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NUCLEAR REGULATORY BODIES AND TIME MANAGEMENT OF NPP PROGRAM IN NEW COMERS COUNTRIES: THE ROLE OF NATIONAL TSO

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ABSTRACT

Nuclear power plants are among the different energies that a lot of countries are looking for as a future source of energy and most of these countries are developing countries who have no experiences in nuclear power plants technologies. On the other hand, it is important that high levels of nuclear safety are maintained in these new comer countries through all the process of these nuclear power plants. This calls for high caliber nuclear regulatory organization to be involved and participated in all nuclear regulatory activities as an active and competent partner. Nuclear regulatory bodies of new comers face different challenges depending upon their role and historical background. Some common challenges were lack of resources, manpower problems, new design concepts, new technologies and also the pressure of time if the contracts with vendor countries were signed. Different international experts had been expressed the increasing importance of TSOs for supporting regulatory bodies in developing of nuclear power plants programs in well-developed or new comers countries. This paper discusses the different challenges which are facing the regulatory bodies in the new comer's countries. It describes the role which TSOs can play in the regulatory activities of the NPP and the different approaches which can implemented. An investigation of regulatory bodies behaviors in some international case studies are summarized to document the lessons learned. Also, the relation of the regulatory bodies with the time managements of the NPP program had been highlighted with emphasis to international practices. It concluded that TSOs can play an important role with the regulatory bodies in the new comers' countries and in the implementation of the time plan of the NPPs.

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INTRODUCTION

Countries embarking on a nuclear power programs need to make sure that the development of their legal, regulatory and support infrastructure keeps pace with the time plan construction of the nuclear power plant itself. This leads to that an efficient and international competent nuclear regulatory bodies must be existing in these countries to ensure that all nuclear activities in NPP's are conducted safely and consistent with the national and international safety regulations and standards. In fact there is a gap in the new comers NPP's countries between their ambitious plans for nuclear power development and the corresponding plans for nuclear regulatory activities and experiences as defined by IAEA (2016). Some new NPP comers' countries had been already signed with vendors to install NPP's and in the same time is not so much infrastructures in these countries to do all regulatory activities by their own. So, different questions are raised in this situation:

- What is the main contribution of TSOs (national-international) in supporting the new regulatory body for enhancing nuclear safety and implementation of regulatory activities?
- What should be done by the regulators in the short, medium and long term to be in parallel with operators needs and time schedule for licensing the NPP's?

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- What is the regulatory role in time management of NPP program?
- The above questions are the base of this research paper with the aim to answer these questions.

Nuclear regulatory body responsibility and structure in new comers countries

Nuclear Regulatory Responsibility

The nuclear regulatory body must have a strong knowledge base and technical infrastructure. They should be able to provide independent technical and scientific advice without pressure from the applicants. Also, they must be competent and have adequate resources and manpower to efficiently perform their regulatory activities, and also to have credible technical and scientific expertise. Nuclear regulatory bodies have the responsibility for providing oversight and assurance of nuclear safety during all the phases of NPP projects. The regulatory body needs to be able to confirm that the licensees have adequate scientific and technical support to maintain safe operations and to address potential unexpected issues. The regulatory body also needs independent scientific and technical information to support its review and assessment of safety submissions from licensees and this can be provided through TSO, as described by Vector *et al*. (2014).

Nuclear Body Structure

One of the key functions of a regulatory body is that through the potential of independent verification of any aspects of a licensee's work, the regulatory body influences all a licensee's internal processes, because any piece of safety-related work can be audited at any time and manner. A good regulatory body structure defines a climate of openness, fairness, and high expectations of safe performance that operators will internalize. In addition, a good regulatory structure ensures that international regulatory trends and approaches are readily adopted and implemented by a national regulatory body, Vector *et al*. (2014). According to IAEA GSG-4, It states that the regulatory body should have, at a minimum, adequate core competence in every core regulatory function, in order to retain the ability both to frame and to manage its requests for advice and to comprehend and act on the advice when it is received, IAEA (2013). The approach plan to recruit a mixture of young and senior professionals could be successful if the competitiveness of the salaries proposed by the government should be as private sector or more. This is a very important issue to reducerevolving-door pattern of attracting young and experienced staff that after training leave for higher paid jobs in industry or private sector. Junior staff who need to be trained before becoming fully operational. There is also a risk that new recruits may leave the organization after being trained so new regulatory body should consider developing a staff retention strategy. Most regulatory bodies are structured somewhat like a corporation, with a Management Technical Commission at the top supported by a small dedicated group of people, and a large separate specialized technical TSO which assesses the safety case in detail, conduct regulatory review and assessment and presents its conclusions, findings and recommendations to the Commission.

Then, the Commission makes the final decision, not the staff or the TSO. The Commission reports directly to, or is accountable to, the national government in a way that is independent of the proponent. Some regulatory bodies have independent advisory committees such as in the United States Nuclear Regulatory Commission (USNRC) who has an Advisory Committee on Reactor Safeguards (ACRS) consisting of highly respected technical experts; The Advisory Committee on Reactor Safeguards (ACRS) is statutorily mandated by the Atomic Energy Act of 1954 of USA, as amended. The ACRS is independent of the NRC staff and reports directly to the Commission, which appoints its members, so that technical inputs to the Commission come from more than one source, USNRC. The Committee has four primary purposes:

- To review and report on safety studies and reactor facility license and license renewal applications;
- To advise the Commission on the hazards of proposed and existing production and utilization facilities and the adequacy of proposed safety standards;
- To initiate reviews of specific generic matters or nuclear facility safety-related items; and
- To provide advice in the areas of health physics and radiation protection.

Also, regulatory bodies must have adequate resources and experience, but they do not have to replicate all the resources of the designer or operator. To ensure adequate financial resources, regulatory bodies must have strong government financial support at the early stage of their development, whereas later most of their daily operations are on a cost recovery basis from the licensees. Figure (1) shows safety review and interaction between regulatory body and its TSO in Russia, Ho (2014).

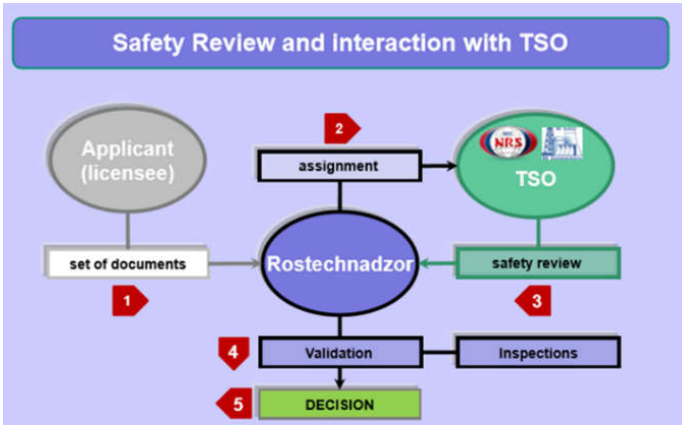


Figure 1. Safety Review Process and Interaction between Regulatory Body and its TSO in Russia, Ho (2014)

Proposed Approaches for new nuclear regulatory bodies

There are different approaches which can be applied for the new regulatory bodies of the new comers, and these include:

To start with the exciting national competent staff trained in the previous nuclear projects such as research reactors, irradiators, and waste management plant. These trained people can be found in the TSOs of the country. So, the regulatory bodies can hire the national TSO to provide technical assistance to the regulatory body. This approach can optimally built the national capabilities in the nuclear power plants fields, use the national manpower resources and infrastructure and can match the developing country economic situation. It

can be applied in the short term and middle term of the nuclear program and can maintain sustainability of workforce in the country. This approach was followed by Canada, where the power reactor program benefited from staff trained in the research reactors and can be applicable option for the new comers who had developed experiences through research reactor regulatory process. Also this approach had been applied successfully in different countries such as Russia, Pakistan, Romania and India.

Also, TSOs can either support the regulatory body and/or the utilities. As example, in Bulgaria the TSO had two main tasks which include the followings: a) to provide expertise and consulting for nuclear regulatory agency and b) to provide technical assistance, design and engineering, for the Utilities, Katia (2007).

1. To use the vendor of a power reactor to help create the required regulatory infrastructure in the country purchasing the NPP by technology transfer and training of personnel. The regulatory staffs in the purchasing country are developed under an agreement with the regulatory body of the vendor's host country.
2. To use IAEA documents and technical assistance. IAEA has developed a comprehensive set of requirements and guides covering all aspects of commercial nuclear applications, including the organization and management thereof. The IAEA also gives technical assistance to countries developing a nuclear program, and it can support them through technical missions, workshops, and training courses in nuclear regulation.
3. To use international consultants or TSOs who have substantial nuclear regulatory experiences of NPP projects or from countries who had established nuclear regulatory regimes. This approach is valuable to nuclear regulatory bodies that are in the early years of the nuclear power plant program. Also, it can be necessary for the countries that do not have any previous experiences in nuclear research reactors or any nuclear facilities. Also it can be necessary step in the beginning but it is insufficient in the long term, (7).

As example, FANR, the nuclear regulatory body of United Arab Emirates (UAE) had been contracted with three TSOs from USA and Europe, based on qualifications in conducting safety evaluations of nuclear facilities for established nuclear regulatory bodies in their home countries. These contracts covered different areas of the review and assessment process such as: PSAR (siting, design, safety analysis, radiation protection…) and finally FANR retains the responsibility for regulatory decisions, Neil (2014).

Role of tsos in nuclear program of new comers

Technical Support Organizations (TSOs), whether part of a regulatory body or a separate organization, are gaining increased importance in providing the technical and scientific basis for decisions and activities regarding nuclear and radiation safety. International organizations such as the IAEA and Nuclear Energy Agency/OECD (NEA) also rely on the active contribution of TSOs, G.Li (2006). According to B. Thomauske, Germany (Managing Director of Vattenfall Europe Nuclear Energy GmbH manpower), he stated and clarified the difference between the operators and the regulators as follows: the difference in expertise required for operators (specific and detailed) and regulators (generic), G. Li (2006). In a presentation titled "Independent Technical and Safety Advice for Regulatory Decision Making", it was pointed out the role of TSOs as a support for nuclear regulatory bodies. The need for comprehensive know-how and know-why on nuclear science and technology as a whole and on the technical aspects of nuclear installations were emphasized. This comprehensive knowledge can only be achieved if the TSO is involved in the nuclear licensing and supervision process and participates in large research and development projects, G. Li (2006). TSOs need to be in the front line of technological development and should participate in national and international research and development programs and networks for exchange of information and lessons learned. TSOs can also contribute towards increasing public confidence by providing information on the scientific bases of decisions, independent of political and economic interests, OECD (2011).

According to Neil (2014), he had mentioned some of the advantages of using TSOs which can be summarized as follows:

- Extensive range of technical resources
- Nuclear regulatory expertise
- Enables knowledge transfer, and reasonable time to develop internal staff and expertise, without delaying immediate program needs
- Flexibility of short- or long-term support
- Work performed locally or remotely
- Enhances quality/effectiveness of technical review; enhances international institutional acceptance such as IAEA and public confidence.
- Regulatory strategy and implementation plan

Also, he stated that TSO activities can cover different regulatory areas such as:

- Development of regulatory infrastructure
- Development of regulations and guides
- Regulatory review instructions and procedures
- Process and work instructions
- Management and organization of regulatory activities,
- Document Control,
- Advisory support, e.g. in support of enforcement actions,
- Technical review of license application in various areas: Electrical, mechanical, civil, structural, seismic, thermal-hydraulics, nuclear fuel, nuclear plant systems, radiation protection, technical specifications, safety analysis, and severe accidents
- Providing Safety Evaluation Reports
- Review of Site and Environmental Impact Assessment Reviews
- Confirmatory Analysis
- Training and knowledge transfer
- Project management, technical review management
- Audits/inspections of suppliers
- On-site inspections during construction and operation

As example, the nuclear regulatory body of Russia (Rostechnadzor) had three TSOs who help it in all nuclear and

industrial regulatory activities as shown in Figure (2) and Figure (3), Ho (2014).

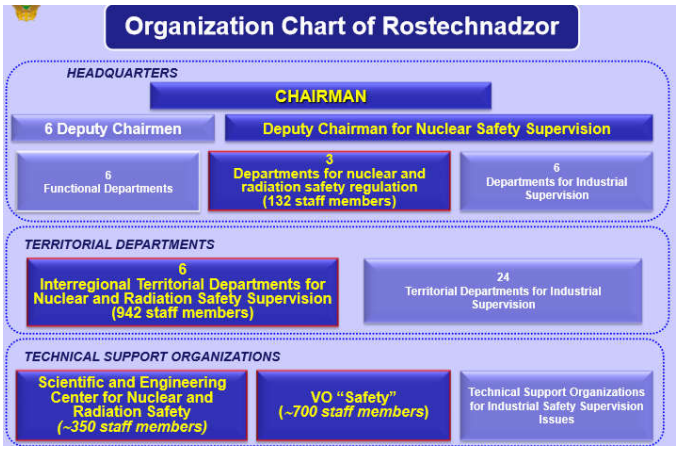


Figure 2. Organization Chart of Rostechnadzor showing the Three TSO, Ho (2014)

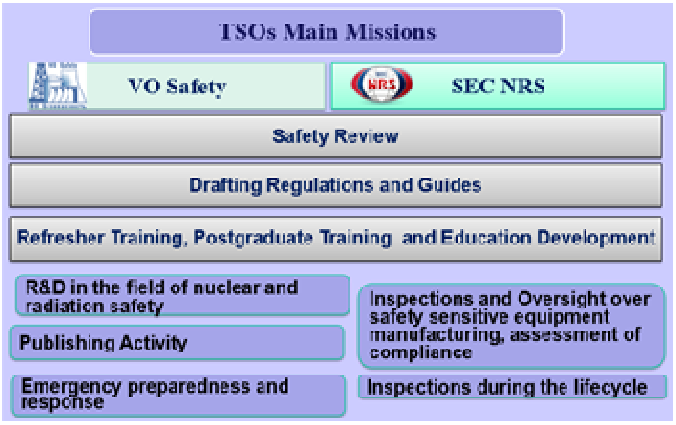


Figure 3. TSOs Main Regulatory Missions in the Russian System, Ho (2014)

Regulatory Bodies Behaviors

Victor *et al*. (2014), had studies and investigated the regulatory bodies behaviors in the three case studies to formalize the lessons learned which can help the new regulatory bodies in nuclear comers' countries. The study covered Three Mile Island (USA), Fukushima (Japan), and Olkiluoto (Finland).

Three Mile Island, USA

The President of the United States appointed a Commission headed by John G. Kemeny. Their report was very broad.

Their concentration was on human aspects: "The equipment was sufficiently good that, except for human failures, the major accident at Three Mile Island would have been a minor incident. "Of interest here are their findings on the U.S. regulatory structure at the time, which are summarized as follows:

- The regulations were too complex, required immense effort for compliance, and equated compliance with safety;
- The preoccupation with the most severe accident (the largest-break LOCA) took attention away from more likely, but slower-developing accidents, which were therefore not analyzed in depth;
- There was too much pre occupation with equipment performance rather than human performance;
- There was no requirement to look beyond the single events specified by the USNRC, for example to multiple failures;
- The role of systems classified as "non-safety-related" in causing accidents was not recognized;
- There was no systematic way of evaluating prior operating experience or looking for patterns;
- There were serious deficiencies in internal communication in the USNRC.

Fukushima, Japan

With respect to the Japanese regulator (the Nuclear and Industrial Safety Agency (NISA)), the National Diet of Japan Nuclear Accident Independent Investigation Commission concluded that "root causes were the organizational and regulatory systems that supported faulty rationales for decisions and actions", and in particular that the inadequacy of the design basis for Fukushima was known to both the utility and the regulator, but was not acted on. The regulator lacked separation from the utility. The Commission recommended formation of a new regulatory body which would be independent, transparent, professional, consolidated, and proactive, Vector el al. (2014).

Olkiluoto, Finland

It is not just accidents than can reveal a regulatory problem. Cost and schedule overruns of the project happened because of poor communication between the vendor/operator and the regulator which cause big damage to a nuclear build project. This has been exemplified by the construction of the third nuclear power plant unit at Olkiluoto in Finland. There actor is based on the European pressurized-water reactor (EPR) and is the first of its kind to have started construction. It was meant to start operation in 2009, but as of this writing (early2014), it is projected to come into service in 2016. This delay has been accompanied by a cost overrun of almost double the turnkey price of ~3.5billion euros.

Because the matter is currently in legal dispute, the parties have not published much objective analysis of what went wrong. However, the Finnish regulator (STUK) did comment publicly on several occasions, listing lessons learned as follows:

- "too ambitious original schedule for a plant thatis first of its kind and larger than any NPP built earlier;
- in adequate completion of design and engineering
- work prior to start of construction;
- Shortage of experienced designers;
- Lack of experience of parties in managing a
- large construction project.

The lessons learned from the above case studies can be summarized as follows:

- The need for mutual understanding between the regulatory bodies and the operators on how the regulatory practices are to be applied: "The licensee and

the regulator need to discuss early enough on how the national safety requirements should be best presented in the call for bids;
- The regulations must be cleared and not too complex which can, required immense effort for compliance, and equated compliance with safety;
- The time schedule should be accurate, practical and not too ambitious especially for the first NPP;
- Experienced manpower should be existing in all phases of NPP starting from site to commissioning phase;
- Experienced project management team with high technical capabilities should be existing in all stakeholders including operators, applicants, and regulatory bodies.

Time management of 1st npp in new comers countries

Time management of NPP is very important especially for the new comers, because any delay will reflect in cost and time implication of the NPP. In a study done in South Korea, a Nuclear Power Plant (NPP) construction schedule delay risk assessment methodology is developed and the construction delay risk is assessed for turnkey international NPP projects. Three levels of delay factors were selected through literature review and discussions with nuclear industry experts, Mahamed *et al*.(2015). This study assigns four main delay factors to the first level: main contractor, utility, regulatory authority, and financial and country factor. This study finds that the top five most important sub-sub-factors, which are as follows: policy changes, political instability and public intervention; uncompromising regulatory criteria and licensing documents conflicting with existing regulations; robust design document review procedures; redesign due to errors in design and design changes; and worldwide shortage of qualified and experienced nuclear specific equipment manufacturers. Decision makers of the nuclear industry can understand the significance of different factors to the NPP construction phase and they can apply risk informed decision making to avoid unexpected construction delays. This study found that the main contractor contributes the highest risk of construction schedule delays for NPPs, followed by utility in second place, regulatory authority in third place, and financial and country factor in fourth place.

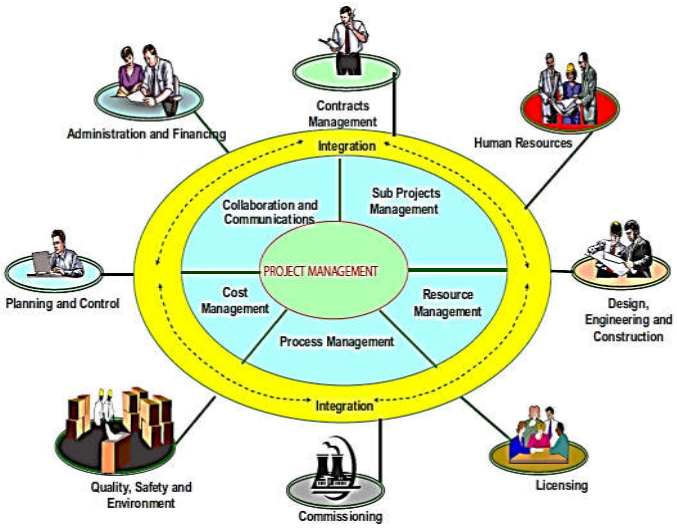
The results show that the six most important sub-factors in the high risk zone according to the risk matrix in level 2 are as follows: “delayed regulatory approval”, “country factor”, “inadequate completion of design before start of construction”, “slow procurement, manufacturing of equipment and delivery to the site for installation”, “delayed progress of construction and commissioning related works”, and “financial matters”.
This study finds the top 10 sub-sub-factors in the lowest level in the hierarchy of the model are: “policy changes, political instability and public intervention”, “uncompromising regulatory criteria and licensing documents conflicting with existing regulations“, “robust design document review procedures”, “redesign due to errors in design and design changes”, “worldwide shortage of qualified and experienced nuclear specific equipment manufacturers”, “delayed procurement contract”, “delayed in approval of design documents”, “lack of communication and coordination among the parties”, “delayed procurement of equipment and bulk material due to unavailability in the global market”, and “rework due to errors and quality control during manufacturing and construction”. Among the top five high risk zone factors of level 2 and level 3, there are no factors from the utility group. The expert panels for this study are mostly from the Korean nuclear industry, which is a limitation of this paper. Therefore, care should be taken when attempting to generalize the results, Mahamed *et al*. (2015).

Time Management and Regulatory Approval of NPP Projects

- A study done in 2016 had showed that around 75 Percent of nuclear reactors under construction worldwide are facing delays, because of different reasons. So, in order to avoid any delays and cost overrun in the first NPP, it is necessary to allocate sufficient time for the planning stage and to assess the preparedness of each party (vendor- applicant-regulatory body) before start construction. All the parties should agree about implementation plan to have a smooth implementation of the project, Nick *et al*. (2016).
- Timing of regulatory approvals of the NPP components must be properly incorporated into the manufacturing and construction planning to mitigate regulatory risks. Long-lead items can represent a substantive regulatory and economic risk to a project.
- For example, in Canada power plant components are usually not officially part of the licensing process until a formal application for a License to construct a reactor facility has been submitted to the nuclear regulator for detailed technical assessment.
- Many experienced national regulators have established pre-licensing processes to review key aspects related to the safety of a specific design. This is to ensure proponents understand which technical requirements should be applied for the proposed design including long-lead equipment. For example, in Canada, specific to nuclear reactor technologies, the Canadian Nuclear Safety Commission (CNSC) has a specific vendor-oriented pre-licensing design review process which can provide regulatory safety-related feedback to the vendor, Nick *et al*. (2016).
- As example in UAE, as pera Reuter’s news report on May 2017, Emirates Nuclear Energy Corporation (ENEC) said that work on the first reactor had been completed but it had not yet received the operating license from the UAE’s Federal Authority for Nuclear Regulation (FANR). ENEC announced “an extension for the start-up of nuclear operations for Unit 1, from 2017 to 2018, to ensure sufficient time for international assessments and adherence to nuclear industry safety standards, as well as a reinforcement of operational proficiency for plant personnel”, Stanley *et al*. (2017).
- Another example about cost implication of delay, "Delays generally cause cost increases, and the question becomes who's going to bear the costs?" said C. Dukes Scott, executive director of the South Carolina Office of Regulatory Staff, a watchdog agency that monitors SCANA Corp.'s spending. He also said that a single day of delay in Georgia could cost $2 million, according to an analysis by utility regulators, Ray (2014).
- So, the time management of the new nuclear power plant should be studied by all the responsible parties to avoid any delay and cost overruns.

Pre-licensing Engagement with Nuclear Regulatory Bodies

The successful construction of new nuclear power plants depends on a robust supply chain and manufacturing. Nuclear manufacturers supply many components necessary to support current and future nuclear power projects including the long-lead items. Integral to demonstration of safety of a specific SSC are the technical codes and standards applied to the design, manufacture and verification. Codes and standards contain generally accepted technical requirements and methodologies. When they are followed reasonable confidence that the SSC will perform its function reliably is assumed, Nick *et al*. (2016). The regulator's role in the long-lead items procurement varies from country to country. Regulator's involvement can range from reviewing licensee's supply chain process including inspection practices, without visiting vendor's facilities, up to complete independent inspections at the vendor's site. In some cases regulators may require certification (accreditation) of vendor's facilities. The management of the planning process for nuclear industries must include properly timed interactions with the nuclear regulator. Such planning must include consideration of the manufacturing aspects of long-lead items. Regulatory risks can be reduced if a regulator can confirm early that licensee's procurement process, as well as the specifications supplied to the vendor will meet regulatory requirements resulting in compliant products. A regulator's technical capacity to engage into high level specialized discussions with proponents seeking early feedback on specific proposals against regulatory requirements is required. This feedback offers an early opinion on whether the proposed design and programs might present fundamental barriers to licensing. Additional work may be identified to meet the requirements. This type of feedback allows the proponent to plan, develop and implement necessary corrective actions early to avoid more severe complications during the licensing process, or even worse difficulties during the licensed activities.



It is important, however, to recognize that the national regulatory body must always retain its regulatory independence and cannot become part of the proponent's preparatory activities. Review outcomes from pre-licensing engagement do not result in formal acceptance of a proponent's approach and do not bind, or otherwise influence, decisions made by the decision-making regulatory entity responsible for licensing. A cohesive management of the holistic logical integration planning of all the inputs to the project, regulatory consideration being critical for NPP construction, must be maintained. Figure (4) shows the relation among essential integration tasks of NPP Construction, IAEA (2012). In some countries, there is a scheduling process between applicant/licensee and regulator, in others not. Most studies make the point that mandatory deadlines for regulators are not feasible because the regulator has to complete his thorough safety review before granting any license. Deadlines and schedules (to be extended when justified) may have the function, however, to put some responsibility on the regulator to plan his budget, resources and activities in a manner to make compliance possible. The practical answer to these conflicting requirements is accurate anticipation of work by all parties (regulator, licensee and vendor), IAEA (2012).

Conclusions

The paper assessed and evaluated the role of nuclear regulatory bodies and its relation with national TSO. It concluded the followings:

- The funding and financing of the regulatory body is a fundamental consideration for establishing and securing the independence of that body.
- A nuclear power project in the construction phase requires interaction among the involved contractually integrated parties, mainly the main contractor, utility, and regulatory authority. That's way development directions needs to be established for all players in the field, including TSOs which will have an important role to sustain this situation.
- To make the construction phase of an international NPP project successful by meeting the schedule, a collaborative teamwork process among parties with different interests, functions, and objectives is prerequisite.
- Personnel movement between TSOs and the regulatory body is fairly common, and is beneficial for the new comer countries because it ensures that regulatory staff have deep hands-on knowledge of the technology they are to regulate.
- Causes for delay of NPPs can be due to a lack of sufficient communication, underestimation of effort required, an initial application that lacked quality or was incomplete, requirements changing during the licensing or construction process, political changes, reactions of the public (contested hearings, appeals against licenses), delays in regulatory assessment of the applicant's safety case, and limited resources of the regulator for multiple projects.
- TSO can play a main task on a short, medium and long term of NPPs projects.
- TSO can maintain the required competence in a proper safety culture environment, in order to be prepared to assure the proper support for domestic NNP and to be able to join huge and continuous efforts required to support development of safe and competitive nuclear energy.

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