

SMALL MODULAR REACTORS (SMR's) IN THE EMERGING MARKETS. THE MEXICAN CASE

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ABSTRACT: This paper belongs to the INLA's Working Group number 3 "International Nuclear Trade and New Build". To be talked during the Nuclear Inter Jura Congress in Abu Dhabi, UAE from 4th to 8th November 2018.

The idea is to analyze from different points of view, such as financial, technical, political, commercial and legal, the viability of using small modular reactors (SMR's from here and after) in the emerging markets. For instance in: United Arab Emirates, Brazil, Turkey, South Africa and Mexico, among other.

The objective of this paper is to provide a legal research linked to the legal issues raised by SMRs. For example: safety, inspections, licensing, emergency preparedness and response, communication strategy, environmental monitoring, radiation protection, liability, security, safeguards, radioactive waste, human resources, insurance and transport.

This paper can be useful for other countries; who consider the SMR's as a possible option for their nuclear sector.

So, we would like to start from the beginning, we mean, what is understood by emerging markets and small modular reactors (SMR's)?

Antoine W. Van Agtmael of the International Finance Corporation was the first in used the term emerging markets in the early 1980s. Today, the term is used freely. Some analysts include under the concept of emerging markets only those economies with considerably low incomes, others only include countries that are expected to have high economic growth, while others include all countries that are not considered developed. (1)

For purposes of this work, an emerging market or emerging country is understood as a market that has been or is in the process of globalization. In other words, it is a market that is opening its borders to the flow of international trade and investment and to the practices of the administration at an international level. So, the expressions "emerging country", "developing country" and "country" less developed country will be used alternatively.

In an economic sense, the nuclear energy option has to face not only the public opinion sensibility, mainly related to nuclear plants safety and waste disposal issues, but also the economic evaluation from private enterprises, investors, international organizations and governments. So, the economics of the nuclear energy is one of the key drivers on the viability and acceptability of the nuclear option. (2)

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In accordance with Carelli et al. (2010) smaller size nuclear reactors can represent a viable solution especially for developing countries, or countries with not-highly-infrastructured and interconnected grids, or even for developed countries when limitation on capital at risk applies. In this way, the interest in the nuclear energy source is coming not only from the developed countries, but also from those belonging to the emerging countries. However, market conditions and political contexts influence the adoption of nuclear power plants in emerging countries when dealing with large size nuclear reactors (LRs).

IAEA defines as small size nuclear reactors those with an equivalent electric power less than 300 MWe, while medium-sized nuclear reactors are those with an equivalent electric power between 300 and 700 MWe. Frequently, both kind of reactors are combined into the termed “Small and Medium-sized Reactors” or “Small Modular Reactors” (SMR) representing those with an electric power less than 700 MWe. (3) (4)

From the economic point of view, investments in SMRs have important advantages due to their modular management intrinsic property, that is: due to smaller sizes and shorter construction times, the capacity additions of SMRs are more flexible in sizing, timing and siting than those of LRs. In particular, the capacity of a plant is more adaptive to changing market conditions. This property in SMRs brings with it implications in terms of generation, revenues and costs. An important financial aspect in terms of profitability, the shorter the SMR construction time, the higher the net present value (NPV) of investment. (5) (6)

In this sense, Shropshire (2011) and Locatelli et al. (2014) suggest that SMRs may effectively compete in future electricity markets as long as there is control over their high capital costs only being available through a limited number of investors, favorable financing, and if there are also similarities in capacity with the current light water reactors. (7) (8)

Liman (2018) argues that the main weakness of SMRs today is a purely economic issue. However, this author explains that incremental construction as well as gradual shutdown options, that is, due to their modular management intrinsic property, it is possible to improve the economics of SMR projects by handling the uncertainty of future prices. (9)

According to the SMR Regulators’ Forum; whose member parts are (as April 2018): Canada, China, Finland, France, Republic of Korea, Russia Federation, Saudi Arabia, United Kingdom and United State, who in January 2018 defined the SMR’s as: “typically have several of these features:

- Nuclear reactors typically <300 MWe or <1000MWt per reactor;
 - Designed for comercial use, i.e., electricity, production, desalination, process heat (as opposed to research and test reactors),
 - Designed to allow addition of multiple reactors in close proximity to the same infraestructura (modular reactors);
 - May be light or non-light wáter cooled; and
 - Use novel designs that have not been widely analysed or licensed by regulators”.
- (10)

Here is an image; which illustrates the SMR's as follows:



IMAGE 1: Small Modular Reactor (SMR's). (11)

Characteristics SMR's

In general:

- Small and simpler units for generating electricity from nuclear power, and for process heat;
- The technologies involved are numerous and very diverse.

“Facility size:

- smaller plant footprint (as compared to a conventional NPP);
- small power of the core: reduced decay heat load, increased core stability, smaller inventory of radionuclides and passive safety.

Use of novel technologies:

- passive cooling mechanisms: natural circulation and gravity driven injection;
- integral design (incorporation of primary system components into single vessel);
- non-traditional or different number of barriers to fission product release;
- unique fuel designs (e.g., ceramic materials, molten salt fuel).

Modular design:

- compact and simplified designs;
- production, assembly and testing in factory
- multi-module facilities

Deployment (siting and transportation):

- siting: on ground, underground, on sea, under water, movable, in regions lacking in essential infrastructure (e.g., electrical grid, cooling water);
- module transportation: during construction, during the operation of other modules, for refueling purposes in some designs.” (12)

Advantages SMR's:

- To reduce the impact of capital costs and to provide power away from large grid systems;
- Smaller and cheaper; (13)
- Size and modularity;
- Construction time and financing;
- Shorter construction time;
- Low capital cost;
- Easier financing strategy;
- Safety and reliable base load;
- Reduced emergency planning zone;
- Site flexibility;
- Clean energy; and
- Economic diversification and job creation. (14)

Disadvantages SMR's

- Large-scale production;
- Licensing;
- Legal issues (as weakness right now in September 2018).

Here are some Countries that already have SMR's: Canada, China, Finland, France, Republic of Korea, Russian Federation, United Kingdom and United States. No one of them has a specific legal framework for the SMR's. (15)

And now let's take the Mexican case as emerging market and its viability using SMR's.

In Mexico there are 124 millions people. This country uses mainly oil as energy source. The nuclear sector is around 3%.

Mexico has signed the following international nuclear treaties:

On Nuclear Safety:

- Convention on Early Notification of a Nuclear Accident,
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency,
- Convention on Nuclear Safety,
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

On Nuclear Security:

- Convention on Physical Protection of Nuclear Material,
- Amendment to the Convention on the Physical Protection of Nuclear Material.

On Liability:

- Vienna Convention on Civil Liability for Nuclear Damage,
- Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean.

Besides the Co-operation Agreement for the Promotion of the Nuclear Science and Technology in Latin America and the Caribbean (ARCAL), The Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA (RSA).

Mexico has one Nuclear Power Plant named “Laguna Verde” (“Green lake” in english) located in the East part of the country; which is integrated by two power reactors. The first one started operating in 1990 and the second one in 1995. From recent years there is the intention in Mexico to enlarge the nuclear sector. Nowadays, this enlargement is considered via Small Modular Reactors (SMRs).

Martínez & Maciel Nuclear Law Firm (www.martinezandmaciel.com) has an extensive experience in the Nuclear sector (national and international). We have been involved for years with some Mexican nuclear authorities, the highest of them shared with us the desire to expand the nuclear sector through SMR´s some months ago (March 2018).

So, now the question is as follows: are the Small Modular Reactors (SMRs) a possible option for Mexico?

Taking into account the financial, technical, human resources that are needed. And, of course, from the legal point of view. More over considering the political, comercial and institutional challenges right now in Mexico (September 2018).

In Mexico, in case that there are SMR´s would be in the Northwest and Southeast part of the country, with russian technology.

Regarding to the legal framework on SMR's in Mexico, there is not yet any, but we would like to suggest some legal framework as follows:

Taking into account that the mexican nuclear legal framework is integrated by:

- 1.-The Mexican Federal Constitution regulates the nuclear sector in its article 27;
- 2.-There is the Law on Constitutional article 27 on nuclear issues; which contains general points on the nuclear sector; such as the main faculties of the regulatory body and the nuclear institute of researching.
- 3.-There is the Civil Liability Law for nuclear damage;
- 4.-Regulations on radiological safety and on transporting in the nuclear sector.
- 5.-There is not regulation for the Nuclear Power Plants (NPP's) in Mexico.

Mexico has Nuclear Power Plants and about time needing legal framework on it; as well for Nuclear Power Plants; which could exist in the future; including the SMR's. Above all, considering that accidents can happen, even in the best regulated countries.

Regarding to the current nuclear politics in Mexico, keeping in mind that this paper is for the Nuclear Inter Jura Congress (to be published and presented) from 4th to 8th November 2018 in Abu Dhabi, United Arab Emirates (UAE), and that is going to be new President of Mexico from 1st December 2018. Right now is unclear.

About the foreign trade with the main counter parts, to be exact the NAFTA, the trade among Canada, United States and Mexico; which existed from 1994 is over and right now there is a bilateral trade agreement between the United States and Mexico; which was signed last 27th August 2018. The desirable issue is that contains the nuclear sector.

So we strongly suggest for any emerging market that consider the nuclear energy as a energy source to keep in mind the following points:

1. To sign every single nuclear international legal instrument issued by the IAEA;
2. To have a long term and well defined nuclear political plan.
3. To have in advance the legal framework for the nuclear sector.
4. In case that considers to include the SMR's the topics that can not be missed in this regulation are: safety infrastructure (such as assessment, design, siting, construction, commissioning, oversight and decommissioning of nuclear facilities) (16), inspections, licensing, emergency preparedness and response (defining first point of contact) (17), communication strategy, environmental monitoring, radiation protection (planned exposures, emergency exposures and existing exposures) (18), liability, security, safeguards (19) (20), radioactive waste (21) (22) (23), human resources, insurance and transport. (24) (25)

We would like to suggest as the ideal structure for the legal framework for SMR's as follows:

To name the regulation "Regulation on Small Modular Reactors (SMR's) in case that be an independent regulation, or to add an specific title to a regulation that already exists. For instance:

Title "x" (any number in case that be added to a regulation that already exists) .

More specifically:

Title XXVIII: On Small Modular Reactors (SMR's)

Chapter I: General Considerations

Article1: to define here the venue,

For example:

Article 1: this regulation applies in all the country. The national authority on charge is the regulatory body.

Article 2: to write here the key words in alphabetical order.

For example:

Article 2: Definitions: these words contained in this regulation must to be understood as follows:

"Accident: Any unintended event, including operating errors, equipment failures and other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection or safety.

Becquerel: The SI unit of activity, equal to one transformation per second.

Competent authority: Authority designated for any purpose in connection with SMR's.

Decommissioning plan: A document containing detailed information on the proposed decommissioning of a facility.

Enforcement: The application by a regulatory body of sanctions against an operator, intended to correct and, as appropriate, penalize non-compliance with conditions of an authorization.

Fuel: (Understood as nuclear fuel). Fissionable nuclear material in the form of fabricated elements for loading into the reactor core of a small modular reactor.

High level waste: (HLW) The radioactive liquid containing most of the fissions products and actinides present in spent fuel. Spent fuel (if it is declared a waste).

Licence: A legal document issued by the regulatory body granting authorization to perform specified activities related to the SMR's.

Monitoring: The measurement of dose or contamination for reasons related to the assessment or control exposure to radiation or radioactive substances, and the interpretation of the results.

Nuclear safety: The achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards.

Operation: All activities performed to achieve the purpose for which an authorized facility was constructed.

Radioactive: Exhibiting radioactivity; emitting or relating to the emission of ionizing radiation or particles.

Siting: The Process of selecting a suitable site for a facility, including appropriate assessment and definition of the related design bases.

Transport: The deliberate physical movement of radioactive material from one place to another.

Waste: Material for which no further use is foreseen." (26)

Chapter II: On Nuclear Safety

Article 3: to include here in all the number of articles needed the main points on nuclear safety. Here is convenient to include the subjects on assessment, design, siting, construction, commissioning, oversight and decommissioning of nuclear facilities) (27),

Chapter III: On inspections

Article 4: to include here in all the number of articles needed the main points on inspections.

Chapter IV: On Licensing

Article 5: to include here in all the number of articles needed the main points on Licensing.

Chapter V: On Emergency Preparedness and Response Plan

Article 6: to include here in all the number of articles needed the main points on Emergency Preparedness and Response. Do not miss to precise the national point of contact. (28)

Chapter VI: On Communication Strategy

Article 7: to include here in all the number of articles needed the main points on Communication Strategy.

Chapter VII: On Environmental Monitoring

Article 8: to include here in all the number of articles needed the main points on Environmental Monitoring.

Chapter VIII: On Radiation Protection

Article 9: to include here in all the number of articles needed the main points on Radiation Protection. Do not miss to include the planned exposures, emergency exposures and existing exposures. (29)

Chapter IX: On Liability

Article 10: to include here in all the number of articles needed the main points on liability.

Chapter X: On Nuclear Security

Article 11: to include here in all the number of articles needed the main points on nuclear security.

Chapter XI: On Nuclear Safeguards

Article 12: to include here in all the number of articles needed the main points on nuclear safeguards. (30) (31)

Chapter XII: On Radioactive Waste

Article 13: to include here in all the number of articles needed the main points on radioactive waste. (32) (33) (34)

Chapter XIII: On Human Resources

Article 14: to include here in all the number of articles needed the main points on human resources.

Chapter XIV: On Insurance

Article 15: to include here in all the number of articles needed the main points on insurance.

Chapter XV: On Transport

Article 16: to include here in all the number of articles needed the main points on transport.
(35)

Chapter XV: On Sanctions

Article 16: to include here very carefully in all the number of articles needed the sanctions as well in the criminal law. For example in the code of criminal issues, remembering “nulla poena sine lege”.

Final articles: here to precise the enforcement of this regulation (date from which the regulation should be applied).

CONCLUSIONS

FIRST: At first sight, it seems to be a very good idea (from the financial and technology point of view) to use SMR's in any country, specially for those who belong to the emerging markets, already having or being newcomer in the nuclear sector.

SECOND: It is strongly desirable to sign the nuclear legal international instruments issued by the International Atomic Energy Agency (IAEA) before to use nuclear energy.

THIRD: It is deeply suggested to have a long and well defined nuclear plan, independently who is governing in an specific country.

FOURTH: It is important also to consider the foreign trade in nuclear issues, in order to be able to improve the nuclear sector in an specific country.

FIFTH: It is absolutly indispensable to have in advance the nuclear legal framework before to use nuclear energy, including the legal framework for the SMR's in case that be decided to use them.

SIXTH: The topics that are suggested to be included in the legal framework for the SMR's are: safety, inspections, licensing, emergency preparedness and response, communication strategy, environmental monitoring, radiation protection, liability, security, safeguards, radioactive waste, human resources, insurance and transport.

ENDNOTES

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