

## HUMAN FACTORS IN NUCLEAR POWER ENGINEERING IN POLISH CONDITIONS – CONFERENCE PAPER

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**Summary of the paper:** The paper “Human factors in nuclear power engineering in polish conditions” focuses on analysis of dynamics of preparing polish society to build first nuclear power plant in XXI century in Poland. Authors compare experience from constructing nuclear power plant Sizewell B (Great Britain) and Sizewell C, which is in preparation phase with polish nuclear power program. Paper includes aspects e.g. of creating nuclear safety culture and social opinion about investment. Human factors in nuclear power engineering are as well important as relevant economical and technical factors, but very often **negligible**. In Poland where history about Czarnobyl is still alive, and social opinion is created on emotions after accident in Fukushima, human factors are crucial and should be **under comprehensive consideration**.

**Key words:** human factor, nuclear power engineering

### 1. HUMAN FACTORS

#### 1.1. Definition and classification

In the beginning it is very important to understand well what a human factor is and how we could describe it. In HSG48 document we could find a complex definition: “Human factors refer to environmental, organisational and job factors, and human and individual characteristics, which influence behaviour at work in a way which can affect health and safety” [1].

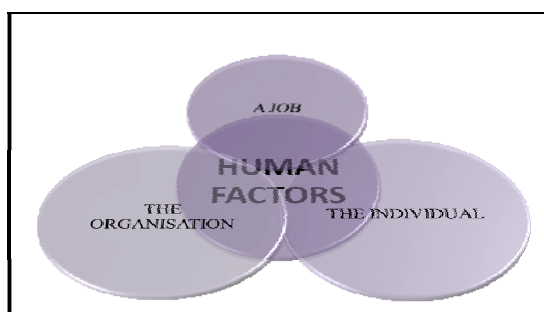


Fig.1. Categories important to consider in comprehensive way a human factor.

In this description of the human factor, mentioned categories are linked between each other, what is show in figure 1.

Human factors in reality are not isolated from surrounded external and internal environmental conditions. We can't think of human factors as isolated phenomena closed in laboratory. This specific environment creates tasks and needs with which human must cope. Concept presented in figure 1 may be considered in relation to external and internal influences, what is shown in figure 2.

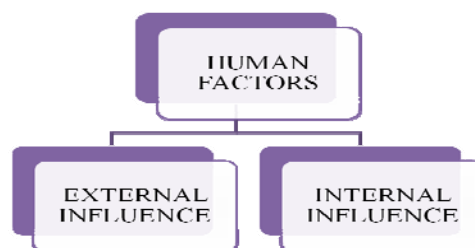


Fig.2. Influence of human factor

Presented classification is general and may be used in any engineering branch with necessary adjustments taking into account its specification which determines in detail the groups of factors to consider in more detail analysis.

Other well known classification in engineering practice is triangle MTO (Man, Technology and Organisation) or in other words HTO (Human Technology, Organisation) – figure 3. Drawing shows the relation between these three areas, what will be describe in subsection below.

#### 1.2. The “Man” aspect of human factors in nuclear power engineering

Human, as individuals are never exactly the same to each other. People could vary from each other personally, mentally, physically and according to level of knowledge and experience.

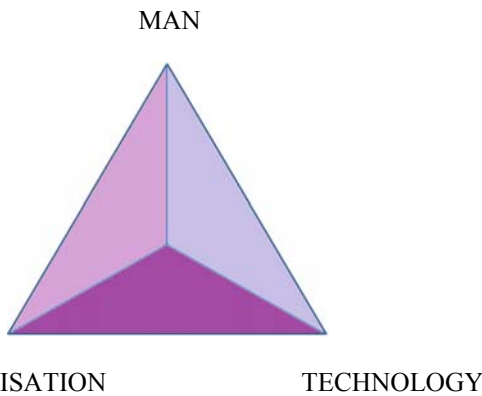


Fig.3. Classification of human factor in NPP

Knowledge about individual's capabilities and limitations in work is very important particularly in nuclear power plant. Not everyone will be good as a reactor operator or shift manager, but could be very good for e.g. as a writer.

Key point in selection of the staff in nuclear power plant or any other industry is to choose the best person for special job according to his/her predispositions. Essential features that selected people need to have are attitude, knowledge and skills. For each person suitable training and chance to personal development should be provided dedicated to its ambitions with relevance to performed job. Good worker is satisfied worker, who works more effectively and takes care about safety during performing the tasks. Definitely is easier to make progress in knowledge or develop some skills than change people's personality. This personality is the most critical and important when we manage human resources and human factors.

### 1.3. The "Organisation" aspect of human factors in nuclear power engineering

The organisation aspect of human factors includes e.g.: structure, the culture of the workplaces, management of resources, structure of communications, leadership, management of health and safety. All factors, which are listed above have influence on creating behaviour of staff. The organisation also changes in time, what implicate creation new processes, trends and new technical solutions. So on organisation side is to prepare the requirements, which include the rules and standard of work for new workers or contractors, which should be updated accordingly.

Every message should be communicate in appropriate way adjusted to knowledge of individual worker. The organisation also should motivate to team work through team tasks and training, integration meetings and social company events.

### 1.4. The "Technology" of human factors in nuclear power engineering

The "technology" aspects of human factors are connected to e.g.: technical requirements, technical training, technical analysis, simulation, planning and maintenance. The technology aspects must be "fit for the purpose", that means adjusted to the position of the employee, his/her role in the organisation and everyday duties. The "Technology" aspect with respect to human factors in nuclear power plant is very wide domain, what is described e.g. in particular procedures and is related to technical risk assessment and optimization processes.

## 2. SPECIFIC OF NUCLEAR POWER ENGINEERING

Nuclear Power Engineering is unique in terms of industrial facility. The utilization of technology in nuclear part of the facility requires appropriate mentality from technical staff and high level of nuclear safety culture. Human factors from practical point of view, authors try to show on examples from Sizewell B Nuclear Power Plant (NPP) which is operating in Great Britain. In NPP triangle MTO should have indication to facilities which are in operation.



Fig. 4. Sizewell A NPP and Sizewell B NPP

Below authors listed good practices based on own experience with short description:

**Safety message** – It is short information which is discussed during every morning team briefing. This is time to exchange the opinion and experiences about specified topic, but also a good opportunity to get some explanation from supervisor. The information to discuss is prepared by dedicated person.

**Nuclear safety culture** – could be summarized in the phrase "Doing the right thing when no one is looking". The safety culture is the way of behaviour in different situations; it is large scale of activities, procedures, habits performed to create safety working conditions; It is a way of thinking and acting e.g. scheme of acting as turning off the mobile phones when going inside NPP in order not to interfere with pagers. Nuclear safety culture is related to communication, training, procedures and unique company structures.

**Training** – it is on-going process. Everybody needs from time to time to refresh, update or fill the gaps of the theoretical knowledge by classroom training, but also very important is practical training to develop and improve skills and experiences. This is the main goal of Technical Training Centre in Sizewell B. On simulators people have a chance to see e.g. how some systems work as in reality. On simulator of control room, which is the most important practical part of training, shift crew (shift manager, supervisor, reactor's operators, support engineer) could train situations in normal and abnormal operating conditions. "The exercises" is the biggest simulation of NPP operation, when everything is simulated in detail, and all personnel are obligated to take a part in training. During "the exercises" is checked how procedures are respected in abnormal conditions by personnel. In the simulator of control room some scenarios of NPP operation are trained, firstly according to normal operation and then immediately are switched into abnormal conditions. The aim of that training is to simulate how people will behave and react during accident/incident in NPP.



Fig. 5. Simulator of control room

Another example is preparing to outage. During this time not only refuelling takes place, but also a lot of tasks which are train on special models what enables to check preparation before starting the repair and estimate required time to perform the necessary actions. It is very important, because during an outage time the reactor is in shutdown mode what results in losing the financial benefits.

**Communication** – is very important in facilities like NPP, very often tasks are performed by international teams and by people with various experience, so it is a clue to understand well the warnings, obligations and messages. It is good when these rules work in both directions, so we understand others and are also understood by them. This is why in NPP “phonetic alphabet” is used to be sure that we talk using the same “language”. In this alphabet all letters are assigned to particular words e.g.: H-Hotel, T – Tango or W-Whiskey.

**Procedure** – lists of particular actions that should be followed on particular time and in particular way, step by step. Procedures are prepared and approved by qualified persons.

**Structure** – it is essential and unique for each company, and is accessible for each employee. It is illustrated by graph with data, position and photo. Such description improves internal communication within company.

**Local society** –group of people who must be considered when it comes to construction or/and operation of NPP.

The local society analyses actions of an investor. As a result the social opinion is created. Local society very often is a key point of the project, what means that this is the main group, which provides accommodation and catering for NPP’s employees, contractors and supervisors during, construction of the plant. Location of NPP is important to consider, because the plant is often the main employer in the region and financial resource for community budget.

### 3. HUMAN FACTOR FROM ECONOMICAL POINT OF VIEW

The business aspect of human factors in nuclear power engineering can be described by analogy to the rule originated in medicine: “better prevent than cure”. It is quite hard to change social opinion about safety technology after accidents like Czarnobyl or Three Mile Island. These two accidents are just the most famous, but of course, the list of accidents and incidents is longer. Since 1989 have been used the [special International Nuclear](#)

[Events Scale \(INES\)](#), developed by International Atomic Energy Agency and the Nuclear Energy Agency Organisation members of Economic Co-operation and Development (OECD/NEA). The aim is to rank from 'anomaly' to 'major accident' the possible incidents in NPP. INES scale is presented in the figure 6.

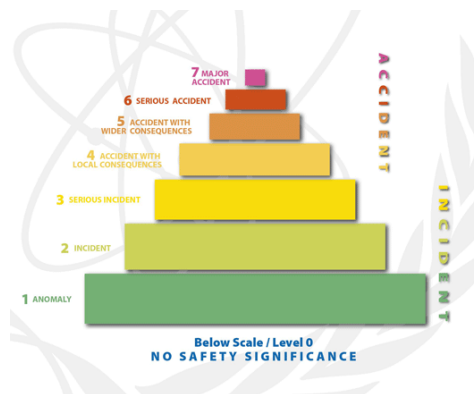


Fig.6. International Nuclear Events Scale (INES) [3]

The previous accidents have a big impact on Polish social opinion about nuclear power technology. It doesn't matter how long and how many nuclear power plants are operating without any problems.

That is why the education about nuclear power engineering is of great importance mainly during conceptual phase of the investment. Well educated society knows well advantages and disadvantages of NPPs. This awareness provides us a chance of fair judgement related to nuclear power technology. Developing the awareness refers also to the information written in the newspapers. This is an issues to give the clear and true messages to the community what prevent from creating the opinion based on imagination.. Company's safe image based on social awareness and knowledge cost a lot. That cost can't be compared with any different industrial branch, but it is worth to invest in it, because this will increase the chances for successful completion of the investment. By providing a good knowledge we can discuss on arguments when it comes to make a decision of NPP localization.

## 4. POLISH NUCLEAR POWER PROGRAM

### 4.1. About Polish Nuclear Power Program

This is not the first time when Poland tries to build nuclear power plant. This fact shows that a lot of factors have influence on success of such unique project. To take this ideas to reality in 2010 polish nuclear power program has been created.

This document considers human factors aspect in two chapters. In chapter 11 the issue regarding preparation of qualified staff to work in nuclear power branch is presented whereas the chapter 16 is devoted to widely understood “people and society” where issues as education and information campaigns are introduced.

Attention should be paid that Polish Nuclear Power Program is just a draft and the polish society at the moment has only experience from operating of nuclear research reactors. Polish society needs more time to get used to NPPs as a normal view outside the windows.



Similar situation was observed before, when the onshore wind power plants were installed. Creating such mentality in society is a long and time consuming process.

The institutions which have impact on preparing society to realisation of Polish Nuclear Power Program are: Ministry of Economy, Ministry of National Education, Ministry of Science and Higher Education, National Atomic Energy Agency, Radioactive Waste Management Plant, Office of Technical Supervision, Investor – Polish Energy Group S.A. and academic and scientific institutions.

One of the actions performed by The Ministry of Economy was program dedicated for academic lecturers – Educators of Nuclear Power Engineering. Program took place in the years 2009-2012 and included three phases. The intention was to prepare 36 lecturers to get knowledge about French experiences from nuclear power branch. In the first phase participants during 6 weeks visited French and Belgian nuclear power plants, scientific institutions, fuel production companies etc. The second phase was aimed to Nuclear Engineering Training in French Commissariat for Atomic Energy and Alternative Energies (CEA) Sacleay. During three months the group, which is shown in figure 7, attended in theoretical course about e.g. nuclear physics, nuclear technology, nuclear reactors and materials. The last phase was an individual internship in institution from nuclear power engineering branch chosen by each participant according to their scientific expectations.

#### 4.2. Universities, Companies and Associations

Polish Nuclear Power Program and plan to build first Nuclear Power Plant in Poland has activated academic society. The result is change of current, and refresh the good old programs from 80-ies, when the NPP in Żarnowiec was built. This is the new age of teaching about nuclear power engineering. Consequently most of technical universities started the new field of studies or specialization in existing studies regarding nuclear power engineering

Another action is to form new association to promote idea of building nuclear power plant e. g. “Association for the construction of a nuclear power plant in the Pomerania area” Very active are also companies which would like to deliver the technology or coordinate the process of building of first Polish Nuclear Power Plant

These companies organize a lot of meetings, conferences and workshops for: engineers, polish companies, students and all interested people.



Fig. 7. Polish Educators in CEA Sacleay in 2010.

## 5. CONCLUSION

“Human factors” is very important factor in each phase on realisation of Polish Nuclear Power Program. If we compare Polish and external experience we will observe that long and difficult way is in front of us. Technical aspects are well known, managing of companies is also well known. Only human aspects are completely new and are the most sensitive factors during whole project. In Polish conditions a lot of things could work differently than in external reality. That is why Polish investor should carefully and in detail consider each task and action within particular phase where success depends on human factors. If we add also the political relation to polish power engineering, and moods of society then we receive a picture of influence on polish nuclear power branch.

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## CZYNNIK LUDZKI W ENERGETYCE JĄDROWEJ W KRAJOWYCH REALIACH – REFERAT KONFERENCYJNY

**Słowa kluczowe:** czynnik ludzki, energetyka jądrowa

Artykuł zatytułowany: “Czynnik ludzki w energetyce jądrowej w krajowych realiach” jest analizą rozwoju przygotowania polskiego społeczeństwa do budowy pierwszej elektrowni jądrowej w XXI wieku. Autorzy porównują doświadczenia z realizacji budowy elektrowni jądrowej Sizewell B w Wielkiej Brytanii oraz przygotowania do realizacji planów budowy elektrowni jądrowej Sizewell C z polskim programem energetyki jądrowej. Artykuł porusza aspekty tj. kreowanie postaw kultury bezpieczeństwa jądrowego oraz opinii społecznej w odniesieniu do planowanych inwestycji. Czynnik ludzki w energetyce jądrowej jest tak samo ważny w eksploatacji oraz budowie elektrowni jądrowej jak aspekty ekonomiczne czy techniczne. Często jest on jednak lekceważony. W Polsce, gdzie pamięć o wydarzeniach z Czarnobyla jest wciąż żywa, a opinia społeczna jest kształtowana na bazie emocji z awarii w Fukushima, czynnik ludzki tym szczególnie musi być rozważany w jakichkolwiek działaniach podejmowanych w obszarze budowy polskiej elektrowni jądrowej.

