# NUCLEAR DEVELOPMENT AND THE IMPACT OF THE DISRUPTIVE TECHNOLOGIES

*Editorial*

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In the last decade an amazing development of some new technologies having a great impact on the development of the entire society occurred. Such technologies usually referred as disruptive technologies include: artificial intelligence, additive manufacturing, big data, material science, blockchain, virtual reality, drones, internet of things.

Most of them have the potential to transform the society, therefore to produce a real revolution in the development. From our perspective the most important questions are:

*Is the nuclear field enough resilient to such transformations?*

*Is it possible to capture the new advantages and implement into the nuclear systems?*

*What kind of efforts are needed?*

*Is the RDI well prepared to produce new added values by considering the real values of the disruptive technologies?*

From the point of view of energy consumption, ***Artificial Intelligence*** (AI) will have at least three major effects: (1) creates new way to optimize energy consumption, including the effectivity of the energy efficiency measures, (2) identifies solutions for flexibility in the conditions of a high penetration of the variable renewables (vRES), (3) allows a wide spread of electrical appliances and applications, (4) produces important changes in the occupational structure.

The energy sector in some countries has already started using *AI* to enable communication between smart grids, smart meters and Internet of Things (*IoT*) devices. Large companies tend to implement the most of these new technologies (*AI*, IoT, blockchain, cloud databases) to increase the efficiency of various processes.

An optimistic vision of the future is a world with all devices connected to the Internet creating an intelligent and optimal system with low energy intensity. The exploitation of the collected data can lead to the construction of optimal algorithms to implement the energy efficiency principles. With this purpose it is possible to reduce energy consumption and the costs, to obtain a better management of resources and of the power systems.

Some results are encouraging for the investments in this direction. For example, DeepMind, a subsidiary of Google, applied neural networks machine learning, for a 700 MW wind farm in order to predict production 36 h in advance. On the other hand, it should be noted any exploitation of a huge amount of collected data and transformation into learning algorithms involves high energy consumption, at least in the initial phase of the optimization process.

*AI* development will have important impacts on the traditional oil, gas and electricity industries, by profoundly transforming the way they operate. *AI* will help to build a better understanding of how energy is supplied and distributed allowing better predictions and decisions, with positive consequences in reducing the costs. Some examples for a better understanding could be mentioned: (1) machine learning can improve the ability to map and understand the value of underground oil and gas reserves, (2) dynamic regulation of the operation of the renewable energy systems, (3) improvement of the quality of solar energy forecasting.

From the point of view of the occupational structure, by 2030, it is estimated that *AI* will influence more than a third of jobs in the European countries. Some jobs will disappear, but new ones will be created. Between 40% and 50% of existing jobs could be partially of fully automated. The most affected jobs are those with low complexity tasks, standardized and repeatable. Employment will increase largely for occupations that require higher education and IT&C knowledge.

Development of *AI* and robotics may eliminate the human intervention in risk associated areas, including accidental situations or manipulation of radioactive materials. On the other hand, development of algorithms by machine learning may allow a better integration of the advantages of nuclear plants (Small Modular Reactors, SMRs or Large Reactors, LRs) into the specificities of the grids, including interconnection peculiarities.

The development of ***biotechnologies*** (*Bt*) will have important effects in: (1) demographic changes (which may influence global and local energy consumption), (2) technical developments (new solutions for energy generation and product development).

Whereas a global population growth will raise the issue of food security and global energy consumption, in Europe the population decline will lead to a decrease in household electricity consumption and possible contraction of the economies. From the point of view of social concerns, conventional production techniques alone cannot meet the future food demand. For this reason, research on plant growth techniques tends to focus on finding methods with maximum yield, in ever-changing climatic conditions. Specialists are convinced that food security can be improved by diversifying agriculture, by using more species for cultivation, but especially by developing biotechnologies.

An important direction for the analysis of the energy market is the cultivation of species favourable to the production of biofuels, in order to produce more efficient energy. Moreover, certain biotechnologies can contribute to improving access to hard-to-exploit resources. For example, by using these technologies, oil that is difficult to exploit from depleted deposits (they contain about 60% of the initial amount of oil) can be converted to natural gas, which is easier to be exploited.

At the same time, coal gasification techniques, as well as those for recycling organic waste are already available. Currently, industrial biotechnology uses enzymes and microorganisms to produce chemicals, food and feed, detergents, paper and pulp, textiles and energy with a direct impact in avoiding the fossil resources use as a raw material, but in some cases competing with resources that could be used for food. This problem, especially in the biofuels case, can be solved by using inedible biomass as a single raw material.

Through synergistic effects, *AI* and *Bt* may restructure society and the economy offering a totally different perspective from that of the industrial age. If the industrial revolution has brought to humanity the power to change the nature, *Bt* gives solutions to alleviate the aging of the body, including ″human augmentation″, ″brain design″, toward the reaching of the dream of the ″a-mortality″.

The important demographic changes, especially regarding the age structure, and the polarizations may accentuate the migration phenomenon. On the other hand, fusion of *AI* and *Bt* can quickly take billions out of the labour market. The expected impacts of *AI* and *Bt* introduces uncertainties in the future energy demand and also in the relation between free carbon electricity alternatives, such as the nuclear energy and vRES.

The amazing development of ***material sciences*** (*Ms*) will influence the energy consumption especially by the new possibilities to reduce the energy losses. For example, the heat produced by large plants will be transported easily at high distance to be used by the existing or new clusters of consumers.

On the other hand, the development of energy-storage materials will open broad possibilities for the energy storage as a key factor for the use of vRES.

Nowadays, the availability of the raw materials is a limitation factor for the development of existing energy technologies. Currently, eight (8) metals were classified as ′critical′: Dy, Eu, Tb, Y, Pr, Nd, Ga, and Te; six (6) materials were classified as ′near critical′: graphite, Re, Hf, Ge, Pt, and In, and should be monitored closely. The most of them are connected with vRES development, electric cars lighting, and fuel cell technology. For the nuclear industry the concerns are generated by the near-critical materials Hf and In.

An extensive development of ***additive manufacturing*** (*3D printing*) may dramatically change the supply chain, including the nuclear industry. Many components may be produced by additive manufacturing at the destination or locally, reducing the transport efforts, duration, and costs. The process is dependent only on the preparing the right alloys for the 3D printing of different parts/components. An important advantage will be the elimination of some constraints for the design due to classical manufacturing process. The designer may approach the systems outside of the existing traditional structures.

A great opportunity is open by the additive printing for the instrumentation and control. Sensors for real-time monitoring may be easily integrated into the components. Based on them, valuable information on the components'/ systems' performance may be collected, including data for preventive operation or even autonomous operation.

***Big data*** is a field dealing with large or complex data-sets to be delt by the classical software applications. Big data analysis includes capturing, storing, searching, sharing, transferring, visualizing, updating, analyzing processes. The volume (size), the variety (type, diversity), the velocity (speed of collection), and the complexity are the most important challenges.

In the last decade, an increasing number of nuclear users and vendors have recognized the great potential of the big data to improve the economics and the safety of the nuclear power plants (NPPs). One of the most attractive areas is the use of big data in combination with the engineering knowledge to obtain safer and more resilient nuclear systems.

The maintenance optimization and the component inventory are some of the big data direct applications in the nuclear sector due to the components volume and diversity. Collecting the data from a multitude of sensors together will be useful for the diagnostics and prognosis of the NPPs operational performances.

Such development may have influence on the plant life management allowing a better use of the components, avoiding burdening states. At the same time, safety and security performances may be significantly improved.

***Virtual reality*** is already incorporated in Education and Training (E&T) or in different services needed by the nuclear sector. However, the potential of the virtual reality is very high especially in terms of new applications to be developed for the nuclear facilities.

**Blockchain** technology may increase cyber security for the data recorded. On the other hand, it may create a more effective and efficient interface with regulators. It is acting as a trusted platform to record transactions and to distribute information among the parties without the control of a central entity. No files are used to store the digital records; instead, the information is represented by transactions written on a cryptographic hash.

Some important applications are already identified in the nuclear sector such as:

(1) the fuel supply chain, involving a large variety of stakeholders and data including mining, processing, purchasing, operation, spent fuel storage etc,

(2) effective management of the nuclear materials used in construction, operation and post-operation of a NPP, even after the decommissioning,

(3) recording events within a single facility or company (security access, safety events, etc).

All of these are contributing to a better transparency and will reduce the risks of fraud.

The commercial unmanned aerial systems, or **drones**, may be used for aerial monitoring including the critical infrastructure facilities, such as NPPs. The use of drones may be extended to the inspection of different nuclear facilities, for example looking for the leaks in boilers, steam isolation valve rooms, rad-waste areas, or fuel recycling areas. On the other hand, drones equipped with adequate sensors may collect the dose data on contaminated areas, even in indoor areas difficult to access.

All these technologies having great impacts on the society will change the nuclear industry. At least from this perspective the *nuclear power will operate into another world, with other rules, standards, and performances*.

The role of the nuclear RDI is to produce, in time, valuable studies, analysis, and solutions to harmonize the nuclear development with the societal exigencies.

In the frame of the climate neutrality objective the role of the nuclear may be crucial, but its future is dependent on the societal understanding of the priorities. The existing constraints in the development such as the level of the pollution, the global warming issue and the finitude of the resources are in profound contradiction with the principle of economic growth based on more consumption.

Fortunately, the new technologies will offer the tools to reduce the consumption by almost elimination of the losses and by optimization of the processes.

*But will they offering us more wisdom to understand the crucial priority of the survival of the humankind?*

On the other hand, the nuclear sector should recognize the necessity to accelerate the capture of most of the advantages of the disruptive technologies for a real progress of the domain.

The new generation of specialists should be ready for some important changes in the nuclear technologies. The innovative systems in the design phase could implement such radical transformation, and for these a deep understanding at the level of all nuclear stakeholders has to be reached.

*In this context, our journal is oriented to publish meaningful results oriented to reflect the efforts of the research and development, education and training, academia and industry, and also the efforts to build sustainable decisions by involving the diversity of the stakeholders.*

*Dear readers and dear potential contributors, you are welcomed in our journal to participate to a balanced debate on the nuclear issues and moreover to contribute with innovative and valuable solutions to the nuclear development in the context of the modern society sustainable development.*