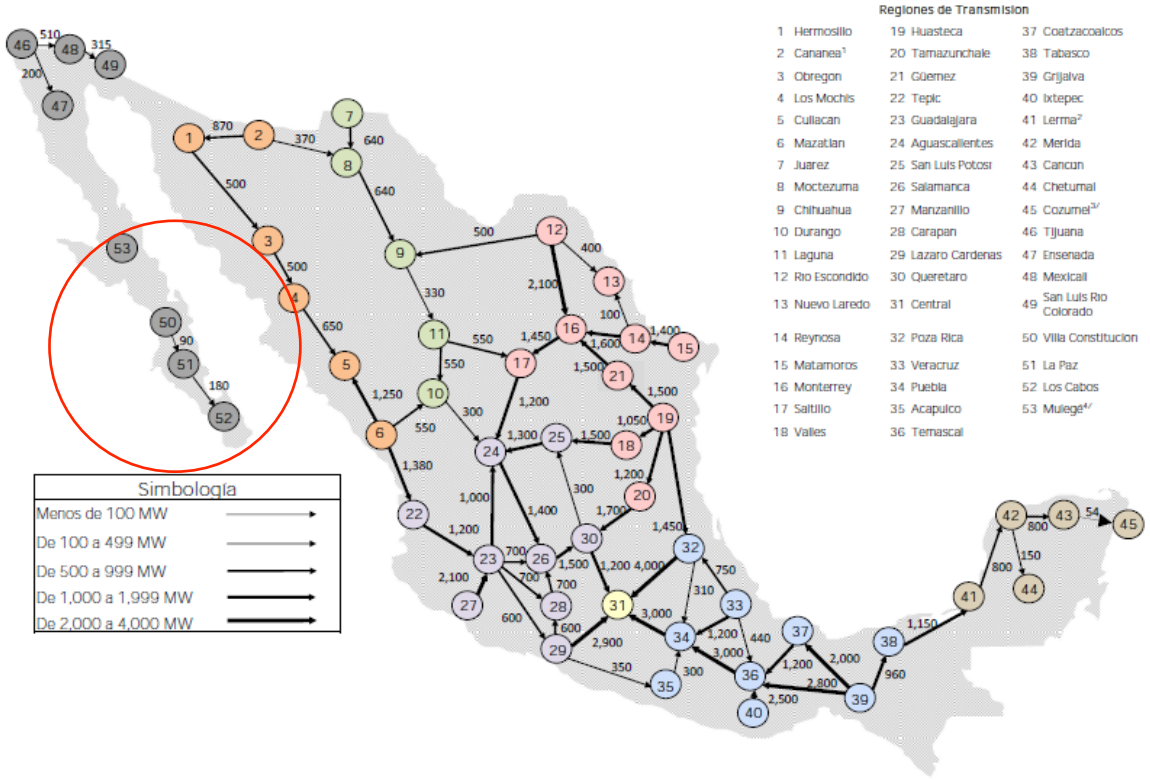
Ref. S. Vargas, G. Alonso, JA. Gonzalez, V. Xolocostli, JR. Ramírez. "Factibilidad de cogeneración de agua y electricidad mediante el IRIS". ININ, 2009.

Use of SMRs in small scale isolated grids

- Electricity Sector Outlook 2015-2029 (Ministry of Energy)
- Use of SMRs in small scale isolated grids as a reliable, economical and more efficient alternative to gas-fired combined-cycle plants

Baja California Sur not connected to National Interconnected Grid System

Electricity grid interconnections in Mexico



- High transportation costs of fuel into the area
- LNG regasification plants have been considered
- Case study compared
  - 115 MW combined-cycle plant
  - 100 MW SMR
  - 100 MW SMR using 10 MW for water desalination

	Gas-fired CC	SMR	SMR w/ cogen
Investment (MUSD)	164.5	584.0	640.4
Annual benefit (MUSD)	4.21	57.12	52.96
NPV (MUSD)	-126	312	169
Benefit/cost	0.24	1.53	1.26
IRR (%)	-1.60	9.70	8.00
Recovery time (years)	--	16.7	24.4

Issues to consider for the implementation of SMR technology in Mexico

- Regulation related to Government acquisitions
  - The Law favours suppliers or technologies with the most experience and lowest cost
  - Conventional technologies for power production will prevail over SMRs, with very few units in operation and no commercial units under construction.
  - Project economics also do not favour SMRs
- Procurement of a nuclear reactor will be a highly-publicised and much-questioned investment. In such a setting, it will be difficult to decide in favour of a new technology with essentially no commercial operational experience and with unproven economic characteristics

Licensing issues

- Regulatory body staff is limited in number (243 - in part due to the fact that the licensing of present reactors occurred 3 decades ago)
- Regulatory staff acquainted only with large LWR technology
- Innovative features of SMRs (passive safety systems, long-life cores, others) or the different technologies used (gas-cooling, sodium-cooling, lead-bismuth cooling) are unfamiliar to regulatory staff, which could make the licensing process more difficult
- It will most probably be a requirement from the regulatory body that technologies to be evaluated in Mexico have been certified or licensed in another country

Economic issues

- In Mexico, by law, nuclear energy production is an activity reserved for the State.
  - High competition for funding
  - No support from private investment funds
- To be approved for implementation, SMRs have to demonstrate economic competitiveness (need to evaluate economics of actual plants being built)
- Per kWe capital costs of SMRs are tens to hundreds of percent higher than for large reactors, impacting the Levelised Cost Of Electricity (LCOE) (NEA). Difficult to justify investment even if total overnight costs are lower

References. OECD/NEA Study on the Economics and Market of Small Reactors. NEA. 2013.
Current Status, Technical Feasibility and Economics of Small Nuclear Reactors. NEA. 2011.

Economic issues

- Modularity, shorter construction times are factors that will positively impact investment costs: it is necessary to prove that there are important savings and that construction times are shorter
- SMRs competitive with gas plants at a gas price of 5 USD/Mmbtu, which is expected until 2020 in North America (NEA)
- First Of A Kind (FOAK) plants will be 15-55% more expensive than subsequent units (NEA)
- Large initial orders are needed for serial production to allow cost reductions

References. OECD/NEA Study on the Economics and Market of Small Reactors. NEA. 2013.
Current Status, Technical Feasibility and Economics of Small Nuclear Reactors. NEA. 2011.

In summary

- Demonstration units have to be built
- To avoid FOAK costs, necessary to have a large number of initial orders. Maybe a joint programme for North, Central and South America?
- Use in co-generation mode. LCOE could be improved by 20-30% (NEA)
- Use as an alternative in isolated off-grid areas where cost of transporting other fuels is uneconomic

References. OECD/NEA Study on the Economics and Market of Small Reactors. NEA. 2013.
Current Status, Technical Feasibility and Economics of Small Nuclear Reactors. NEA. 2011.

Thank you