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Lessons Learnt from Some Natural Energy Sources

Dan Serbanescu

Abstract

The chapter presents in a systematic manner the lessons learnt from the natural energy systems (NES) and their specific features. The conclusions are based on the evaluation of the risk impact on environment and for the improvement of the risk evaluation methodologies of such systems. A specific feature of the NES is the interdependence between them and society/mankind and the environment. Risk analyses for such systems have specific features underlined while compared with the features of the artificial (man-made) energy systems (MMES). Previous works illustrated in detail the NES versus MMES differences. This chapter presents the main aspects of such a review, when applied to a specific NES, the natural nuclear fission reactor in Oklo, Gabon (NES_Oklo). NES_Oklo operated about two billion years ago for about two hundreds millions of years. The lessons drawn from studying how this reactor was built, operated and self-decommissioned are of high importance for nuclear energy and not only. There are conclusions drawn from the study of Oklo reactor, which seem to shake some taboo issues in Physics, like for instance the light speed limit and other fundamental aspects of Quantum Mechanics, which have also important philosophical implications.

Keywords: natural energy system (NES), man made energy systems (MMES), risk, nuclear reactor, quantum mechanics, philosophy of science, speed of light, ecology, energy systems life cycle (ES_LC), knowledge process (KP), topological structure (K(i)), theory of a given topological structure (Th(K(i)), Backward engineering)

1. Introduction

Two and a half billion years ago a natural fission reactor operated on the Earth (Oklo). The discovery of this natural energy source created a series of theories and had implications yet to be evaluated both on the man-made artifacts of similar type and on some fundamentals considered so far as improbable to be challenged in quantum physics, biology, ecology, nuclear reactor theory. It also has an impact on knowledge management, on the epistemology and ethics. Aspects of the implications for mankind and the lessons learnt so far on the actions to build a sustainable civilization are presented in this chapter.

In 1972 the international community involved in the research, design and operation of MMES of fission type reactors was surprised and challenged by a discovery of the remains of an ancient natural fission reactor, in Oklo (Gabon). It was a NES type reactor (NES_Oklo).

However the discovery was predicted long time before by PK Kuroda [1]. The reactor in Gabon operated, intermittently, two and a half billion years ago for about two hundreds millions year and had an approximate power of 100 kW. It operated with uranium ore (using the isotope U235) and water [2–5].

As the reactor physics classic results show, this would not be possible, provided the concentration of U235 (considered as a constant for the whole universe) being presently 0.71% was not higher (around 3.3%) by the time the reactor started operating. And this is not all. The reactor had to have a concentrated amount of U235 in a place forming a geometry and a configuration of cooling (with cooling water) of a very specific precise type. Apparently cyanobacteria concentrated the uranium and the water from the underground, pushed by the geological moves by that time (Africa and South America were splitting apart) created actually the reactor core, as called in the nuclear engineering. Even more than that, the type of soil assured the retention of the radioactive elements resulted from fission, which actually did not migrate further than the site.

All those aspects were very troubling for the nuclear community. In addition the calculations for the MMES reactors were seriously challenged when they were used to describe NES_Oklo.

Findings did not stop here, as series of other theories were developed, as for instance:

- Theories related to how the oxygen formation (taking place exactly by that time) were related to the activity of the geyser nuclear reactor splitting water vapors, as water got overheated, to the atmosphere.

- As for the biology the time of NES_Oklo operation is also coincident with the appearance of eukaryotes, living beings having cells with nucleus in a membrane, to which we also belong.

- As a top of troubling discoveries, the site evaluations challenged some fundamentals of quantum mechanics and relativity, related to the alpha constant and the speed of light.

- Not to mention the fact that new theories and observations started to assume that, may be even the Earth core is a nuclear fission reactor and may be Oklo was not the only surface reactor.

- More than that evidence on existence of fission reactors is found also in our neighboring planets (Mars), all taking place at a certain time of evolution of energy chains of the universe, of the solar system and of our Earth. Operation of such NES reactors appears to give serious inputs on how an ecological type of such source of energy might be designed by mankind. All those aspects are really of high interest and researches are going on.

- A troubling set of correlations and coincidences illustrate for this particular case how various phenomena with their lifecycles, their appearance, and development are connected to each other and how Mother Nature gives us lessons on how to manage complicated lifecycles of high energies without damaging it.

There is a vast literature on Oklo reactor, of which the references are representative in our view. The references could be started with the works of PK Kuroda, who predicted the first the possibility of the existence of a natural fission reactor on Earth.

2. Evaluation method

This chapter will focus only on the lessons learnt so far. However, there are more than only natural sciences implications, but also on the manner we acquire knowledge, on how we build models and interact with their reality and how we related to their lifecycles.

Therefore the chapter will not address the details of the researches on Oklo, but rather the lessons learnt to the humanity for such a discovery. The approach adopted in the presentation of Oklo lessons in this chapter is also based on some author's researches on the philosophy of science and models proposed to consider, model and interact with the energy sources, by describing their creation/emergence, their lifecycle and their interaction with mankind and its knowledge.

For this endeavor, a systematic approach was adopted and presented previously [6–9]. Based on this approach the NES and MMES are evaluated in their interaction and development/transformation from one to another in a systematic manner, which is based on some assumptions, as follows:

1. Energy sources create systems, which might be considered Complex Systems (CS) [6] These systems are composed of elements and connectors between them defined as categories, in the mathematical sense [6].

2. For the ES considered as CS, defined by NES and MMES, because they have a behavior of topological nature and for their models, a topological description is possible, as they

   - are described by invariants, that preserve their nature after transformations,

   - create complex networks fractal like structures and

   - their emergence/transformation from one phase/state/form/source to another takes place step by step [10].

The KP of a given ES for a given NES cannot be predicted in detail, but in its general features. The proposed approach considers that the KP generates a topological structure (K(i)) based on a set of relationships between the objects modeled and it is developed in accordance with a certain Theory (Th(K(i))). The topological structure resulting from the KP is in isomorphism with the topological structure describing the emergence rules of the NES from one state to another. The method is based on three principles [10]:

Principle 1: The topological structure K(i) is described by the notion of category considered as:

   - reflecting a hierarchical "matrioshka" type of structure

   - being a general description of cybernetic description of objects and models as "black-boxes" for each level of construction and for each object.

   - being described by objects, morphisms, and identity morphisms

Principle 2: KP is performed in iterations on the categories for each object and each level up to the moment of reaching a critical status due to number and type of paradoxes that result at each step.

- The set of invariants (syzygies) is continuously optimized from diverse points of view (using tools from different sciences) and based on the existing results on them a final set of minimal syzygies for a given model —using a given scientific tool—is reached (Hilbert's syzygy theorem).

- The process of reaching a status for a set of syzygies is therefore predictable and has an end. However the end state described by the resultant set of syzygies in that KP phase may not correspond to the real object. Therefore, a new iteration using another type of methods— analogy from another science that the previous iteration—is used for a new iteration.

- The KP with these new tools will lead to another set of syzygies and have a status of paradoxes in comparison with the real object that will require a new iteration etc.

- An example of NES group is presented in this paragraph. NES are assumed to consist of the following levels of energy sources (NES):

    ○ Subquantic (SQ)

    ○ Quantic (Q)

    ○ Electromagnetic (EM)

    ○ Molecular (MO)

    ○ Molecular and life (MOL)

    ○ Conscious planetary life (CPL)

    ○ Stellar and universe not alive (SUNA)

    ○ Stellar and universe life (SUA)

    ○ Conscious stellar and universe (CSU)

Principle 3: KP is asymptotically stable and complete. However the resultant final structure of this process, which is a CAS, may not be known by its detailed phenomenological characteristics, nor predicted, but rather known for its dominant syzygies.

3. The invariants are called syzygies and they are in the format described by formulas (1) and (2).

$$\text{Gen [NES]} = [\text{EnTh EnI Sy Em NlnCx Fr}] \qquad (1)$$

$$\text{Syzygy [NES]} = f\,(\text{Gen[NES]}) \qquad (2)$$

There are some specific generators (in the sense of syzygy theory) for a K(i) structure built for NES:

- Exergy (Ex) of a NES (defined as the maximum useful work possible during a process that brings the system into equilibrium with a heat reservoir), as a

measure of the efficiency of an energy conversion process. This generator has some specific characteristics:

- It is conserved only when all processes of the system and the environment are reversible

- It is destroyed whenever an irreversible process occurs.

- Entropy in a thermodynamic (EnTh) interpretation as a measure of disorder

- Information entropy (EnI) (as a measure of knowledge limits themselves)

- Synergy (Sy) as a measure of a resultant set of features for a NES appearing from the existence and interaction of all systems and subsystems, leading to a set of characteristics for the whole NES than exist in the sum of its parts

- Emergence (Em) from one level to another (in the example for NES presented from SQ to CSU) a process in which larger entities, patterns, and regularities arise through interactions among smaller or simpler entities that themselves do not exhibit such properties and evolve to new levels.

- Nonlinearity (even for simple systems) and/or complexity (NlnCx) of NES as sources of chaotic structure and behavior

- Features of CAS—fractals type of structure (Fr) of NES and K(i) knowledge topological structures built for them.

4. The physical meaning of the dominating syzygies, defining the phase change of ES (NES and MMES) is that they are a triadic set of characteristics of the state of the ES/syzygies and are [10, 11]:

- Energy (E)

- Mass (m)

- Entropy (ψ)

These are optimal descriptors of each ES state and are described by the formulas (3)–(5)

$$E^{(k)} = E_0^{(k)} + \sum_{j=1}^{8} E_j^{(k)} * i_j^{(k)} \tag{3}$$

$$m^{(k)} = m_0^{(k)} + \sum_{j=1}^{8} m_j^{(k)} * i_j^{(k)} \tag{4}$$

$$\psi^{(k)} = \psi_0^{(k)} + \sum_{j=1}^{8} \psi_j^{(k)} * i_j^{(k)} \tag{5}$$

where

- E_0, m_0, ψ_0 –and $E_1^{(k)} * i_1^{(k)}$; $m_1^{(k)} * i_1^{(k)}$ $\psi_1^{(k)} * i_1^{(k)}$ (Noted for the states 0 and 1) define the term called real energy/mass/entropy; examples of energy in such

states are the energies perceived at Earth level by a human observer (including such as NES_Oklo), defining the Real Reality.

- indexes 2 and 3 the simple complex part (for the states 2 and 3); examples of states of this type are the paranormal phenomena, energies, information channels perceived by a human observer becoming part of the observed object, defining the Intuition Reality of the second level Realm (cosmic) and

- the rest of components are the hyper-complex part (for the states 4–8); examples are states of paradoxical situations coming from other realities and totally unexplainable for a human observer, but managing them by enantiotropy feedback chain (entropy of states of the triadic ES) and they are our connection to the Universe Realm and diverse realities (Universes) (formula (6))

- The entropy has the following dominant syzygies for each state, as follows [11]:

  ○ Thermodynamic entropy, for the states 0 and 1 for the real states

  ○ Shannon entropy for the states 2 and 3, for the simple complex states

  ○ Enantiotropy for the states 4–8

The triadic set of syzygies defined the set of Realities (as in formula (6))

$$R^{(k)} = R_0^{(k)} + \sum_{j=1}^{8} R_j^{(k)} * i_j^{(k)} \tag{6}$$

5. ES and their models define topological algebraic spaces, which might be represented as polyhedral type, describing their states and illustrating the optimal cases.

6. The description of emergence/transformation of one source in another or of passage from one phase to another is based on the method presented in [6, 10].

7. ES and their models exist in two types of interconnections, with:

   - Other natural phenomena

   - At a given level of civilization

For instance NES_Oklo appeared 2.5 billion years ago, while the "Reactor designer" had at its disposal:

- A certain geological configuration

- A certain status of living beings

- A certain status of interface with cosmos

- No existing civilization

- Environment as we know being under construction

However, the interpretation we make of this source is done at a certain level of our civilization (in its very early beginnings, judging by the criteria of what kind of energy we could harness) [6]. We are far away by several centuries before being able to harness the energy of our sun, which is quite a primitive phase. On the other side, our KP is based on an extremely advanced tool (the interdisciplinary and trans disciplinary one) which may push us to advance much faster than we may envisage now. However, the stronger the forces we harness, the higher the risk to get to the finish of civilization by self-destruction.

We are at a crossroad of the evolution and lessons from NES like Oklo are extremely useful, as they show us how to harness better high energy with high risk sources [6].

8. In our present knowledge the KP assumes for the ES cases a set of assumptions generated by the paradigms, creating paradoxes, as for instance [6]:

- **Paradigm 1-ES as a CS:** A modeling system has to be built in order to represent Risk Analyses for ES (RES) as a complex system, too. RES is converging to a stable unique real state. However the KP results, including those RES are limited by our present knowledge, as described by the real Earth level mentioned above.

- **Paradigm 2:** ES model involves knowledge of the risks associated to a certain source of energy. However, usually we actually are not aware of the real risks and we know very little about the interconnections of lifecycle dangers for interfering processes (energy level, emergence correlated with civilization one or with geological one etc.)

- **Paradigm 3:** Details of ES and their lessons learnt. We design ES (MMES) for which Nature already indicated the optimal solutions. However, due to our reduced technical and scientific level at a certain moment we cannot understand the lessons from the beginning, but step by step.

- **Paradigm 4:** Understanding the ES risks (RES) and defining them is a difficult task as we design first of a kind MMES and as we are not aware of all the aspects of the lifecycle. The MMES are challenged inevitably by serious events, which apparently test the design continuously.

- **Paradigm 5:** ES risk analyses results are seen as inputs to decision making risk calculation results are used for decisions. However we are facing decisions under high uncertainties and the use of lateral thinking is decisive.

- **Paradigm 6:** In the ES risk analyses results there are limits and biases specific to the level of knowledge of that issue, but also there are "hidden" biases due to the level of KP in the whole civilization at that moment. Inter and trans disciplinarity is not just a desired option, but a mandatory one to minimize such biases.

- **Paradigm 7:** RES results evaluation for further iterations in the.KP is an iterative process and the Principle 3 mentioned above applies. The result could be a better understanding by the use of diverse tools, as for instance the information one can get by "backward engineering" from natural examples.

3. Lessons learnt from NES_Oklo

NES_Oklo sends to us messages. By diverse evaluations one could mention so far messages as the following:

1. The issue of the meaning of risk analyses for ES is very important, as the lessons learnt from NES_Oklo show. NES_Oklo was a combined non-live living organisms operation to produce energy. This is a high important topic for the future MMES to be designed by assuming the use of Artificial Intelligence, may be also natural and living organisms, etc. The evolution of our civilization and/or possible future interactions at cosmic level require a clear strategy on how to proceed if combined (natural, artificial, living non-living, etc.) energy sources production is to be evaluated and designed.

2. NES_Oklo teaches us on the absolute importance of intrinsic safety (the reactor operated, got decommissioned without being of any harm to its environment, but on the contrary, being part of the evolution "plan").

3. NES_Oklo has the following features of importance for future evolutive MMES to be designed, built and operated by the mankind:

    a. The limits of NES_Oklo were very well defined for all its lifecycle phases

        i. During operation

            1. Geometry stability of the core assured by the rocks configuration (the concrete part of any MMES)

            2. Climate was stable in the parameters of the period

            3. Interface with living organism was designed to be not only harmless, but also useful for both sides (cyanobacteria were prosperous for several millions of years).

        ii. During decommissioning

            1. There was no migration beyond the site of the heavy radioactive solid waste.

            2. The aerosols were actually part of the plan to rebuild the Earth atmosphere and generate new living beings—eukaryotes.

            3. Apparently the design assumed how to better decommission it at the end of the lifecycle. Thinking of decommissioning from the research phase is a mandatory requirement for a well-designed MMES.

    b. There is a fractal like design of the whole NES_Oklo reactor, as for instance the manner the following reactor functions were assured, as reflection at lower levels of the same principles:

        i. Fuel load (uranium 235) to the reactor core, assured by cyanobacteria, as an intrinsic self-regulated process, in mirror with the operation of the whole reactor.

    ii. Diffusion of small distances in the specific rock of the site (several meters for more than 2 billion years [12]).

    iii. Radioactive radio-sols were part of the creation of new living organisms; therefore the containment was the whole atmosphere, without damaging it, but helping it.

    iv. There was an intrinsic safety assured by delayed neutrons, preventing transformation of the reactor into a bomb

  c. The validity of reactor physics codes used for MMES was highly challenged. Although it seems so far that they could reproduce the reactor core design, there are yet issues to be clarified.

  d. NES_Oklo has a direct impact on the lifecycle preparation of existing and future MMES, as follows:

    i. Review the type of best plant control—centralized versus decentralized

    ii. Review of the safety analyses models for all the lifecycles and especially for decommissioning

    iii. Review existing researches on the future man machine interface for new reactors, role of artificial intelligence and the role of KP and generations to operate the plants

    iv. Set the goal of maximum simplification of MMES, counting to the highest extent possible on passive features and intrinsic safety protection.

    v. Review the manner various phenomena are modeled for the reactor in coupled computer codes and either use higher computing capacities or simplify them

    vi. Design MMES as part of regional/global energy sources systems, integrated in the environment, based on ecological principles.

  e. Several aspects from fundamental quantum mechanics and theory of relativity are yet to be reviewed, as the NES_Oklo measurements are challenging some of them

    i. How constant is the alpha constant and the role of the amazing number 137 in the architecture of the universe

    ii. It appears that some constants are not so constant (for instance speed of light). If so the impact is very high on many aspects already considered confirmed and taboo to be challenged. An epistemic revolution is to be generated in Physics on the way to change the existing paradigms.

    iii. There is an amazing set of coincidences to have a reactor core designed (geological, biological, cosmic, etc.). If the rare

coincidence might be more or less accepted, the troubling finding that the NES_Oklo is not the only one of this type leads to the debate about anaphatic and kataphatic approaches to the understanding of the *Designer* of the world.

iv. The NES_Oklo operated from the design to decommissioning phase as a cybernetic machine understandable with high level cybernetics considering all the three levels from formulas (3)–(6) —real, simple complex and hyper-complex. The hyper-cybernetics, governed by the feedback control via the enantiotropy (entropy of the optimal ES states) is a very possible answer to previous questions. High level cybernetics—the cybernetics of CS states is indicated as describing such systems.

f. NES_Oklo raises a series of philosophical debates, too:

i. The evolution of life on Earth, the meaning of life and the role of randomness (if any) in its emergence and evolution.

ii. The future of our civilization and how to use better the lessons so that to avoid destroying ourselves by the time we harness more and more powerful energy sources.

iii. Why and how was it possible at a certain moment in time to have NES_Oklo? How to explain strange coincidences of NES_Oklo with eukaryotes, Earth terraforming and conditions for us to appear in the evolution (or what?) chain.

iv. How to understand/manage messages for which we do not have yet the capability to understand, as they are from the category of hyper complex reality?

4. Conclusions

NES_Oklo had so far a significant impact on nuclear physics and nuclear engineering. However, its impact is yet to be completed, as new investigations and interdisciplinary works discover unexpected facts of the lessons transmitted by Oklo to us.

NES_Oklo is an example of how to build and operate an optimal, environmental friendly, for all lifecycle phases, nuclear fission reactor.

Summarizing, its lessons are related to:

- Improvement of the design strategies for new MMES

- Lessons on how to solve the waste management problem

- The high advantages of using combined live-non alive elements in the fuel cycle

- Foster the fundamental research in quantum mechanics, as the lessons are that, we are not yet understanding even basic aspects (as for instance the role of various universal constants)

- Review the models we build for the Physics and ES and improve the KP for those aspects by using systematic approaches

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