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Consequences of Electricity Deregulation on Nuclear Safety

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ABSTRACT

The evolution of deregulation of electricity market started a couple of years ago and has not been finished yet. Deregulation causes increased pressure to reduce the costs of electricity generation. This presents a new challenge to regulatory bodies. They have to assess the impact of these changes on the safety of nuclear power plants. Accordingly, it is important to identify the risks to the nuclear power industry resulting from the deregulation.

Today's trend is that the number of electricity generating power companies will be reduced in Europe and also in Slovenia due to tough competition in the electricity market. The electricity price has decreased after the introduction of the deregulated market in most countries. This has been also the main reason for less investment to new generating capacities since the price has been lower than the generation costs. Investment problems are also present for the existing units, because of danger of inappropriate maintenance and reduction of the number of staff and their qualifications below the desired level that leads to loss of institutional memory. It is expected that only the biggest companies can stand the consequences of competition in electricity prices and consequential pressure to reduce the cost. In order to review the impact of deregulation of the electricity market some relevant points are discussed in this paper such as the need to cut costs of companies by reducing the number of their activities and increasing the efficiency in the remaining activities and /or outsourcing of activities, power station operating regime, safety culture, grid reliability, reliability and safety of operation, increased number of transients, ageing of components, outage duration, extended cycle and response of nuclear regulators.

From a regulatory point of view the impact of deregulation on nuclear safety is an important issue. This paper also discusses analyses and evaluations of this impact and proposes some measures how to prevent or to mitigate the consequences of deregulation impact on nuclear safety.

1 INTRODUCTION

Deregulation is necessary and it has a lot of advantages which are the reason for its introduction. The total liberalization of this field gives an opportunity for free market in other areas, without the hidden state subsidy and unfair competition. However, deregulation has also negative effects arising from tendency for bigger profit without proper consideration of nuclear safety. Similar problems are also present in the regulated state-owned systems; however the state can solve them easier and more effectively. Such problems would not appear on the ideal free market. However, deregulation also would not be necessary if the regulated state-owned systems functioned normally and the state did not exploit them.

On the deregulated, economically competitive market, power generators want to invest in profitable options that have relatively well-known technical, economic and political risks. On such a market, nuclear power might be at a disadvantage, since it may be considered to be encumbered with political risks (such as those arising from public opposition), technical risks related to waste disposal issues, and economic risks associated with liabilities for eventual decommissioning and dismantling of nuclear power plants. On the other hand, nuclear does have environmental advantages. In particular, practically zero emissions of greenhouse gases, particulate and other atmospheric pollutants. Also high capital cost, long construction time and need for operation at high capacity factors are relevant to nuclear power.

2 DEREGULATION IMPACT

Negative impacts of deregulation are first of all decreasing grid reliability, excessive cost reduction and improper investment. Besides there are influences on power station operating regime, safety culture, reliability and safety of operation, increased number of transients, ageing of components, outage duration and extended cycle.

All these influences are mixed and difficult to be separated and they do not depend just on deregulation, since the deregulation is just one factor. No universal solution exists; every problem needs to be treated in its own way. Nevertheless, problems can be approximately defined and some solutions can be proposed.

2.1 Grid reliability

Major weakness for arrangement of electricity trading is the nature of electricity. Electricity can not be stored and without good connections could not be transported over long distances. Even with good connections its transportability is still limited. The ideal arrangement would be if the biggest generators were close to consumer centres. Unfortunately, this is not the case and this disadvantage is the first negative factor which influences grid reliability. Deregulation has no influence on this factor.

Sufficient electricity production is necessary for the consumer covering. Locally, the production capability should be sufficient for trip of the largest generator. An advantage of largest systems is that they absolutely need more reserve, but relatively less. After the introduction of liberalization, less competitive producers are on the road to ruin. In addition, some power plants are intentionally closed by producers, causing higher prices due to electricity power shortage. The oldest power plants were also closed since their modernization is not profitable. For the same reason new power plants were not constructed. On the other side, consumption is continuously increasing. A consequence is too small power reserve which is not sufficient in case of large consumption coinciding with a trip of an important unit or connection. Dry seasons with hydro centrals having low production in coincidence with outage of large units are most critical. If there was simultaneously large consumption, reduction would be necessary being a highly undesired measure. This is the second negative factor and deregulation has an important impact on it.

Subsequent negative factor is too slow evolution or unsuitability of the grid. After the development of free market, the need for transmission capabilities was increased. Even if the production capabilities were close to large consumption centres, the deregulation issued would be more complicated because everyone could choose its own supplier. The grid should be strong enough to enable free choice of the supplier and consequently fair competition. Consumers can select a distant supplier. Under the deregulation conditions the grid should be of stronger dimension that can successfully bear such deviations and assure grid operation reliability in free market conditions. Bearing in mind technical and environmental limitations,

up to now the target of grid planning has been focused on achievements of minimal cost. Now additional activities are required to assure that market function, i.e. enlargement of transmission capabilities, stimulation of new construction and increased usage of existent capabilities, prevention of potential risk etc.

Only strong connections with the grid are no longer so important to a nuclear power, but also that these connections are free for transmission of energy to the grid, which is a technical minimum and nuclear power plants capability of energy transmission to any consumer; (with technical possibility consideration) being a minimum prerequisite for free market and competition. If the company owing and operating the grid system is separated from the nuclear generator, it is questionable whether the security of the grid system remains adequate to meet the safety case requirements. The NPP requires close collaboration with the grid operator to ensure a continued reliable grid connection.

Many circumstances connected with grid reliability have influence on nuclear safety. That was evident during blackout in North America in August 2003.. Nuclear power plants lost offsite power for 1 to 6 hours. Although they had emergency power supply, the event was dangerous because eventual loss of emergency power could lead to station blackout, which is one of the largest contributors to core damage probability.

2.2 Cost reduction and investment

Cost reduction is the most important problem in conditions of free market. Too large cost reduction is very dangerous in case of staff reduction, minor investment, maintenance reduction or something else. There should be achieved an optimum should be achieved. Besides other factors nuclear power plants should pay attention to nuclear safety and increase it or at least keep nuclear safety on the same level. There are many possibilities to achieve this target and a nuclear power plant should choose the most appropriate way. Reducing operating costs could mean an attempt of reducing the number of staff. This is the area of a major difference between nuclear power plants and other competitive power stations. Table 1 shows the staffing levels in some power plants. Due to specific work nuclear power plants need more employees then other comparable power plants.

Table 1: Staffing levels

	Output (MW)	Staffing
NEK(PWR)- SI	700	573
TEŠ (Coal) – SI	755	534
TEB (Gas) – SI	218	120
Sizewell B (PWR)-UK	1188	500
Aberthaw(Coal) – UK	1500	250
Barking(Gas) – UK	1000	80
Didcot B (Gas) – UK	1360	35
Wind farm (offshore)	500	40-50

According to Table 1 a typical large coal-fired power station in England of a similar age has about half as many staff. One of the earlier gas fired station in England had staff of only 80 workers, but one of the latest has staff of only 35 employees. For comparison, the projected staff number for a new large off-shore wind farm is around 40-50. Staffing levels in Slovenia are comparable just in NEK although it is NEK, where a different number is expected due to specific work of the nuclear power plant. The developers of new nuclear power station designs also aim at lower staff numbers. The team designing the Pebble Bed reactor in South Africa believes that a 1000MW PBMR station could be operated by around

120 staff, while the Westinghouse experts suggest that their AP1000 design could have staff of only 180 employees. The abovementioned number is just for illustration, since such data are not directly comparable and there are many reasons for differences. Employment policy has to keep the level of knowledge needed for nuclear power plant operation. This is difficult in a small country like Slovenia with only one power plant and the limited number of specialists in this area. Nuclear power plants should take continuous care of skilled workers, without break in transfer of knowledge between generations. Some utilities intended to significantly reduce their staffing levels, which would inevitably result in greater involvement of contractors. This can lead to loss of skilled specialists and institutional memory influencing all nuclear knowledge. In addition, there is more overtime work, especially during outages. Workers are not so effective during overtime and there is more possibility for a mistake.

Another issue is investments. Investments bringing profit are not questionable for owners, but the investments into nuclear safety improvement are not so profitable, not profitable at all or imply commercial advantages only indirectly. For this reason it is necessary for every new investment to make a detailed analysis including a cost-benefit analysis taking into account nuclear safety. Then investments giving the best results for a defined amount of money will be selected.

Maintenance is of the same importance. Owners have a tendency to reduce maintenance costs. On the other side, insufficient maintenance consequently contributes to wear out, faster ageing and more frequent trouble causing damage which could be more expensive then maintenance costs.

2.3 Other influence factors

Profitability is an important objective for owners of nuclear power plants. As a result there has always been pressure to optimize and where possible, increase plant capacity factors. Deregulation cause utilities to look even closer at all opportunities to increase availability of the nuclear power plants. Plant capacity factors could be achieved withy improvements of operational management and an adequate emphasis on improving nuclear safety. On the other side, nuclear power plants tried to achieve better capacity factors with operational cycle extension and outage shortening. Reducing the outage period is achieved by improvement of preparation, planning and organization of the outage activities. This is also directly connected with transferring maintenance activity from outage to on – line. Shorter period of the same activity increases probability of a mistake. Core damage probability of transferred maintenance activities is also higher on–line than during outage. The extended cycle increases capacity factors. For this purpose higher enrichment and higher fuel efficiency are needed, but this causes problems with reactivity, higher probability of fuel damage and consequently more radioactive releases. An additional analysis should be made considering influence on nuclear safety. A test period and maintenance strategy should be also changed. The most profitable power plants are those which are already depreciated. Up-rating the power output of nuclear reactors is recognized as a highly economic source of additional generating capacity. The refurbishment of the plant’s turbo generator combined with utilization of benefits of initial margins in reactor designs, digital instrumentation and control technologies can increase plant output significantly. There are many examples throughout the world. For companies in the private sector, extending the lifetime of plants may also allow them to reduce their annual depreciation charge thereby spreading decommissioning charges over an extended lifetime and further improving profitability. Nevertheless, it is accepted that requirements to undertake substantial capital expenditure, possibly for safety reasons, may still force closure of some current nuclear plants, which can not justify the sums involved especially in case of smaller, older and inherently less efficient units. Another open nuclear

safety issue is also whether the changes would require a change in a nuclear power plant operating regime. (i.e. whether they could continue to operate only at steady load). Whether this is an issue it will depend on the characteristics of the plant and the attitude of the nuclear regulator. Electricity production should follow electricity consumption. In the past, when the electricity system was state-owned, it was very clear that nuclear power plants had steady load operating regime. In the deregulation environment, only those power plants with the lowest price operate. Owners, possessing a different type of the power plant have sometimes decided that the nuclear power plant has to be shut down during the weekend. Nuclear power plant operation with variable power has undesired consequences. Boron concentration should be changed to follow the power and consequently more coolant goes into recirculation and there is more radioactive waste. The second negative impact is on fuel. By power changing there is change of temperature and pressure in fuel and consequently there is more radioactive release from fuel. This effect is iodine spike and has appeared by power changes.

New conditions for power plants operation should not influence the relation between the operator and the regulator. This report is not about that relation. I will just point out two factors influencing nuclear safety. The first one is operator's behavior towards the regulator. In some countries new operators do not devote enough attention to regulator's recommendations. Due to the liberalization there are many changes of ownership. New owners and sometimes also new operators present a bigger risk, since they are not so familiar with nuclear safety. Even if they have experience from other countries, there is different legislation and a different regulator's approach. This is the reason for troubles of some operators which are taking over nuclear power plants in a foreign country. First there is trouble on reporting level, especially misunderstanding, incorrect reporting and finally covering and preventing regulator's work. Plant managers have to participate in a training programme organised by the utility including courses on nuclear safety in relation to their responsibilities. In addition, some courses are organized by the regulator.

On the other side, there is regulator's behavior toward the operator. The liberalization as such is not negative and has many positive consequences. Therefore, nuclear regulators should not interfere in areas which have nothing to do with nuclear safety. They should not impose additional requirements arising from liberalization and are not connected with nuclear safety. This can lead to unnecessary financial burden or incorrect arrangement of funds.

3 PROPOSED ACTIONS

One measure on operating level is for a nuclear power plant to have insight into the grid conditions. The nuclear power plant should be also notified about events and troubles which can have influence on nuclear safety. This can help operators get earlier warning so that they will have more time to take some preventive steps. Safety regulators can help arrange such an agreement.

The safety regulator plays an important role on the legislation level. New conditions should also reflect in legislation. In cases of decisions involving market and safety regulators, safety regulators' decision should prevail over market's decision. The second issue is financial guaranty. The nuclear power plant should have sufficient financial resources for safe operation of nuclear plants. The regulator should incorporate such measures into legislation to keep appropriate safety level. These measures include assessment of financial aspects when operating licences have been granted and supervision of nuclear facilities: shutting down the plants in case of financial problems.

The regulator should set up requirements for plant managers who will be new to the nuclear industry. Plant managers have to participate in a training programme organised by the

utility, which include courses on nuclear safety in relation to their responsibilities. In addition, some courses will be organized by the regulator. Plant managers are also made aware of their responsibilities in meetings with the regulator's management, which is good practice in Slovenia.

The regulator should observe staffing level over the years. It is difficult and unfair to compare the staff number between nuclear power plants, because of various influences of factors. But it is recommended to observe the trend of staffing level. If there is significant decrease, the regulator should make an analysis of conditions and take appropriate actions.

When electricity prices are that high that they may affect nuclear safety judgements; the regulator should pay attention to evidence of keeping reactors on line. In such a case the reason for operation should not be just profit and the plant should be monitored.

And finally the regulator has the most powerful tool - a possibility to close the reactor. This is an extreme and the last step, but the regulator should take this step if there is clear evidence that the operator does not operate safely.

4 CONCLUSIONS

Economic deregulation in the power sector raises new challenges for the prospects of nuclear power. The impact of electricity market deregulation on the existing nuclear power plants is expected to be generally positive, assuming that competition will result in improved efficiency, increased plant capacity and higher availability. The worst area is grid reliability which is evident in more grid collapses which was not the situation in the past. Consumption increases and causes larger power flows through the grid and that cause larger losses. Grid evolution is too slowly and with power production deficit in some areas which again causes larger power flows there is higher probability of grid collapses.

Competition may increase the chances of nuclear power plant life extension, particularly for plants that are already economically competitive, since the cost of life extension is much lower than the cost of constructing a new plant of any kind. There is some concern that nuclear safety can be compromised by overemphasis on short-term economics in a competitive market. However, safety remains a prerequisite even in a competitive market, since nuclear power plants not operating safely will be closed.

And finally, the regulators should adapt theirselves to the new conditions. Control of nuclear safety should include also observations of consequences arising from deregulation. There is only limited, but positive, experience with the regulation of nuclear safety in competitive markets. One of the challenges will be the ability of utilities and regulatory bodies to assume their respective responsibilities in a way that ensures continued safe and economic operation of nuclear units.

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